Epiphysis, thyroid, parathyroid and adrenal glands

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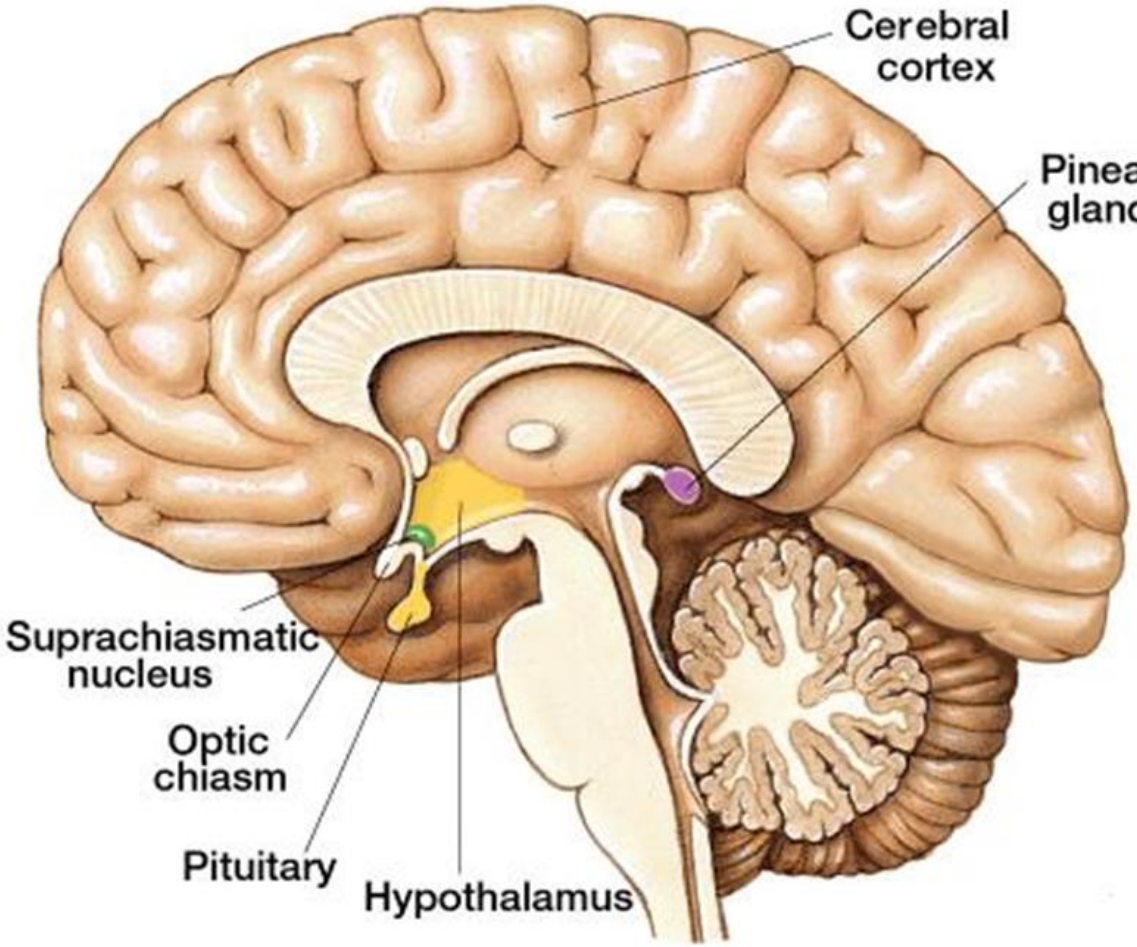
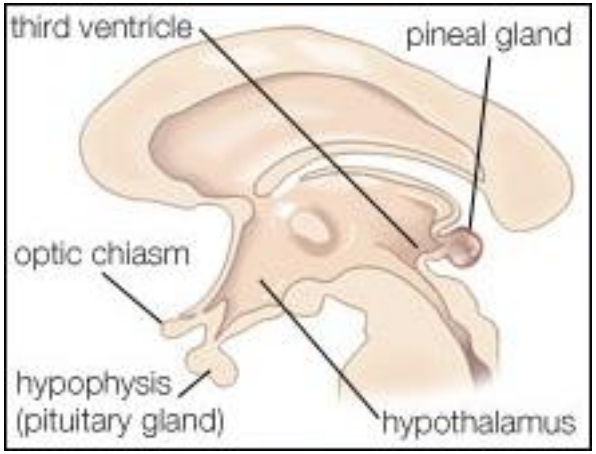
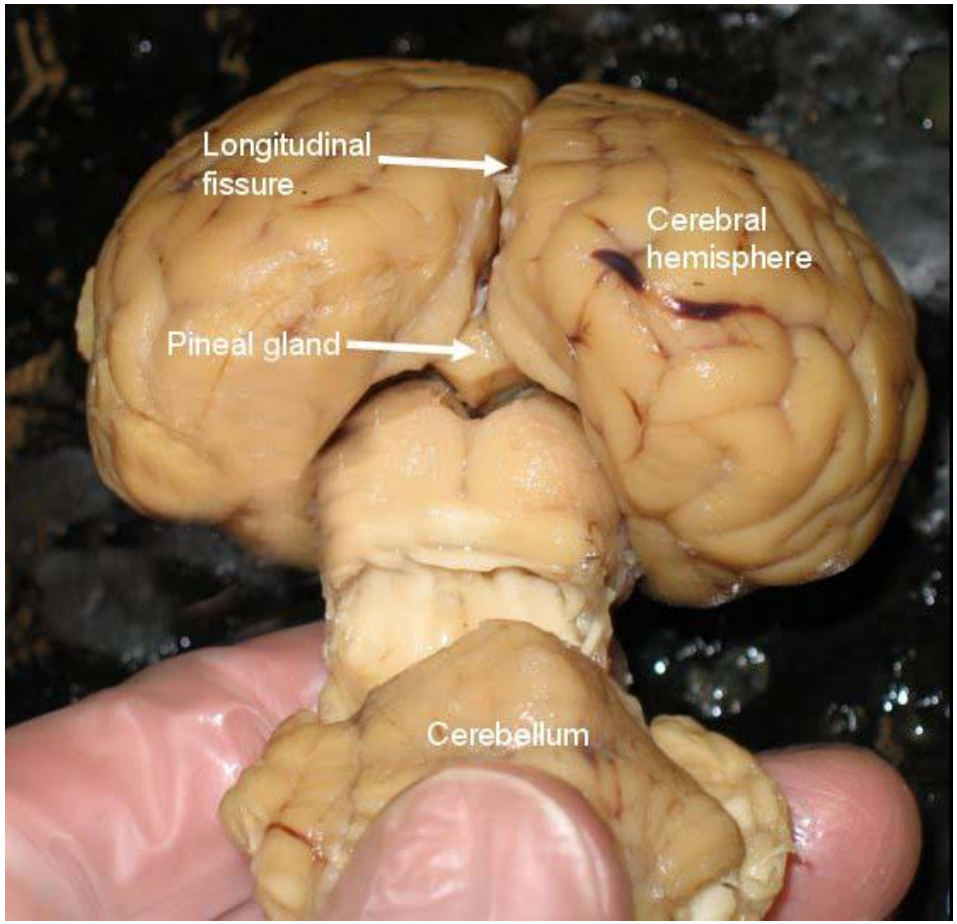
Epiphysis or pineal gland





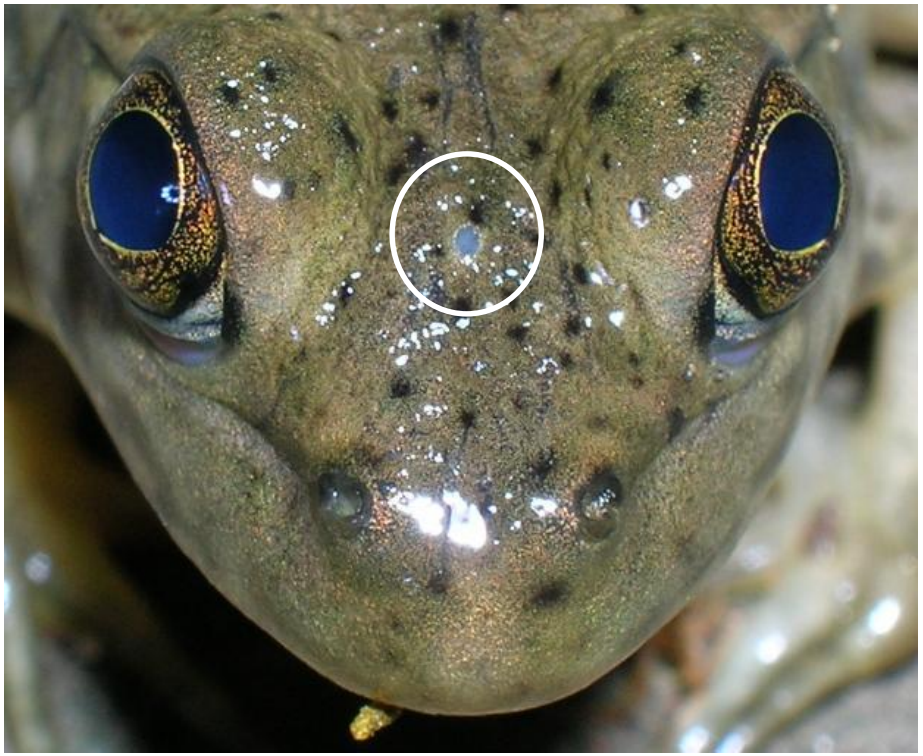
Develops from neuroectoderm as an evagination in the roof of the diencephalon.

The epiphysis belongs to the epithalamus



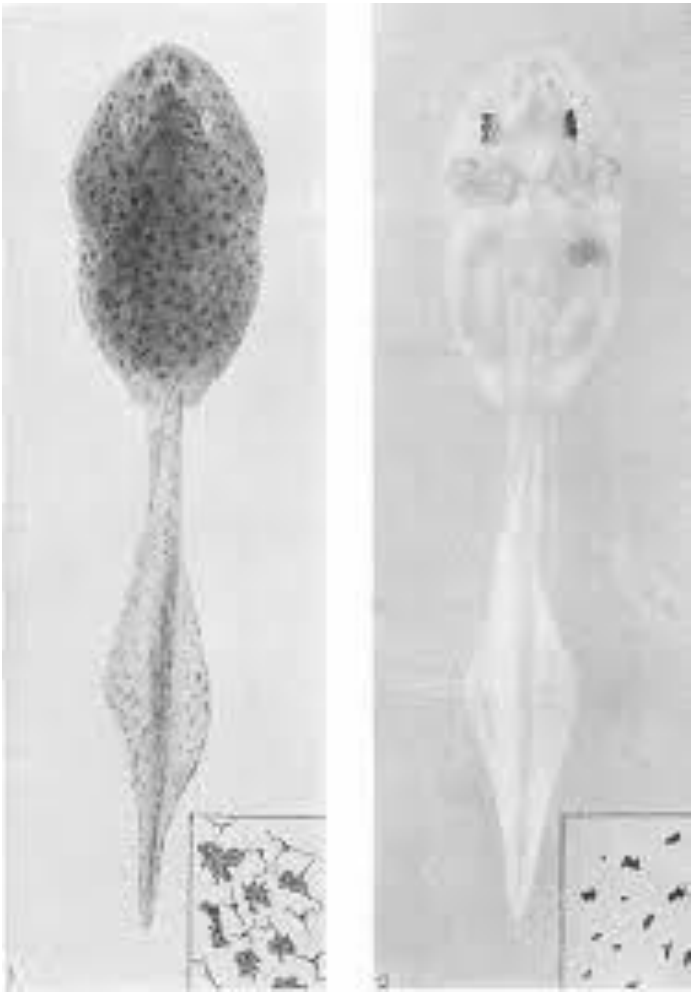
- Size : 5-8 mm. Develops until age of 2, than shrinks in elderly.
- It is covered by the pia mater.
- It is outside the blood-brain barrier.

The pineal complex: the pineal gland and the parietal eye



- Parietal eye (organ): photoreceptive in reptiles, humans do not have it.
- An anterior evagination of the epiphysis.
- Only few of today's lizards have it.
- Thermoregulation, reproduction, orientation.
- Parietal nerve: does not project to the visual cortex.

The pineal gland secretes melatonin



Carey Pratt McCord andFloyd P. Allen. Evidences associating pineal gland function with alterations in pigmentation.

1917. Feeding extract of the pineal glands of cows lightened tadpole skin.

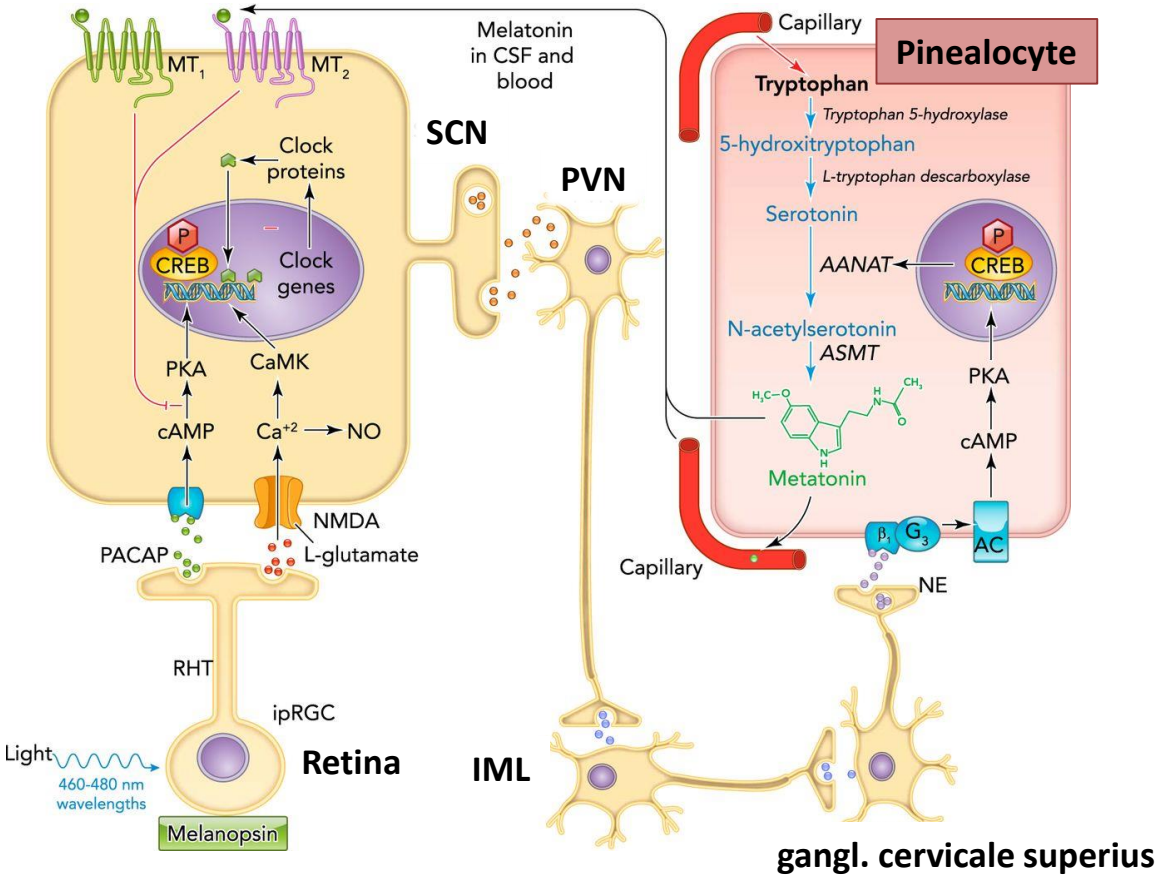
1958: isolation of the hormone from bovine pineal gland extracts.

