Endocrine glands

David Kachlík

Endocrine system

- one out if two regulator systems
- phylogenetically older than the nervous system
- regulates activity of other systems so that they could react to changing requirements of outer and inner environment (maintains homeostasis)
- does not originate from anatomically similar structures
- secretion into blood – possesses no ducts
- nearly all organs and tissues of the human body produce a hormone

Hormone

- *horman* in Greek = to arise
- chemical messanger produced by endocrine gland and transported into blood to target organs
- proteins (polypeptides) – *insuline*
- amines – *adrenaline*
- steroids – *estrogenes*

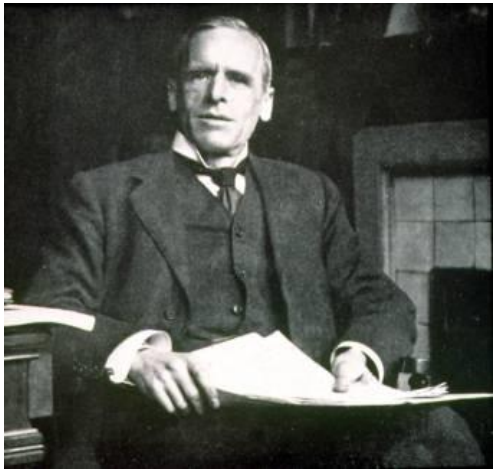
Clinical consequence

- **hormonal excess**
  - primary gland overproduction
  - secondary to excess production of trophic (releasing, stimulating) substance (hormone)
- **hormonal deficiency**
  - primary gland failure
  - secondary to lack of stimulation by trophic (releasing, stimulating) substance (hormone)
  - target organ resistance

Endocrine glands History

Thomas Wharton

- 1614-1673
- *Adenographia*
- first detailed description of glands



Ernest Henry Starling

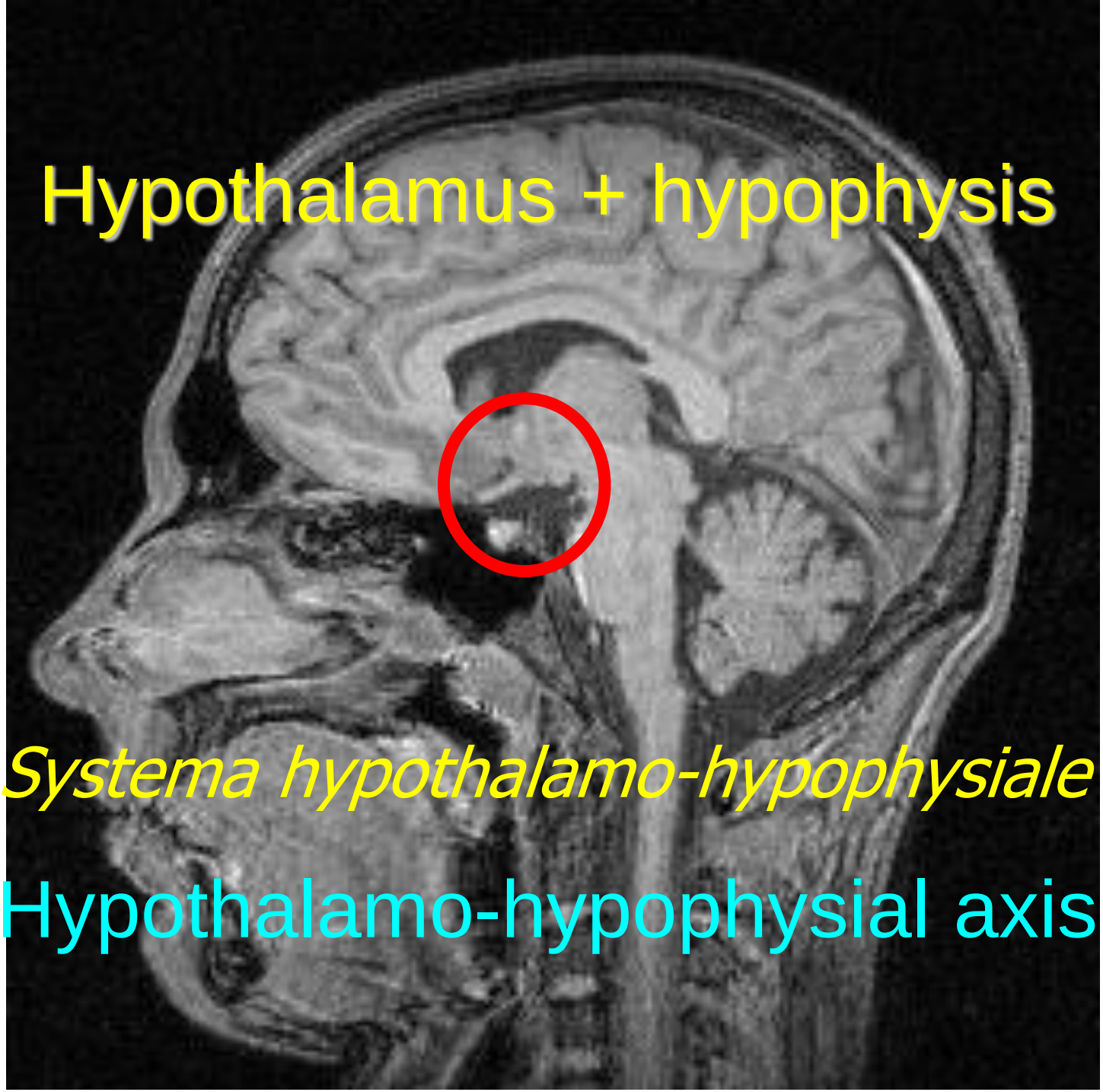
- 1866-1927
- general schemes of „endocrine secretion“
- used the already exsiting word „hormones“

Endocrine system arrangement

- glands
- disseminated cells
- neuroendocrine cells

Endocrine glands – list

- hypothalamus (*hypothalamus*)
- pituitary gland (*hypophysis; gl. pituitaria)*
- thyroid gland (*glandula thyroidea*)
- parathyroid bodies (*gll. parathyroideae)*
- suprarenal glands, adrenals (*gll. suprarenales*)
- pancreatic (Langerhans‘) island (*insulae pancreaticae*)
- pineal glands, epiphysis (*gl. pinealis; corpus pineale*)


Hypothalamus + hypophysis
Systema hypothalamo-hypophysiale
Hypothalamo-hypophysial axis

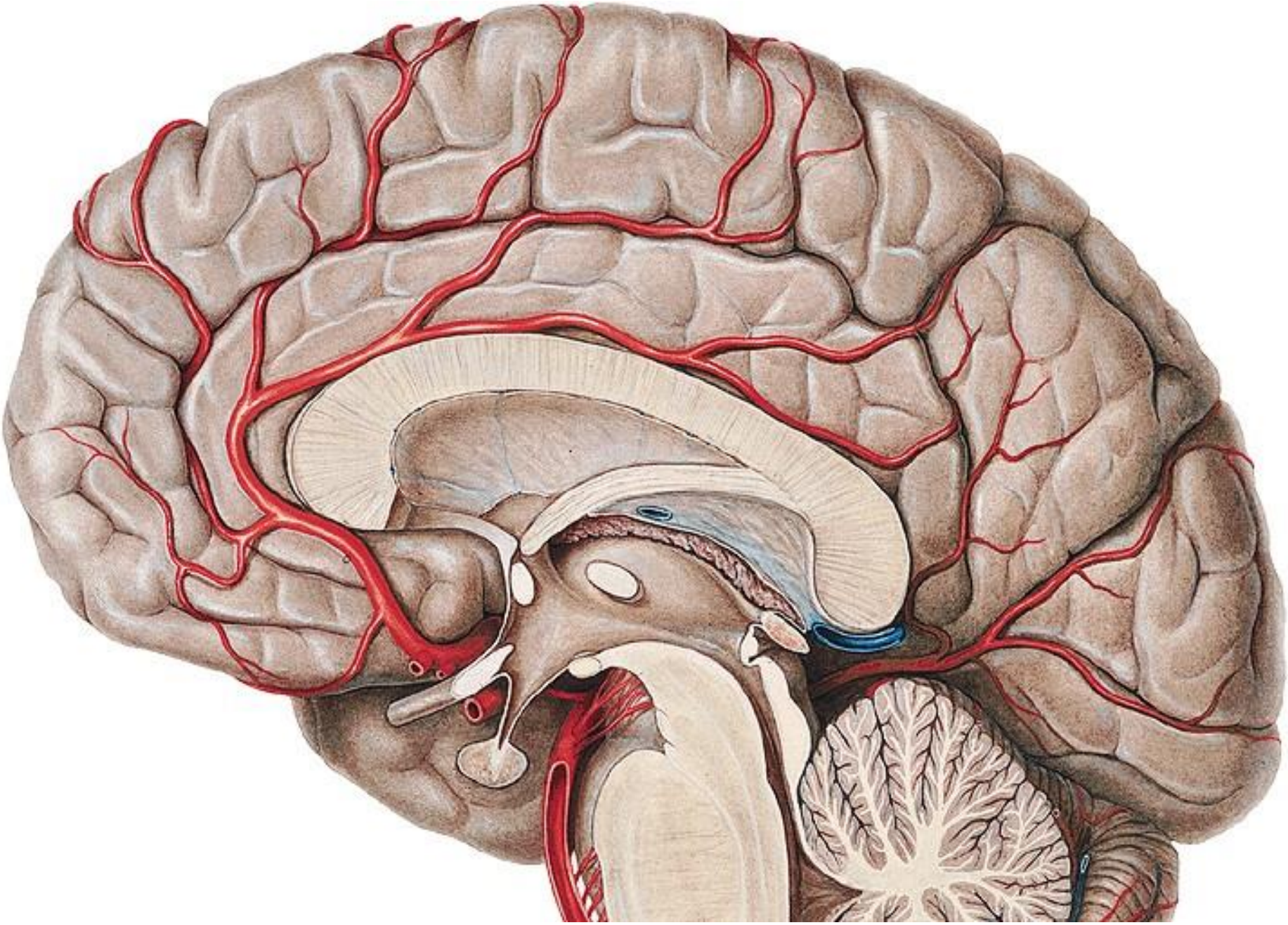
Hypophysis; Glandula pituitaria History

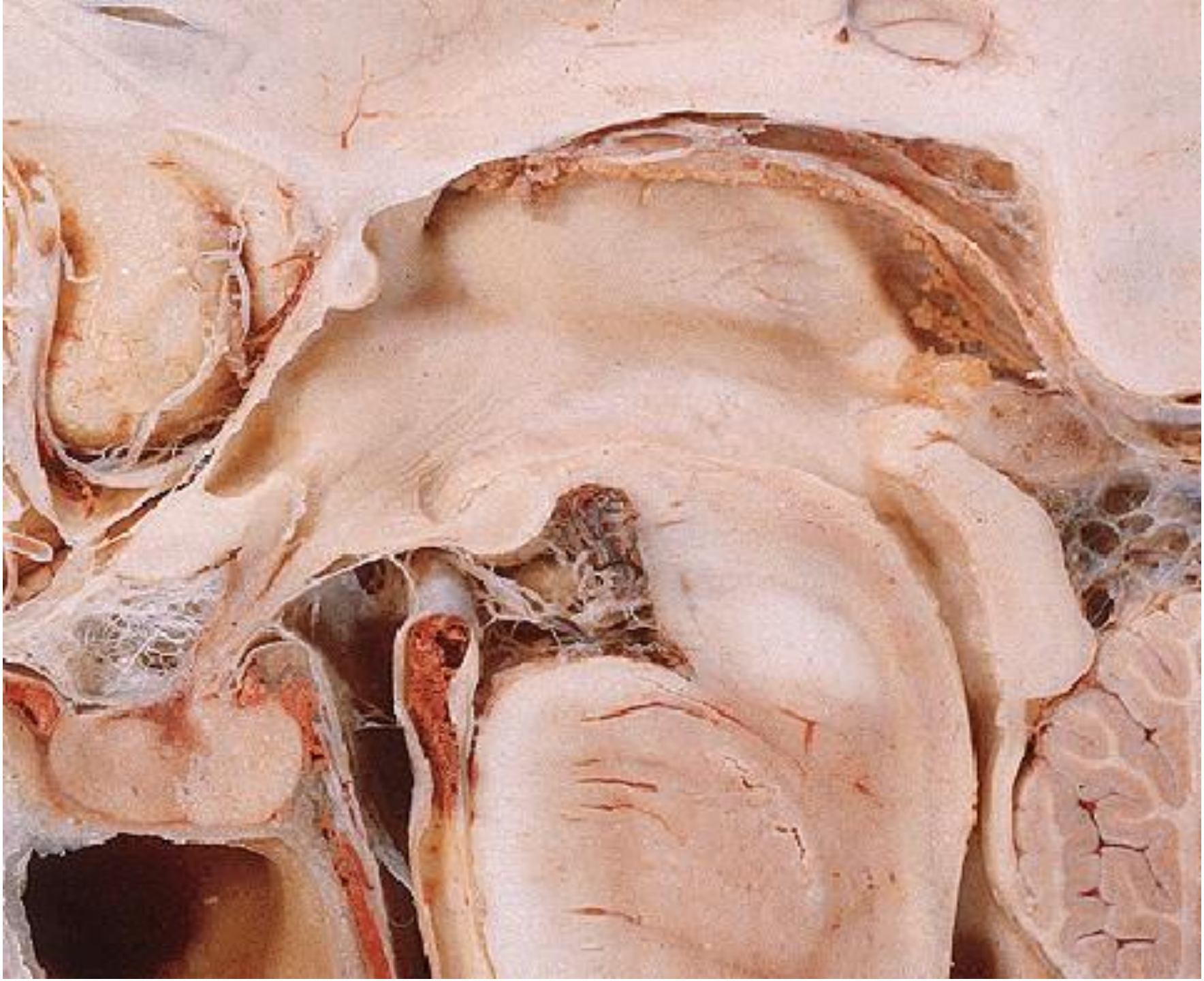
- *Galenos* – mucus production for nasal mucosa
- *Schneider* – 1655 refused Galenos‘ idea
- *Minkowski, Hutchinson* – connection between growth disroders and hypohysial hypertrophy
- ***Cushing*** – explained the function

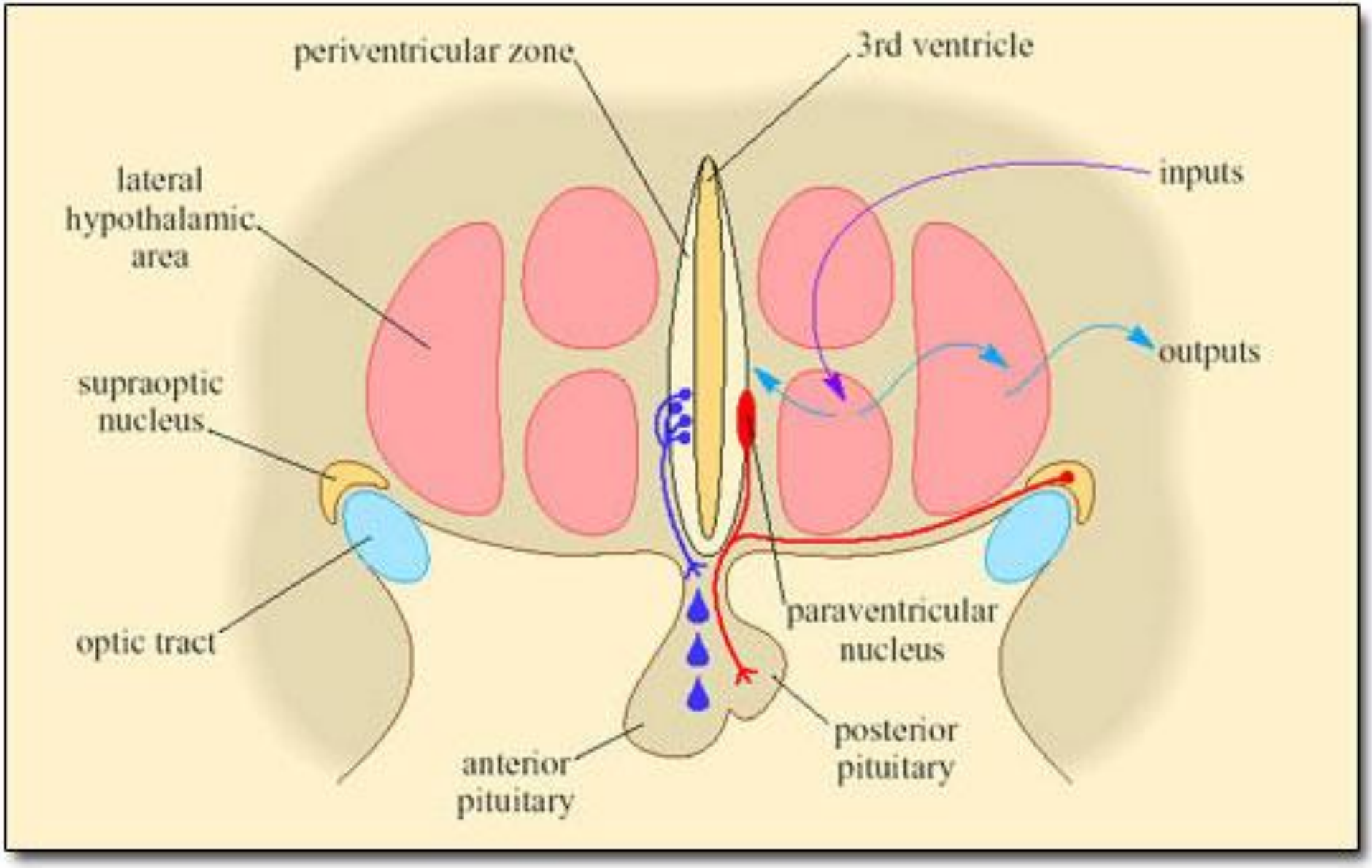
„a conducter of endocrine system, a prime minister“

Hypothalamus

- basal part of diencephalon
- basally to 3rd ventricle
- function
  - information collection center from body and surroundings
  - highest autonomic center
  - part of limbic system
  - manages other endocrine glands
- corpora mammillaria, tuber cinereum, infundibulum, hypophysis

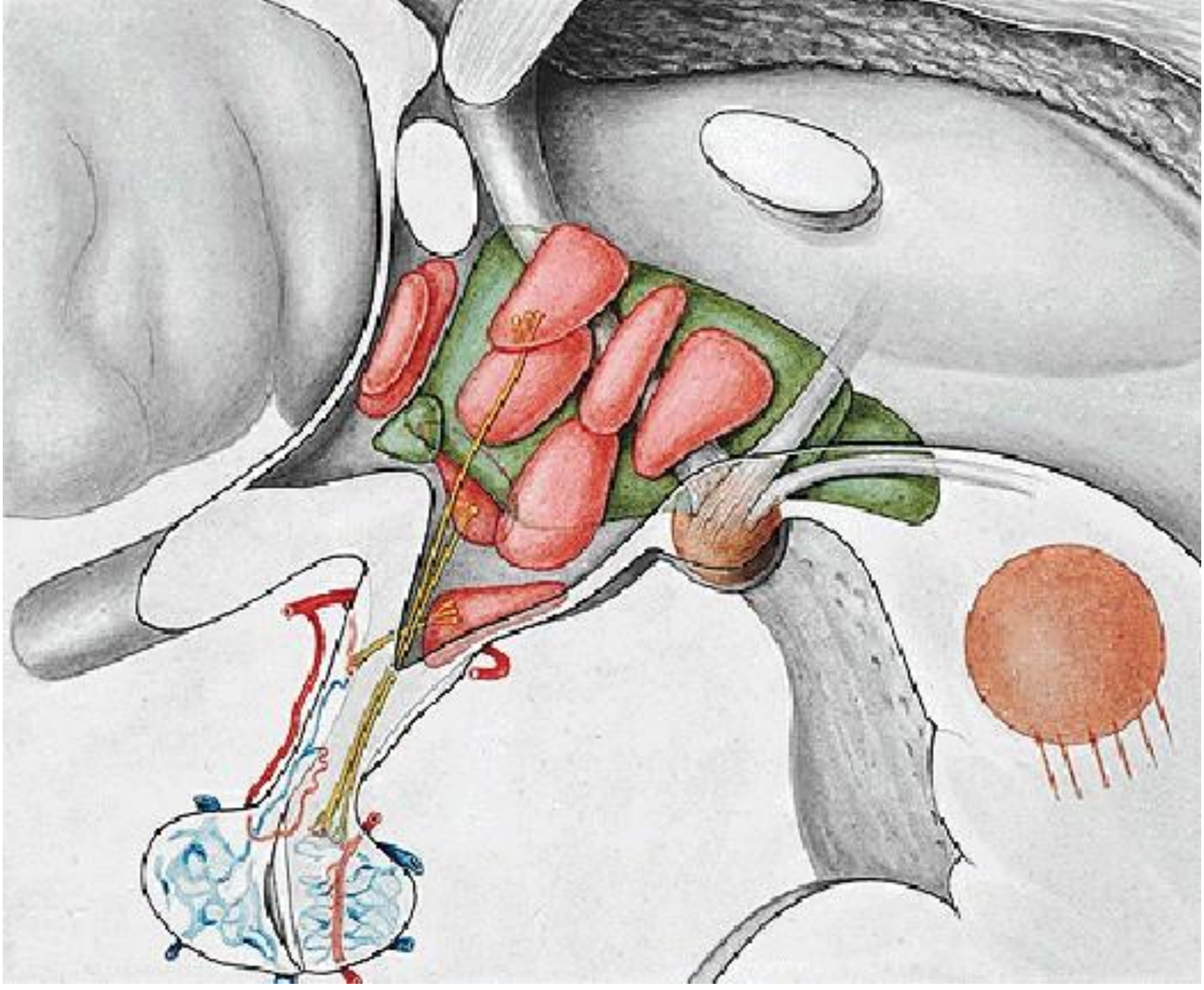





periventricular zone
3rd ventricle
lateral hypothalamic area
inputs
outputs
supraoptic nucleus
optic tract
paraventricular nucleus
posterior pituitary
anterior pituitary

Hypothalamus

- anterior hypothalamus – ncl. magnocellularis
  - **ncl. paraventricularis + supraopticus** – oxytocine and vasopressin (ADH)
- middle hypothalamus (tuber cinereum) – ncl. parvocelularis
  - **ncl. arcuatus** and surroundings – management of adenohypophysis
- posterior hypothalamus



Hypothalamus – hormones

- ncl. arcuatus – production
- eminetia mediana – releasing into first capillary network

- releasing hormones = liberins
  - SRH, PRH, GnRH, TRH, CRH
- inhibiting hormones = statins
  - somatostatin, PIH (= dopamine)

Hypophysis – anatomy

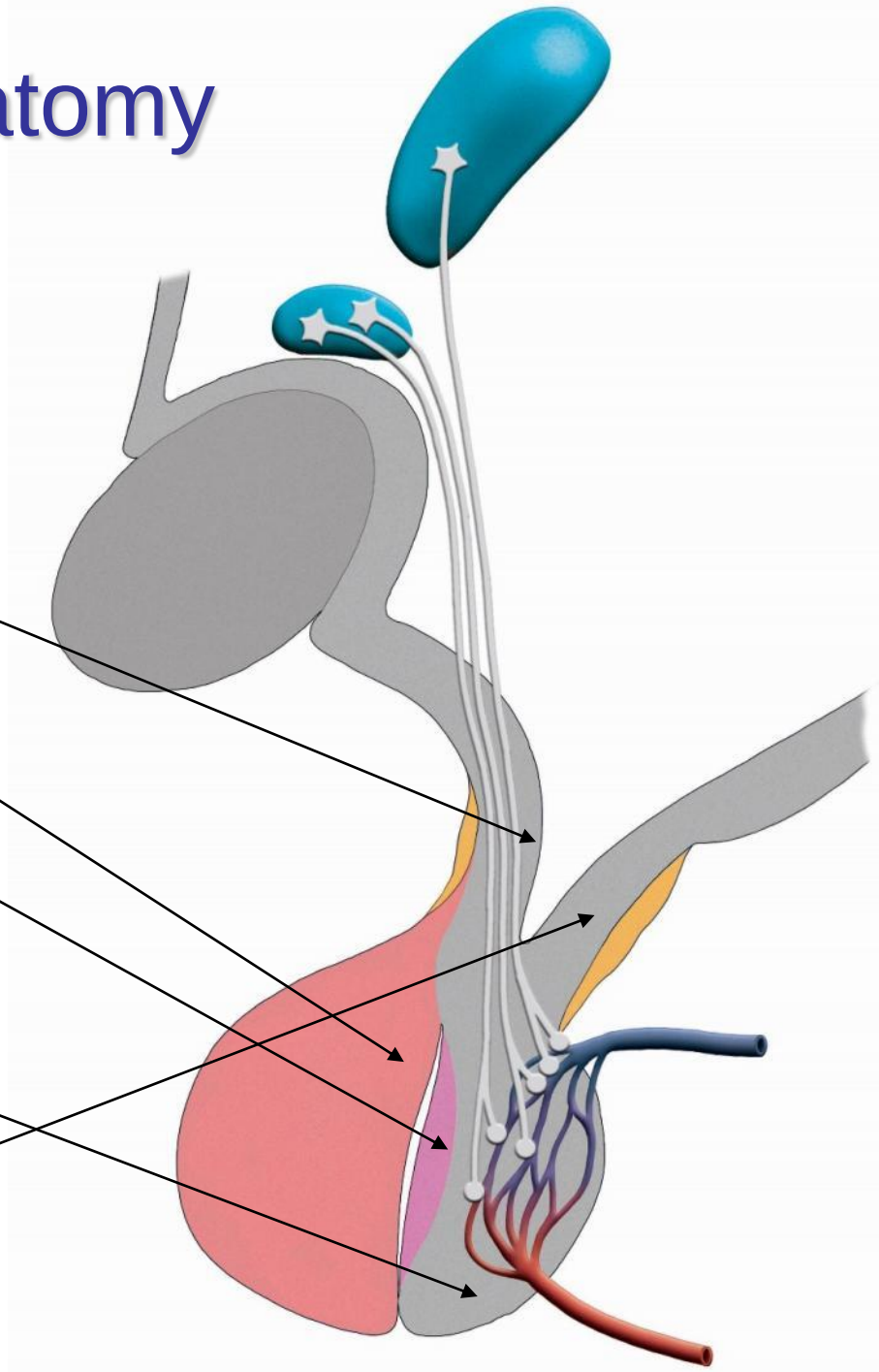
„double glands“

- two different tissues

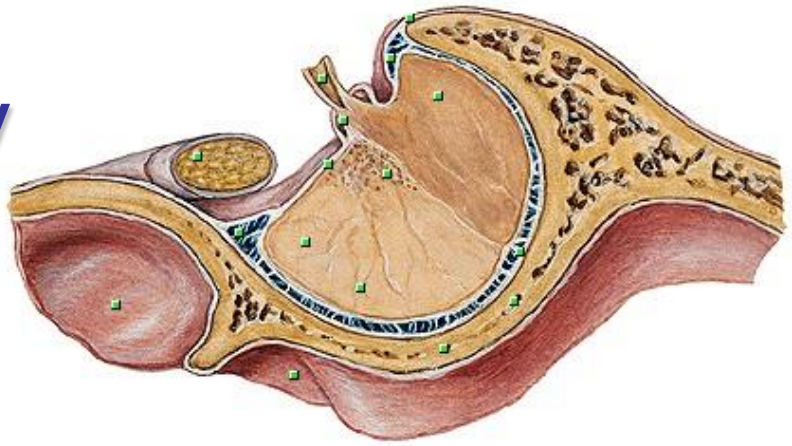
- two lobes
  - anterior = adenohypophysis
  - posterior = neurohypophysis
- located within *sella turcica ossis sphenoidalis*
  - transsphenoidal operation approach
- covered with dura mater – *diaphragma sellae*
  - foramen diaphragmatis *Pacchioni* – transmits *infundibulum*

Hypophysis – anatomy

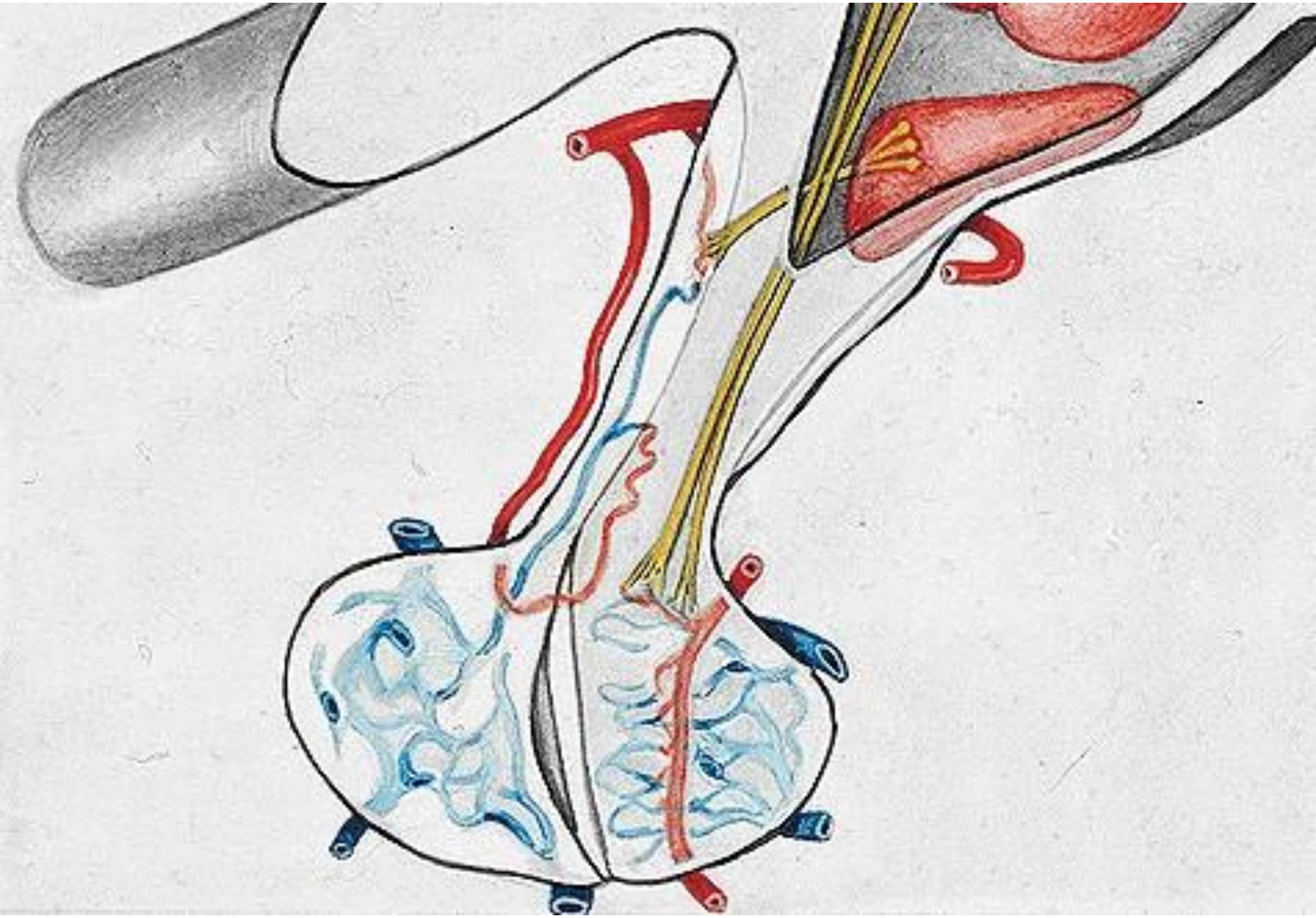
- anterior lobe (*adenohypophysis; lobus anterior*)
  - pars tuberalis
  - **pars distalis** (principalis)
  - pars intermedia
- posterior lobe (*neurohypohysis; lobus posterior*)
  - lobus nervosus (pars nervosa)
  - infundibulum



Hypophysis – anatomy



- anterior lobe (*adenohypophysis; lobus anterior*)
  - **pars distalis** (principalis) – largets part (75%)
  - pars intermedia – between both lobes
  - pars tuberalis – cranially at infudibulum
- posterior lobe (*neurohypohysis; lobus posterior*)
  - lobus nervosus (pars nervosa) – proper posterior lobe
  - infundibulum – connection to hypothalamus

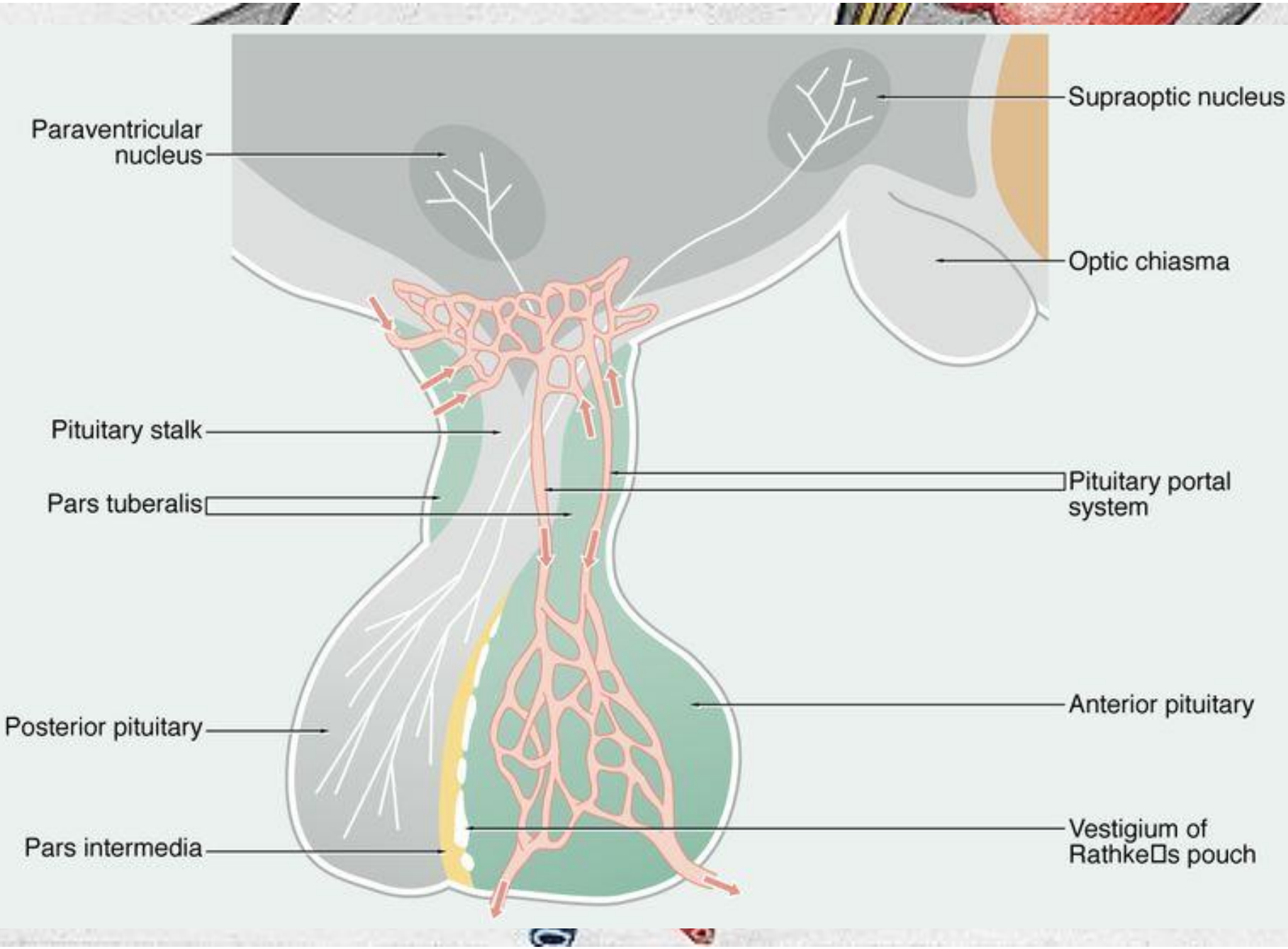


Hypohysis – blood supply

hypophysial portal system

- a. hypophysialis inferior (from pars cavernosa ACI to neurohypophysis)
- a. hypophysialis superior (from pars cerebralis ACI via hypothalamus to adenohypophysis)

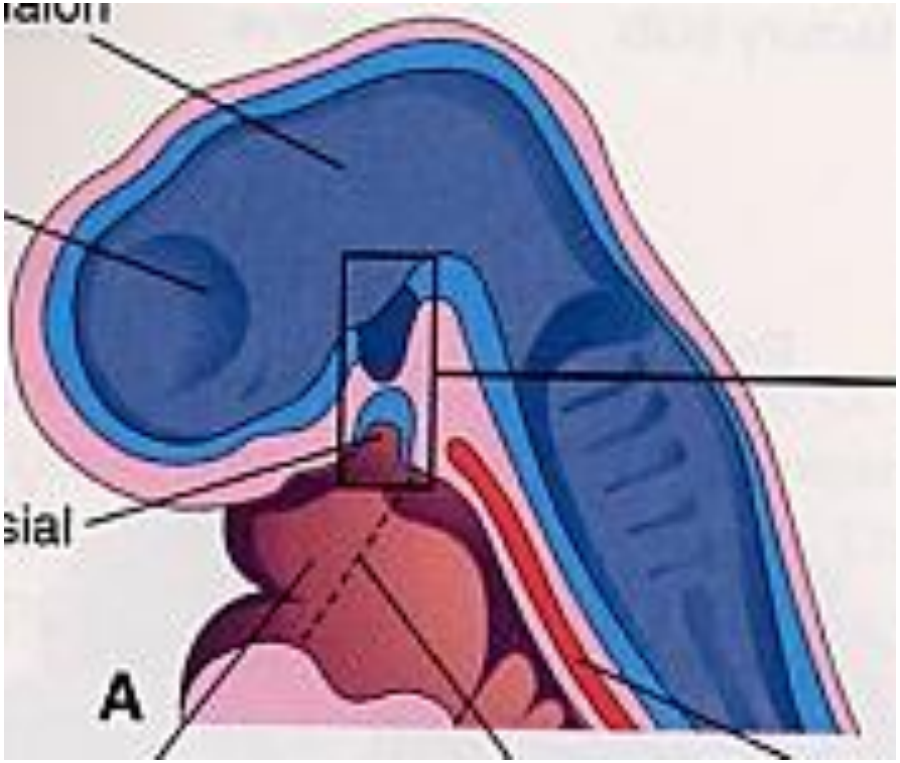
- vv. hypophysiales into sinus cavernosus

