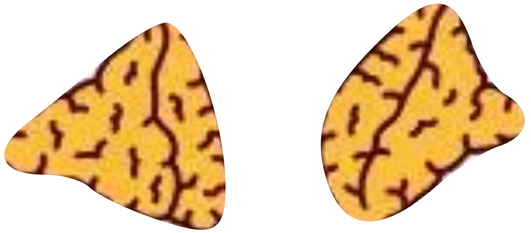
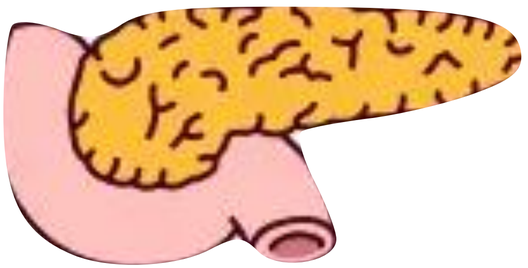
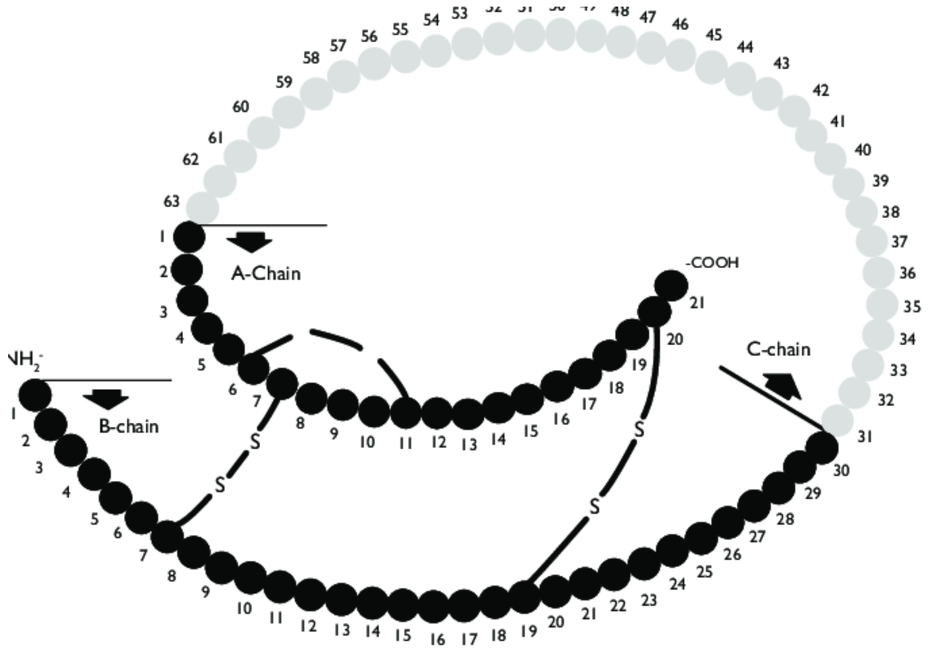



Endokrinní systém

MUDr. Andrea Felšöová

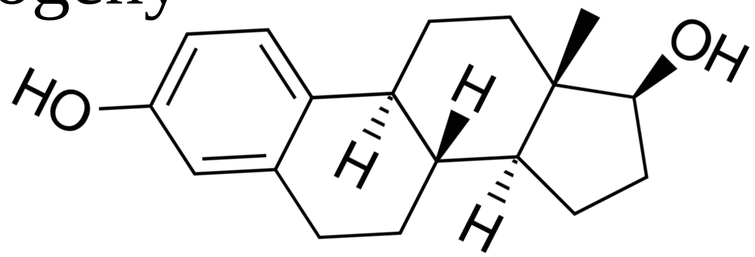




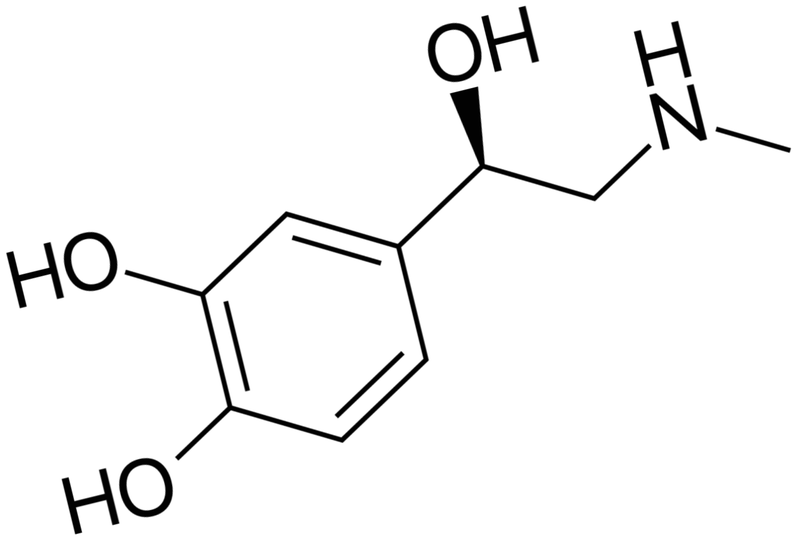

Žlázy s vnitřním vyměšováním
Glandulae endocrinae



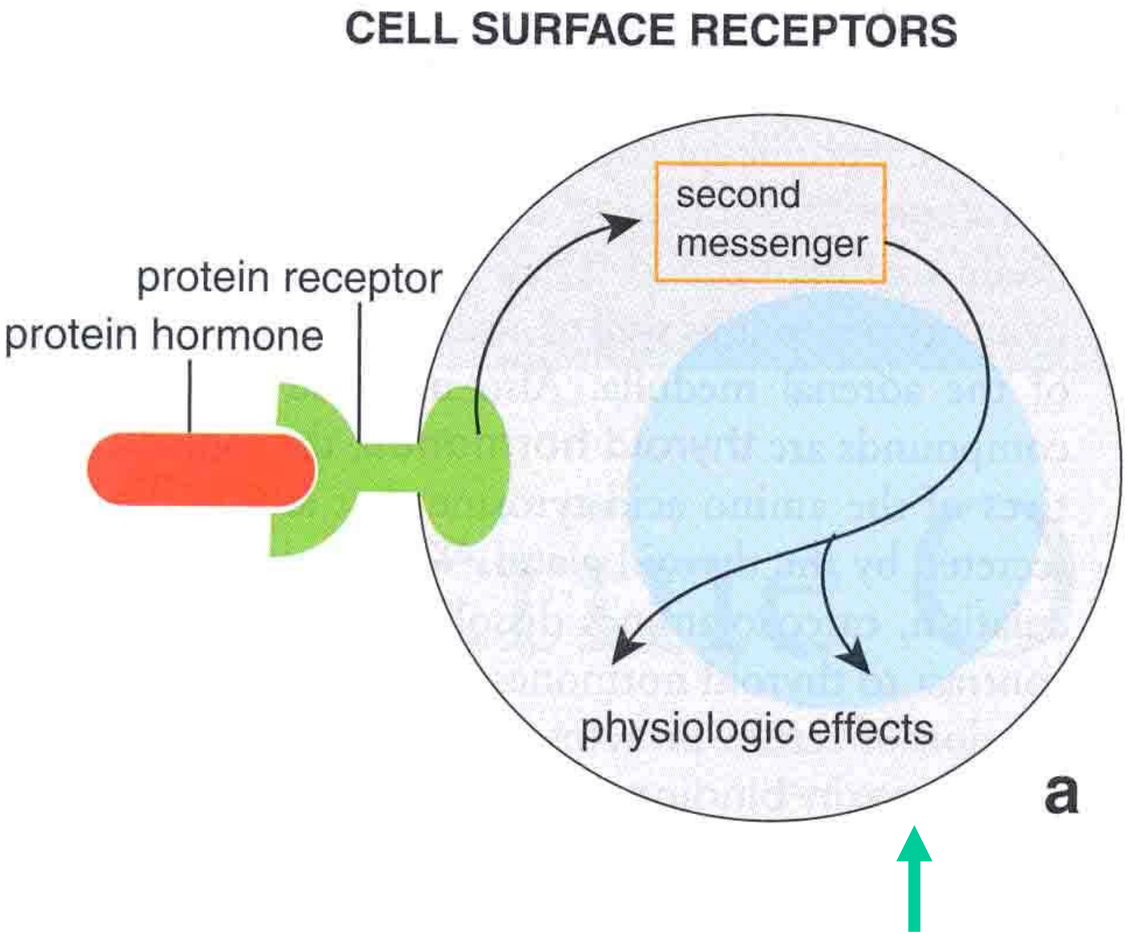
- jeden z regulačních systémů
- **hormon** (ř. hormao –pobízet, rozběhnout)
  - chemický posel tvořený žlázou s vnitřním vyměšováním a přenášený krví k cílovým orgánům

  - **proteiny** (polypeptid) – inzulín
  - **biogenní aminy** – adrenalin
  - **steroidy** – estrogeny

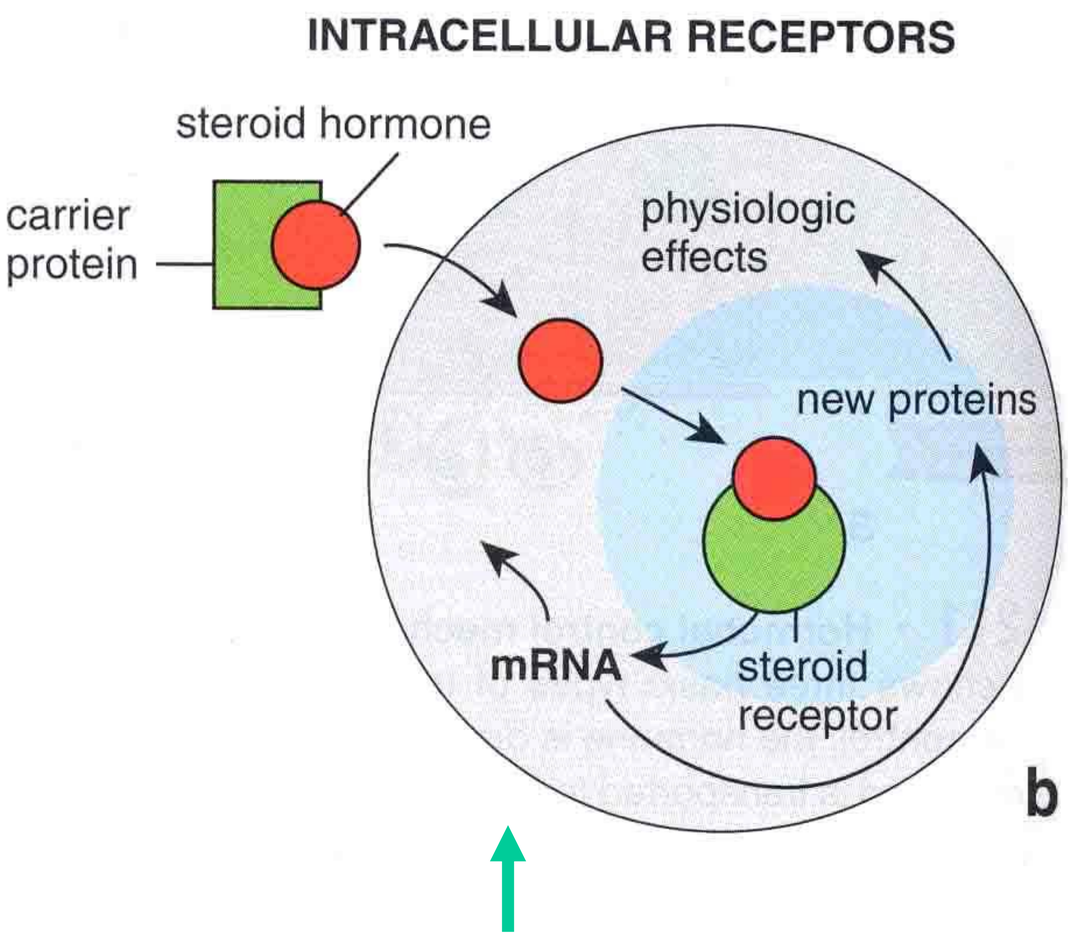




Hormonální signalizace

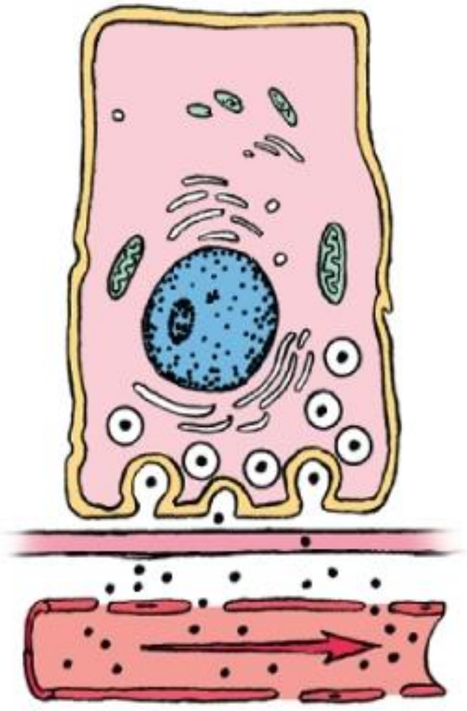


peptidy a proteiny
biogenní aminy

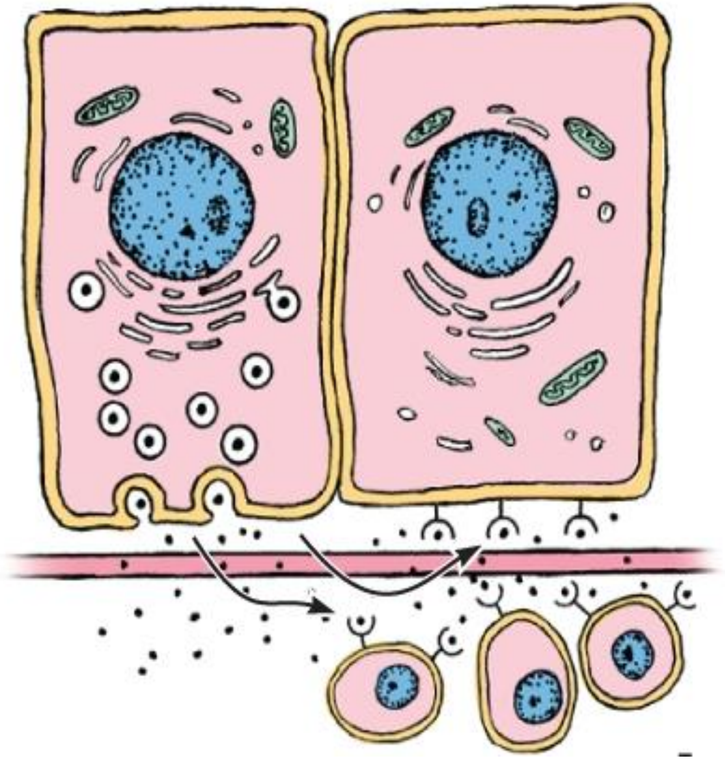


steroidy
a další malé
hydrofóbní molekuly

Působení hormonu na cílovou strukturu (orgán, buňku)

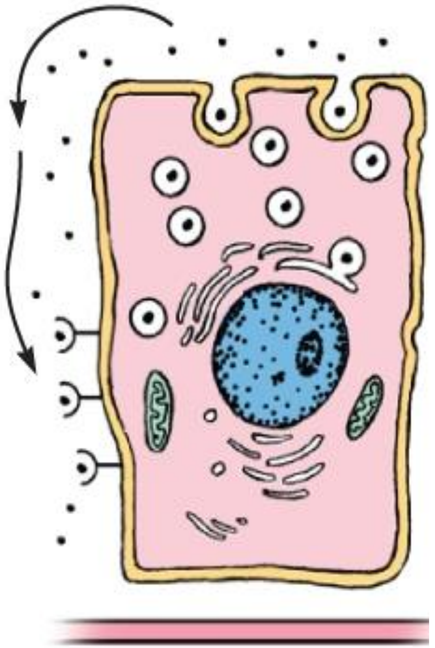


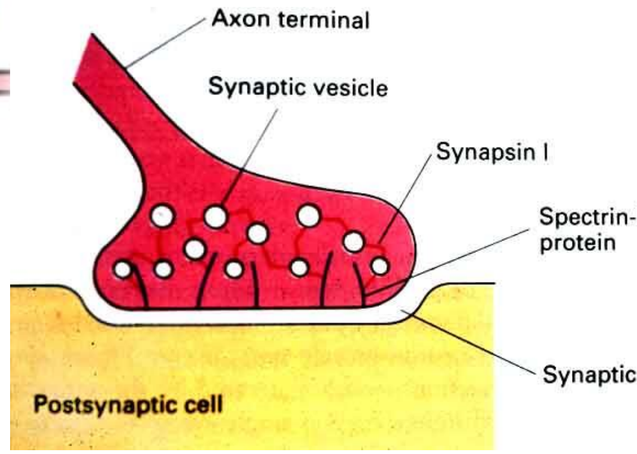
endokrinní sekrece



parakrinní sekrece

autokrinní sekrece



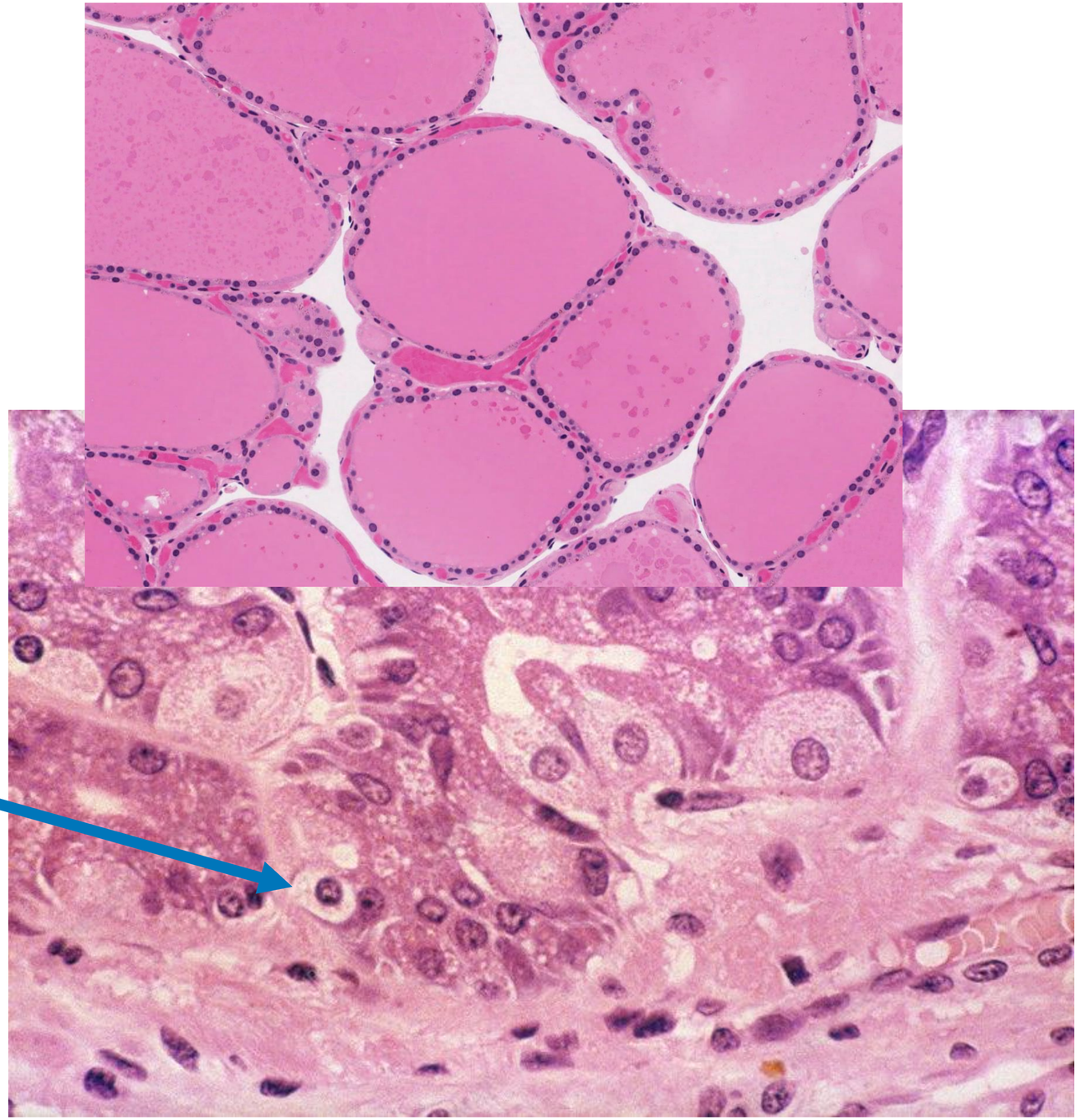


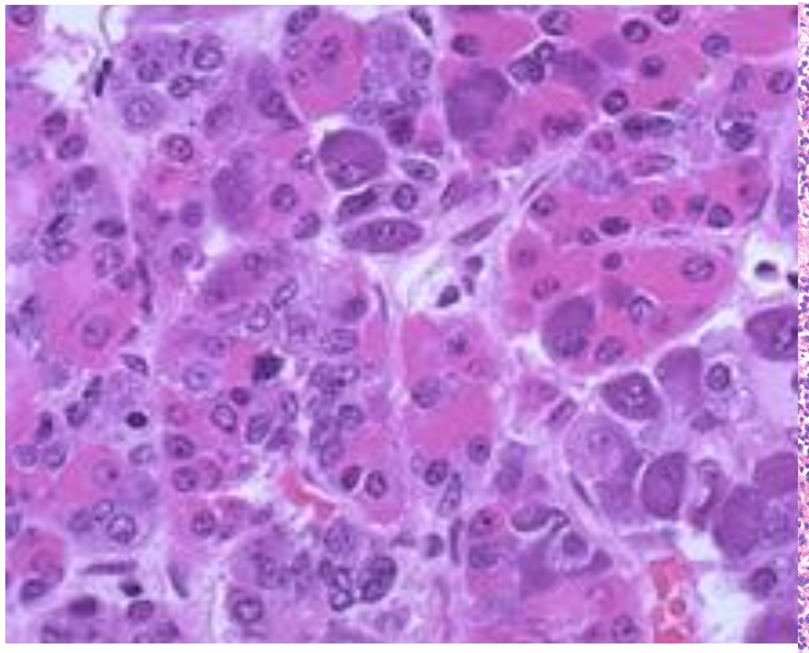
synaptická sekrece

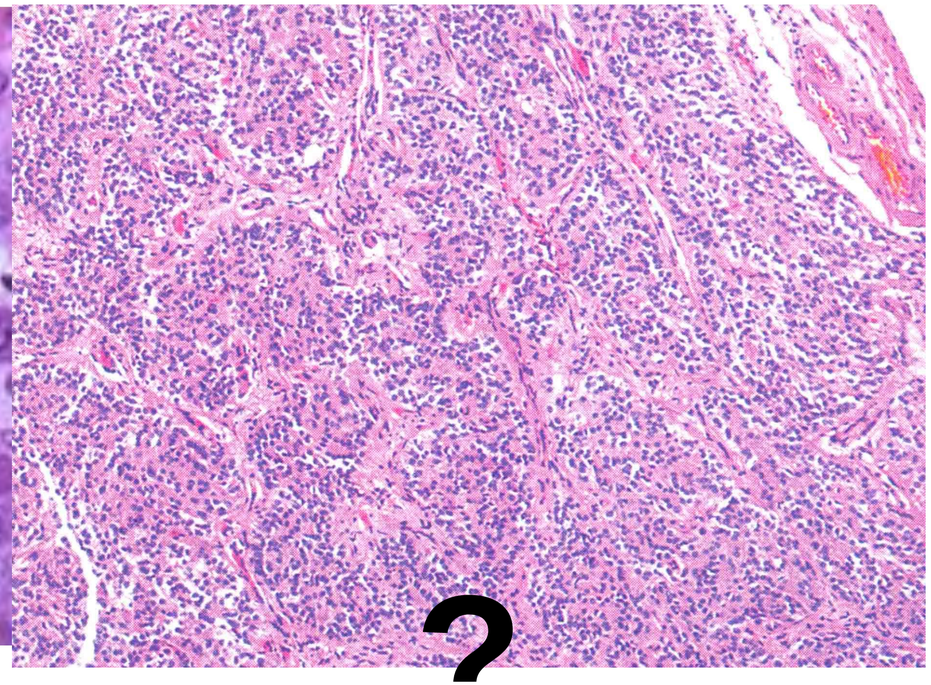
Žlázy s vnitřním vyměšováním

- žlázy

- roztroušené (diseminované) buňky







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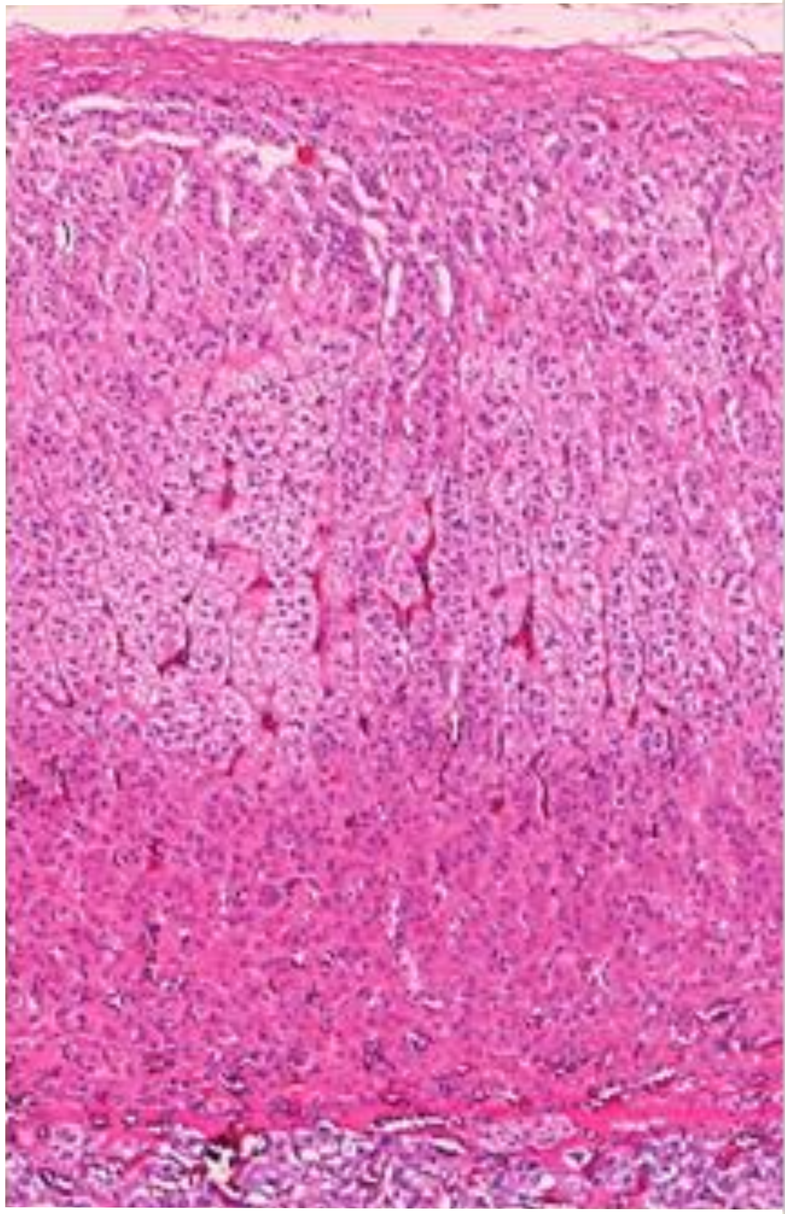
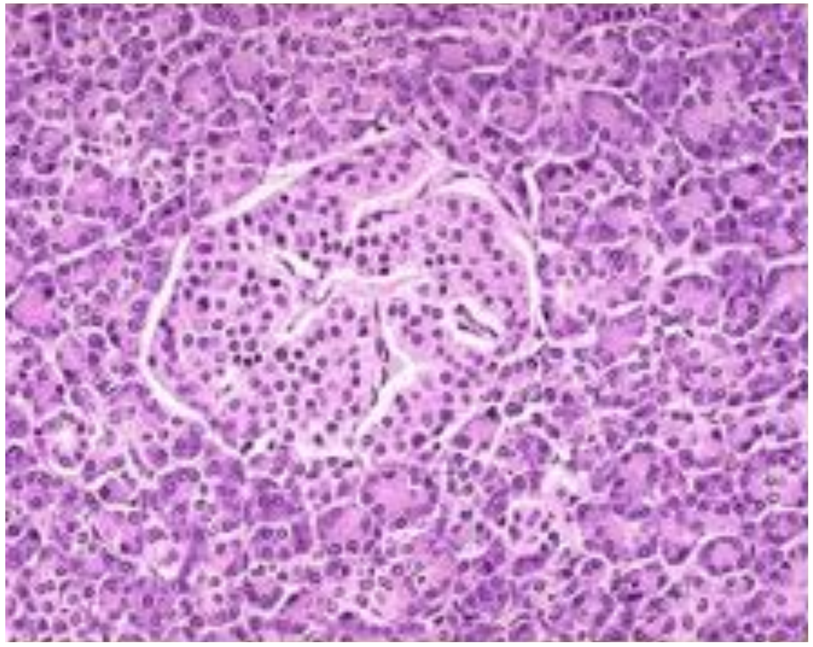
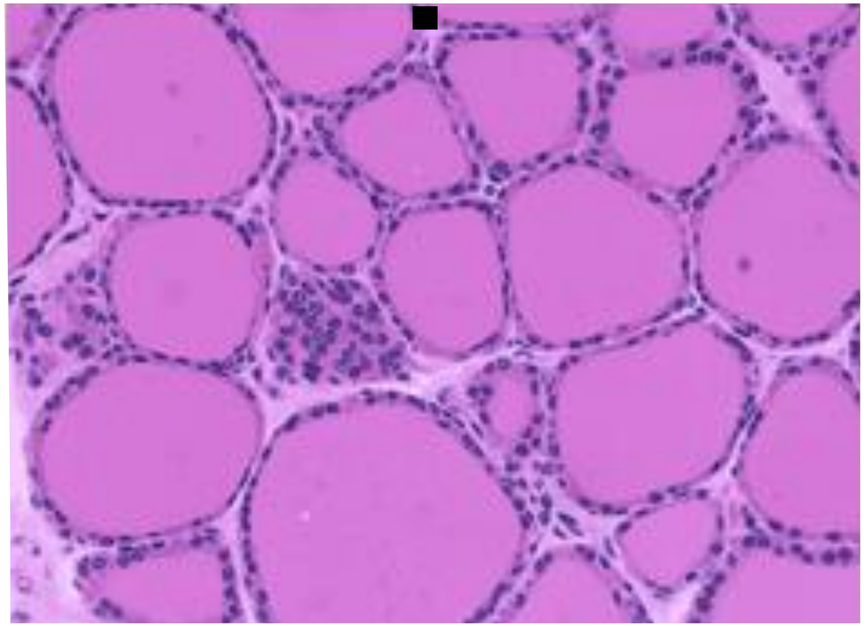






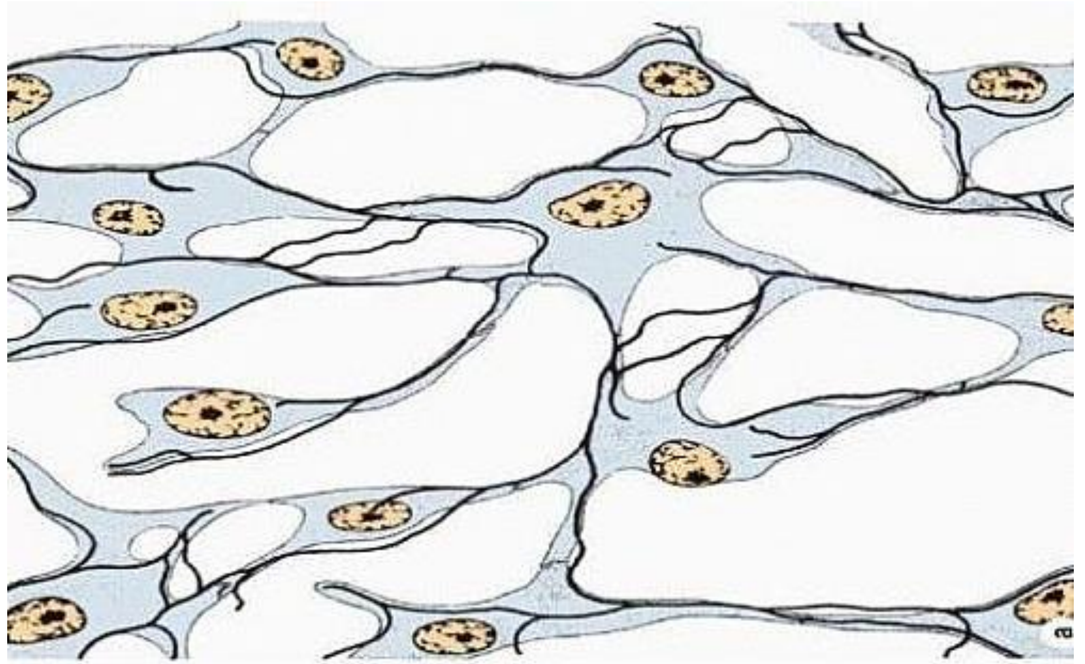
Endokrinní žlázy

- **hypothalamus** + **hypofýza** (adenohypofýza + neurohypofýza)
- **šišinka** (corpus pineale, epifýza)
- **štítná žláza**
- **příštítné žlázy**
- **nadledviny** (kůra a dřeň)
- **Langerhansovy ostrůvky** pankreatu

- endokrinní buňky v srdci, ledvinách, gonádách, placentě
- buňky DNES (epitel trávicího a dýchacího systému)
- endotelové buňky, hepatocyty

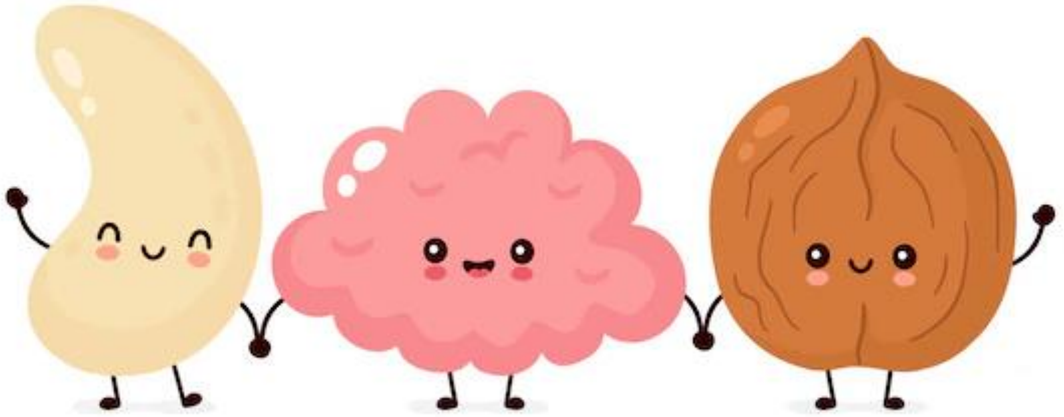
Obecné stavební schéma

- **stroma** – retikulární vazivo



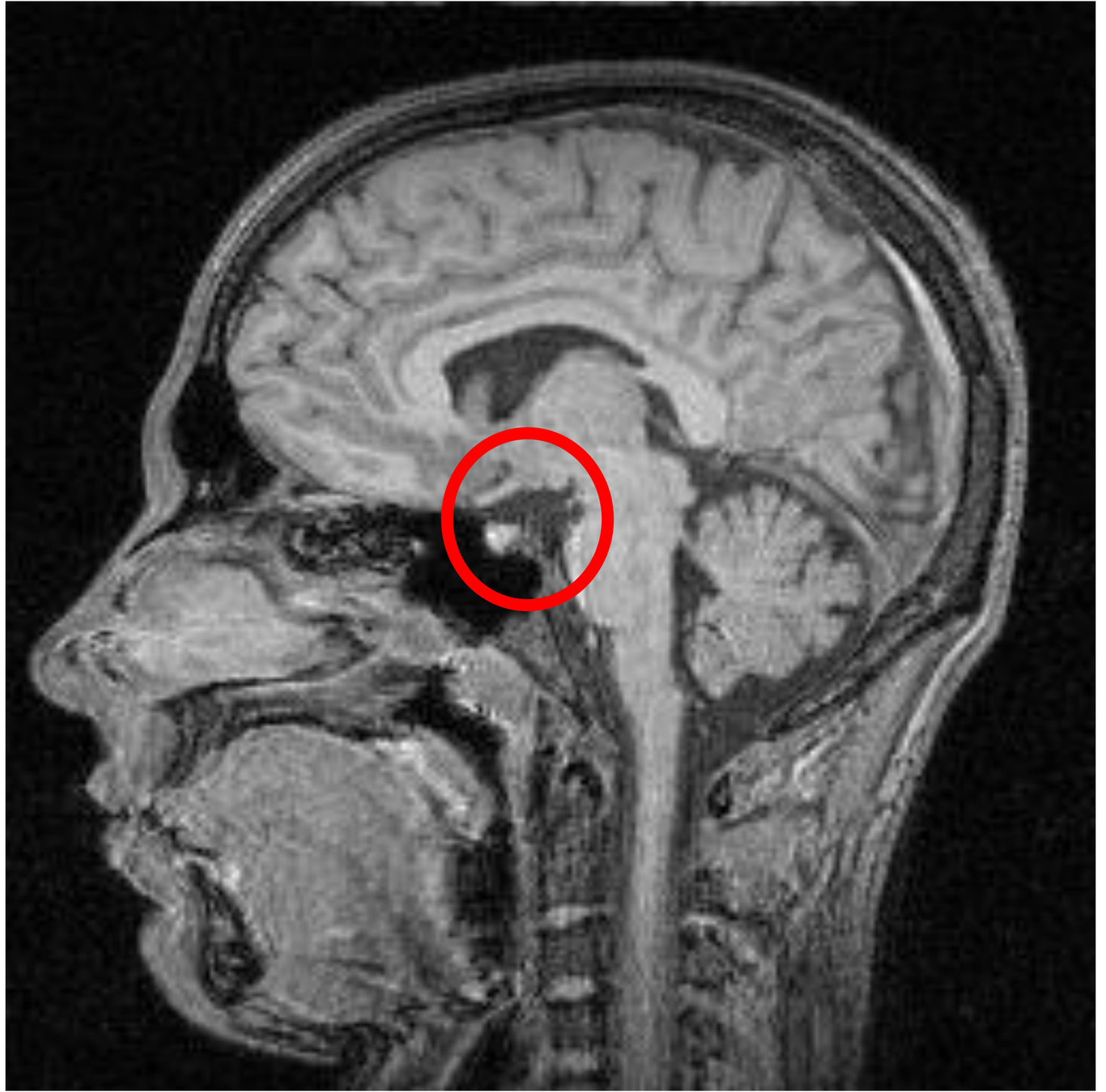
- **parenchym**
  - trámčitý epitel (adenohypofýza, příštítné žlázy, nadledviny, Langerhansovy ostrůvky)
  - plošný epitel uspořádaný do folikulů (štítná žláza)
  - specializovaná nervová tkáň (neurohypofýza, epifýza)