„mela" (melanin) + „tonin „ (serotonin)

mid-1960s: the pineal gland is recognized as a component of the endocrine system:

- influenced seasonal reproduction in photosensitive species,
- it required its sympathetic innervation to remain functional.

Synthesis of melatonin takes place in a circadian fashion



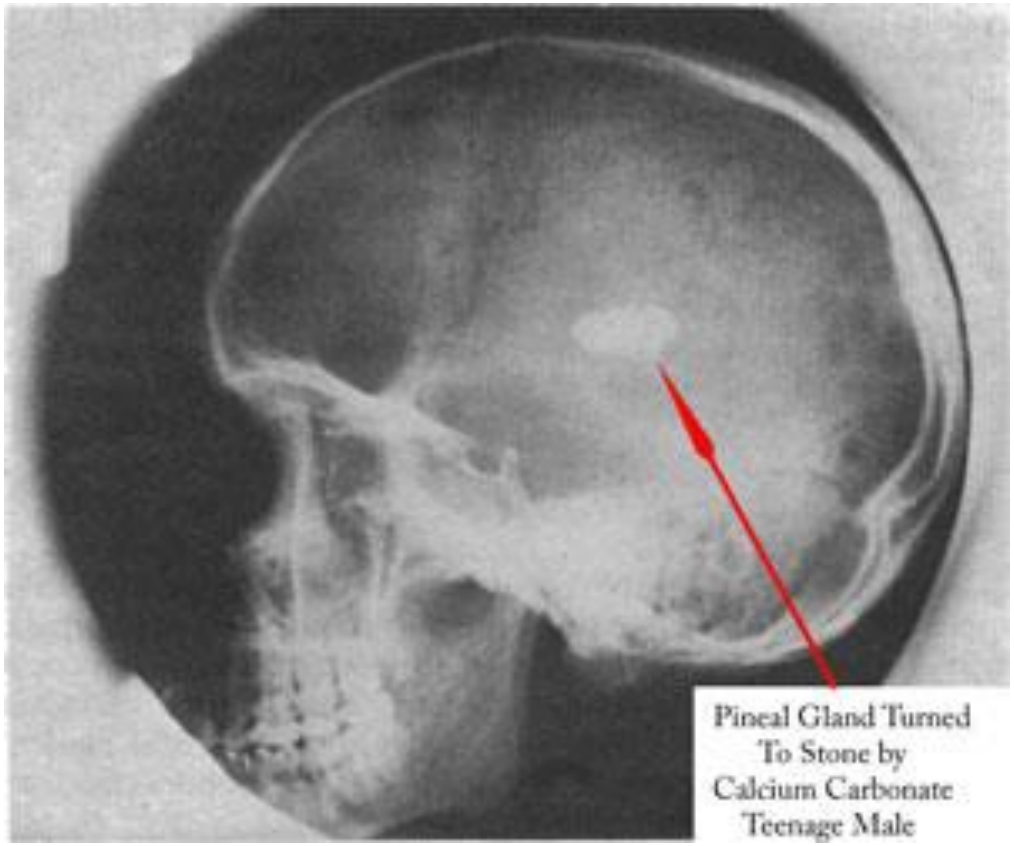
Alterations from other endocrine organs:

- Hormone production is controlled by neuronal input - inhibition during the light phase.
- There is no peripheral feedback.

Melatonin is produced also in the retina, kidneys, liver and GI tract by non circadian manner.

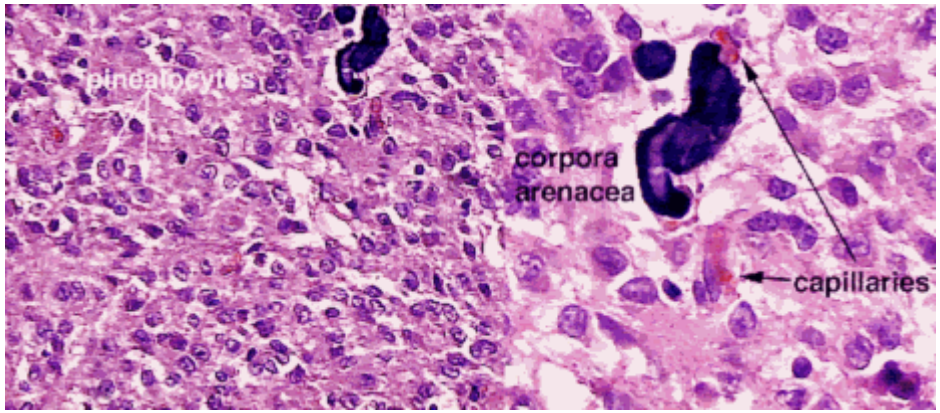
Reiter R J et al. Physiology 2014;29:325-333

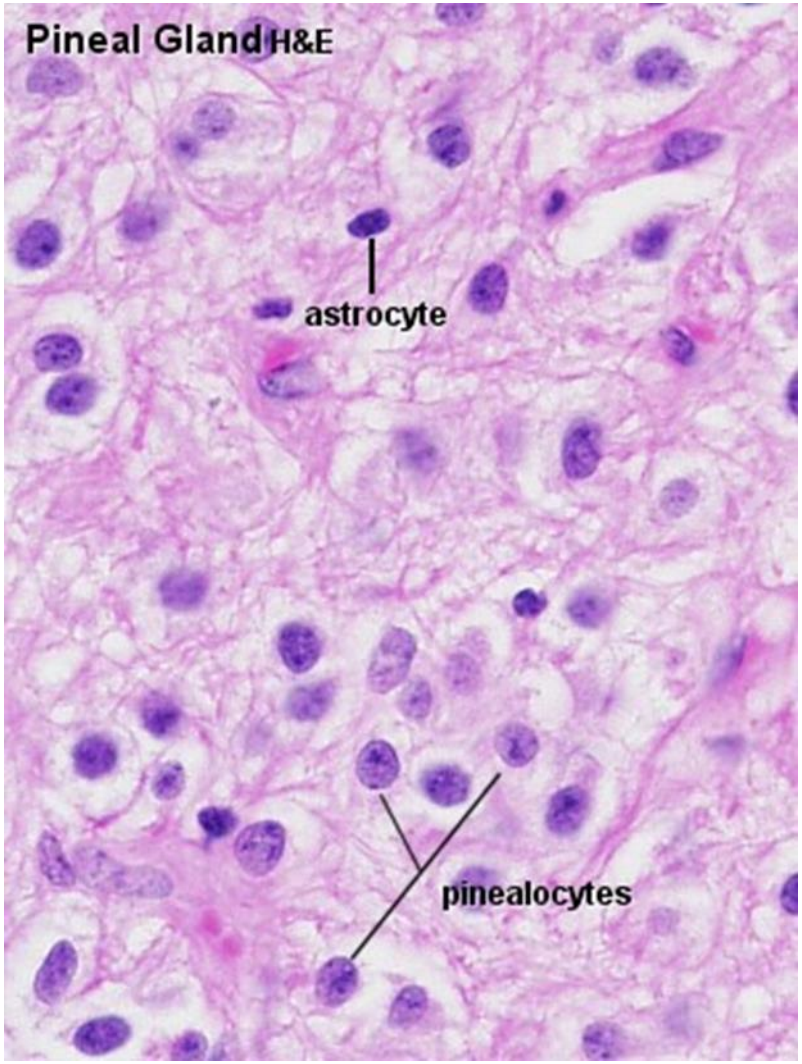
The pineal gland is a mineralizing tissue



- Brain sand: corpora anaracea (acervurus cerebri).
- Fluorides enhance calcium accumulation.

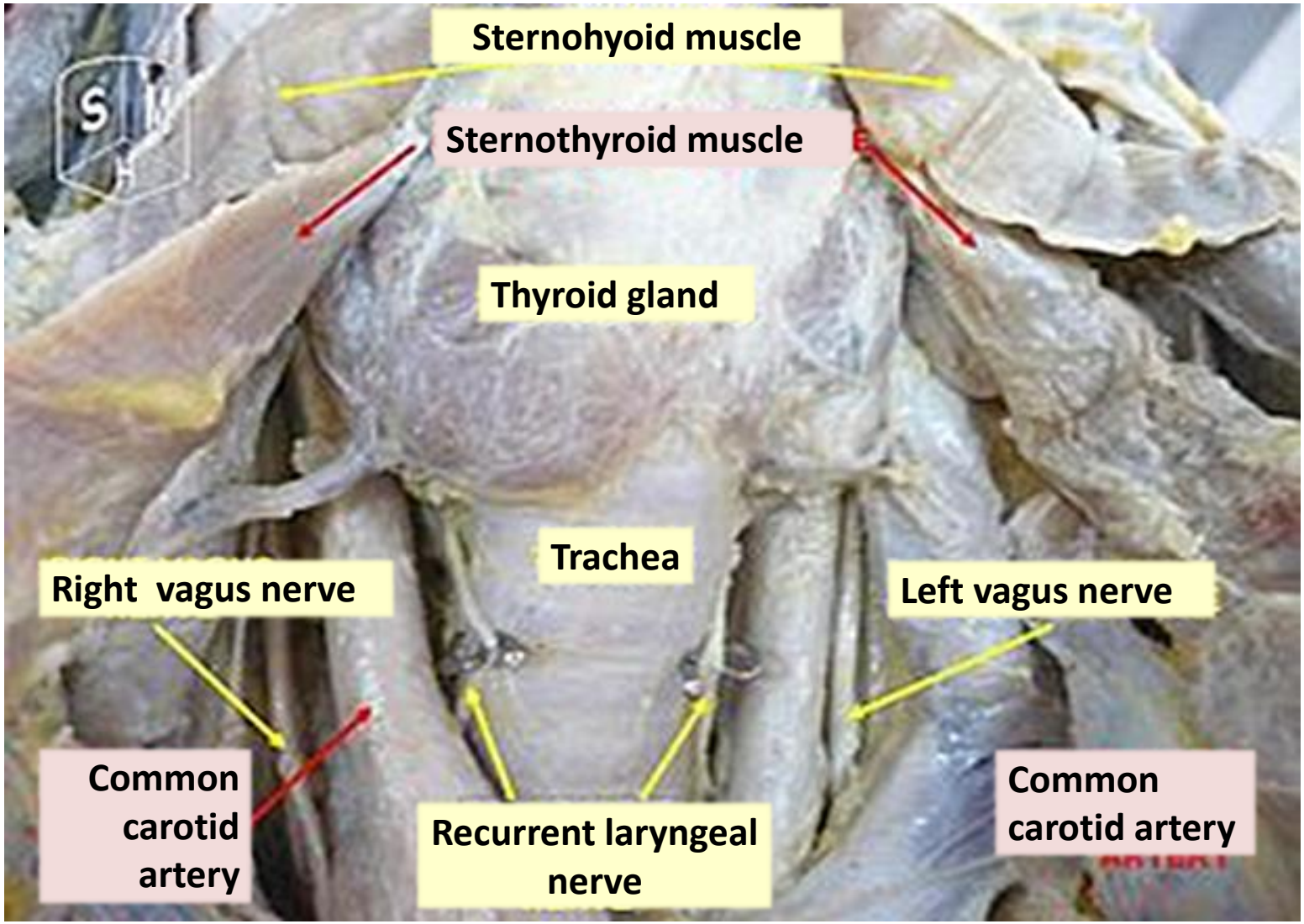
Histology of the pineal gland





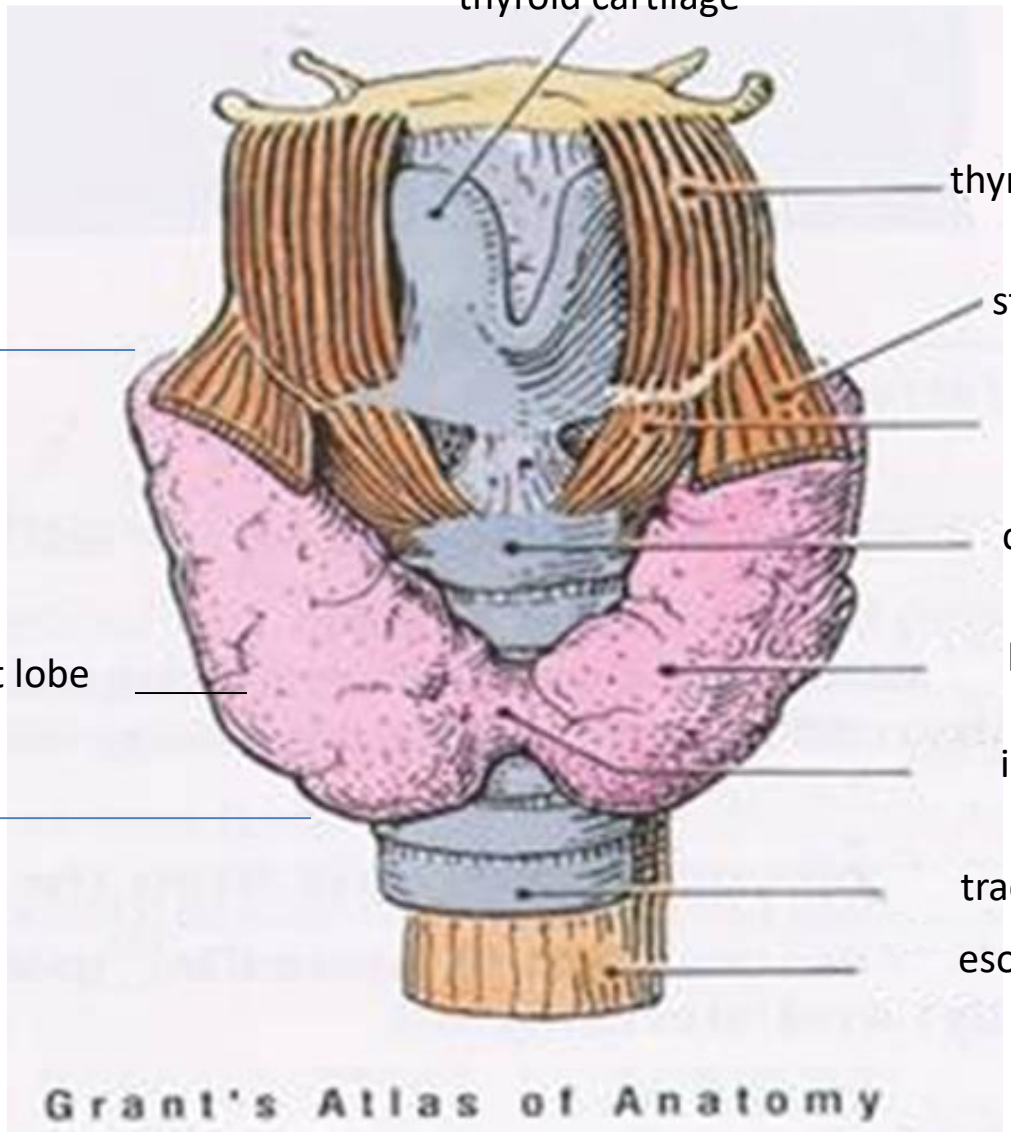
- Pinealocytes
- Glial cells
- Mast cells
- Connective tissue, septa
- Nerve fibers
- Capillaries
- Acervulus cerebri