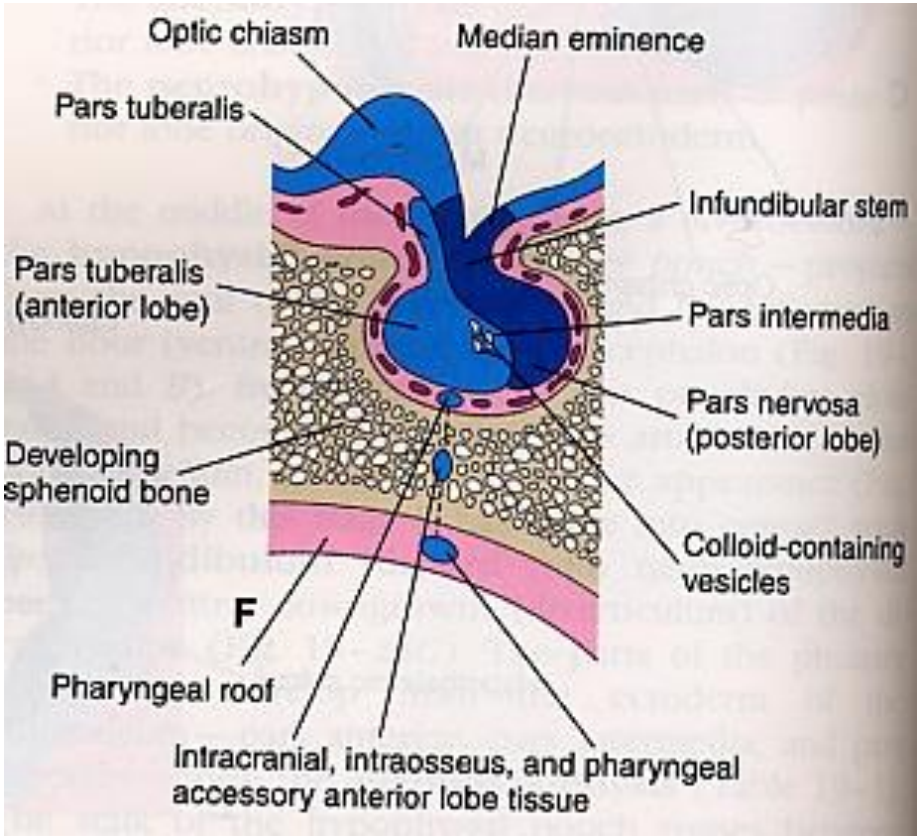

Paraventricular nucleus
Supraoptic nucleus
Optic chiasma
Pituitary stalk
Pars tuberalis
Pituitary portal system
Anterior pituitary
Posterior pituitary
Pars intermedia
Vestigium of Rathke□s pouch

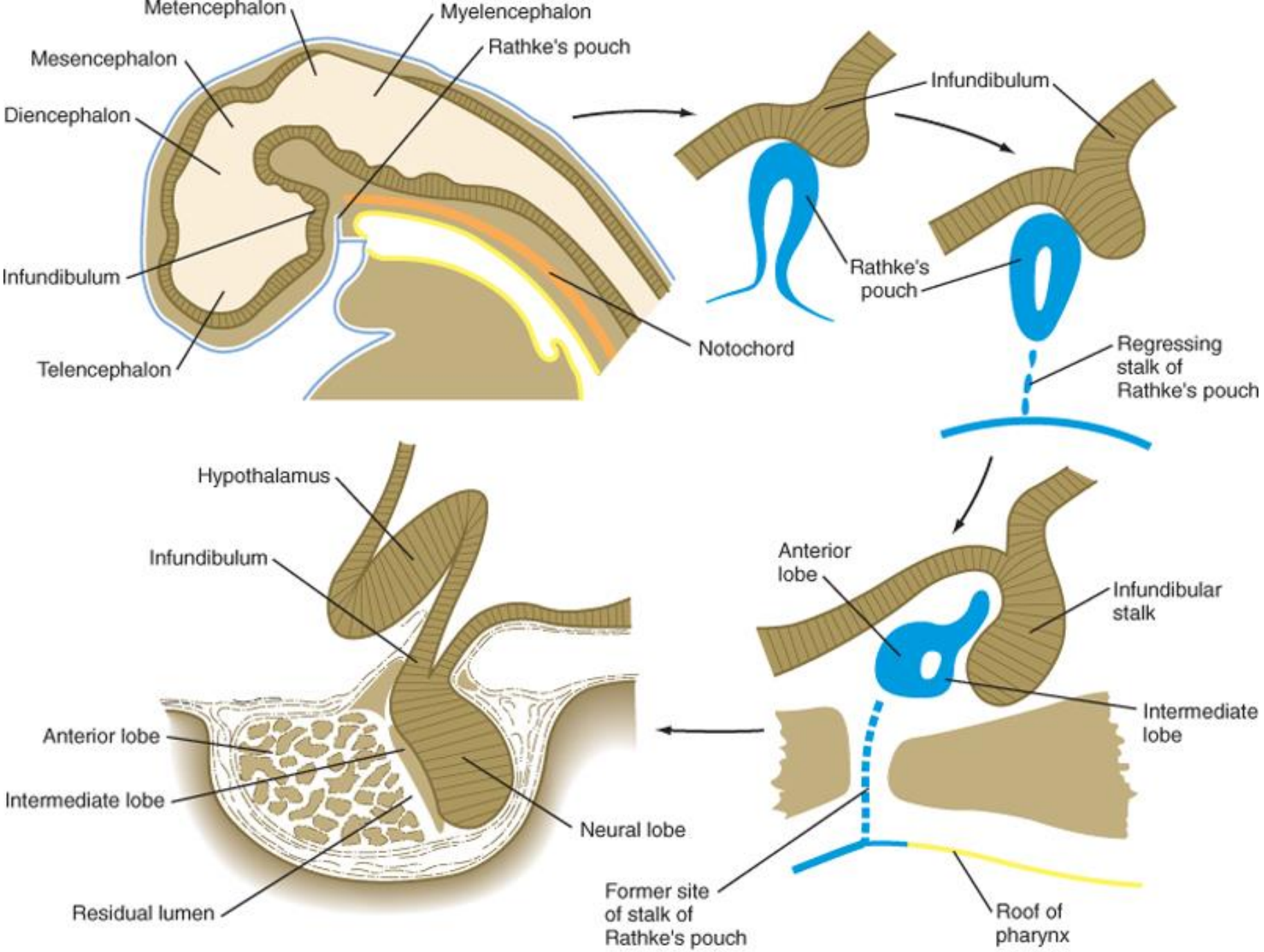
Hypophysis – development

- pouch of Ratke
  - ectoderm → anterior lobe
  - 3rd week: in the roof of stomodeum
  - pouch towards diencephalon
  - separation of pouch, proliferation of anterior wall
- pouch of diencephalic base
  - neuroectoderm → posterior lobe
  - differentiation into v pituicytes (glia)

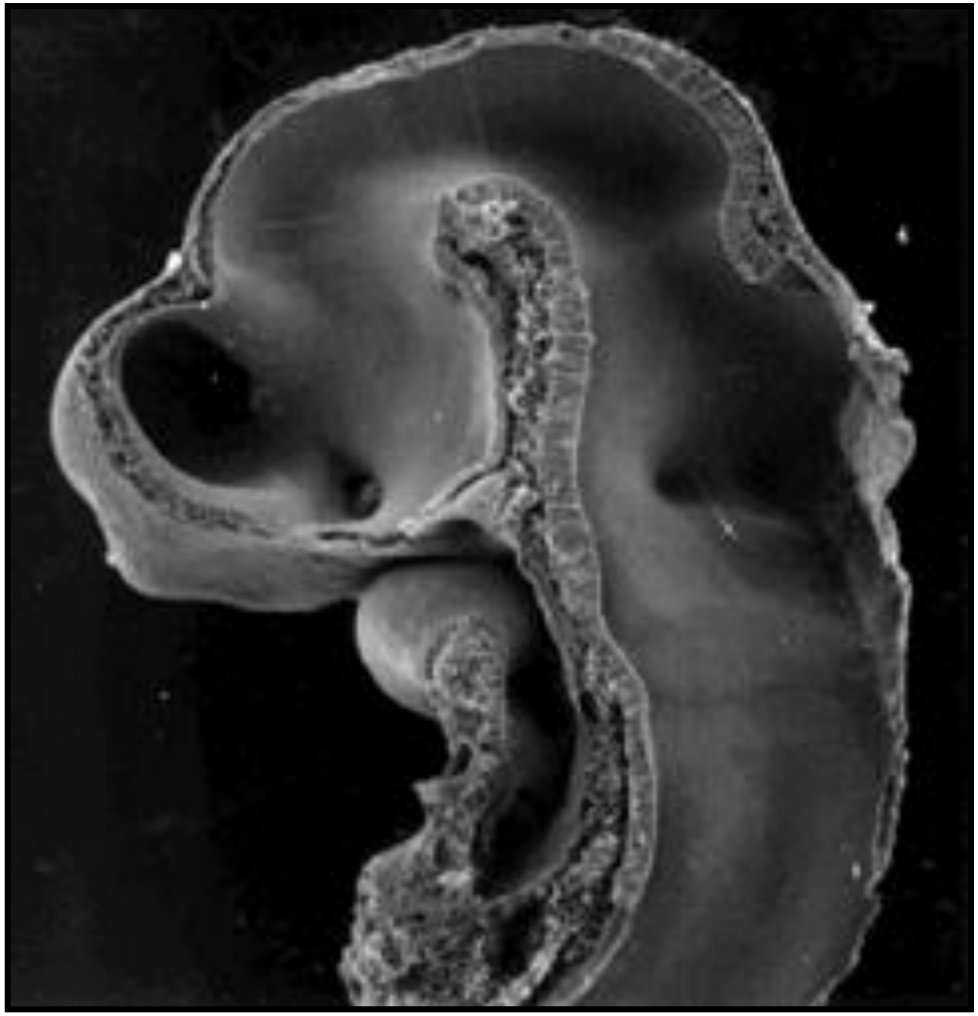
Hypophysis – development

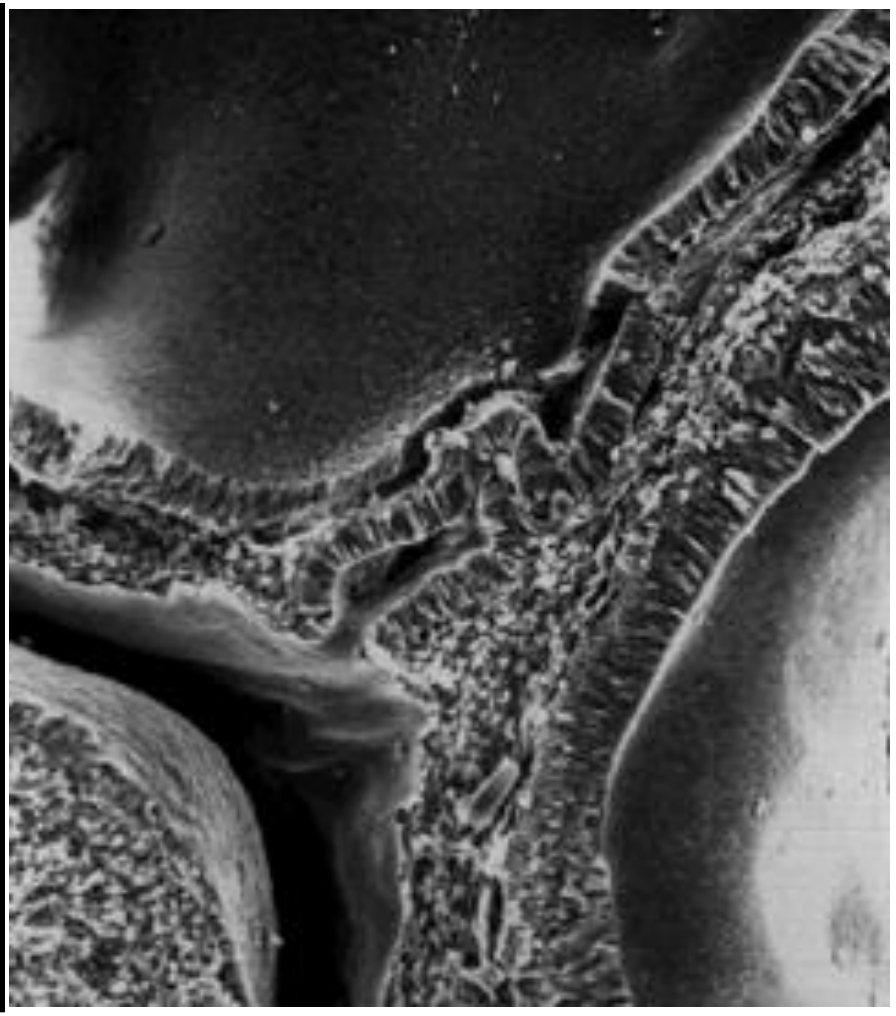






Hypophysis – development





Pars distalis adenohypophysis

- cords of cells (*chordae endocrinocytorum*)
- fenestrated capillaries inbetween cords
- 3 types of cells in HE staining:
  - acidophilic
  - basophilic
    - PAS-positive
  - chromophobe
    - no granule, undifferentiated elements

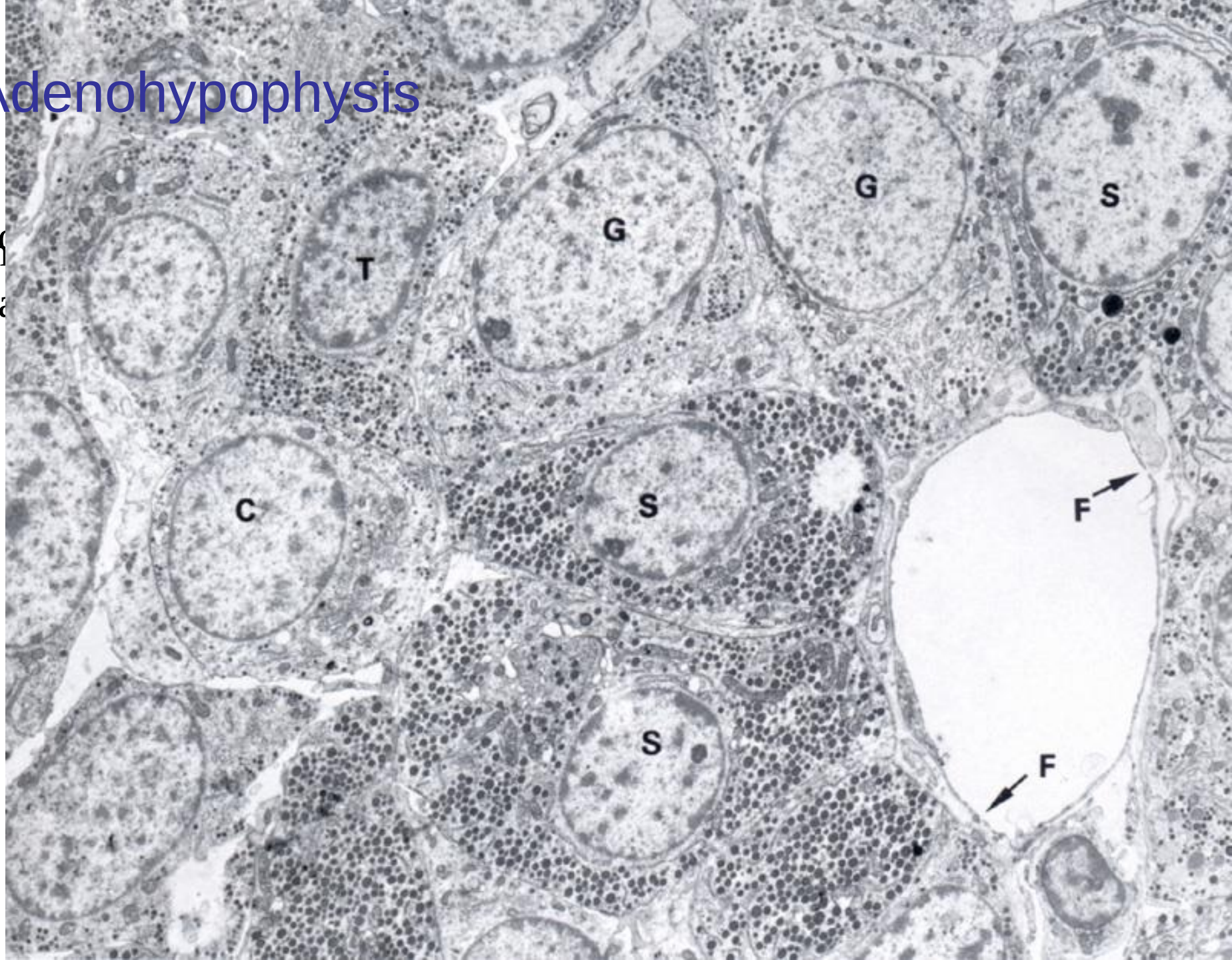
Pars distalis – acidophilic cells

- α – cells (*endocrinocytus somatotropicus*)
  - large granulee, GER
  - zone without granules around nucleus (GA)
  - **somatotrophin (human growth hormone, GH)**
- ε – cells (*endocrinocytus prolactinicus*)
  - usually small, infrequent
  - multiplication in gravidity and lactation
  - little granules (larger in gravidity)
  - **prolactin (PRL)**

Pars distalis – basophilic cells

- β_1 – cells (*endocrinocytus corticotropicus*)
  - large granules at cytoplasmatic membrane
  - **ACTH, β-MSH**, Met-enkefalin, endorphine
- β_2 – cells (*endocrinocytus thyrotropicus*)
  - large cells, small granules at BM
  - **TSH**
- δ – cells (*endocrinocytus gonadotropicus*)
  - large cells, middle granules
  - **FSH, LH (lutropin)**

Adenohypophysis

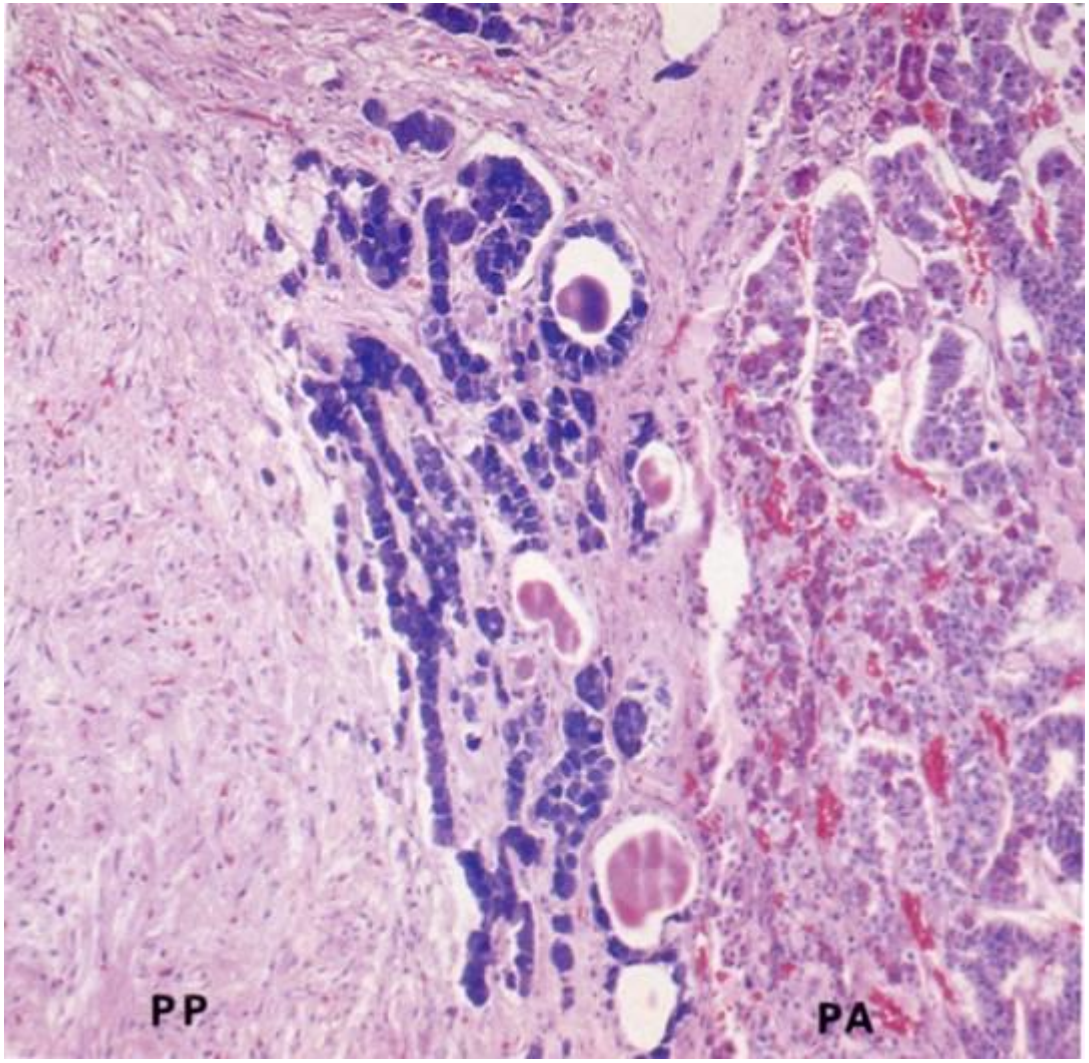


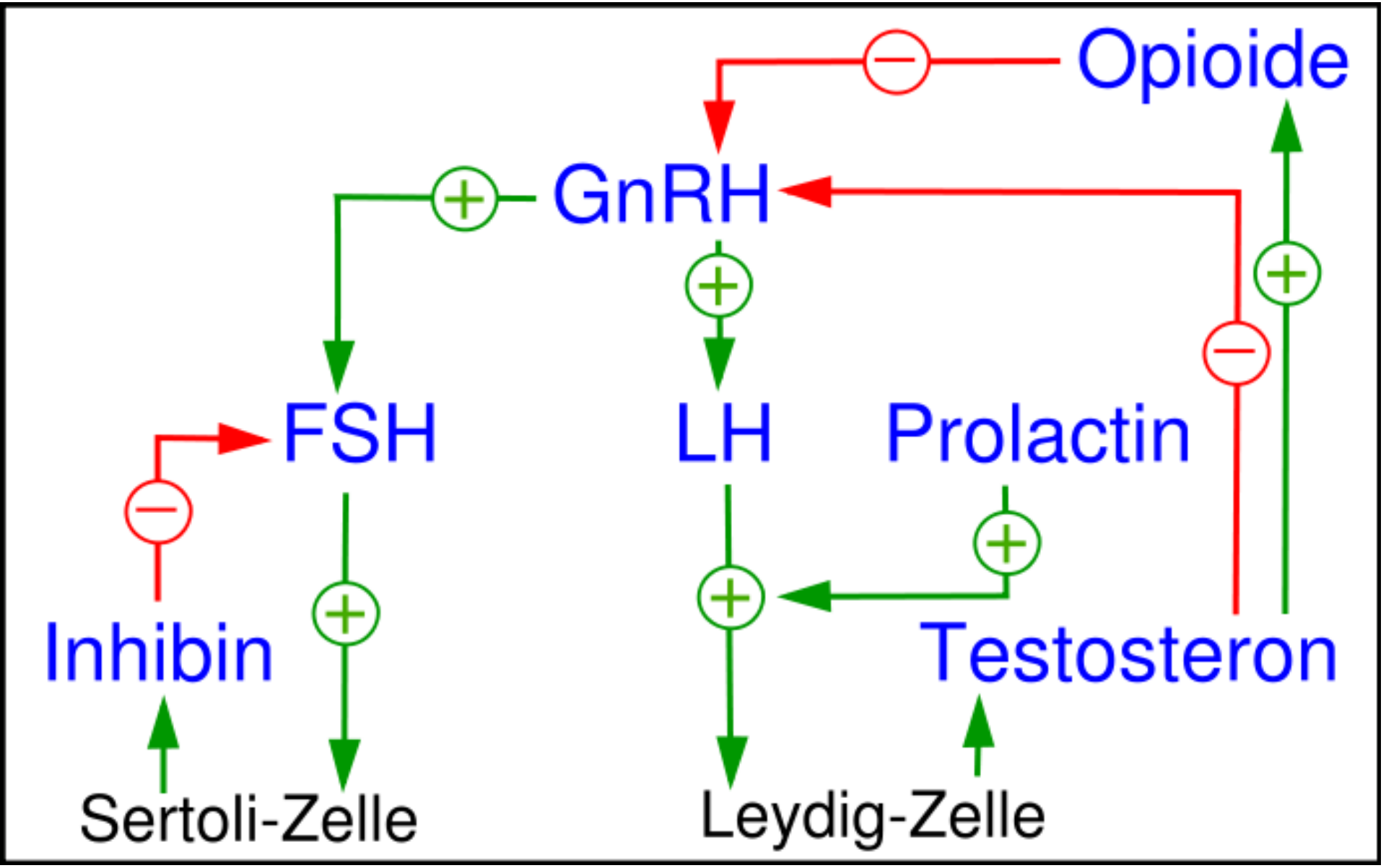
Pars tuberalis adenohypophysis

- encircles the infundibulum
- frequent capillaries
- majority: **δ-cells**
  - few β_2-cells

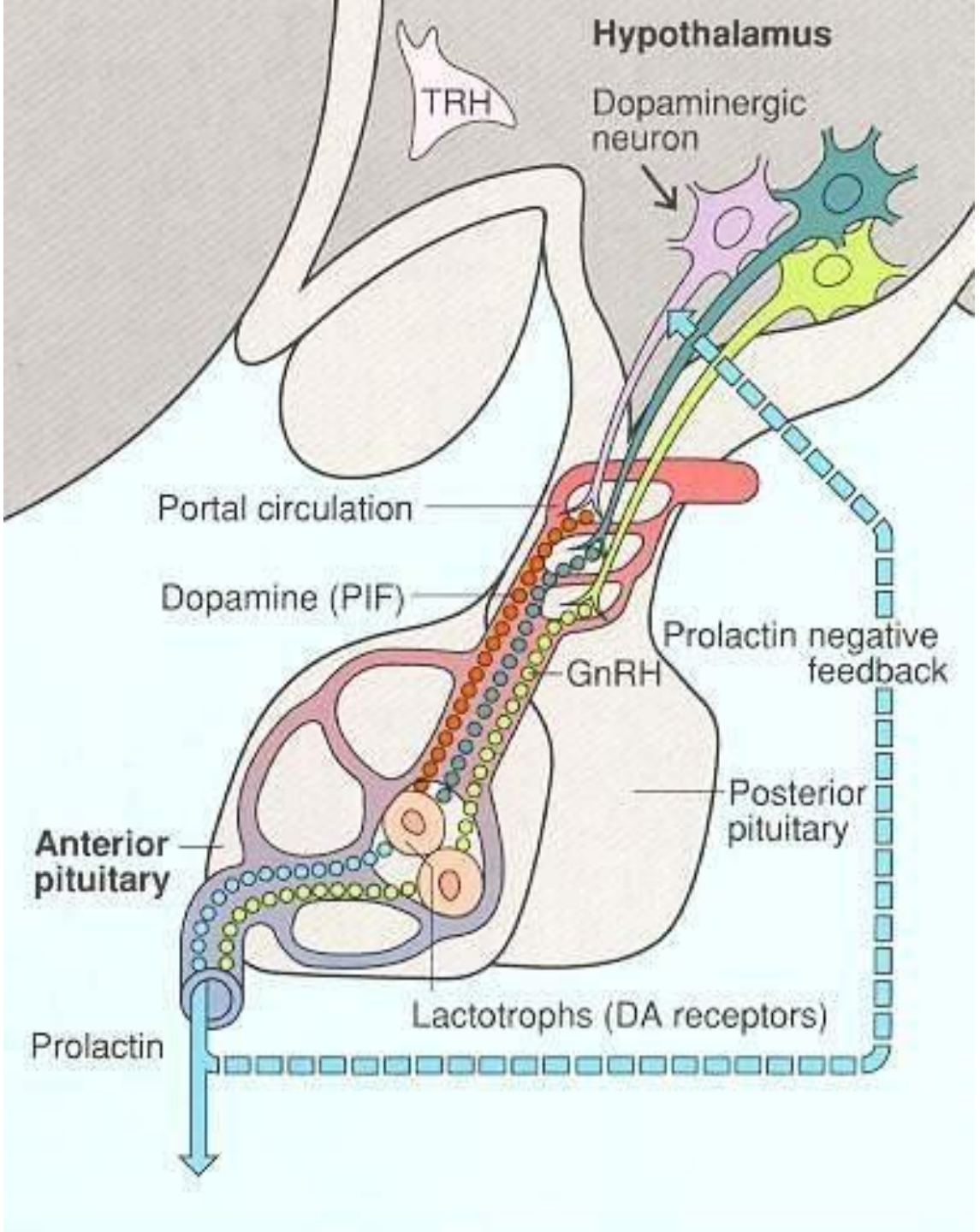
Pars intermedia adenohyophysis

- *rudimentary*
- cells form trabecules
- basophilic cells
- follicle of Ratkhe can be formed




Opioide
GnRH
FSH
LH
Prolactin
Inhibin
Testosteron
Sertoli-Zelle
Leydig-Zelle

- **PIH** (dopamine) from hypothalamus → inhibition →
- **prolactin** from anterior lobe of pituitary gland

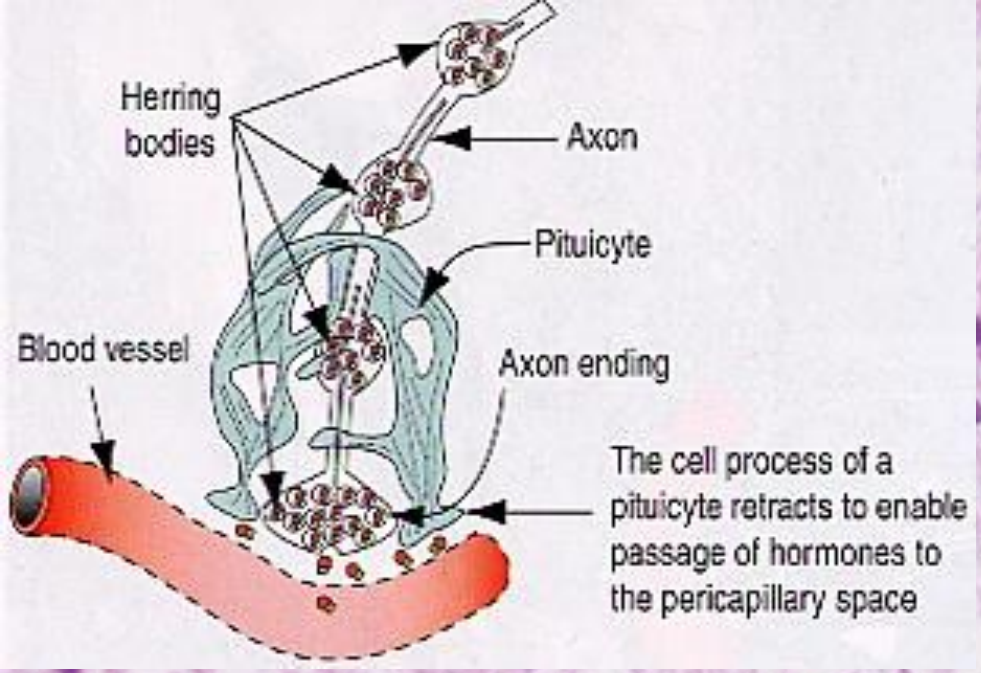


Posterior lobe = *Neurohypophysis*

- eminentia mediana
  - floor of the 3rd ventricle
  - frequent nonmyelinized nerve fibers
- infundibulum
  - tractus hypothalamohypophysialis
  - neurofibra neurosecretoria (+ vesicula neurosecretoria) = nonmyelinized nerve fibers
    - some terminate at capillaries
- lobus nervosus (pars nervosa)

Lobus nervosus neurohypophysis

- nerve fibers
  - axons of hypothalamic neurons
  - corpuscula neurosecretoria (bodies of *Herring*) – accumulation of granules
  - **oxytocin** + **ADH** (adiuretin, antidiuretic hormone, vasopressin)
- pituicytes (*pituicyti*)
  - glial cells
- capillaries (*synapsis neurohaemalis*)


Herring bodies
Axon
Pituicyte
Blood vessel
Axon ending
The cell process of a pituicyte retracts to enable passage of hormones to the pericapillary space

Examination and diseases

- CT
- hormone levels in blood

- tumors of hypophysis – usually benign, hormonactive
- Sheehan‘s syndrome – postpartal bleeding into hypophysis

Thyroid gland

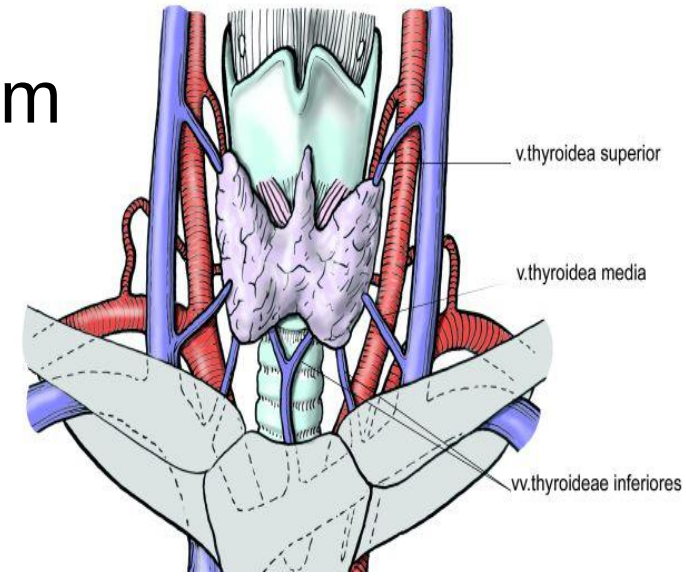
Glandula thyroidea

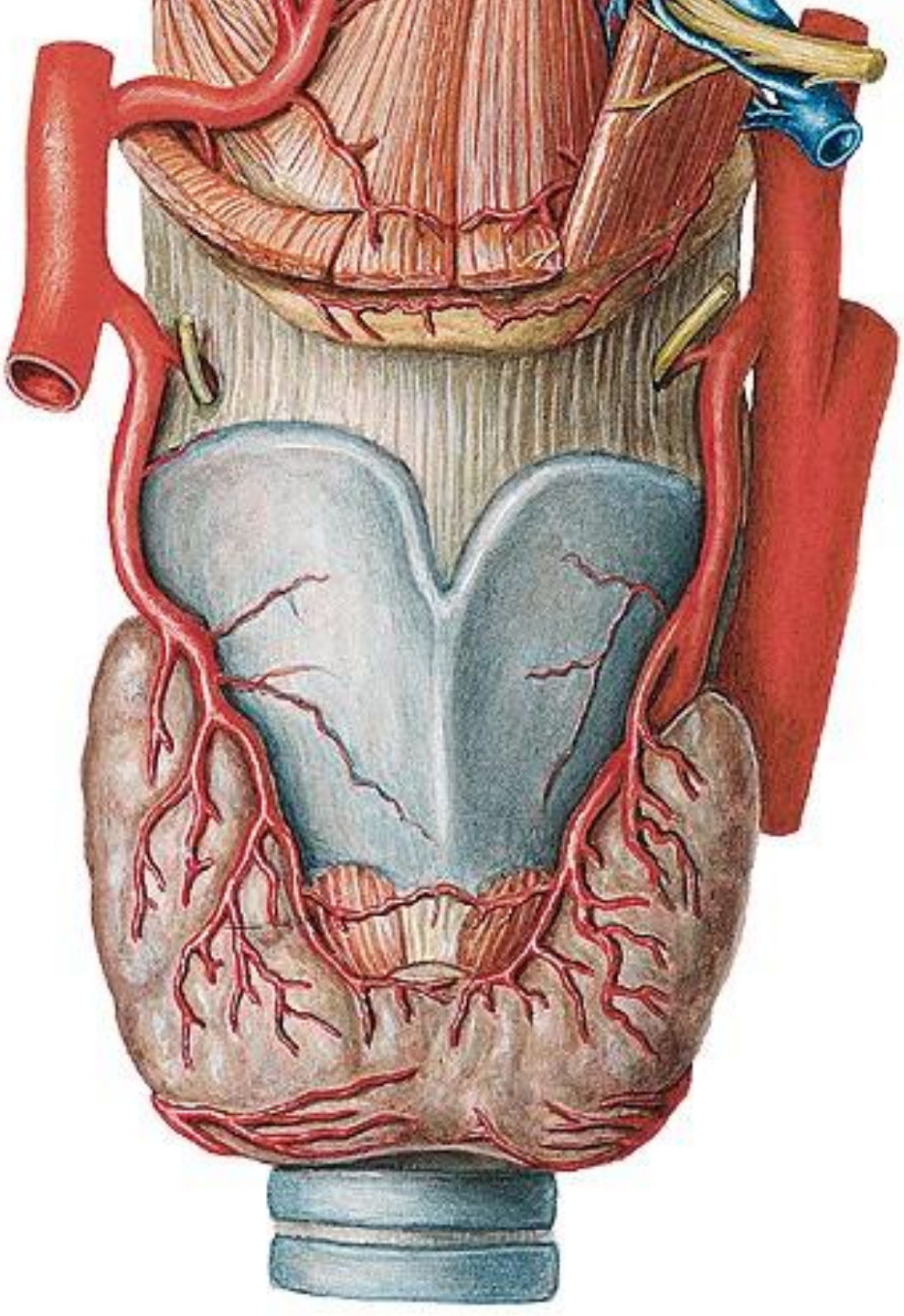
Thyroid gland – history

- Galenos – makes the pharynx wet inside hltanu
- Paracelsus – goiter + cretenism
- Wharton (1614-1673) – decoration of female neck
- Simon (1844) – endocrine glands
- Murray (1891) – application of thyroid gland extraction
- Baumann (1895) – thyroid glands contains iodium compounds