Hypothalamo-hypofyzární systém



Hypothalamus + hypophysis

Systema hypothalamo-hypophysiale

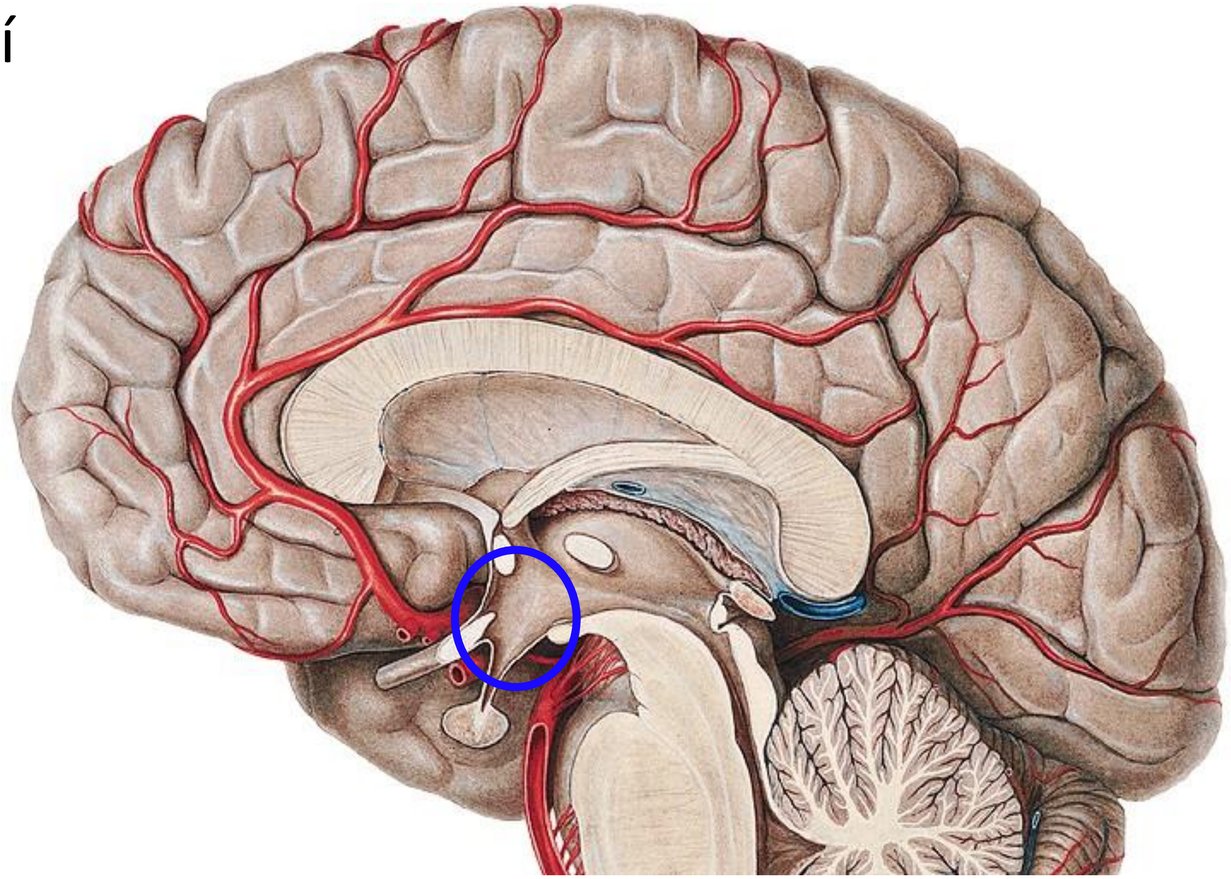


Podhrbolí – *Hypothalamus*

- bazální část mezimozku (*diencephalon),* bazálně od III. komory

- funkce
  - sběrné centrum informací z těla i okolí
  - nejvyšší autonomní ústředí
  - součást limbického systému
  - řídí ostatní žlázy s vnitřním vyměšováním

- corpora mammillaria, tuber cinereum, <u>infundibulum, hypophysis</u>



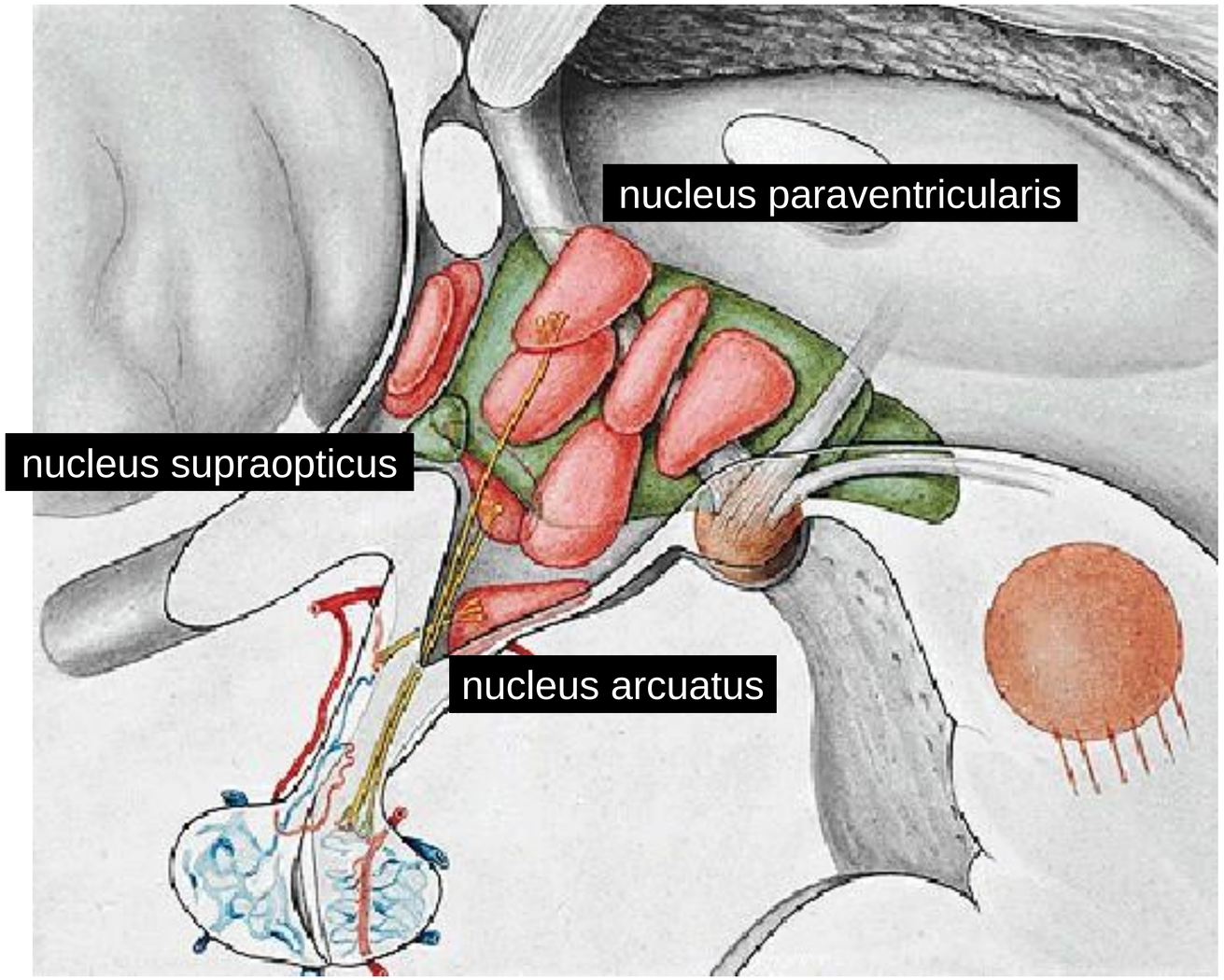
Hypothalamus

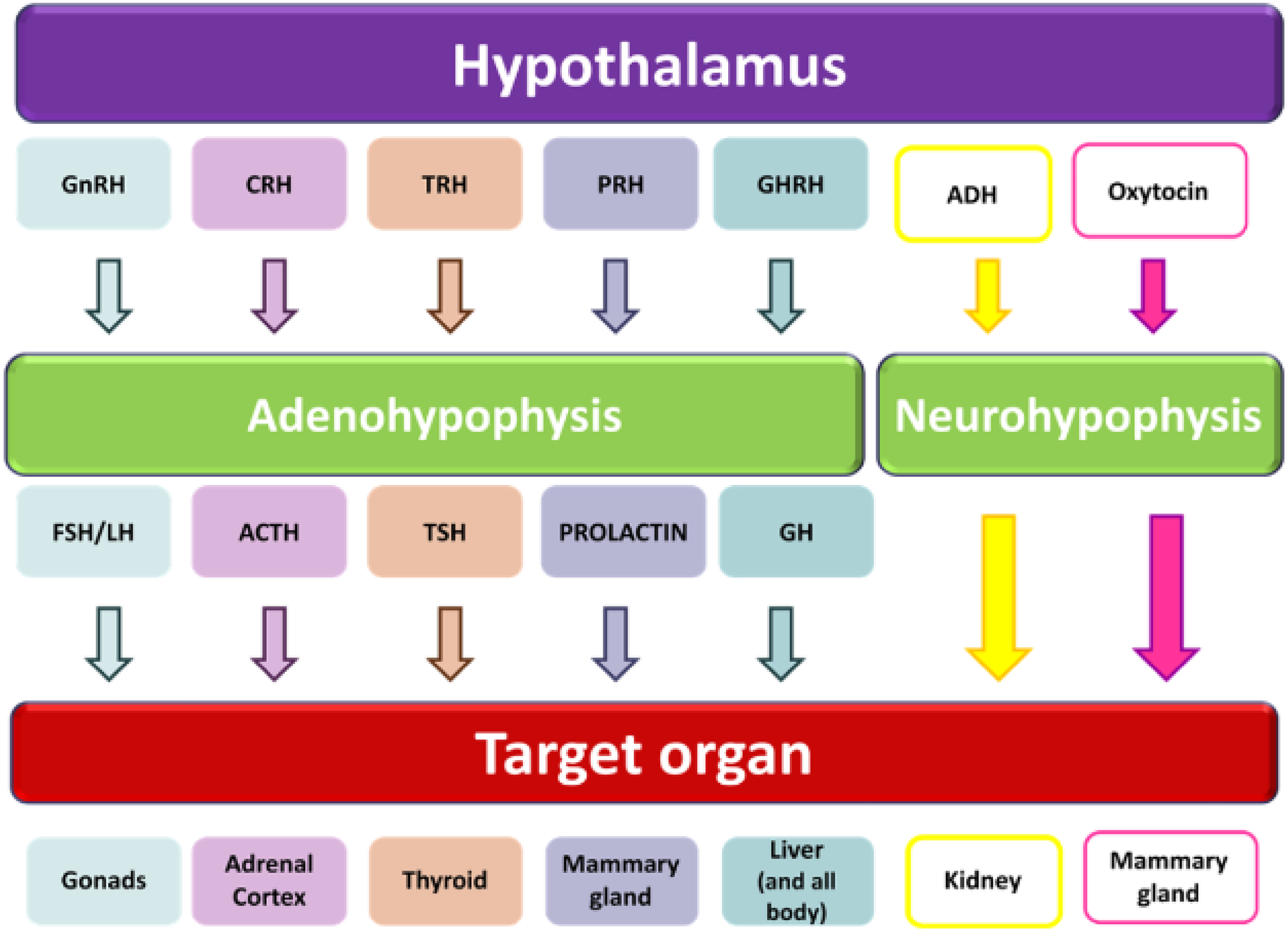
- přední hypothalamus
  – **ncl. paraventricularis + supraopticus – oxytocin a vazopresin (ADH)**
  (+ ncl. chiasmaticus, preopticus, anteriorní jádra a suprachiasmatická jádra)

- střední hypothalamus (tuber cinereum)
  – (+ ncl. DM a VM)
  – **ncl. arcuatus** a okolí – řízení adenohypofýzy
    - uvolňovací (releasing) = **liberiny**
      – hormony **SRH, PRH, GnRH, TRH, CRH**

    - tlumivé (inhibiting)= **statiny**
      – hormony **somatostatin, PIH** (= dopamin)

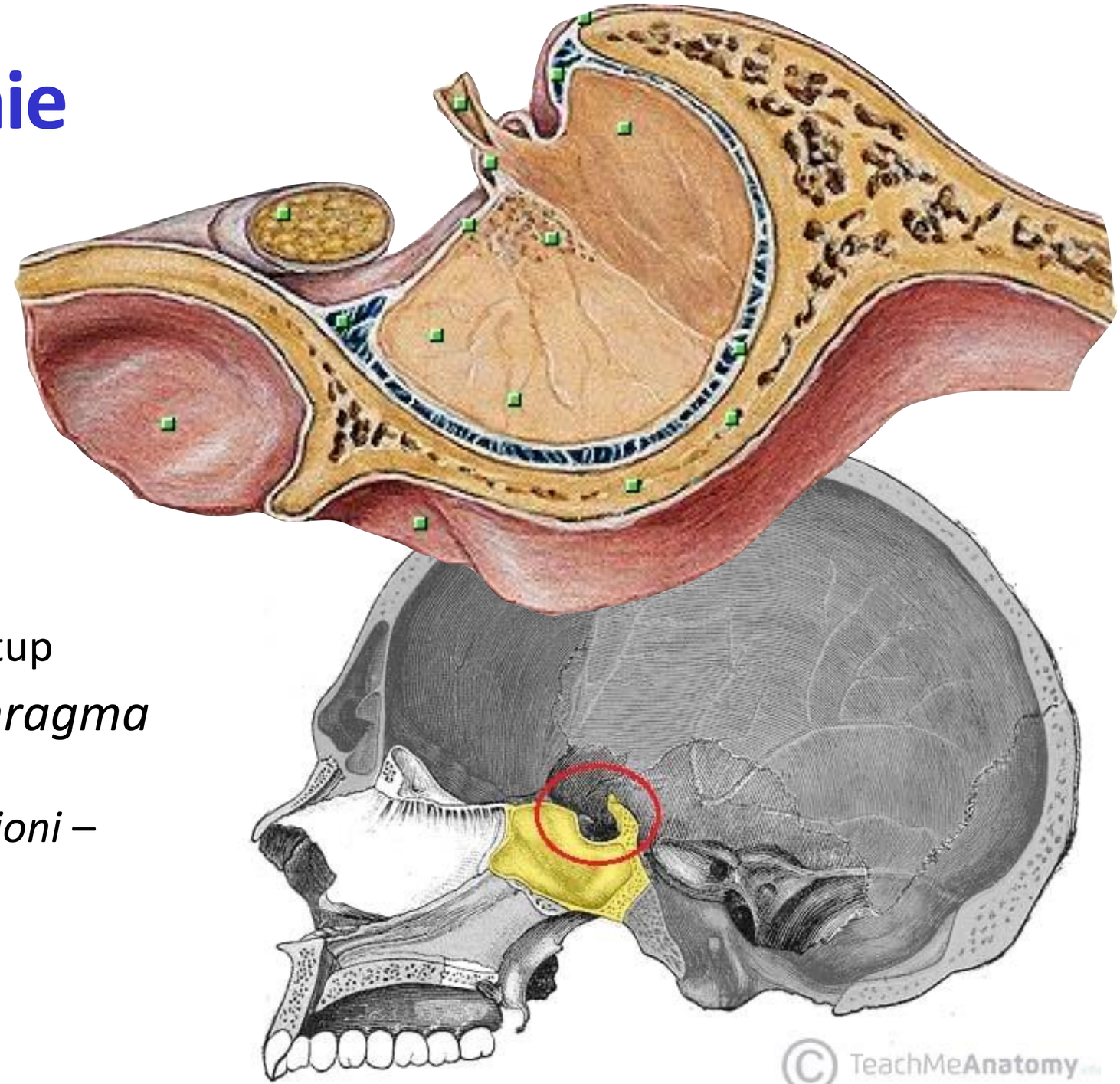
- zadní (kaudální) hypothalamus (corpora mammillaria, ncl. posterior)

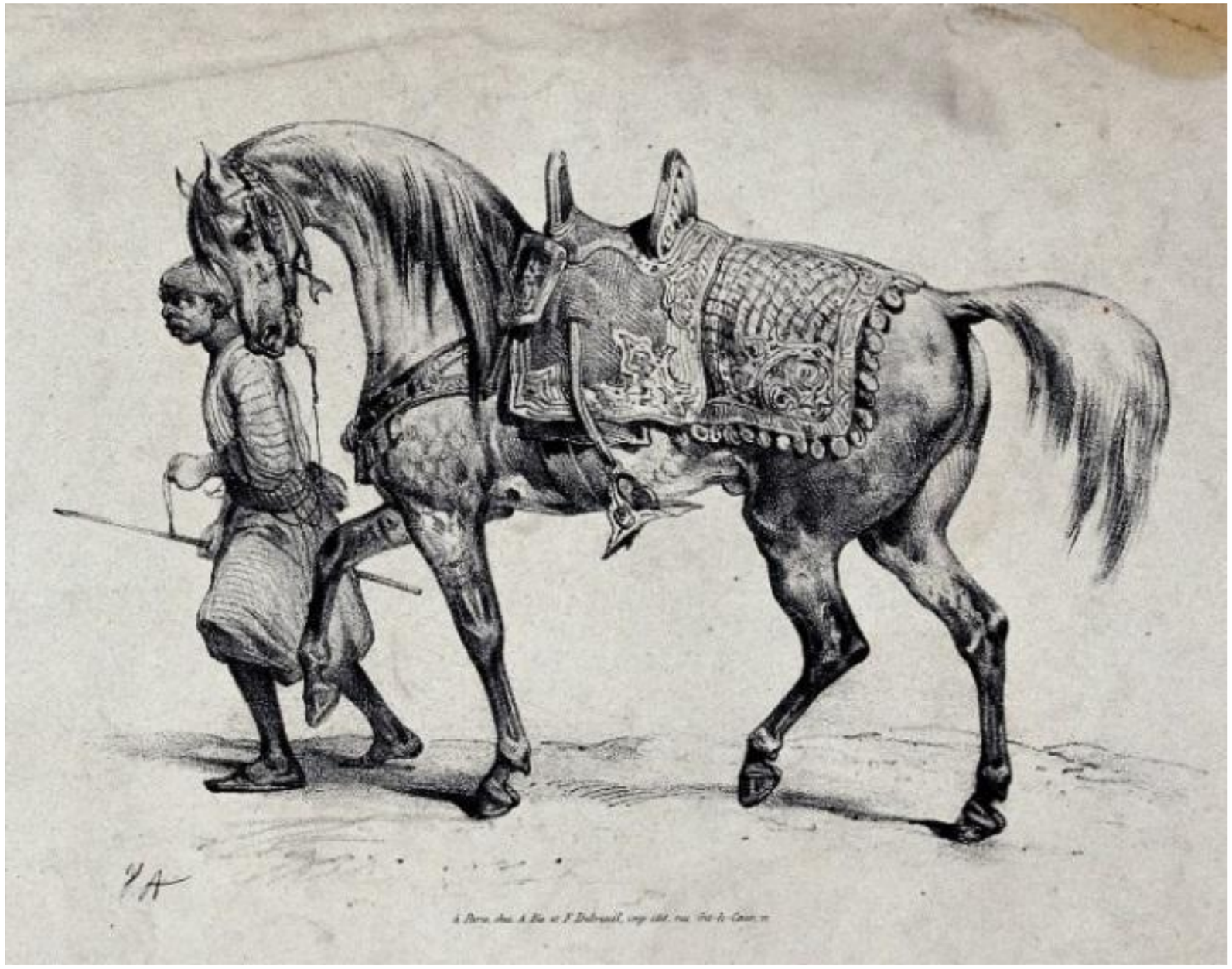



Hypothalamus
GnRH
CRH
TRH
PRH
GHRH
ADH
Oxytocin
Adenohypophysis
Neurohypophysis
FSH/LH
ACTH
TSH
PROLACTIN
GH
Target organ
Gonads
Adrenal Cortex
Thyroid
Mammary gland
Liver (and all body)
Kidney
Mammary gland

Hypofýza – anatomie

„dvojitá žláza“
  - dvě rozdílné tkáně
- tvoří ji dva laloky
  - přední = adenohypofýza
  - zadní = neurohypofýza
- uložena v *sella turcica ossis sphenoidalis*
  - transsfenoidální operační přístup
- kryta tvrdou plenou – *diaphragma sellae*
  - foramen diaphragmatis *Pacchioni* – obsahuje podvěskovou stopku (*infundibulum*)

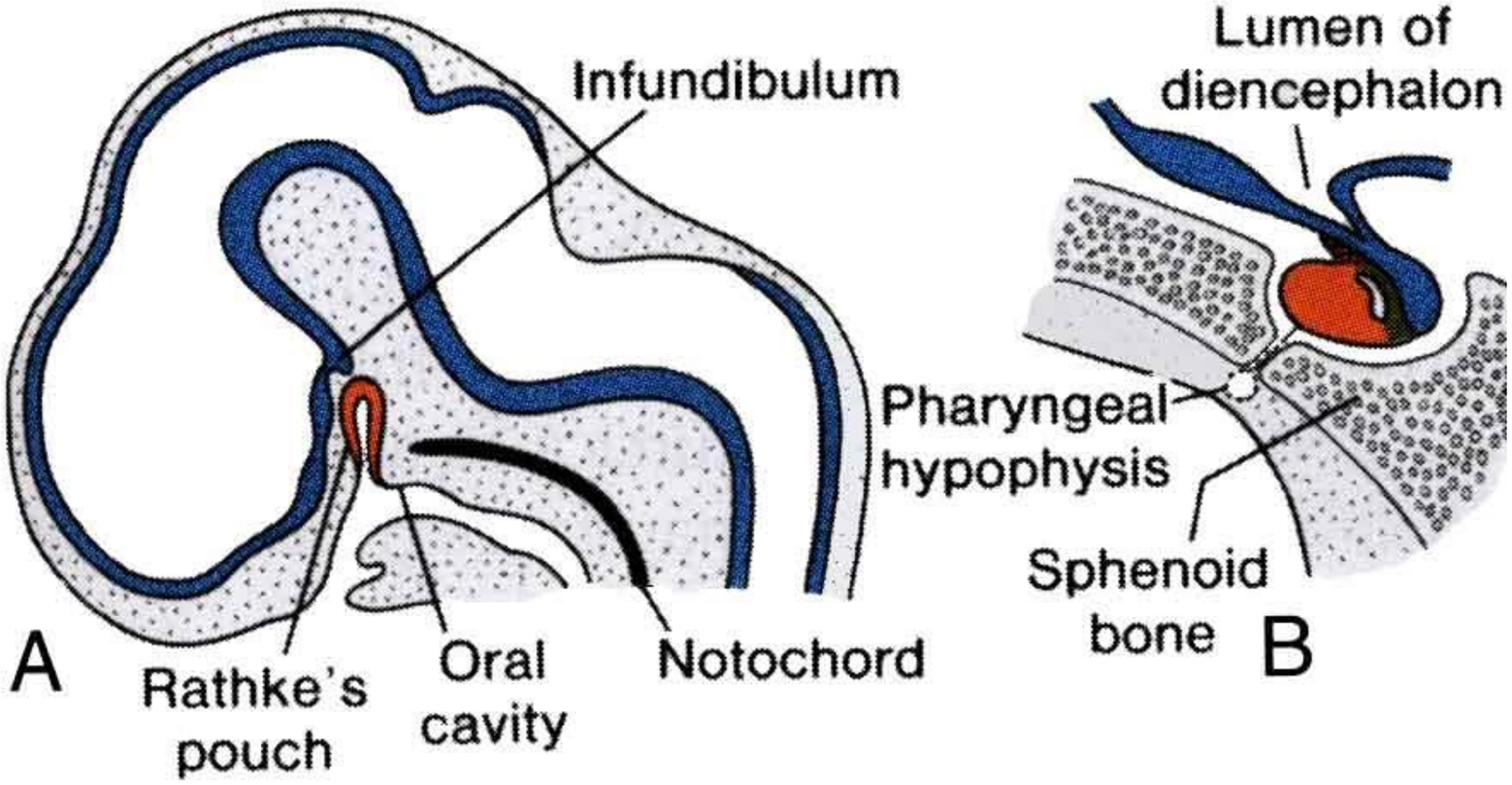


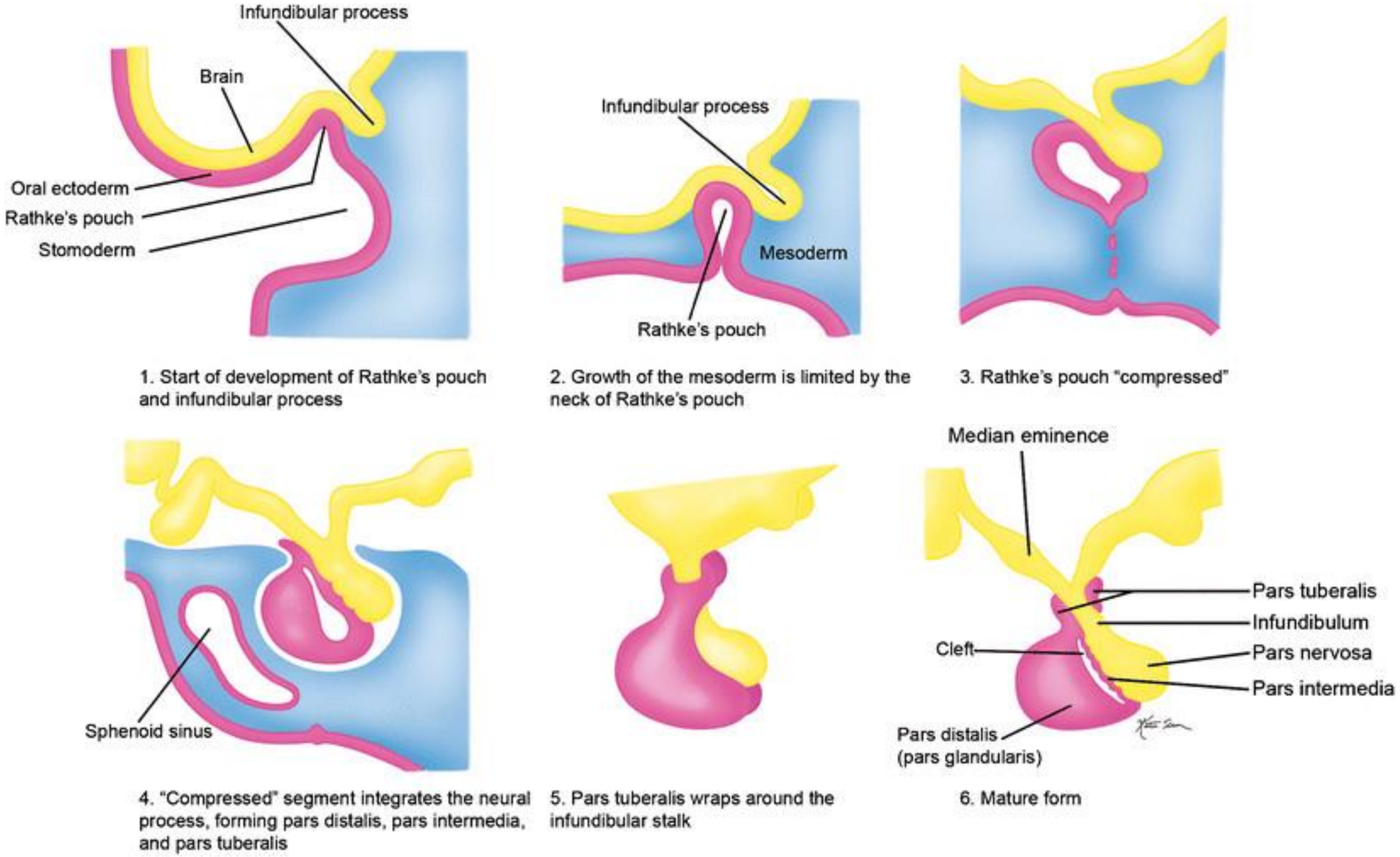


Tekiner, Halil. (2015). A cultural history of the Turkish saddle. Journal of Turkish Studies. 10. 319-319. 10.7827/TurkishStudies.8071.

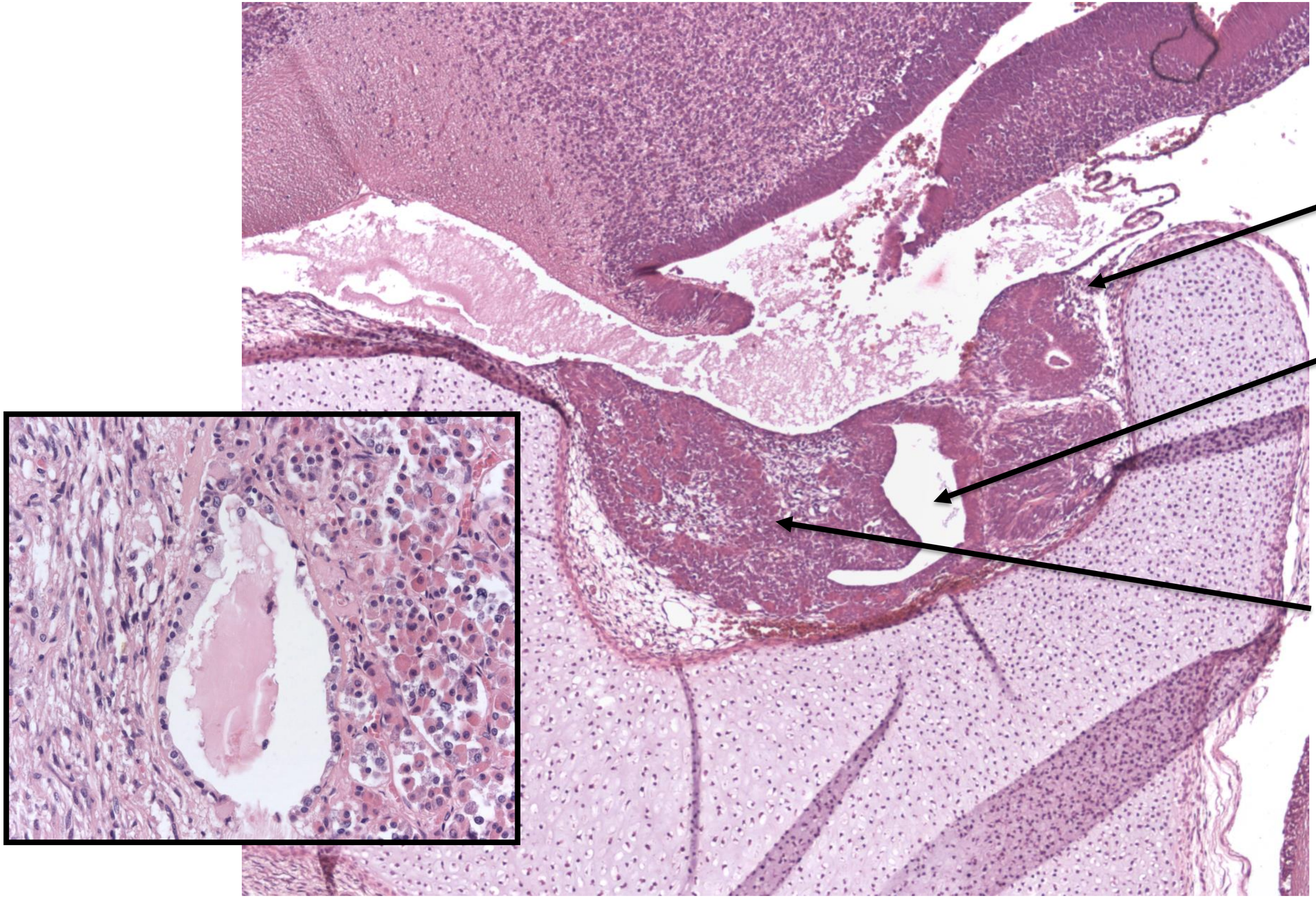
Hypofýza – vývoj

- **Rathkeho** výchlipka - **ektoderm**
  - 3. týden: ve stropě ústní dutiny (*stomodeum*)
  - výchlipka směrem k mezimozku
  - adenohypofýza
- výchlipka báze mezimozku
  - neurohypofýza
  - diferenciace v pituicyty (glie)

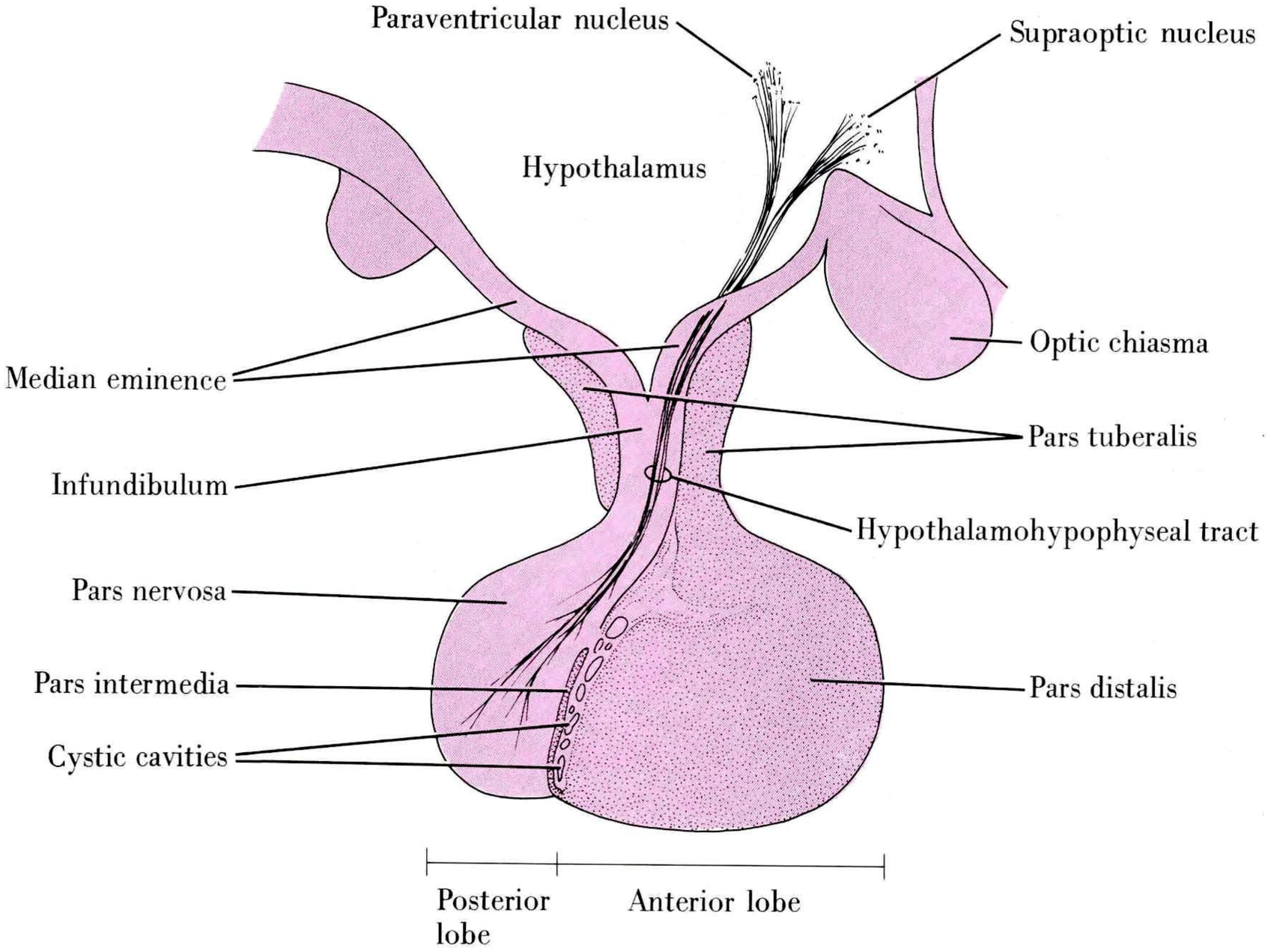


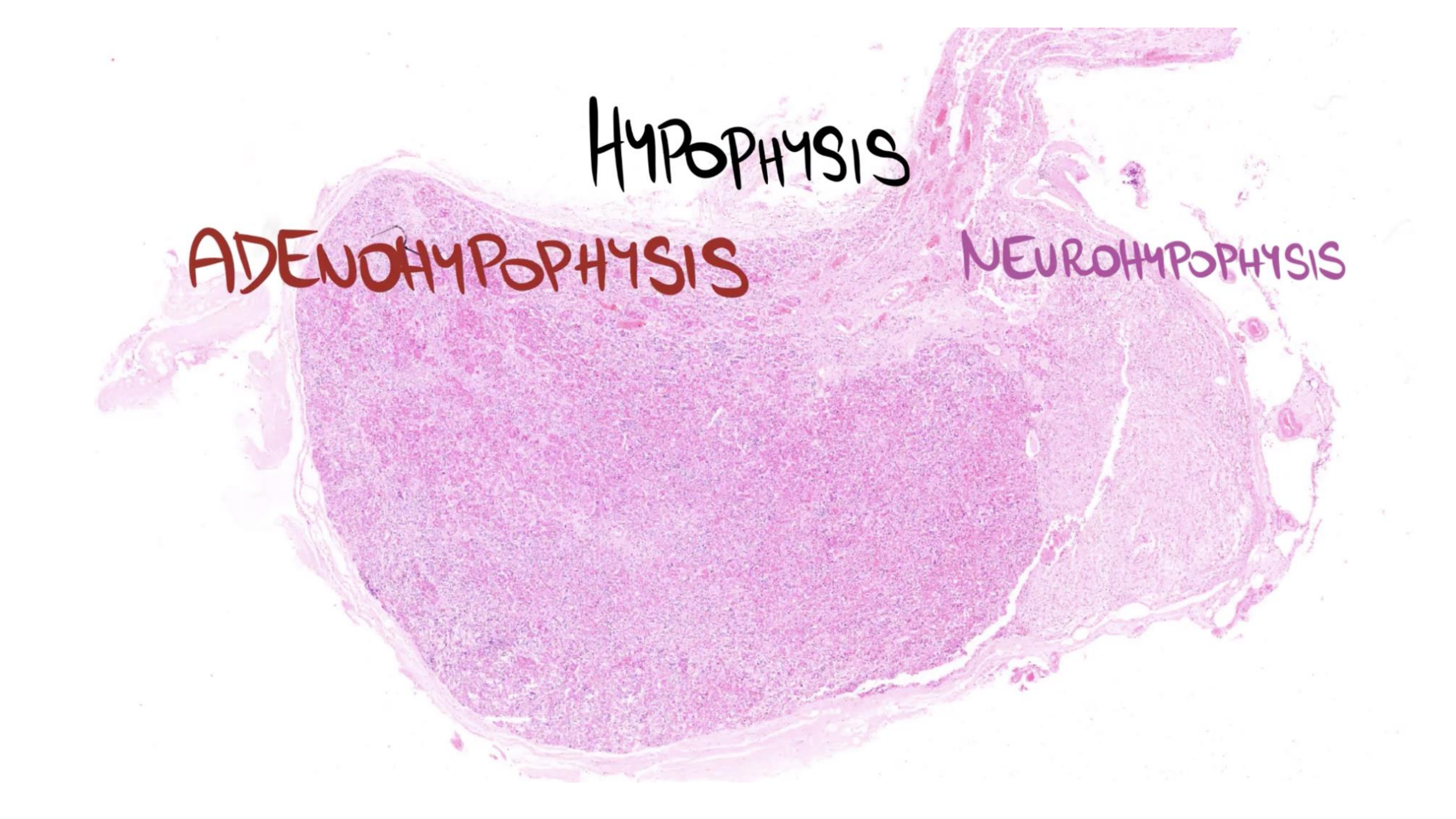


Shields, Rachel & Mangla, Rajiv & Almast, Jeevak & Meyers, Steven. (2015). Magnetic resonance imaging of sellar and juxtasellar abnormalities in the paediatric population: an imaging review. Insights into imaging. 6. 10.1007/s13244-015-0401-5.