The thyroid gland

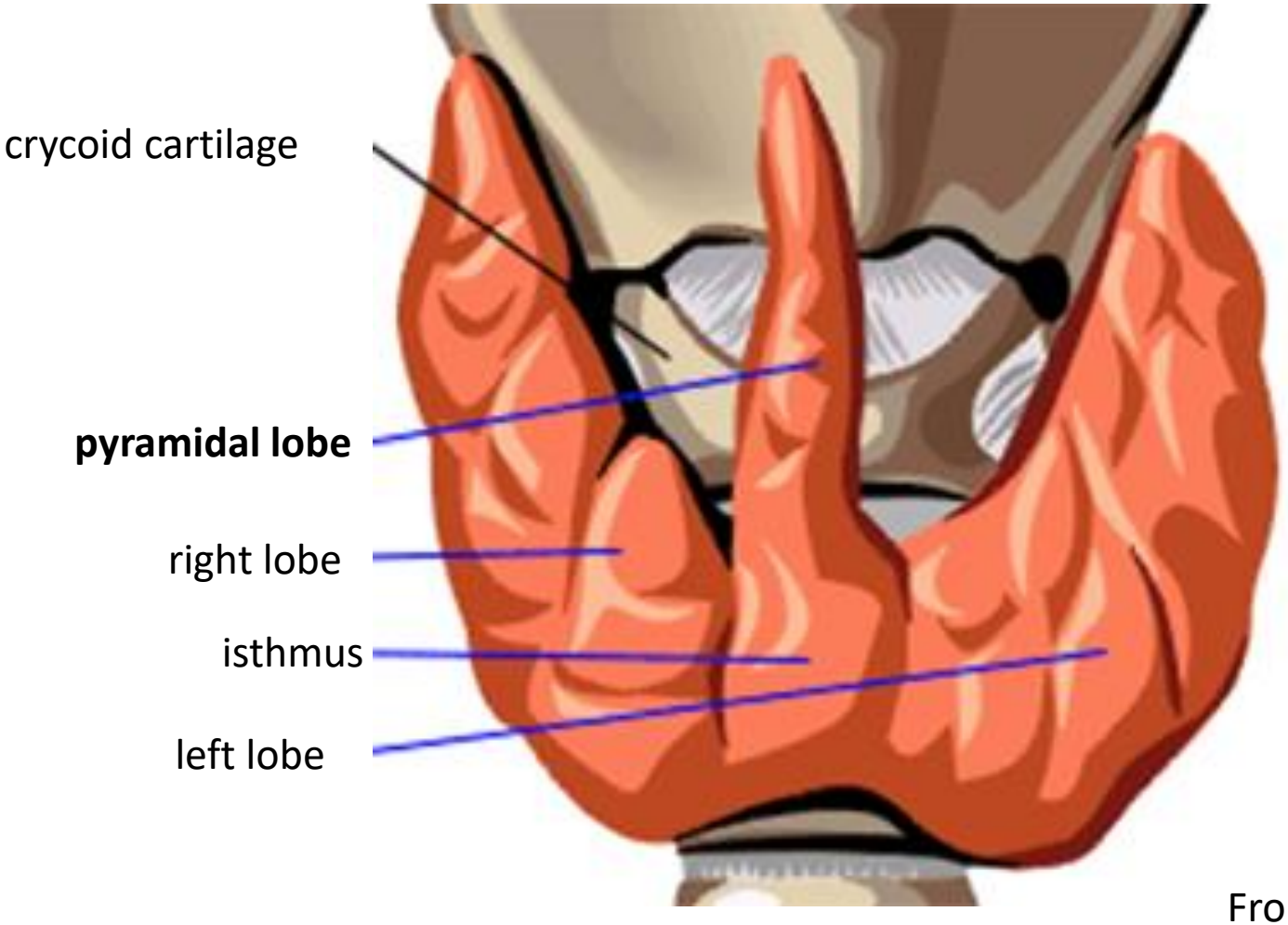


Frontal view

The thyroid gland is located anterior to the upper part of the larynx and the trachea

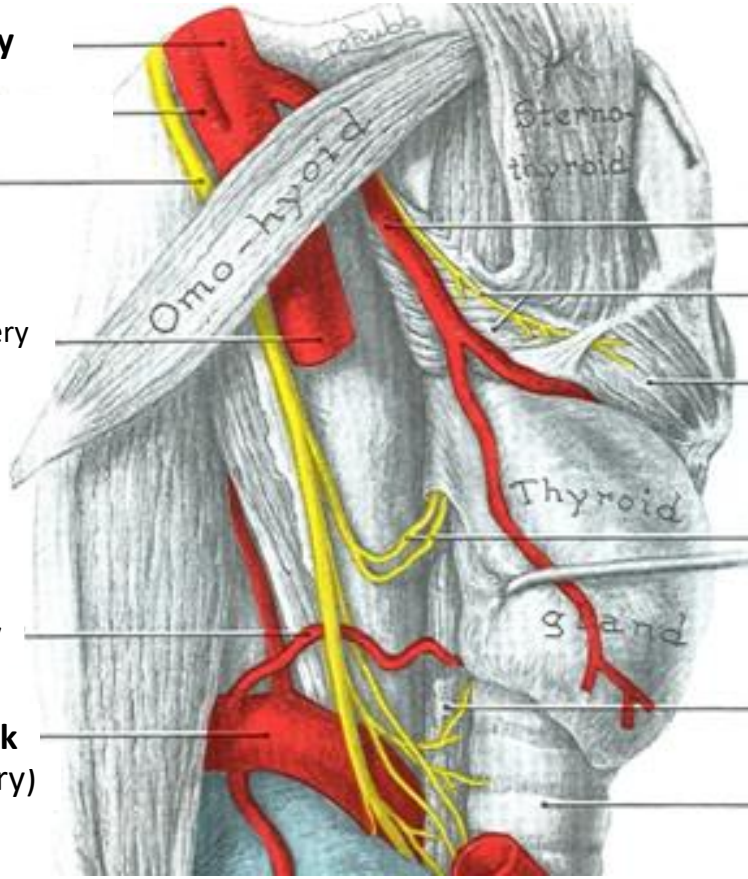


A third lobe called pyramidal lobe may be present ascending from the isthmus or the adjacent part of either lobe



Frontal view

The thyroid is supplied from the superior and the inferior thyroid artery



external carotid artery

internal carotid artery

vagus nerve

common carotid artery

inferior thyroid artery

thyrocervical trunk
(right subclavian artery)

thyroid ima artery

superior thyroid artery

external laryngeal nerve (sup. lar. n)

↓

cricothyroid muscle

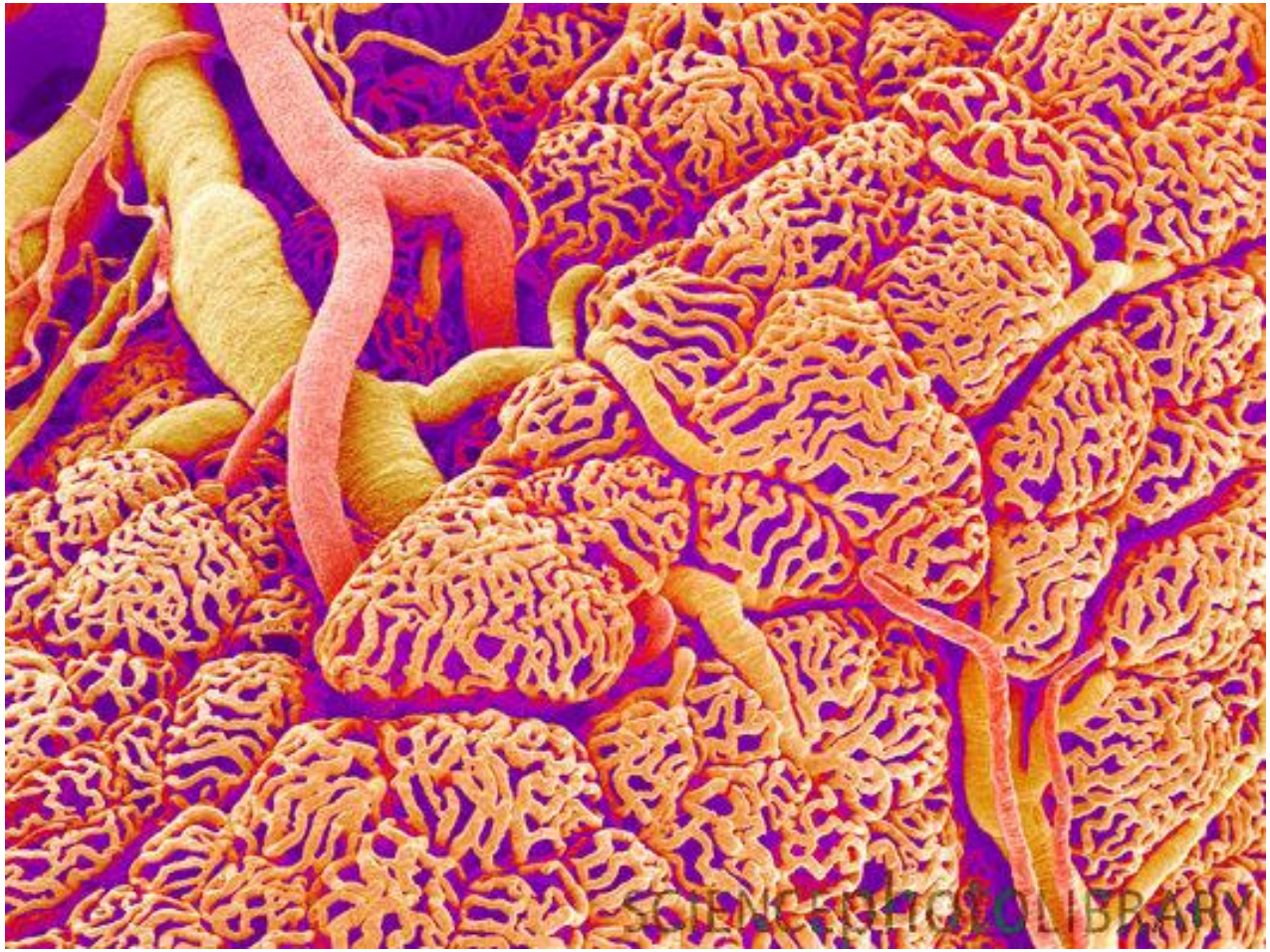
right recurrent laryngeal nerve

esophagus

trachea

Lateral view

The lobes are surrounded by a dense capillary network



Coloured scanning electron micrograph (SEM)

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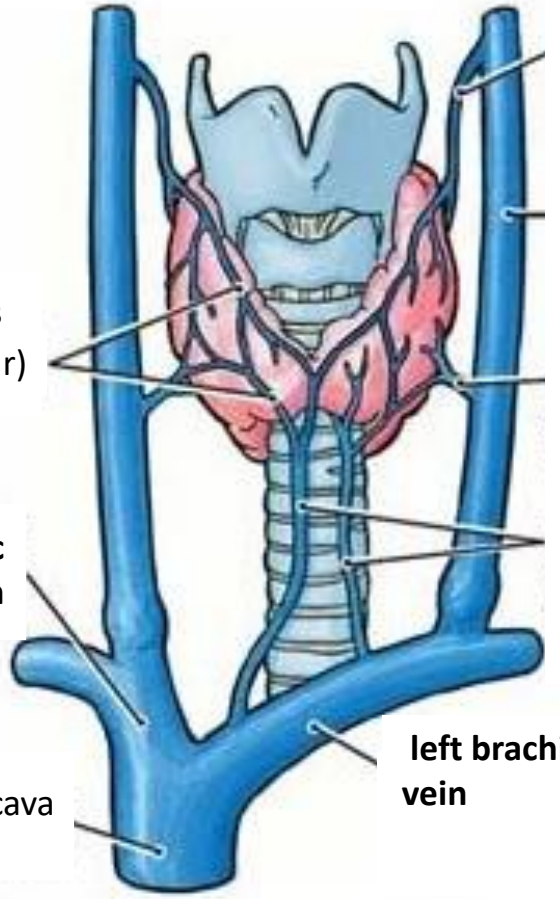
Venous drainage is provided mainly by the unpaired thyroid venous plexus

Frontal view



superior thyroid vein

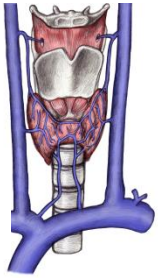
internal jugular vein

unpaired thyroid venous plexus
(plexus thyroideus impar)

middle thyroid vein

right brachiocephalic vein

inferior thyroid veins-high variability



May also form a common trunk : thyroid ima vein.

left brachiocephalic vein

superior vena cava

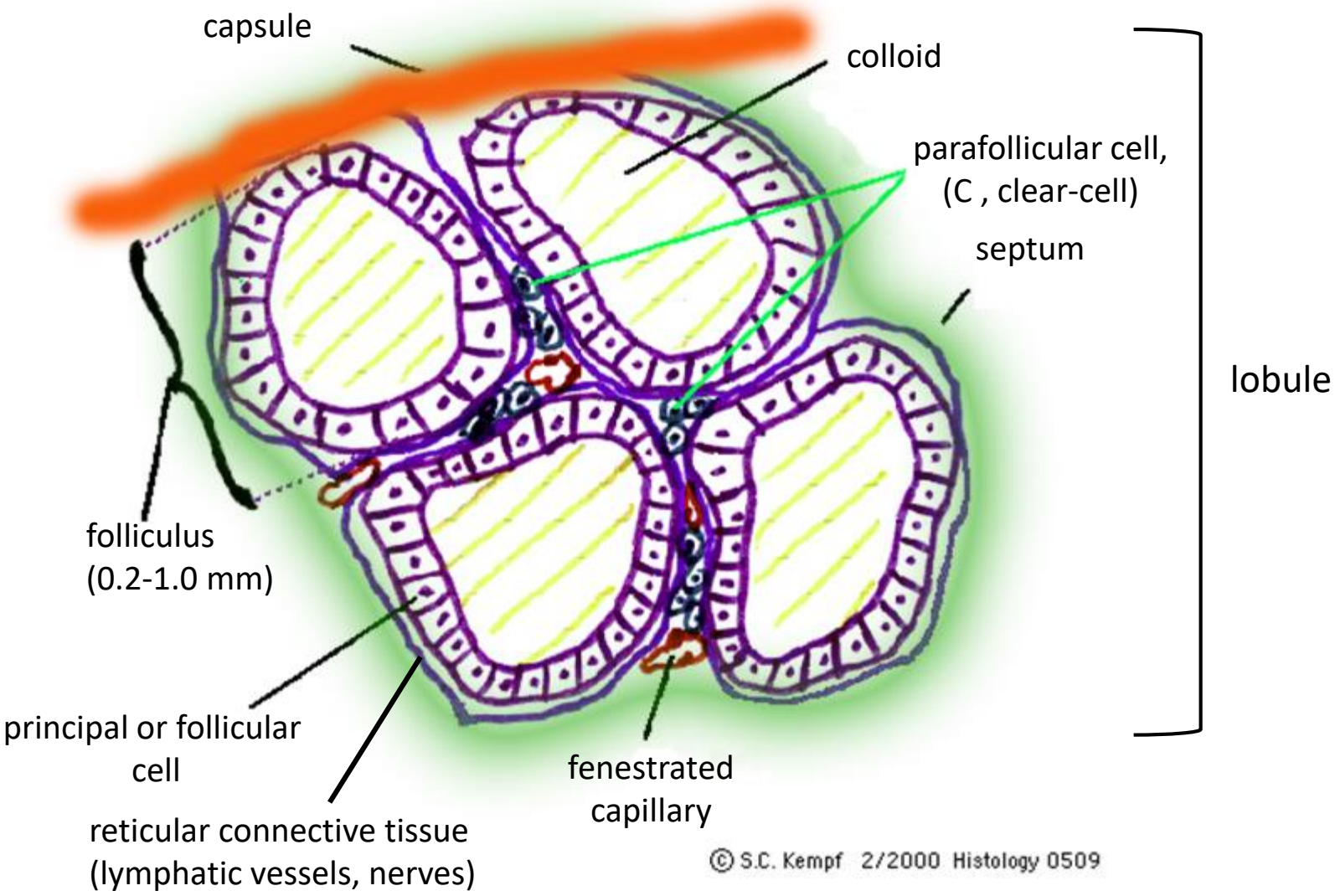
Lymphatic drainage : lateral deep cervical and mediastinal lymph nodes