Thyroid gland – anatomy

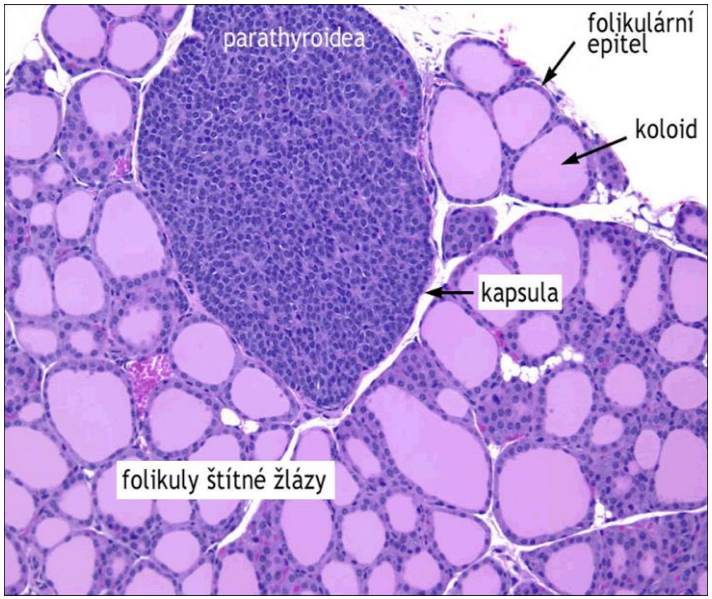
- located at level of C6-C7
- shape of letter H
- lobus dexter et sinister
- isthmus glandulae thyroideae
  - at 2nd-4th tracheal cartilage
  - height of isthmus about 1.5 cm
- lobus pyramidalis (40 %)
  - length of lobe 5-8 cm
- 30-40 g (20-60 g)





Thyroid gland – anatomy

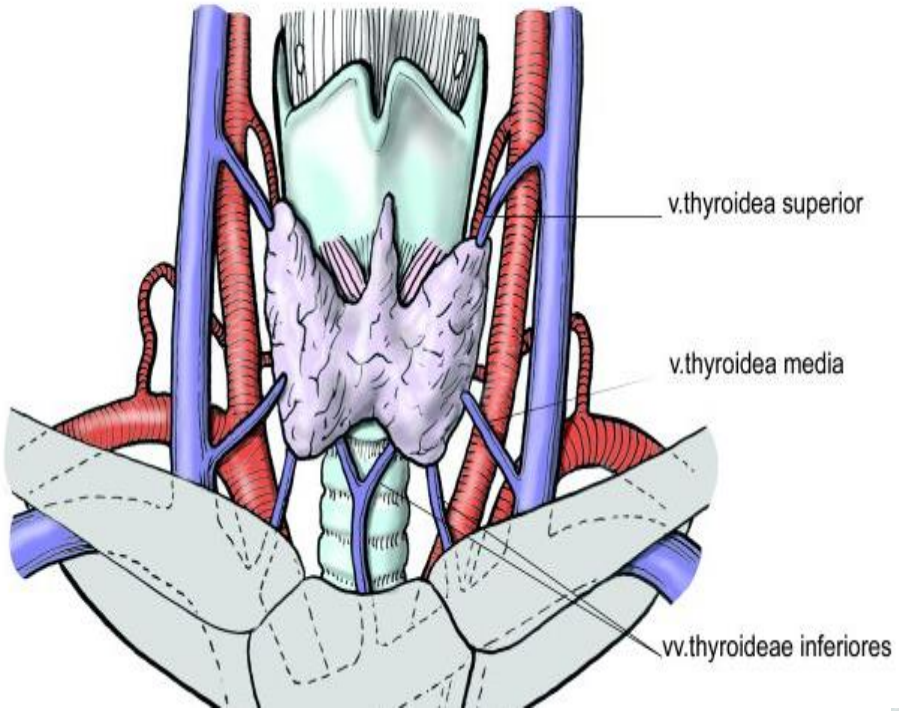
- **thyroxine** T_4, **triiodothyronine** T_3
- **calcitonine**
- capsula fibrosa – 2 layers – stroma
  - septa (between lobuli)
- parenchyma
  - lobi →
    lobuli →
    folliculi (50–900 μm)

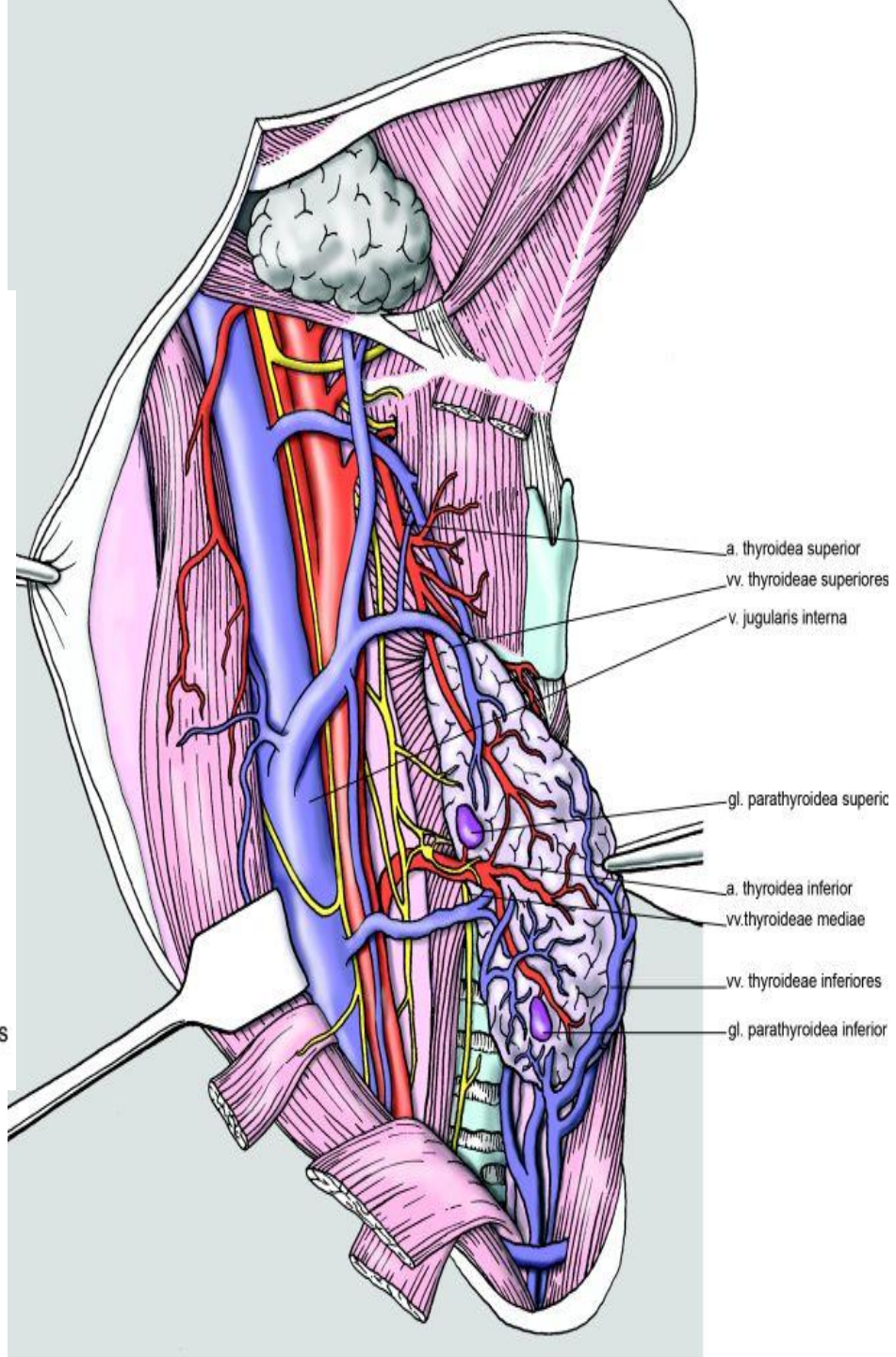


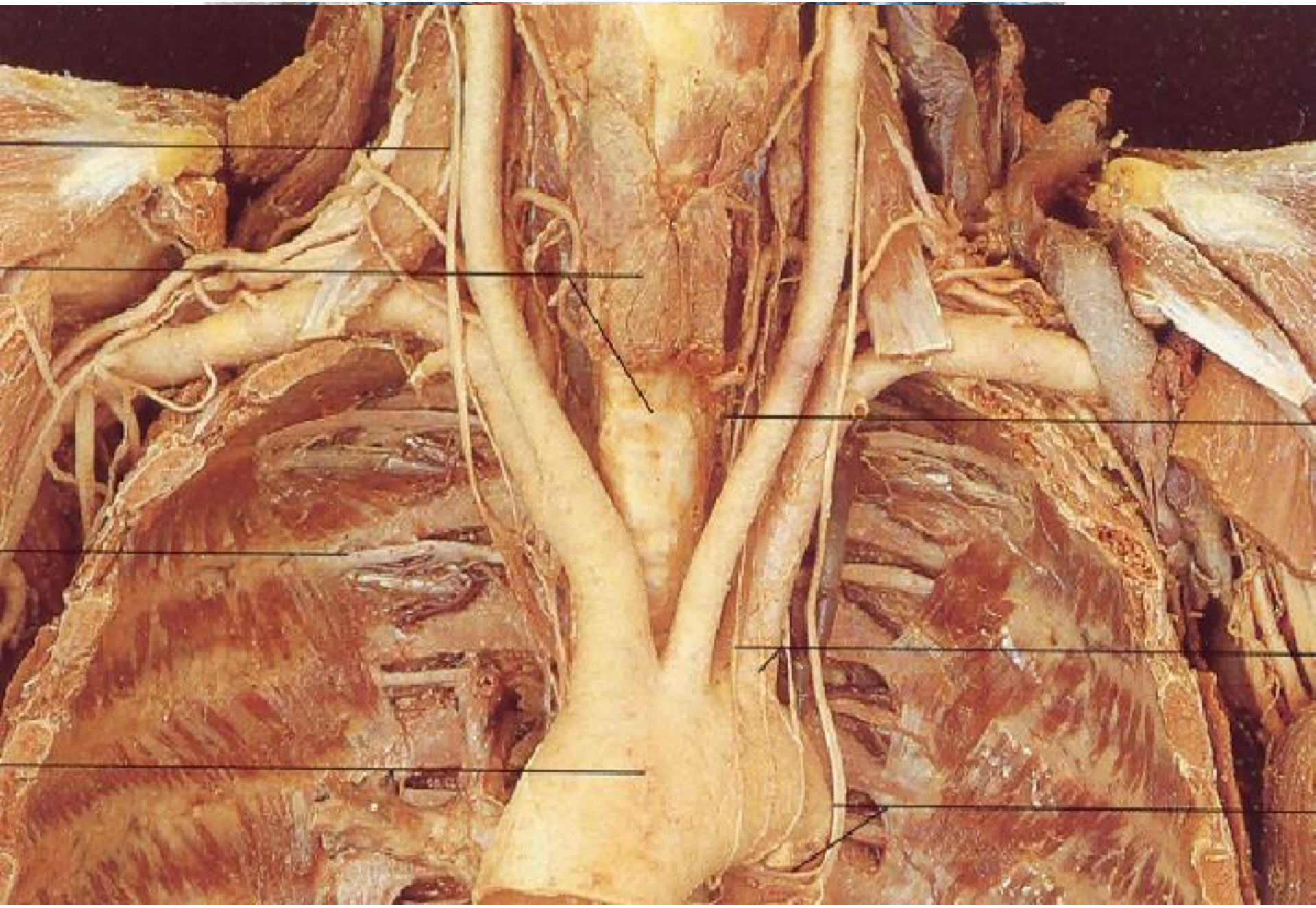
Thyroid gland – blood vessels

- a. thyroidea superior (← a. carotis externa)
- a. thyroidea inferior (← truncus thyrocervicalis)
  - ***crossing with n. laryngeus recurrens***
- a. thyroidea ima *Neubaueri* (← arcus aortae)
  - 2%

- vv. thyroideae superiores
- Vv. thyroideae mediae *Lichačevae-Kocheri* (50%) → vv. jugularis interna
- vv. thyroideae inferiores → plexus thyroideus impar → v. brachiocephalica sinistra

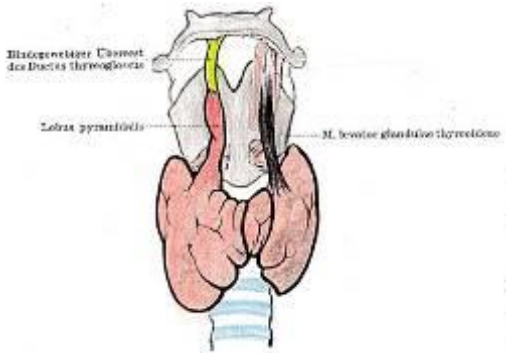

v.thyroidea superior
v.thyroidea media
vv.thyroideae inferiores


a. thyroidea superior
vv. thyroideae superiores
v. jugularis interna
gl. parathyroidea superic
a. thyroidea inferior
vv.thyroideae mediae
vv. thyroideae inferiores
gl. parathyroidea inferior



Thyroid gland – development

- from 24th day
- pouch of primitive pharynx endoderm
- both relative and absolute descent → *ductus thyroglossus*
- *foramen caecum*
- *gll. thyroideae accessoriae*
- lobes formation
- *lobus pyramidalis*
- *ligamentum suspensorium gl. thyroideae* / *musculus levator glandulae thyroideae* (smooth)

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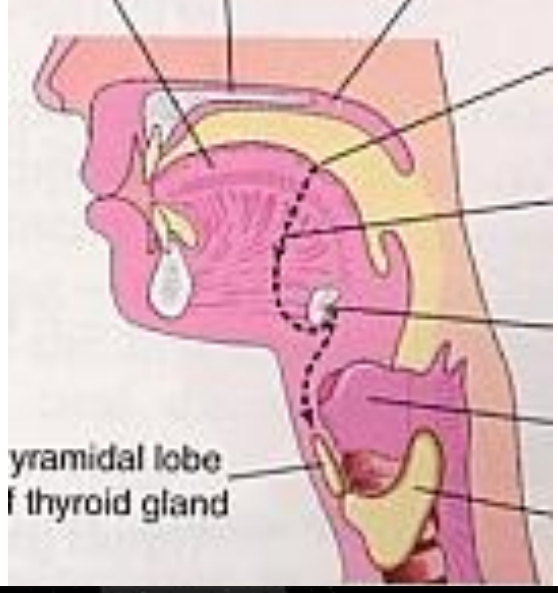
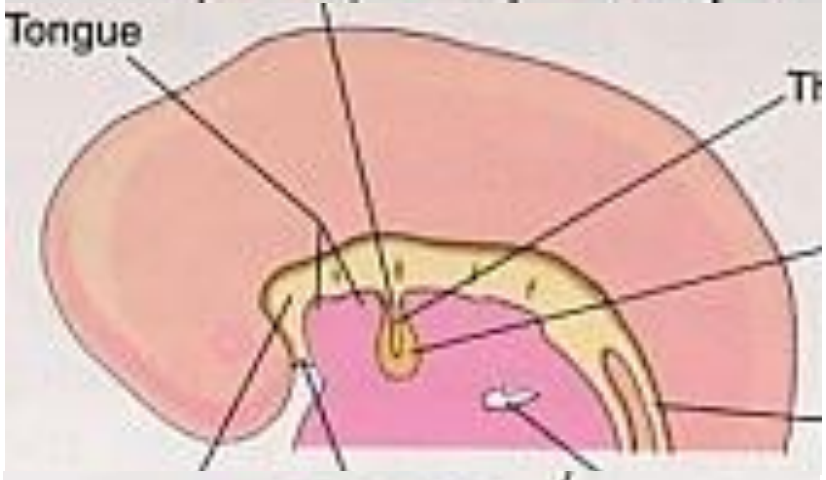
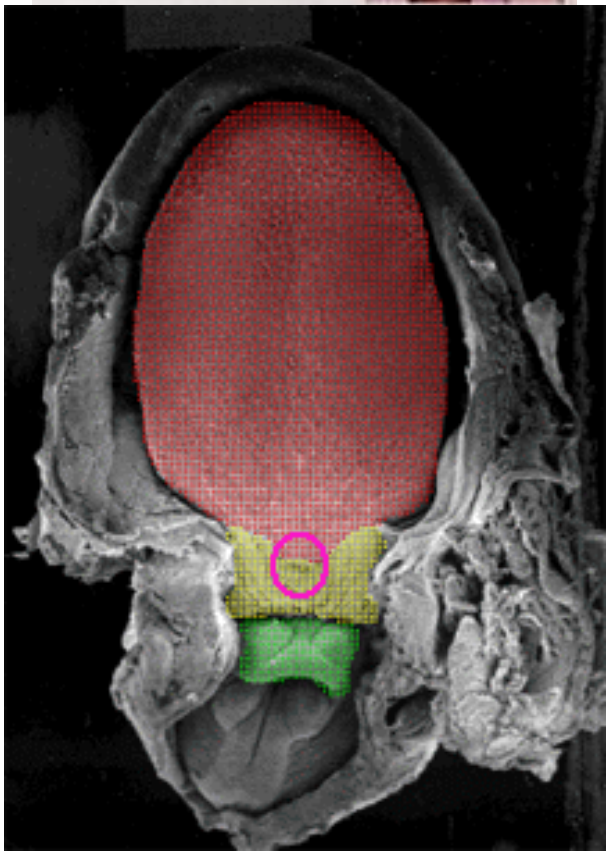
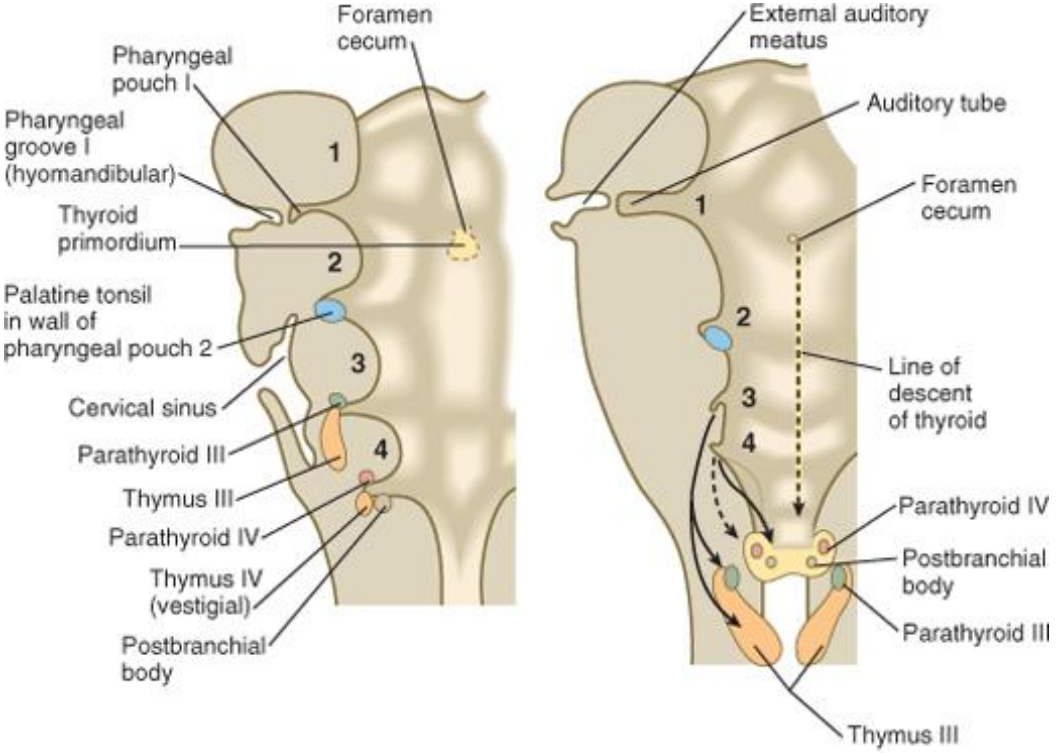
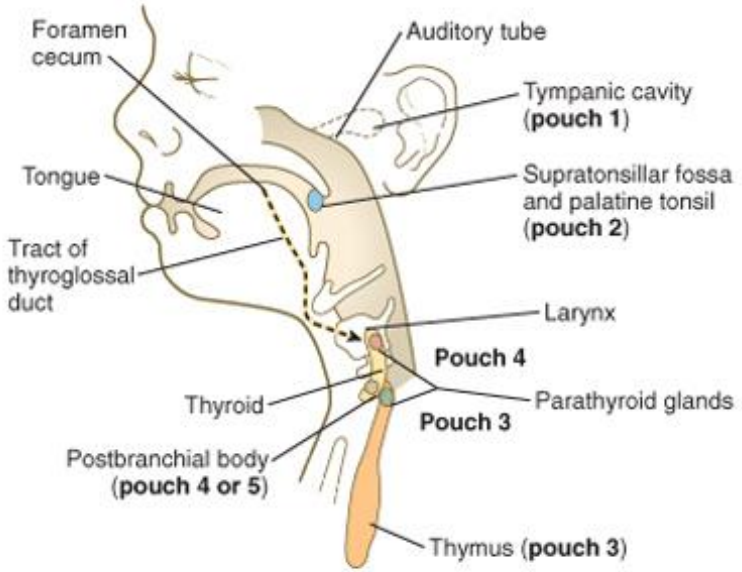

yramidal lobe
f thyroid gland


Tongue







Thyroid gland – histogenesis

- solid endodermal structure
- ingrowth of surrounding mesenchyme and vessels
- ingrowth of ultimopharyngeal (ultimobranchial) bodies
- 10th week: division of cells into groups
- simple epithelium around lumen
- 11th week: colloid production starts

Thyroid gland – structure

- *capsula fibrosa*
- stroma
- septa (between lobules)
- lobus → lobulus → folliculus
- follicles (50–900 μm)
  - spheric
  - simple epithelium of follicular cells
  - contains *colloidum* (colloid) – thyreoglobulin
- follicular cell (*thyrocytus T)*
- parafollicular cell (*thyrocytus C*)

Follicular cells (*Thyrocytus T)*

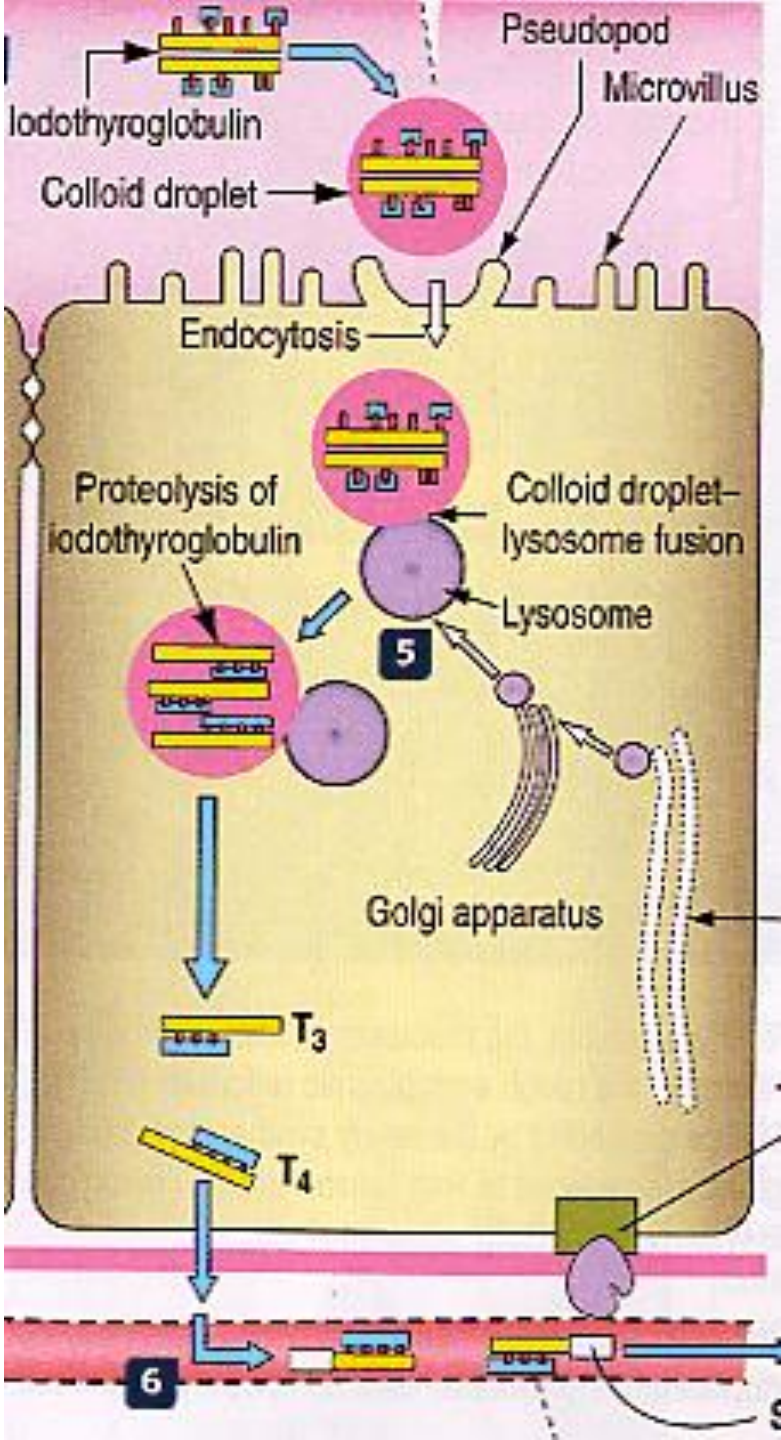
- spheric nucleus
- large gER (basally) and mitochondria
- numerous lysosomes

- thyreoglobulin, cleavage of T_4 and T_3

Synthesis of thyroid gland hormones

- 1. iodine pump using ATP transport hte iodine form blood to colloid
- 2. + 3. synthesis of thyreoglobulin and peroxidase, storage in one secretory vesicle and their release into the colloid by exocytosis
- 4. iodination of thyreoglobulin by peroxidase within the colloid and formation of iodinethyreoglobulin

- endocytosis of iodinethyreoglobulin
- 5. fusion of primary lysosoma with this vesicle
- proteolysis of iodinethyreoglobulin into T3, T4 and other fragments
- release of T3 and T4 into circulation
- 6. binding to transport plasmatic protein (TBP)



Parafollicular cells (*Thyrocytus C*)

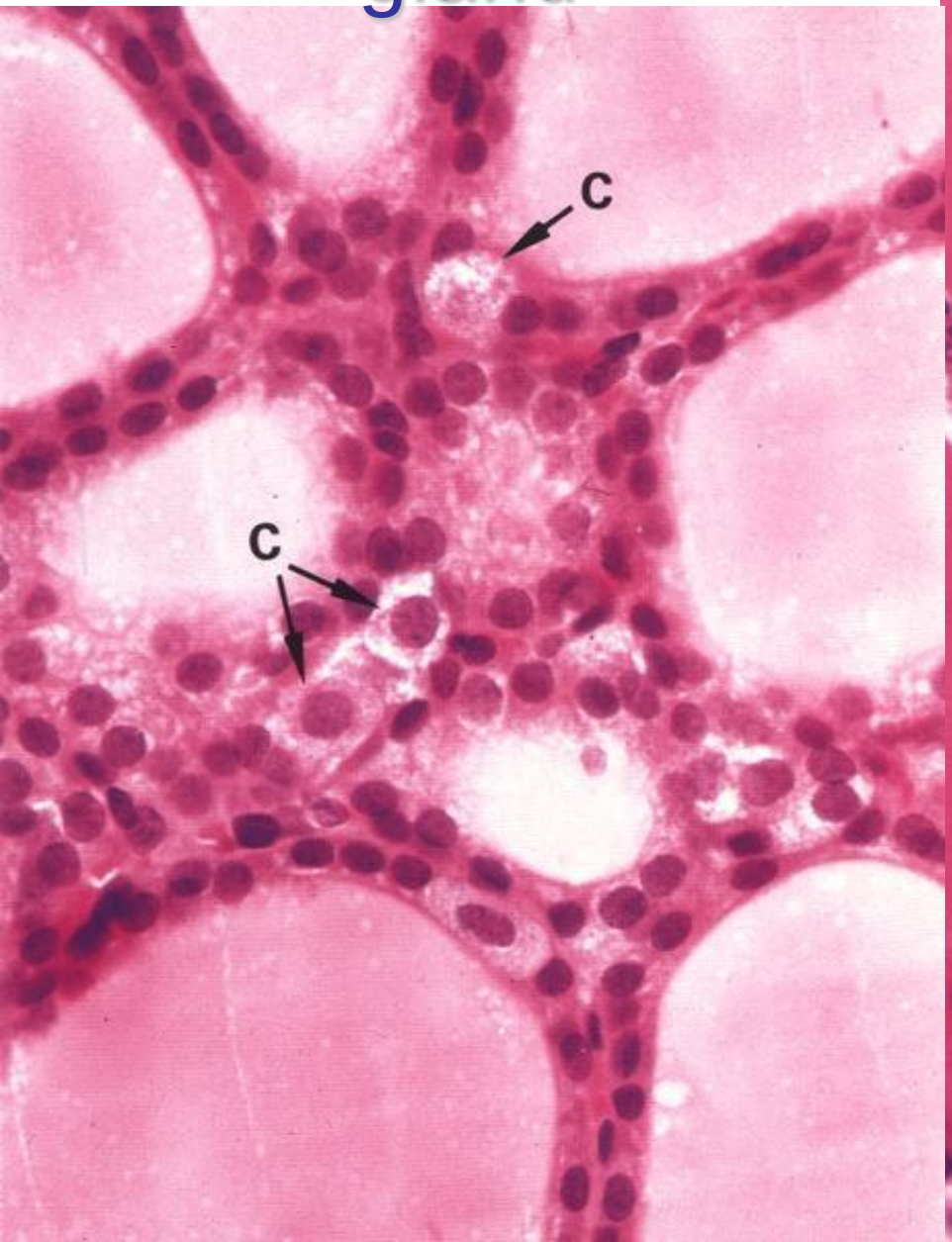
- C-cells
- derived from neural crest from ultimopharyngeal body
- located between follicles (individually or in groups)
- larger, brighter
- rich gER, GA, MIT
- granule – spherical, dark
- production and storages of **calcitonine**

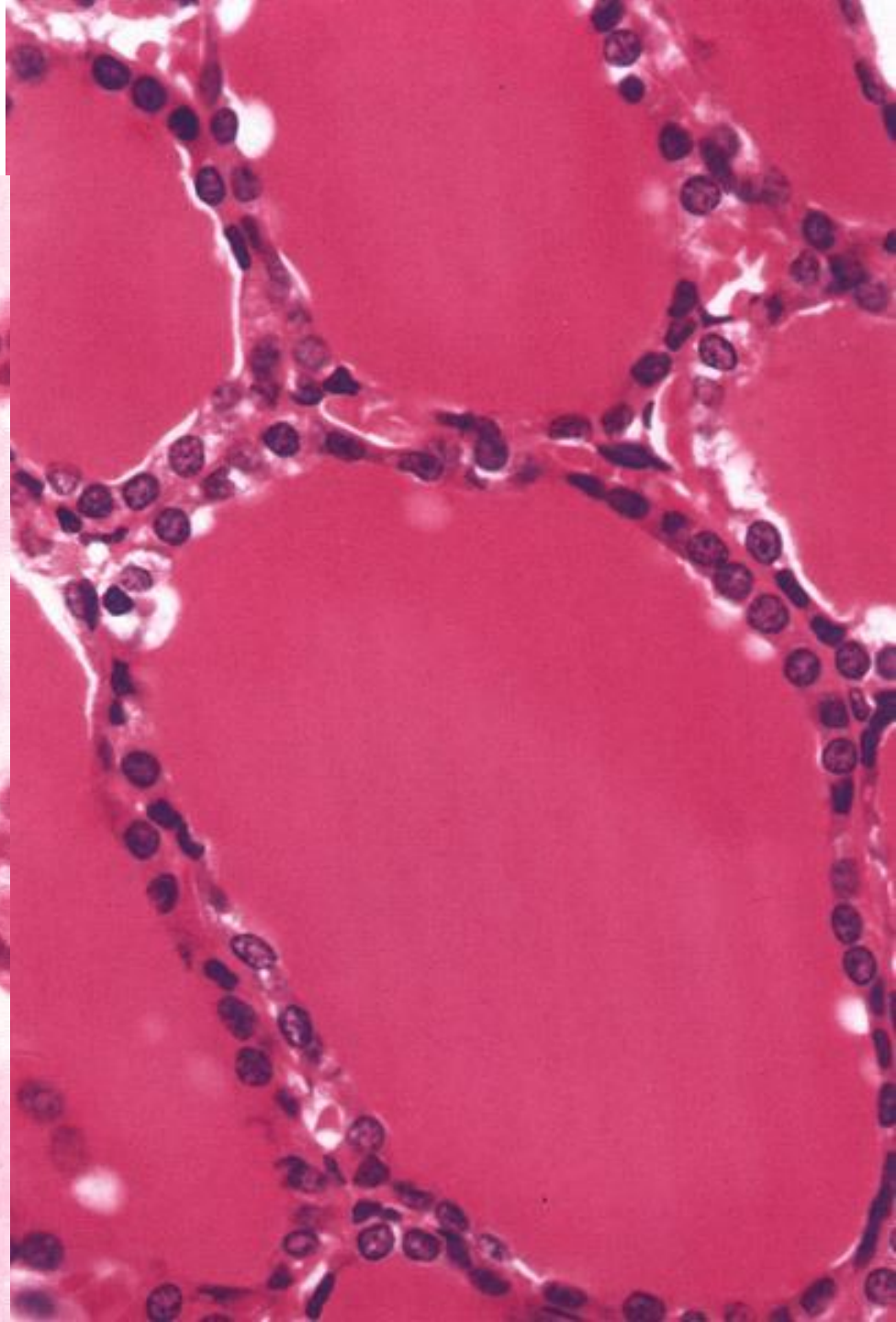
Calcitonine

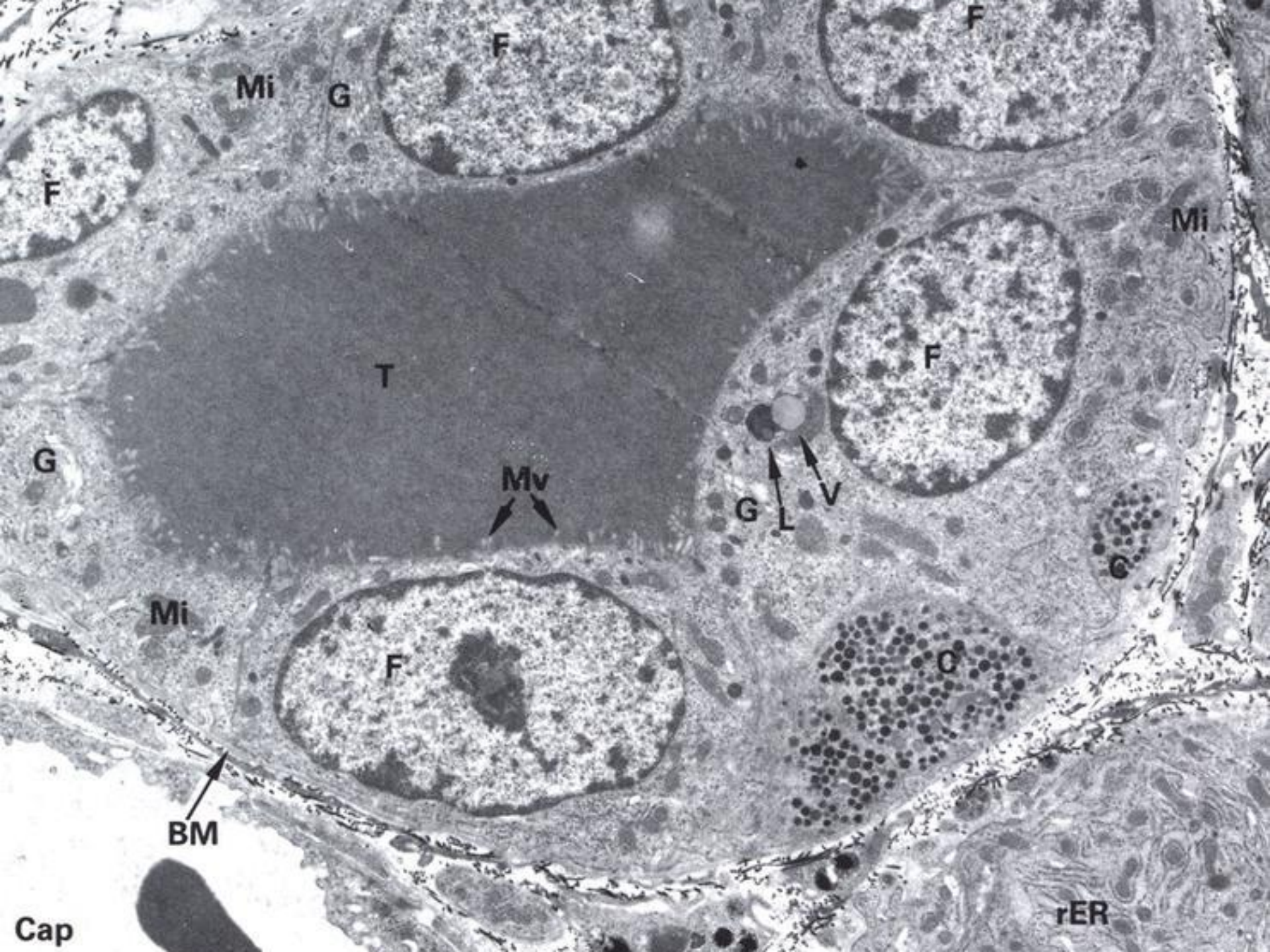
- reduces blood calcium (Ca2+)
- opposing the effects of parathormone

- inhibits Ca2+ absorption in intestines
- inhibits osteoclasts‘ activity in bones
- inhibits Ca2+ reabsorption in renal tubules