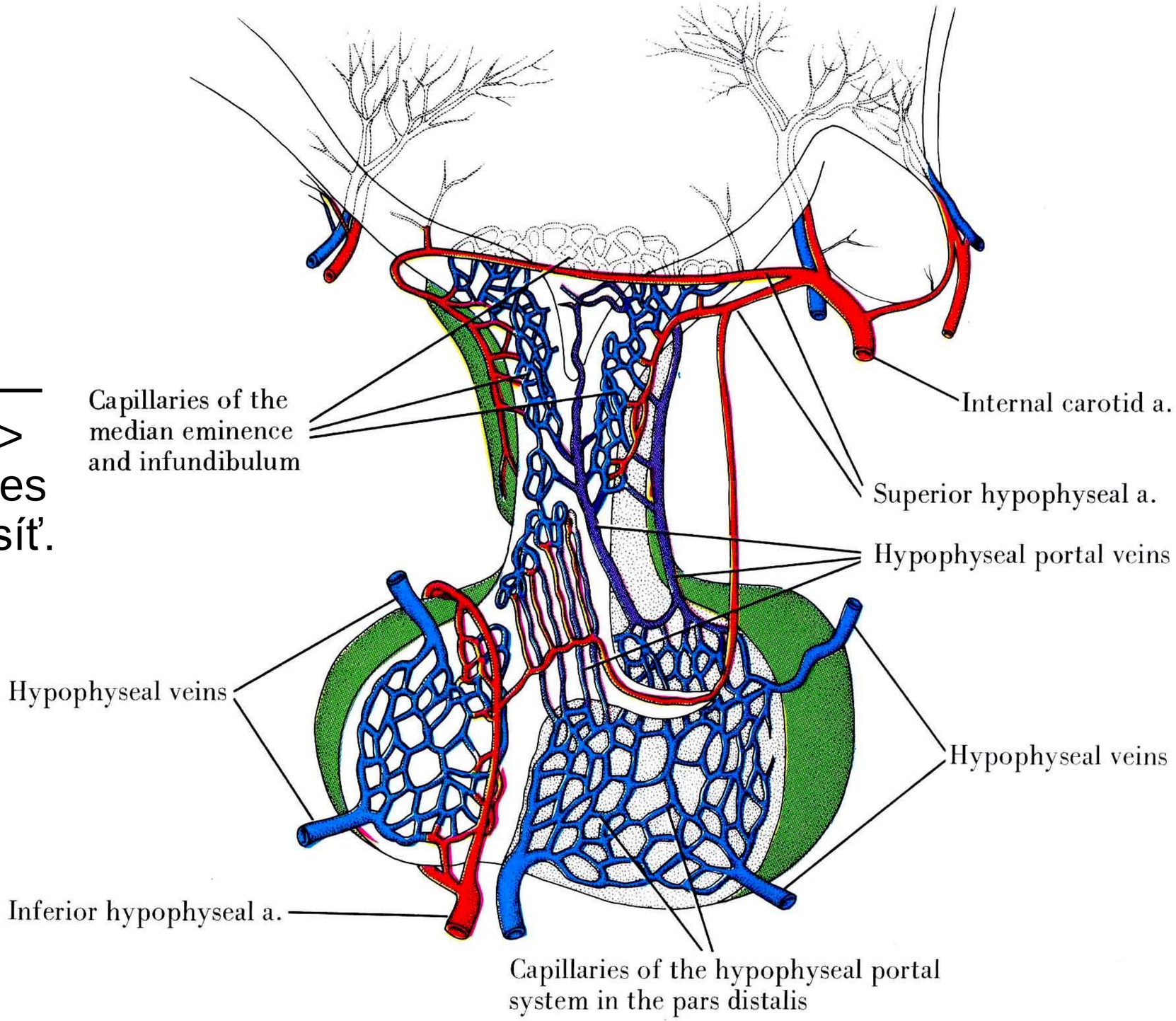

Neurohypophysis
Rathke´s pouch - lumen
Adenohypophysis

Hypofýza (glandula pituitaria)




HYPOPHYSIS
ADENOHYPOPHYSIS
NEUROHYPOPHYSIS

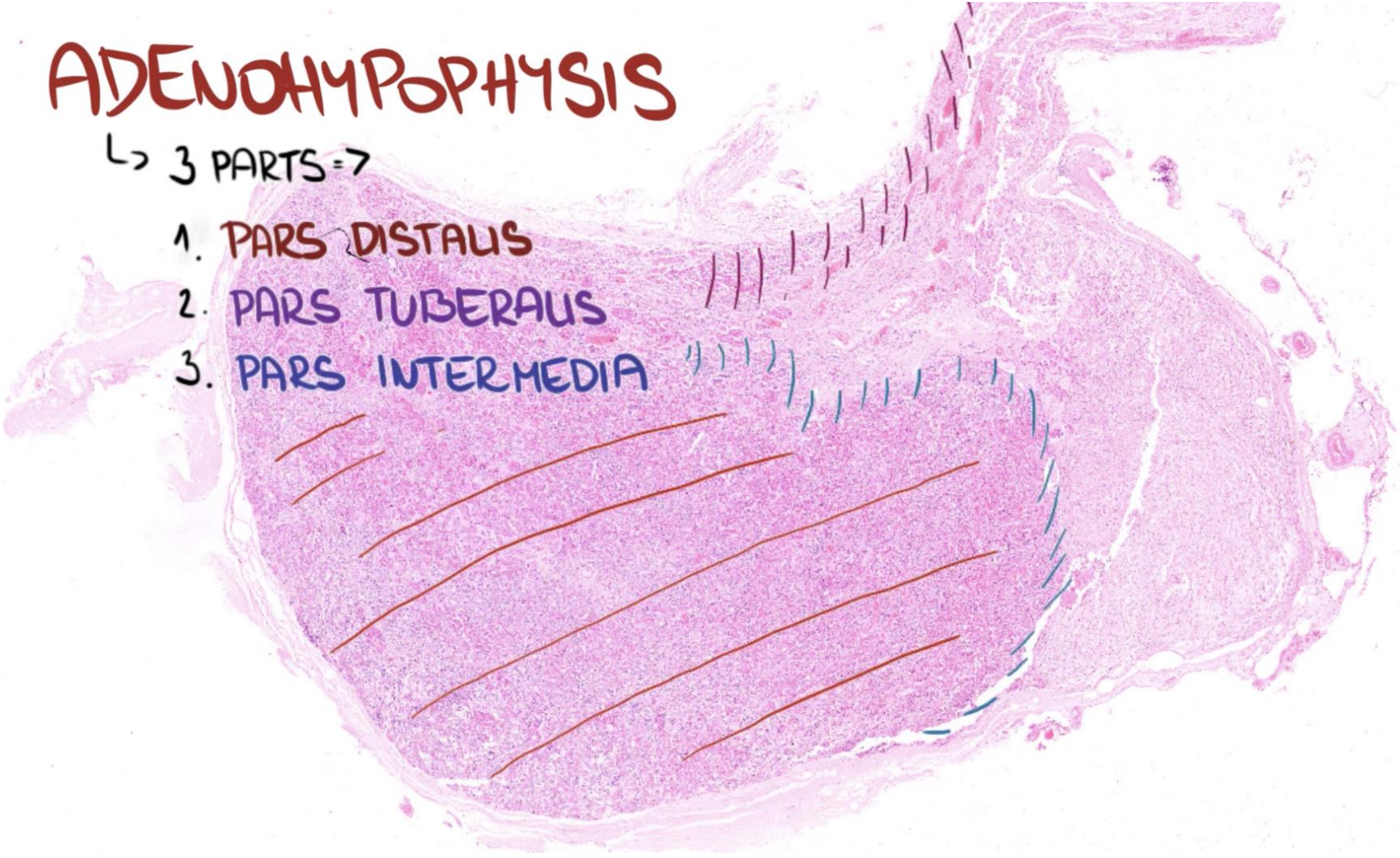
- **a.hypophysialis inf.** - pars cavernosa ACI -> neurohypofýza
- **a.hypophysialis sup.** - pars communicans ACI — > primární kapilární síť -> vv. hypophysiales portales -> sekundární kapilární síť.
- **vv. hypophysiales** -> sinus cavernosus



ADENOHYPOPHYSIS

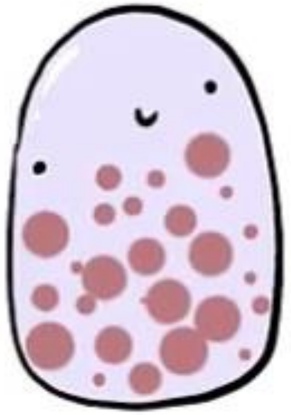
↳ 3 PARTS =>

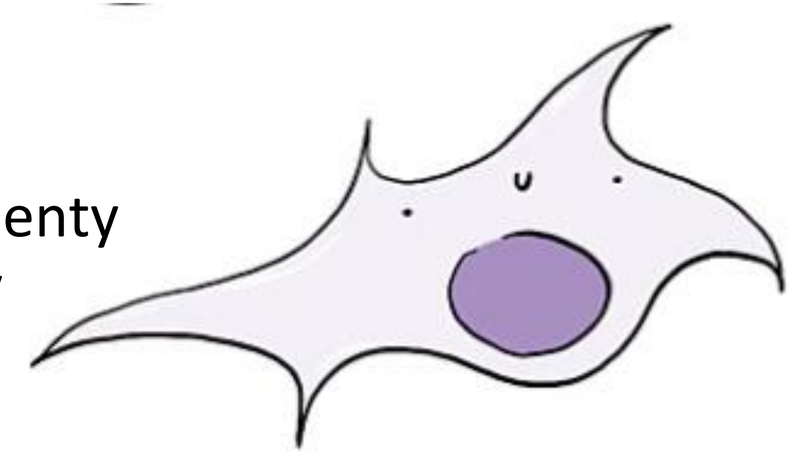
1. PARS DISTALIS
2. PARS TUBERALIS
3. PARS INTERMEDIA



Pars distalis adenohypophysis

- provazce epitelových buněk
- mezi nimi fenestrované vlásečnice
- na HE 3 typy buněk
  - acidofilní (jednoduché proteiny)
  - bazofilní (glykoproteiny)
    - PAS-pozitivní
  - chromofóbní
    - bez granul
    - nediferencované elementy
    - **Folikulostelární** buňky

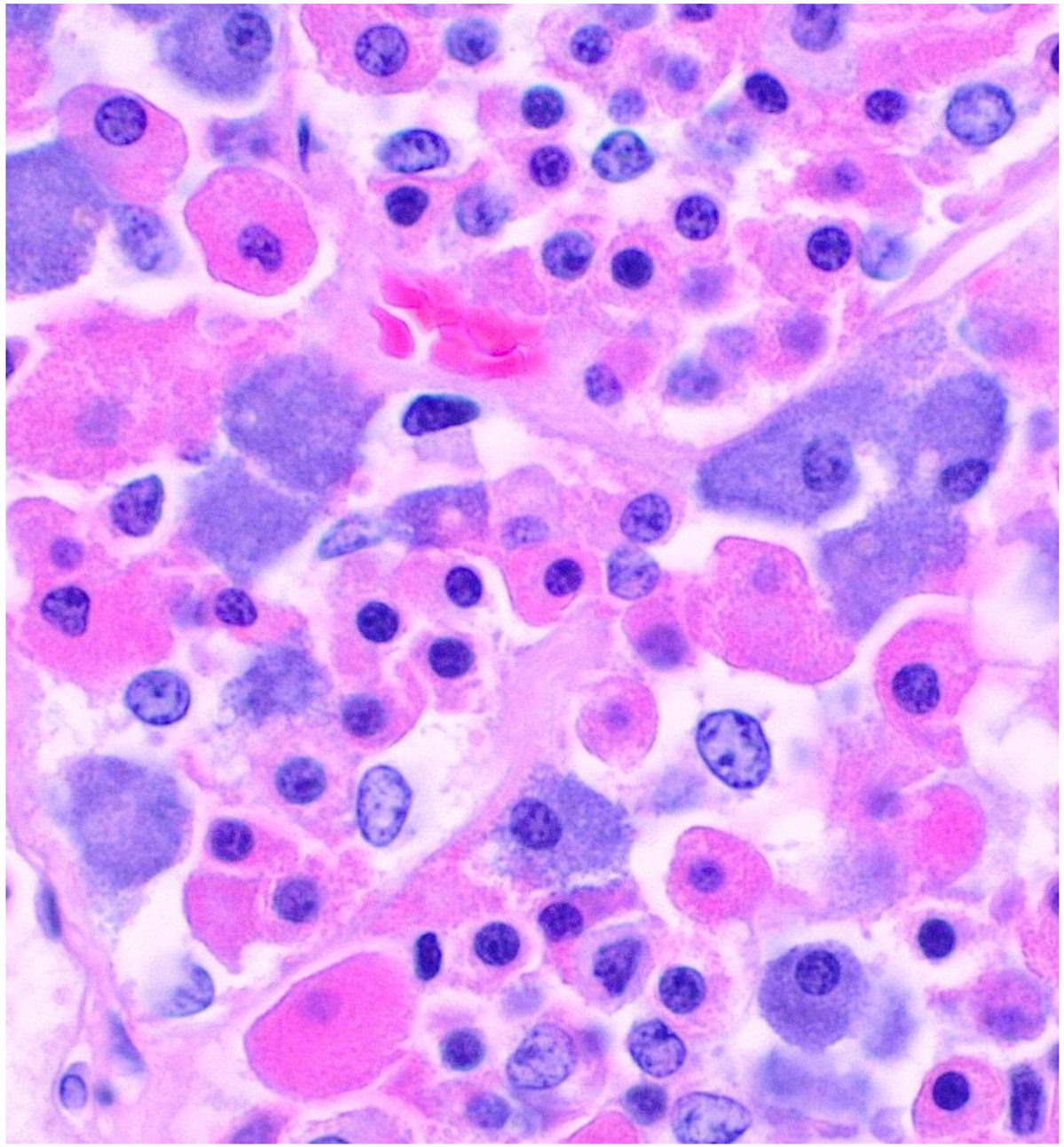




Pars distalis – acidofilní buňky

- **α – buňky (somatotropní)**
  - hrubá granula, GER
  - okolo jádra zóna bez granul (GA)
  - **růstový hormon (somatotropin, GH)**

- **ε – buňky (laktotropní)**
  - obvykle malé, nepočetné
  - zvýšení počtů v těhotenství a při kojení
  - drobná granula (zvětšení v těhotenství)
  - **prolaktin (PRL)**

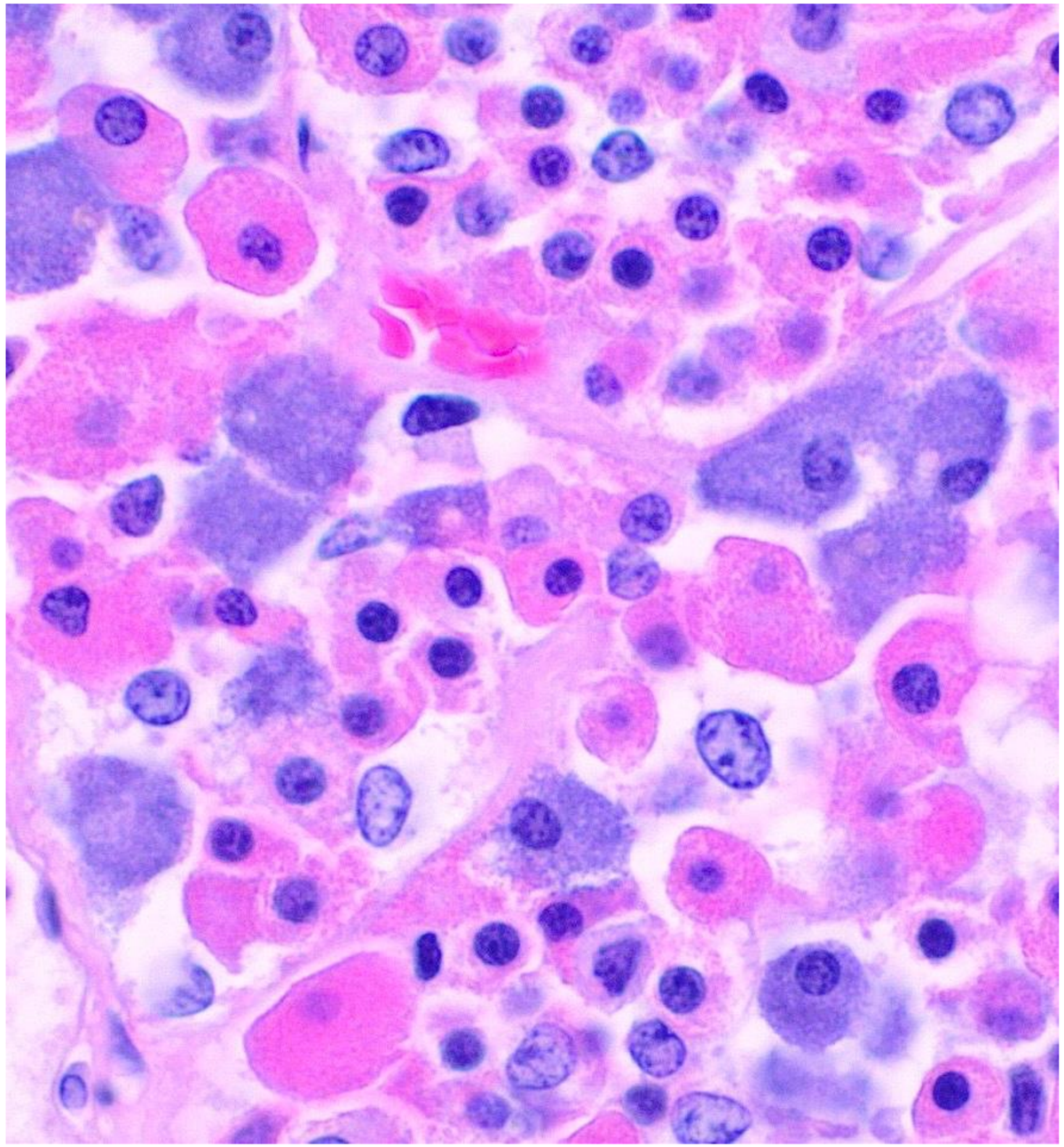


Pars distalis – bazofilní buňky

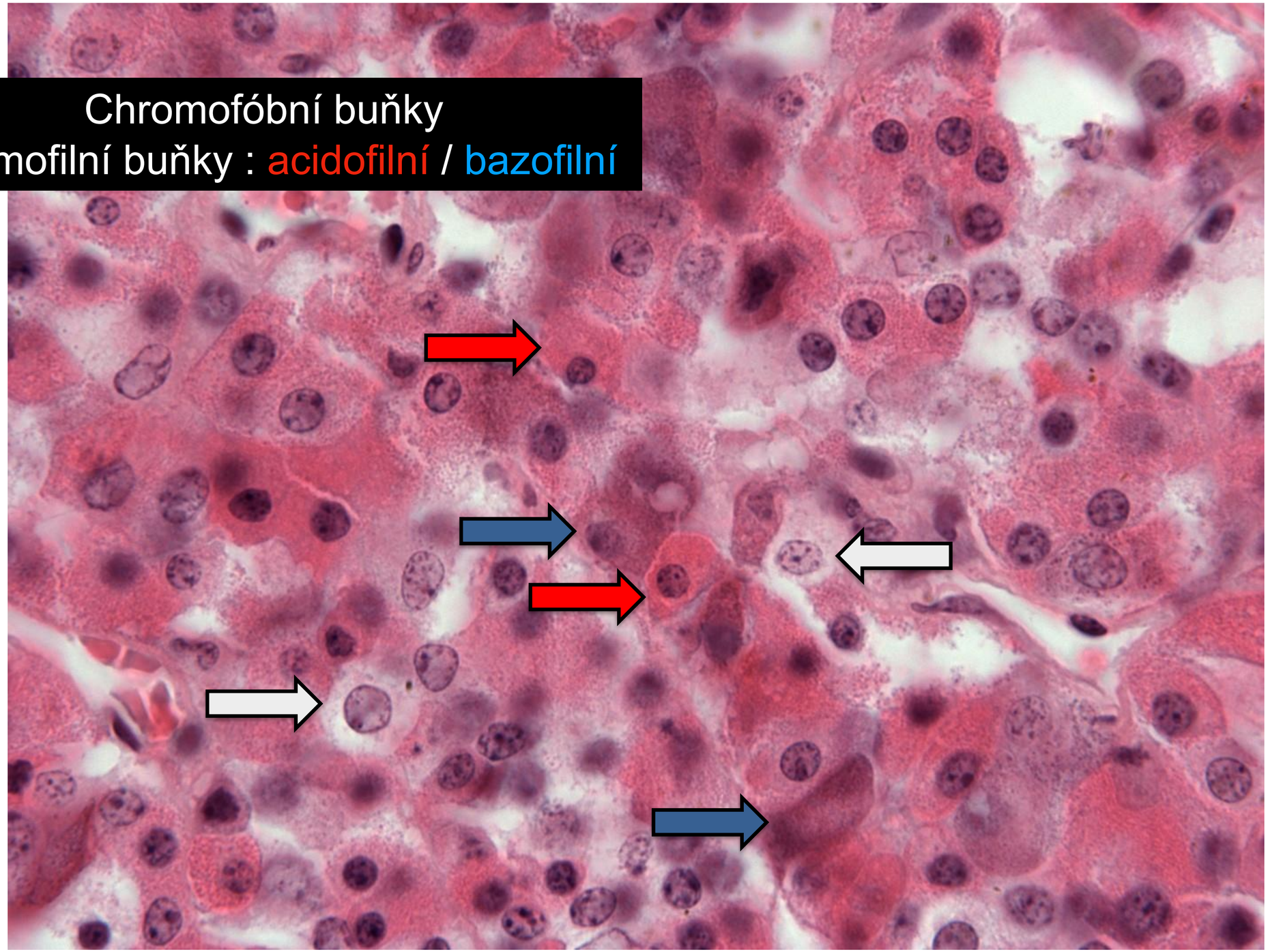
- **β_1 – buňky (adrenokortikotropní)**
  - velká granula při buněčné membráně
  - **ACTH, β-MSH**, Met-enkefalin, endorfin

- **β_2 – buňky (thyreotropní)**
  - velké buňky, malá granula u BM
  - **TSH**

- **δ – buňky (gonadotropní)**
  - velké buňky, středně velká granula
  - **FSH, LH**



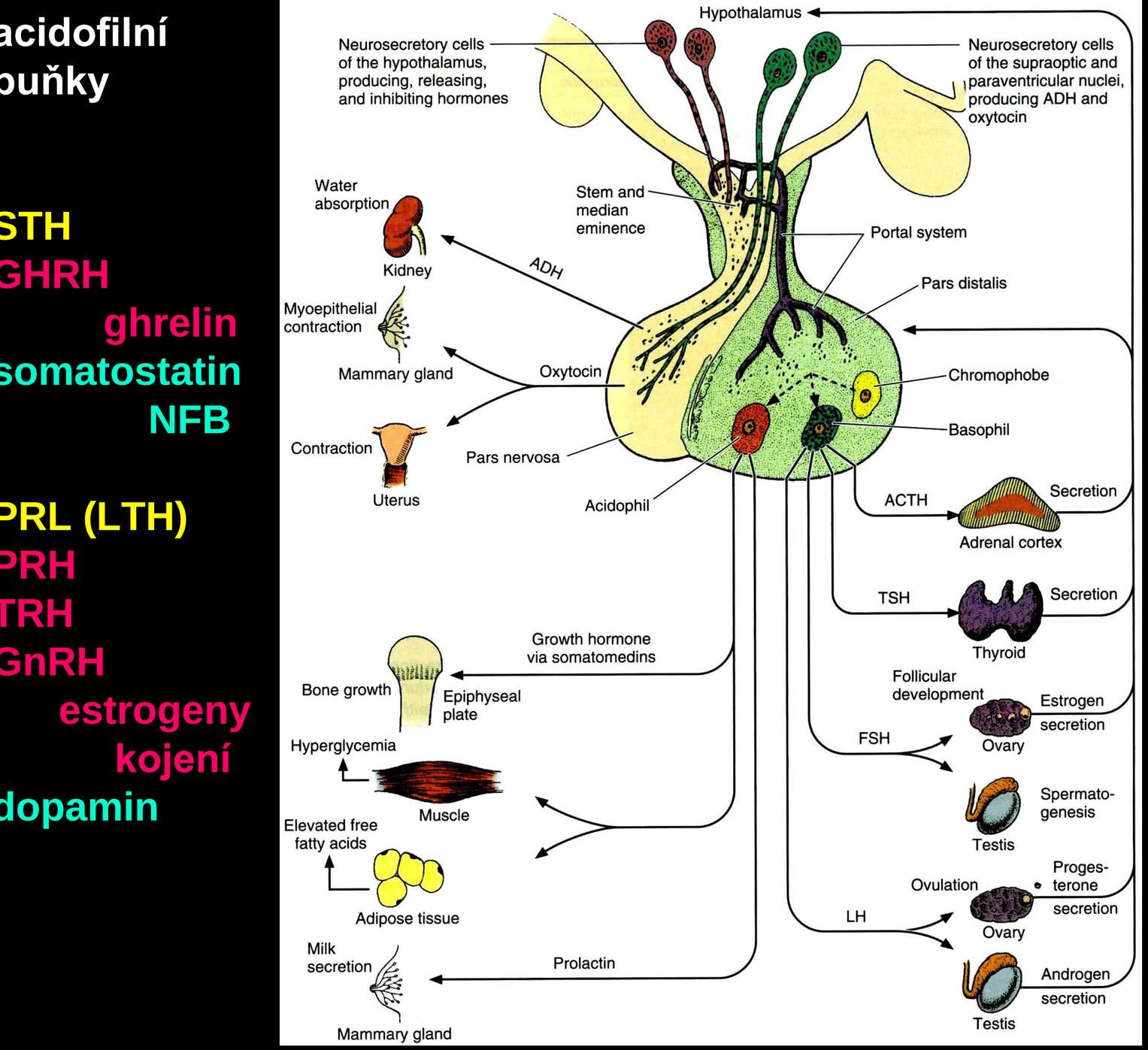
Chromofóbní buňky
chromofilní buňky : acidofilní / bazofilní



acidofilní buňky

STH
GHRH
ghrelin
somatostatin
NFB

PRL (LTH)
PRH
TRH
GnRH
estrogeny
kojení
dopamin



bazofilní buňky

TTH
TRH
NFB

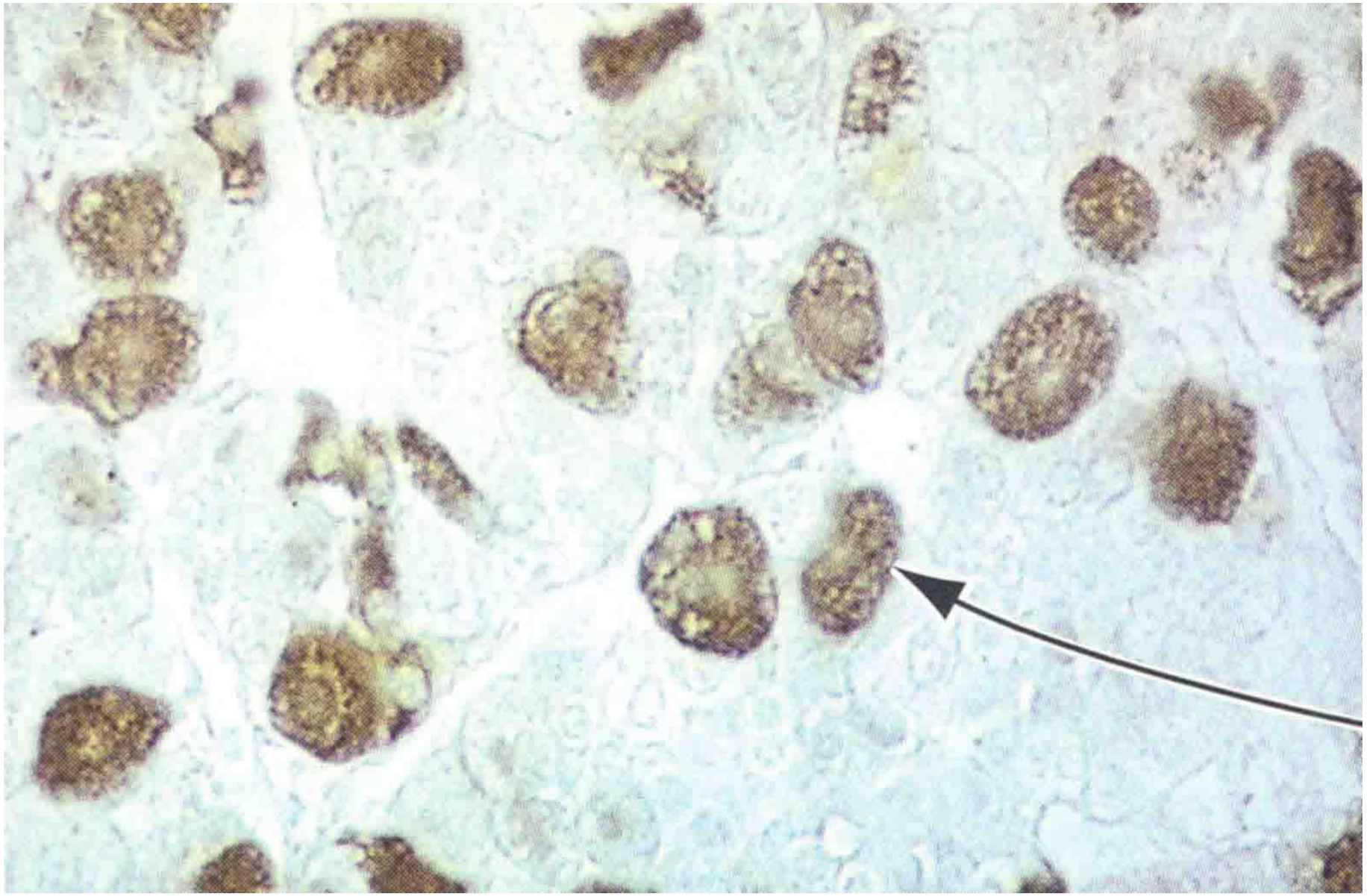
FSH / LH
GnRH
FSH-activin
NFB
FSH-inhibin

ACTH
CRH
NFB

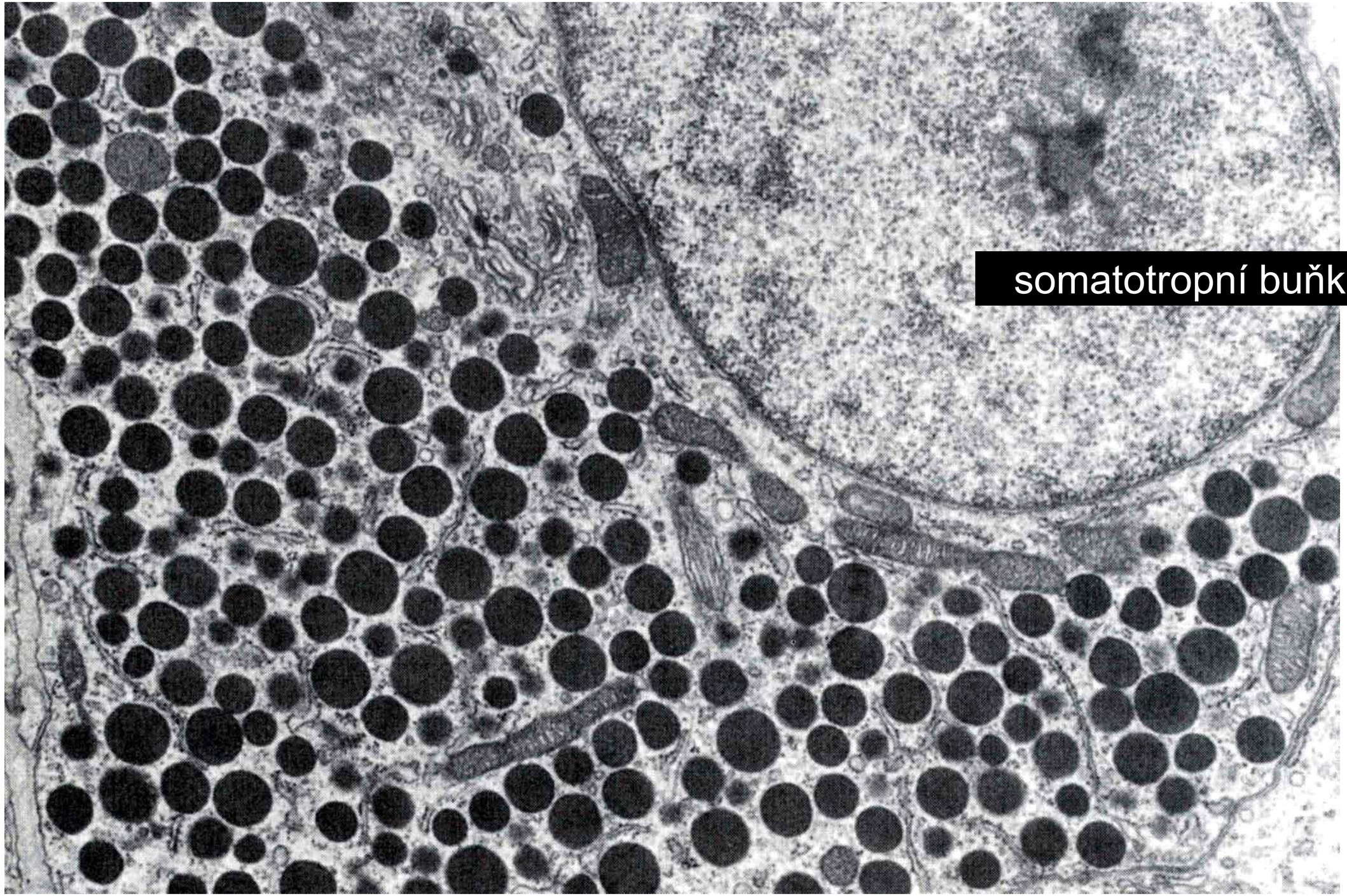
MSH

hormon stimulace inhibice NFB = negative feedback

imunohistochemický průkaz hormonu

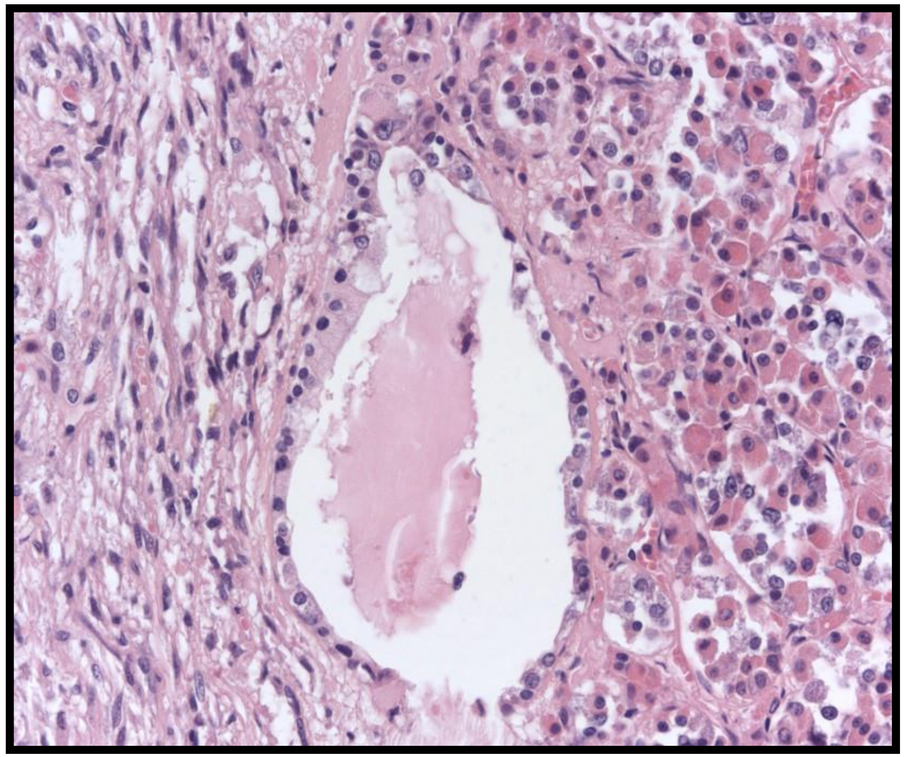


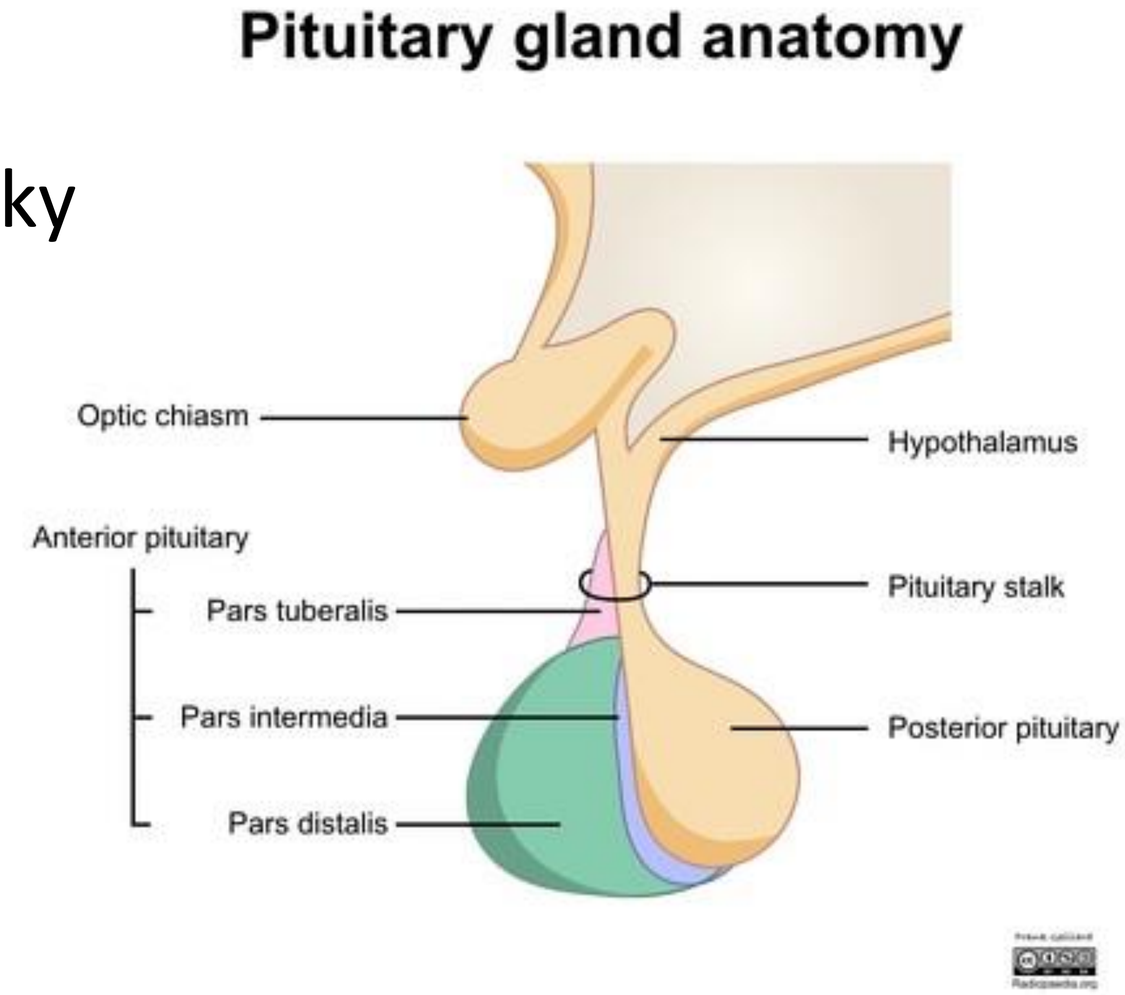
FSH

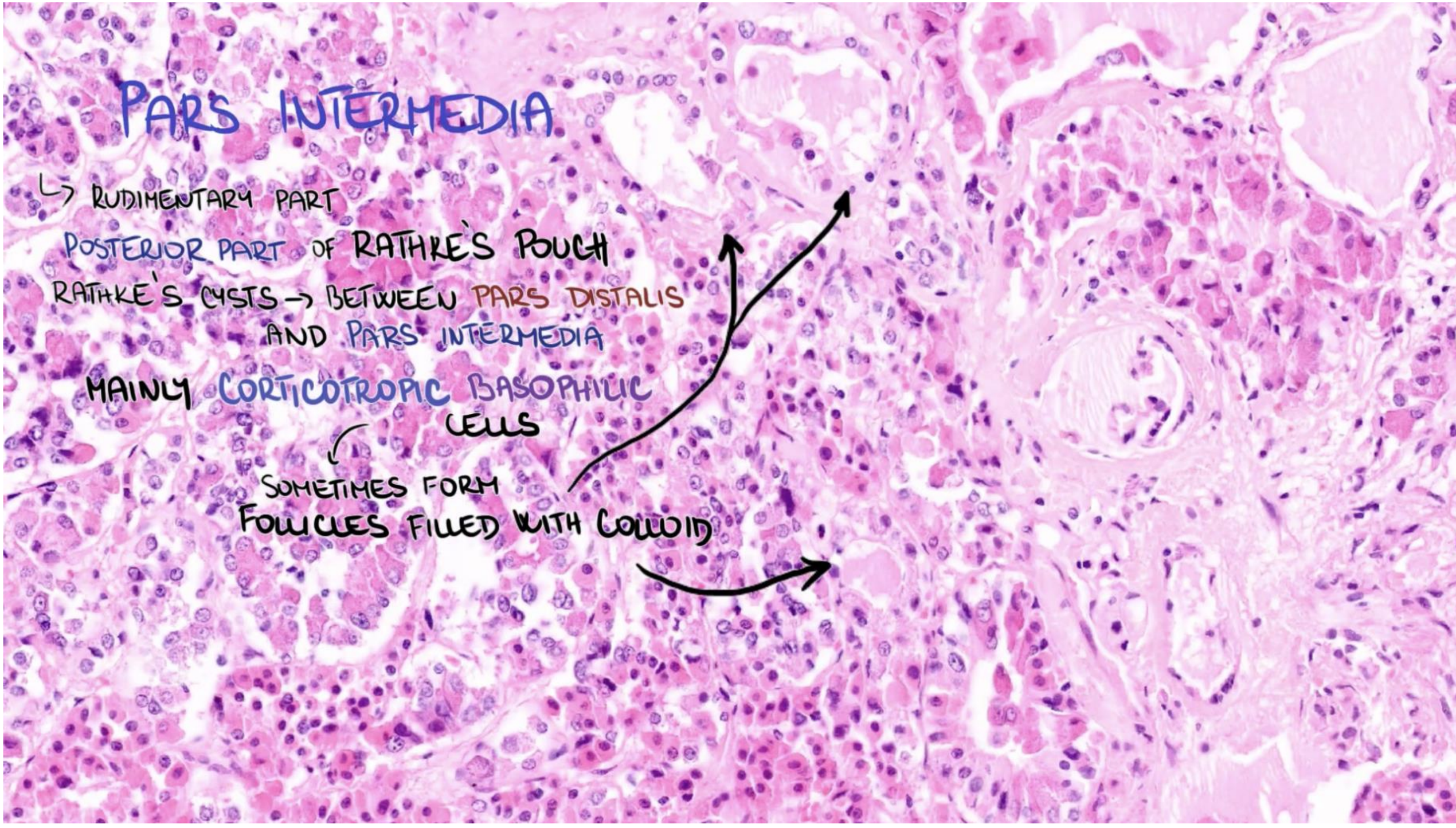

somatotropní buňka

Pars intermedia

- Rathkeho cysty (jednovrstevný epitel)
  - chromofóbní buňky
  - převážně bazofilní buňky