Low power microscopic view of thyroid tissue by H&E staining

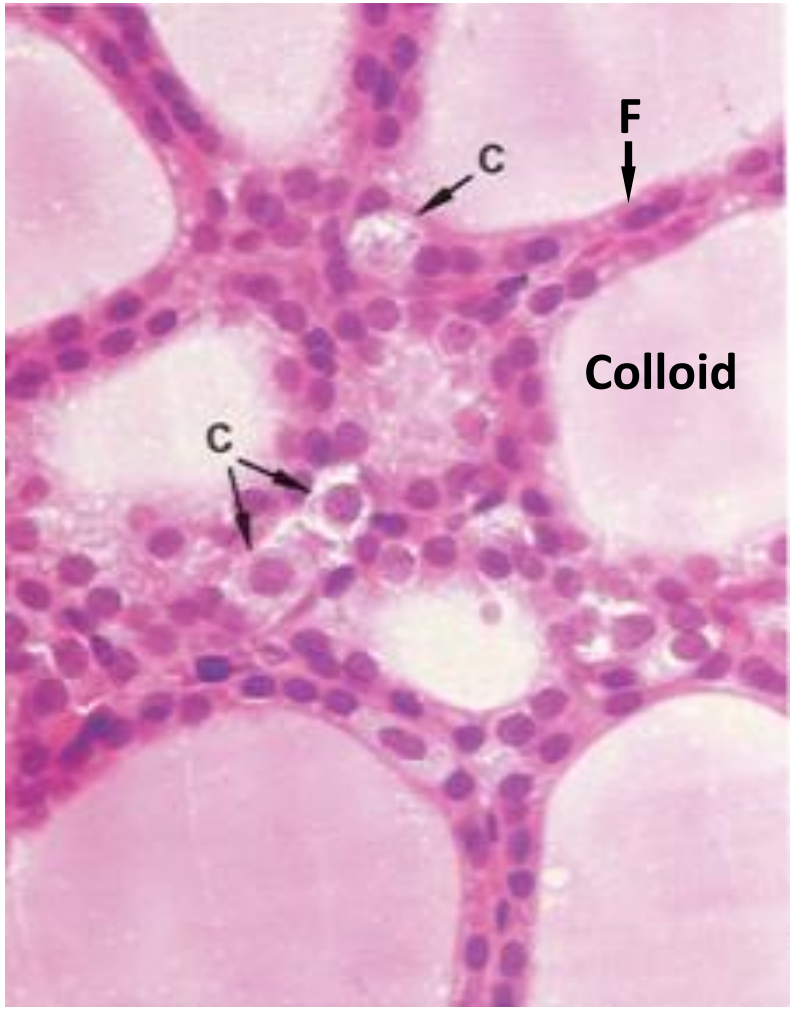
H&E staining

MICHAEL ROSS/SCIENCE PHOTO LIBRARY

Folliculi compose the structural units of the thyroid



Both principal and C-cells produce hormones, but different ones



H&E staining

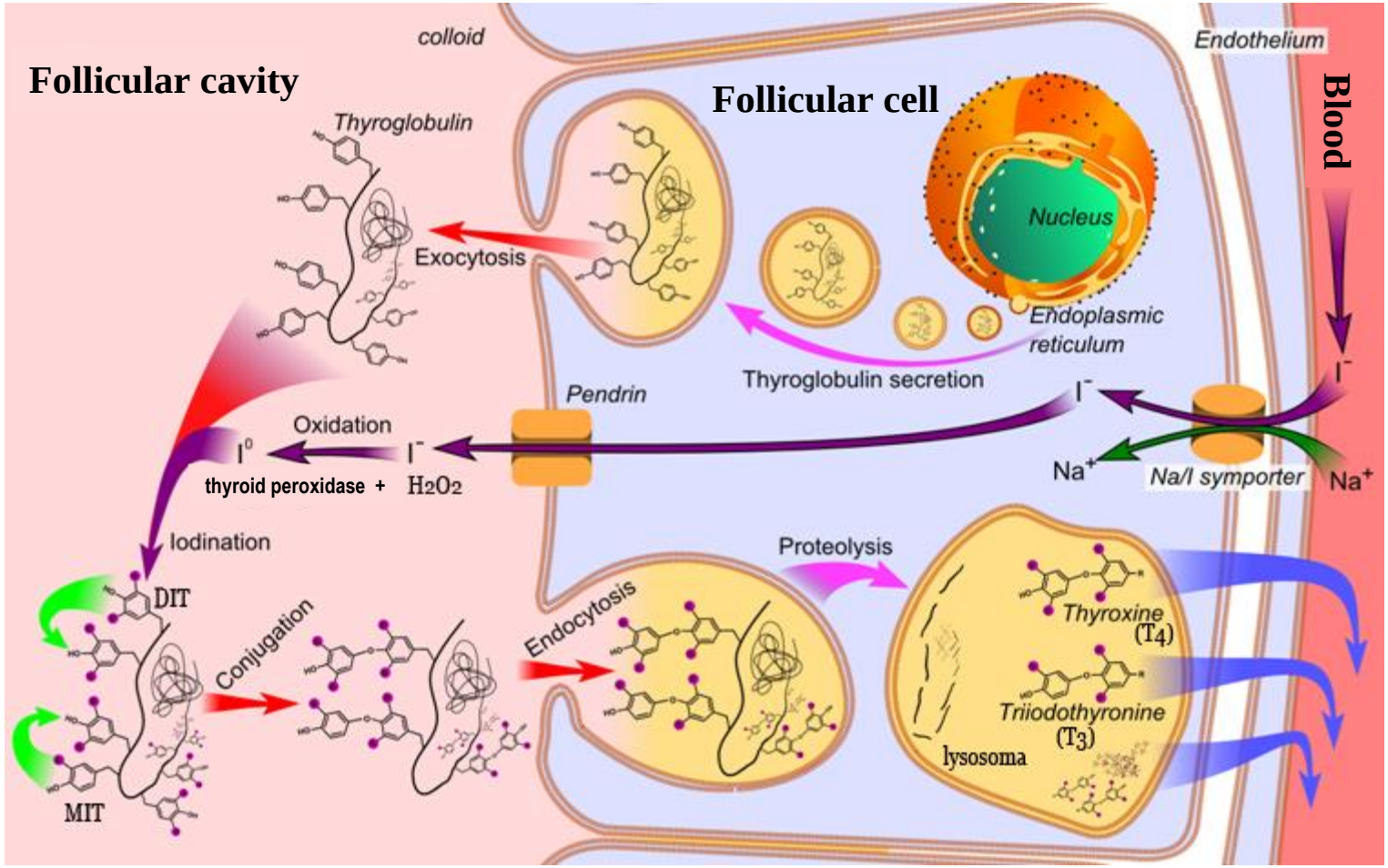
Follicular cell (F) :

- simple squamous or cuboidal epithelium
- basofil cytoplasm
- produces thyroglobulin =colloid
- add or substract thyroglobulin into and from the cavity of the folliculus:
  - -glycoprotein (~120 tyosine)
  - -precursor of thyroid hormones

Parafollicular cell (C):

- light or clear cytoplasm
- localizes in the epithelium inside the basal lamina or in groups between the folliculi
- produces calcitonin

Thyroglobulin production and hormone release happens paralelly



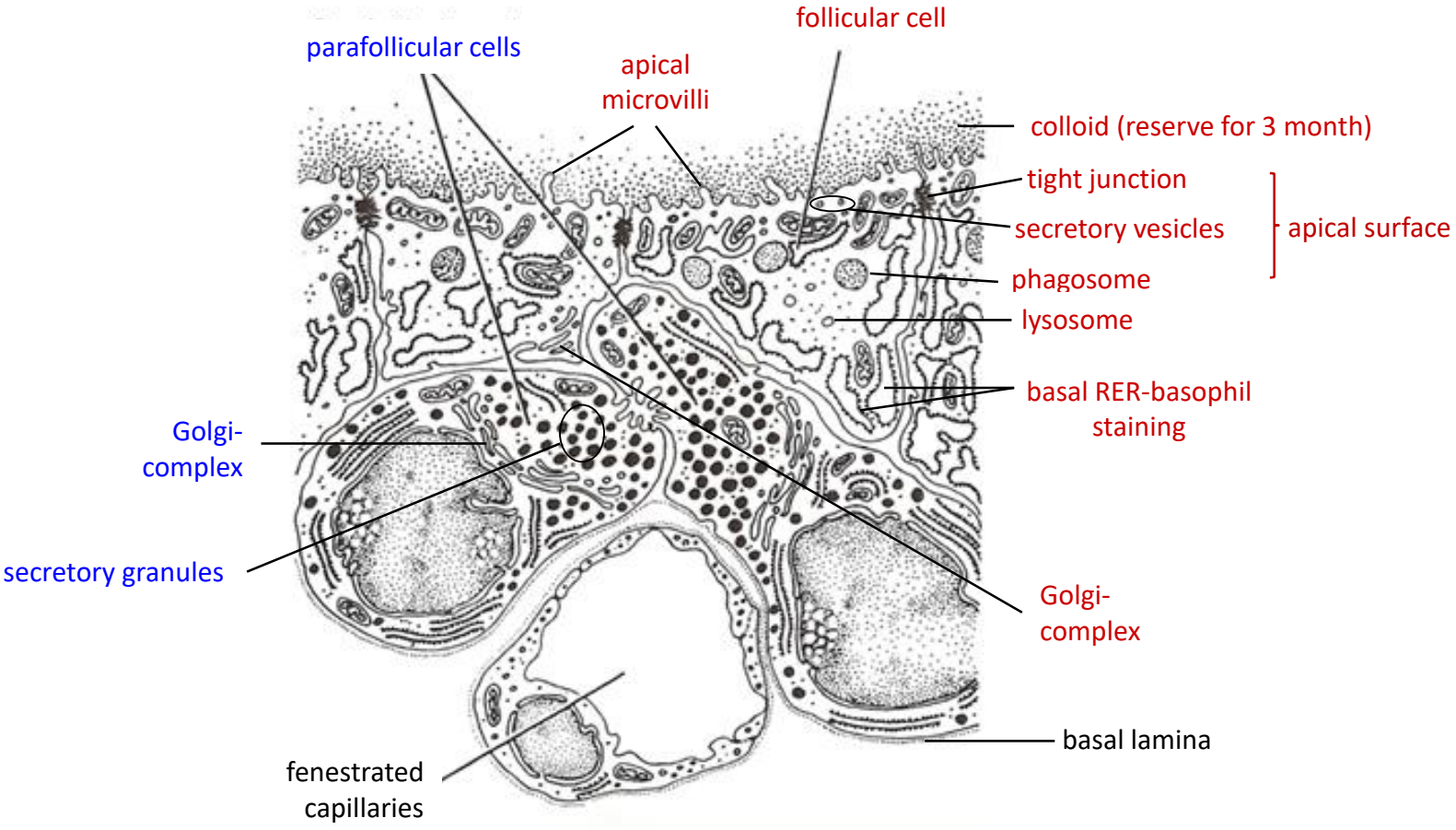
MIT: monoiodotyrosine

DIT: diiodotyrosine

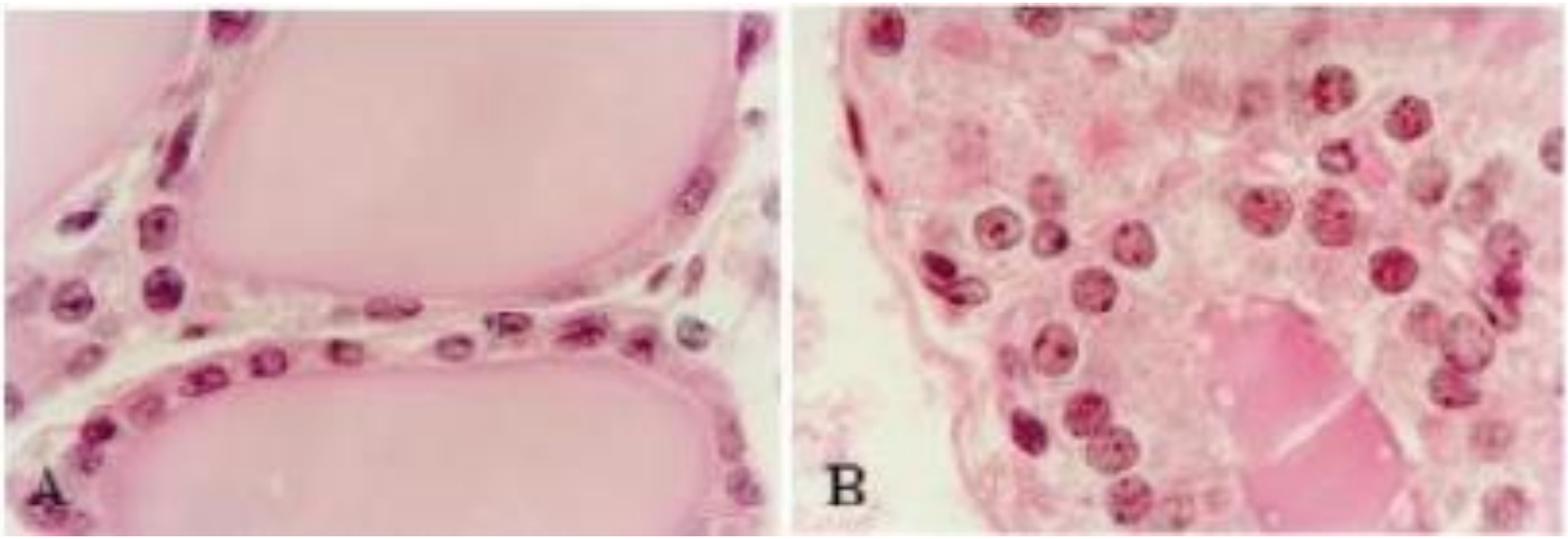
T4= DIT+DIT

T3= MIT+DIT

Ultrastructure of follicular and C cells



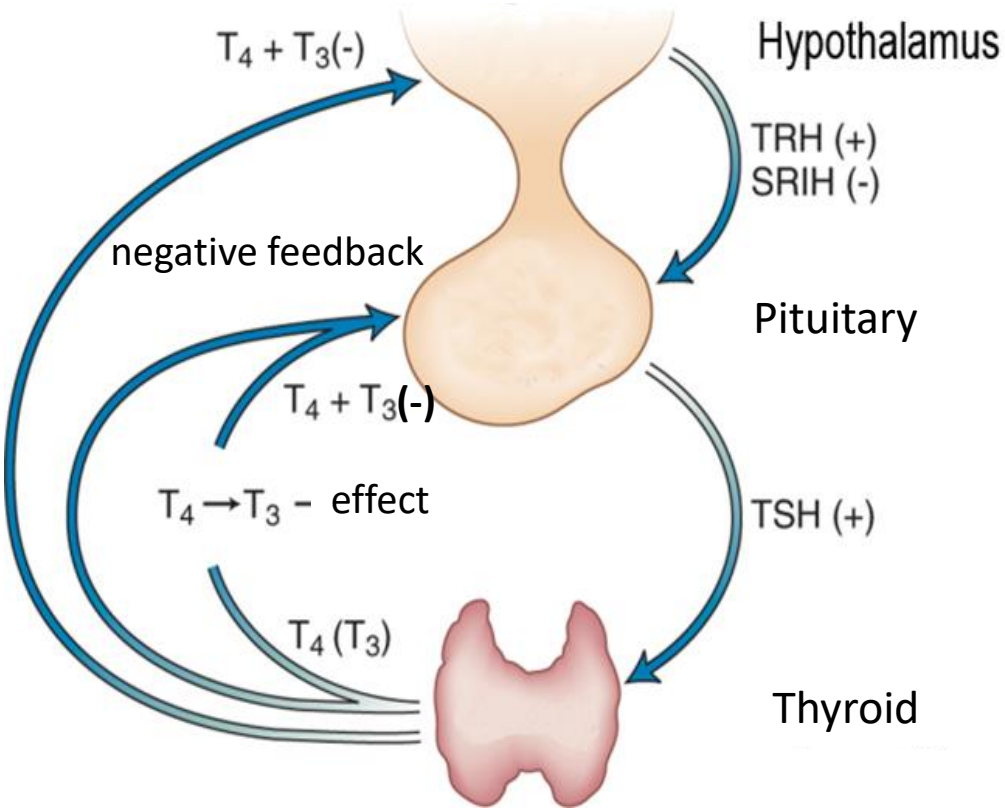
Functional phases of the follicle



Hypoactive phase: flatter epithelium, big cavity – storage of colloid

Active phase: columnar epithelium, schrinked cavity – little colloid, reuptake

Production of T3 and T4 is regulated by the hypothalamo- hypophyseal system



Hypothalamo-pituitary-thyroid (HPT) axis

Main functions:

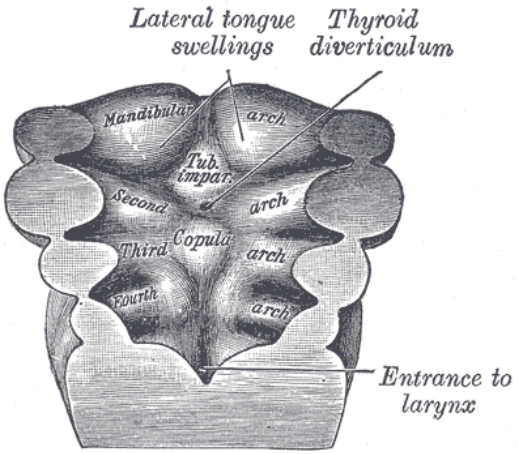
- regulation of basal methabolic rate
- necessary for the normal development of the central nervous system

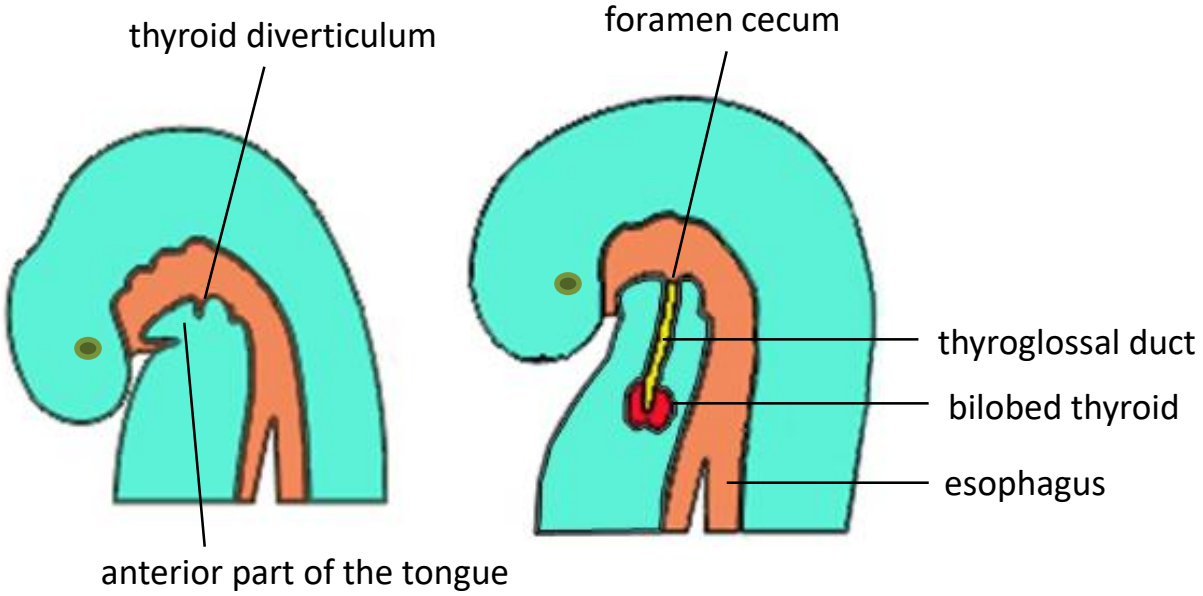
Hypo- and hypertyroidism cause goiter

Dietary iodine supplement is important!

Follicular and C- cells are originated differently during development

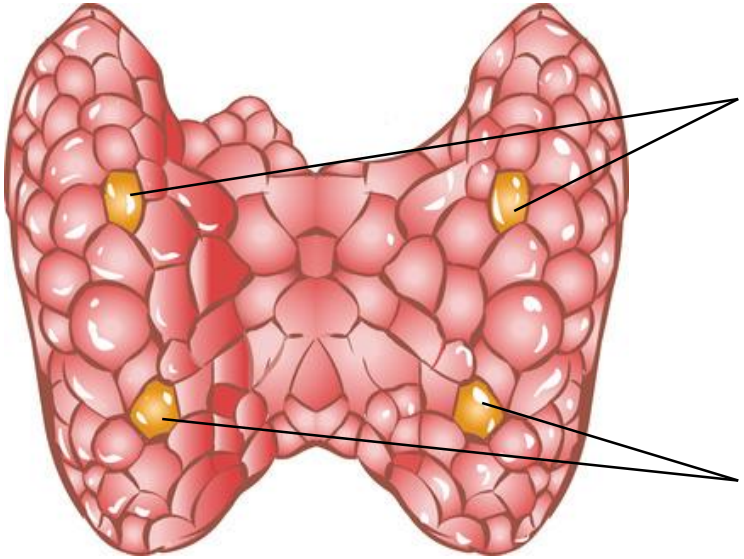
3.-5. week





1. The thyroid primordium, starts as a simple midline thickening of endodermal epithelial cells and develops to form the thyroid diverticulum. This site later is occupied by the foramen cecum.
2. The initially hollow structure, solidifies and becomes bilobed. The 2 lobes are connected via an isthmus.
3. The gland descends toward its final place in the neck, but remains connected with the tong via the thyroglossal duct. Remnants of the thyroglossal duct may persist as accessory nodules or cysts.
4. During the 7.-10. week the duct obliterates. The thyroid develops follicles and starts to function at the end of the 10th week.
5. C cells are derived from the ultimobranchial body, and migrate the primordial thyroid gland during its descent to its final location in the anterior neck.

Parathyroid glands are small, oval-shaped glands near the posterior aspect of the thyroid gland



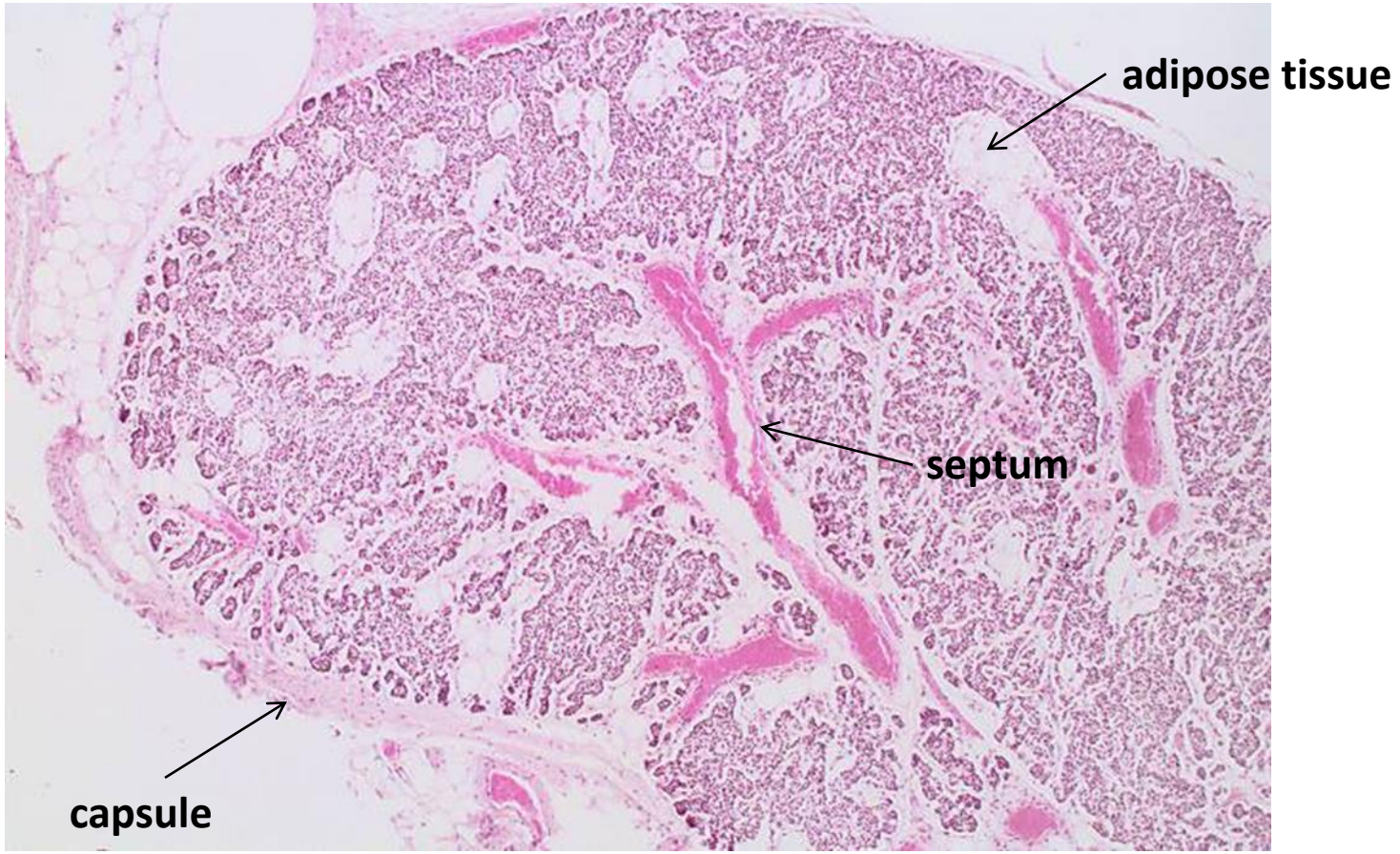
dorsal view

Superior glands-
develop from the
4th pharyngeal pouch

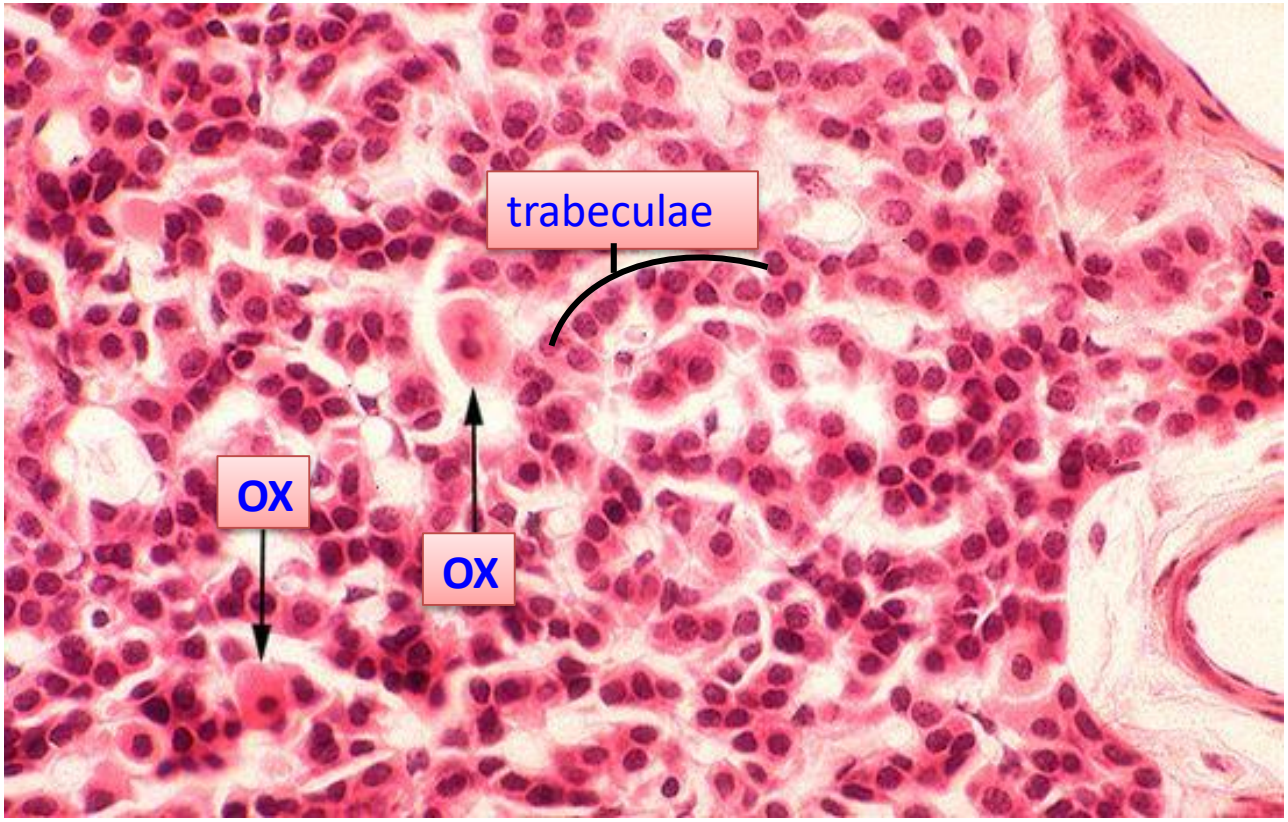
Inferior glands-
develop from the
3rd pharyngeal pouch

- Each gland has its own fibrous capsule.
- Localization can vary- in 10% of the people the glands are attached to the thymus.
- They develop from the endoderm of the third and fourth pharyngeal pouches.