Follicles of thyroid gland



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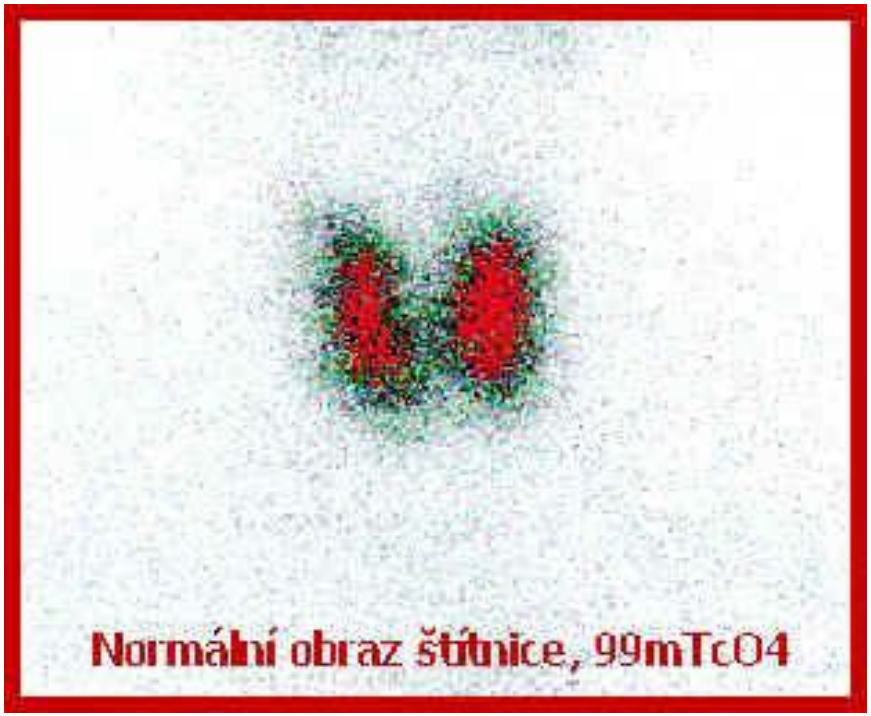
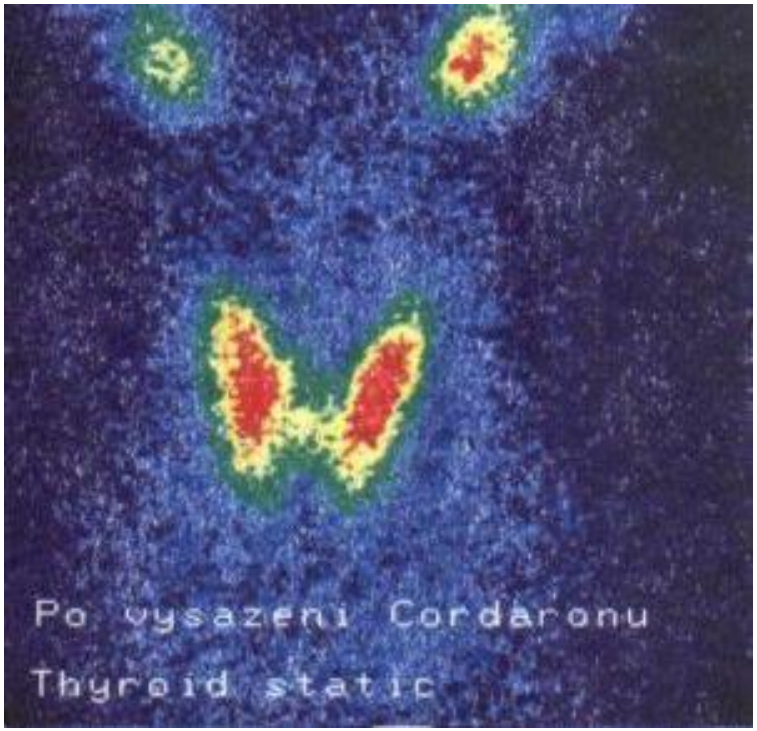
Thyroid gland examination

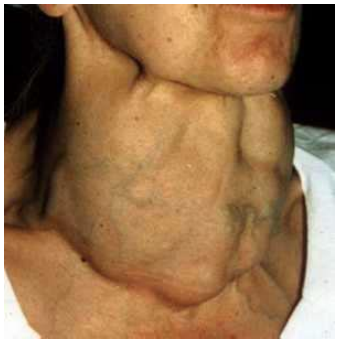
- utrasound
- scintigraphy with radioactive iodine 131





Thyroid gland – diseases

- less than 10 μg of iodine daily → goiter from lack of iodine
- hypothyroidism → goitre
  - cretenism (*children*) – screening of newborns
  - myxoedema (*adults*)
  - autoimunne – thyroiditis of Hashimoto
- hyperthyroidism (thyreotoxicosis)
  - autoimunne – exophthalmic goiter = disease of Graves-Basedow



Parathyroid glands

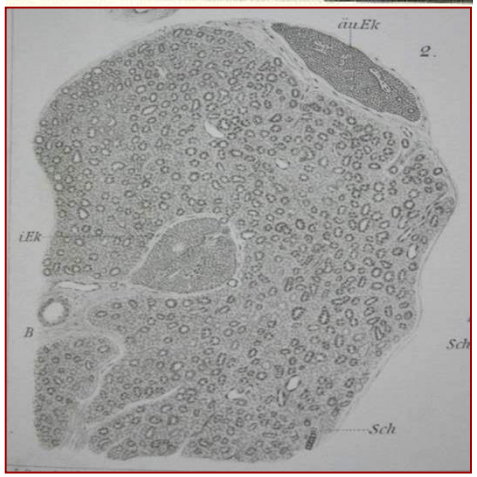
Glandulae parathyroideae

Parathyroid glands – history

1880 – I. V. Sandström – first description

Alfred Kohn (1867–1959)

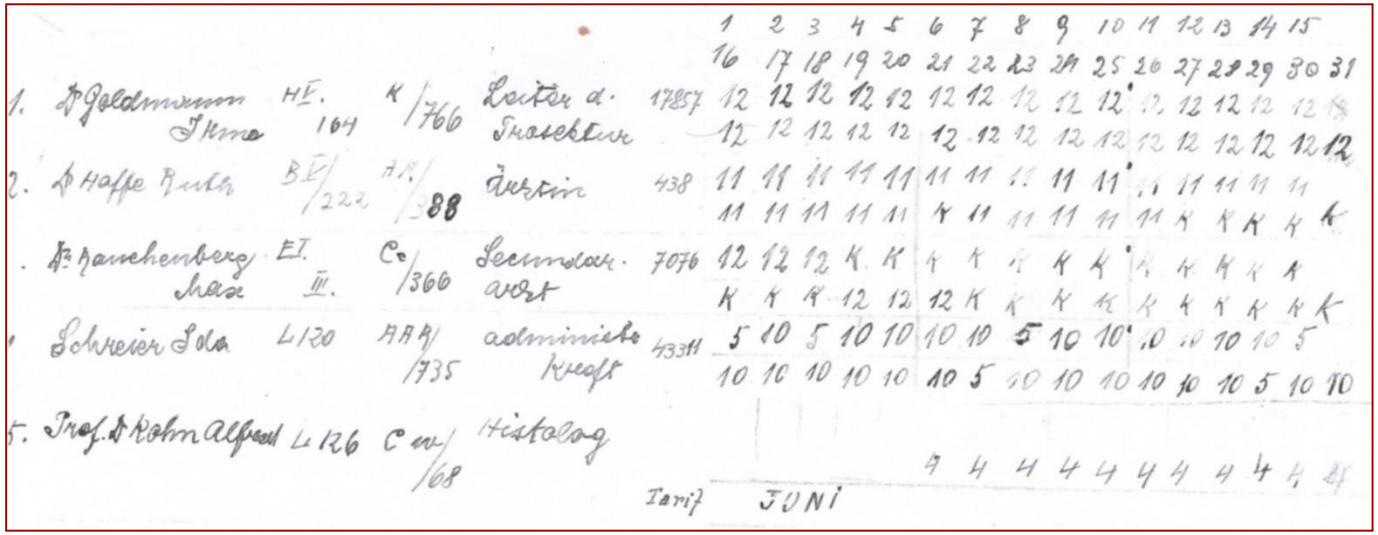
- independent organ
- independent of the thyroid gland function (1895)
- independent development (1898)
- its removal leads to tetanus
- he also introduced and defined the terms "chromaffin tissue" and "paraganglia" and determined their connection the sympathetic system and their endocrine function



The Nomination Database for the Nobel Prize in Physiology or Medicine – 1930, 1932

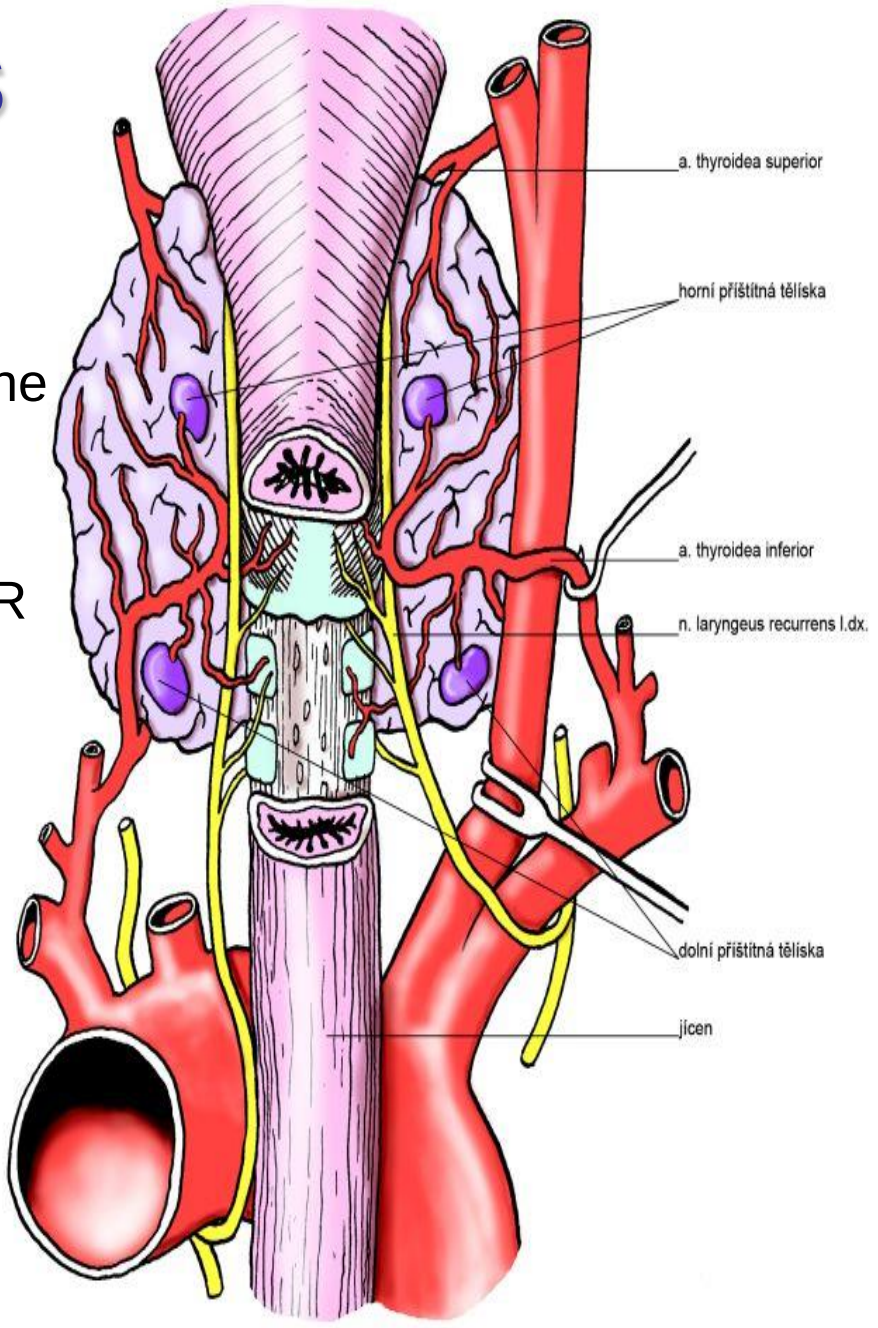
Name:	Alfred Kohn
Profession/Category:	Prof. histology
University:	Prague
City:	Prague - CZ
Motivation:	Work on the parathyroid gland and chromaphine tissue.
Nominator:	E. Starkenstein
Profession/Category:	Prof. pharmacology
University:	Prague - CZ
Evaluation:	Yes
Evaluators :	
Name:	Gösta Häggqvist - yes
Name:	Hans Gertz - yes

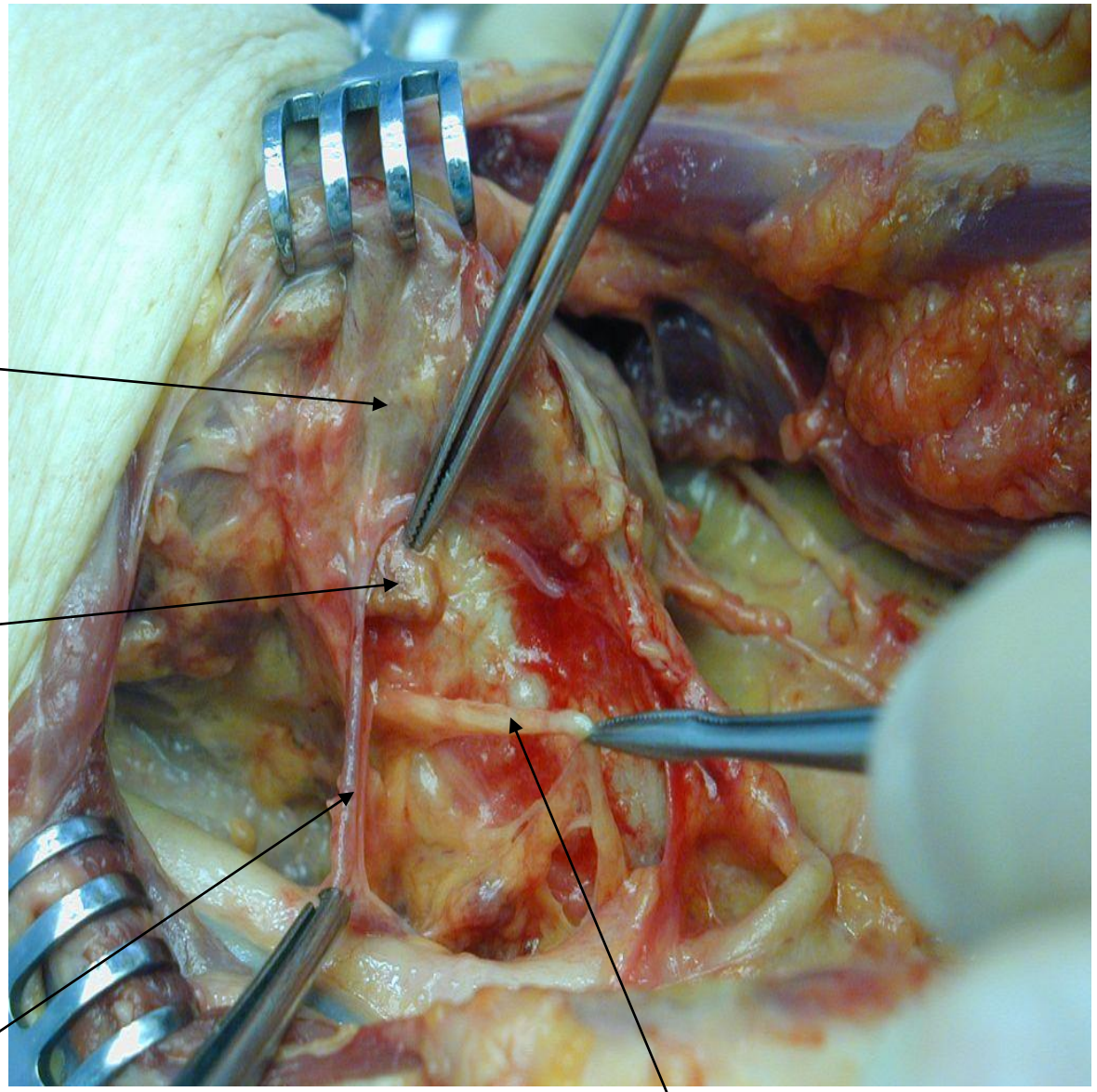
Transport Cw – no. 68 9.3.1943 Praha – Terezín
freed in Terezíně – May1945
worked there as histologist at prosections



Parathyroid glands

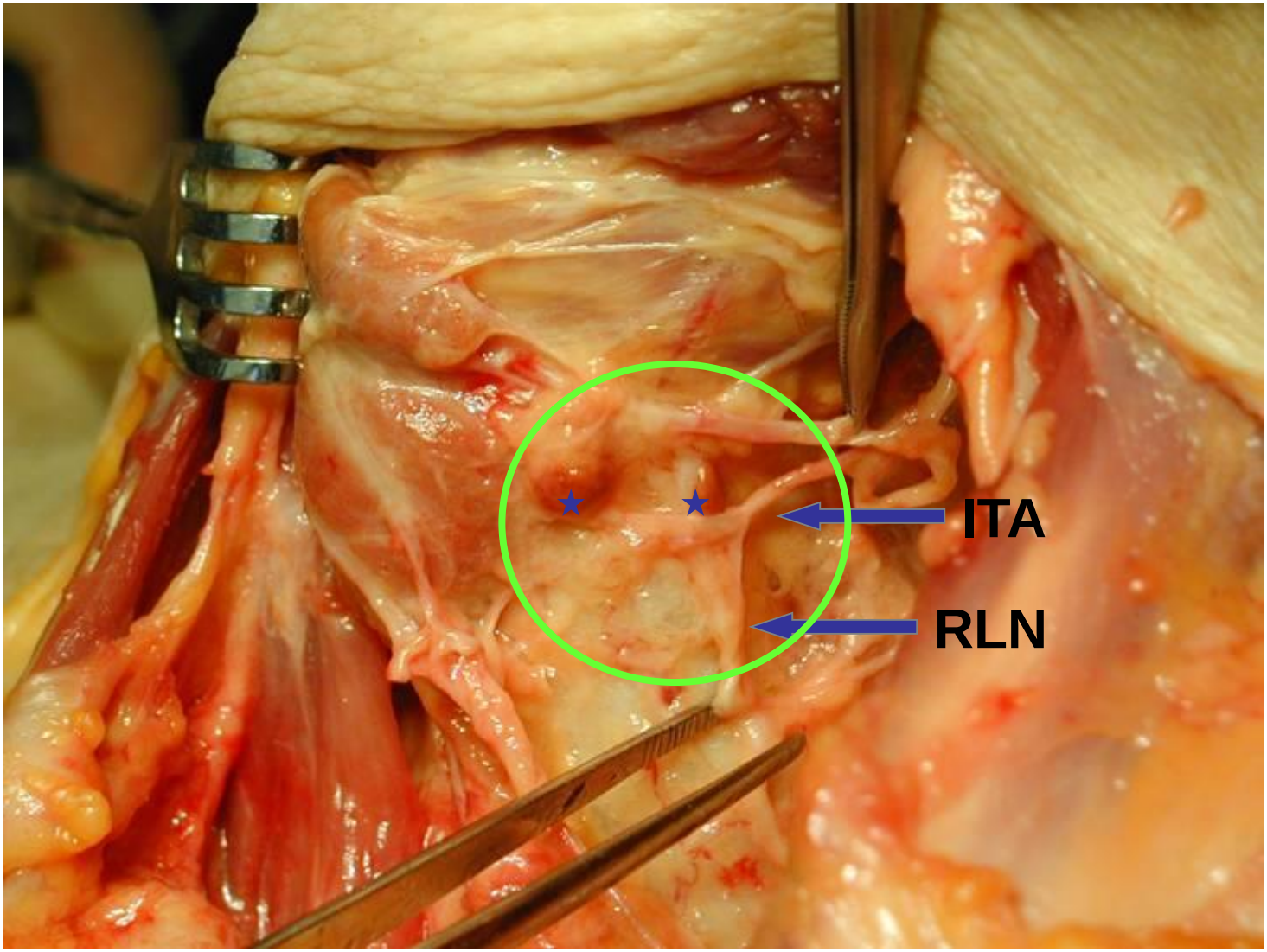
- *glandula parathyroidea superior et inferior*
- 2 pairs of small spheric structures on the posterior side of thyroid gland lobes
- 3 x 4 mm, 25-40 mg
- upper – above crossing of ATI and NLR
  lower – below crossing, usually ventral to NLR
- branches from a. thyroidea inferior
- variability: 1-12 glands
  - **80-85% – 4 glands**
  - 10% – 2-3 glands
  - 5% – 5 glands
  - 0.2% – 6 glands
- bilateral symmetry:
  - upper 80%
  - lower 70%





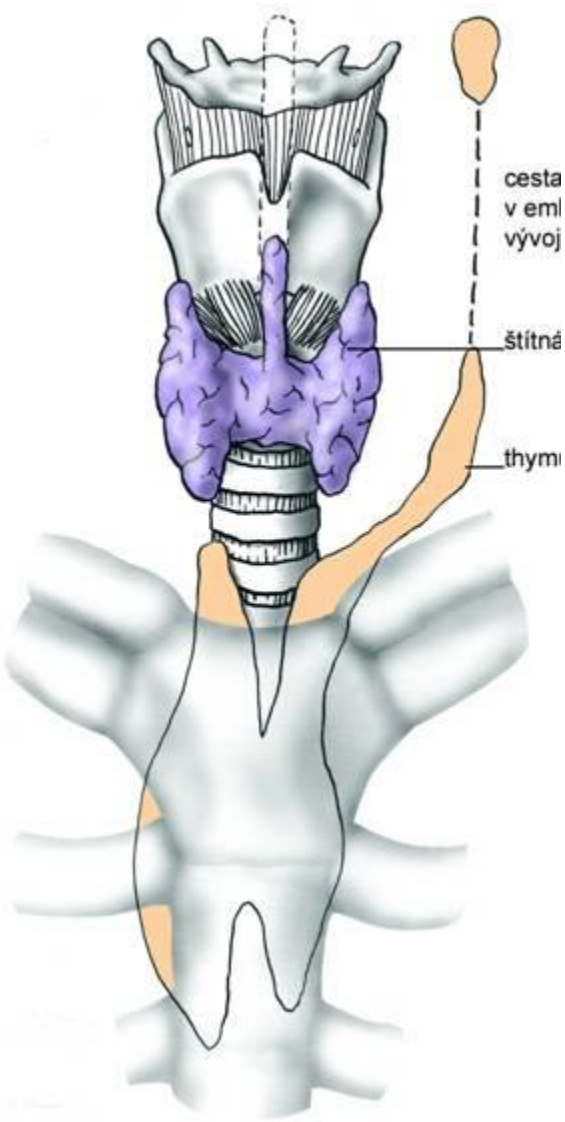
Thanks to kindness of doc. Ondřej Naňka

The most common location of parathyroid gland

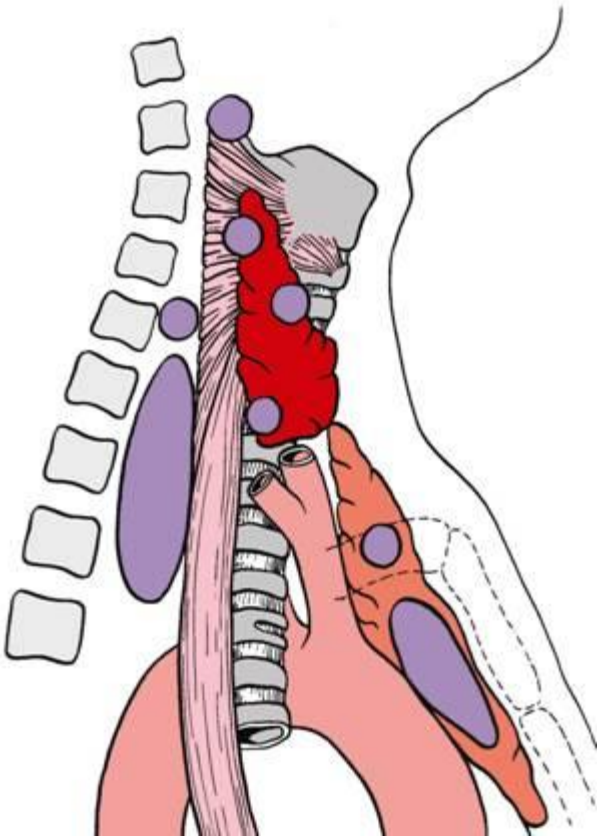


Thanks to kindness of doc. Ondřej Naňka

Variability of location of parathyroid gland



- inside **parenchyma** of thyroid gland
- inside **capsule** of thyroid gland
- outside
  - behind pharynx
  - behind oesophagus
  - inside cervical extension of thymus
  - in mediastinum

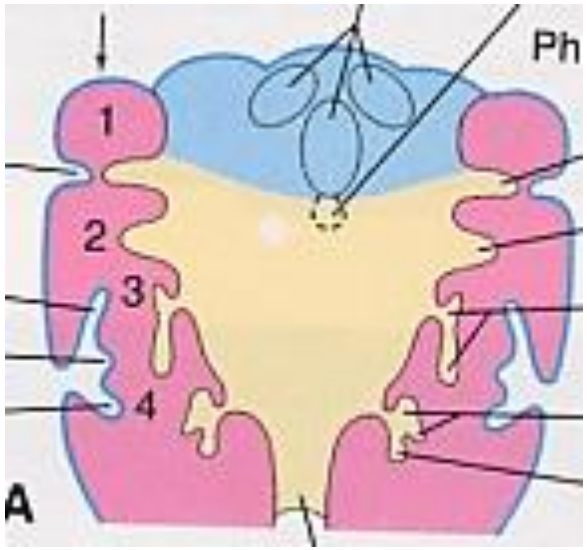


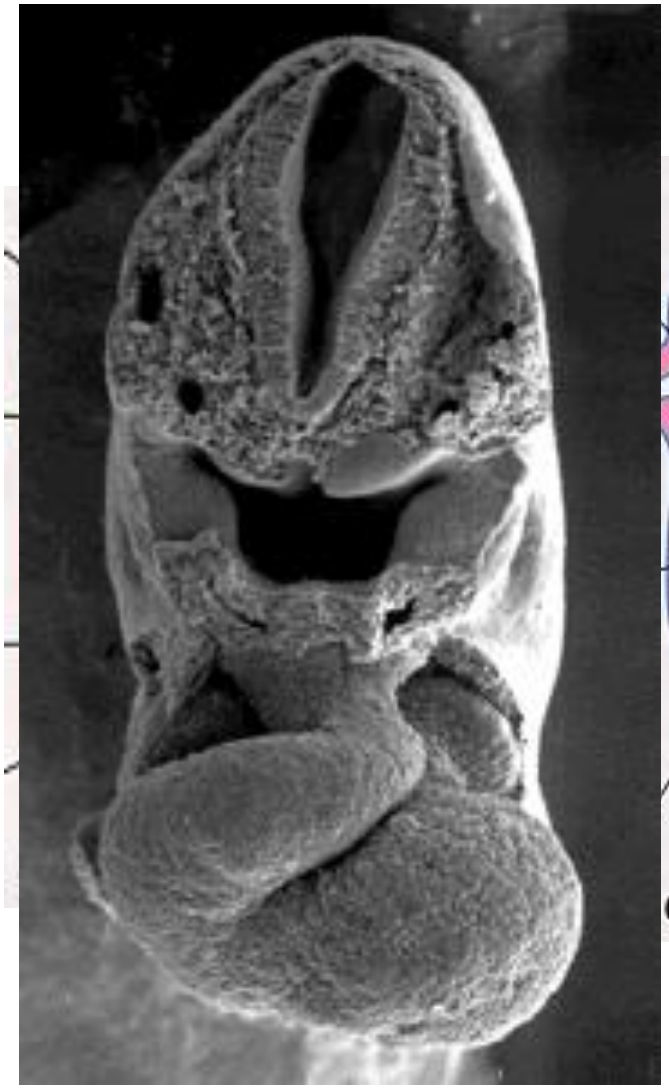
Parathyroid glands – development

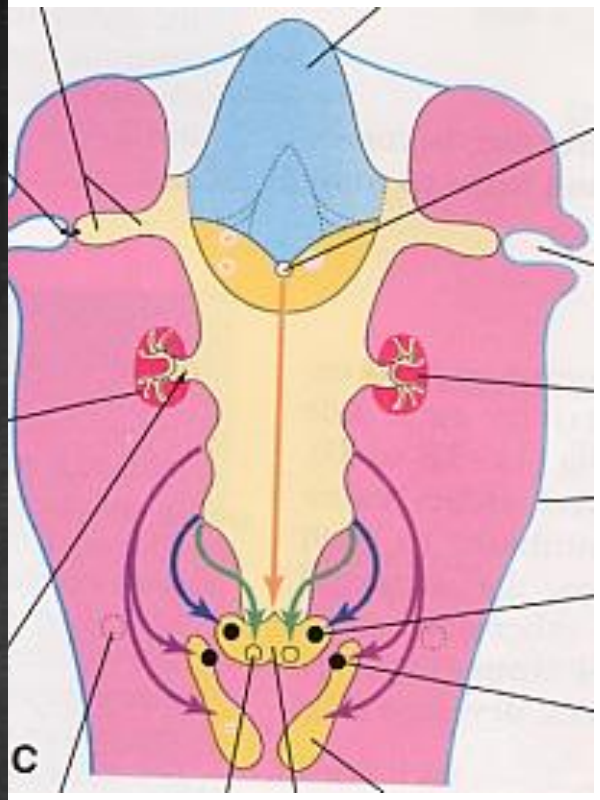
- dorsal parts of 3rd and 4th pharyngeal pouch
- 5the week: proliferation of endoderm, loss of lumen
- ingrowth of vessels from mesenchyme

- principal cells: fetal metabolism of calcium
- oxyphillic cells: appear in approximately 7th year postnatally

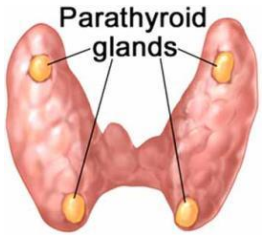
Parathyroid glands – development

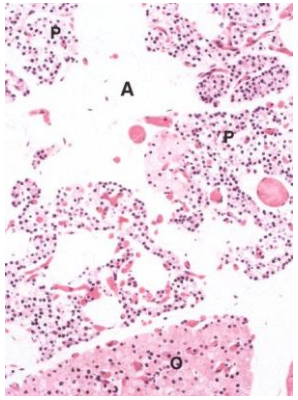




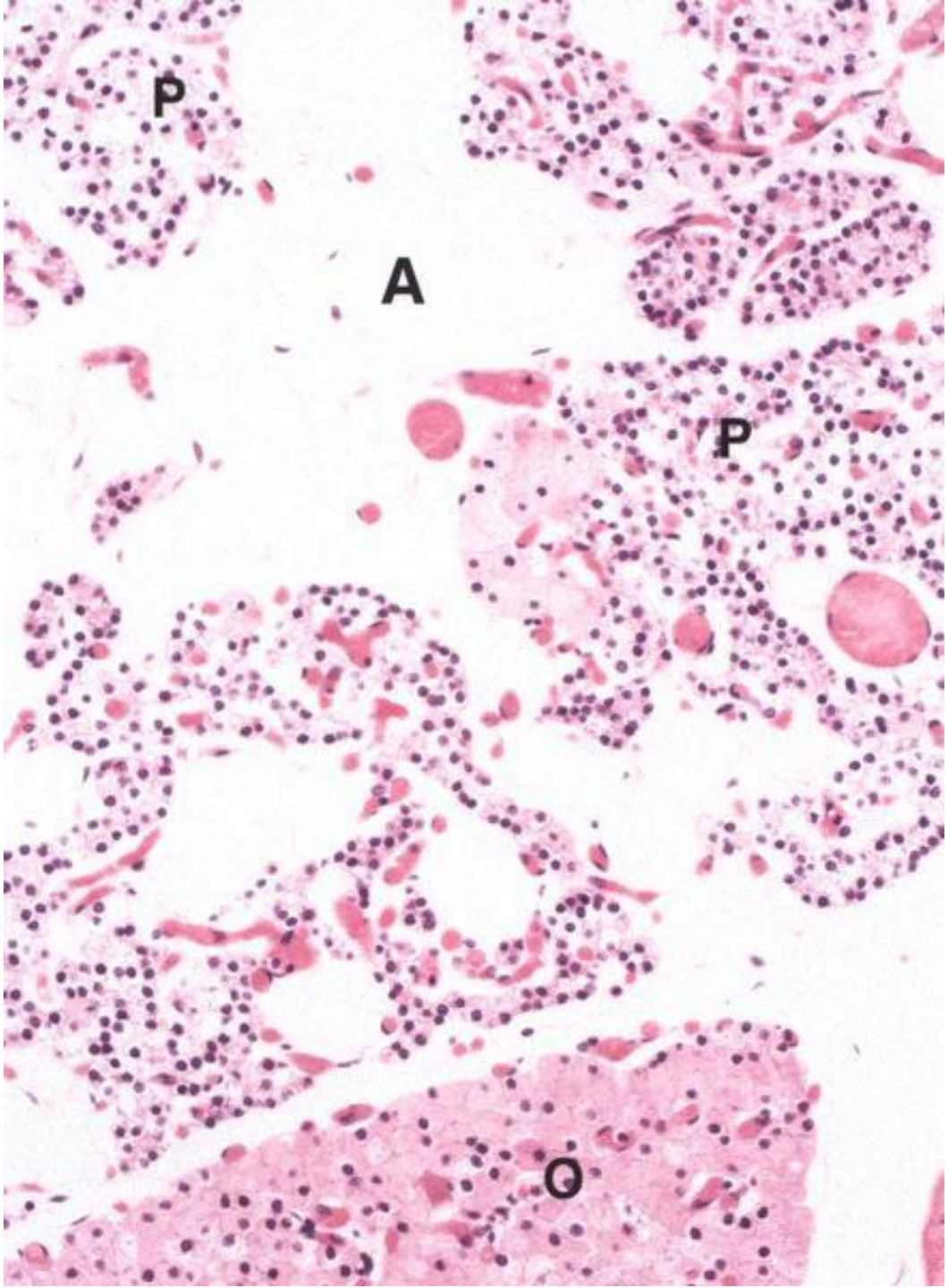


Parathyroid glands – structure





- function in bone metabolism
- **parathormone (PTH)**
- capsule + septa
- parenchyma divided into cords
- **principal cells** (*parathyrocytus endocrinus*)
  - relatively large (4-8 μm)
  - light cytoplasm, granule containing PTH
- oxyphillic cells (*parathyrocytus oxyphilicus*)
  - fewer, larger
  - darker cytoplasm, no granules, numerous MIT
  - unclear function, appear as late as 7th year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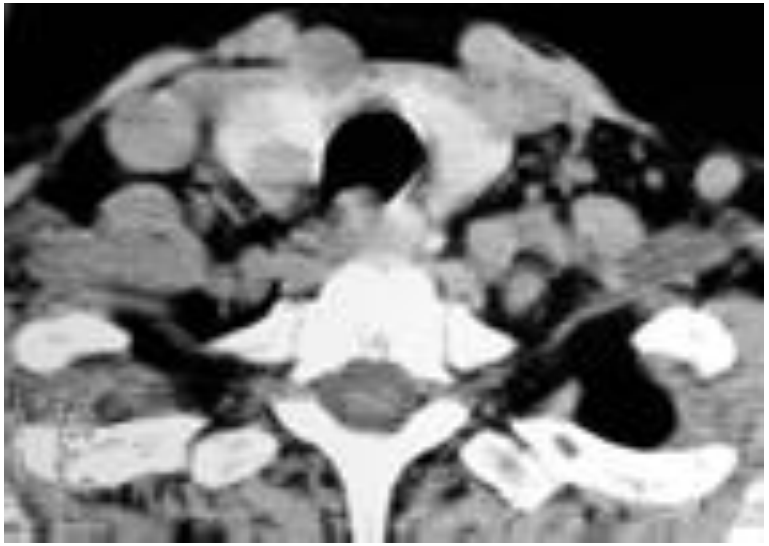
Parathormone (PTH)

- increases blood calcium (Ca^{2+})
- opposing the effects of calcitonine

- increases Ca^{2+} absorption by intestines
- stimulates osteoclasts‘ activity in bones
- increases Ca^{2+} reabsorption by renal tubules

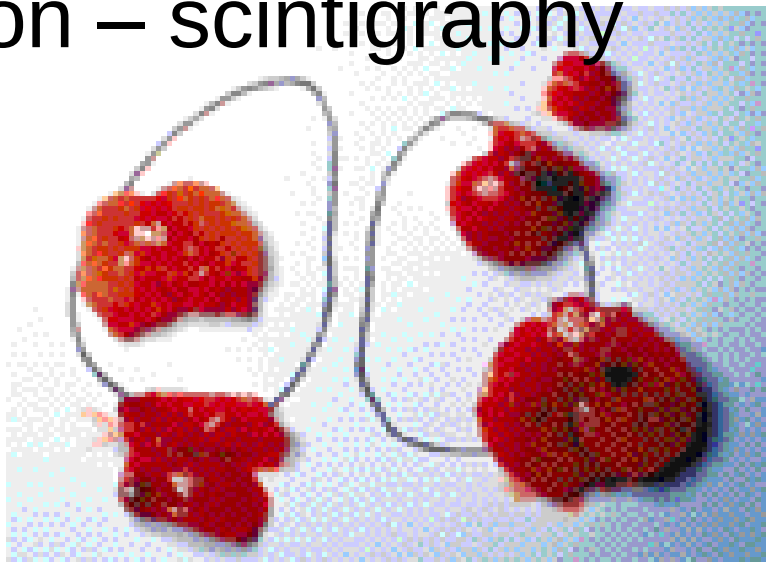
Parathyroid glands diseases



- hyperparathyroidism
  - **primary** (adenoma)
    - pathologic calcification of tissues (cause by hypercalcemia)
    - von Recklinghausen‘s osteodystrophy (fractures)
    - nephrolithiasis
  - secondary (reactive hyperplasia in hypokalcemia when renal disease is present)
  - tertiary (if remaining after successful kidney transplantation)

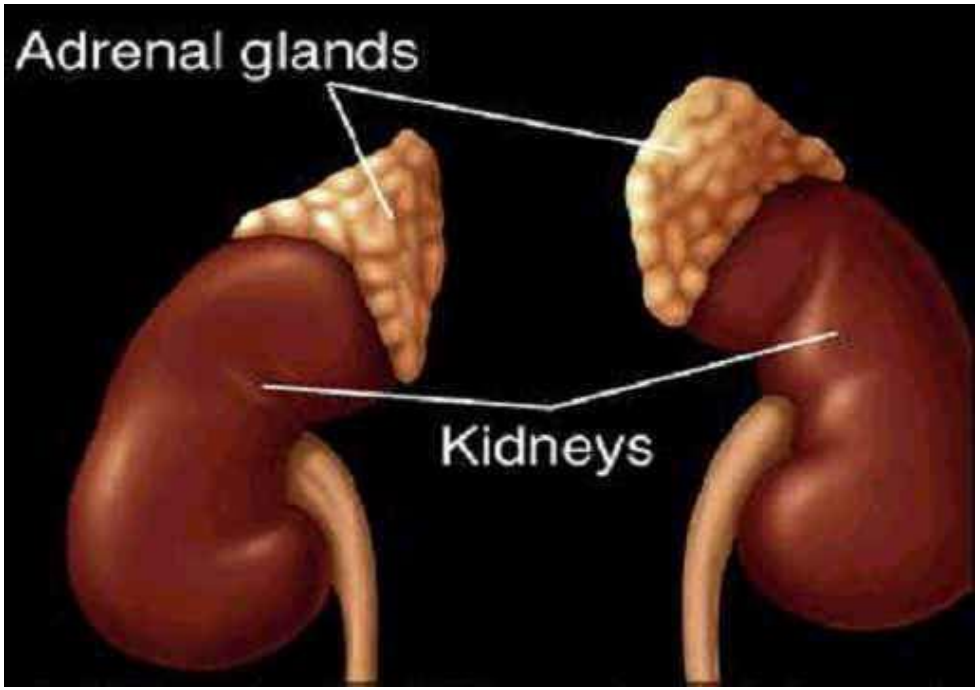
Parathyroid glands – diseases

- hypoparathyroidism
  - tetany
  - iatrogennic after gland removal dhue to cancer
    - transplantation of bodies subcutaneously into forearm
- examination – scintigraphy