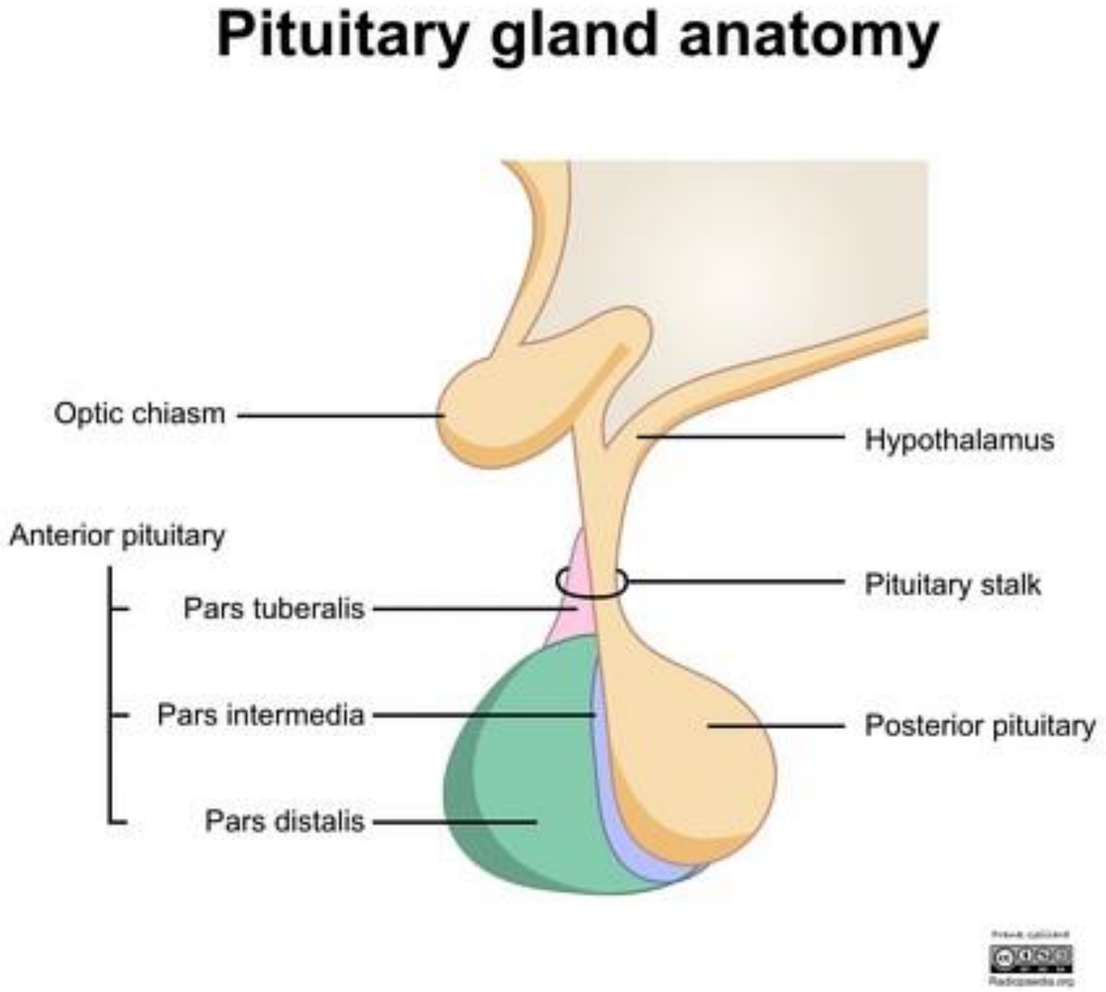


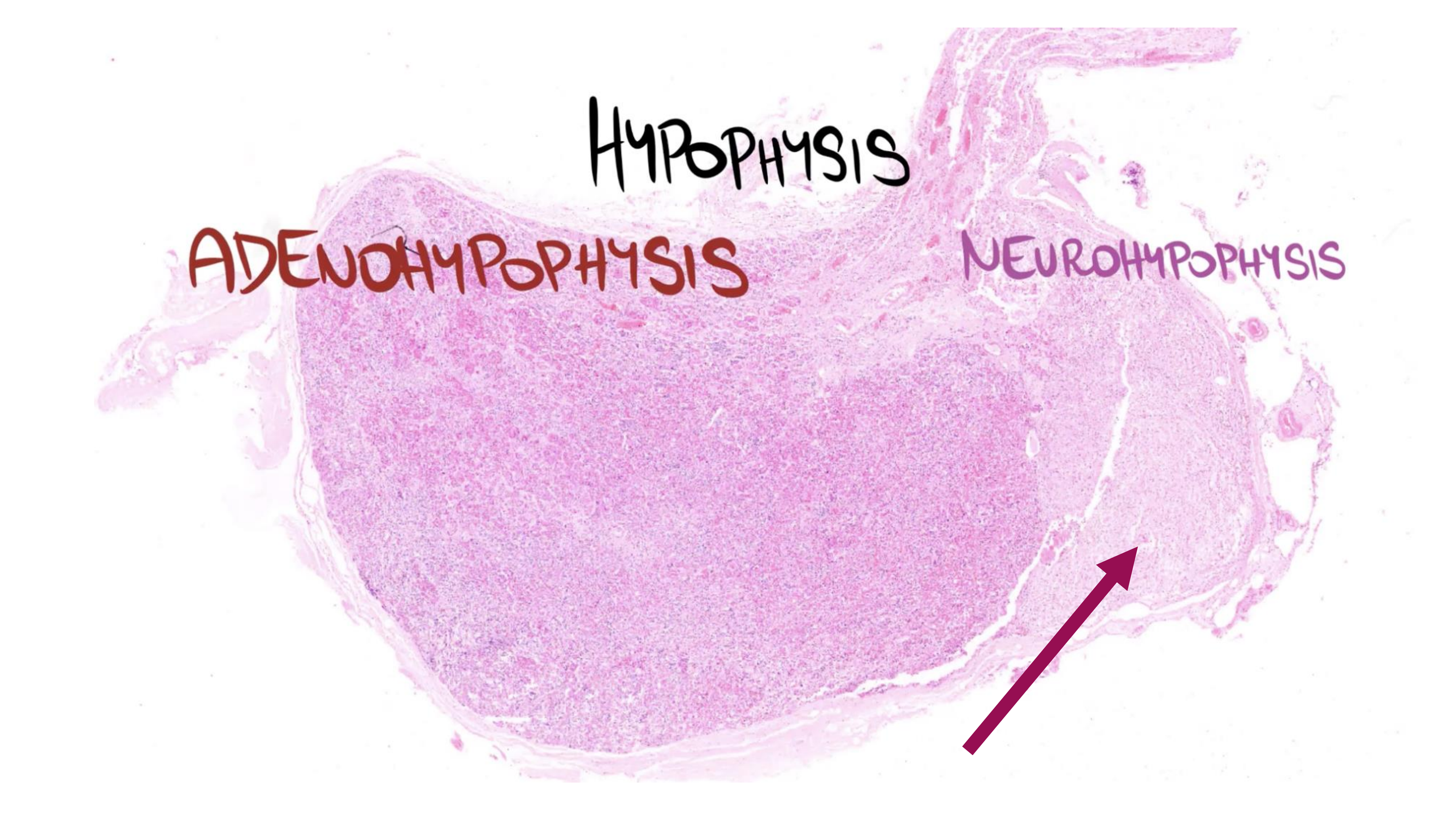



PARS INTERMEDIA
↳ RUDIMENTARY PART
POSTERIOR PART OF RATHKE'S POUCH
RATHKE'S CYSTS → BETWEEN PARS DISTALIS AND PARS INTERMEDIA
MAINLY CORTICOTROPIC BASOPHILIC CELLS
SOMETIMES FORM FOLLICLES FILLED WITH COLLOID

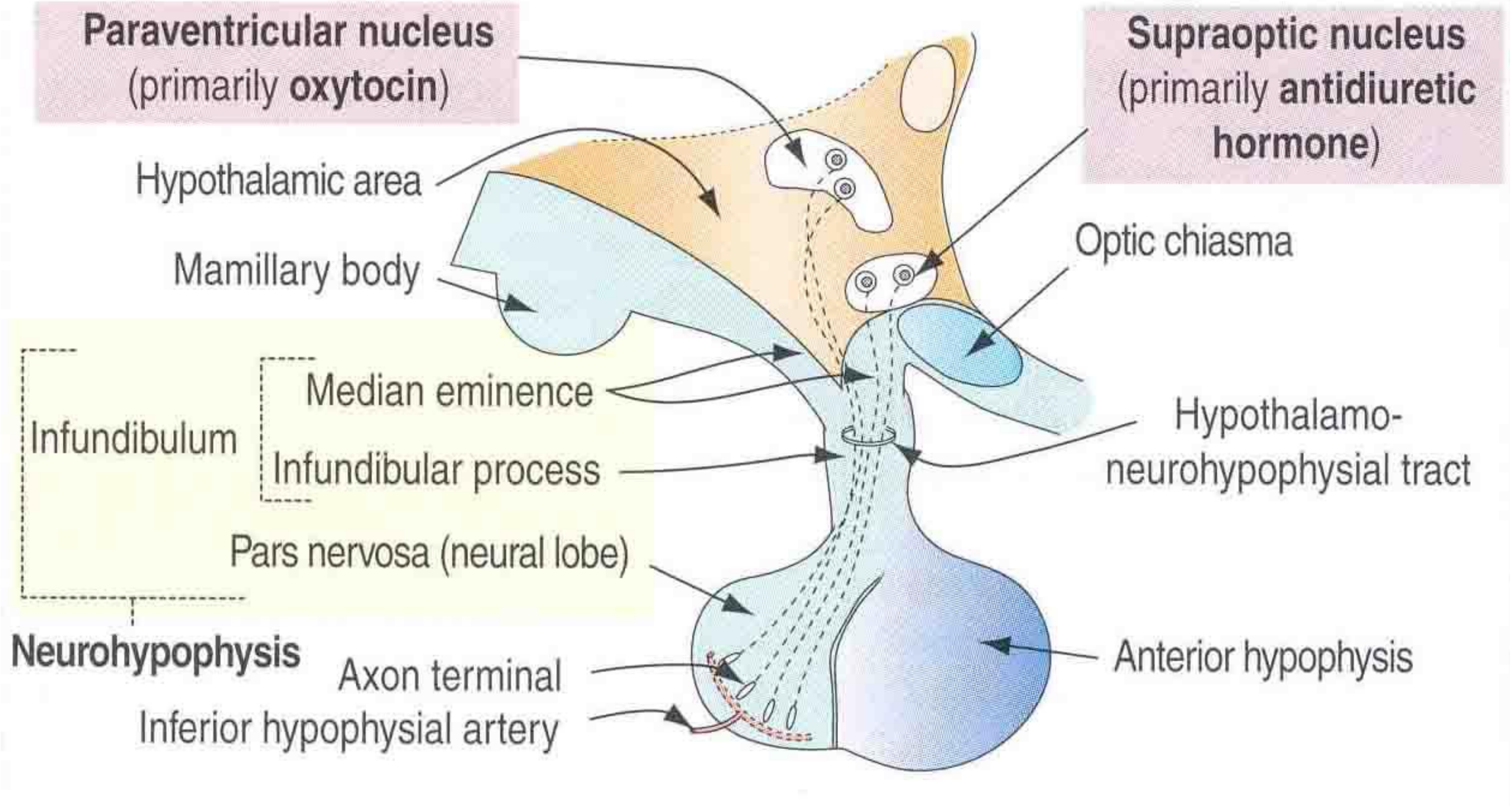
Pars tuberalis

- horní výběžek pars distalis, obklopující část infundibula
- převážně chromofóbní buňky + bazofilní buňky




HYPOPHYSIS
ADENOHYPOPHYSIS
NEUROHYPOPHYSIS

Zadní lalok - Neurohypofýza

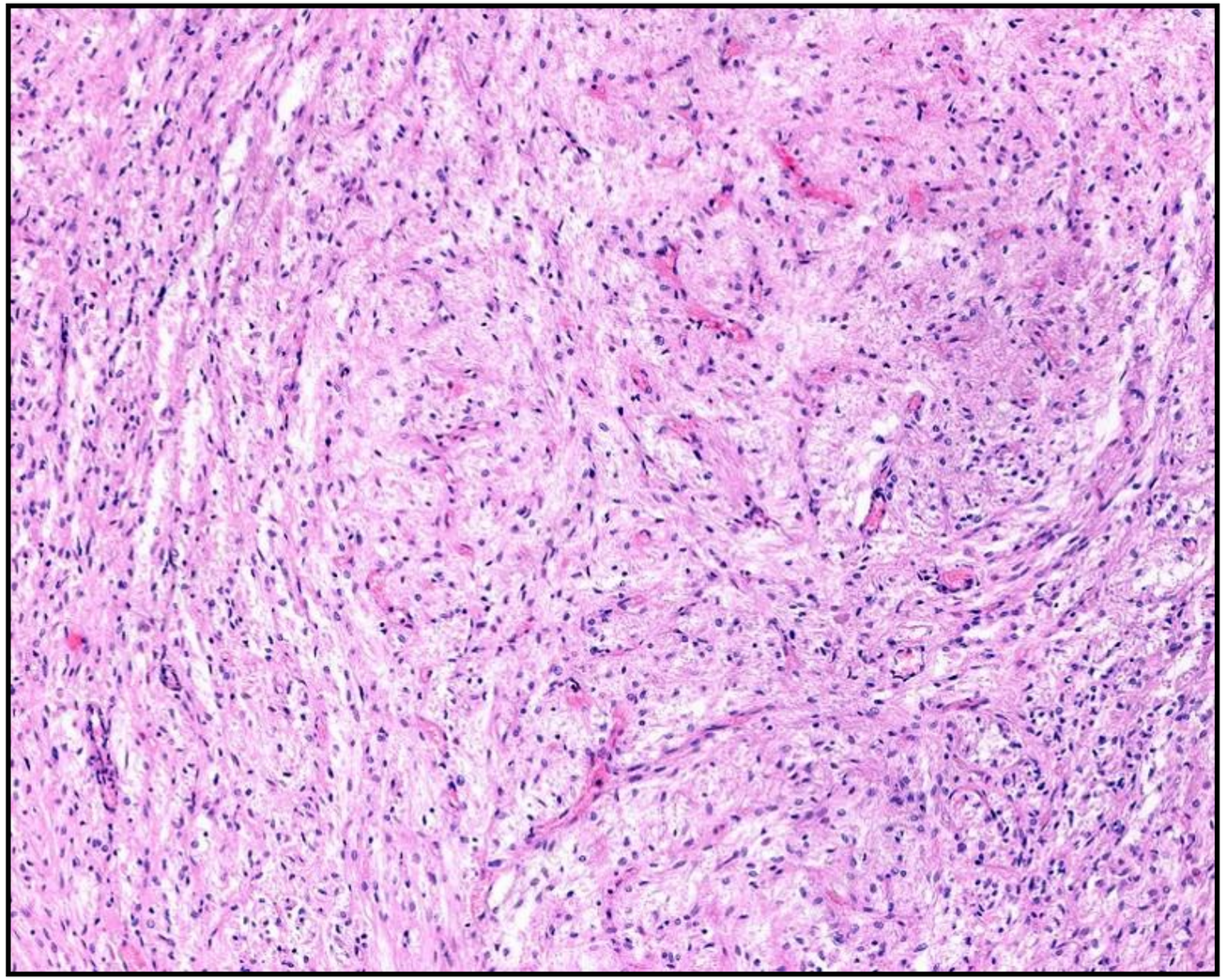


Zadní lalok = *Neurohypophysis*

- eminentia mediana
  - dno III. mozkové komory
  - četná nemyelinizovaná nervová vlákna

- stopka (i*nfundibulum*)
  - tractus hypothalamohypophysialis
  - neurofibra neurosecretoria (+ vesicula neurosecretoria) = nemyelinizovaná nervová vlákna
    - některá končí u vlásečnic

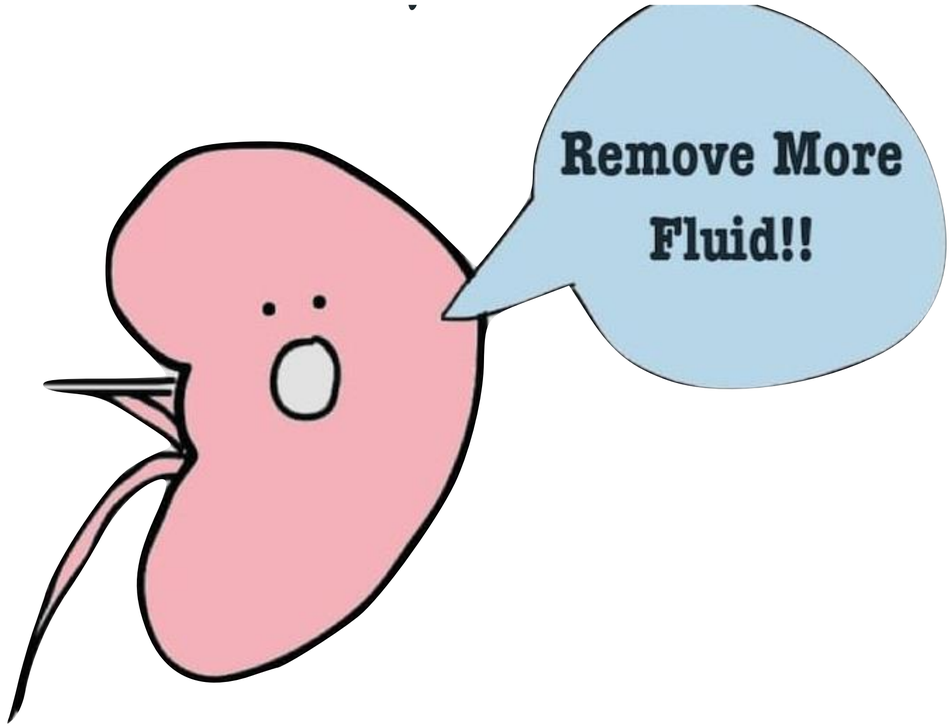
- lobus nervosus (pars nervosa)

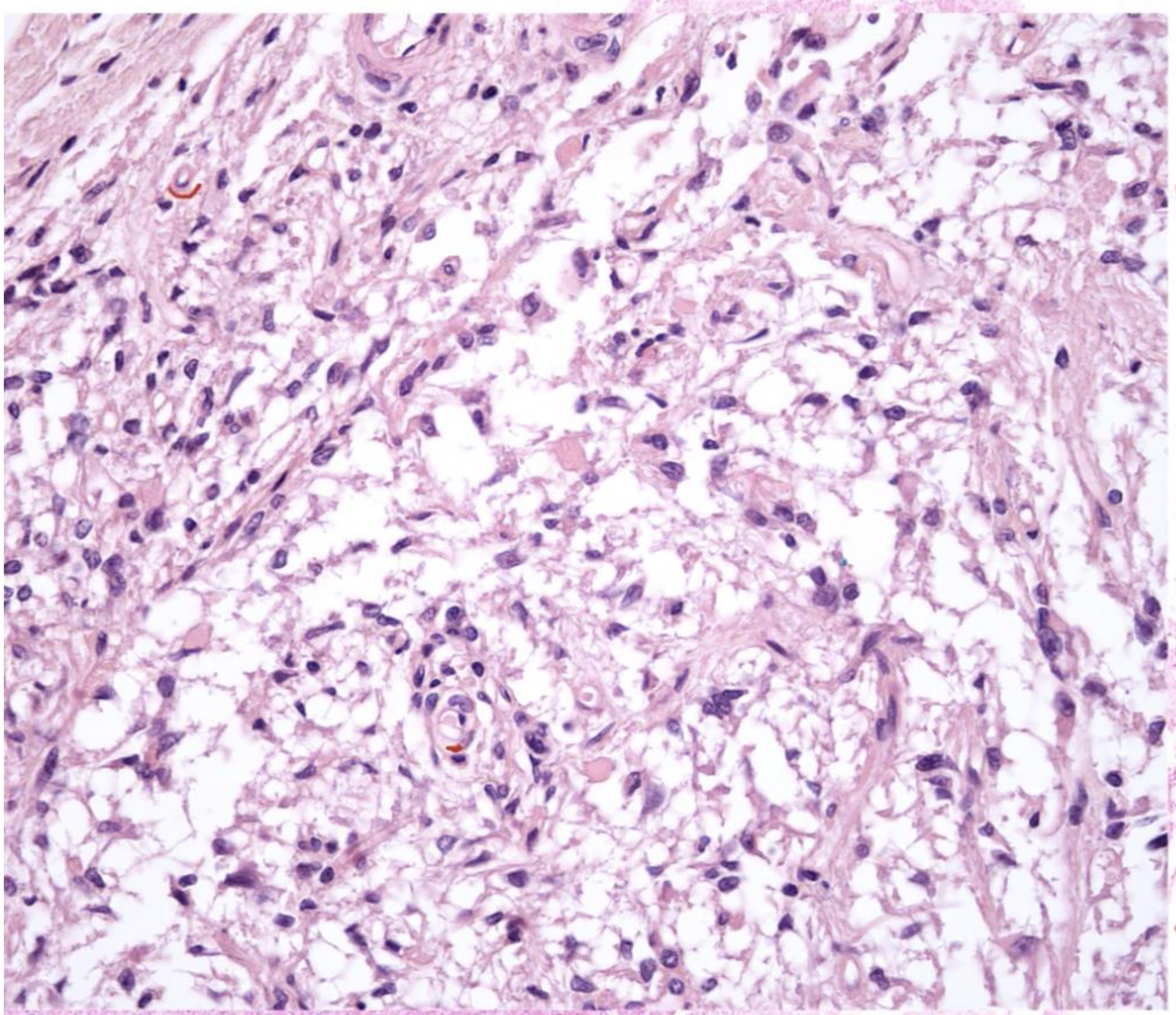


Lobus nervosus neurohypophysis

- nervová vlákna
  - axony neuronů hypotalamu
  - corpuscula neurosecretoria (Herringova tělíska) – nahromadění granul
  - **oxytocin** + **ADH** (adiuretin, antidiuretický hormon, vazopresin)
- pituicyty
  - gliové buňky
- fenestrované vlásečnice (*synapsis neurohaemalis*)

diabetes insipidus





NEUROHYPOPHYSIS

PARS NERVOSA

⇓

! ~~SECRETORY CELLS~~

COMPOSED OF:

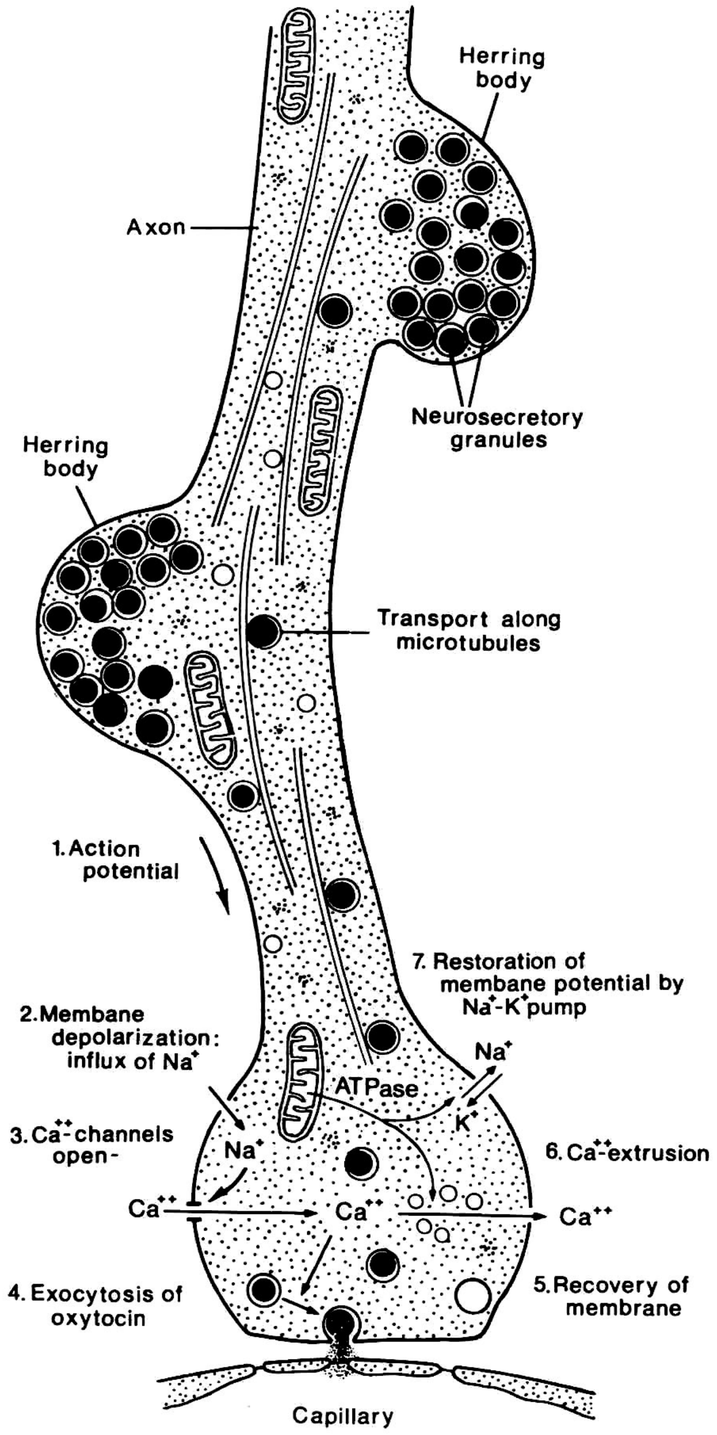
NEURAL TISSUE
(UNMYELINATED AXONS)

+

SPECIAL GLIAL CELLS

PITUICYTES

+ FENESTRATED CAPILLARIES


Herring body
Axon
Neurosecretory granules
Herring body
Transport along microtubules
1. Action potential
7. Restoration of membane potential by Na^+-K^+ pump
2. Membane depolarization: influx of Na^+
Na^+
ATPase
K^+
3. Ca^{++}-channels open-
Na^+
6. Ca^{++}-extrusion
Ca^{++}
Ca^{++}
Ca^{++}
4. Exocytosis of oxytocin
5. Recovery of membrane
Capillary

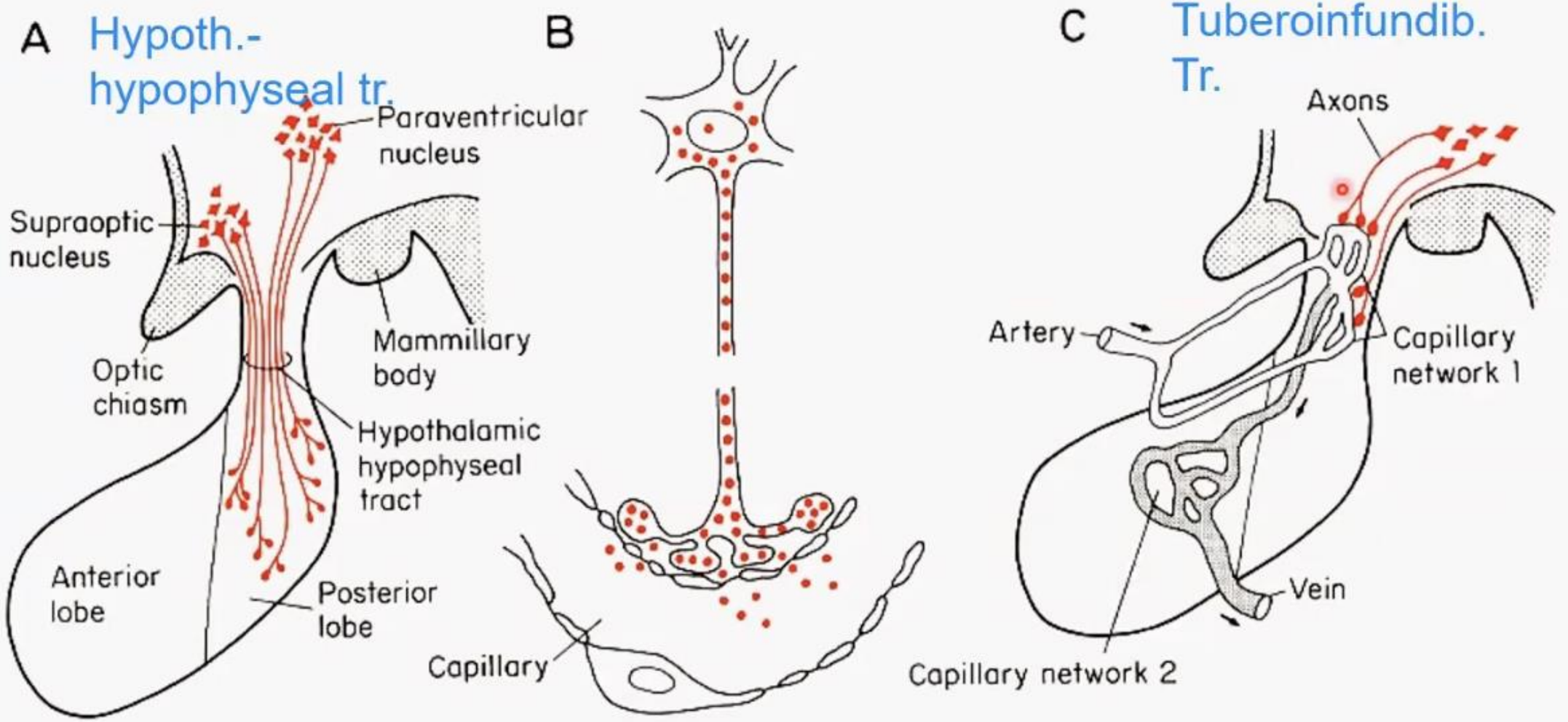
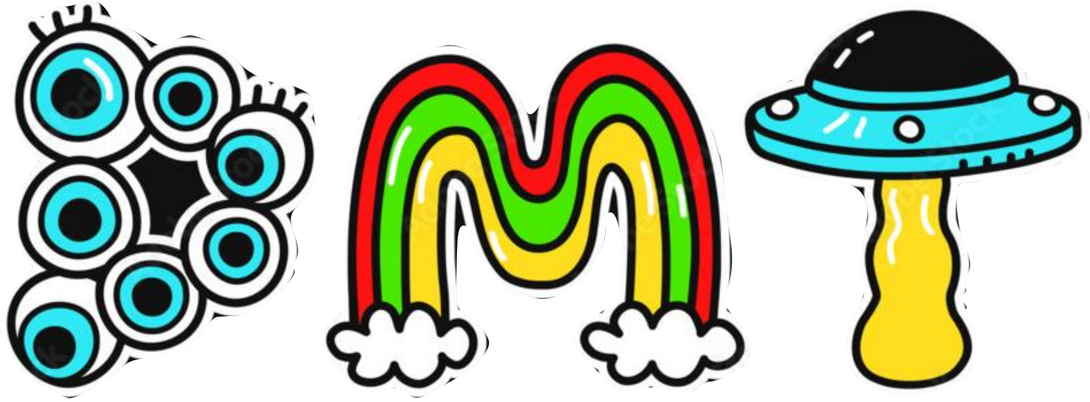


Fig. 15.5. *The relationship between the hypothalamus and the pituitary gland.* **A.** Connections from the hypothalamus to the posterior lobe. **B.** Axonal transport of peptide hormones (neuropeptides) from the hypothalamus to the pituitary. **C.** The portal vessels of the pituitary stalk ensure that releasing hormones (factors) are transported from the median eminence in the upper part of the stalk to the epithelial cells of the anterior lobe.