Cells are arranged in irregular cords



Two main cell types are the principal and oxyphil cells



Principal or chief cells:

● small, polygonal, central round nuclei, contain secretory granules of parathyroid hormone (PTH) and may contain glycogen

Oxyphil cells:

● larger than chief cell, oval, acidophilic cytoplasm

● no secretory granules, no hormone production

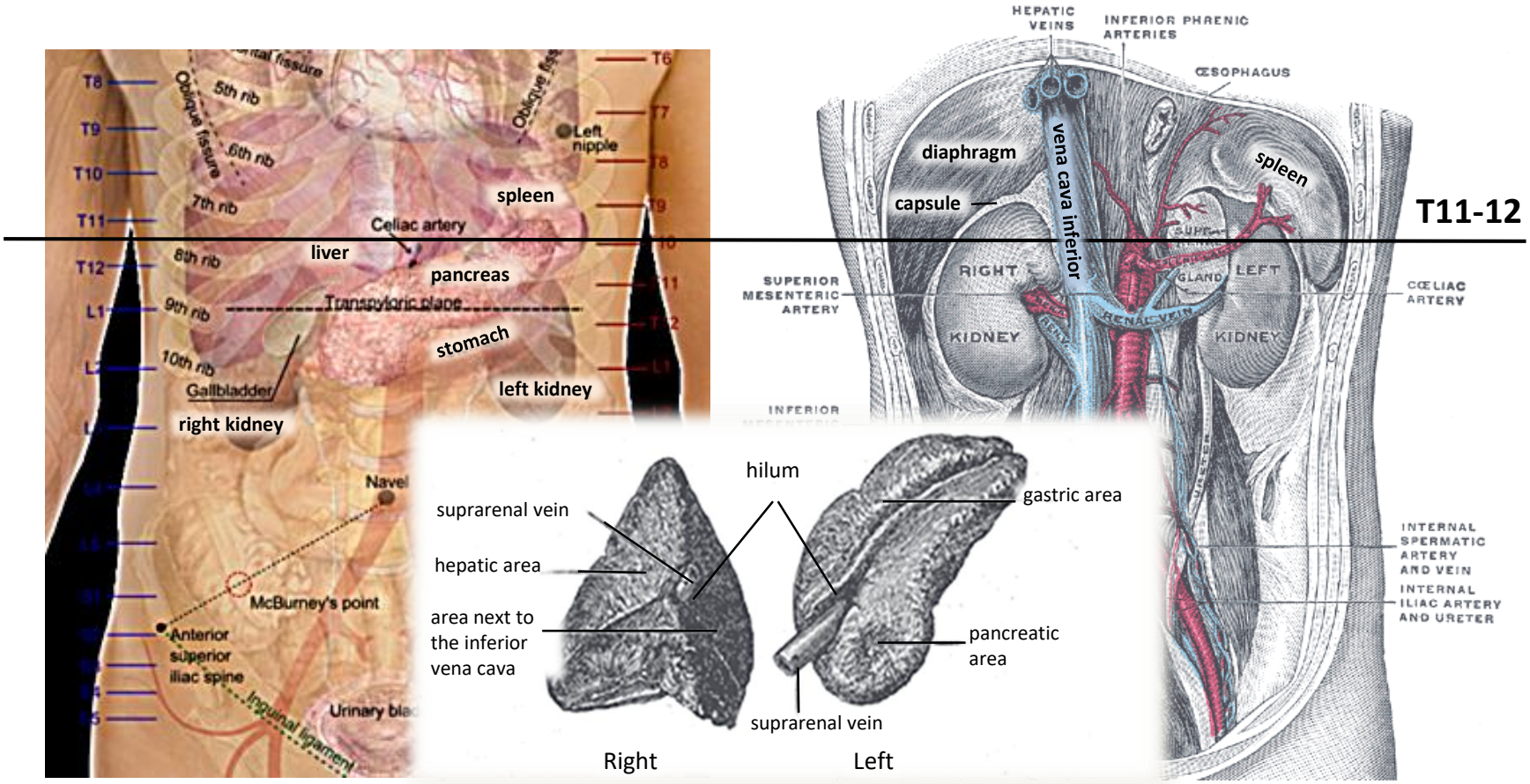
● first appear at puberty as single cells, then pairs, then nodules at around age 40

Calcitonin and parathyroid hormone regulate Ca^{2+} metabolism

	calcitonin	parathyroid hormone (PTH)
production	**thyroid C-cell**	**parathyroid chief cell**
blood Ca^{2+} level	**reduces**	**increases**
regulation	**blood Ca^{2+} level**	**blood Ca^{2+} level**
bone break down	reduces	increases
Ca^{2+} reabsorption in the kidney	reduces	increases
Ca^{2+} absorbtion in the gut	reduces	increases (indirectly)
active vitamine-D production	-	increases
blood phosphate level (renal reabsorption)	-	reduces

Physilological importance is different. Lack of PTH-tetany, lack of calcitonin-no symptomps.

The adrenals are retroperitoneal, situated on the upper pole of the kidneys, enclosed within the renal fascia



Right adrenal:

- triangular
- surrounded by the:
  - diaphragm dorsally
  - liver anteriorly
  - inferior v. cava medially

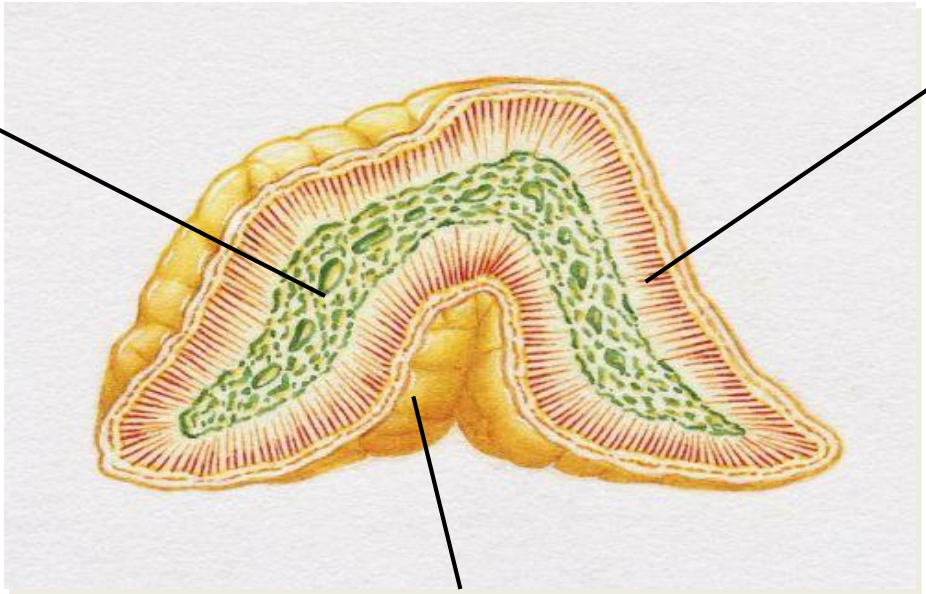
Left adrenal:

- semilunar, extends to the hylum of the kidney
- surrounded by the:
  - diaphragm dorsally
  - stomach anteriorly,
  - pancreas ventrally
  - spleen laterally

The cortex and the medulla of the adrenal have different origin and functions

medulla

- 10%
- brownish-red
- catecholamines*:*
  adrenaline,
  noradrenaline
- ectodermal-neural crest



cortex

- 90%
- yellowish
- corticosteroids
- mesodermal

capsule

- thick, dense connective tissue
- septa extend into the cortex:
  - loose connective tissue
  - fenestrated capillaries
  - lymph vessels
  - *preganglionar sympathetic nerve fibers in the medulla*

Arterial supply comes form the three suprarenal arteries

suprarenal arteries :

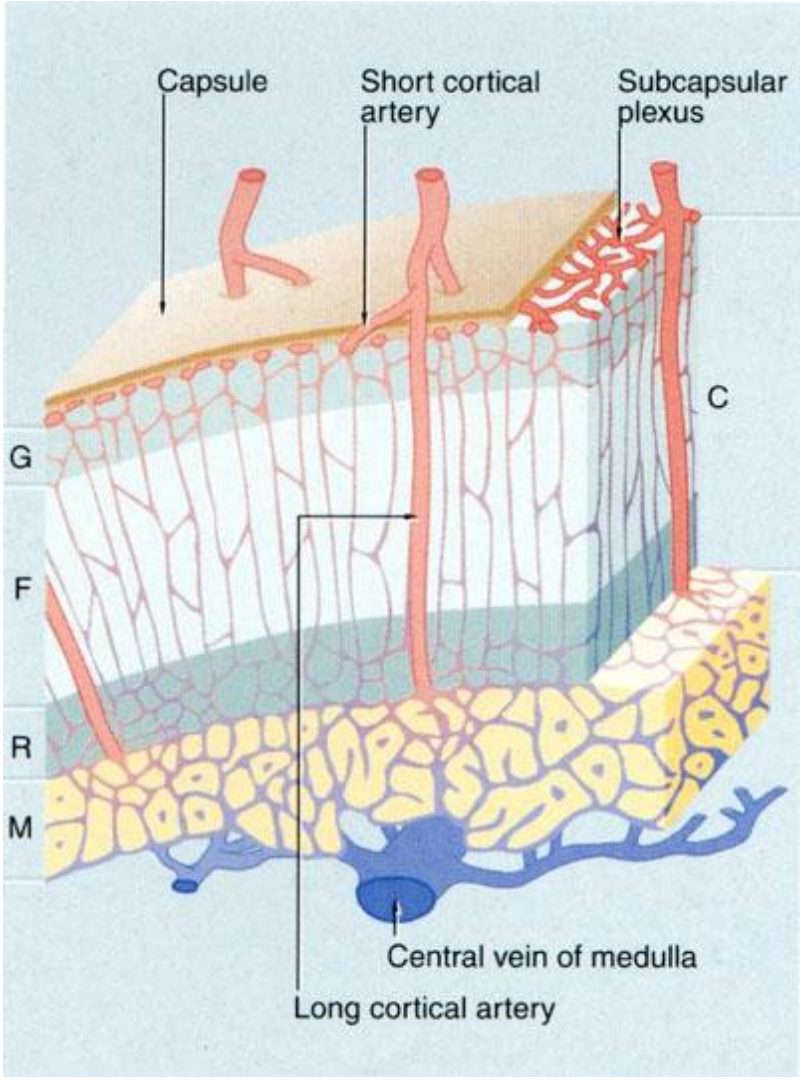
1. superior
2. middle
3. inferior

arise from:

1. inferior phrenic artery
2. abdominal aorta
3. renal artery

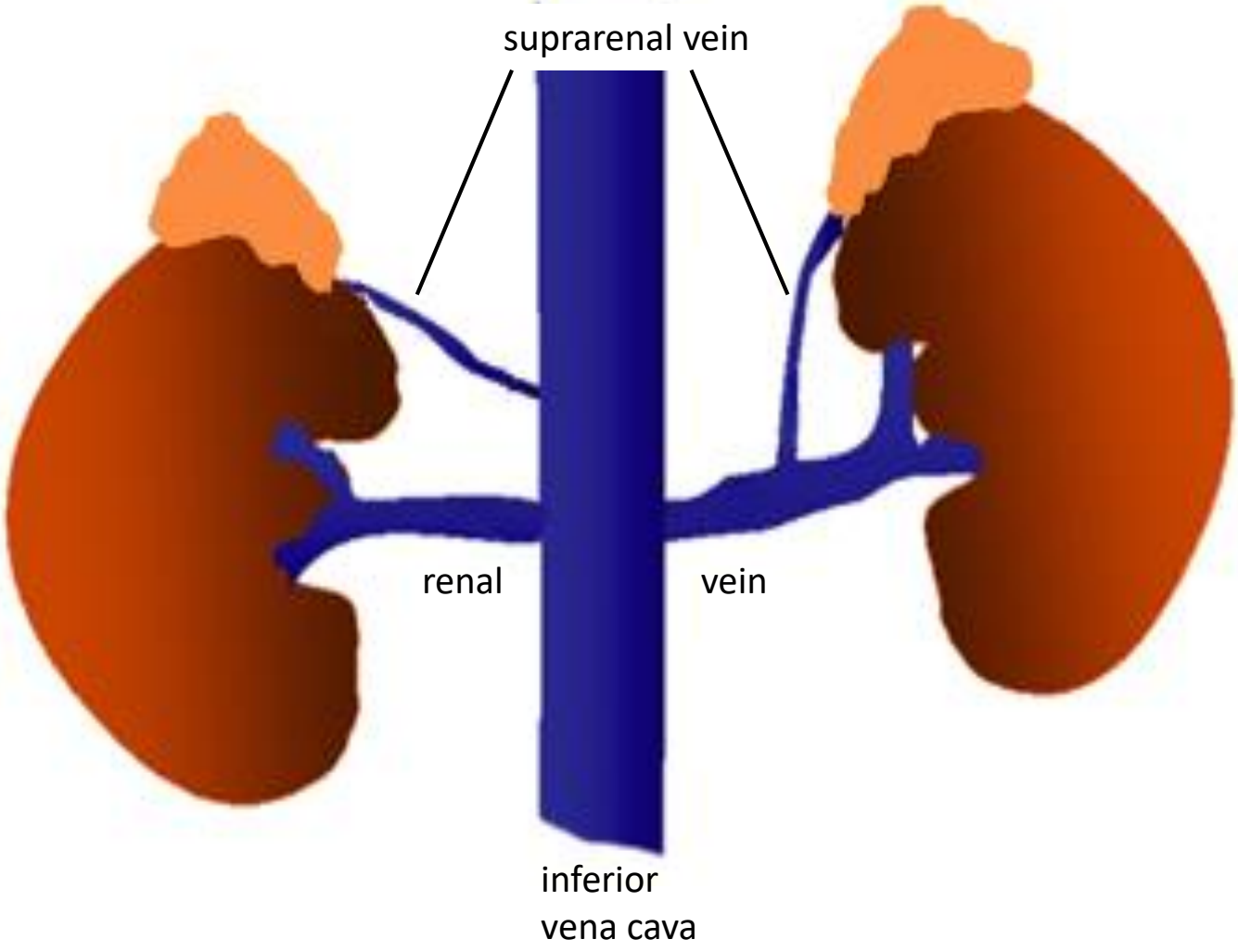
Originally published in the *Lippincott Williams and Wilkens Atlas of Anatomy*, 2009, by Patrick Tank and Thomas Gest.

The medulla has a dual arterial supply

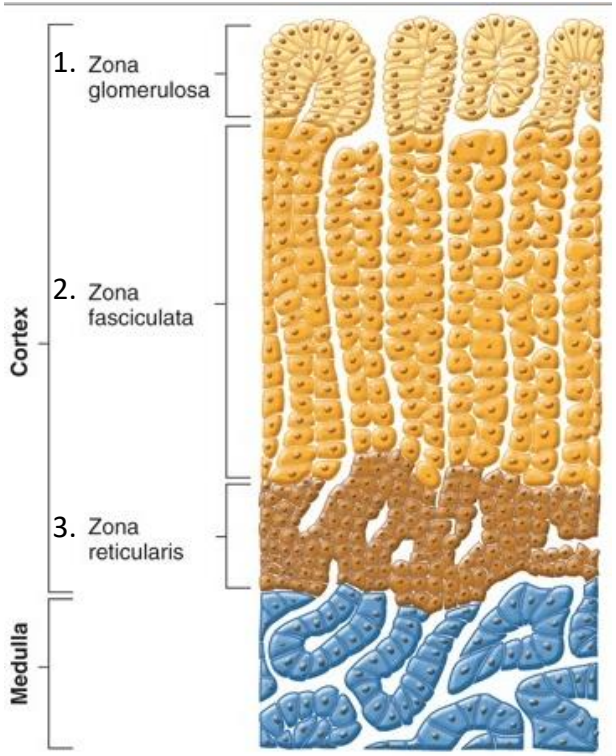


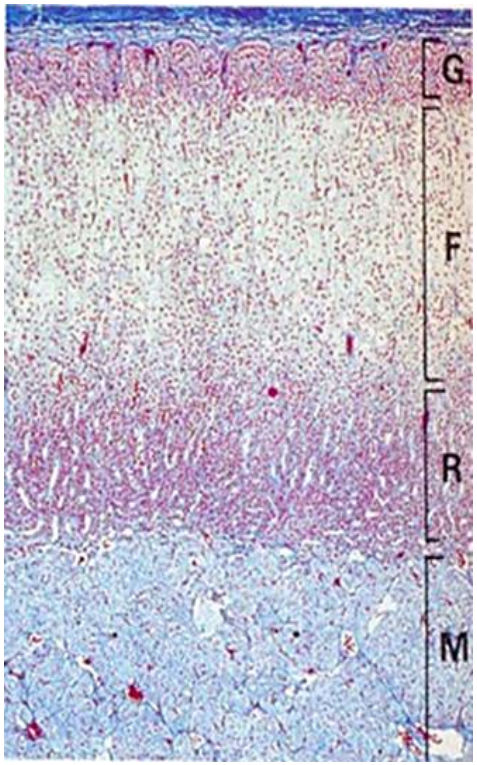
1. Suprarenal arteries penetrate the capsule at several places and form a subcapsular plexus.
2. Short cortical arteries give rise sinusoids in the cortex.
3. Long cortical (medullary) arteries pass through the cortex and ramify into sinusoids in the medulla.
4. Blood from all plexuses enters the medullary central veins.
5. Finally, the suprarenal vein carries away blood from the organ.