Suprarenal gland
Adrenal gland
(*Glandula suprarenalis*)

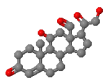
- at level of vertebrae T11-12
- weight 6-12 g



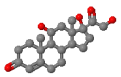
Suprarenal gland, Adrenal gland (*Glandula suprarenalis*)

„doubled gland“ – two different tissues – cortex and medulla

- <u>cortex</u>

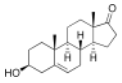


– **mineralocorticoids** – aldosterone



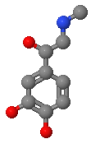
– **glucocorticoids** – cortisol, corticosterone

– **androgenes** –

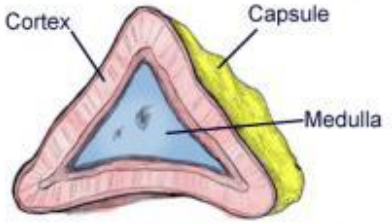


DEAS=dihydroepiandrosterone

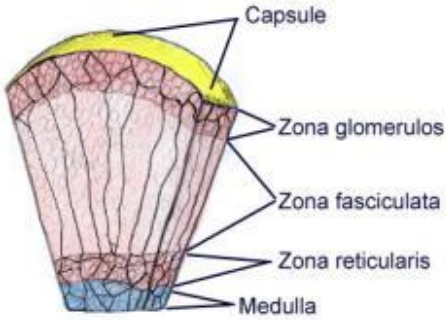
- <u>medulla</u>



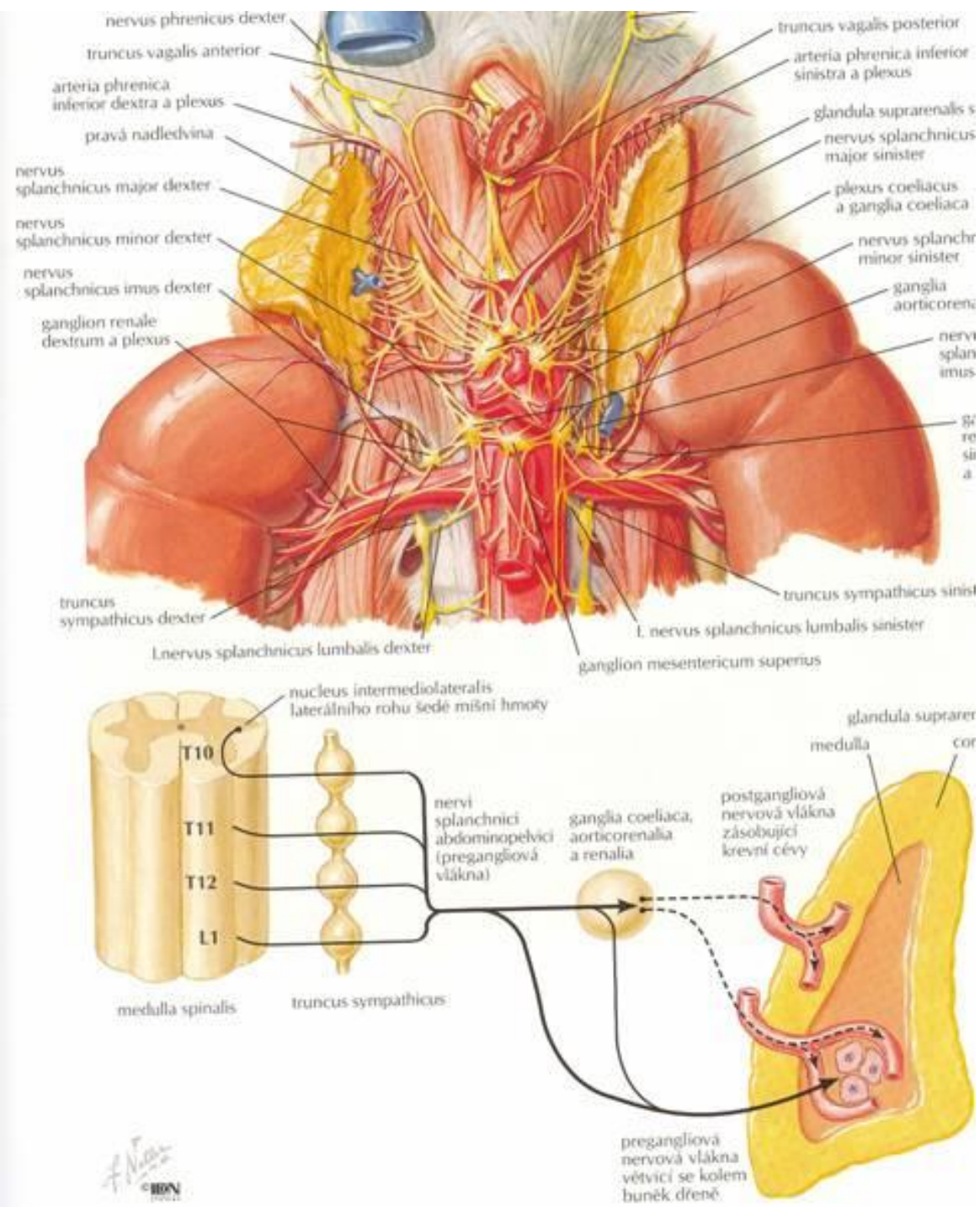
catecholamines – adrenaline, noradrenaline



Transverse section



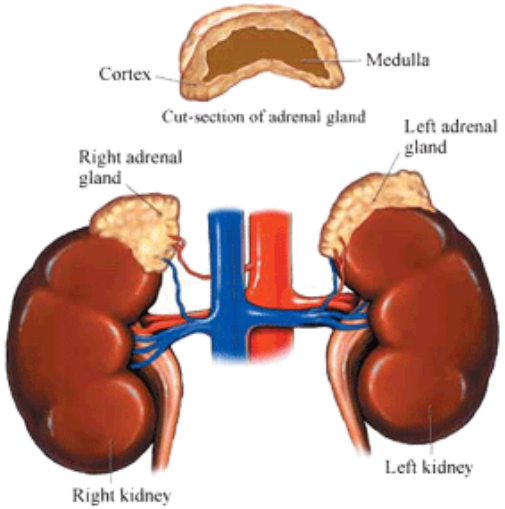
Microscopic section

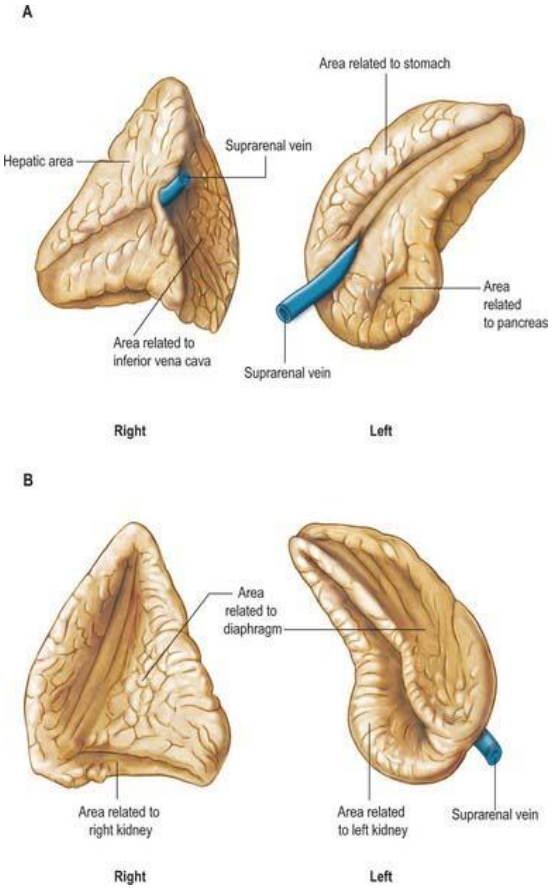


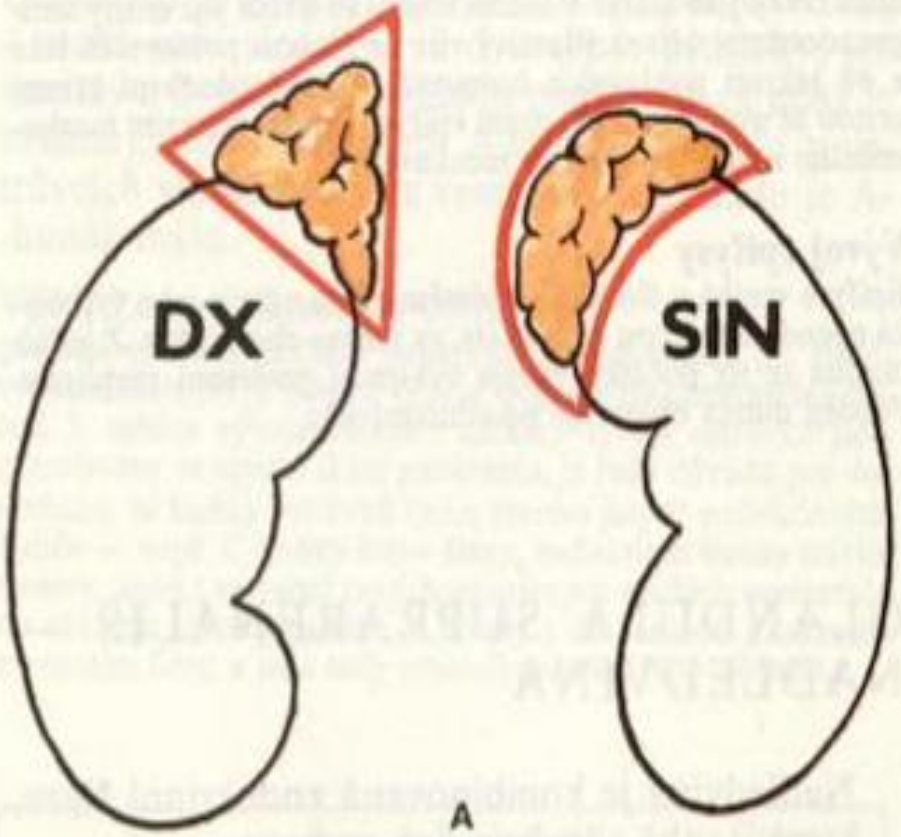
F. H. Netter: Anatomický atlas člověka. Grada/Avicenum, Praha, 2003

Suprarenal gland – anatomy

- retroperitoneal organ
- at level of T11-T12
- *facies anterior* + *posterior* + *renalis*
- *margo superior* + *medialis*
- *hilum*
  - at facies anterior
  - v. suprarenalis emerges here
- *capsula* (proper)
- common *corpus adiposum perirenale* + *fascia renalis* with kidney







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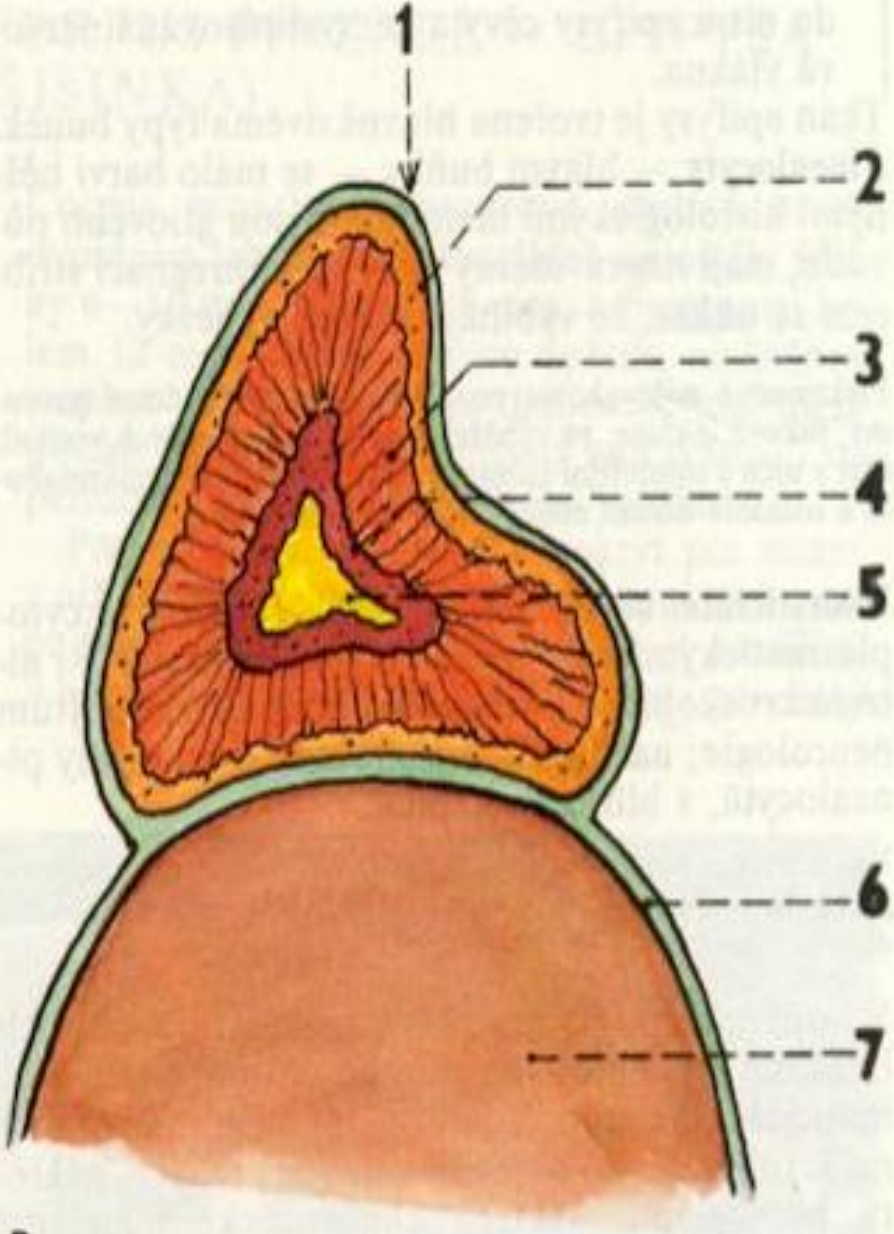


B

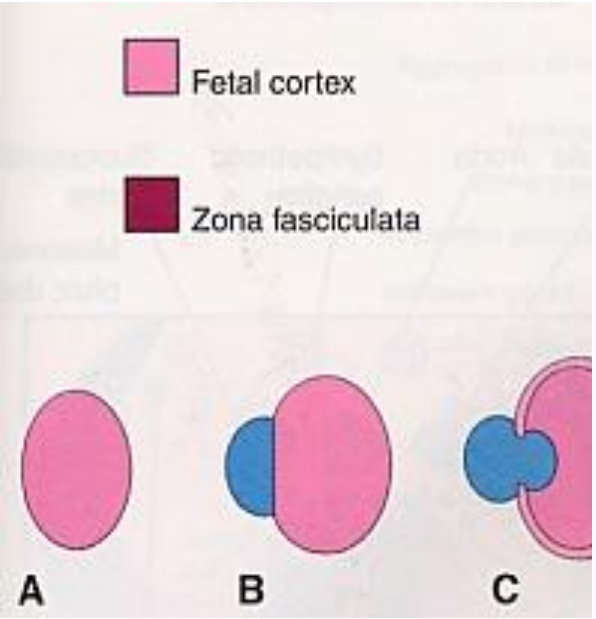
265. GLANDULA SUPRARENALIS — tvar a cévní zásobení (schéma)
A. TVAR PRAVÉ A LEVÉ NADLEDVINY

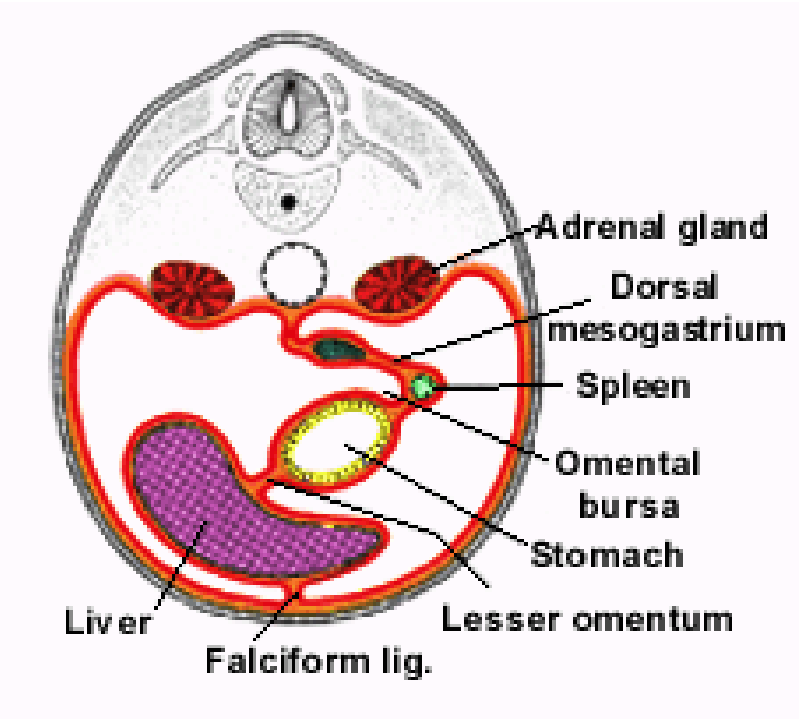
B. ŘEZ NADLEDVINOU, kůra a dřeň
1 / capsula fibrosa
2, 3, 4 / cortex, kůra nadledviny
2 / zona glomerulosa
3 / zona fasciculata
4 / zona reticularis
5 / medulla, dřeň nadledviny
6 / capsula fibrosa ledviny
7 / ledvina

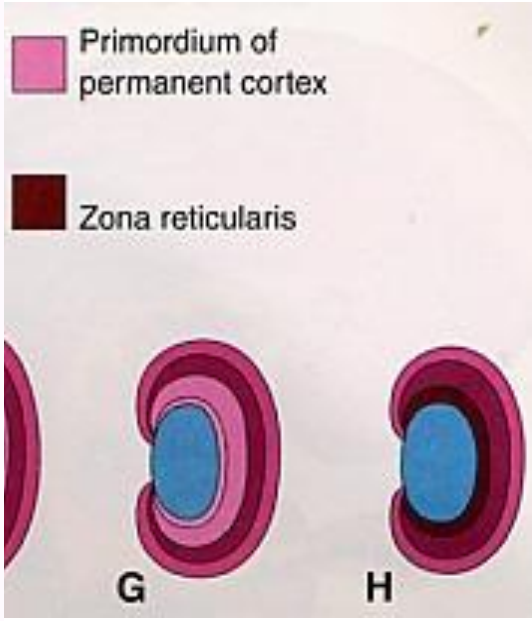
Suprarenal gland – development

- cortex
  - from coelomic epithelium laterally to dorsal mesenterium
  - proliferation and migrate towards aorta
  - secondary proliferation of cortex → arise of definitive cortex
- medulla
  - from base of ganglion coeliacum
  - sympatoblasts
  - migrate to base of cortex

Suprarenal gland – development

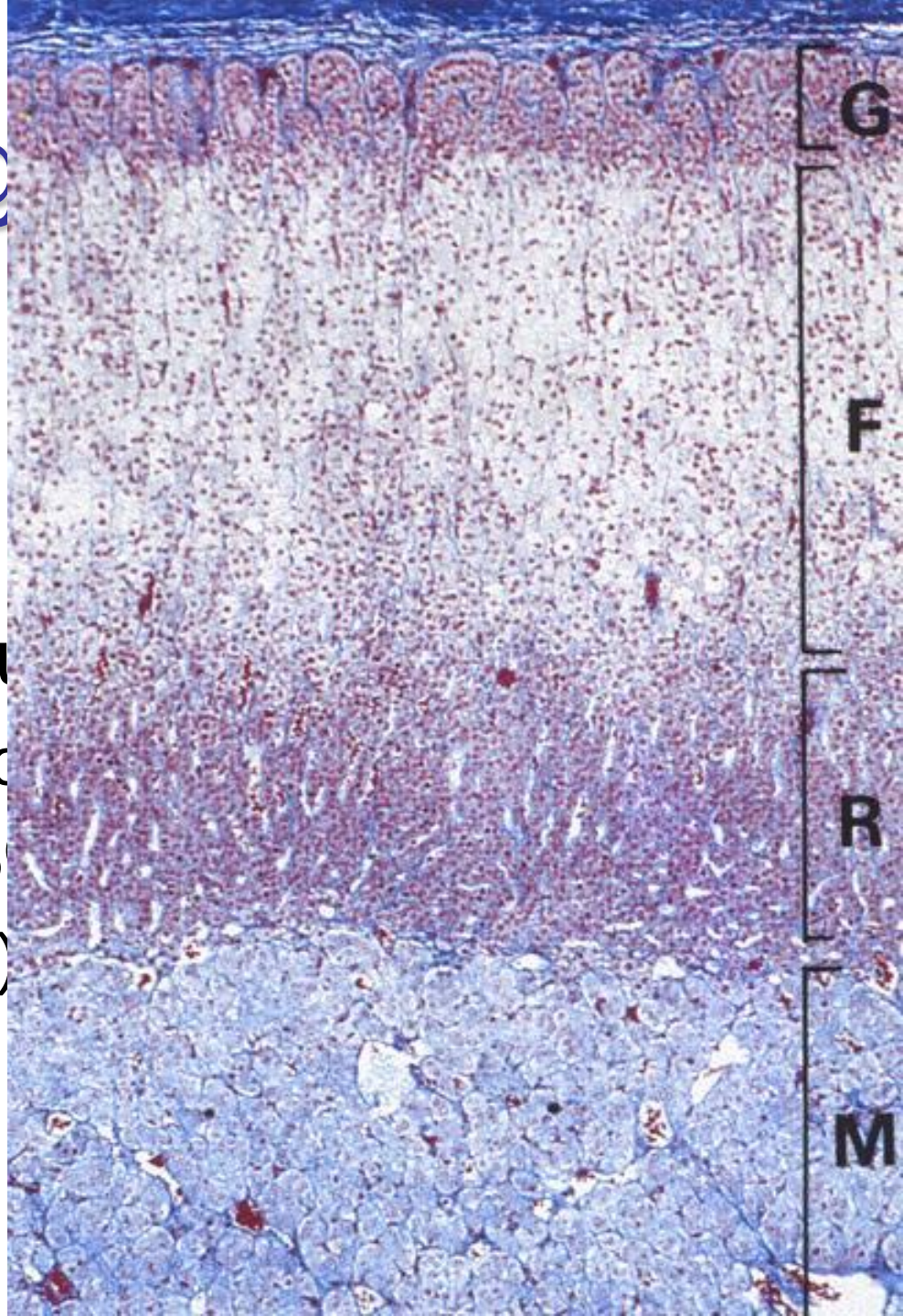






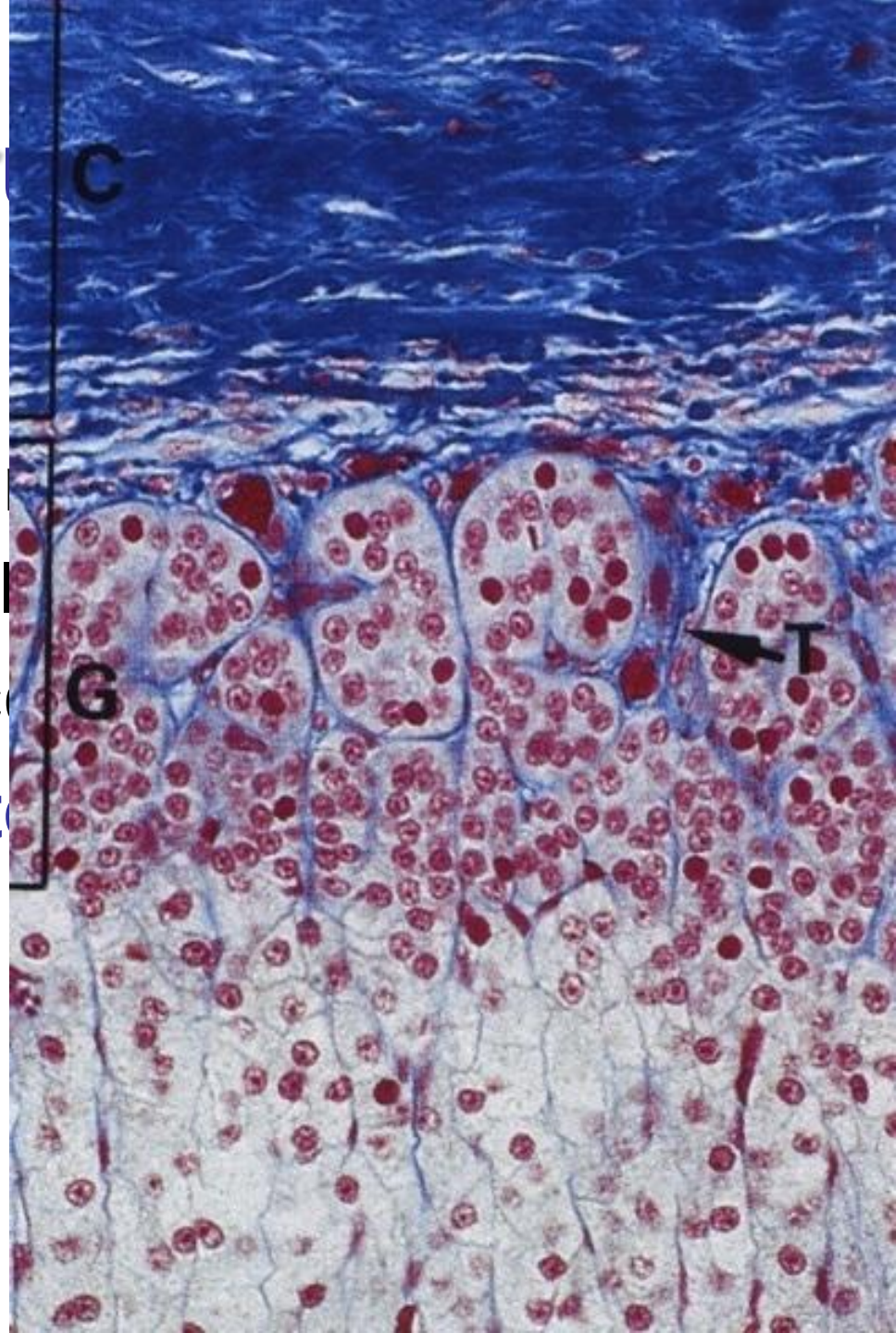
Suprarenal g

- capsula → septa
  - fibroblasts, collagen
    muscle fibers
- cortex of glandula su
  - zona glomerulosa co
  - zona fasciculata (65
  - zona reticularis (7%)



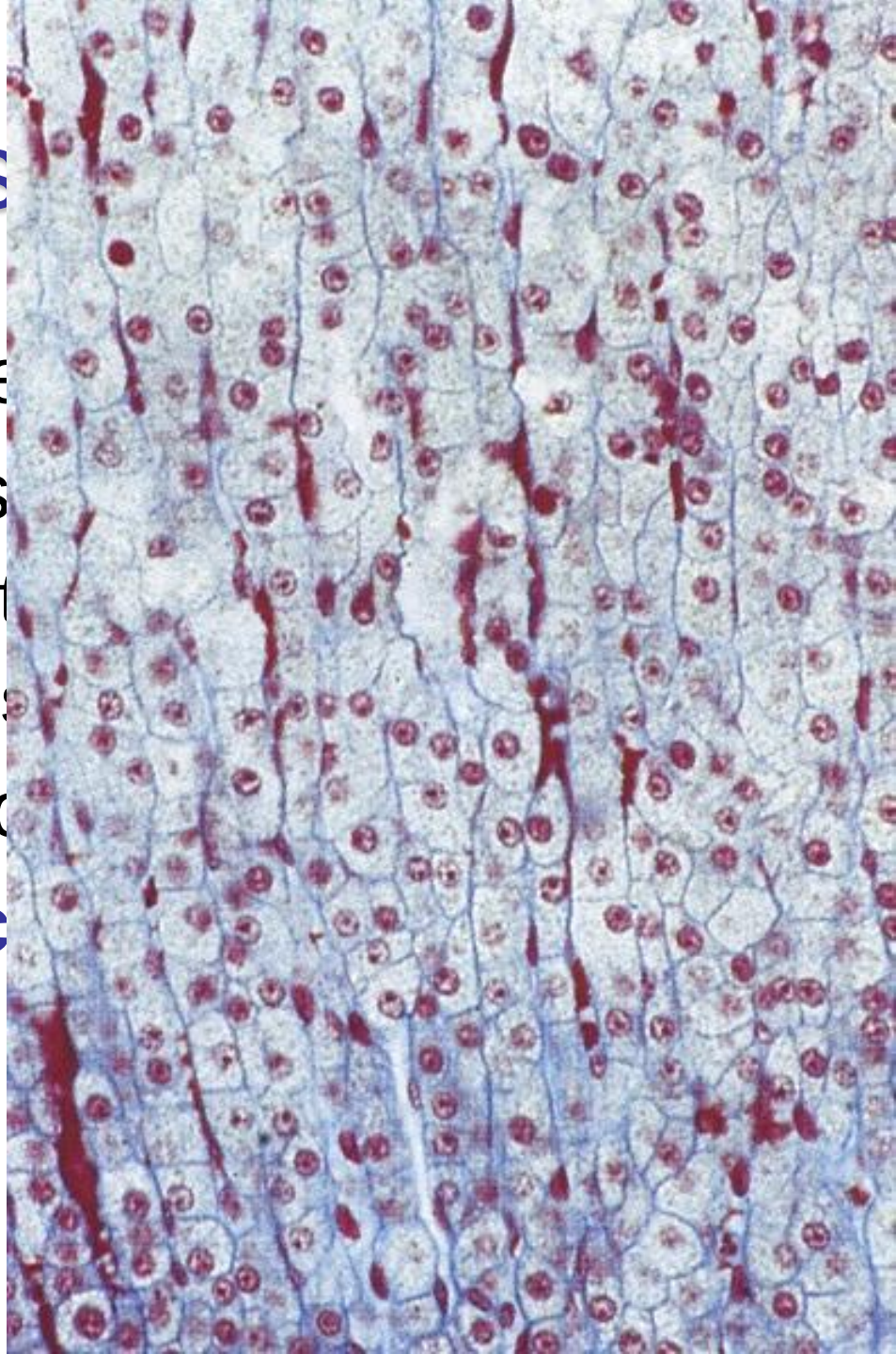
Zona glomer

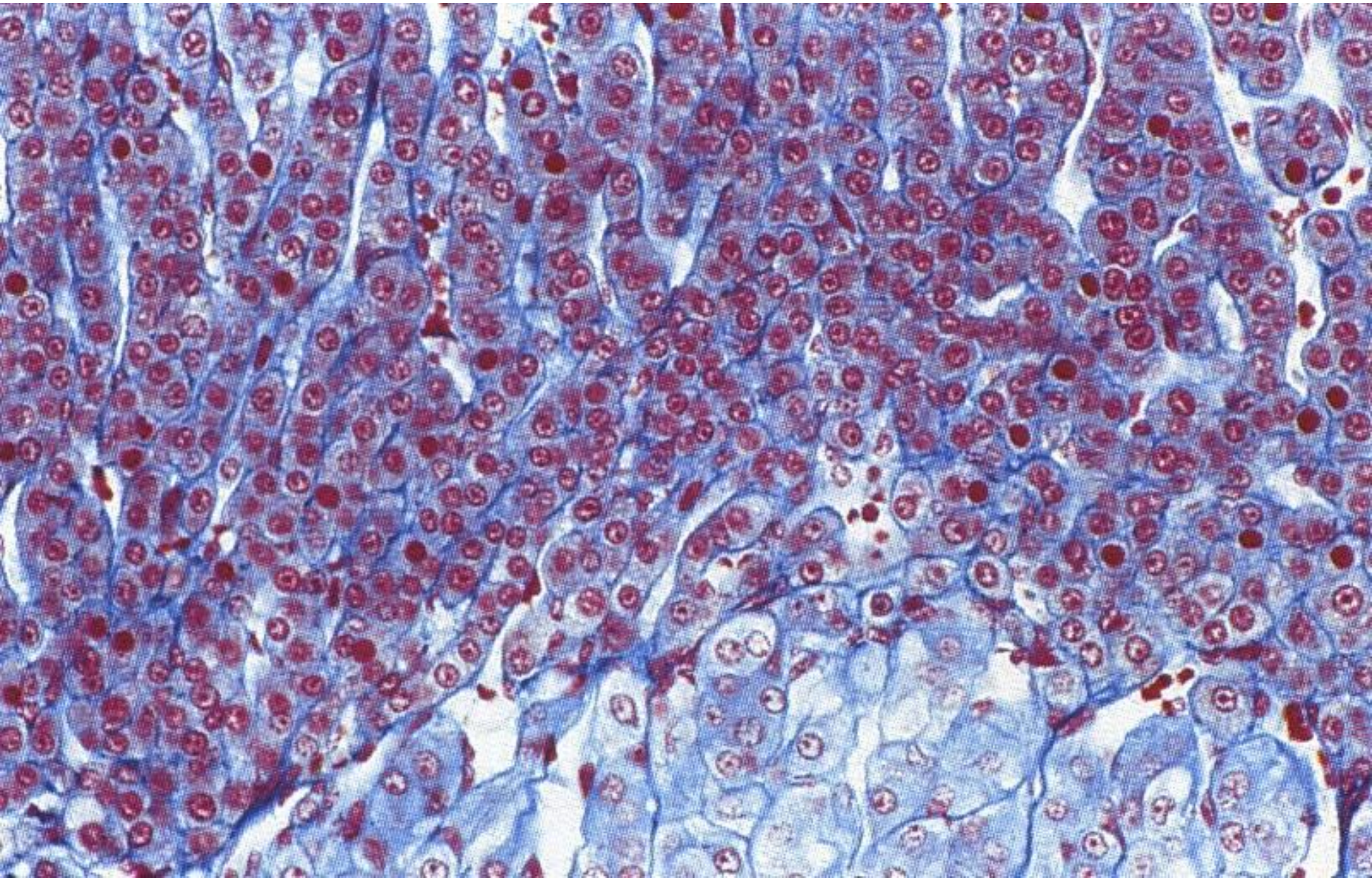
- outer layer
- curved cords (colum
  - *corticosterocyti* = cell
- sinusoids between c
- production of **aldost**



Zona fas

- middle, broadest laye
- long columns of cells
  - many adipose droplet
  - *corticosterocyti* = cell
- sinusoids between co
- production of **glucoc**
  androgenes

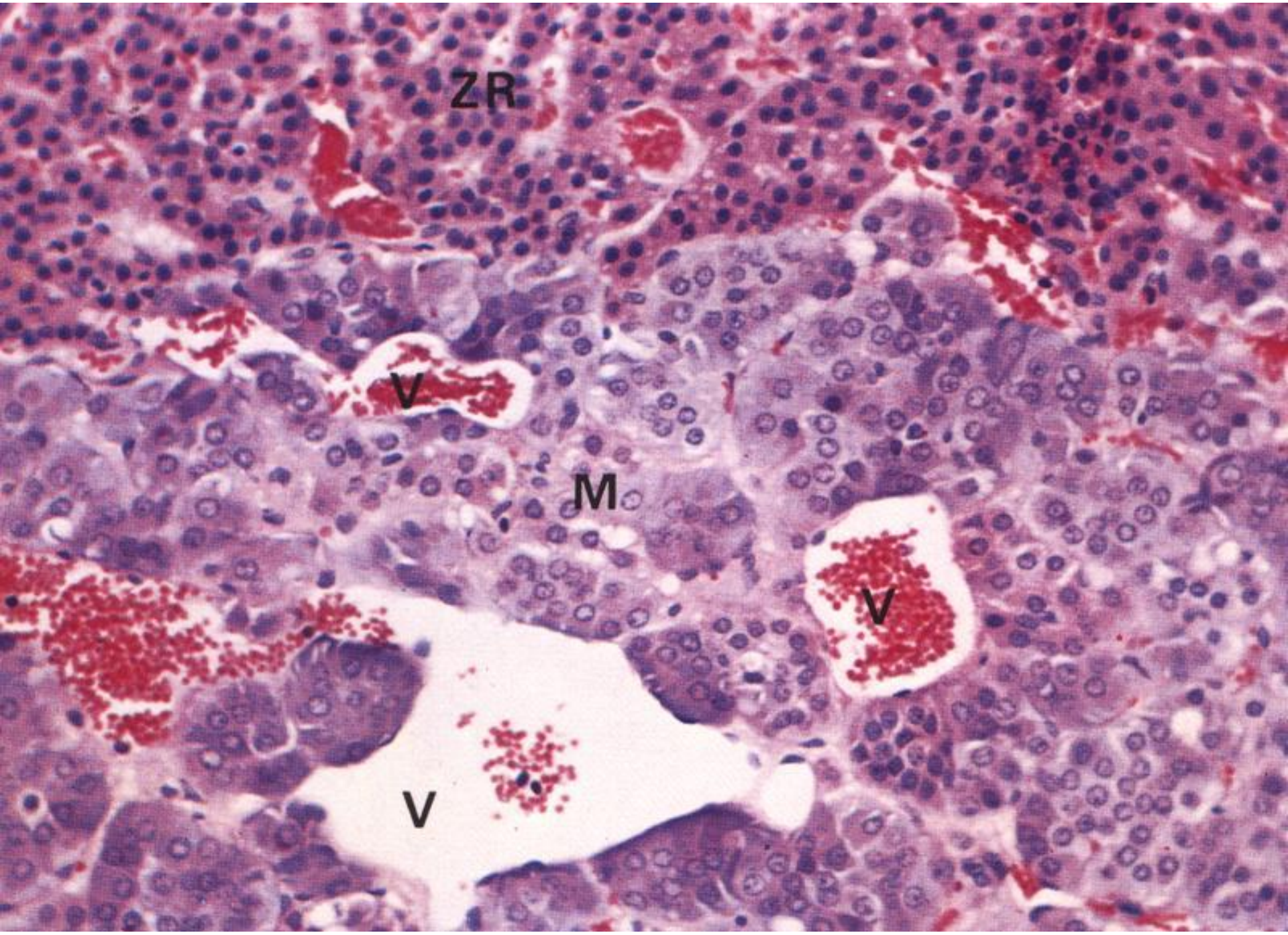




Suprarenal gland – medulla

- anastomosing columns of polyhedric cells
- large cells (*Endocrinocytus medullaris*)
  - large nucleus
  - gER, MIT, GA, granula
  - **adrenaline**, **noradrenaline**, chromogranines, ATP
  - dopamine-β-hydroxylase, Leu- a Met- enkefalin
- between columns – capillary network