Šišinka (epifýza, corpus pineale)



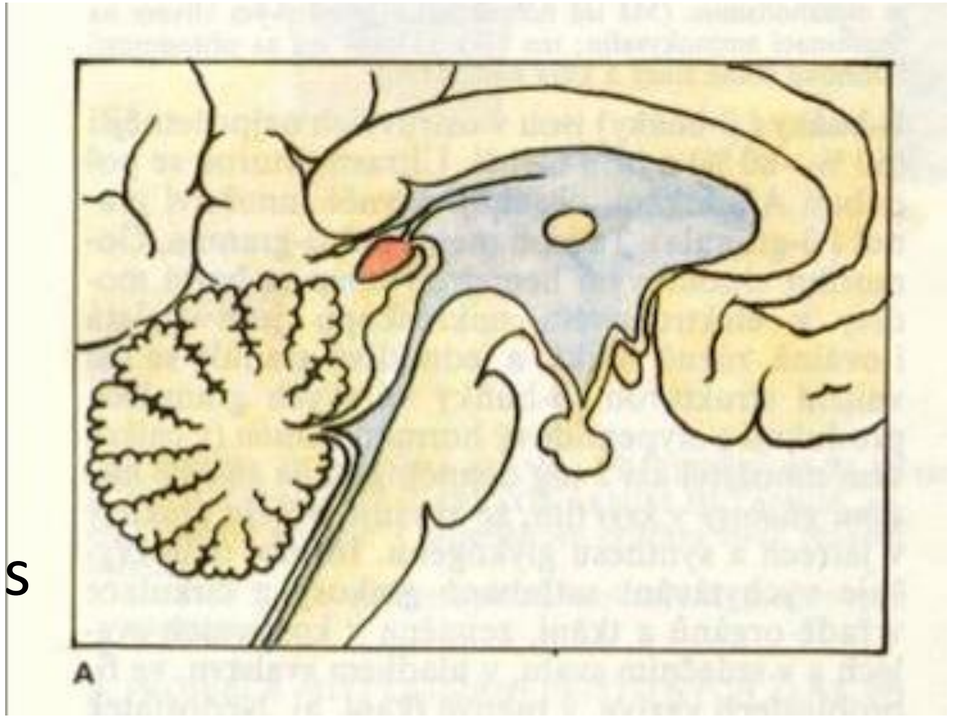
Šišinka

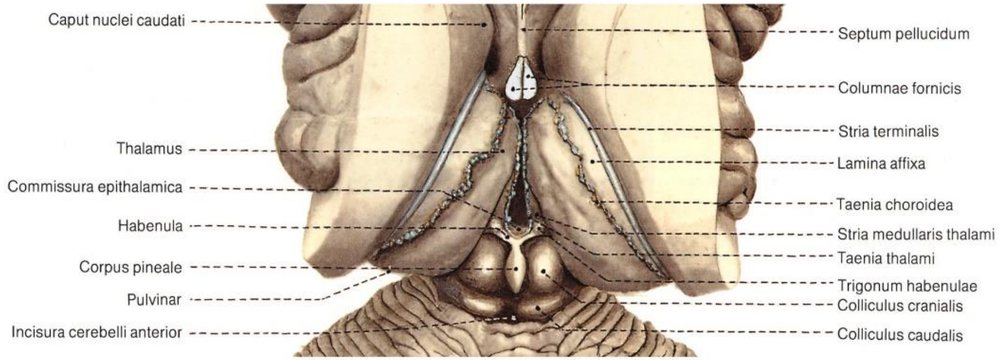
- za horním zadním koncem

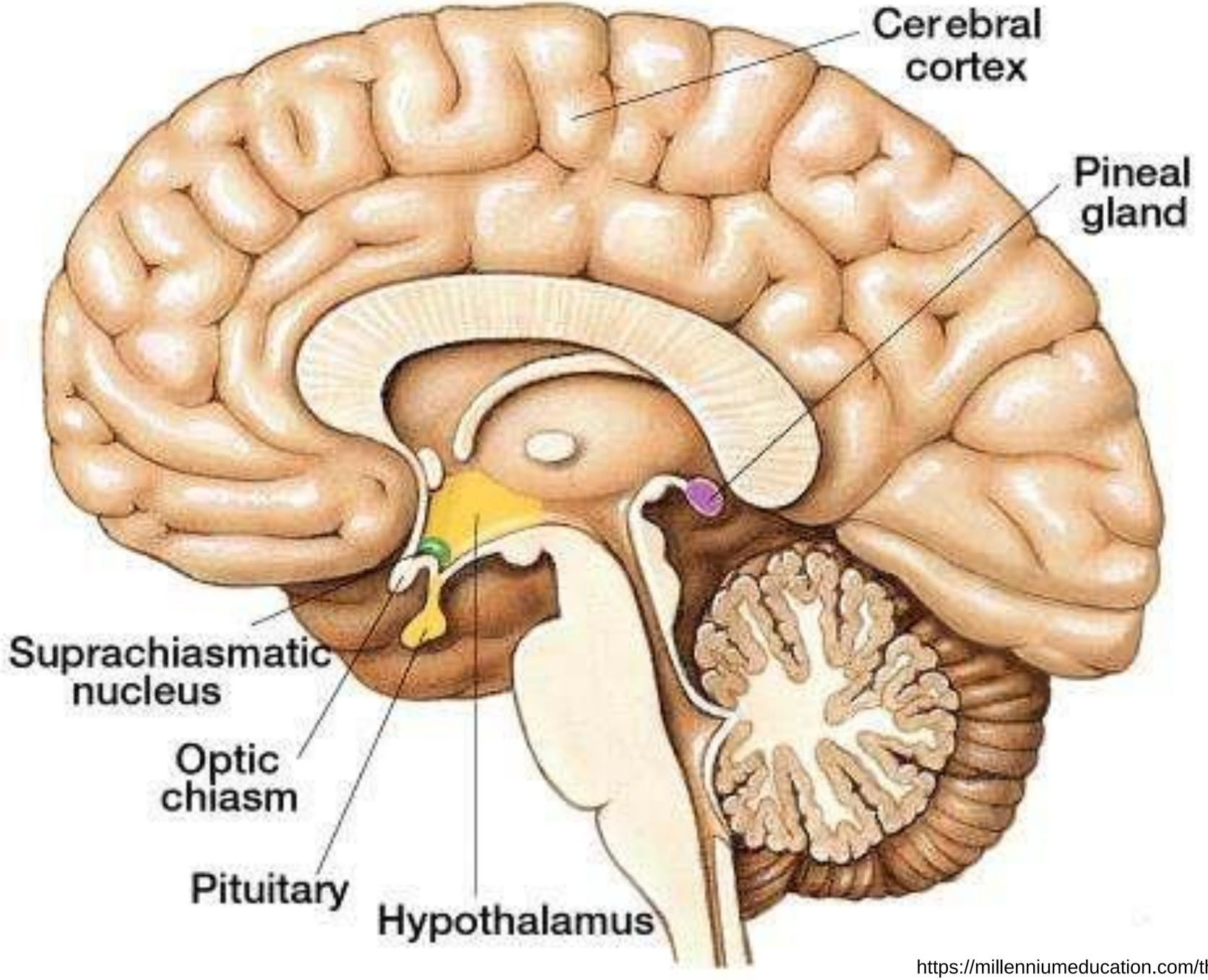
III. komory

- součást epithalamu
- “rudimentární” endokrinní žláza s tlumivým účinkem na činnost pohlavních žláz →pubertas praecox
- dorzálně vybíhá nad mozkový kmen (nad čtverohrbolí středního mozku)
- ***melatonin***
- acervulus cerebri = corpora arenacea

= vápenaté konkrementy
u dospělých) – CT, MRI

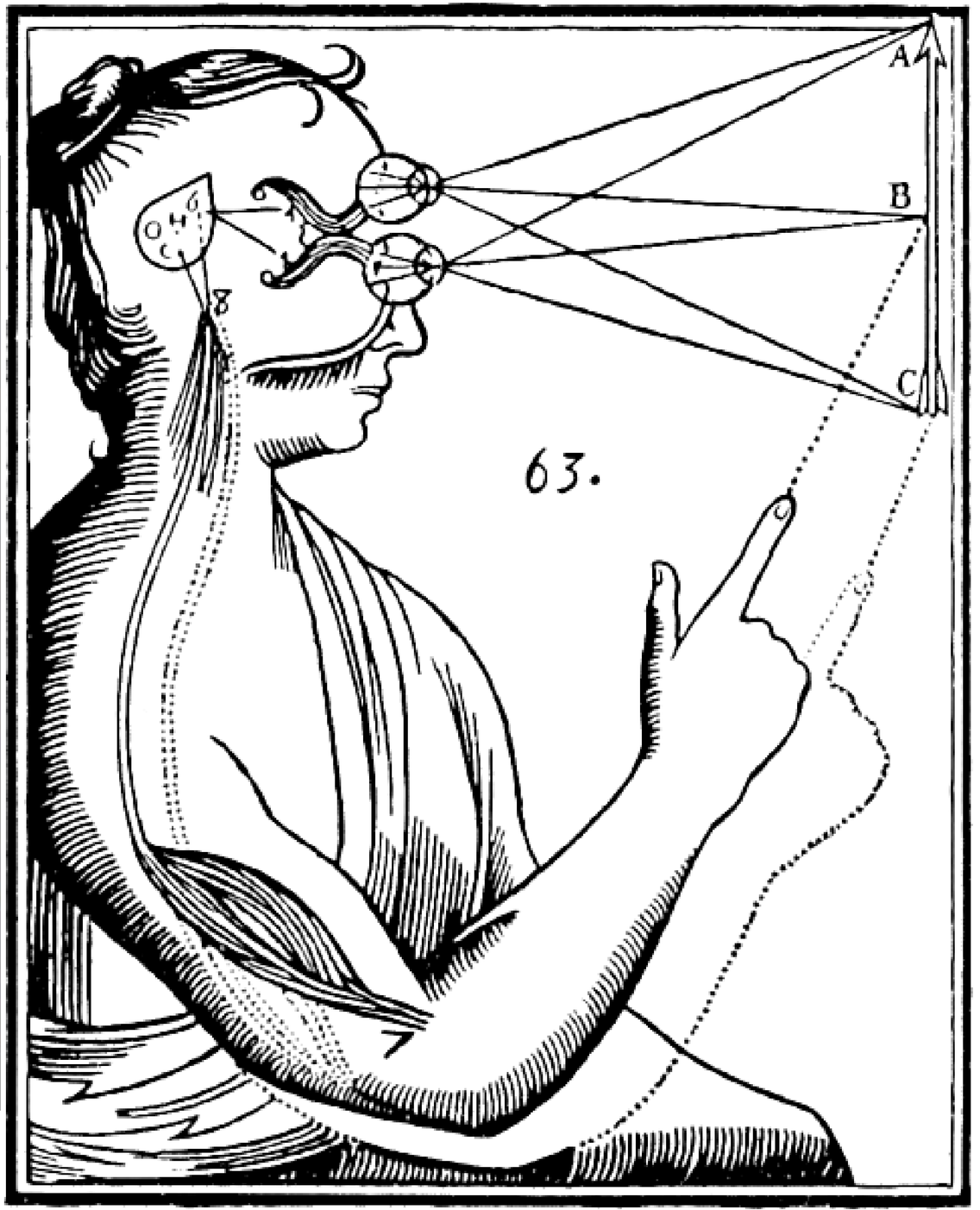


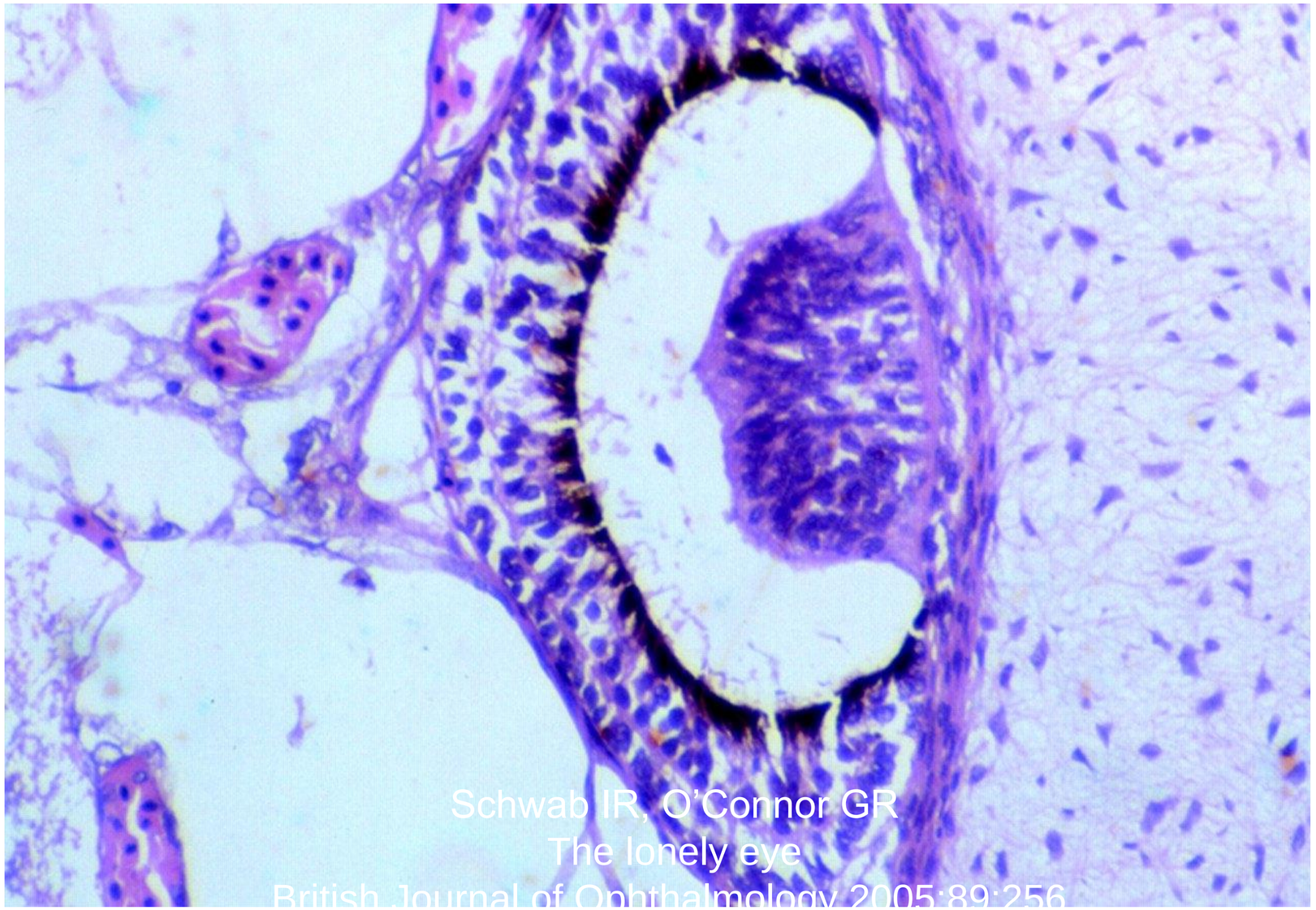




https://millenniumeducation.com/the-pineal-gland/

It is famous for the big development of the "third eye" on the head, visible in the young, called parietal eye © Southland Museum & Art Gallery, Invercargill



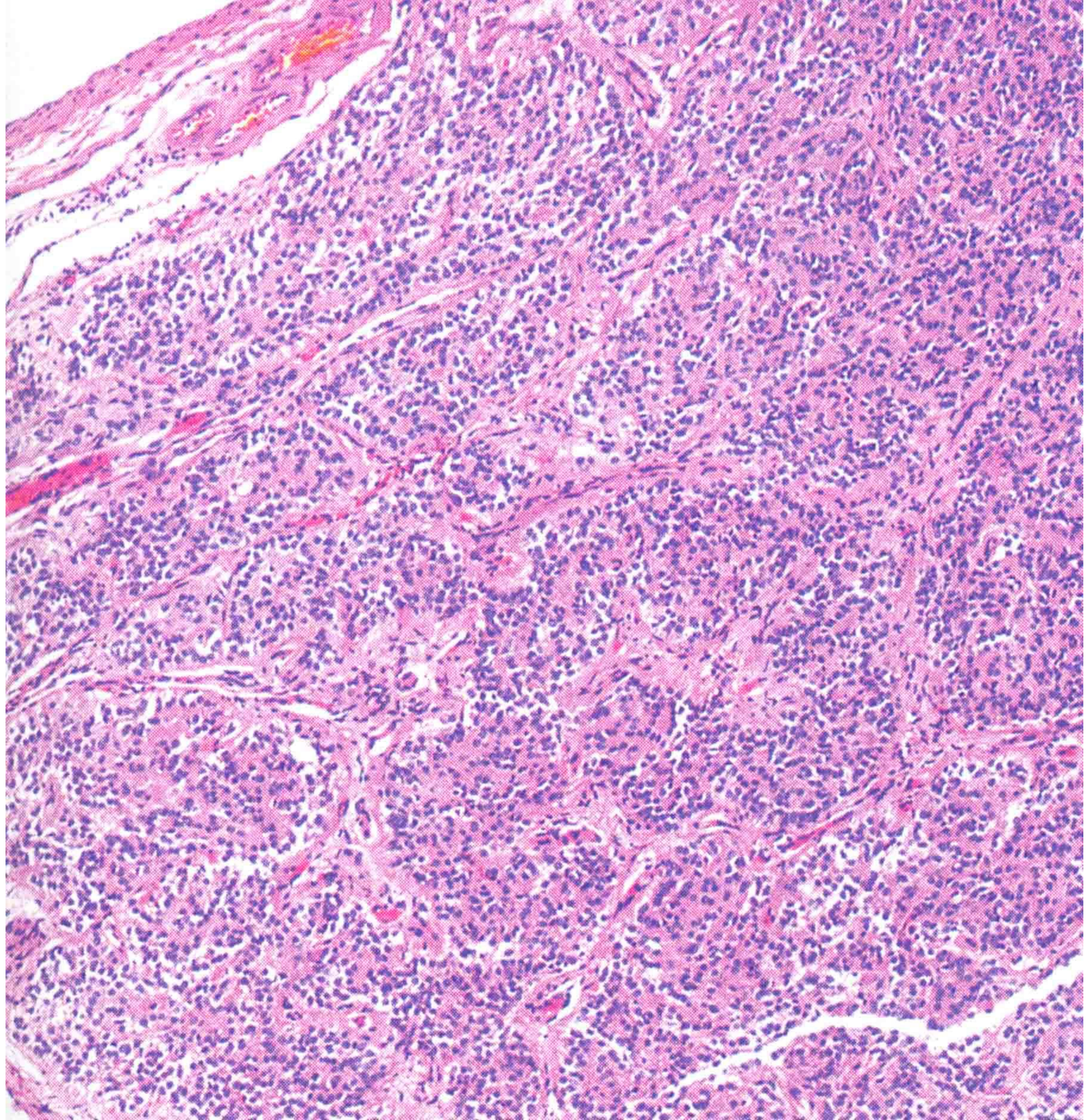


Schwab IR, O'Connor GR
The lonely eye
British Journal of Ophthalmology 2005;89:256

Marques, Bruno & Mcintosh, Jacqueline & Hatton, William & Shanahan, Danielle. (2019). Bicultural landscapes and ecological restoration in the compact city: The case of Zealandia as a sustainable ecosanctuary. JoLA - Journal on Landscape Architecture. 14. 44-53. 10.1080/18626033.2019.1623545.

Šišinka – stavba

- pouzdro z ***pia mater*** → přepážky
- hlavní buňky (***pinealocyty*** = *neurony*) – 95 %, velká jádra
  – tvorba **melatoninu**
    - změna hladiny během dne
- intersticiální/astrogliové buňky (*astrocyty*)
  – tmavé tyčinkovité jádro
- n. pinealis → neurofibra non myelinata

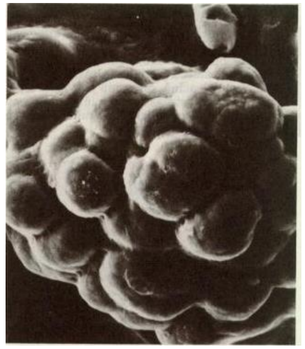


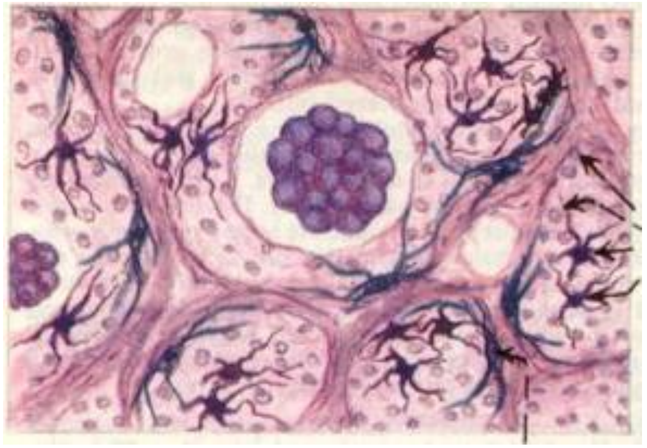
Šišinka – písek

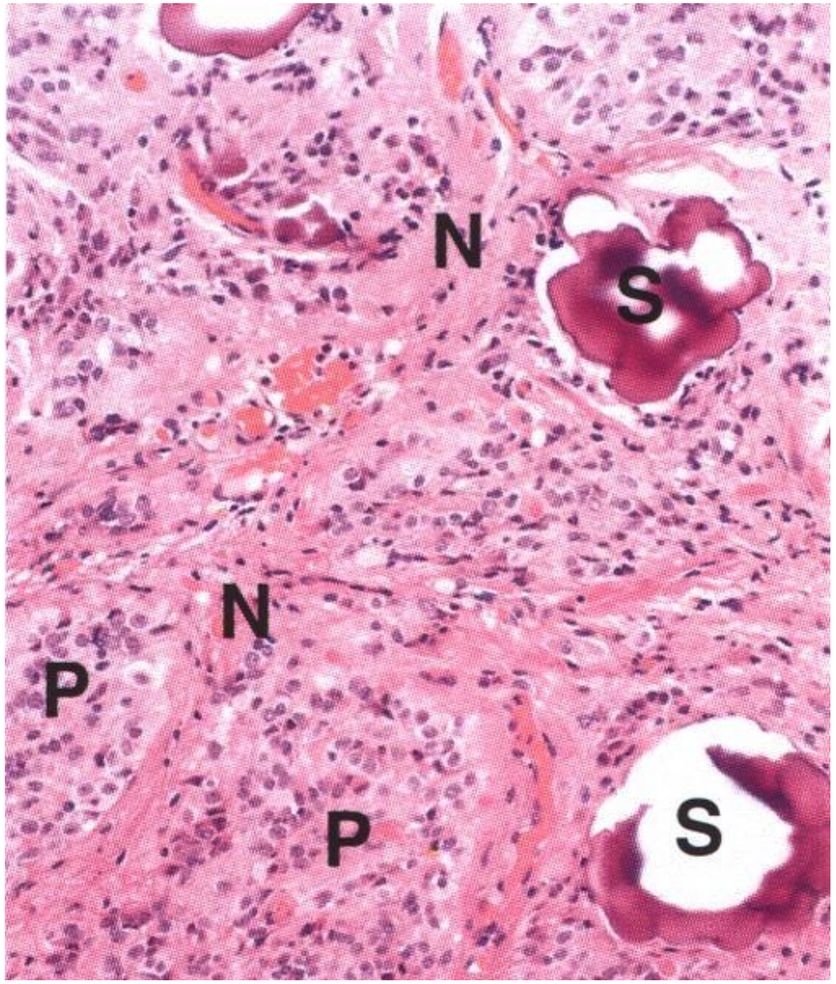
acervulus cerebri; corpora arenacea (mozkový písek)

konkrementy bílkovinného materiálu s vápenatými solemi

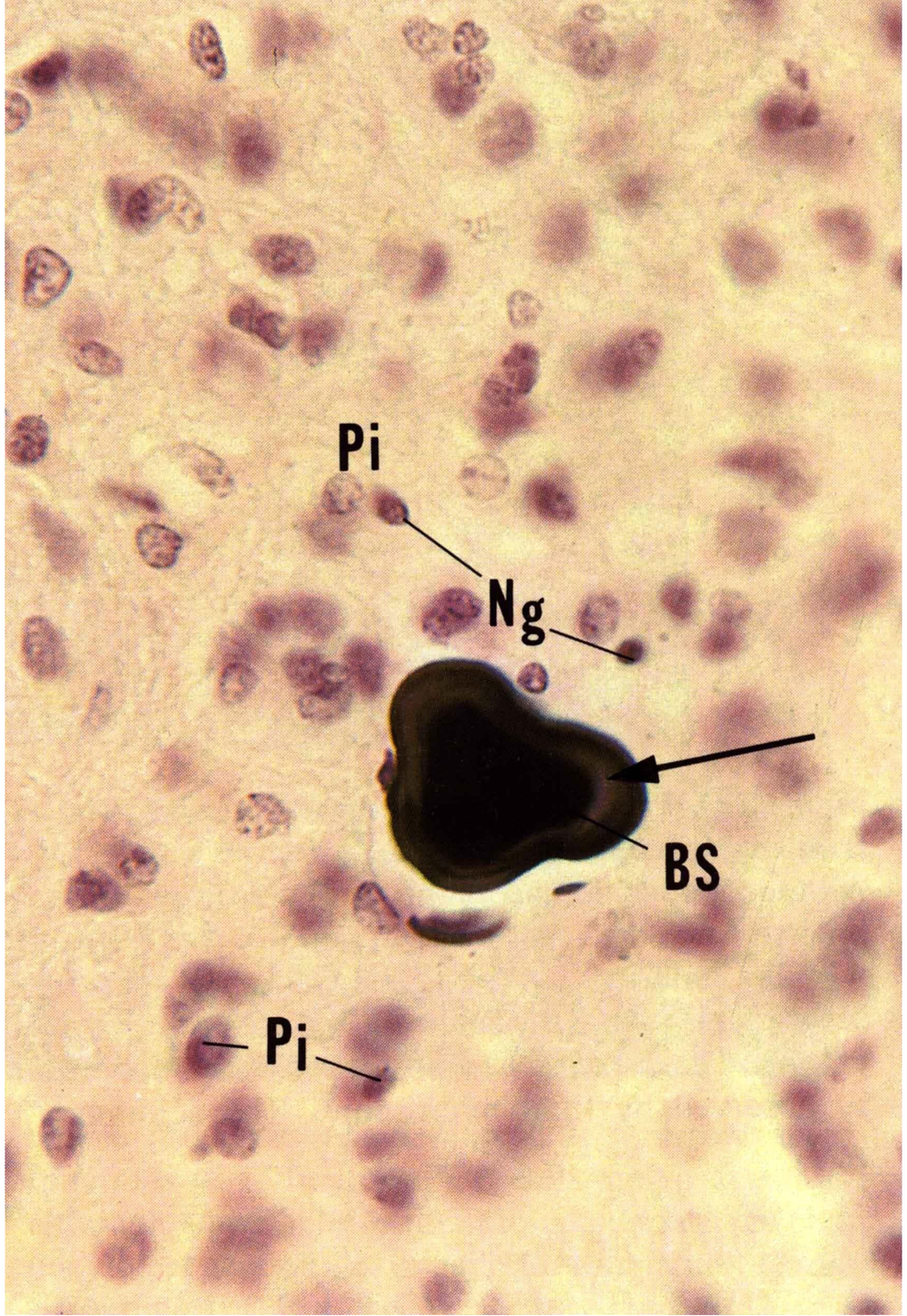
- počet stoupá s věkem
- CT, MRI



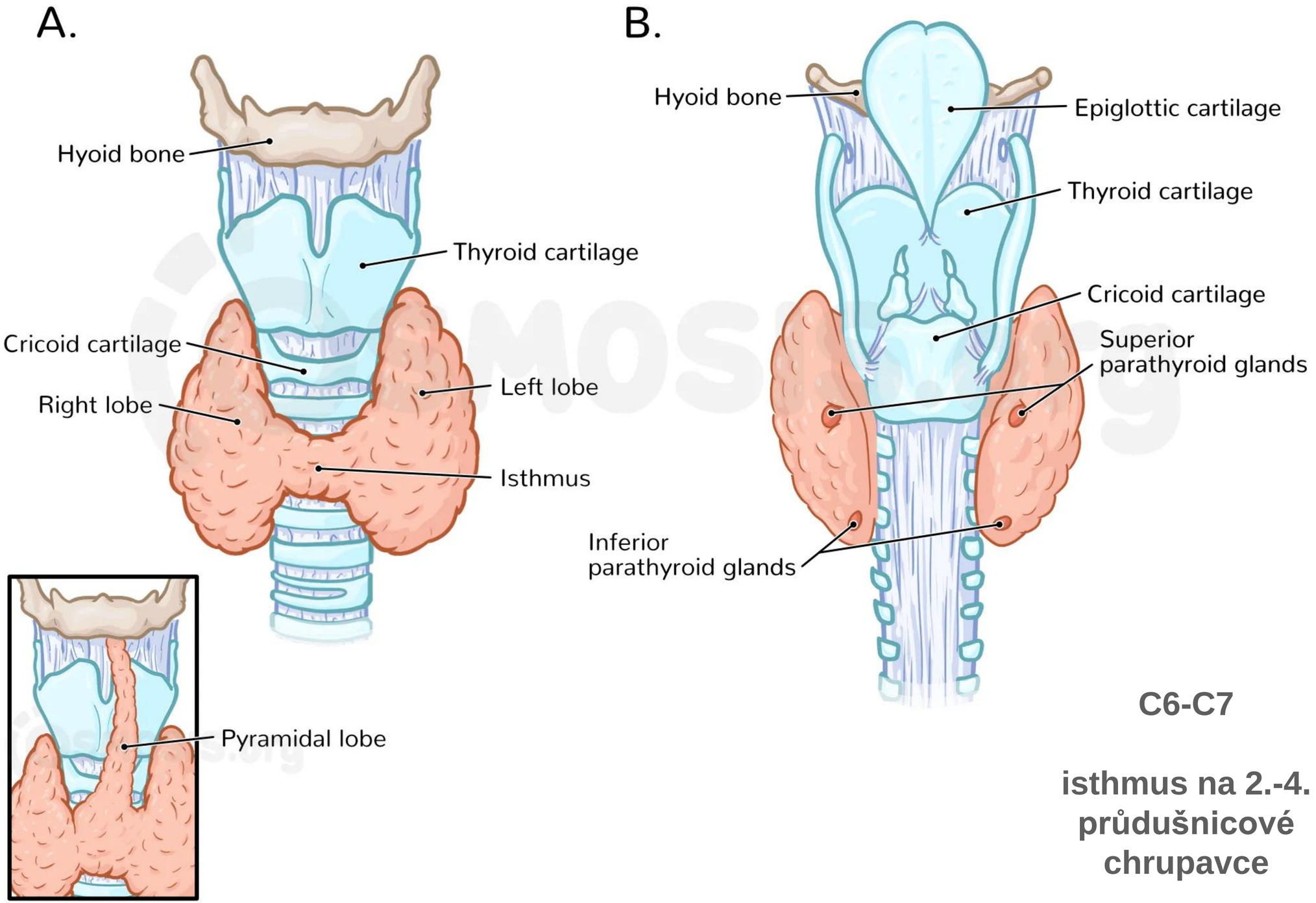




Pi = pinealocyty
Ng = neurogliové buňky
BS = acervulus cerebri
šipka = lamely



Štítná žláza (glandula thyroidea)



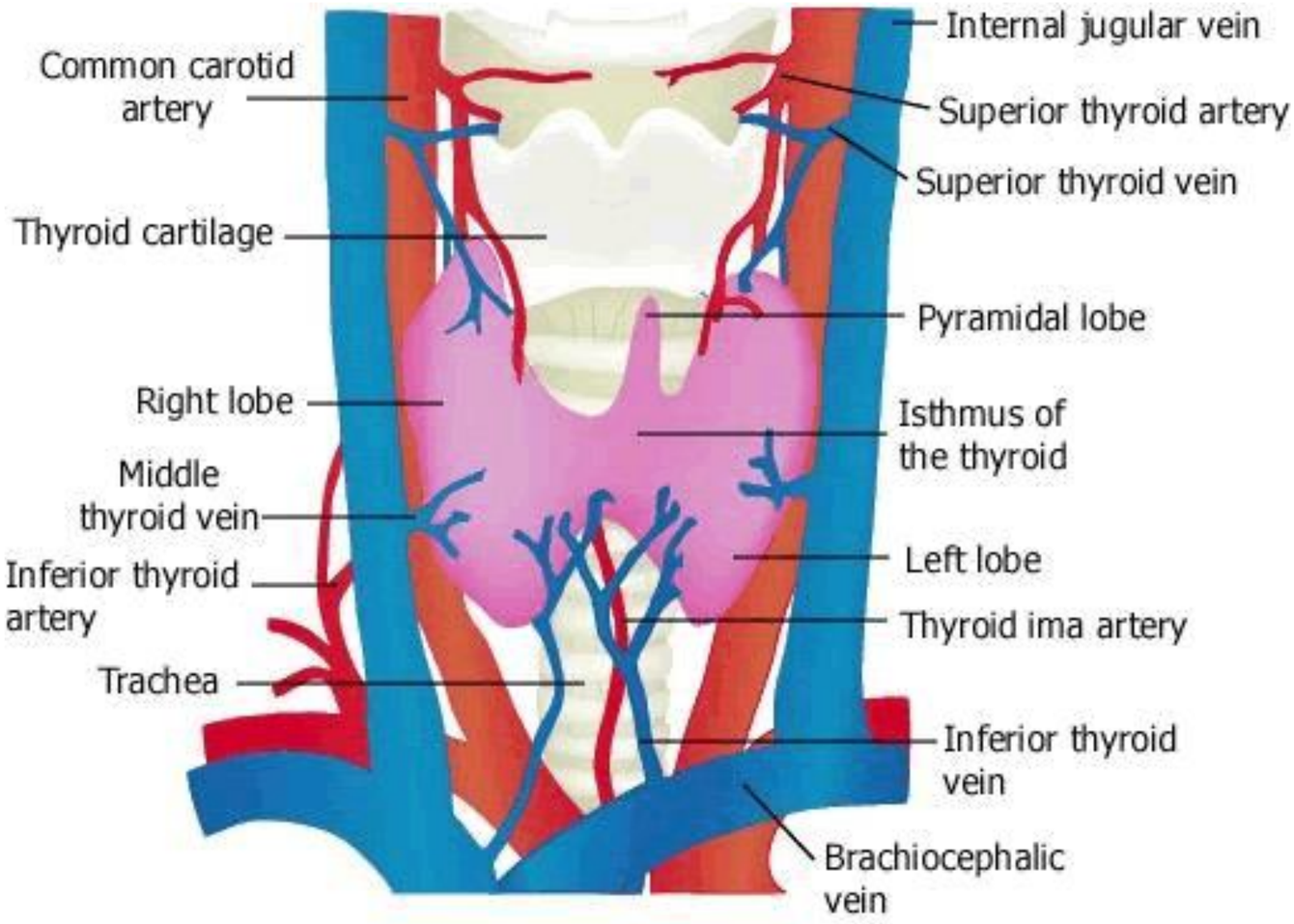
C6-C7

isthmus na 2.-4. průdušnicové chrupavce

Štítná žláza – krevní cévy

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

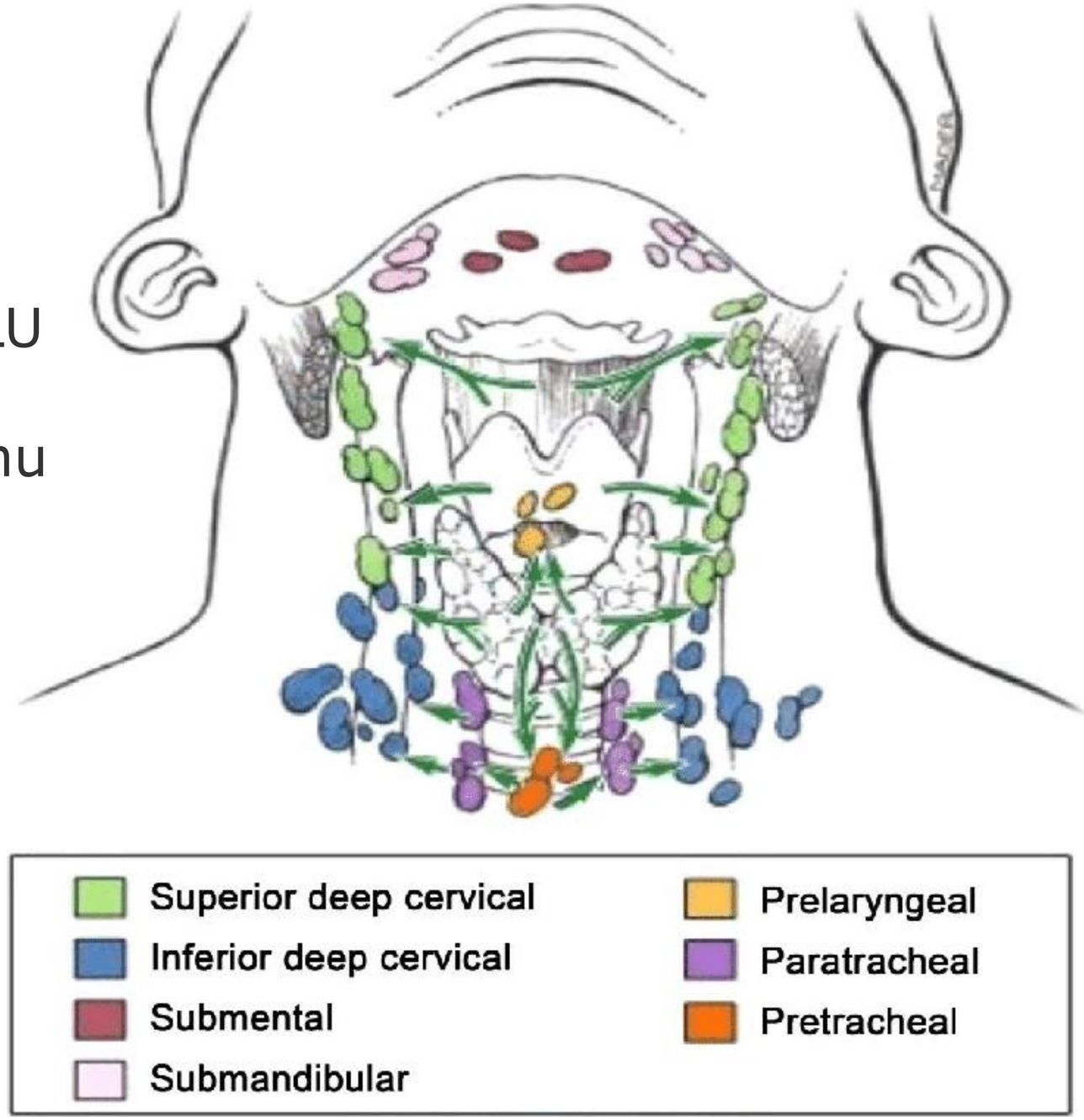
- vv. thyroideae superiores et mediae → vv. jugularis interna
- vv. thyroideae inferiores → plexus thyroideus impar → v. brachiocephalica sinistra