The suprarenal vein drains in the inferior vena cava directly, or through the renal vein



The cortex is subdivided into three concentric layers





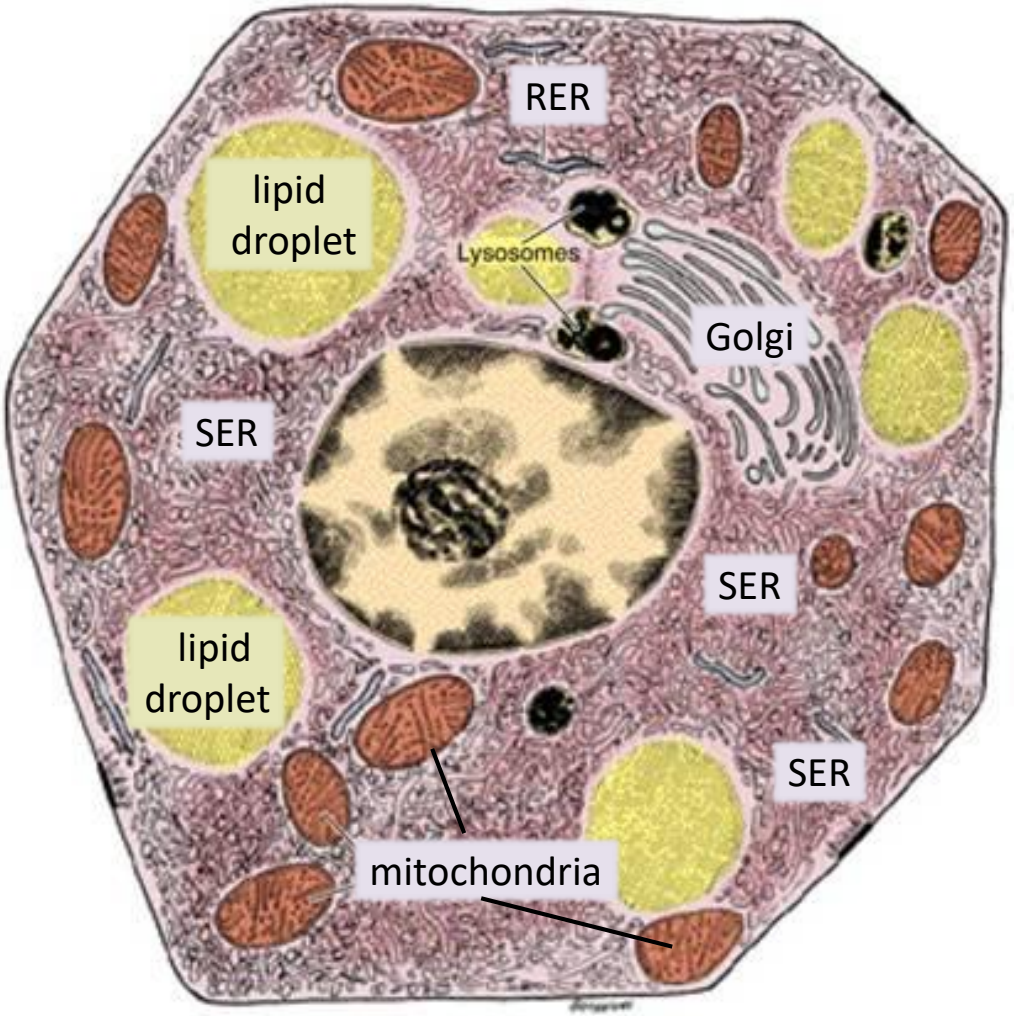
Azan staining

1. Thin outer layer, small cells arranged in rounded clusters or curved columns.

2. Thick middle layer, large cells arranged in two cell thick cords.

3. Thin inner layer, the cells are arranged in a net-like structure.

The ultrastructure of the cortical cells reflects the steroid synthetizing activity



Cell body:

- polygonal or round

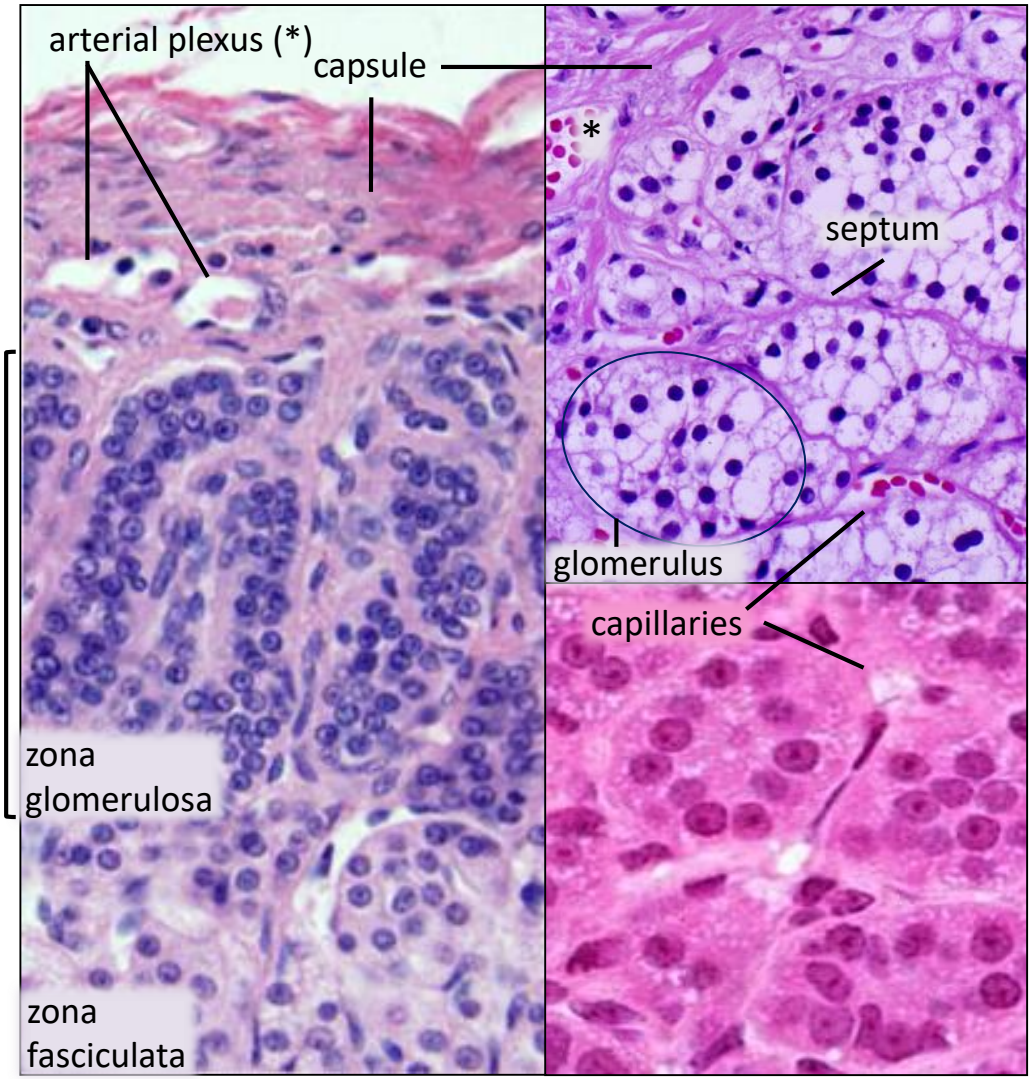
Cytoplasm:

- light, acidophil:
  abundant SER -cholesterol synthesis
  Golgi bodies
  tubular mitochondria (enzymes)
- lipid droplets - hormones

Nucleus:

- round, central

Zona glomerulosa cells secrete mineralocorticoids, mainly aldosterone



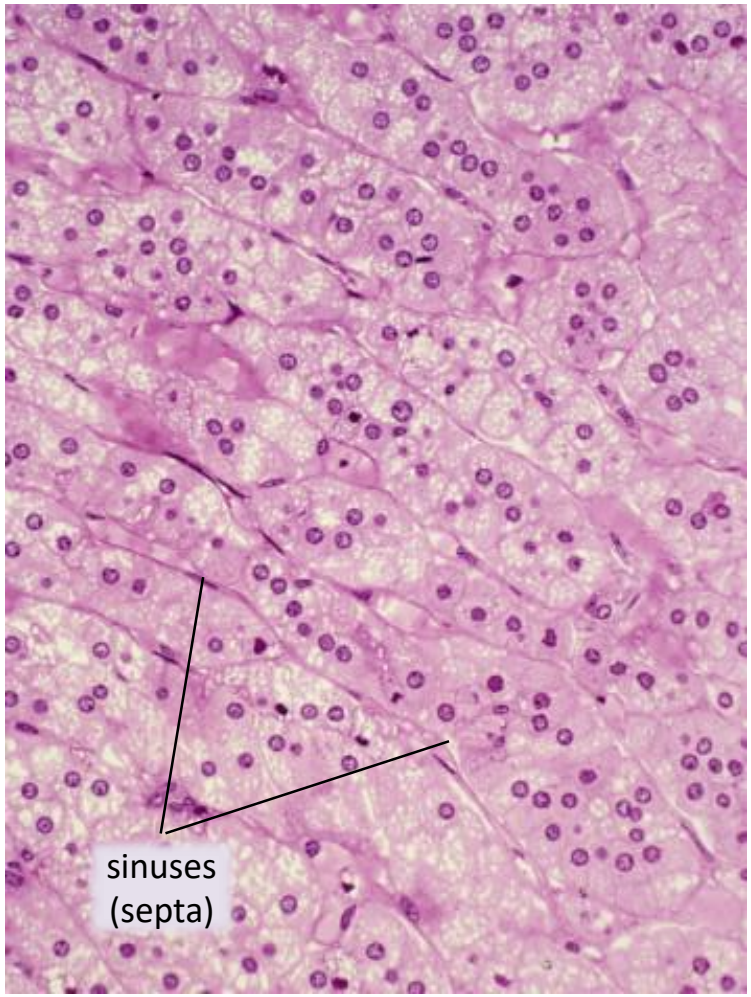
Glomerulosa cells:

- columnar or pyramidal
- ovoid groups (glomeruli)
- dark nucleus
- light cytoplasm
- (few lipid droplet)

- fenestrated capillaries between cells

- Aldosterone:
  - increases Na^+, decreases K^+ resorption in the distal tubules in kidney
  - regulated by angiotensin II, blood K^+, Na^+concentration, (ACTH)

Zona fasciculata cells secrete glucocorticoids



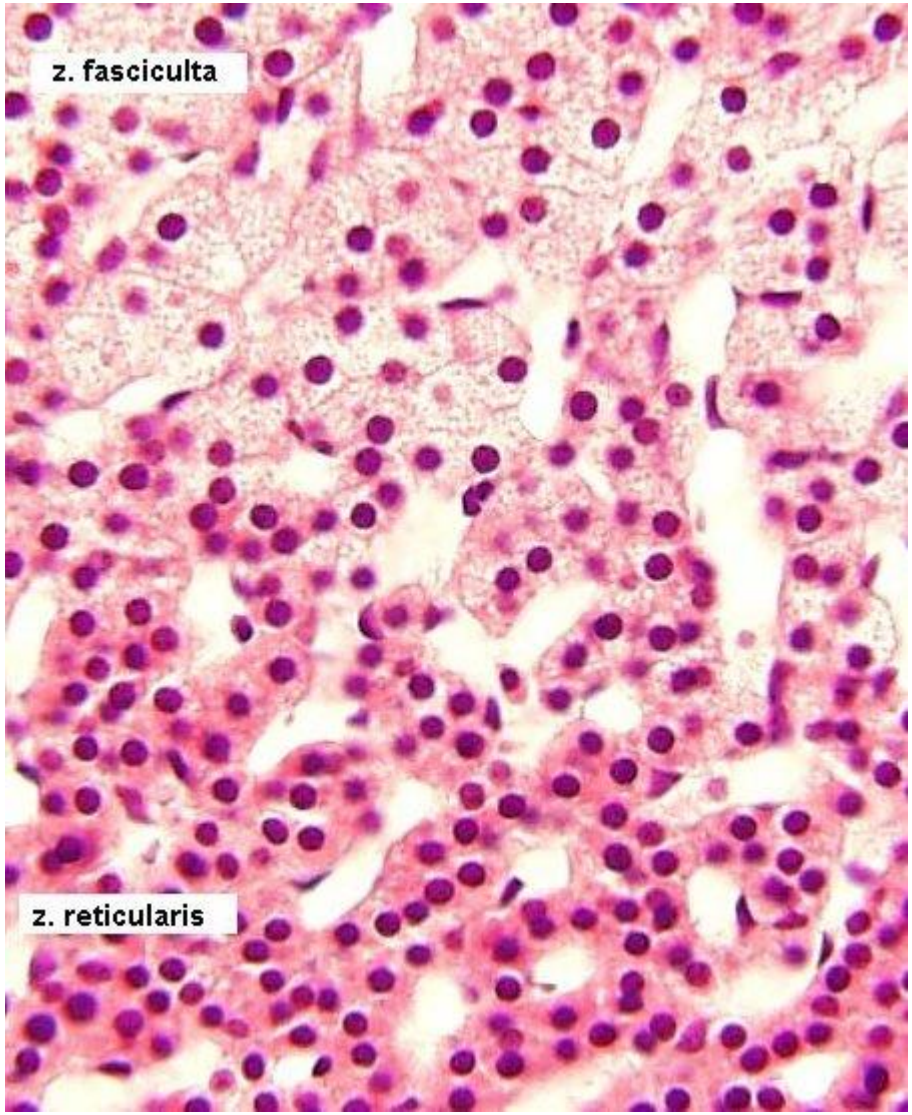
Fasciculata cells:

- paralell cell cords usually 2 cell-thick, separated by sinusoids
- acidophil cytoplasm
- light nucleus
- numerous lipid droplets-”foamy” appearence

- sinuses follow septa

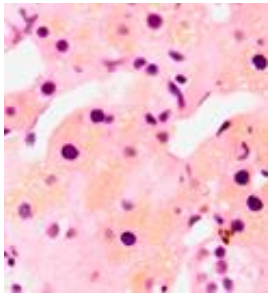
- glucocorticoids (cortisol):
  - increase blood glucose level, promote normal metabolism, supress inflammation, protects against stress
  - regulated by ACTH