- rare – parasympathetic ganglionic cells (*neuron multipolare anatomicum*)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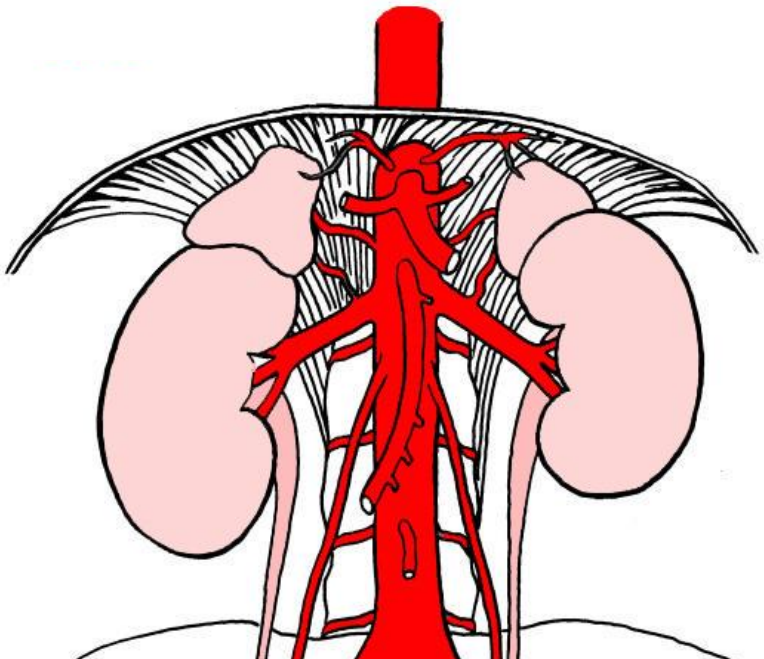
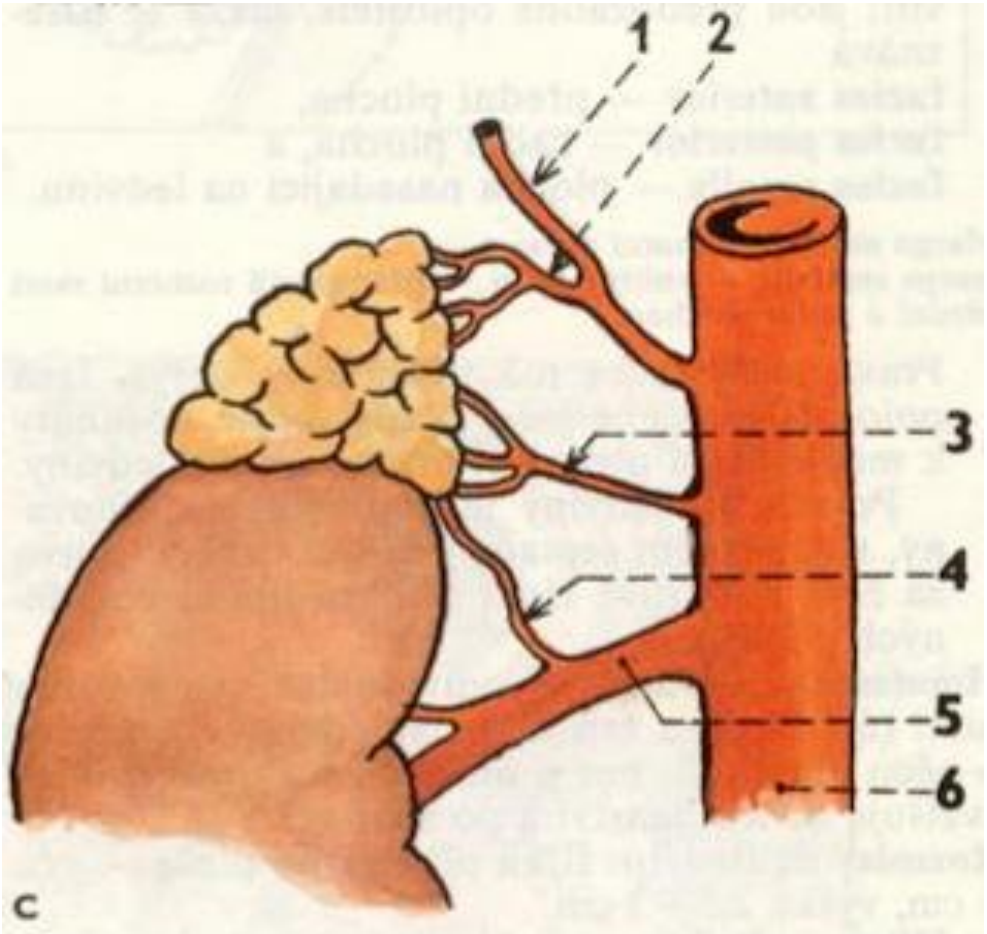
Suprarenal glands – blood vessels

- a. suprarenalis superior (← a. phrenica inferior)
- a. suprarenalis media (← aorta abdominalis)
- a. suprarenalis inferior (← a. renalis)

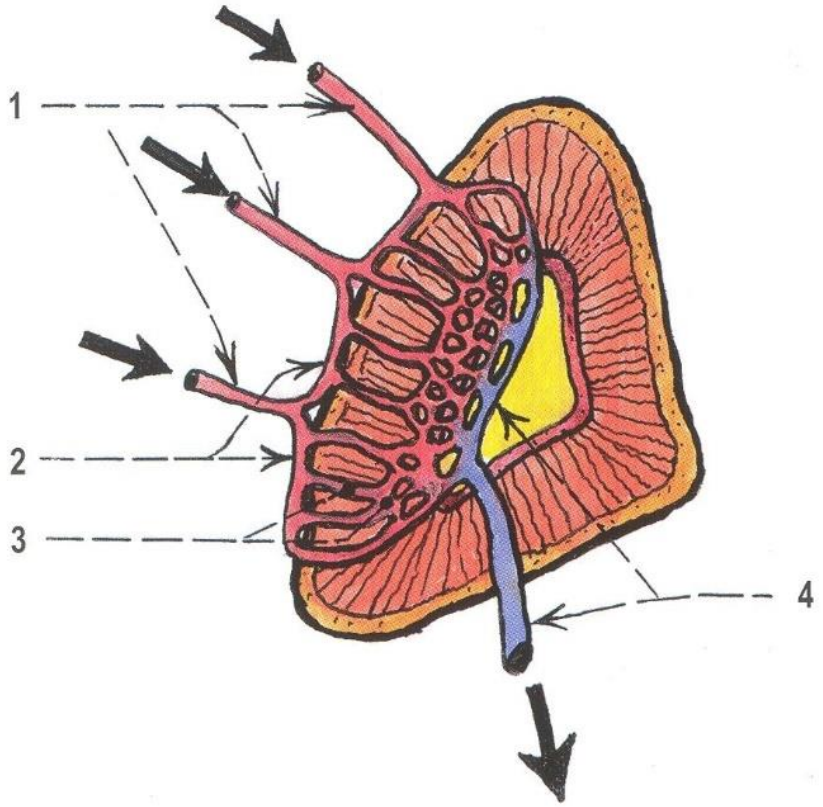
→ subcapsular plexus, capillaries + sinusoids pass through cortex →

- vein from medulla → v. centralis → v. suprarenalis → v. renalis sinistra / v. cava inferior on the right side





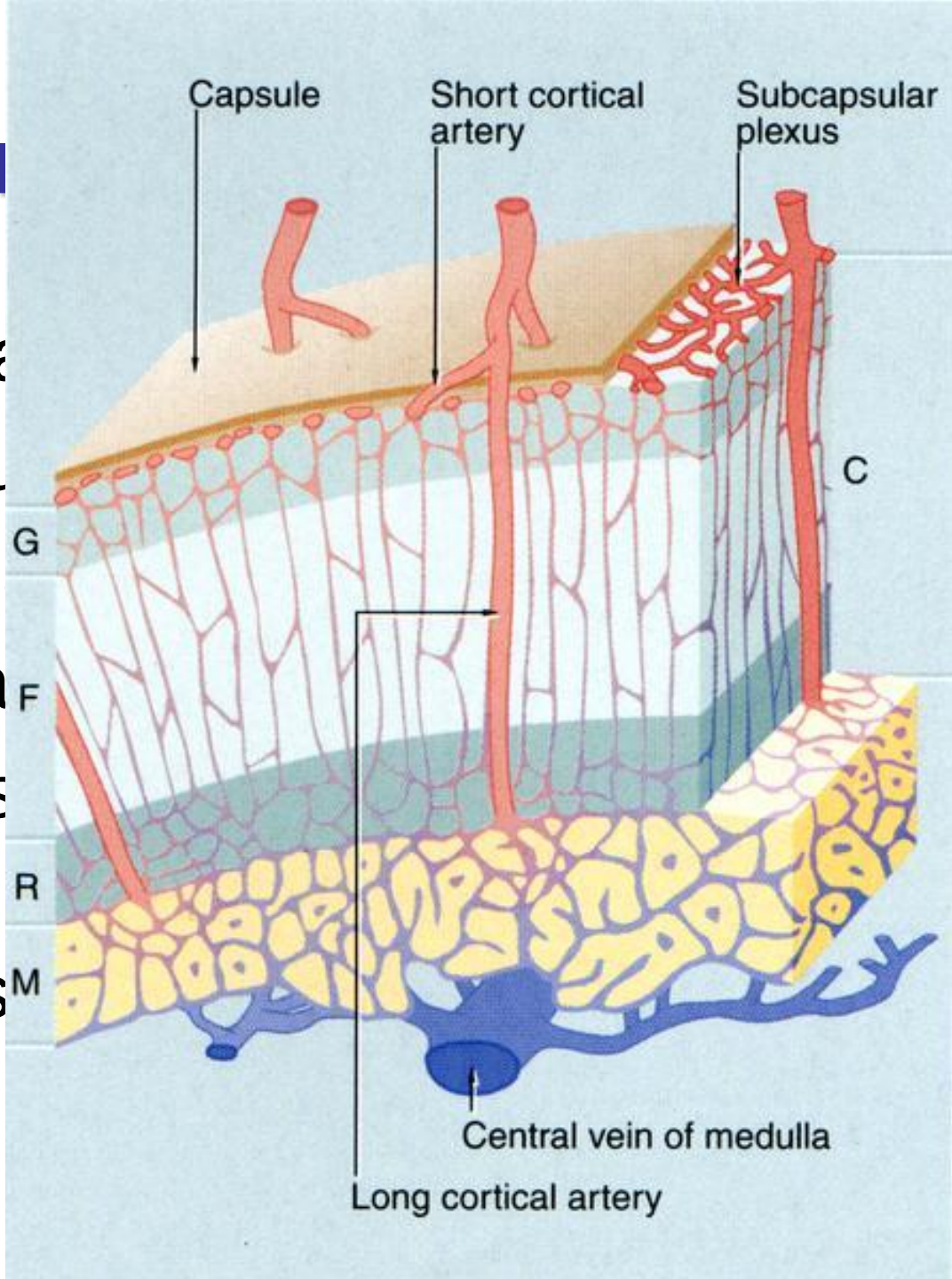
C. CÉVY NADLEDVINY (pravé strany)
1 / a. phrenica inferior (dextra)
2 / a. suprarenalis superior (dextra)
3 / a. suprarenalis media (dextra)
4 / a. suprarenalis inferior (dextra)
5 / a. renalis (dextra)
6 / aorta abdominalis

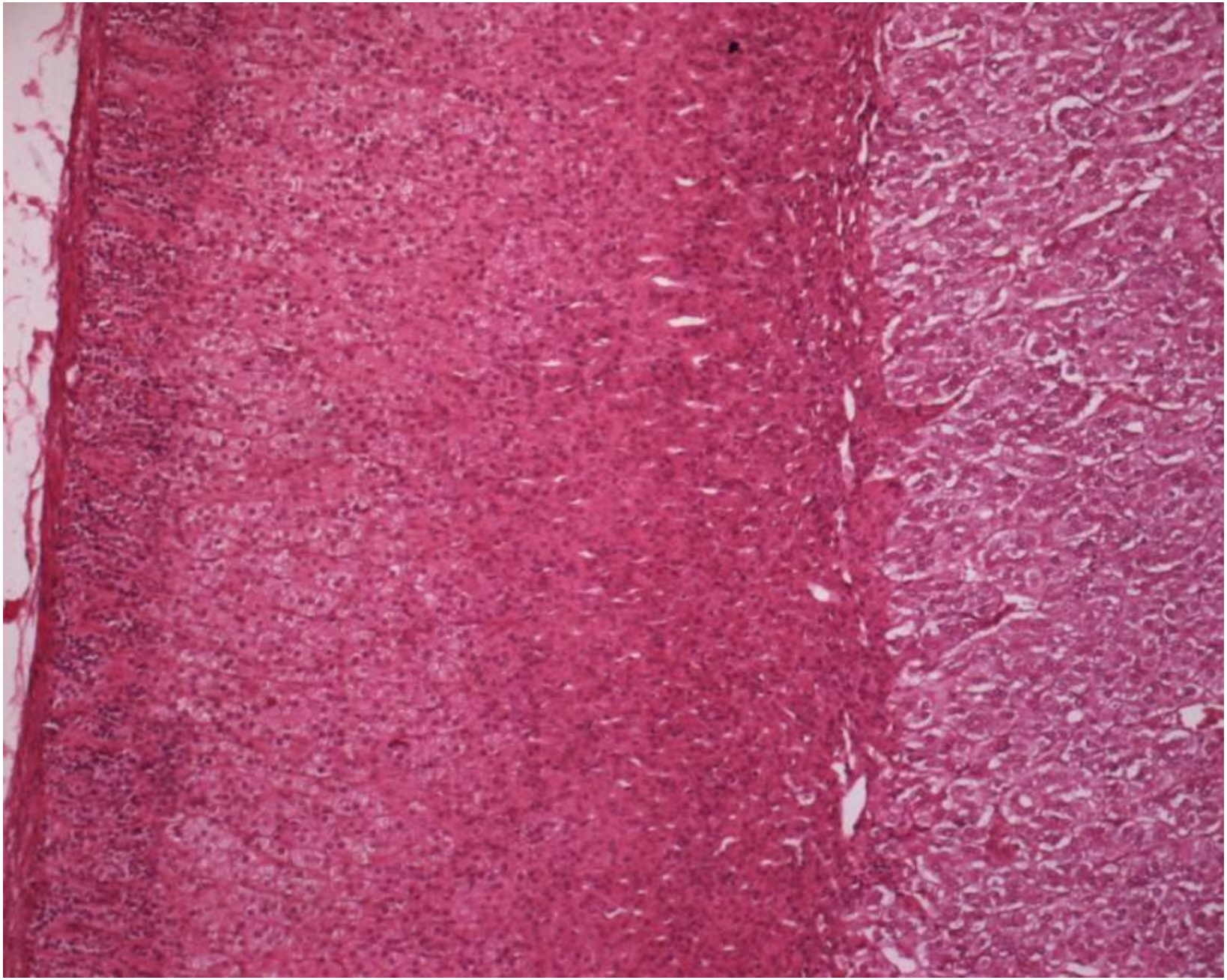


Obr. 307. SCHEMA PRŮTOKU KRVE NADLEDVINOU (srov. text)
1 přívodné tepenné větve z nadledvinových tepen
2 povrchová a subkapsulární pleteň
3 sinusoidý a kapiláry jdoucí kůrou podle buněčných trámců do dřeně
4 žilní odtok z dřeně nadledviny

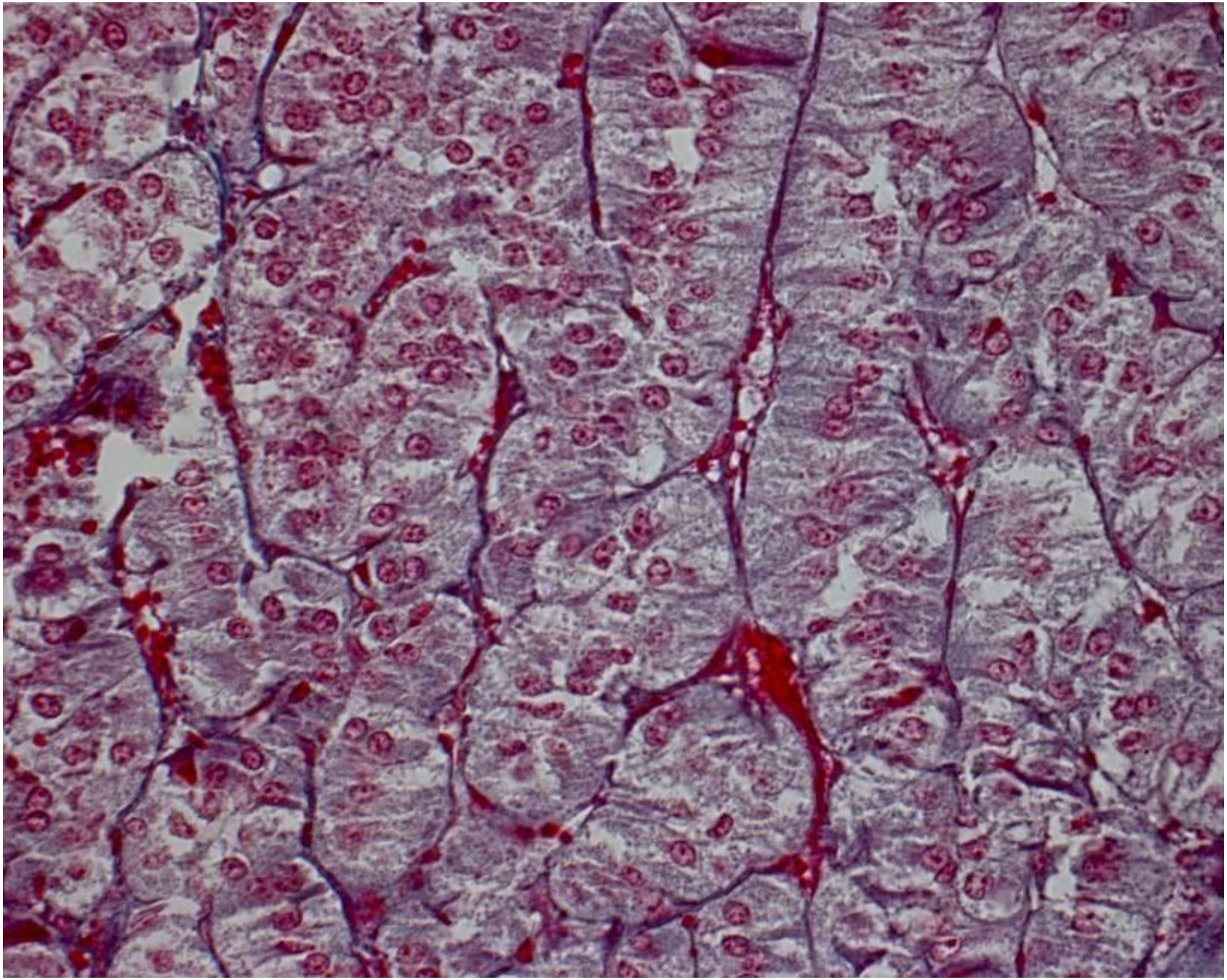
Suprarenal gla

- arteriae suprarena
- subcapsular plexu
- capsular, cortical
- in medulla: both a
- in medulla*: plexus vena centralis* →
- vena suprarenalis





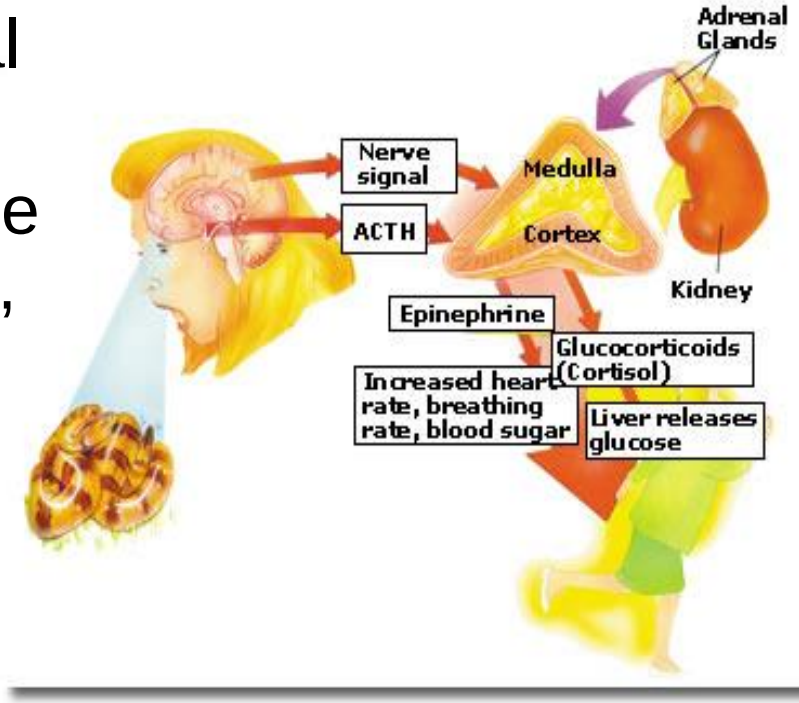
AZAN - E8



Stress reaction (fight or flight or fright)

sympathetic activation (suprarenal cortex and medulla)

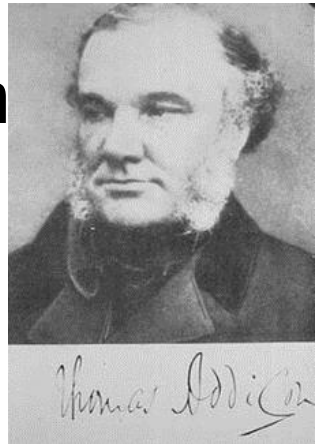
- effect on vascular smooth muscle → vasodilation inskeletal muscles, vasoconstriction in the skin
- metabolic effect of glycogen → glycogenolysis in the liver
- sympathetic activation → activation of appropriate organs



negative effect of stress on the psyche – stress is not accompanied by physical response today

Suprarenal glands – diseases

- medulla: **pheochromocytome** → hypertension in attacks
- cortex: hyperfunction
  - **Cushing´s syndrome** (endogenous hypercorticalism) – peripheral disorder
  - **Cushing´s disease** (adenome of hypophysis) – central disorder
  - **Conn´s syndrome** = hyperaldosteronism
- cortex: hypofunction
  - **Addison´s disease** = hypocorticalism



Cushing´s symptoms

- high blood pressure
- abdominal obesity
- thin arms and legs
- reddish stretch marks
- round red face
- a fat lump between the shoulders
- weak muscles and bones
- acne
- fragile skin
- women may have more hair and irregular menstruation

Pancreatic islets (of Langerhans)
Insulae pancreaticae

- endocrine part of pancreas
- 0,1–0,2 mm large
- totally 1–1.5 million
- various type of cells: A, B, D, PP (G)
- hormones:
  - **insulin**
  - **glucagon**
  - **somatostatine**
  - **pancreatic polypeptide**

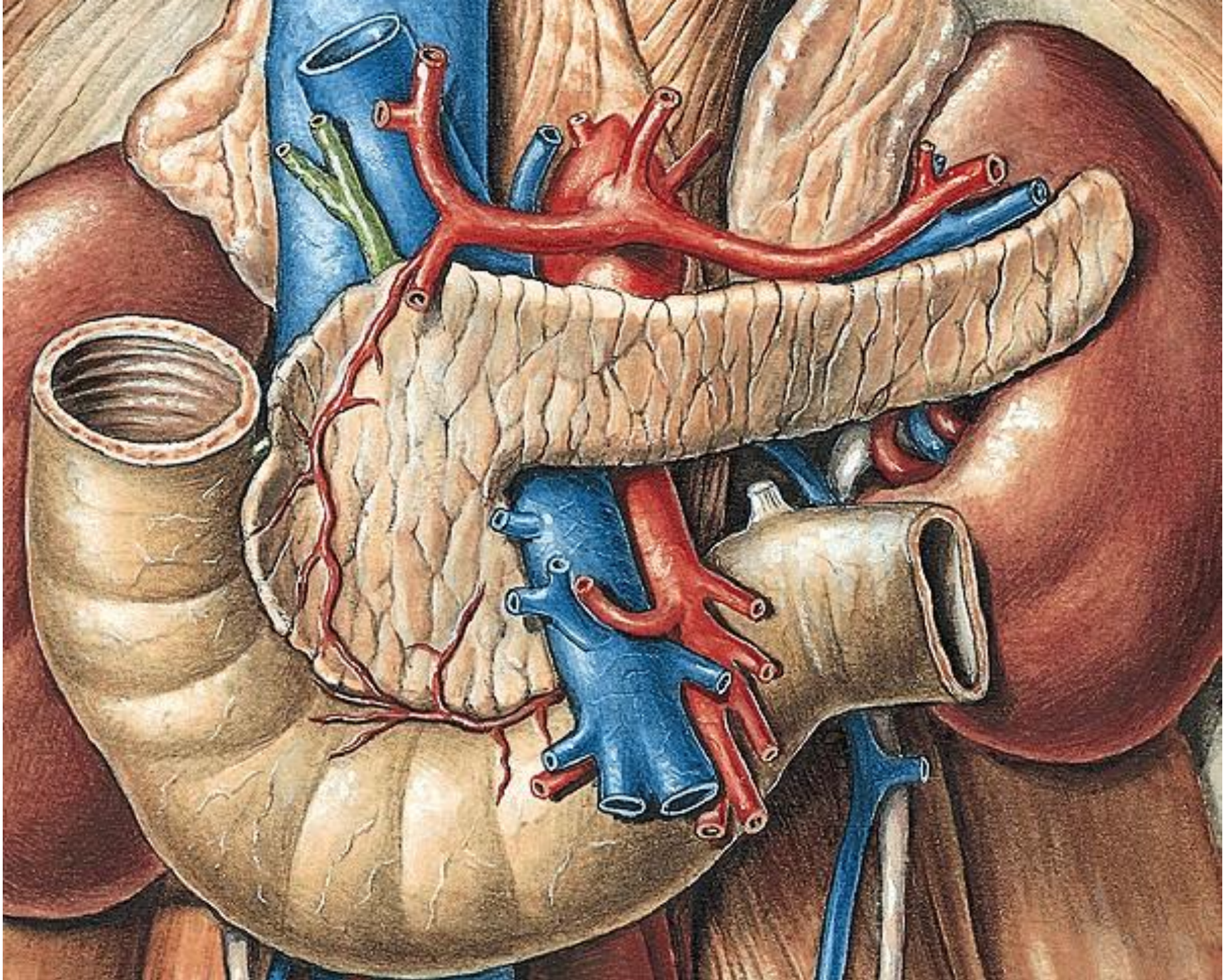
Pancreatic islets (of Langerhans)
Insulae pancreaticae
history

- Areteus of Kappadocia – diabetes = flow through
- Avicenna – sweet urine – diabetes mellitus
- **Langerhans** (1869) – discovered islet within pancreas
- Minkowski and Mering (1889) – experimentally evoked diabetes
- Sharpey-Schäfer – discovery of insulin
- **Banting and Best** (1921)
  - extract from canine pancreas → treatment of dogs with diabetes
  - treatment of patients
- 1929 – Nobel prize for Banting and Macleod

Paul Langerhans
(1847–1888)

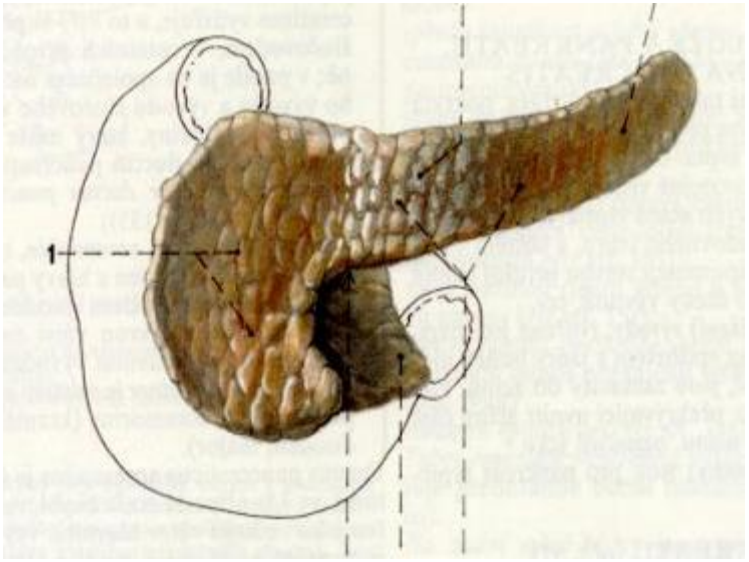
Pancreas – anatomy

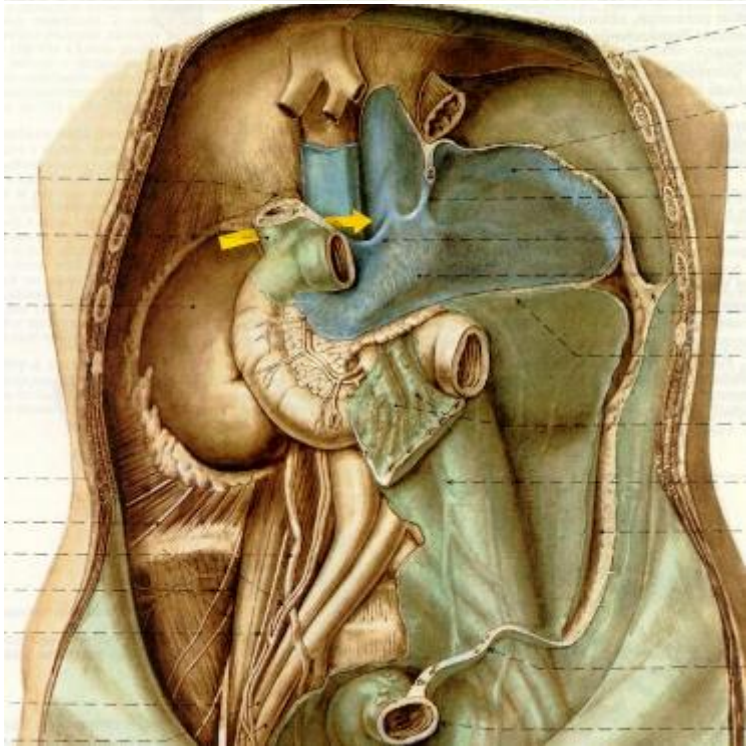
- double gland: exocrine and **endocrine** part
- topography – duodenal window at L2
- secondary retroperitoneal organ
  - only tail is intraperitoneal
- blood supply:
  - truncus coeliacus + a. mesenterica sup.
- 3 surgical approaches to pancreas

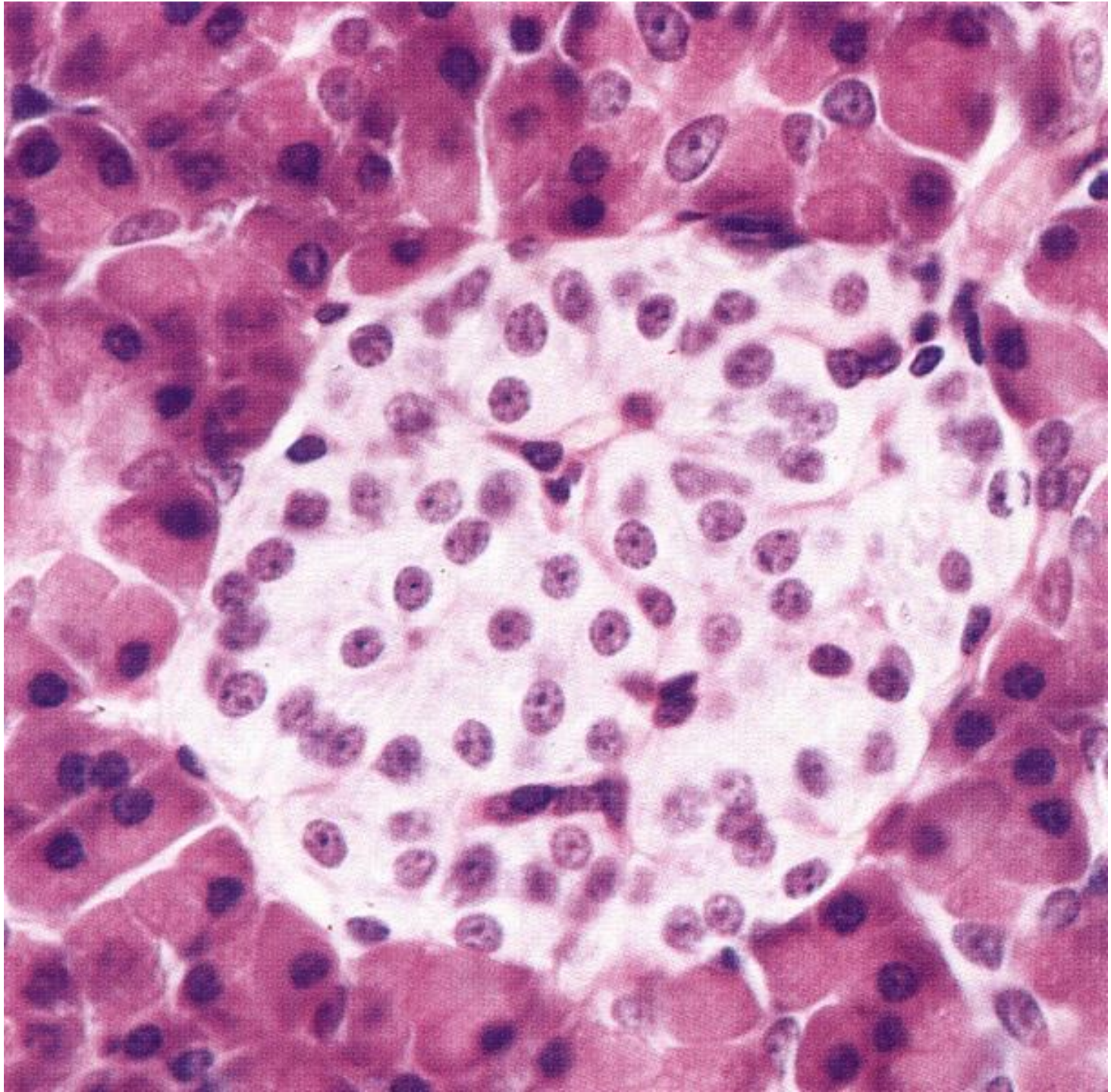


Pars endocrina pancreatis
Pancreatic islets (of Langerhans)
Insulae pancreaticae

- weight about 1 g
- after total pancreatectomy it is necessary to supply with insulin only
- cords of epithelial cells





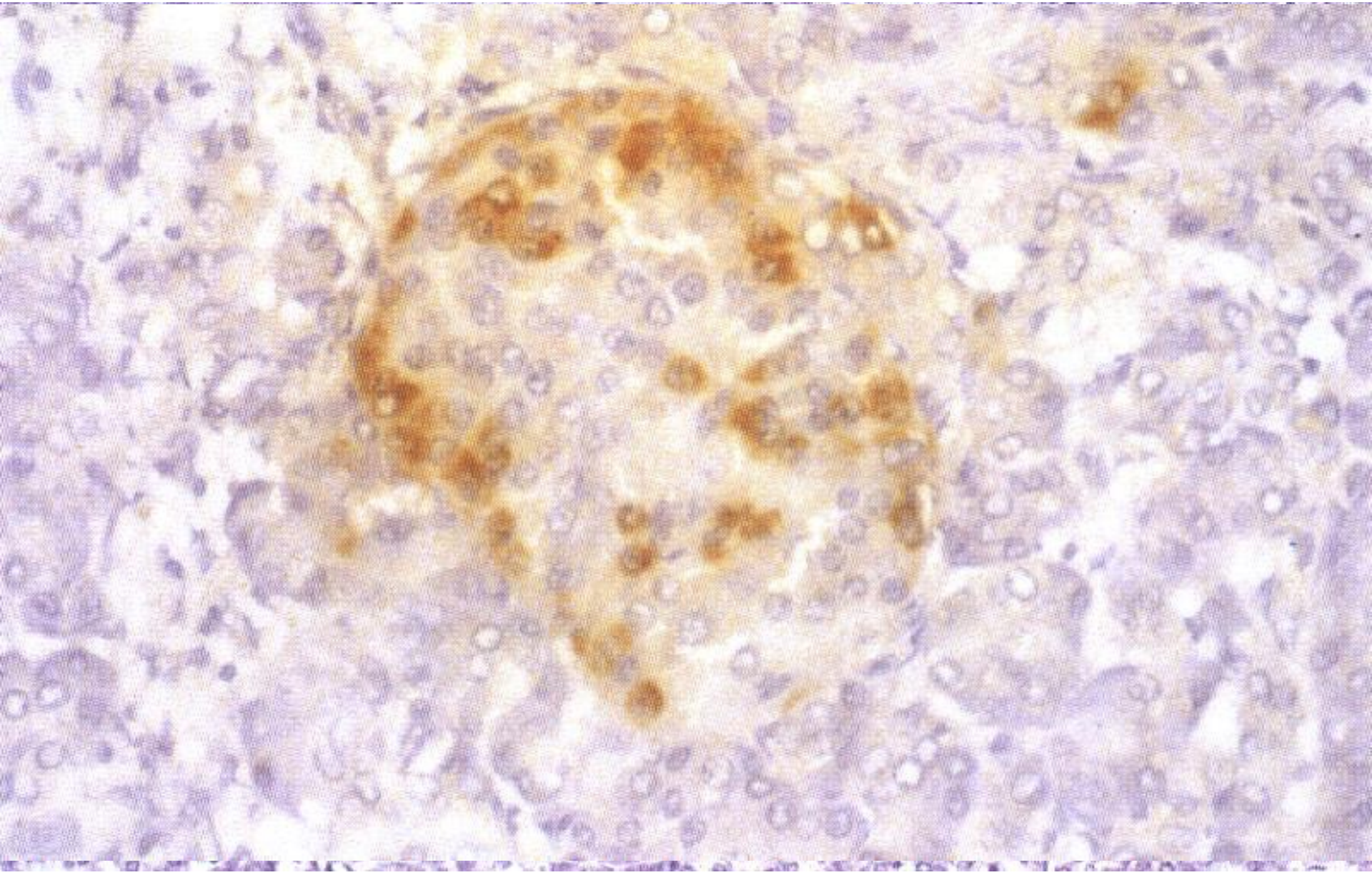


Pancreatic islets (of Langerhans) types of cells

gER, GA, granules

- A – cells (*endocrinocytus A; glucagonocytus*)
  - A-granules – spheric (300 nm)
  - **glucagon** – hyperglycaemic-glycogenolytic factor