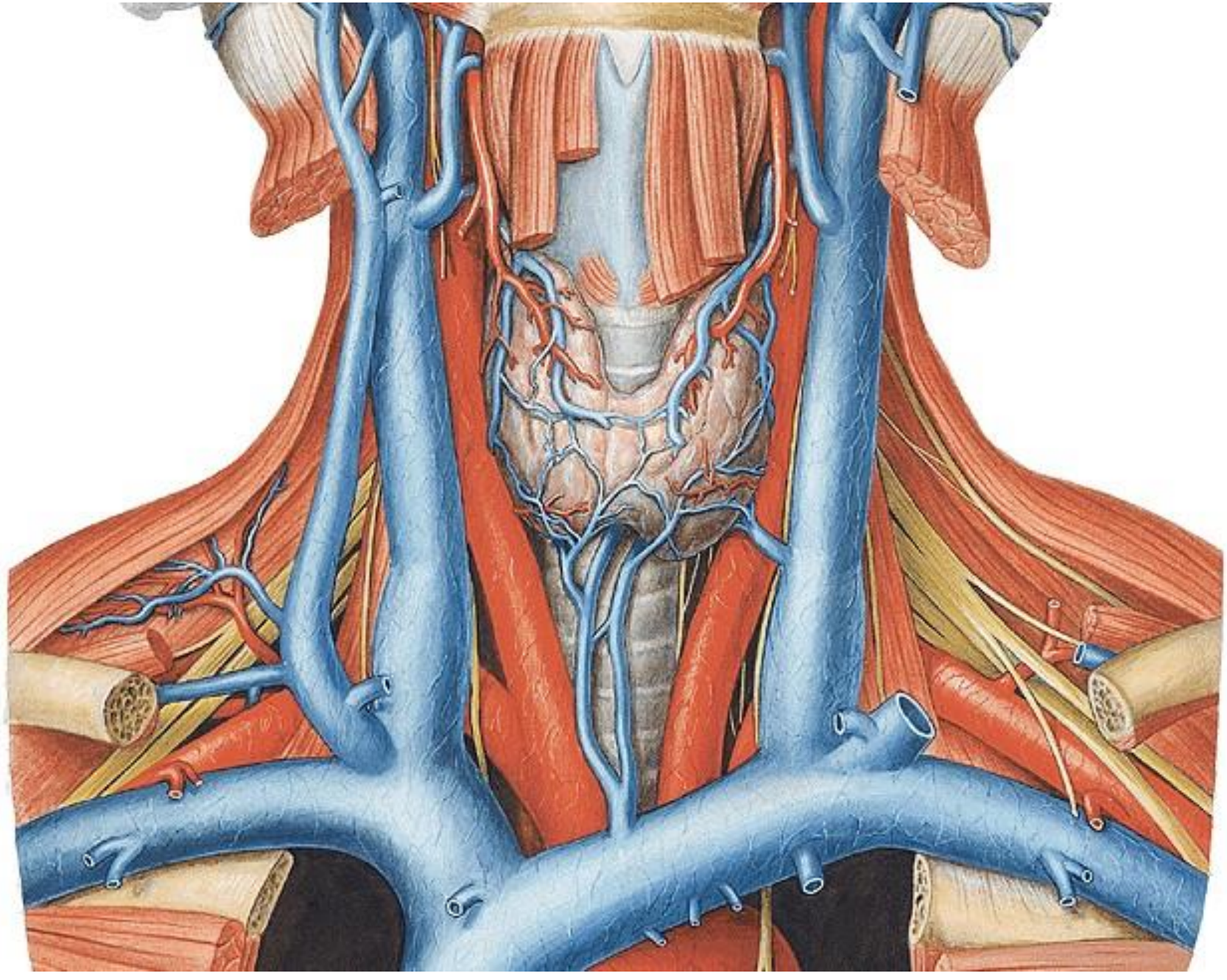


lymfatické cévy z horní oblasti laloků a isthmu - > jugulární LU

z dolních oblastí -> pre-, paratracheální a prelaryngeální LU

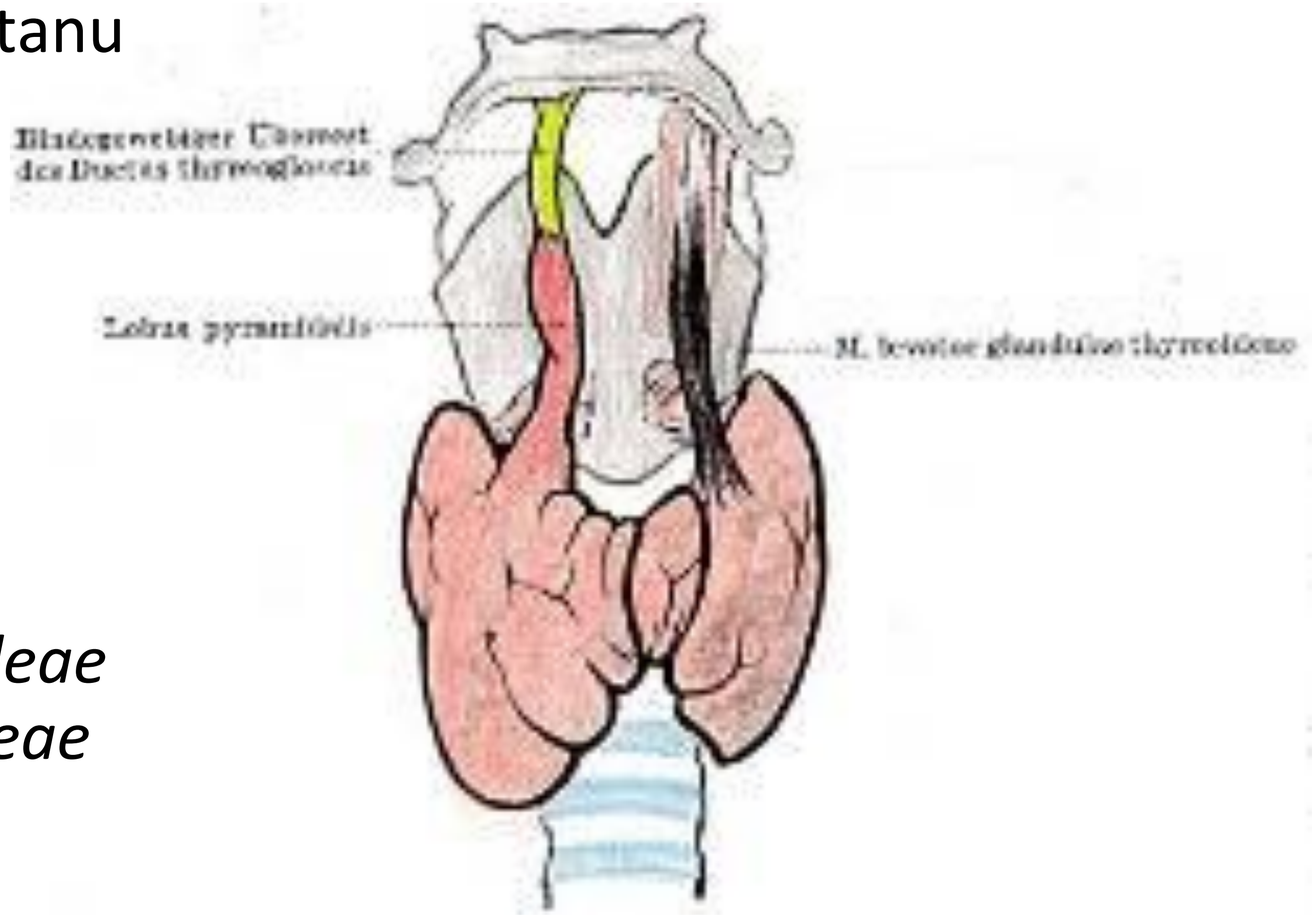
pretracheální LU v blízkosti isthmu - the ***Delphian*** *node*



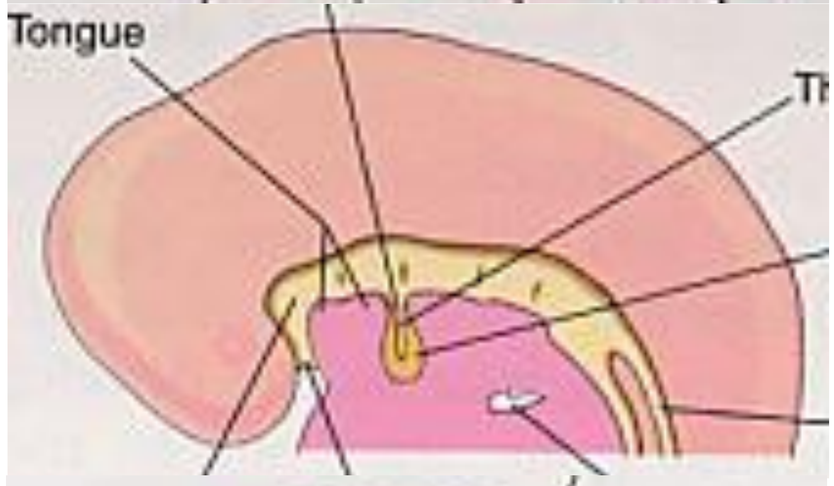


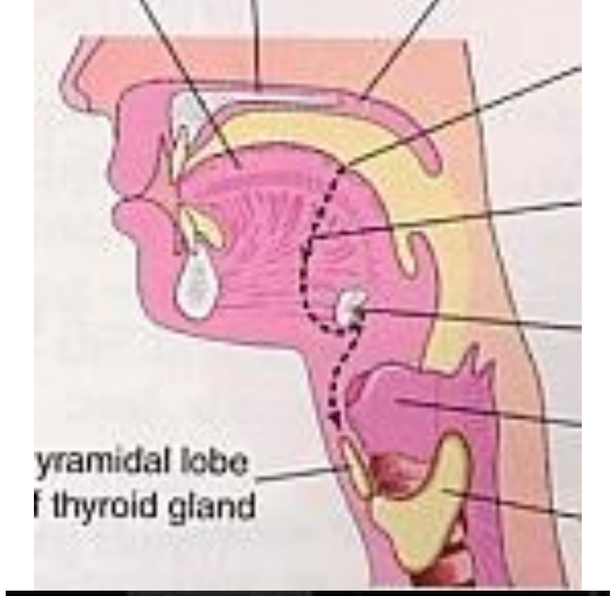
Štítná žláza – vývoj

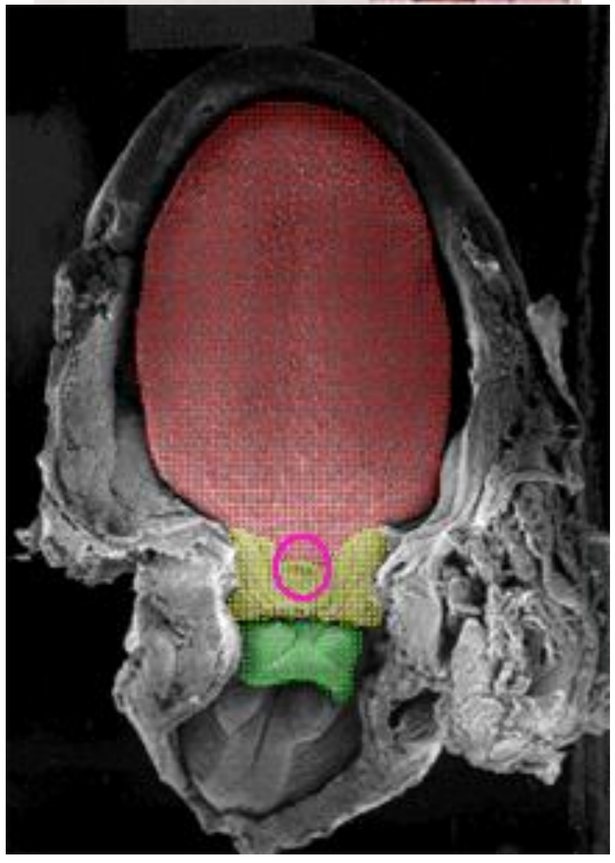
- vývoj od 24. dne
- výchlipka endodermu primitivního hltanu
- relativní i absolutní sestup → *ductus thyroglossus*
- *foramen caecum*
- *gll. thyroideae accessoriae*
- vznik laloků
- *lobus pyramidalis*
- *ligamentum suspensorium gl. thyroideae / musculus levator glandulae thyroideae* (hladký)



Štítná žláza





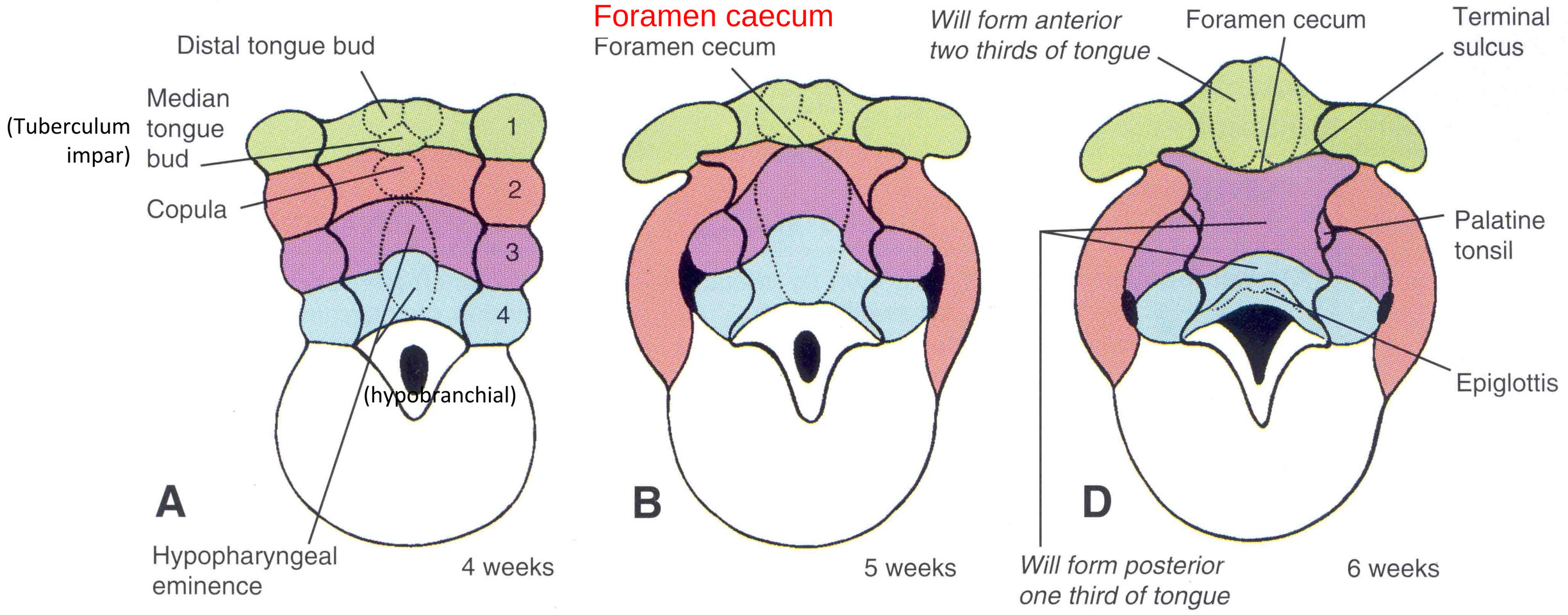


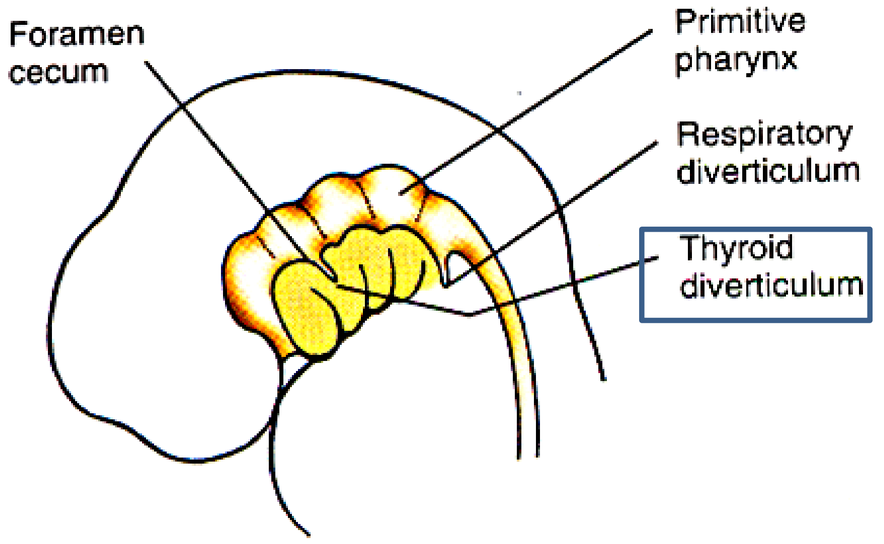
Vývoj

Development of thyroid gland

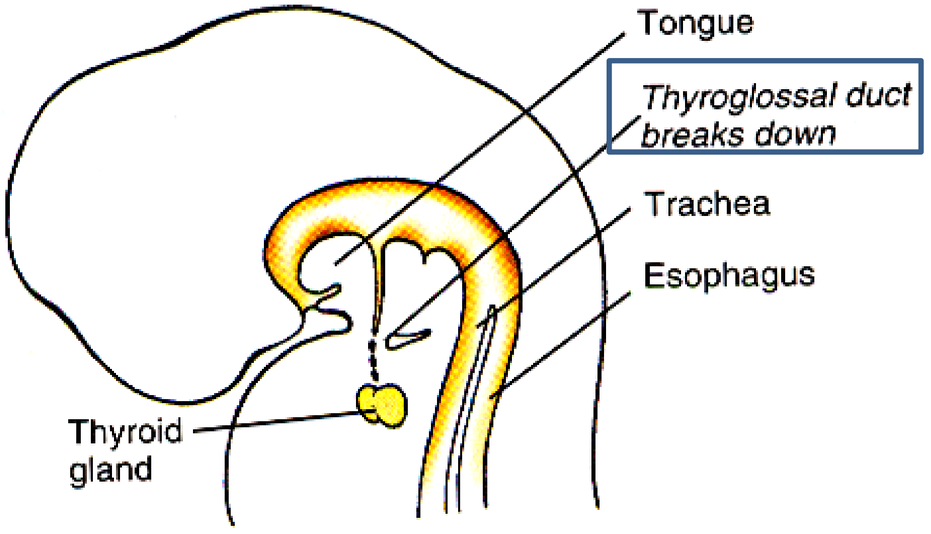
(Lateral lingual swelling)

Foramen caecum

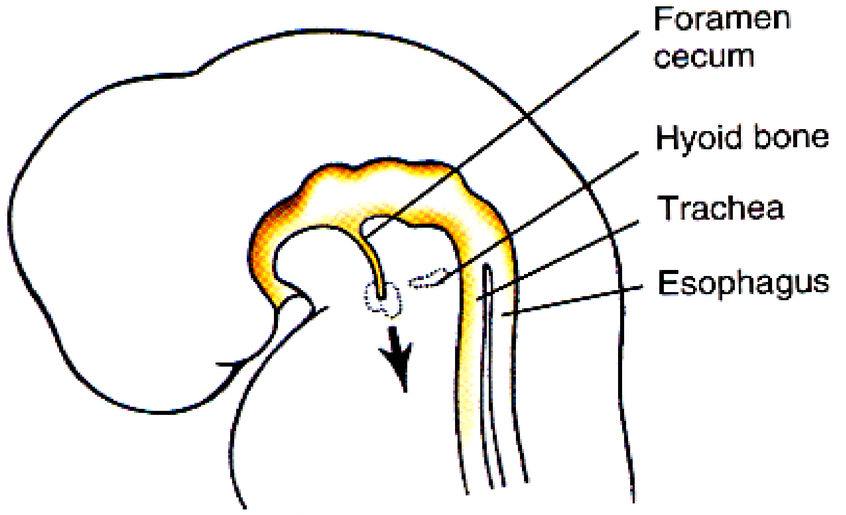




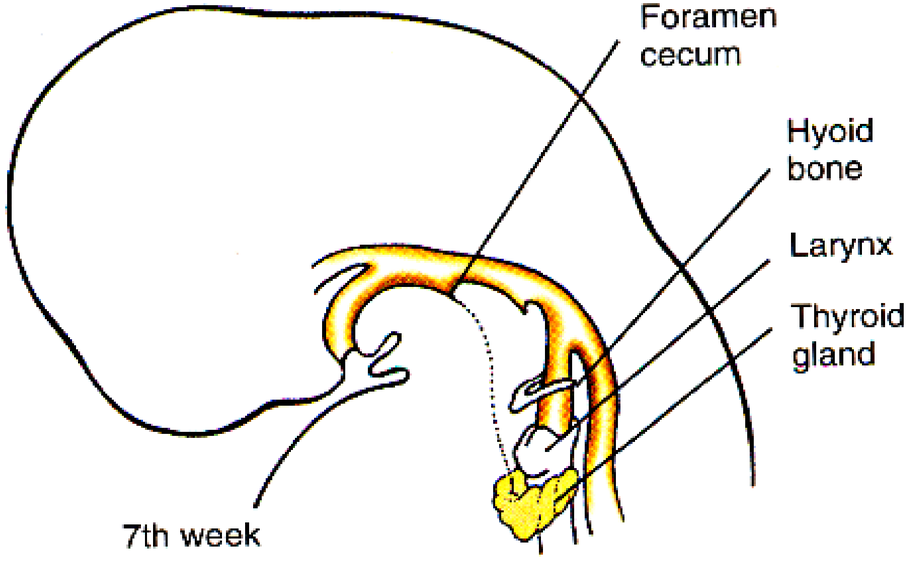
4th week



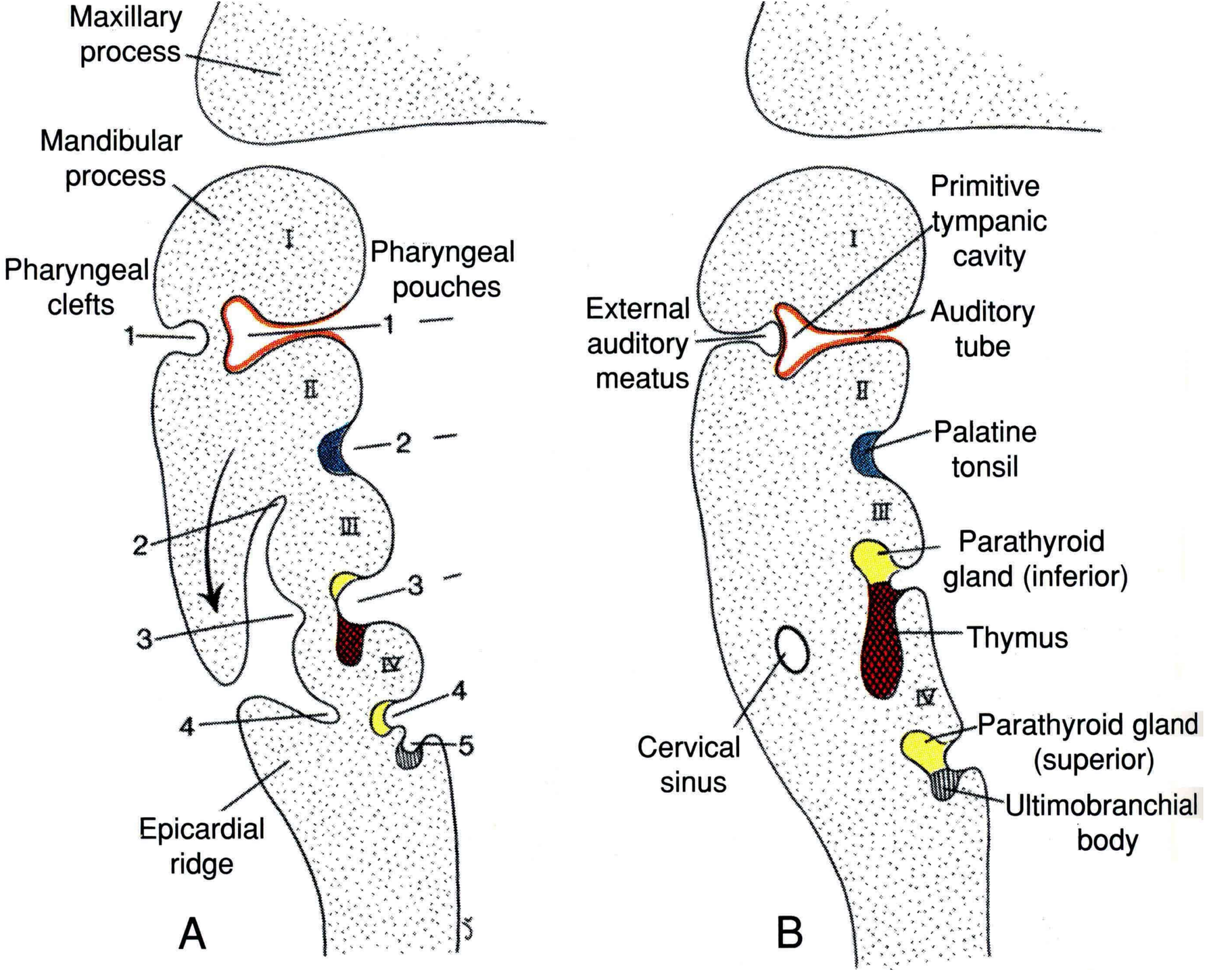
Late 5th week



Early 5th week

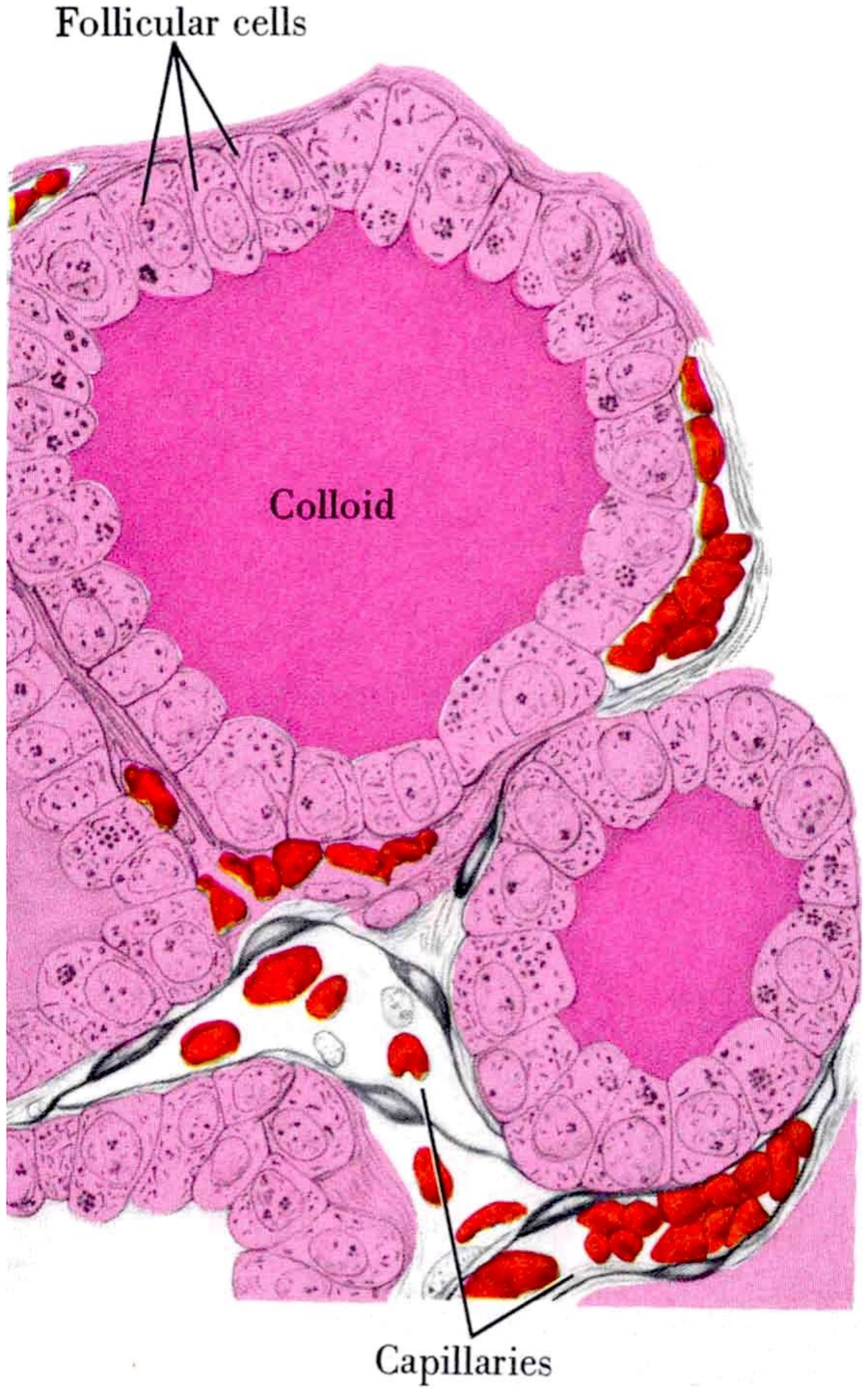


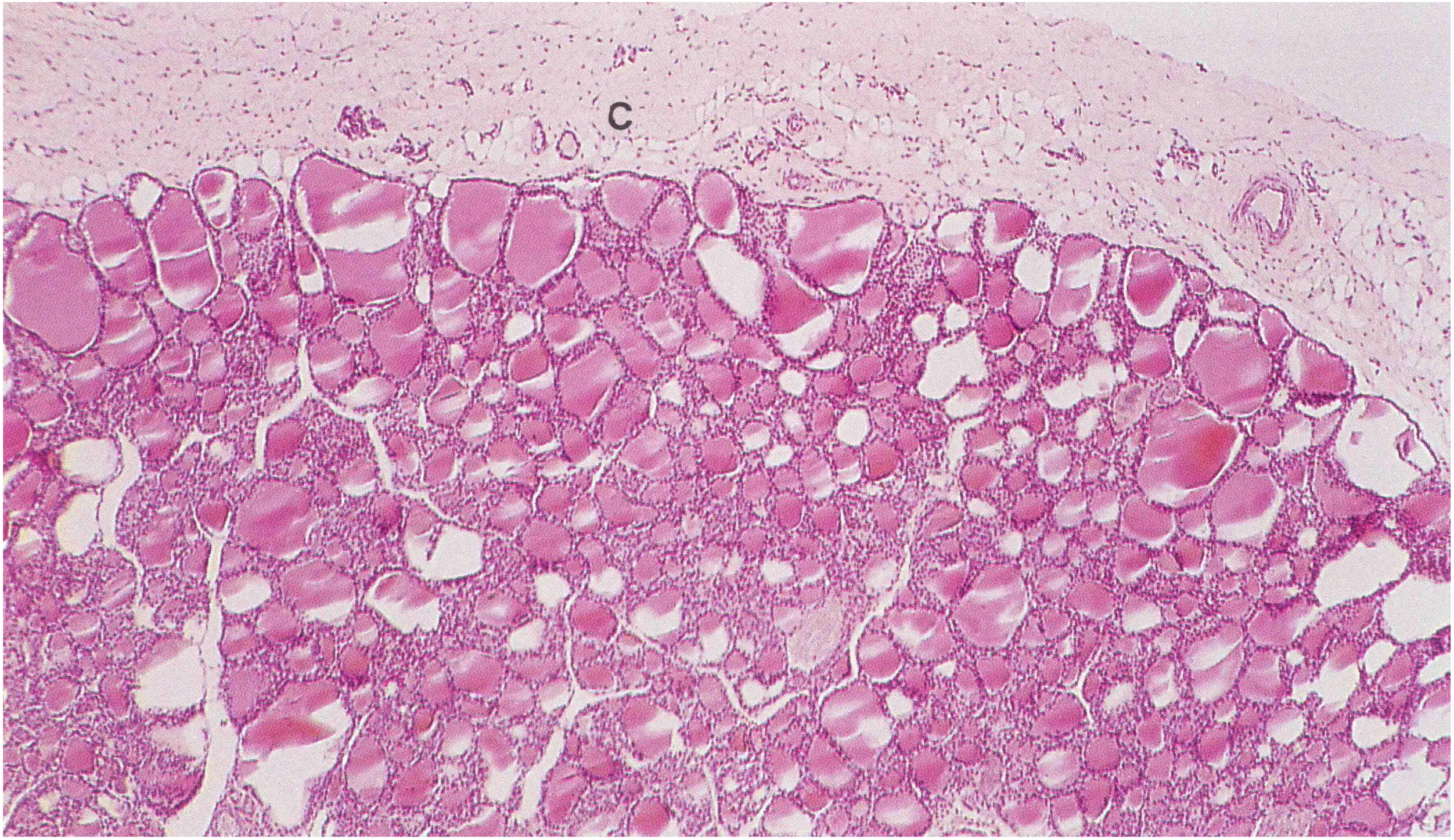
7th week


Maxillary process
Mandibular process
Pharyngeal clefts
Pharyngeal pouches
I
II
III
IV
1
2
3
4
5
Epicardial ridge
A
Primitive tympanic cavity
External auditory meatus
Auditory tube
Palatine tonsil
Parathyroid gland (inferior)
Thymus
Parathyroid gland (superior)
Ultimobranchial body
Cervical sinus
B

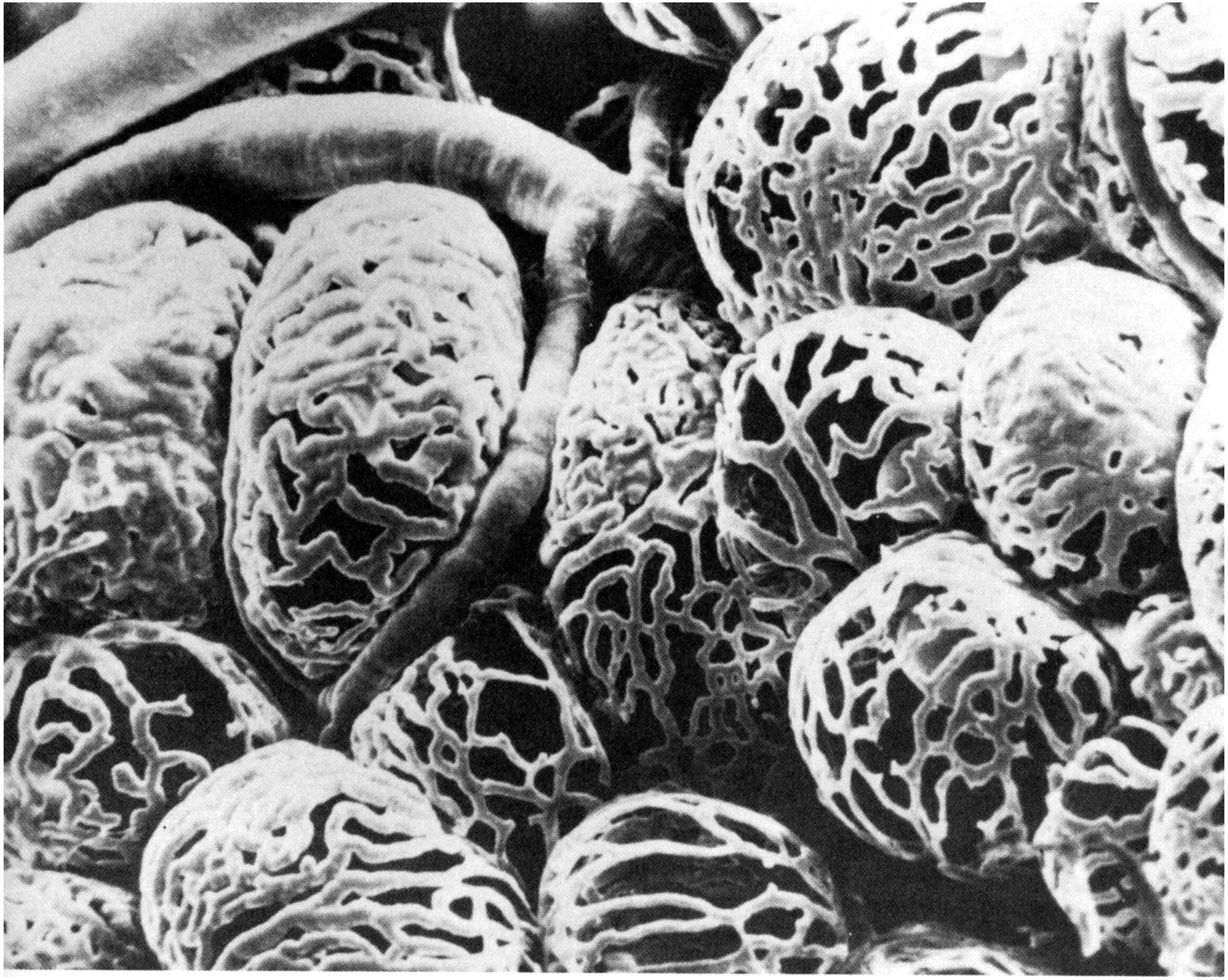
Štítná žláza – stavba

- pouzdro (*capsula fibrosa*)
- stroma
- septa (přepážky mezi lalůčky)
- lobus → lobulus → folliculus
- folikuly (50–900 µm) – kulovité útvary
  - jednovrstevný epitel folikulárních buněk
  - obsahuje *colloidum* (koloid) – tyroglobulin
- **folikulární buňky**
  - tyroglobulin, vyštěpení T_4 a T_3
- **parafolikulární buňky** (C-buňky)
  - derivát neurální lišty z ultimofaryngového tělíska
  - leží mezi folikulárními buňkami (jednotlivě, “skupinky”),
  - bez kontaktu s koloidem
  - tvorba a střádání **kalcitoninu**