Zona reticularis cells secrete gonadocorticoids



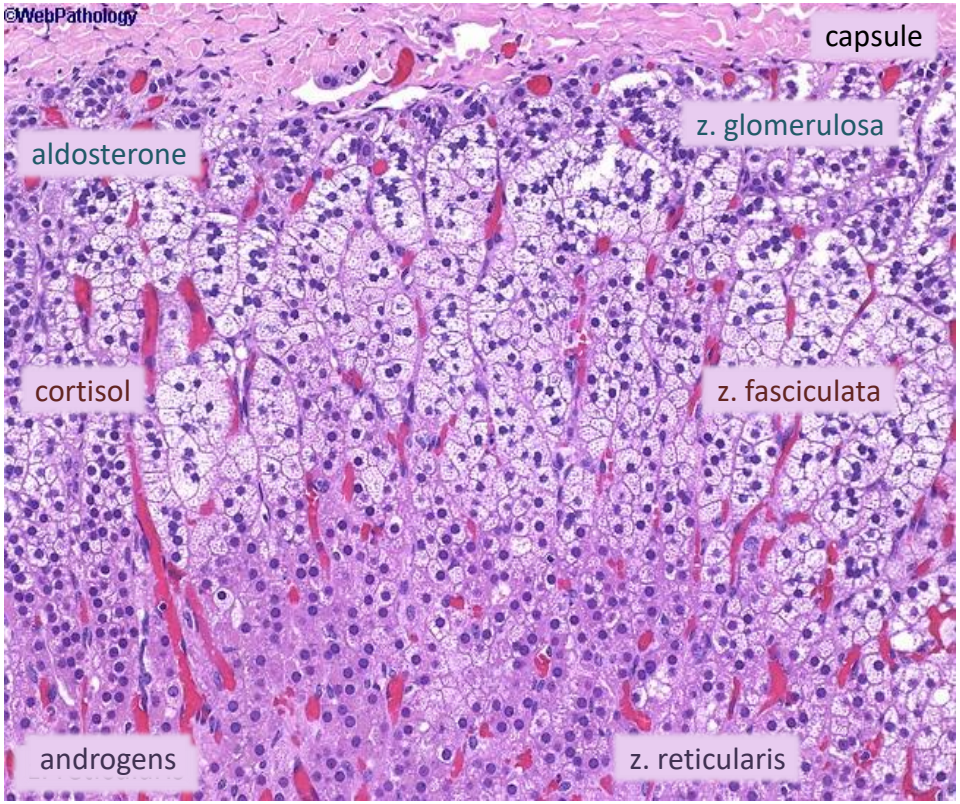
Reticularis cells:

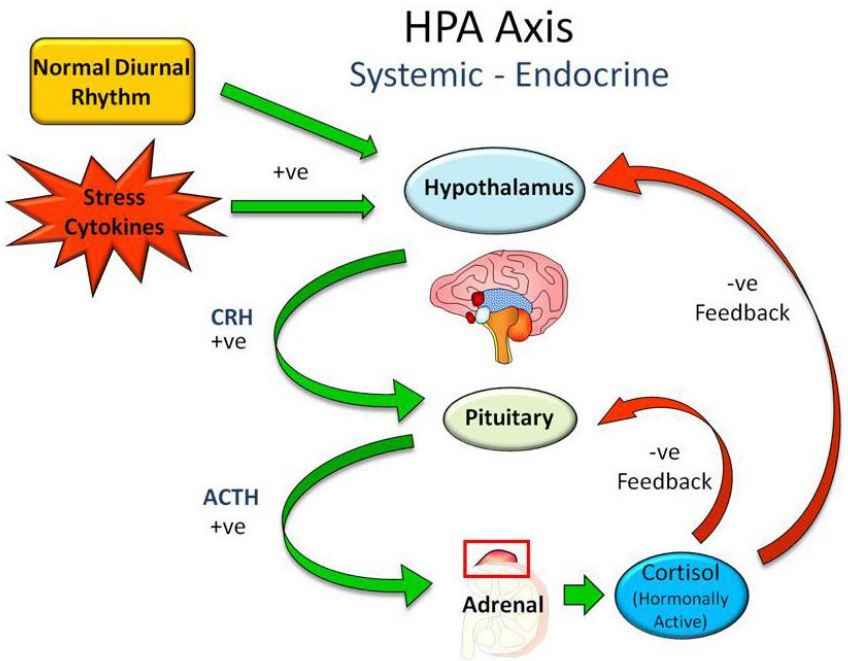
- irregular network of cells
- sinusoids
- small cells
- darker cytoplasm:
- little lipid droplets
- lipofuscin



- small amount of sex steroids: androgens
- (cortisol)
- ACTH regulated

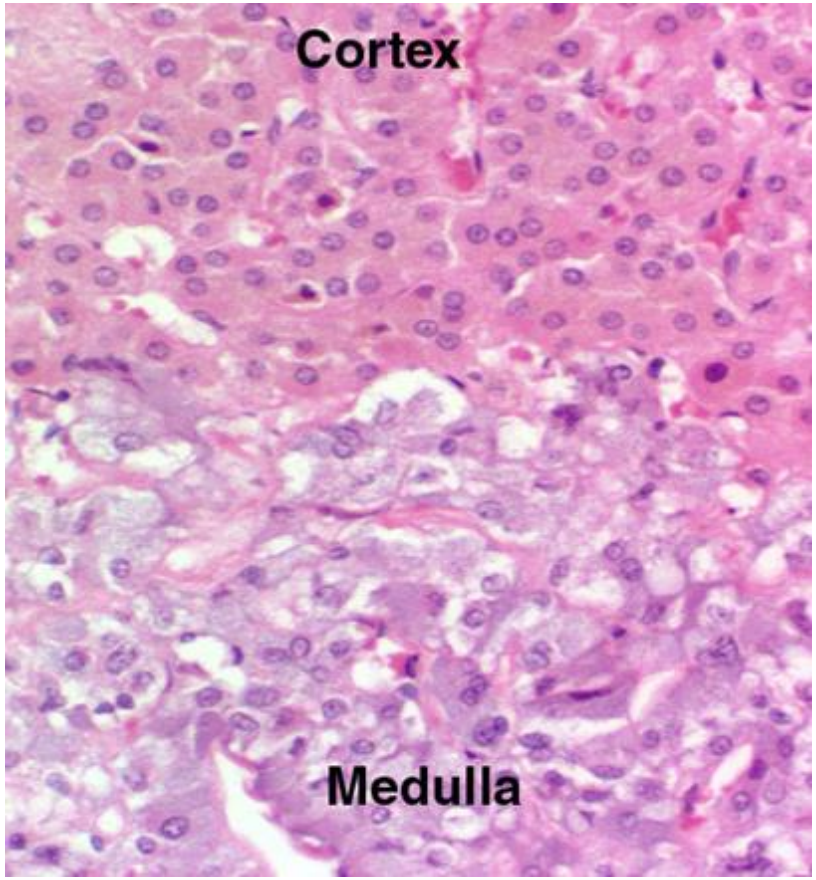
The hypothalamic – pituitary – adrenal (HPA) axis regulates the secretory activity of the zona fasciculata and reticularis





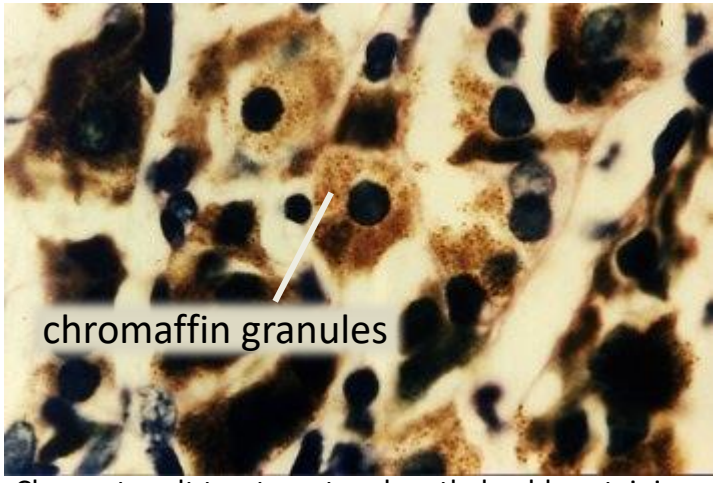
Systematic steroid treatment cannot be stopped suddendly!

Parenchymal cells of the medulla are also called chromaffin cells



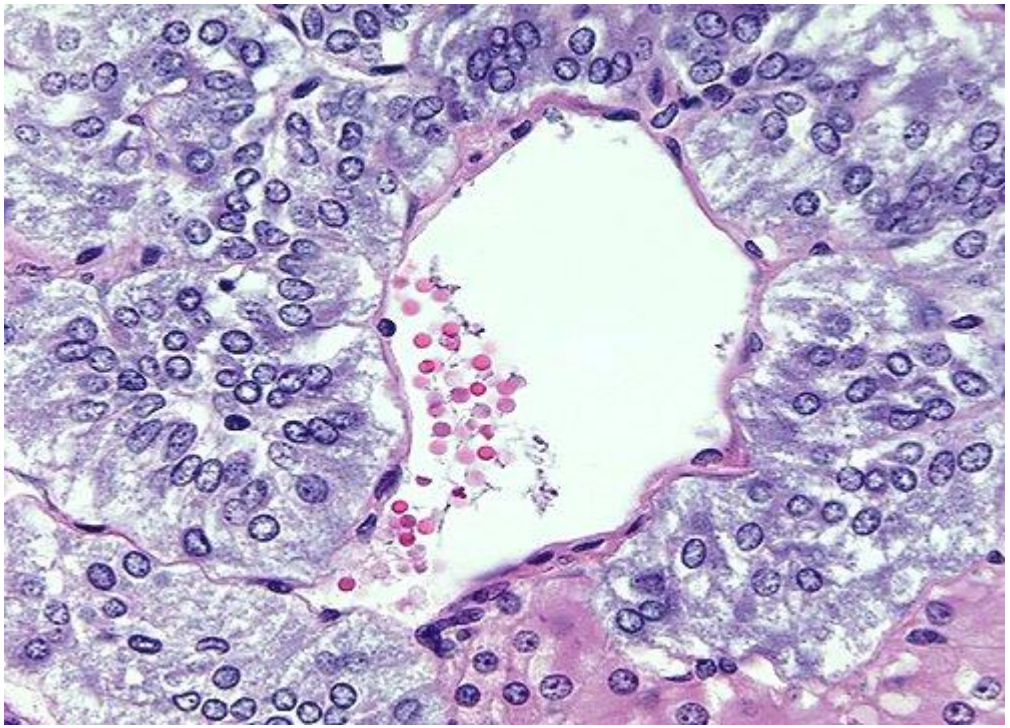
Medullary cells:

- relatively large, round or columnar
- basophil cytoplasm (RER)
- secretory granules
- adrenaline and noradrenaline production in different cell types
- chromaffin reaction: catecholamines are oxidized by chromate salts resulting brownish color:



Chromate salt treatment and methylen blue staining

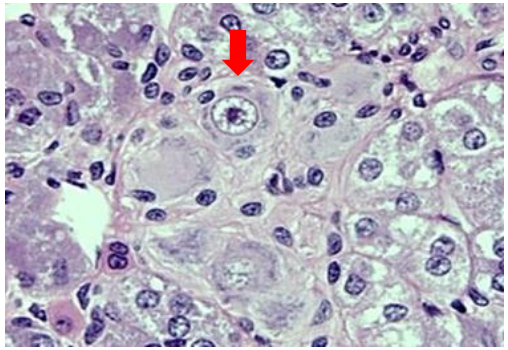
Medullary cells are modified sympathetic postganglionic cells



Medullary cells:

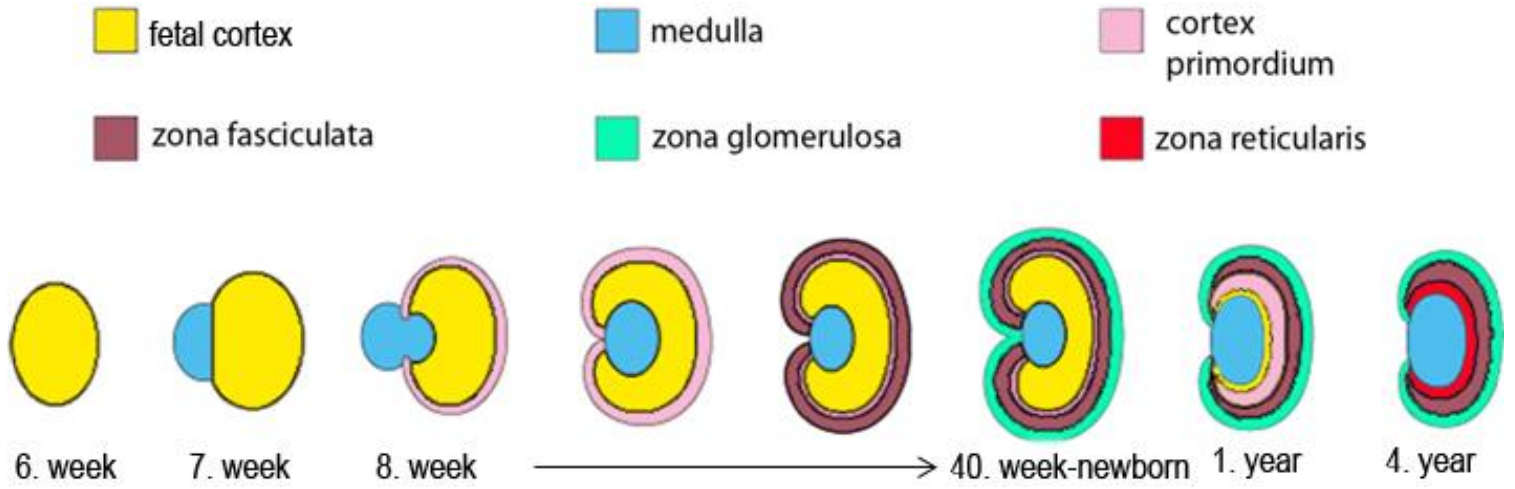
- surround venous sinusoids and release catecholamines upon stimulation by exocitosis
- are innervated by preganglionic sympathetic fibers (acetylcholine)
- have dual blood supply – cortisol increases adrenaline synthesis!

- adrenaline: fight or flight reaction
- noradrenaline: peripheral vasoconstriction



Between the secretory cells real sympathetic ganglion cell clusters can be found:
round or polygonal cells, big nucleus,

Fetal adrenal is transient and produces androgens used by the placenta for estrogen byosinthesis



5. week: Mesothelial cells from the posterior abdominal wall proliferate, penetrate the underlying mesenchyme and form the fetal or primitive cortex of the adrenal.

7. week : Neural crest cells (sympathicoblasts) migrate toward the adrenal cortex –future medullary cells.

8. week : Medullary cells gradually invade the medial aspect of the cortical tissue along its central vein to gain a central position, and a second wave of cells from the coelomic epithelium penetrates the mesenchyme and surrounds the original cell mass. These cells will form the adult or definitive cortex.

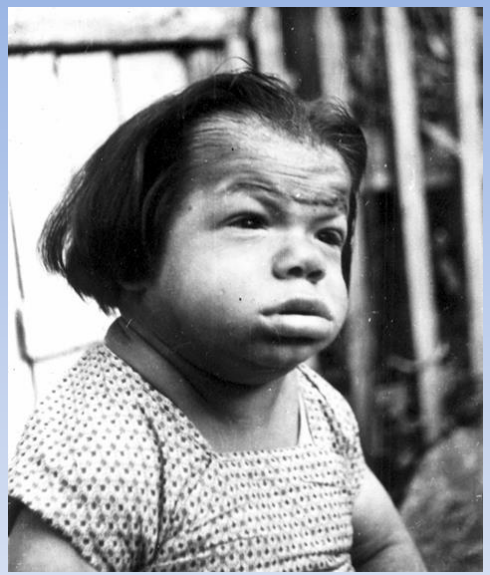
8.-40. week : The adrenal grows, first the zona fasciculata then the zona glomerulosa develops.

1th year: The fetal cortex undergoes involution, there is still no zona reticularis.

4th year: All the three cortical layer is present. The adult structure of the cortex is not achieved until near puberty.

Basedow disease
hyperthyreosis

hypothyreosis untreated = mixodema treated



cretinism
congenital hypothyreoidism

Cushing disease
increased cortisol level

Addison disease
adrenal insufficiency

tetania
hypoparathyreoidism