- B – cells (*endocrinocytus B; insulinocytus*)
  - B-granules – spheric (300 nm), specific for species
  - **insulin** – hypoglycaemic factor

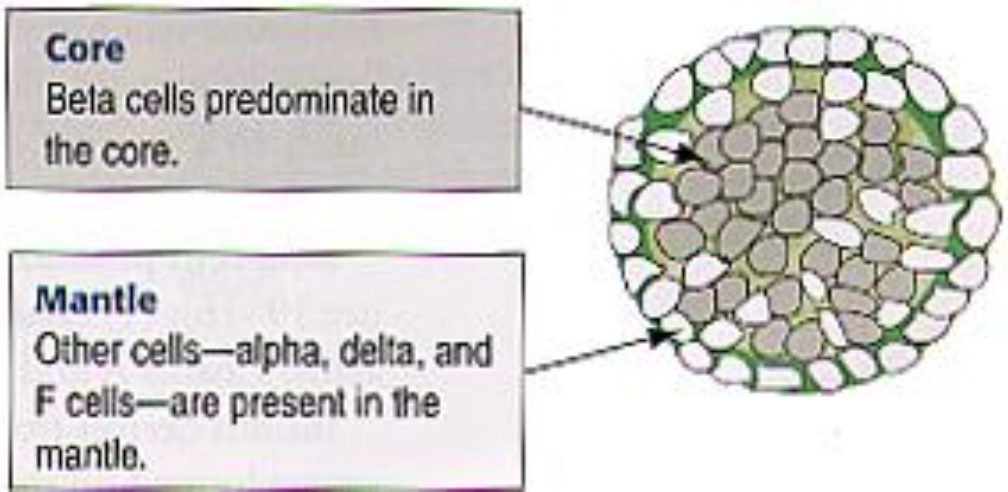


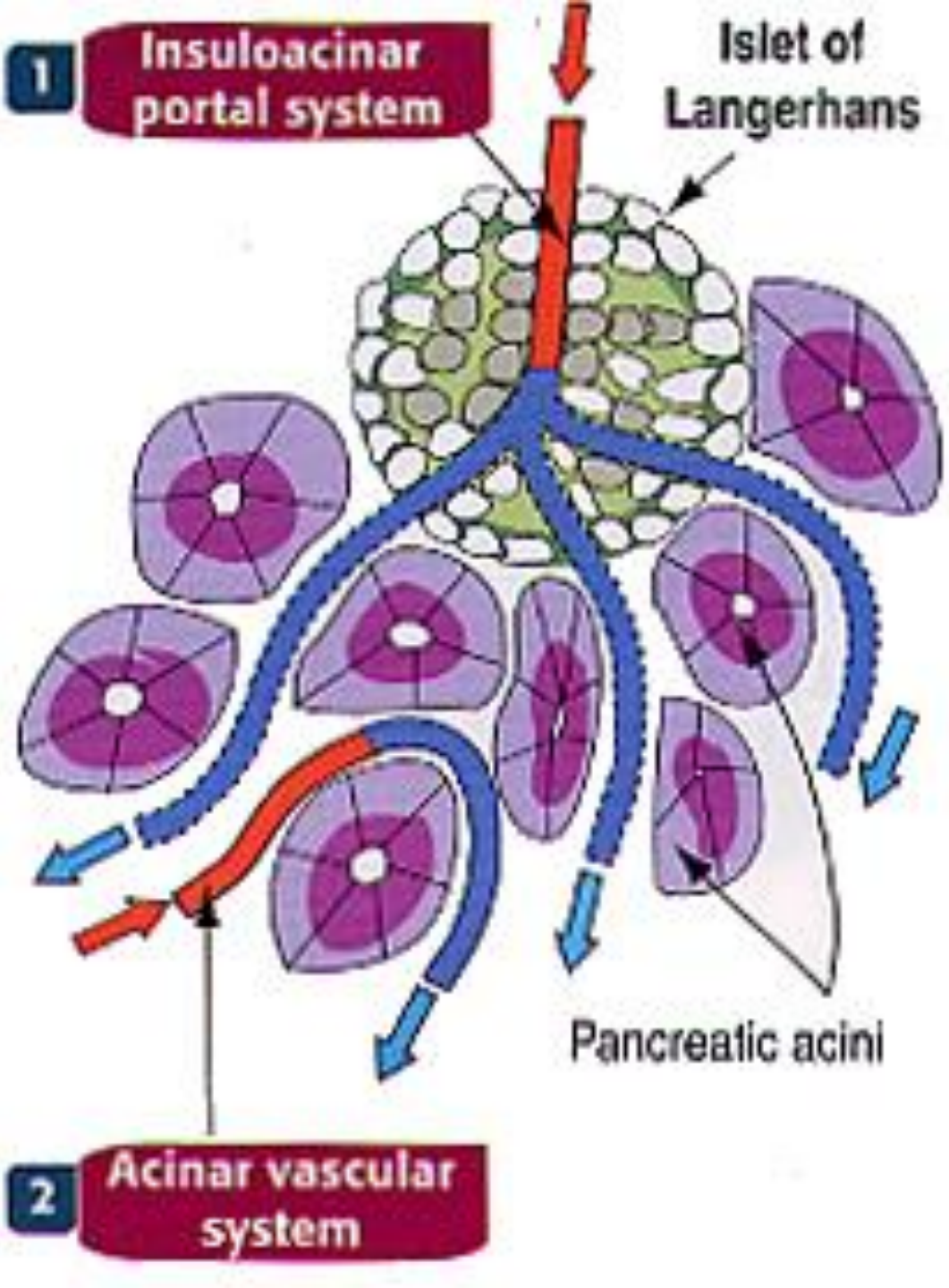
Pancreatic islets (of Langerhans) types of cells

- D – cells (*endocrinocytus D; somatostatinocytus*)
  - δ-granules – spheric (250 nm), totally filled
  - one long process → paracrine secretion
  - **somatostatin**
- PP – cells (*endocrinocytus PP*)
  - granules – 180 nm, brightest
  - **pancreatic polypeptide** → regulation of pancreatic exocrine part
- (G - cells)
  - production of **gastrin**
- (other)
  - cells producing ghrelin, PYY, D1, EC)

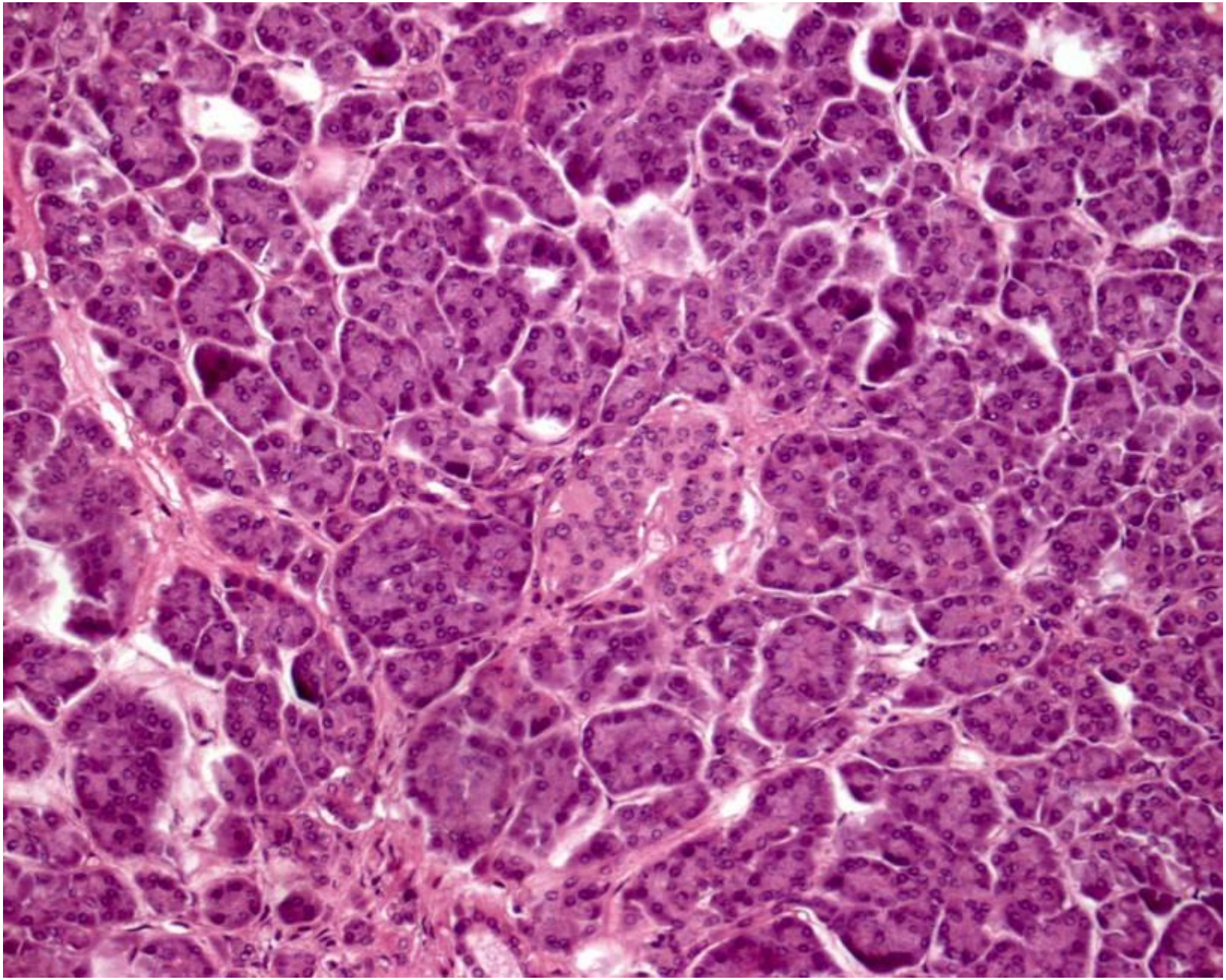
Pancreatic islets (of Langerhans) localization of cells

- cell ratio in pancreas: tail > body > head
  - body + tail – 70 % B, 20 % A, 10 % D, 1 % PP
  - head – 65 % PP, 25 % B, 7 % D, 3 % A
- cell localization within an islet:
  - B-cells in the core
  - A, D, PP in the mantle

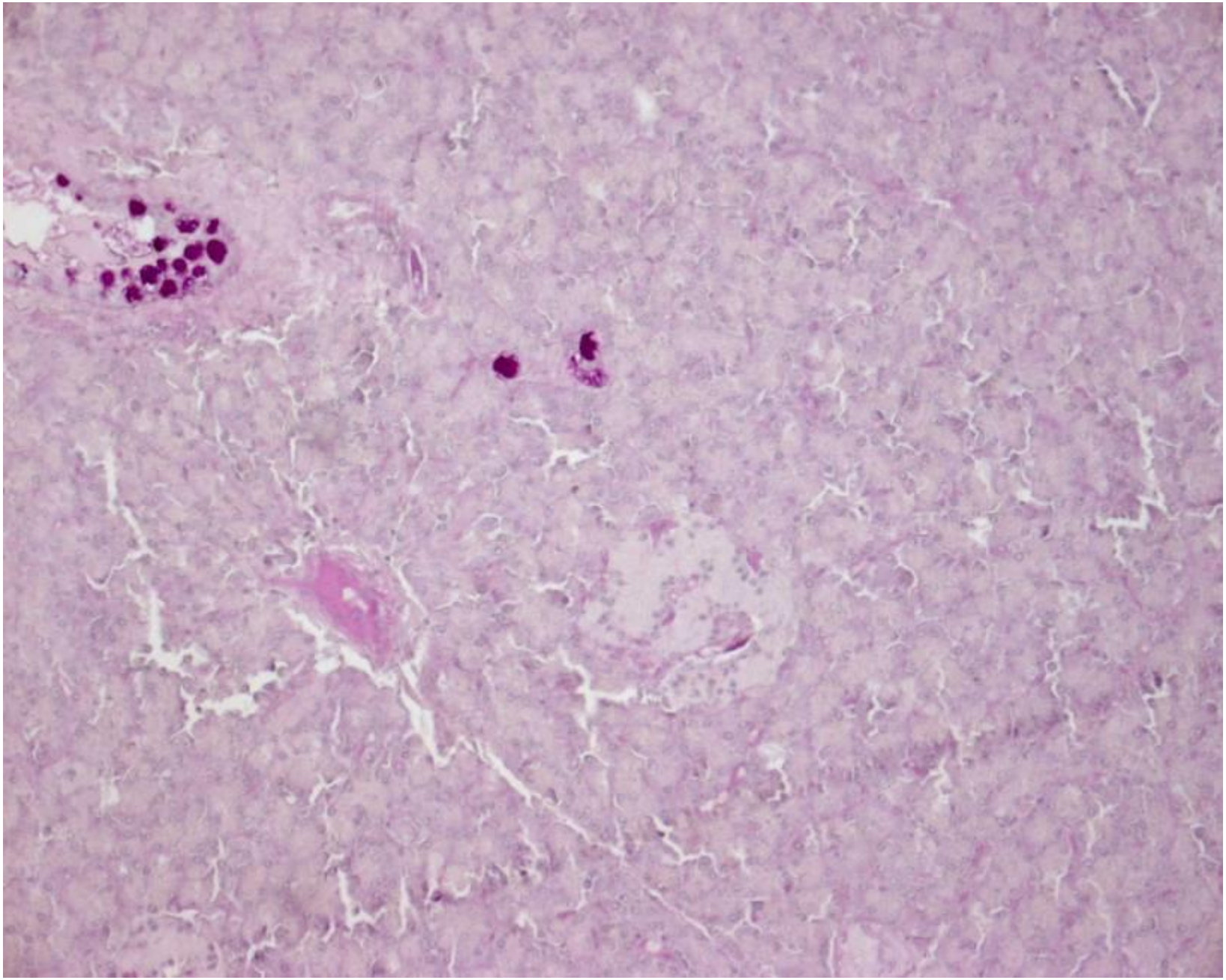



1
Insuloacinar portal system
Islet of Langerhans
Pancreatic acini
2
Acinar vascular system

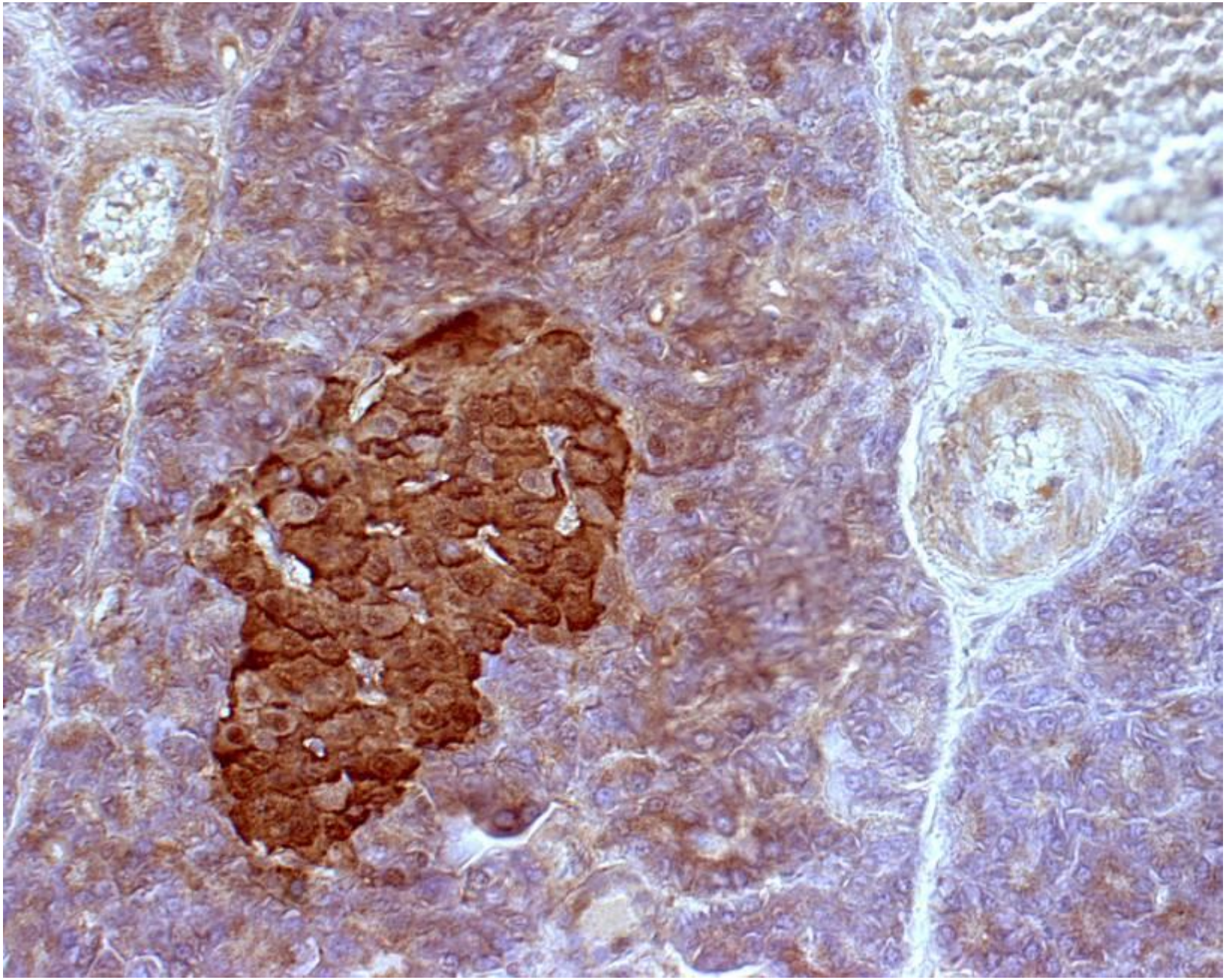
Insulae pancreaticae



Insulae pancreaticae PAS + Hem



Insulae pancreaticae - ABC prove of insulin E10



Pancreatic islets (of Langerhans) development

- differentiare from indifferent pancretic cells
- separate from ducts
- first A-cells, later B, D and PP
- *insular field* – all types mixed
- *mantle islets* – B in core, A in mantle

- insulin from 10th week
- glucagon in 15th week

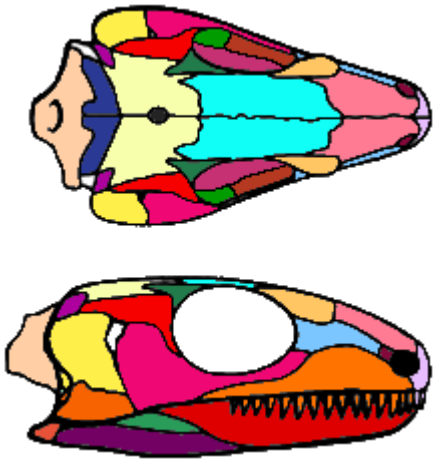
Multiple Endocrine Neoplasia = MEN sydrome

- multiple neoplasia of endocrine glands
- usually hereditary (autosomally dominant)
- 3 types
- MEN 1 = carcinoma of gl. parathyroidea, pancreas and hypophysis
- MEN 2a = medullary carcinoma of gl. thyroidea (MTC), pheochromocytoma and carcinoma of gl. parathyroidea
- MEN 2b = medullary carcinoma of gl. thyroidea (MTC), pheochromocytoma and neuromas

Glandula pinealis; Corpus pineale
Pineal gland

= epiphysis – obsolete term

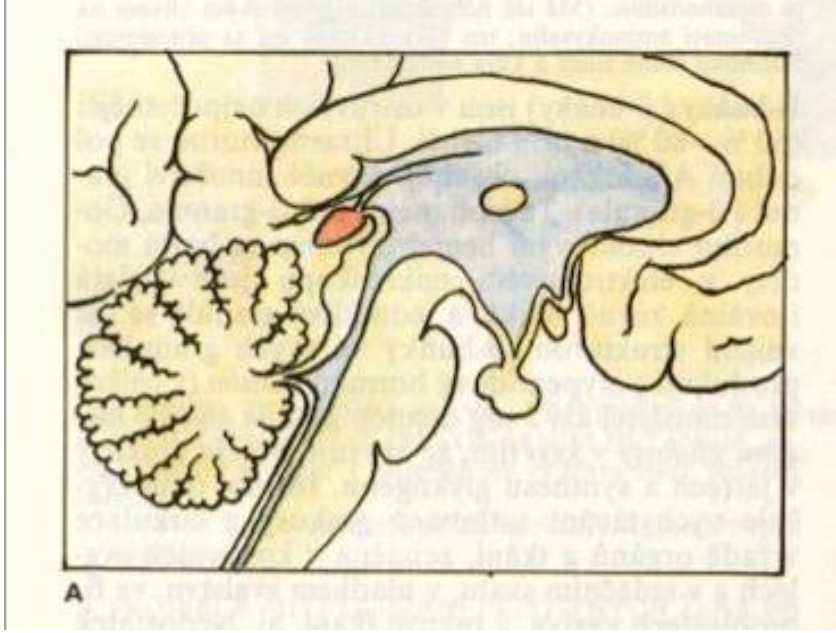
- developmental relation to parietal eye
- hateria – New Zealand (*Sphenodon punctatus*)
- reaction to polarized light (lunar biorhytms)

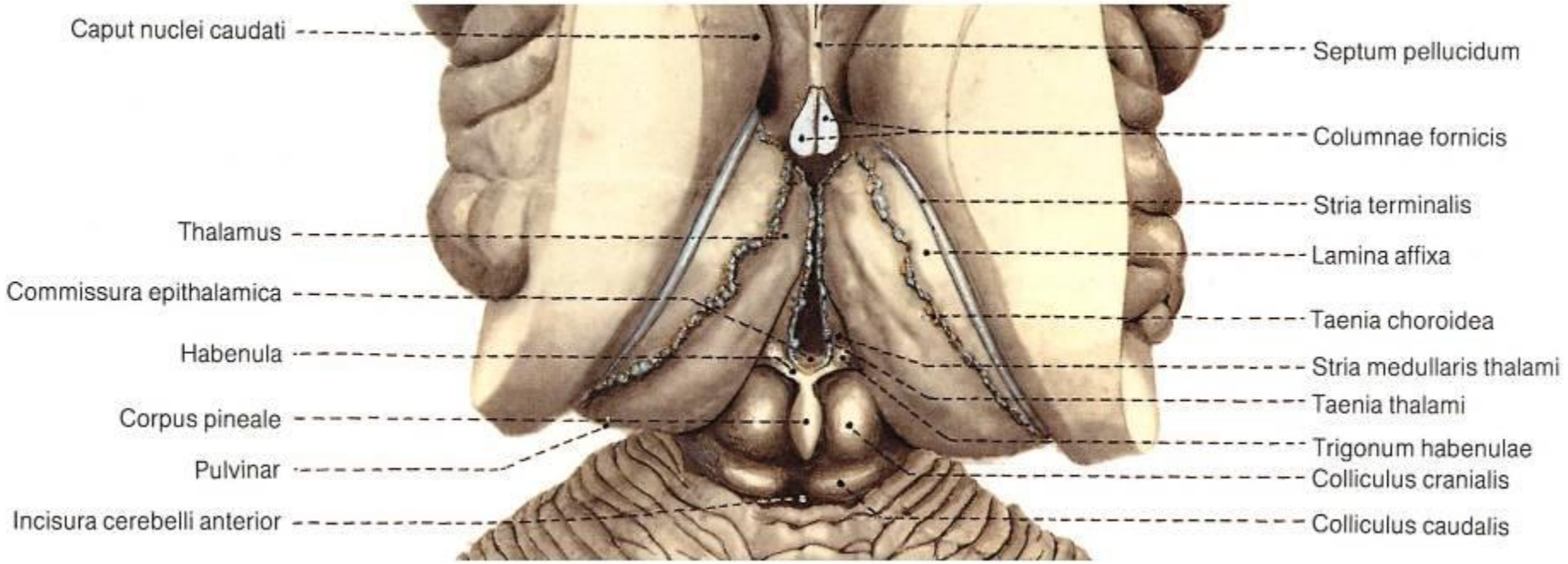


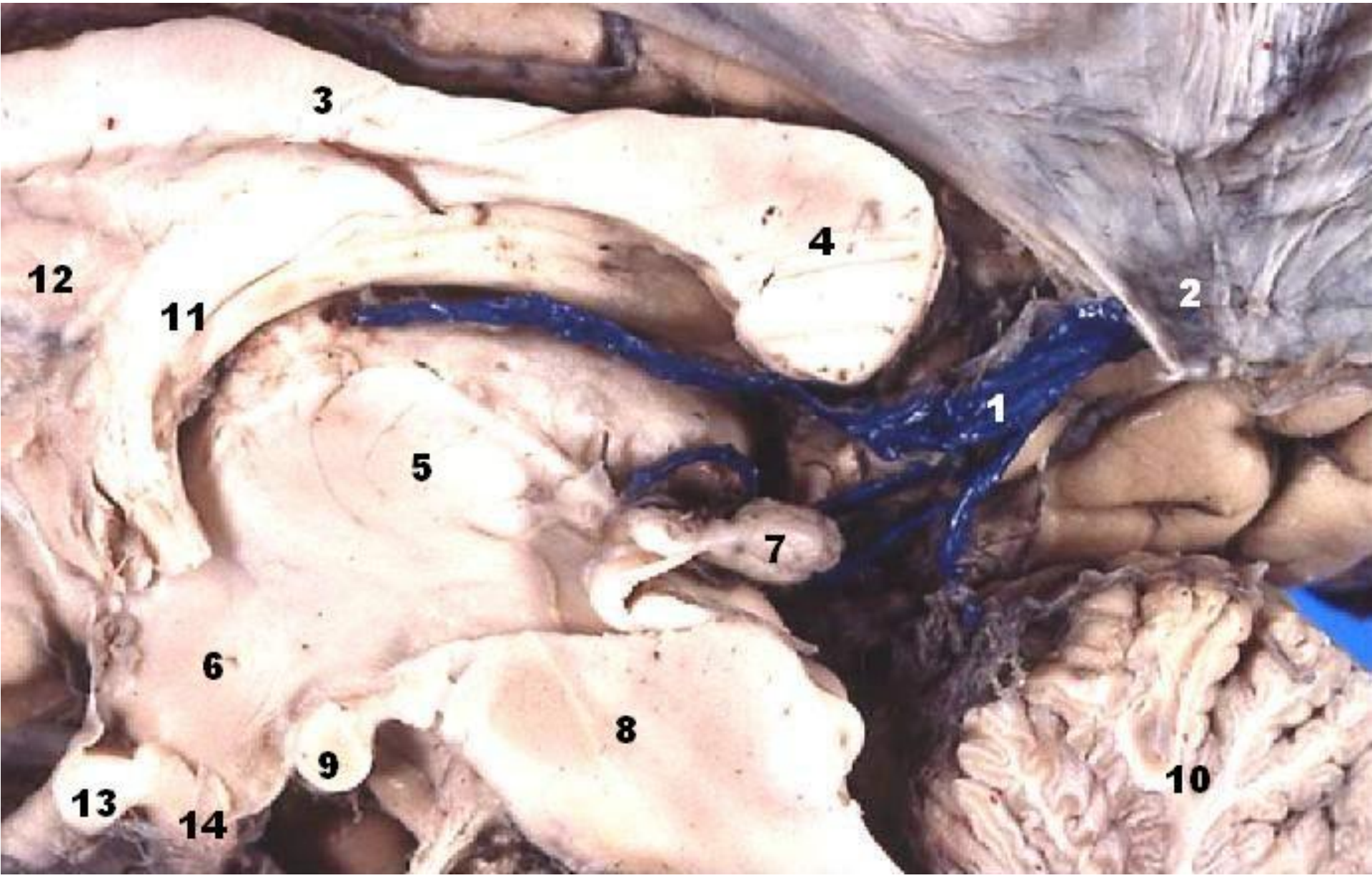
Pineal gland

- behind upper posterior end of 3rd ventricle
- part of epithalamus
- rudimentary endocrine gland with suppressive effect on sexual glands → pubertas praecox
- dorsally extends above brain stem (above lamina quadrigemina of midbrain)
- *melatonine* → change of level during day
- acervulus cerebri (= calcium concrements in adults) – CT, MRI

Pineal gland






3
4
12
11
2
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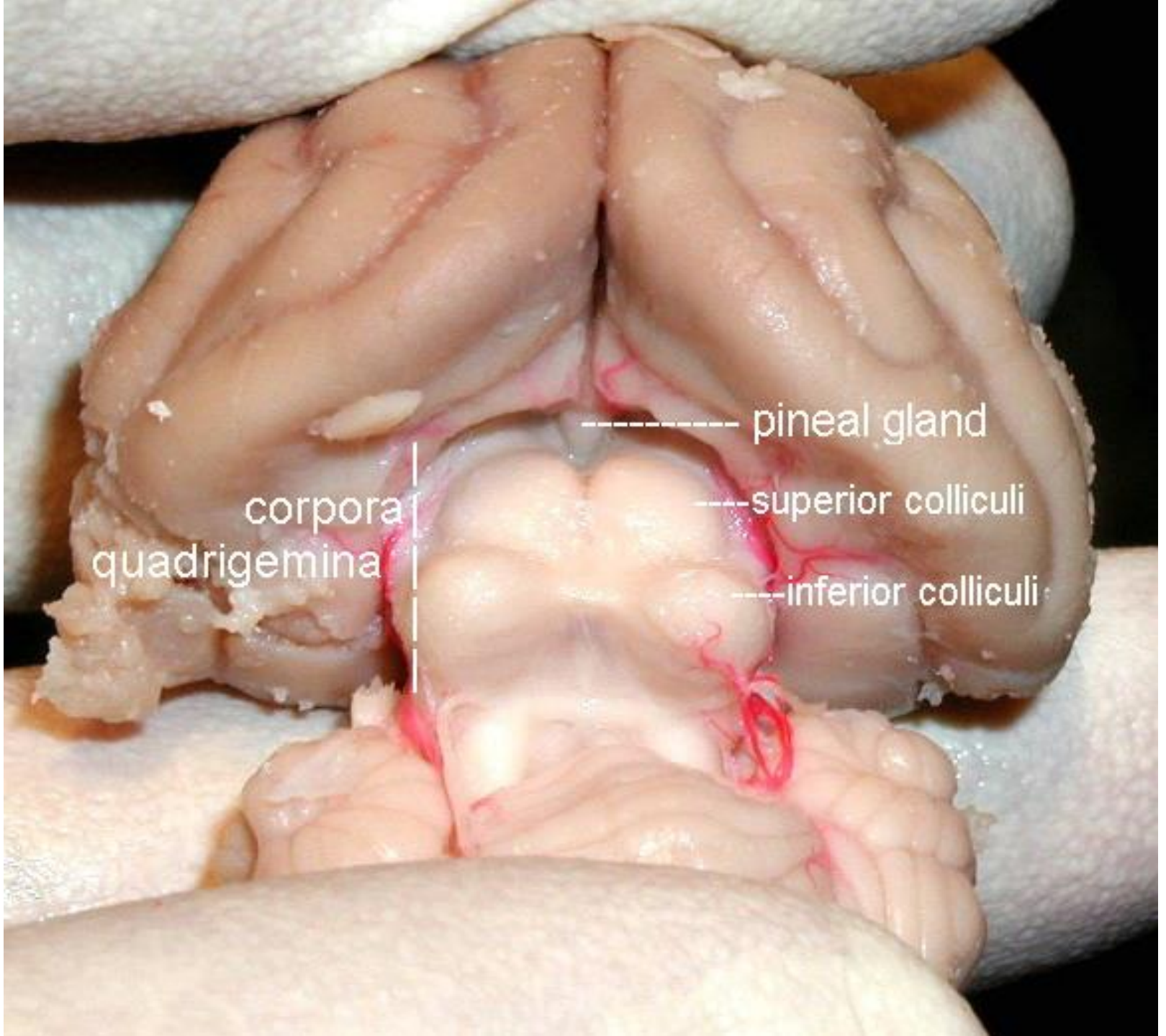
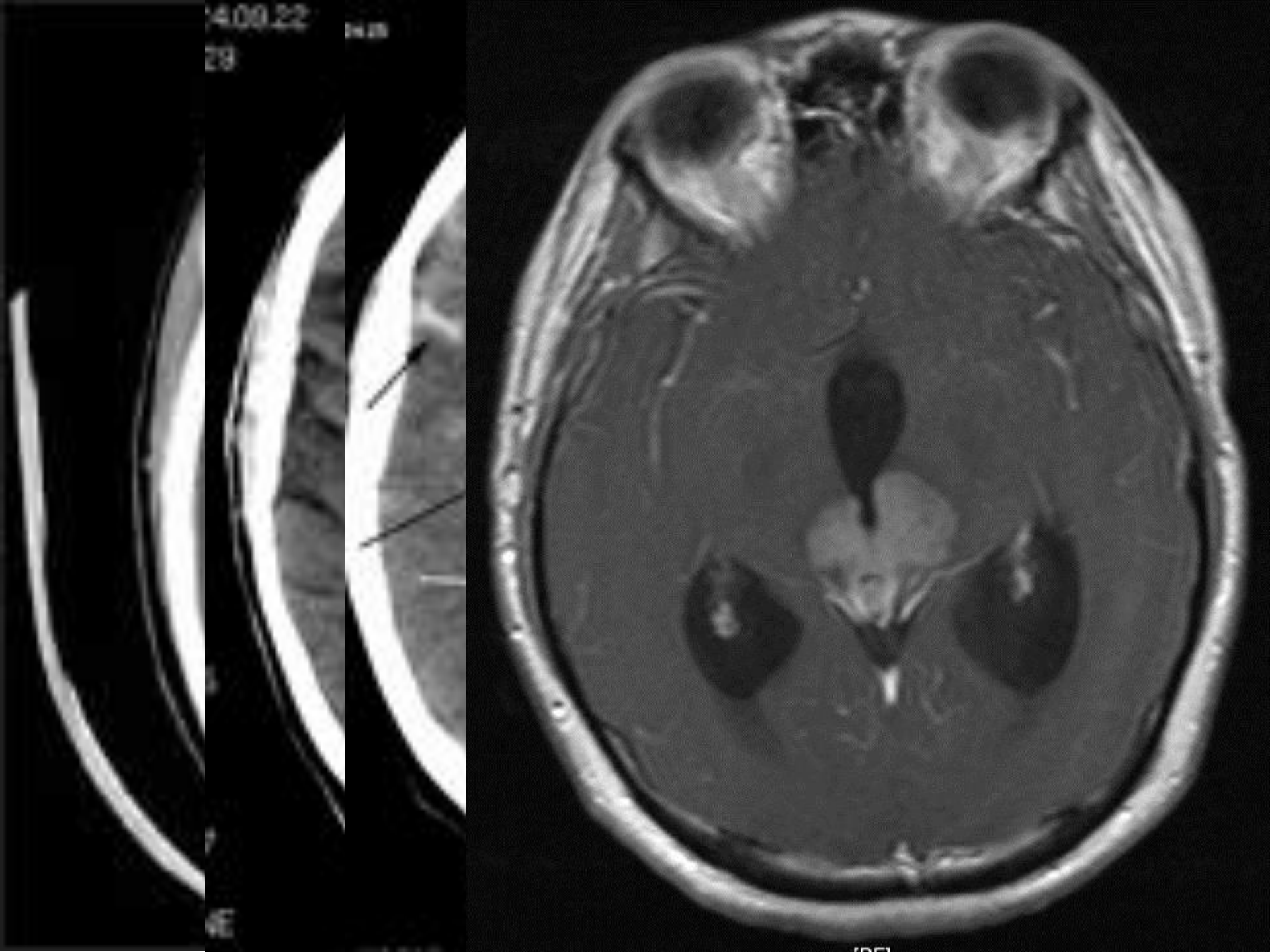
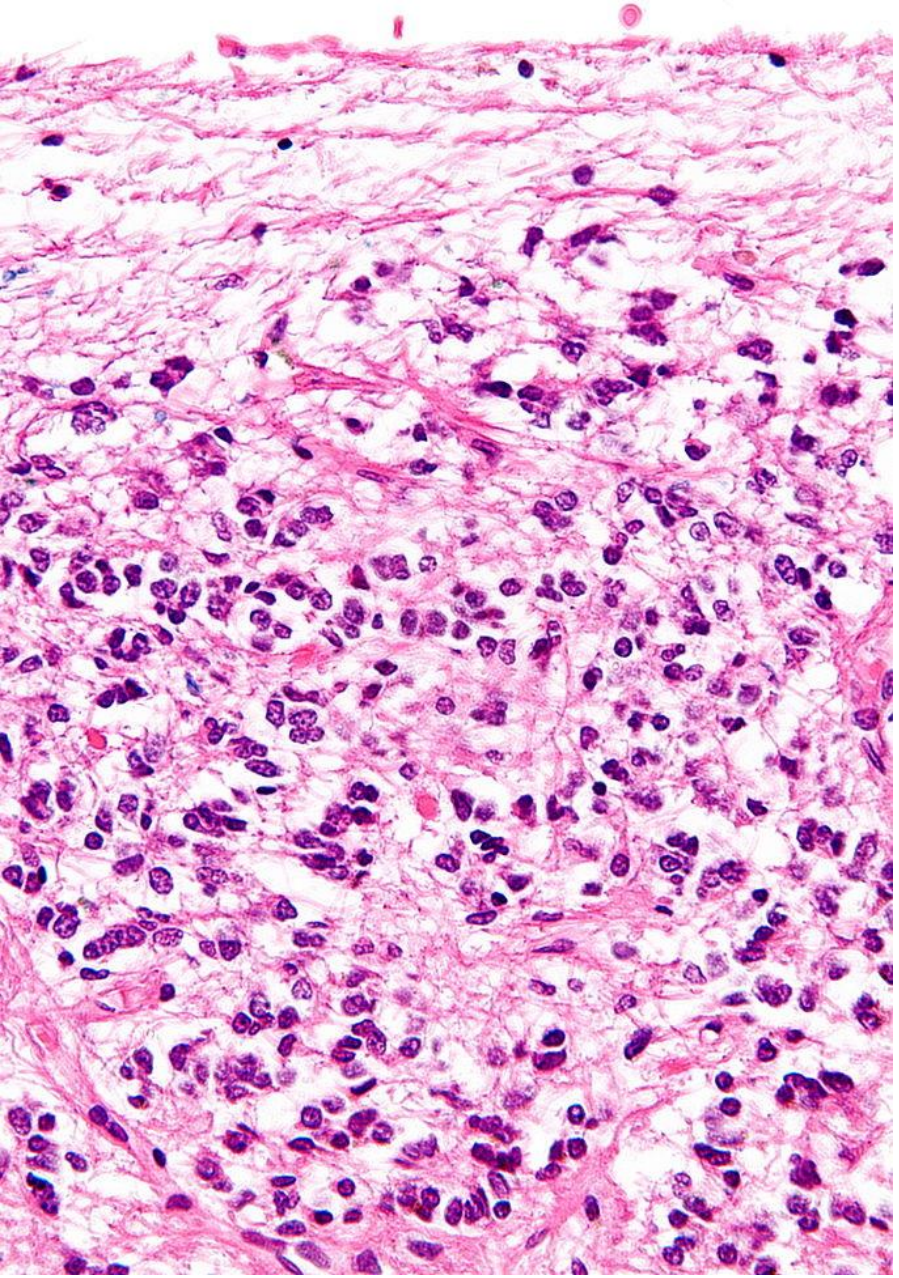
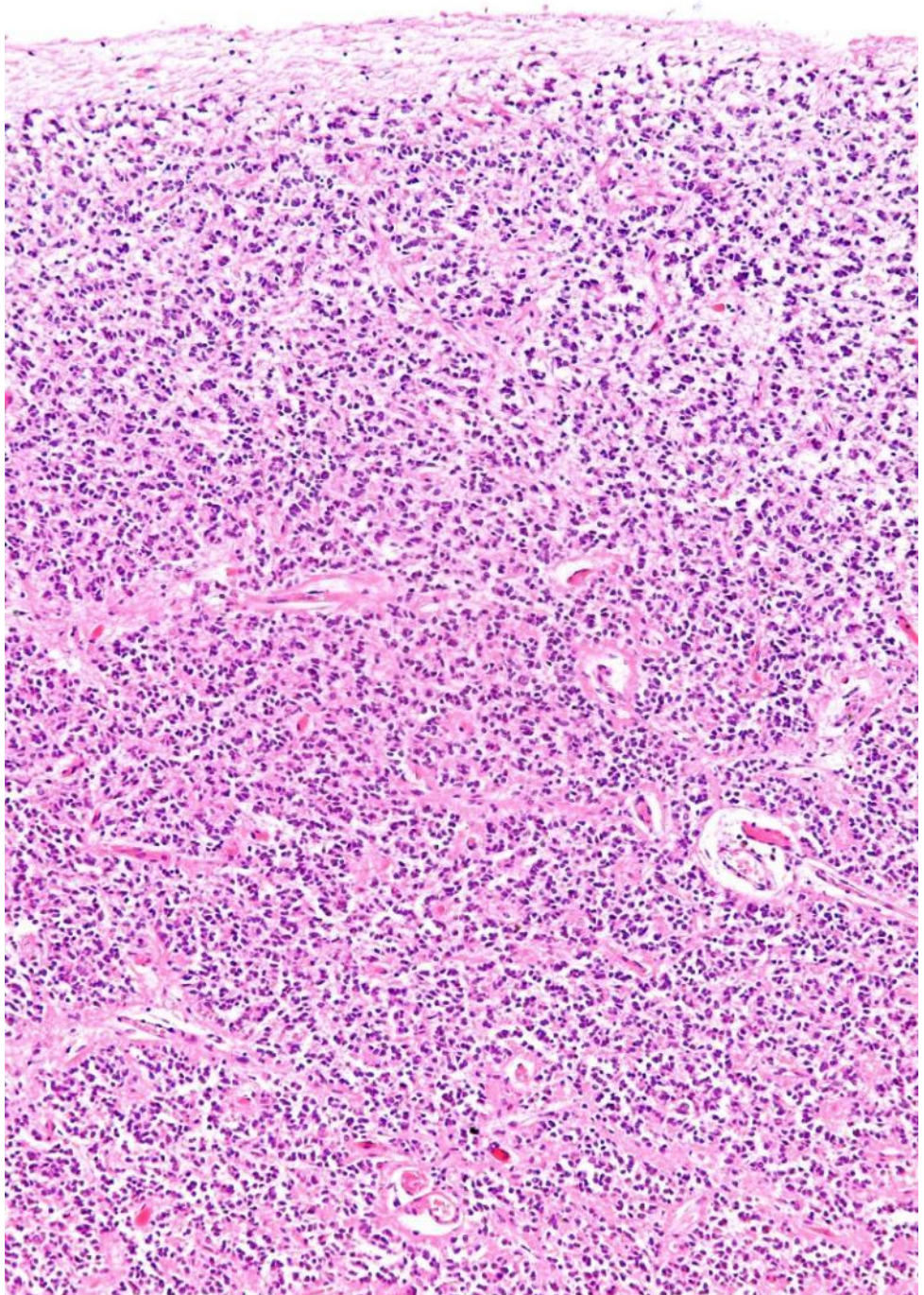