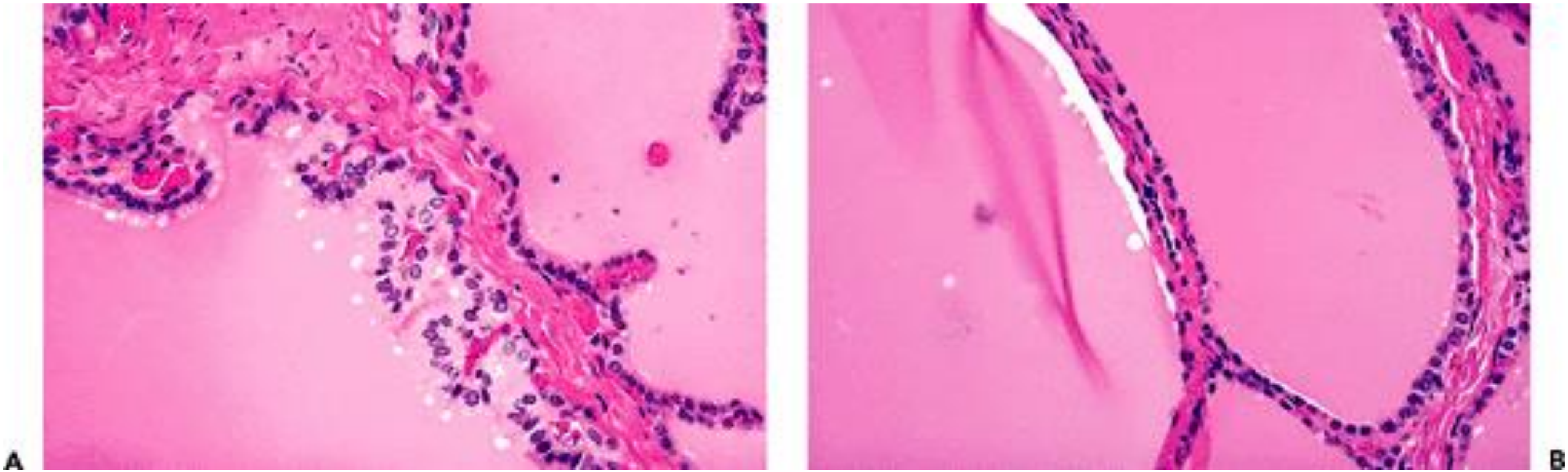



C

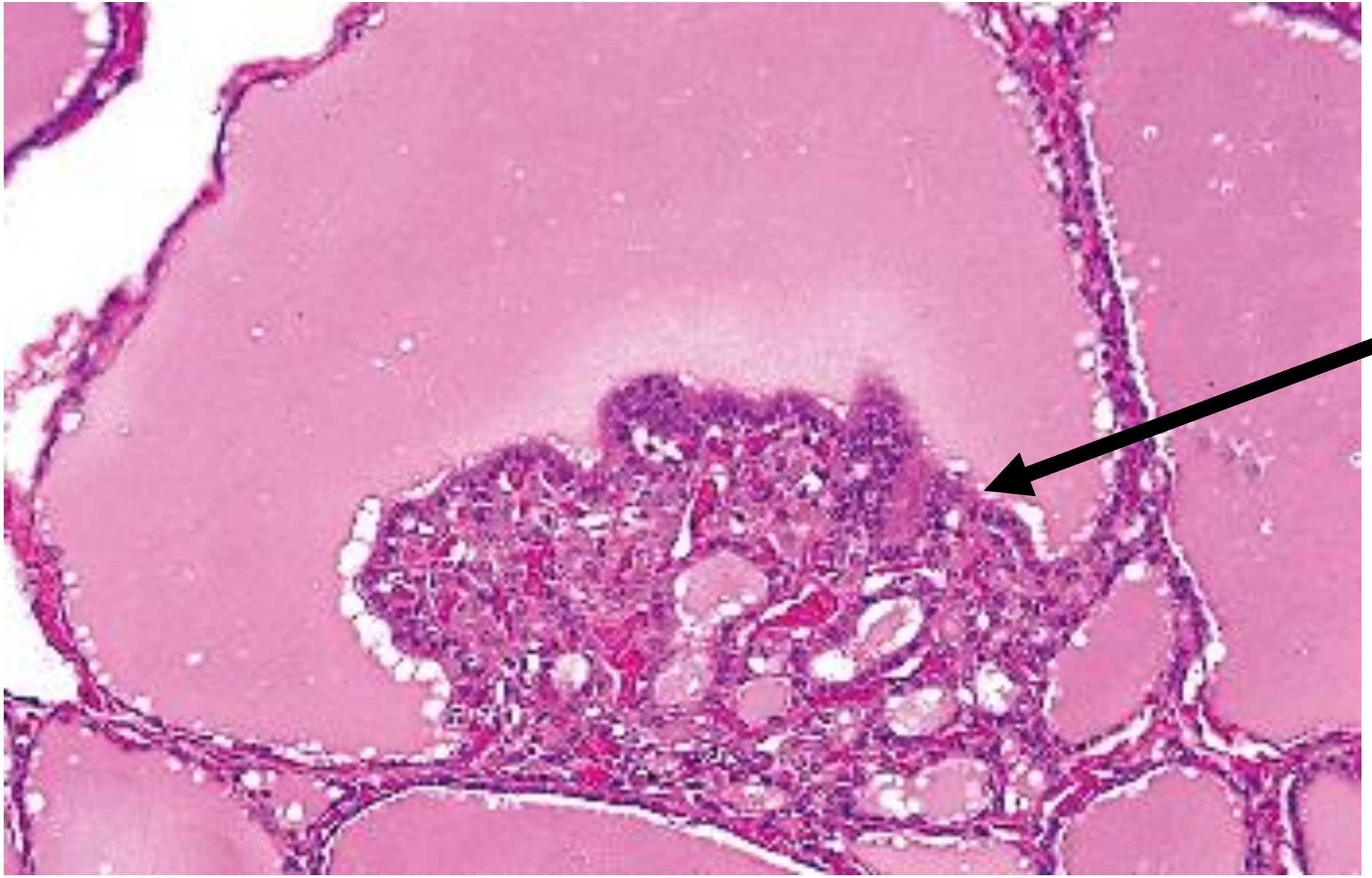

Thyrocyty (folikulární buňky) - folikuly
Stroma: retikulární vazivo



TE = epitel folikulu
BM = bazální membrána
TC = koloid
C = kapilára

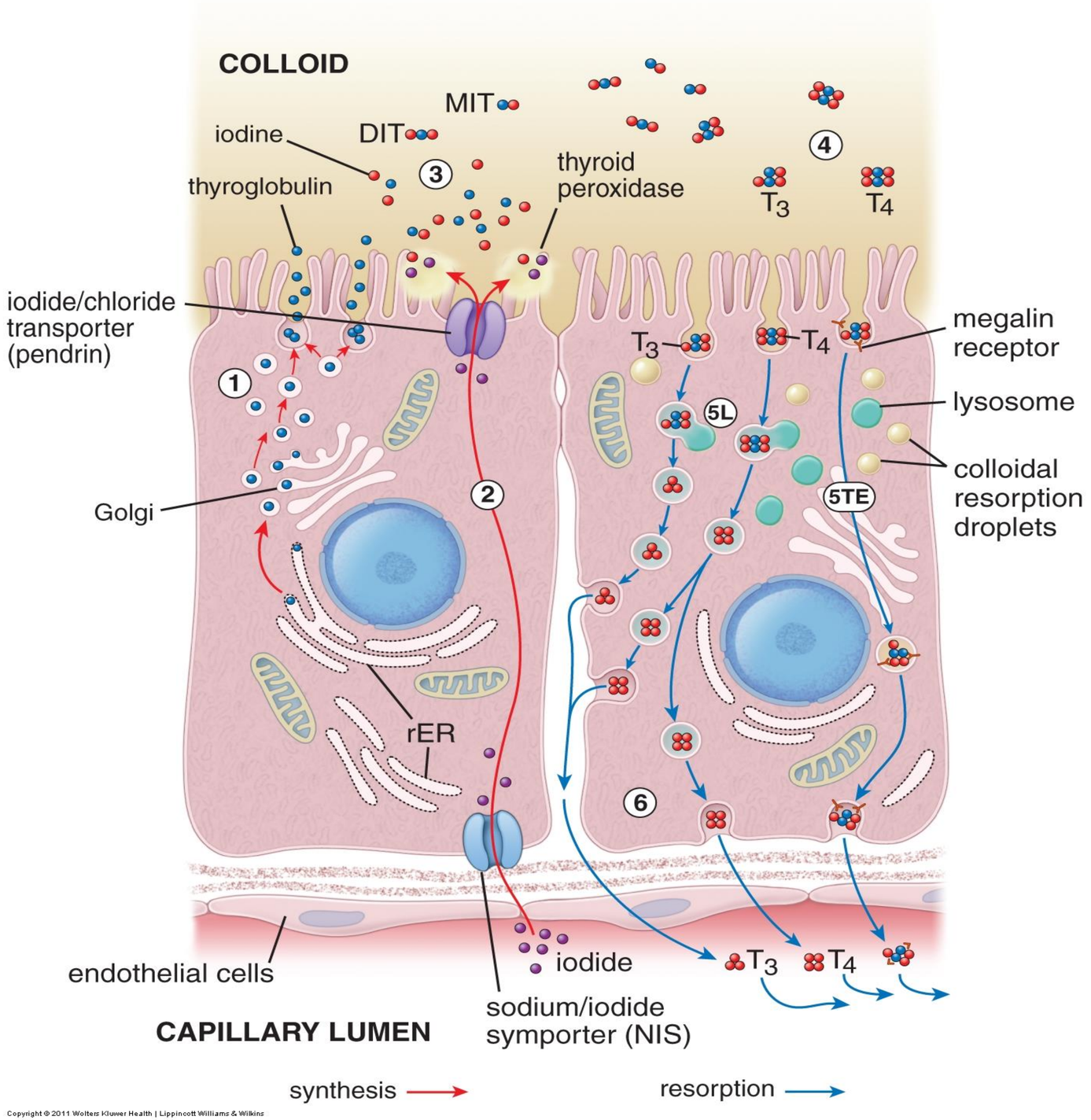


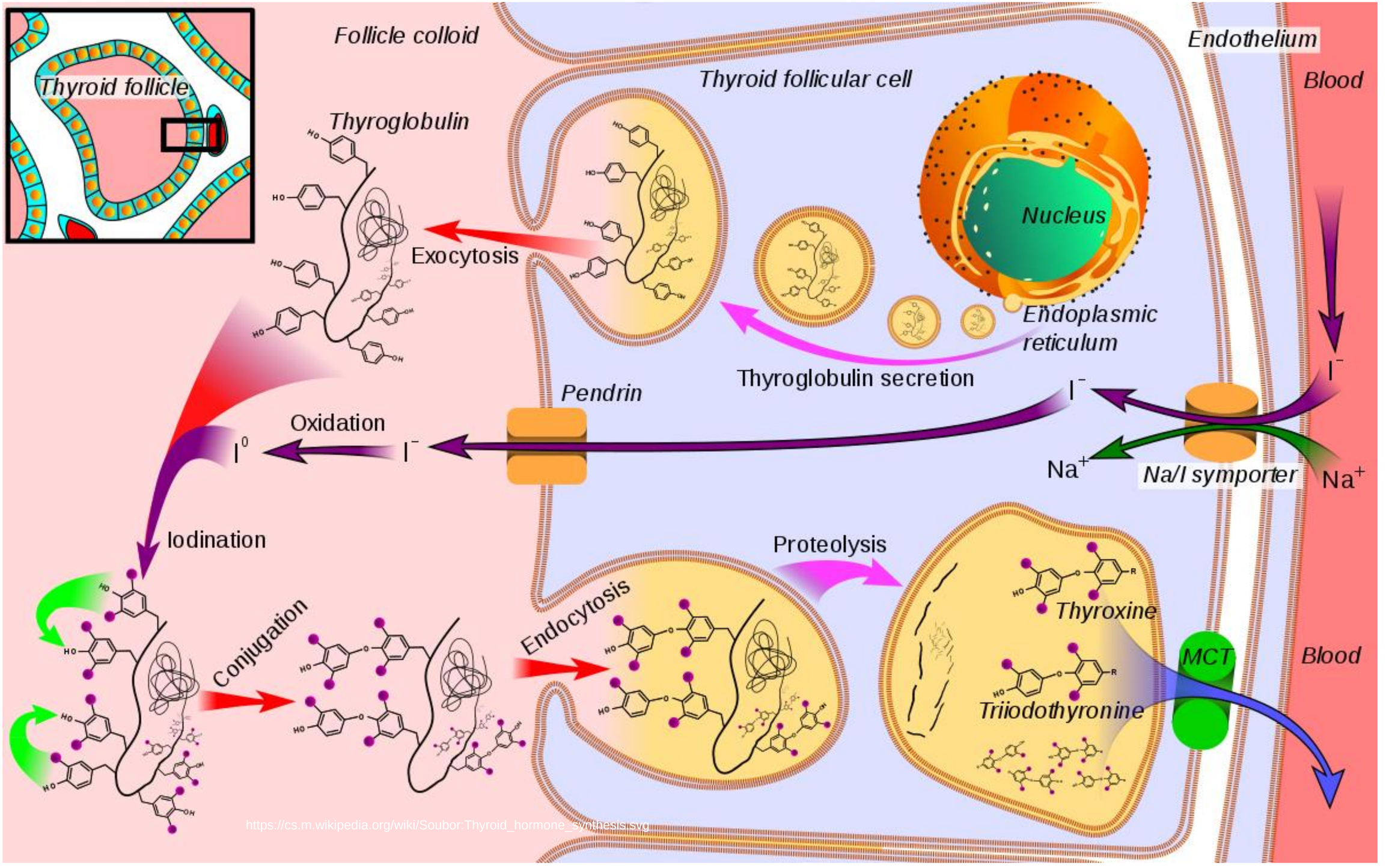
A The epithelium of one follicle is low cuboidal and relatively inactive. The adjacent follicle shows a taller epithelium and reabsorption vacuoles. **B.** The epithelium of the same follicle is flattened on one side and cuboidal on the other, as an expression of functional polarization.



Sandersonův polštářek

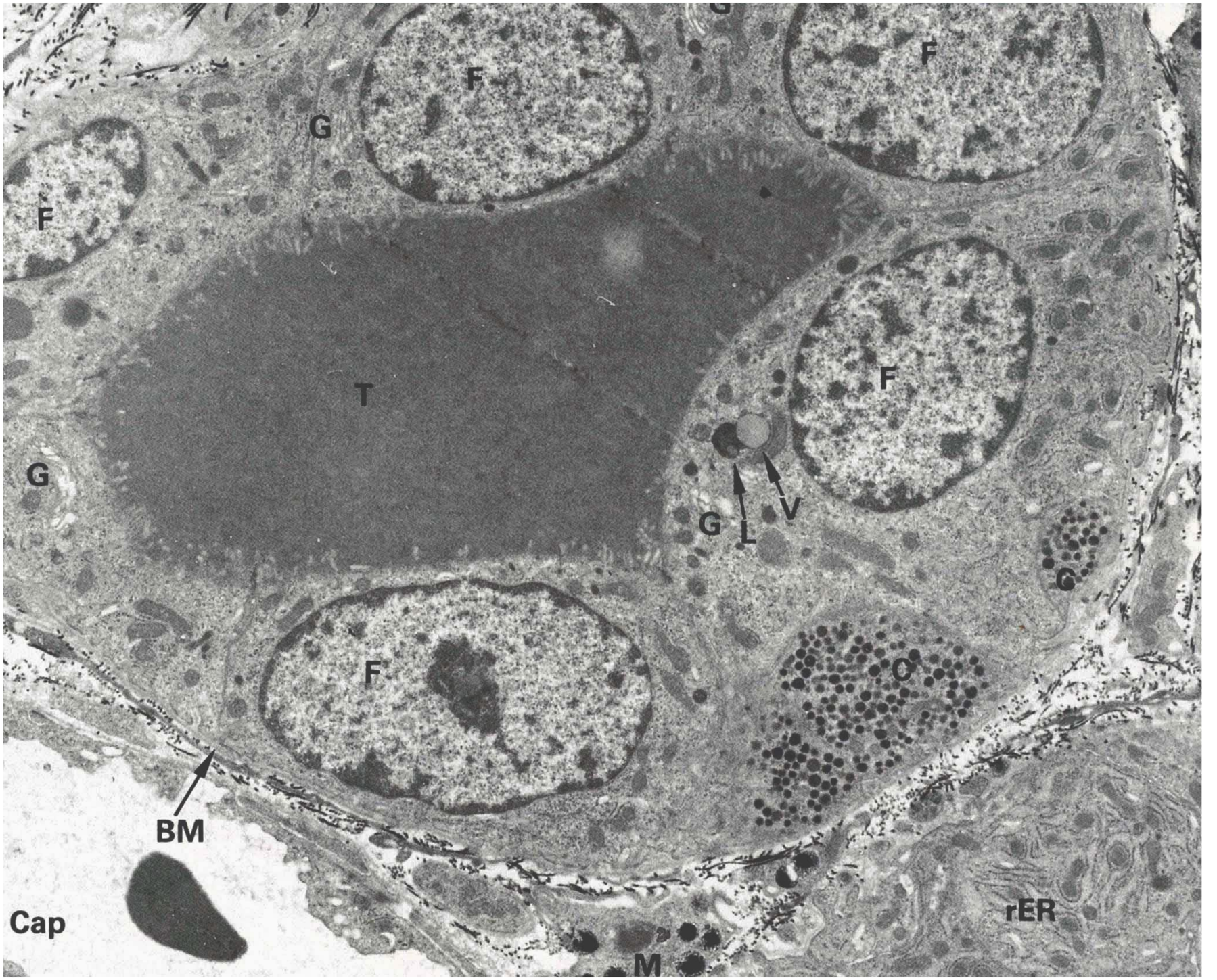
hormony:
T3 (trijódthyronin)
T4 (thyroxin)

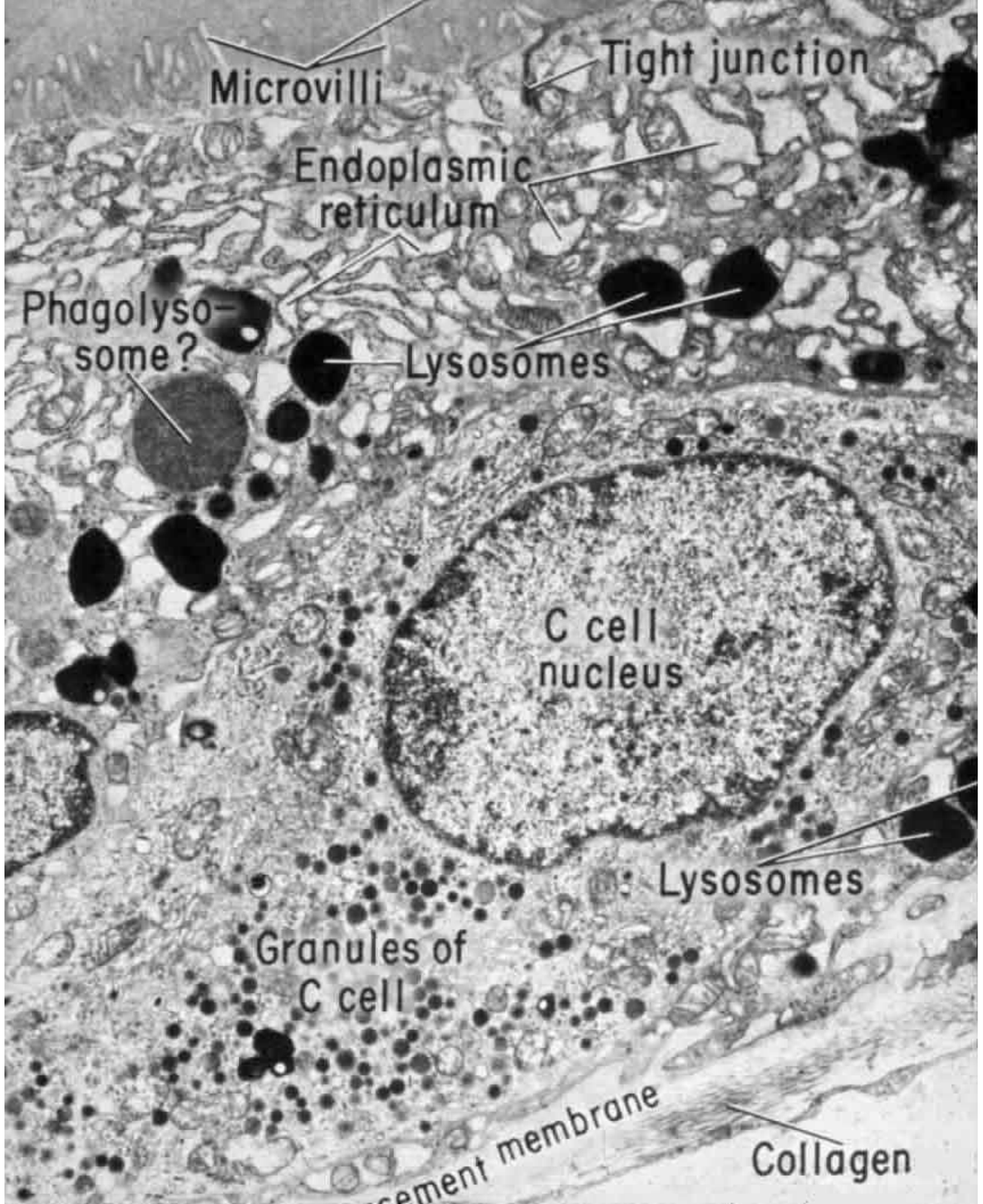




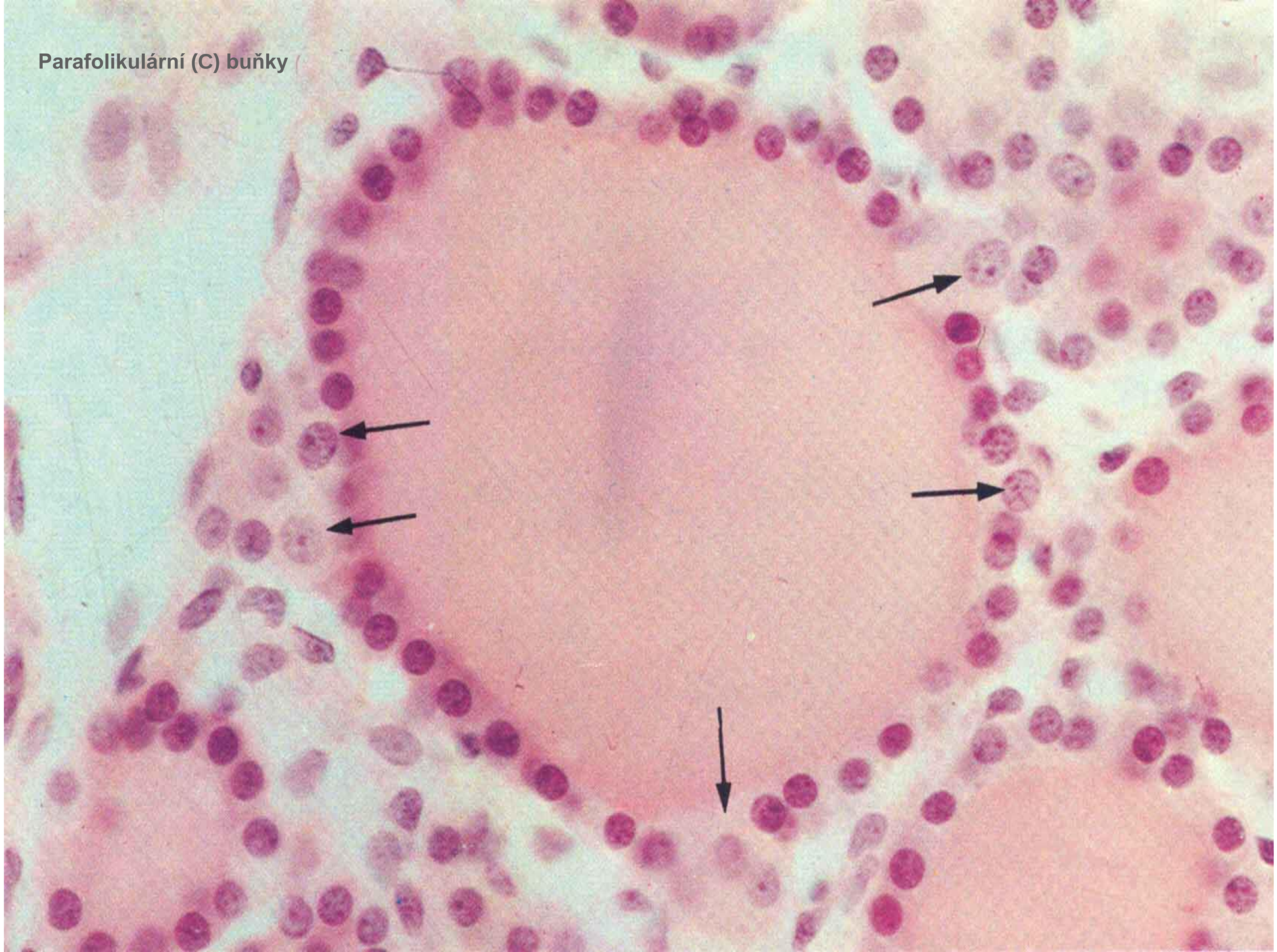
https://cs.m.wikipedia.org/wiki/Soubor:Thyroid_hormone_synthesis.svg

F = folikulární buňky
T = koloid
C = parafolikulární buňky
BM = bazální membrána
Cap = kapilára
G = Golgiho komplex
V = vesikula obsahující koloid
L = lysosom splývající s vesikulou
rER = granulární ER ve folikulární buňce sousedního folikulu
M = část žírné buňky



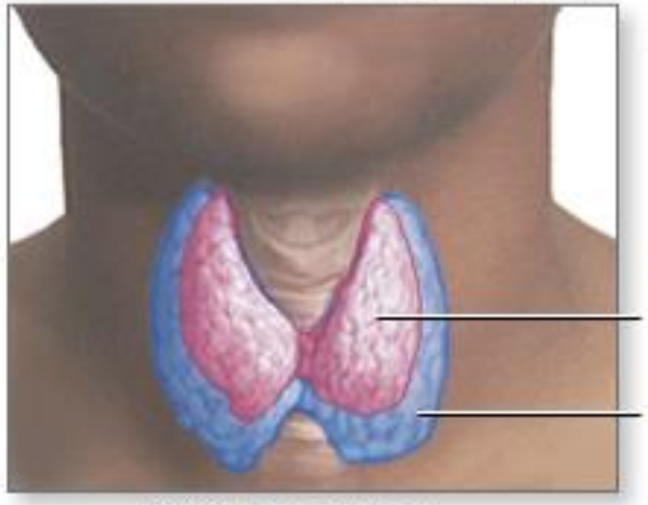

Microvilli
Tight junction
Endoplasmic reticulum
Phagolyso-some?
Lysosomes
C cell nucleus
Lysosomes
Granules of C cell
Collagen

Parafolikulární (C) buňky



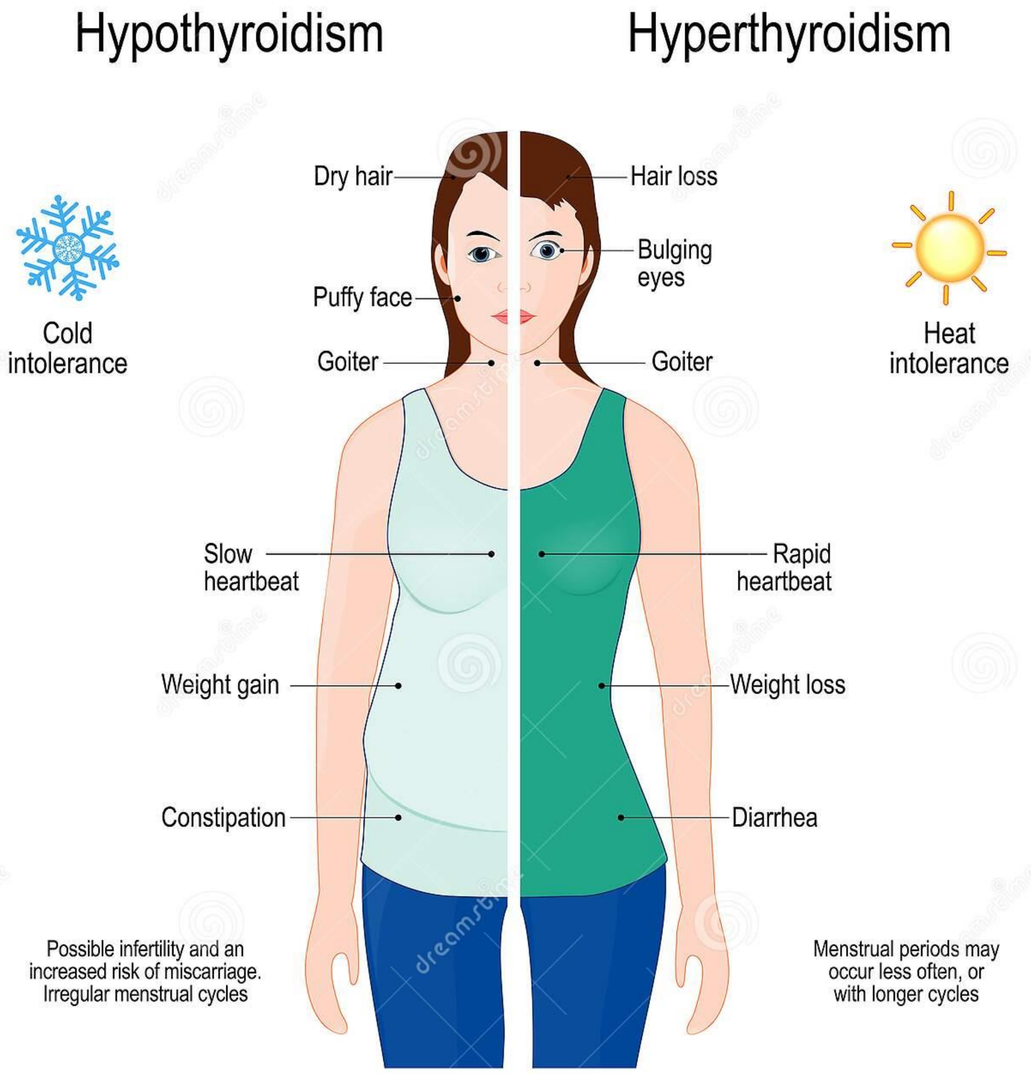
Disorder of the thyroid gland

Exophthalmos (bulging eyes)

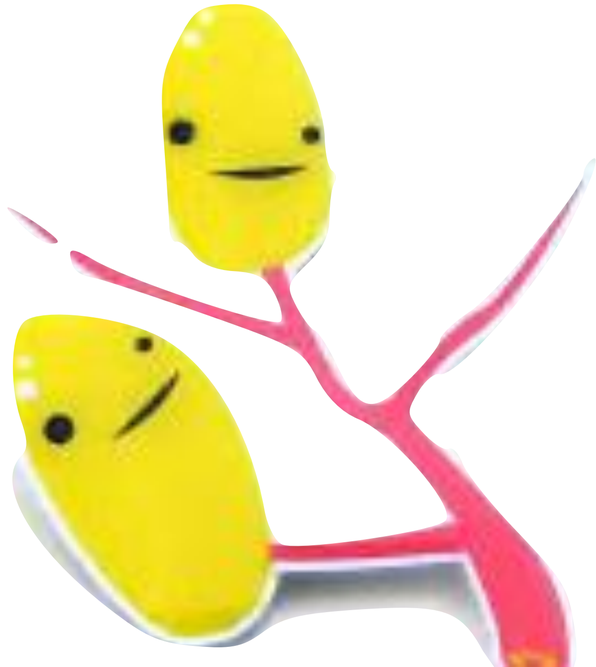


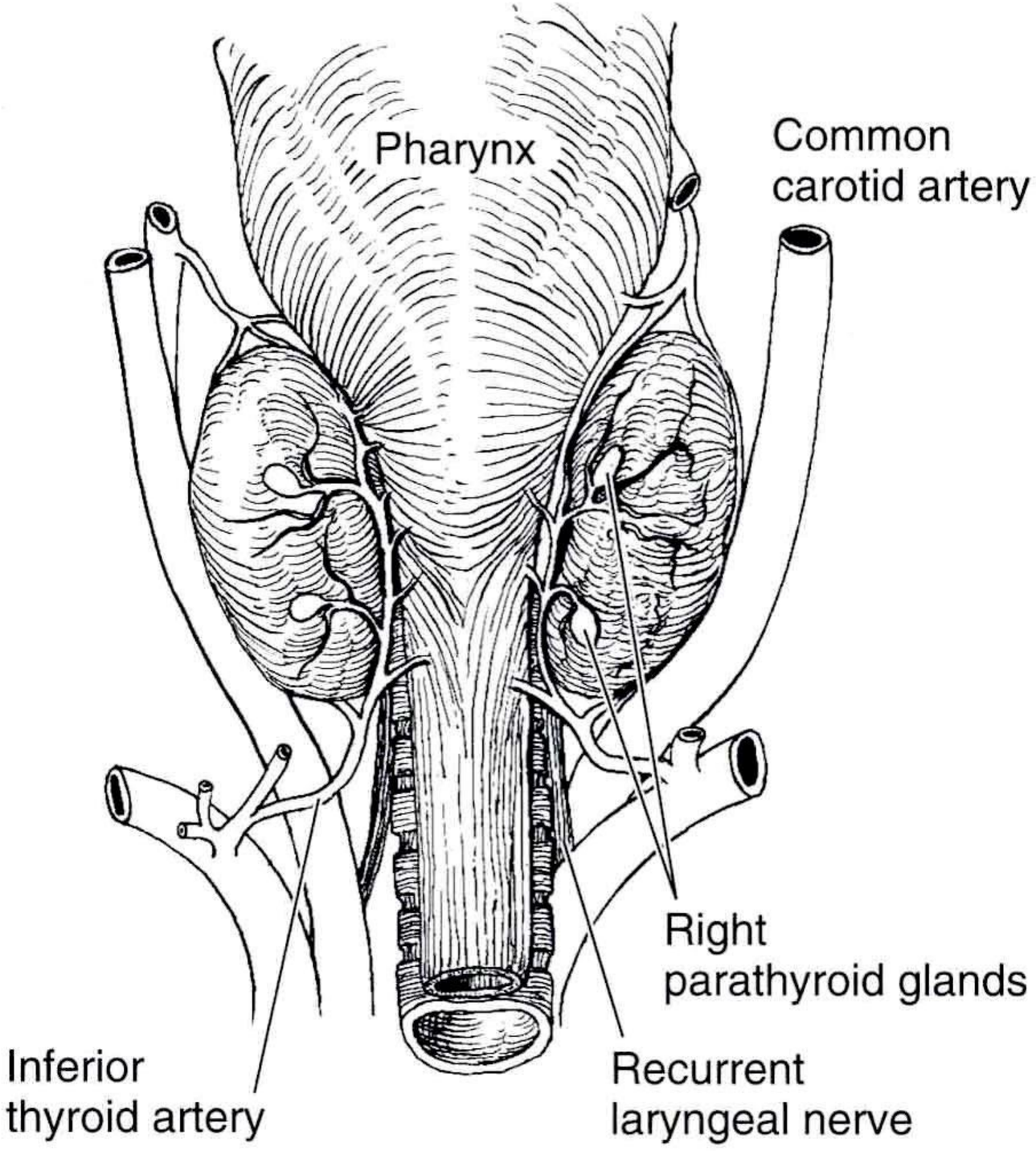
Diffuse goiter

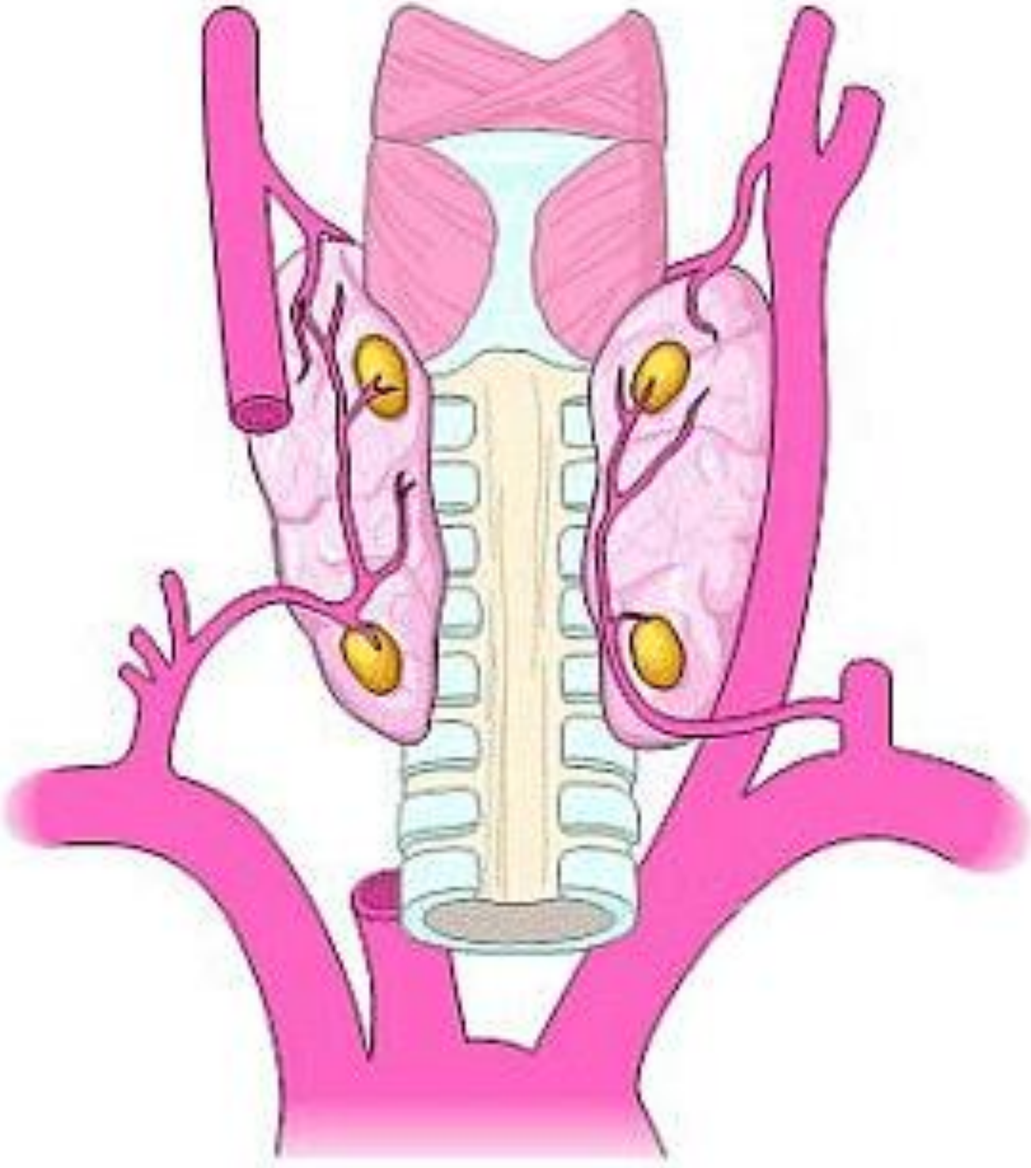
Graves' disease is a common cause of hyperthyroidism, an over-production of thyroid hormone, which causes enlargement of the thyroid and other symptoms such as exophthalmos, heat intolerance and anxiety

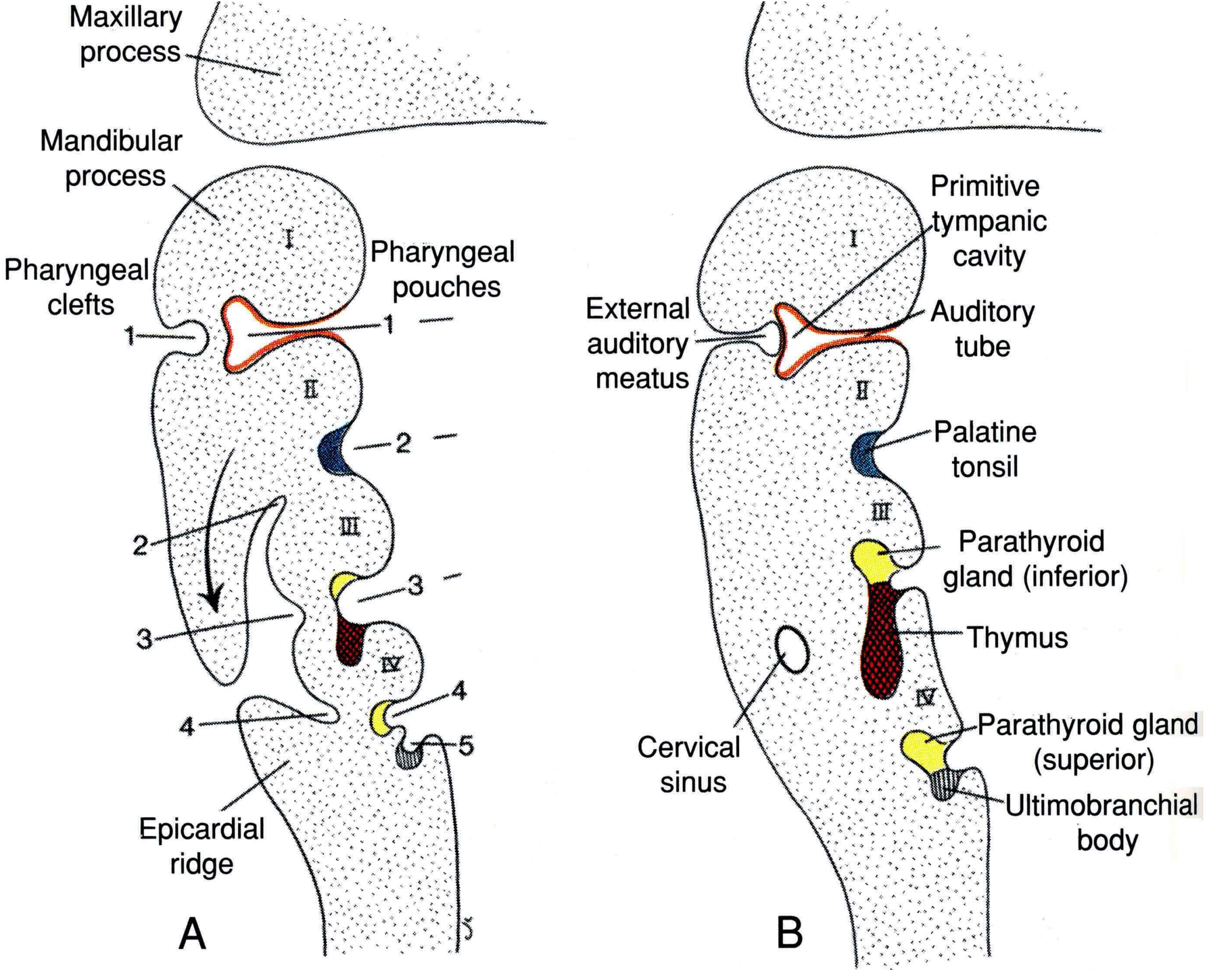


Příštítné žlázy (příštítná tělíska, glandulae parathyroideae)



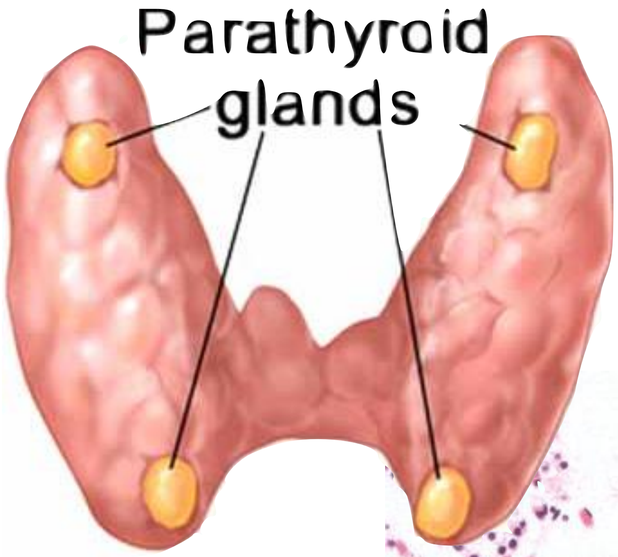

Pharynx
Common carotid artery
Right parathyroid glands
Inferior thyroid artery
Recurrent laryngeal nerve