pineal gland
corpora quadrigemina
superior colliculi
inferior colliculi



Glandula pinealis – structure

- capsule from *pia mater* → septa
- pinealocytes (*pinealocyti*)
  - nucleus with prominent nucleolus, basophillic cytoplasm
  - production of **melatonine**
    - level changes during the day
- interstitial/astroglial cells (*astrocyti*)
  - bar-shaped nucleus
- n. pinealis → neurofibra non myelinata

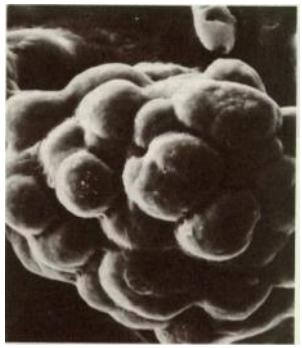


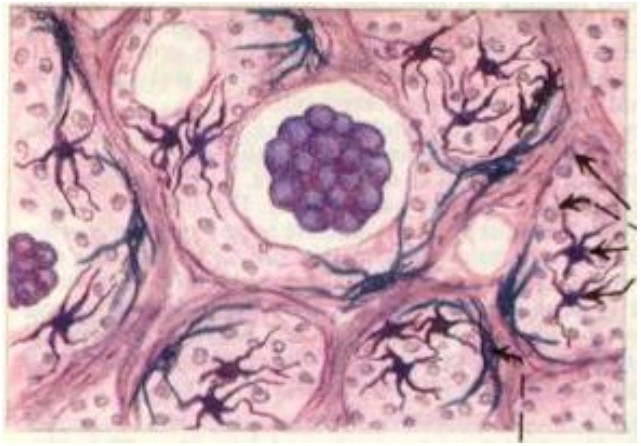


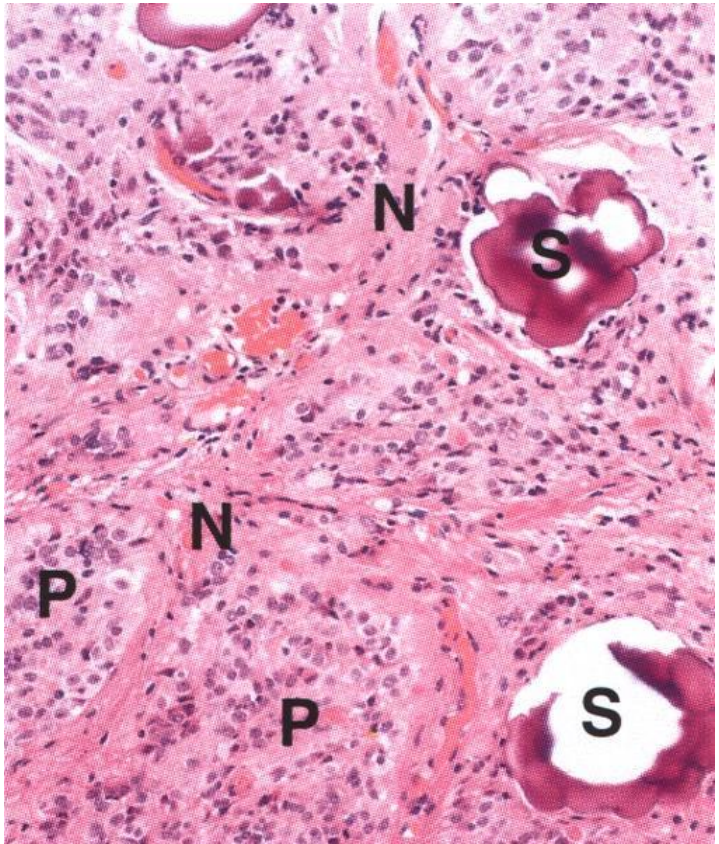
Glandula pinealis – „brain sand“

acervulus; corpus arenaceum

- concrements of protein material with calcium salts
- amount elevates with age
- CT, MRI







Heart

- atrial cardiomyocytes
- **atrial natriuretic peptide / factor (ANP / ANF)**
- peptide
- vasodilatory and natriuretic effects (increased excretion of Na+ ions and consequently water in the kidneys)

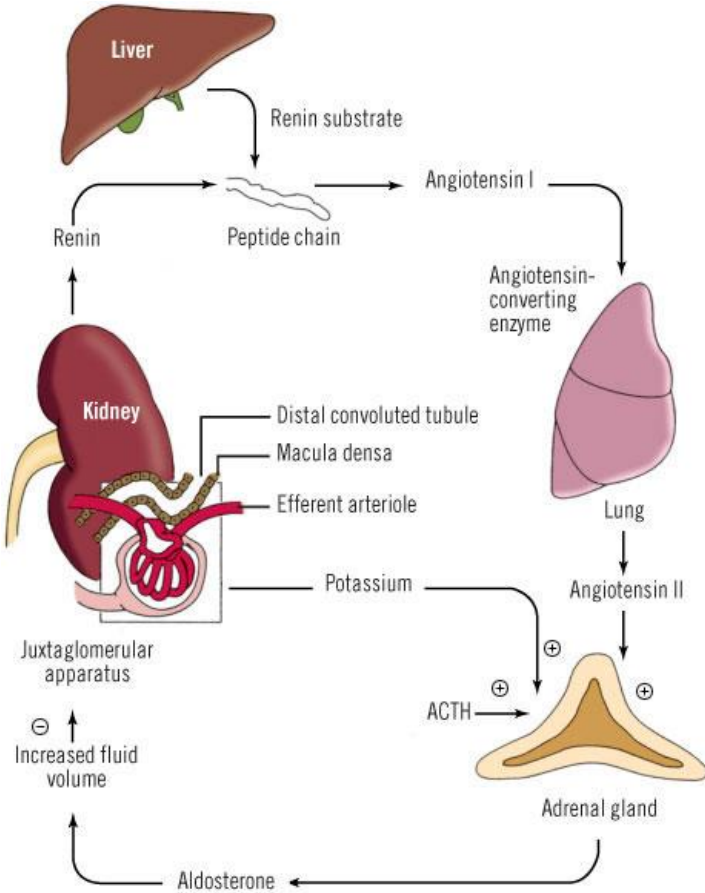
- ventricular cardiomyocytes
- **brain natriuretic peptide (BNP)**
- higher plasma concentration in heart failure → diagnostic marker

Kidneys – erythropoietin

- peritubular interstitial cells of the cortex
- **erythropoietin**
- glycoprotein
- the stimulus is hypoxia (reduced oxygen level in the kidney)
- it ensures erythropoiesis alignment and reduces the physiologically occurring progenitor cell apoptosis
- in case of lack anemia develops, e.g. in chronic kidney disease
- possible substitution treatment
- abuse in sports doping

Juxtaglomerulární aparát
Complexus juxtaglomerularis

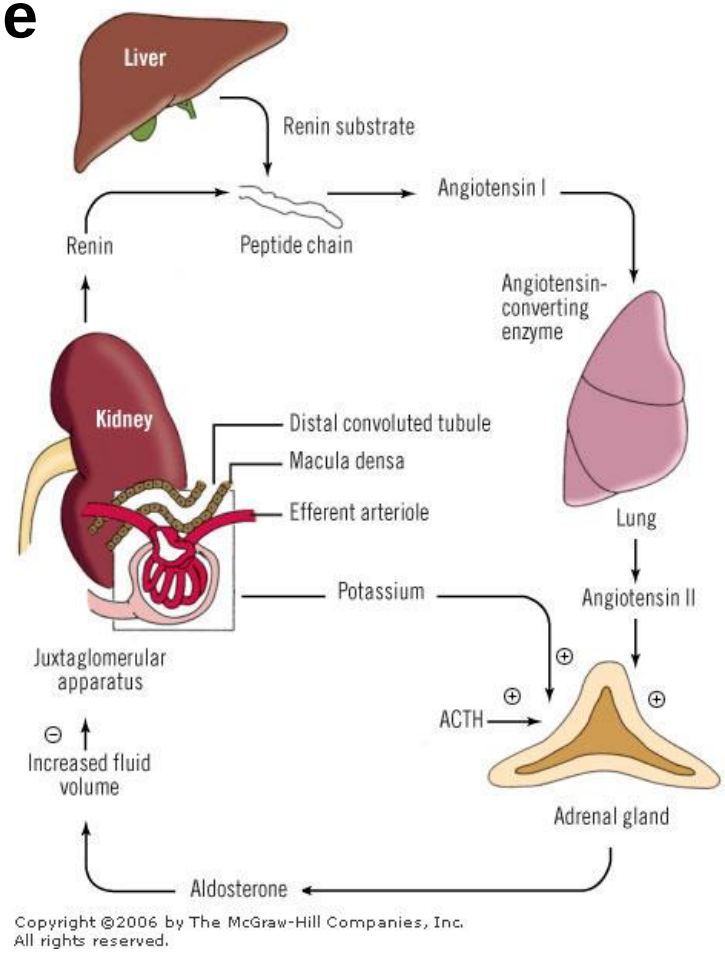
- granulární buňky arteriola afferens + efferens
  = juxtaglomerulární buňky (*juxtaglomerulocytus*)
  – přeměněné svalové buňky tunica media
  – mechanoreceptory
  – tvoří renin
- macula densa distálního kanálku (*epitheliocytus maculae densae*)
  – chemoreceptory
- mezangiální buňky (*mesangiocytus extraglomerularis Goormaghtighi;* Lacis cell)
- <u>funkce:</u>
  – **regulace krevního tlaku**
    – systém **renin-angiotensin-aldosteron** (RAA)



Kidney – RAA axis

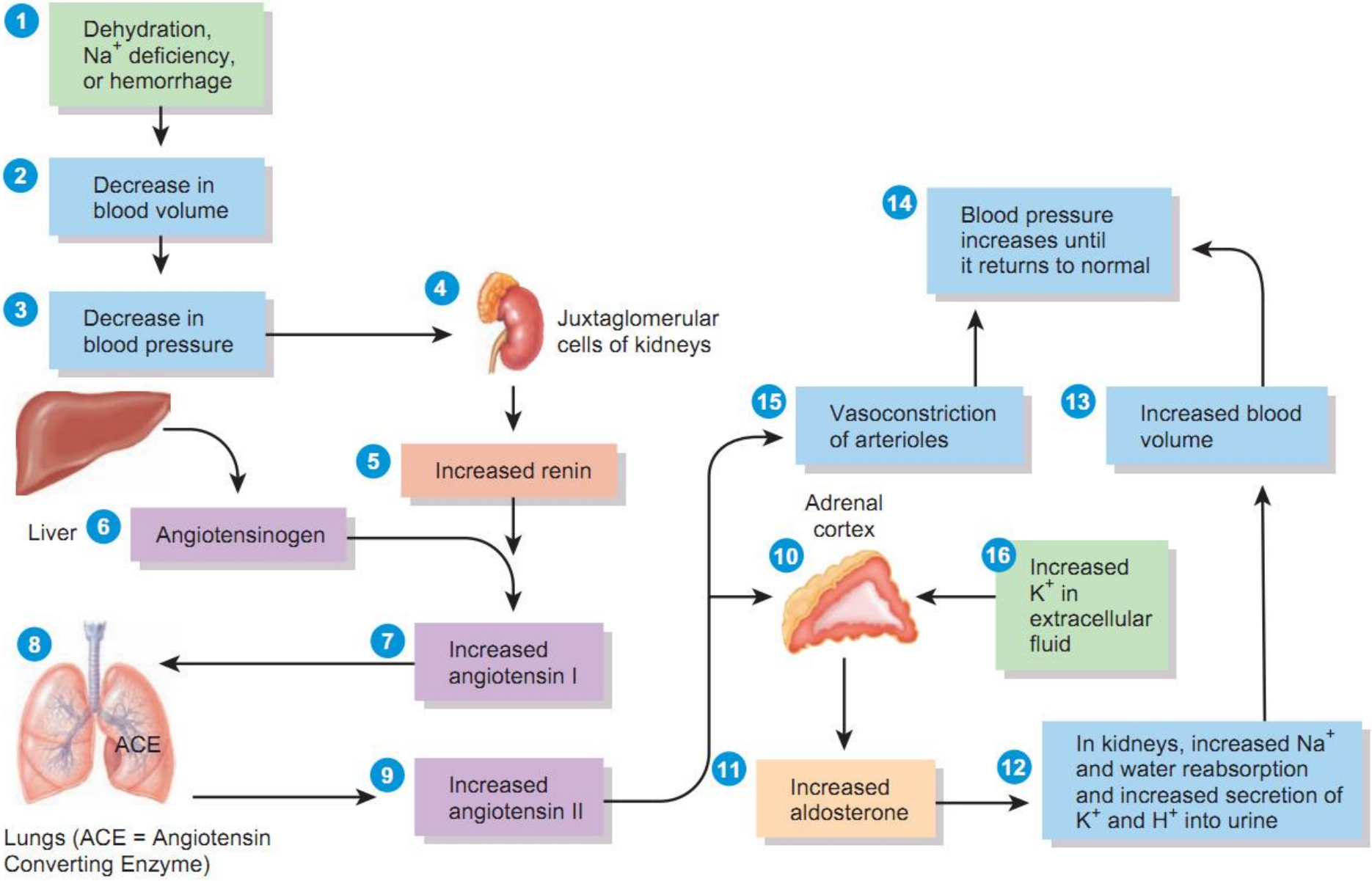
Juxtaglomerulal apparatus (*Complexus juxtaglomerularis*)

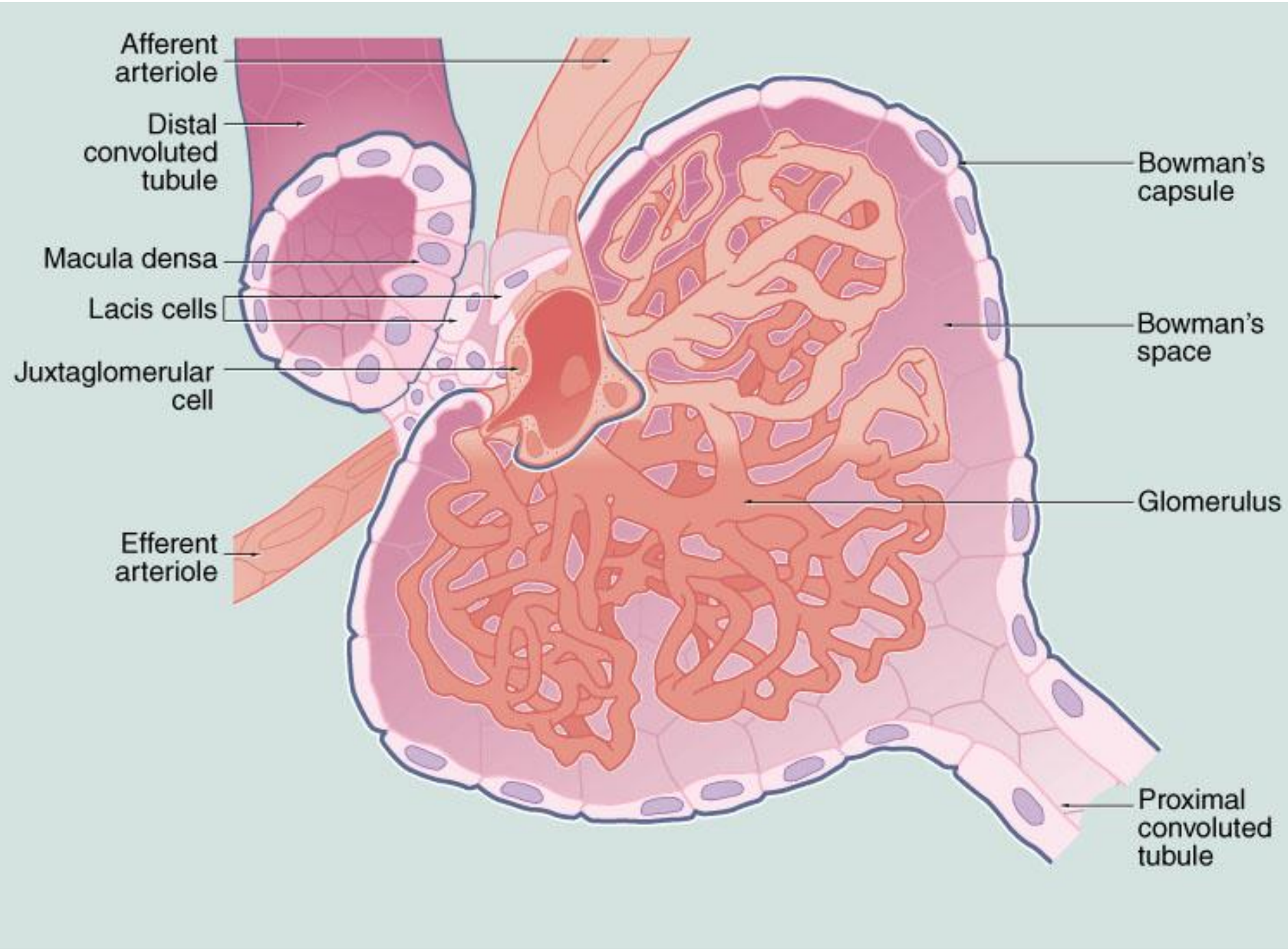
- **regulation of blood pressure**
- system **renin-angiotensin-aldosterone** (RAA)
- granular cells of arteriola afferens + efferens
  = juxtaglomerular cells (*juxtaglomerulocytus*)
  – transformed muscle cells of tunica media
  – mechanoreceptors
  – produce renin
- macula densa of distal tubule
  = *epitheliocytus maculae densae*
  – chemoreceptor
- extraglomerual mesangial cells
  = *mesangiocytus extraglomerularis Goormaghtighi;* lacis cell



Regulation of aldosterone secretion by the renin–angiotensin–aldosterone (RAA) pathway.

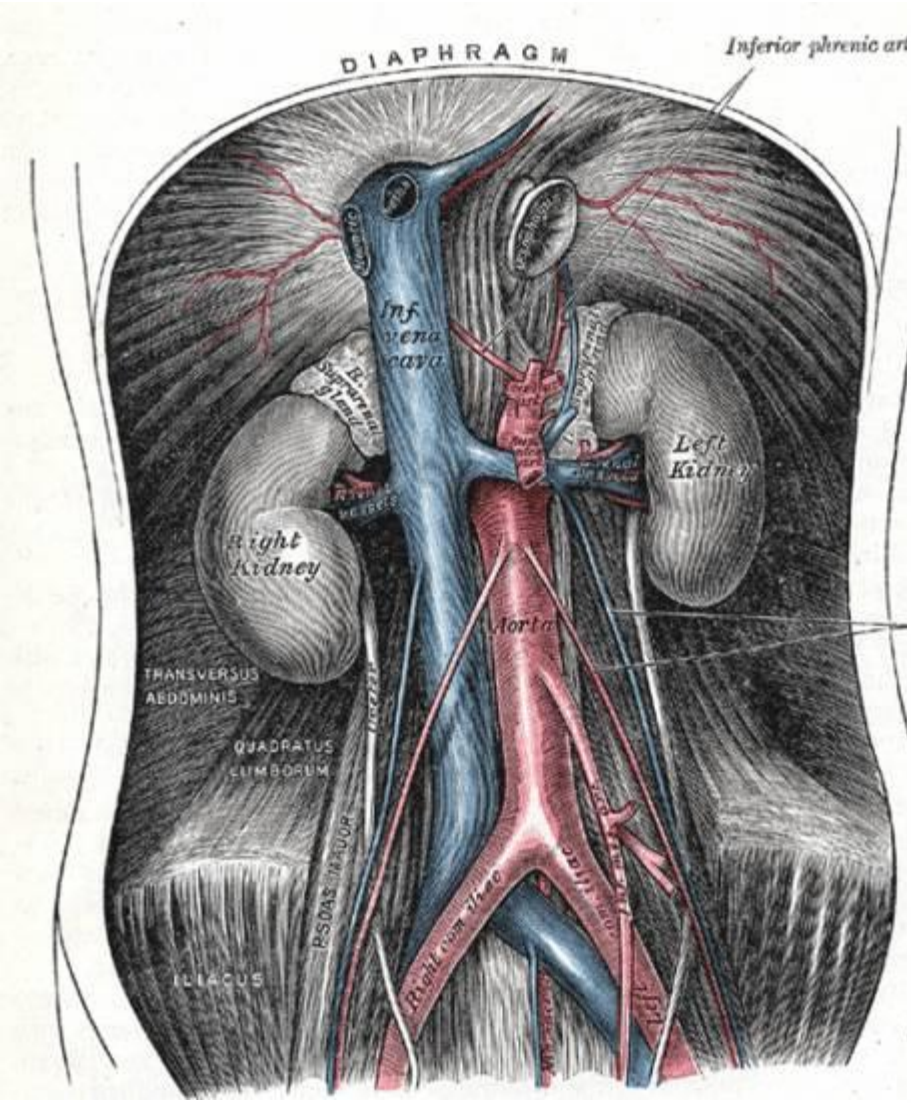
Aldosterone helps regulate blood volume, blood pressure, and levels of Na^+, K^+, and H^+ in the blood.

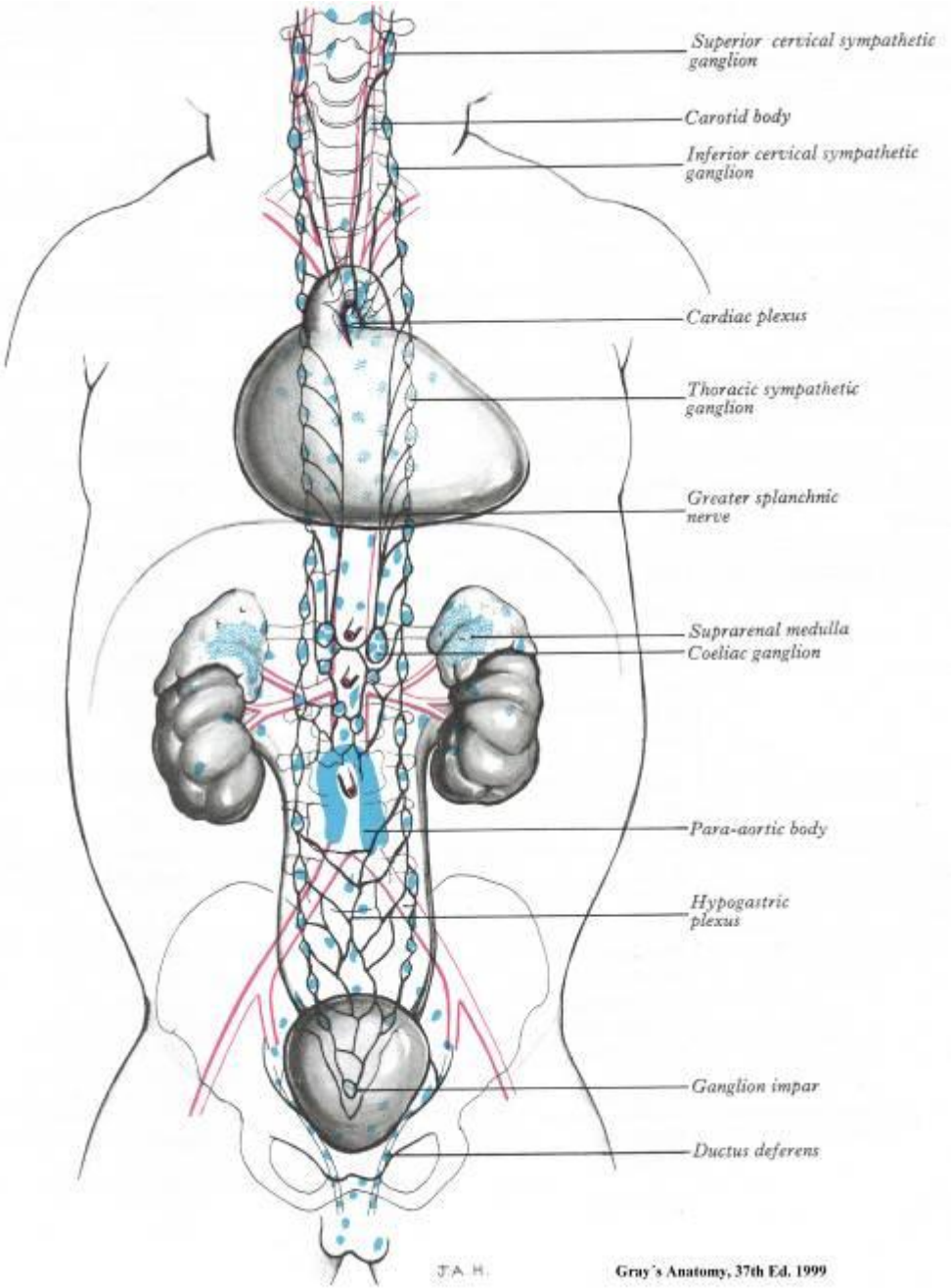



Afferent arteriole
Distal convoluted tubule
Macula densa
Lacis cells
Juxtaglomerular cell
Efferent arteriole
Bowman's capsule
Bowman's space
Glomerulus
Proximal convoluted tubule

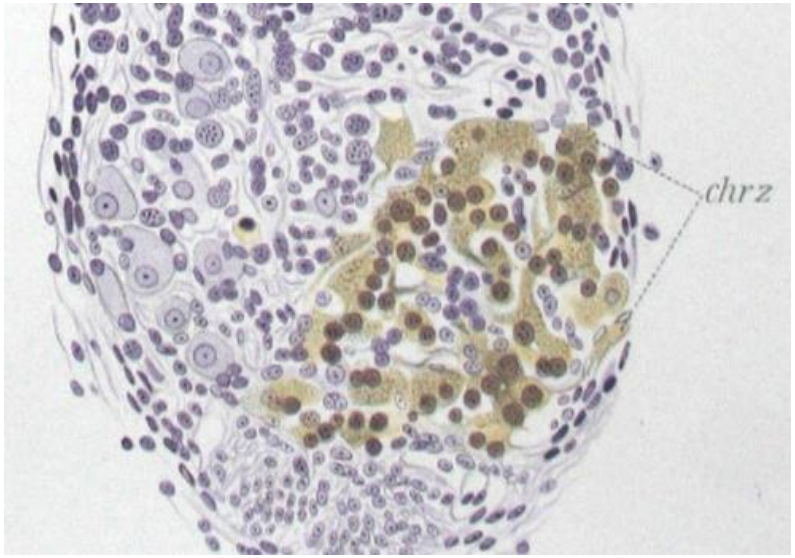
Paraganglia

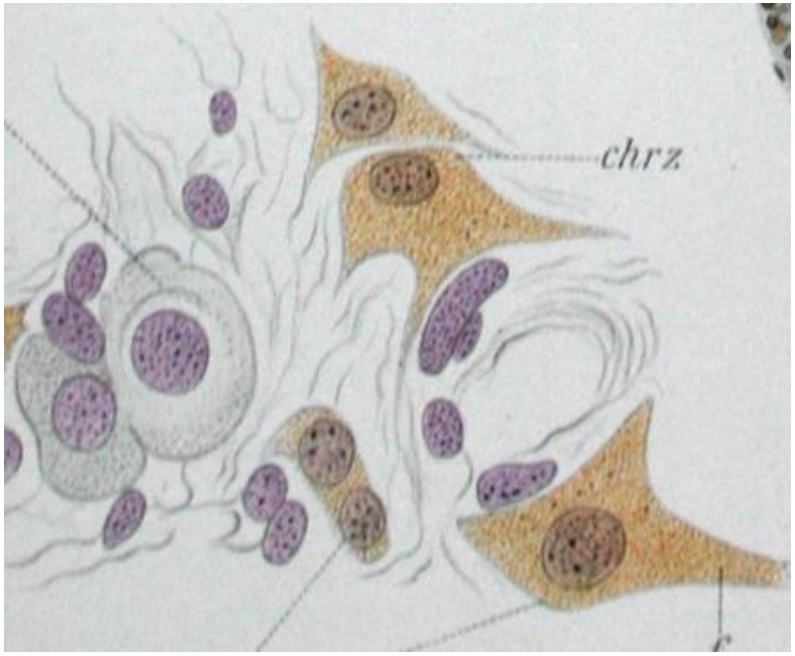
- chromaffin (former *paraganglia sympathica*)
  - paraganglion aorticum abdominale *Zuckerkandli*
  - glomus coccygeum *Luschkae*
  - glomus jugulare
- without chromaffin reaction (former *paraganglia parasympathica*)
  - baro- and chemoreceptors
  - *glomus caroticum* and *glomus aorticum*

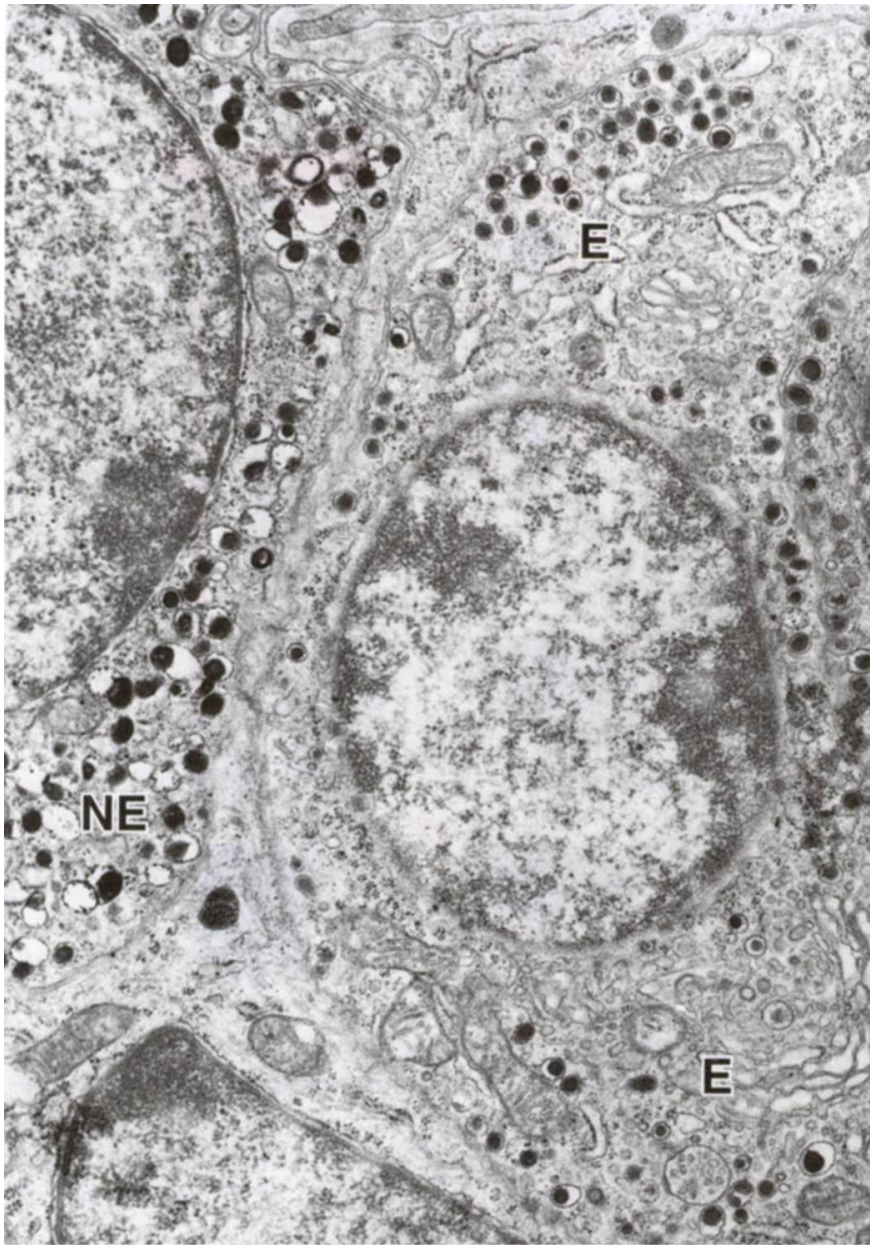

DIAPHRAGM
Inferior phrenic ar
Inf. vena cava
Left Kidney
Right Kidney
Aorta
TRANSVERSUS ABDOMINIS
QUADRATUS LUMBORUM
PSOAS MAJOR
ILIACUS


Superior cervical sympathetic ganglion
Carotid body
Inferior cervical sympathetic ganglion
Cardiac plexus
Thoracic sympathetic ganglion
Greater splanchnic nerve
Suprarenal medulla
Coeliac ganglion
Para-aortic body
Hypogastric plexus
Ganglion impar
Ductus deferens
J.A.H.
Gray's Anatomy, 37th Ed. 1999

Chromaffin cells of paraganglia







Disseminated endocrine cells

- endocrine cells of digestive and respiratory tract buňky (DNES, obsolete APUD)
- „closed“ type – „opened“ type
- contain frequent granula
- many types = plenty of hormones regulating functions of digestive and respiratory tracts