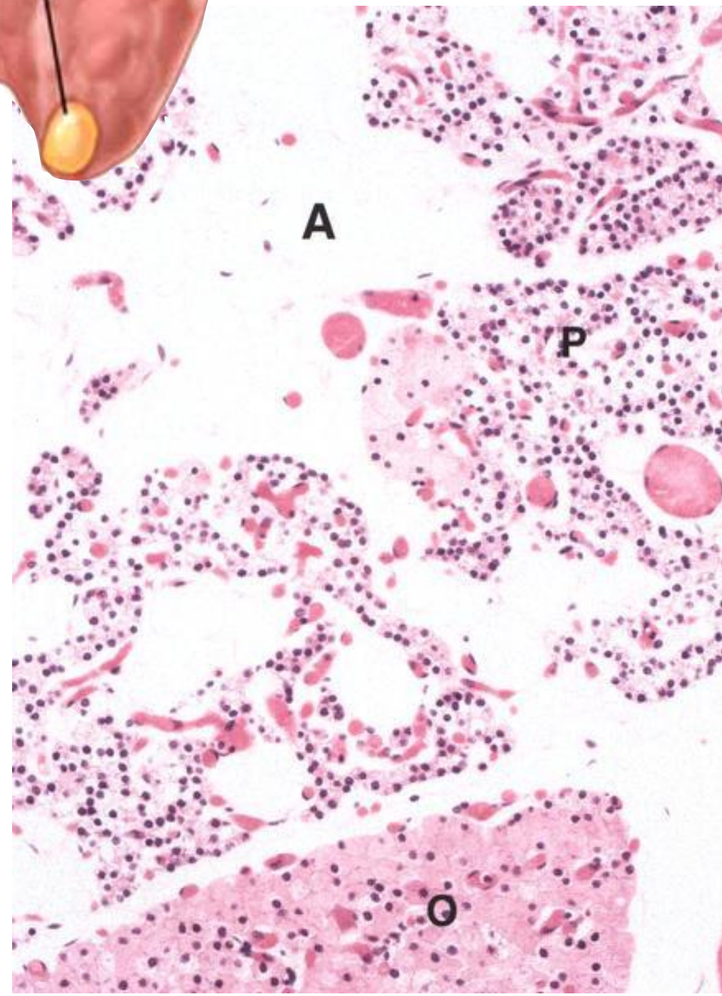



Maxillary process
Mandibular process
Pharyngeal clefts
Pharyngeal pouches
I
II
III
IV
1
2
3
4
5
Epicardial ridge
A
Primitive tympanic cavity
External auditory meatus
Auditory tube
Palatine tonsil
Parathyroid gland (inferior)
Thymus
Parathyroid gland (superior)
Ultimobranchial body
Cervical sinus
B

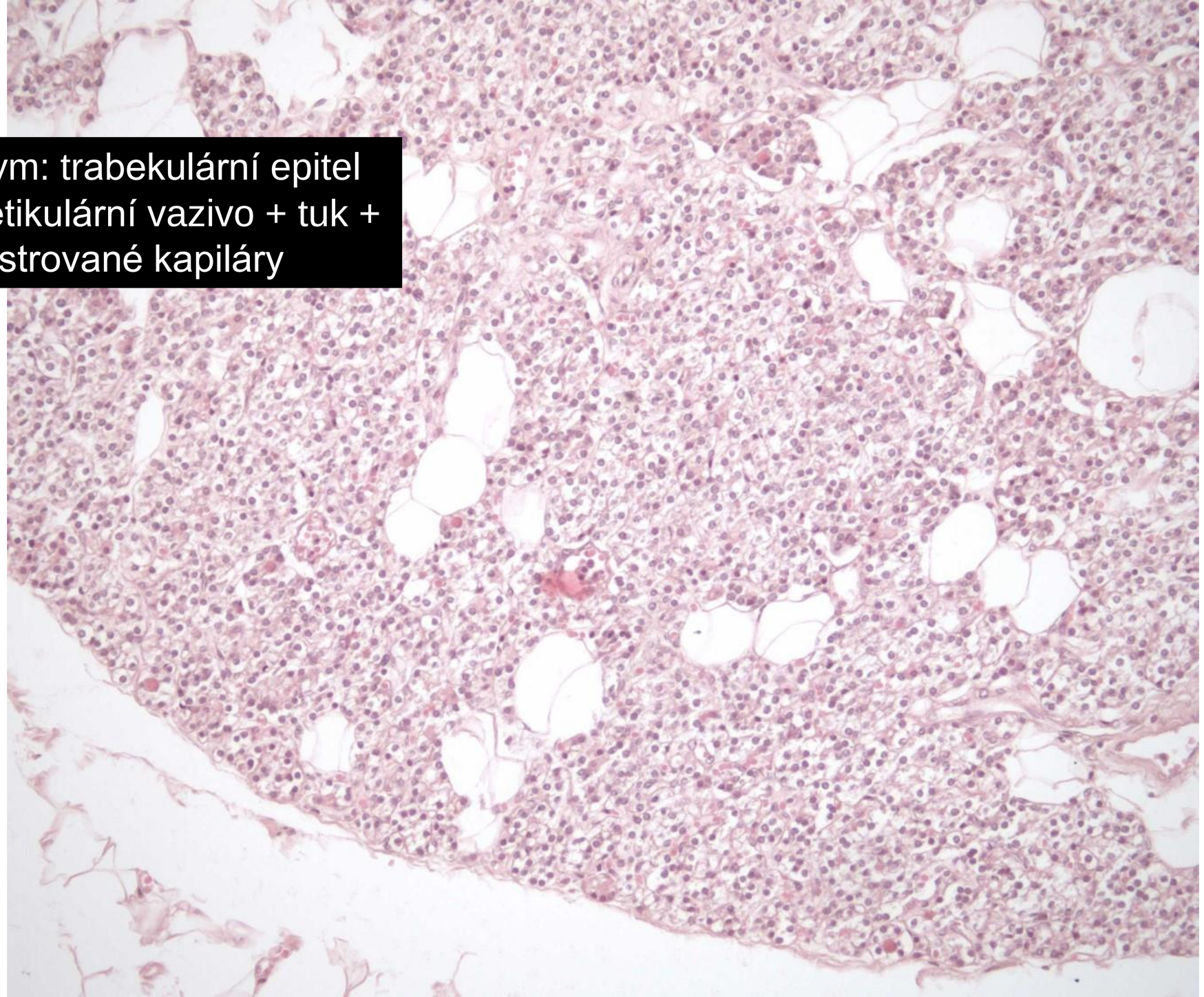
Příštítná tělíska

- *glandula parathyroidea superior et inferior*
- 2 páry drobných kulovitých útvarů na zadní straně laloků štítné žlázy
- samostatné větve z a. thyroidea inferior
- úloha v metabolizmu kostí
- pouzdro + přepážky
- parenchym rozčleněn na trámce
- **hlavní buňky**
  - **parathormon (PTH)**
- oxyfilní buňky
  - silně acidofilní, mitochondrie, glykogen

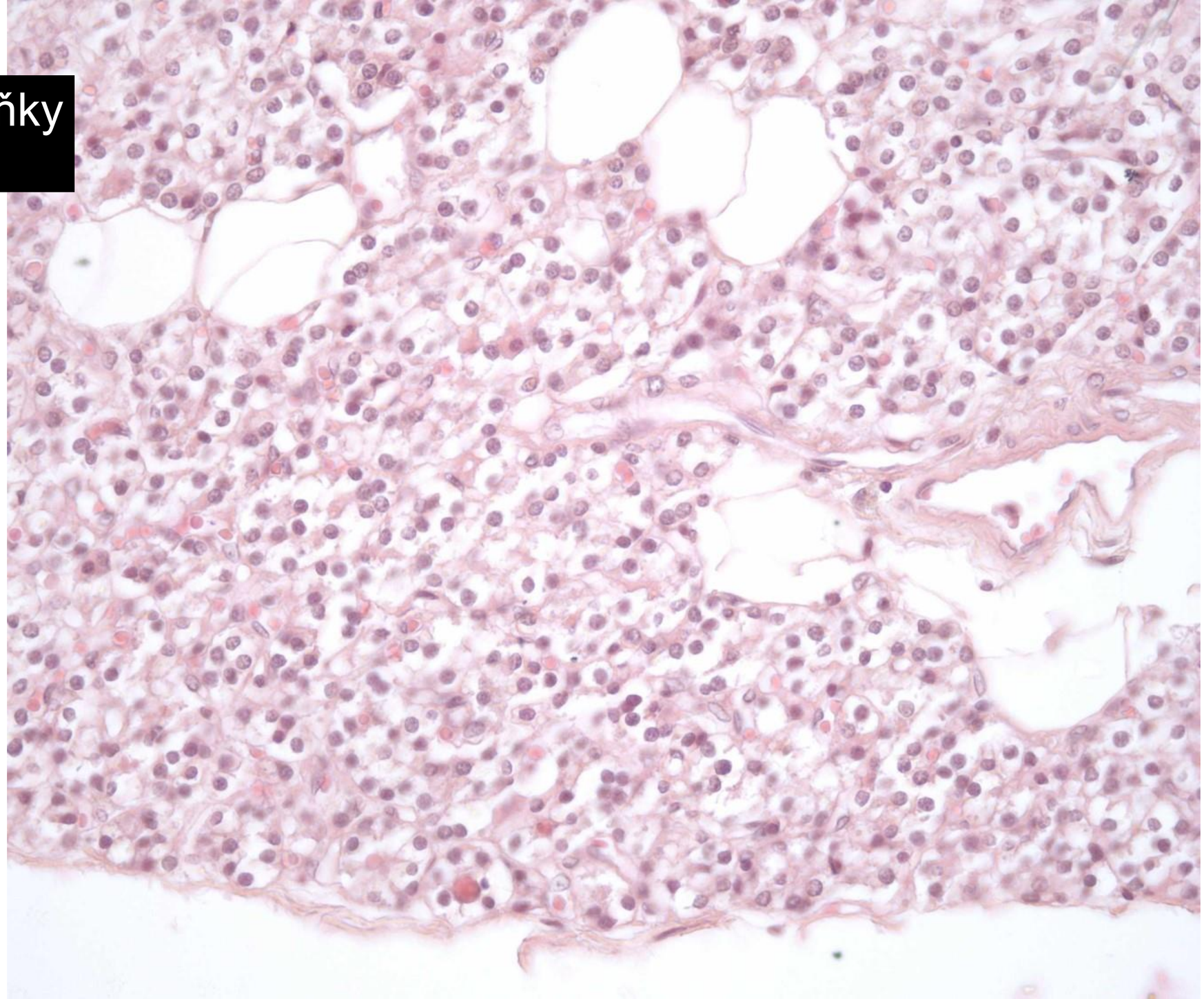




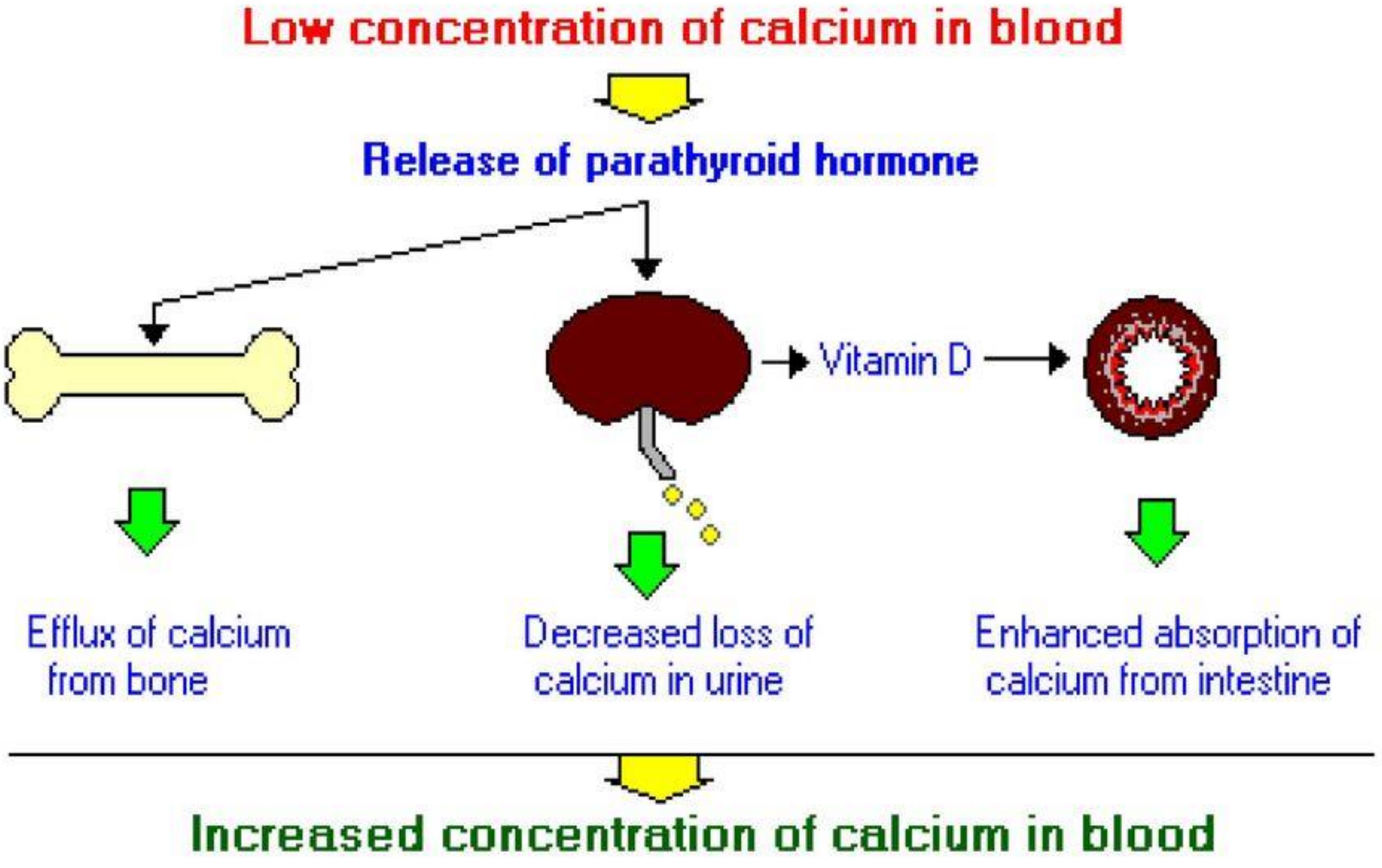
Parenchym: trabekulární epitel
Stroma: retikulární vazivo + tuk + fenestrované kapiláry



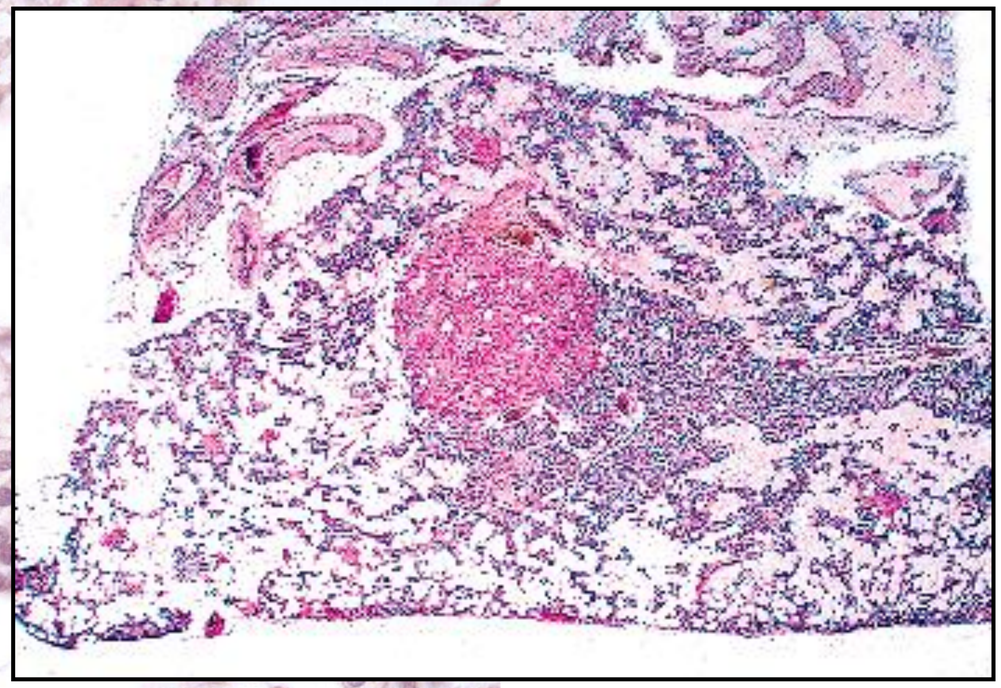
Hlavní buňky
PTH



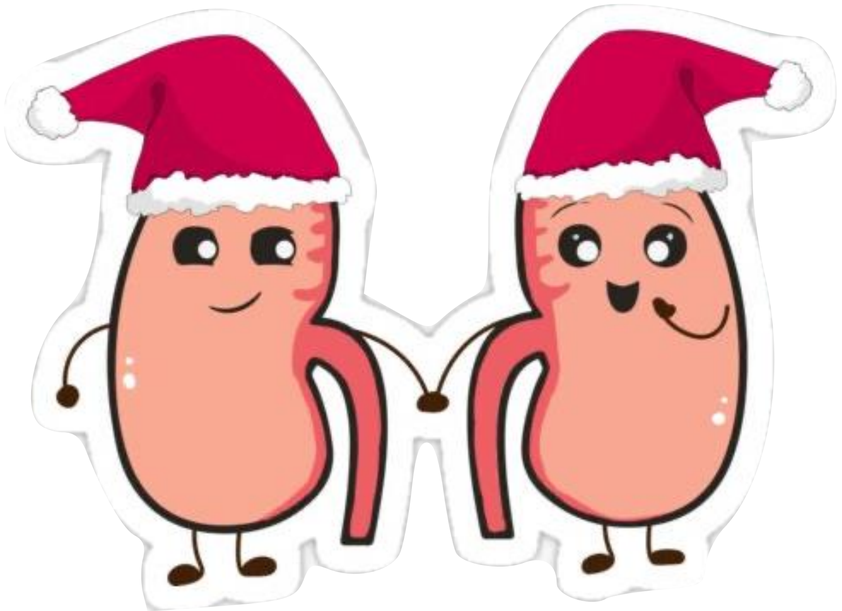
Regulation of PTH – Direct pathway



Oxyfilní buňky - často tvoří ostrůvky

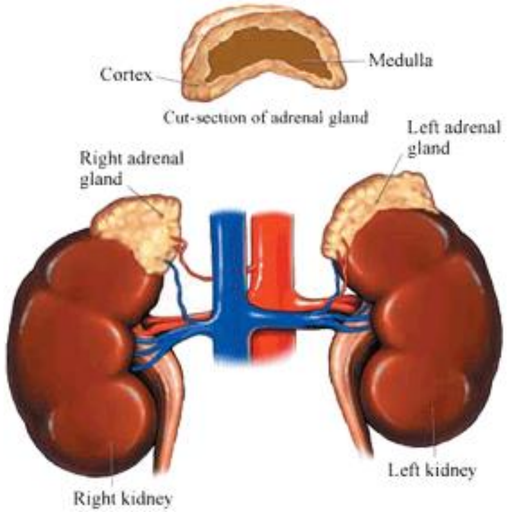


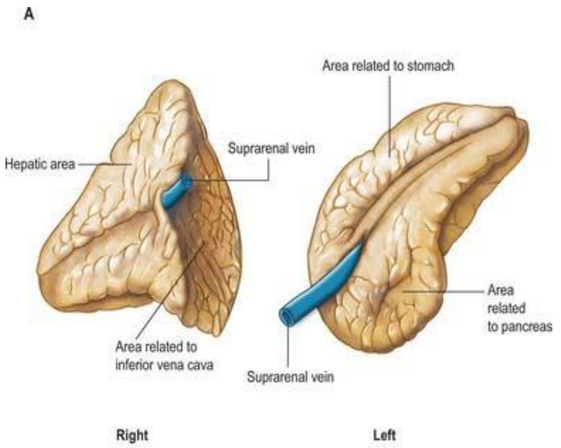
Nadledviny (glandulae suprarenales)

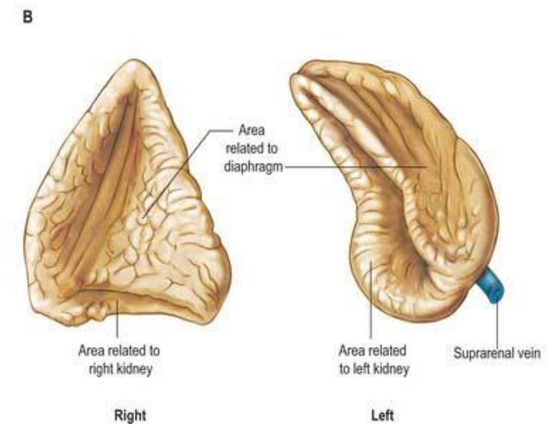


Nadledviny – anatomie

- retroperitoneálně
- výše T11-T12
- *facies anterior* + *posterior* + *renalis*
- *margo superior* + *medialis*
- *hilum*
  - na facies anterior – výstup v. suprarenalis
- *capsula* (vlastní)
- společné *corpus adiposum perirenale* + *fascia renalis* s ledvinou





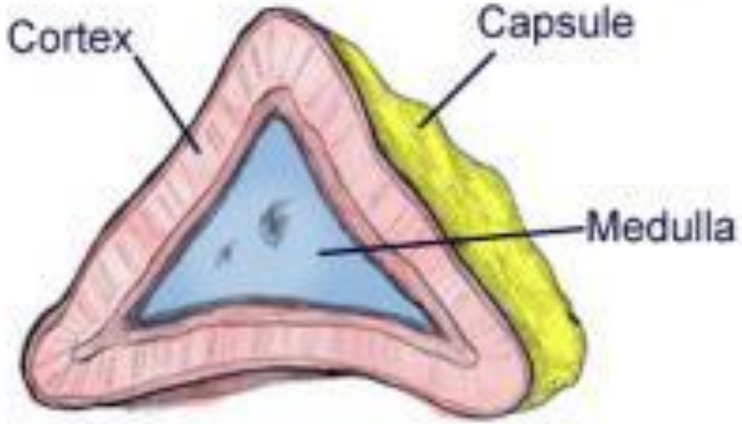


Nadledvina (*Glandula suprarenalis*)

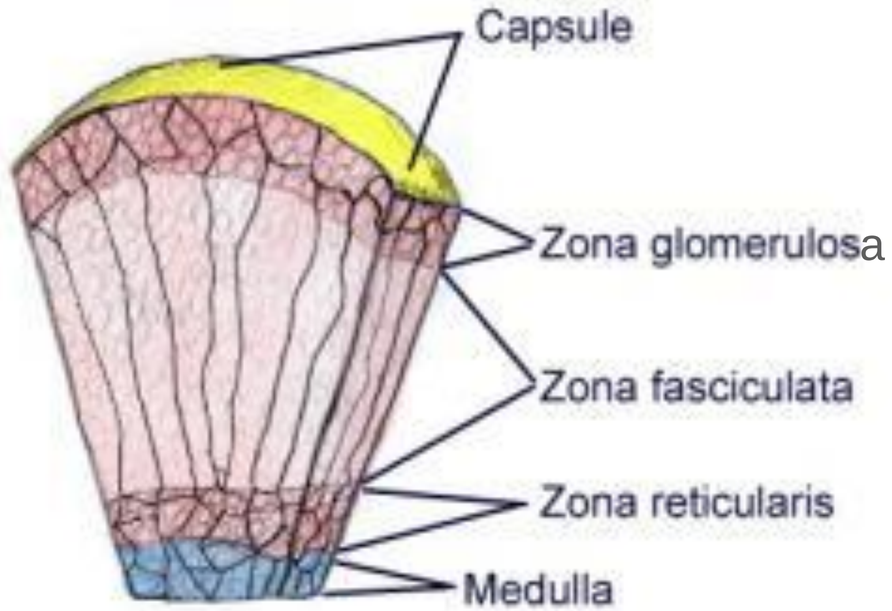
„dvojitá žláza“
- dvě rozdílné tkáně: kůra a dřeň

- kůra nadledvin (*cortex*)
  - **mineralokortikoidy** – aldosteron
  - **glukokortikoidy** – kortizol, kortikosteron
  - **androgeny** – DEAS=dehydroepiandrosteron

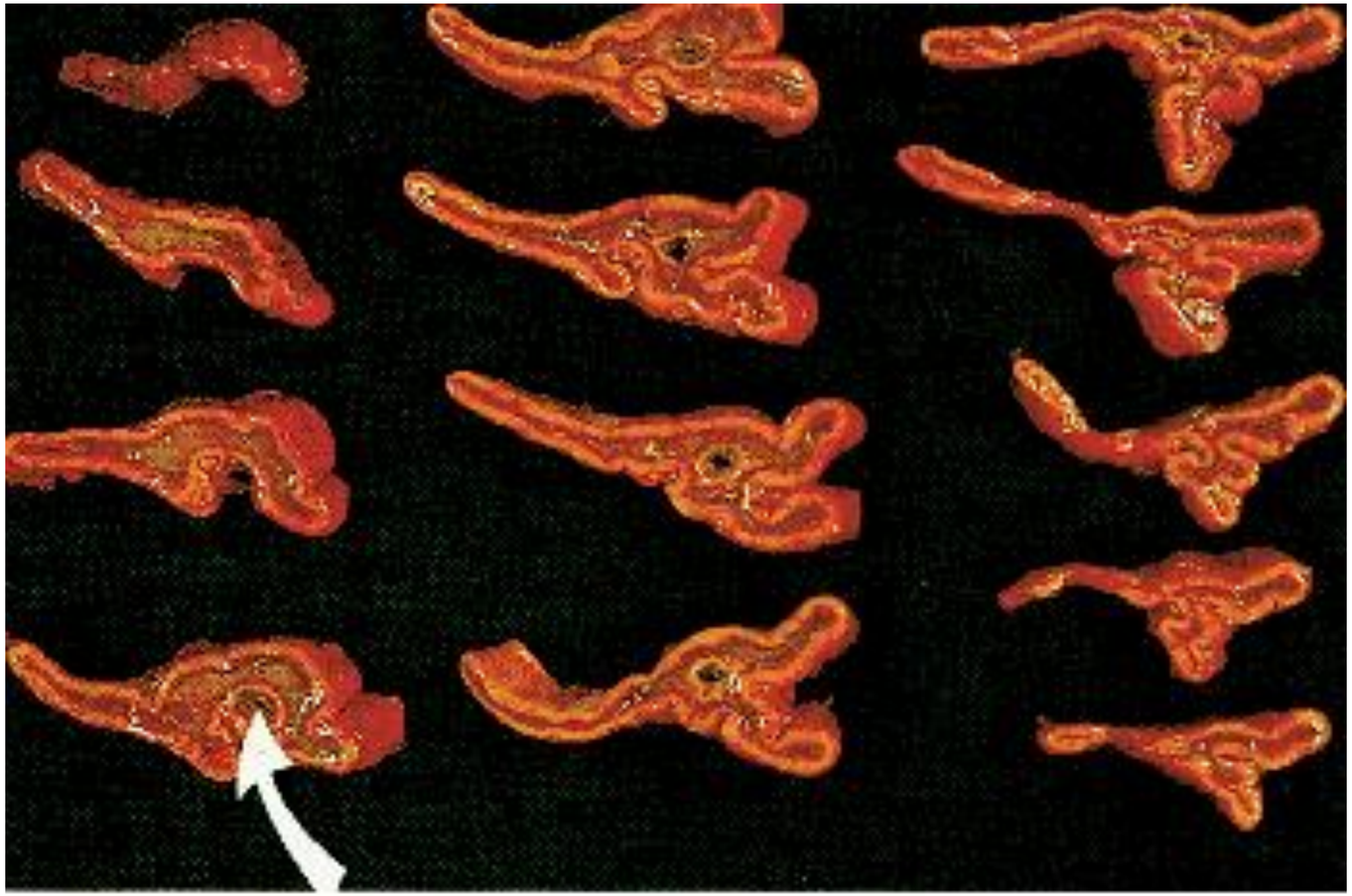
- dřeň nadledvin (*medulla*)
  - **katecholaminy** – adrenalin, noradrenalin

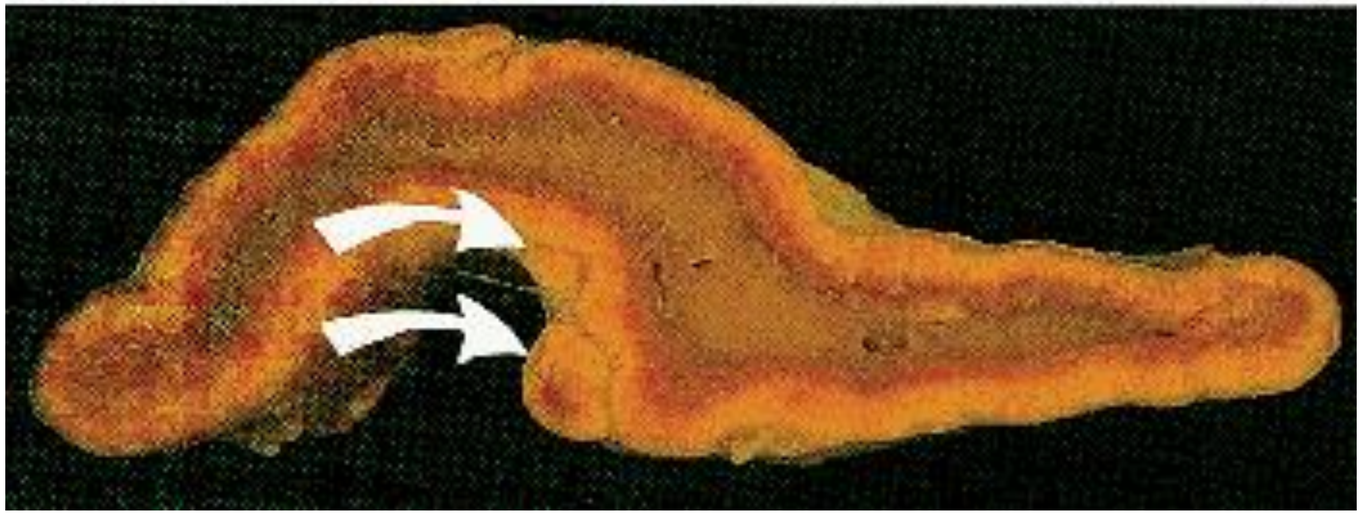


Transverse section



Microscopic section

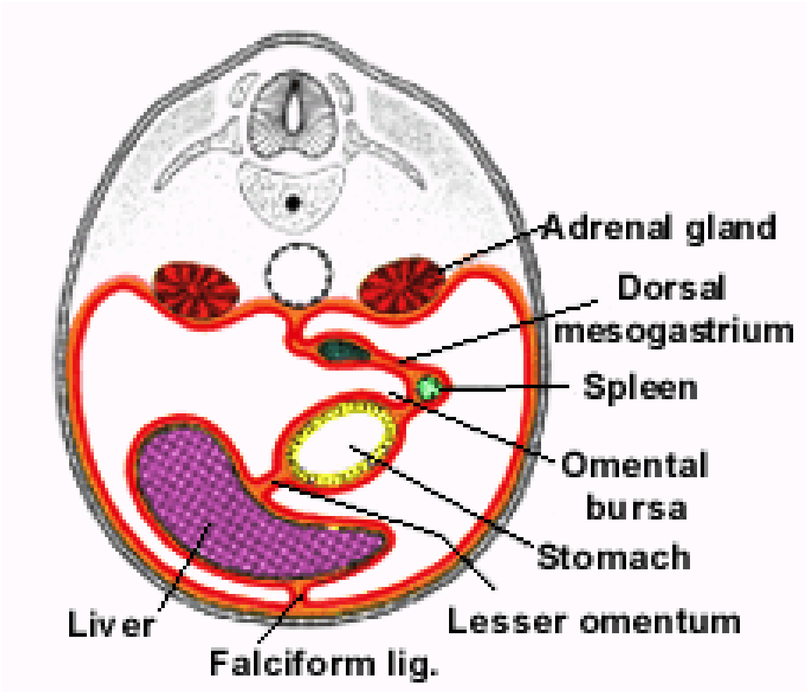


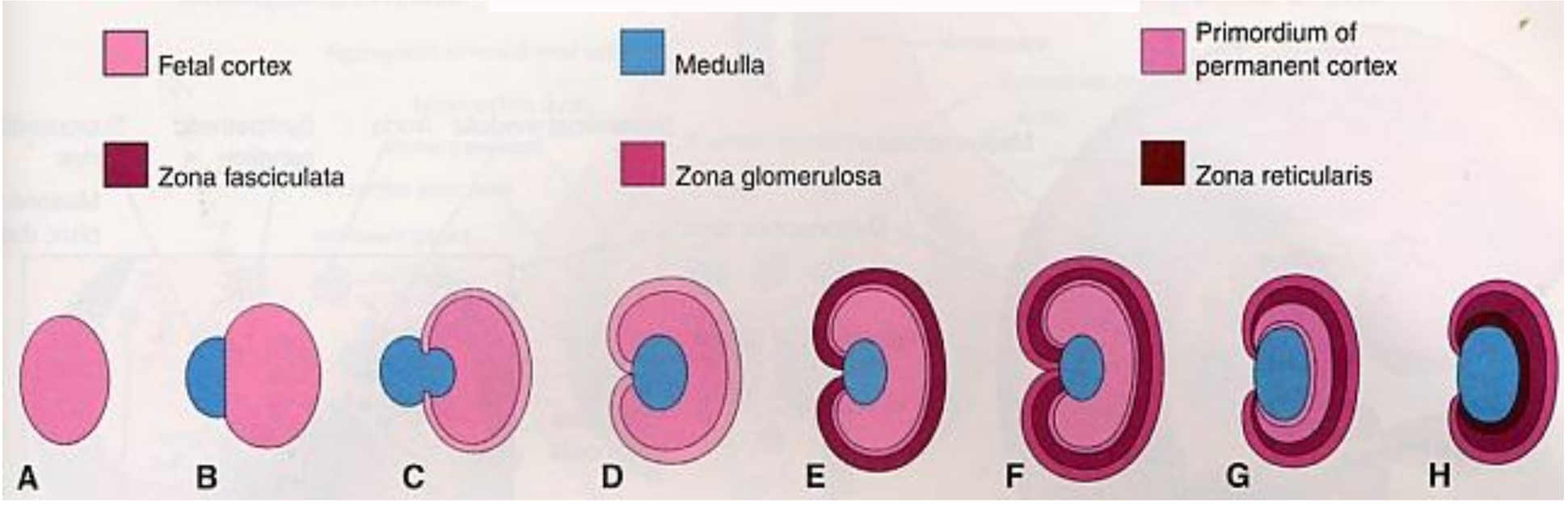


Nadledvina – vývoj

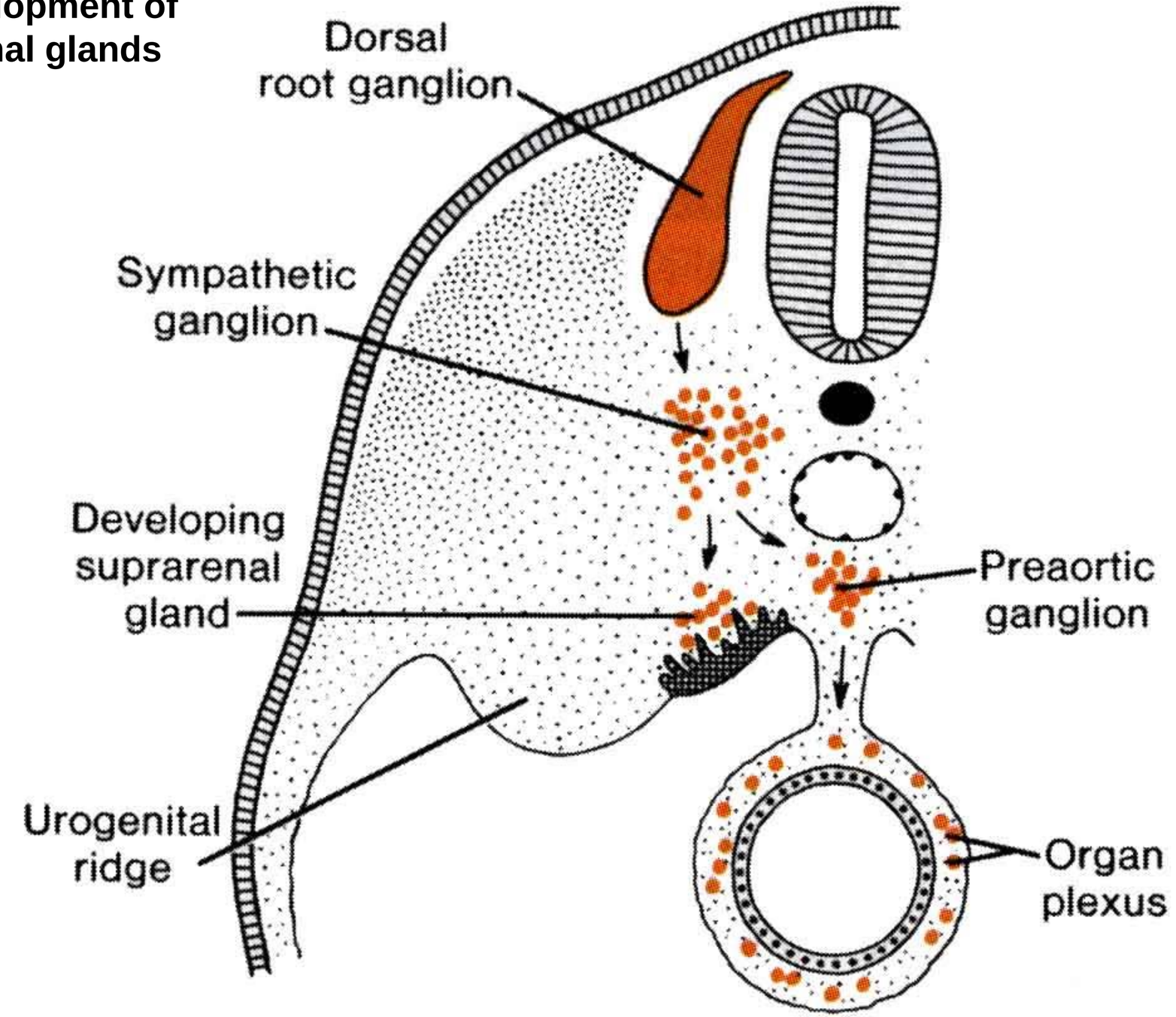
- kůra
  - z **coelomového epitelu (laterální somatický mezoderm)** mediálně od urogenitální lišty
  - proliferace, vcestovávání směrem k aortě
  - sekundární proliferace kůry → vznik definitivní kůry

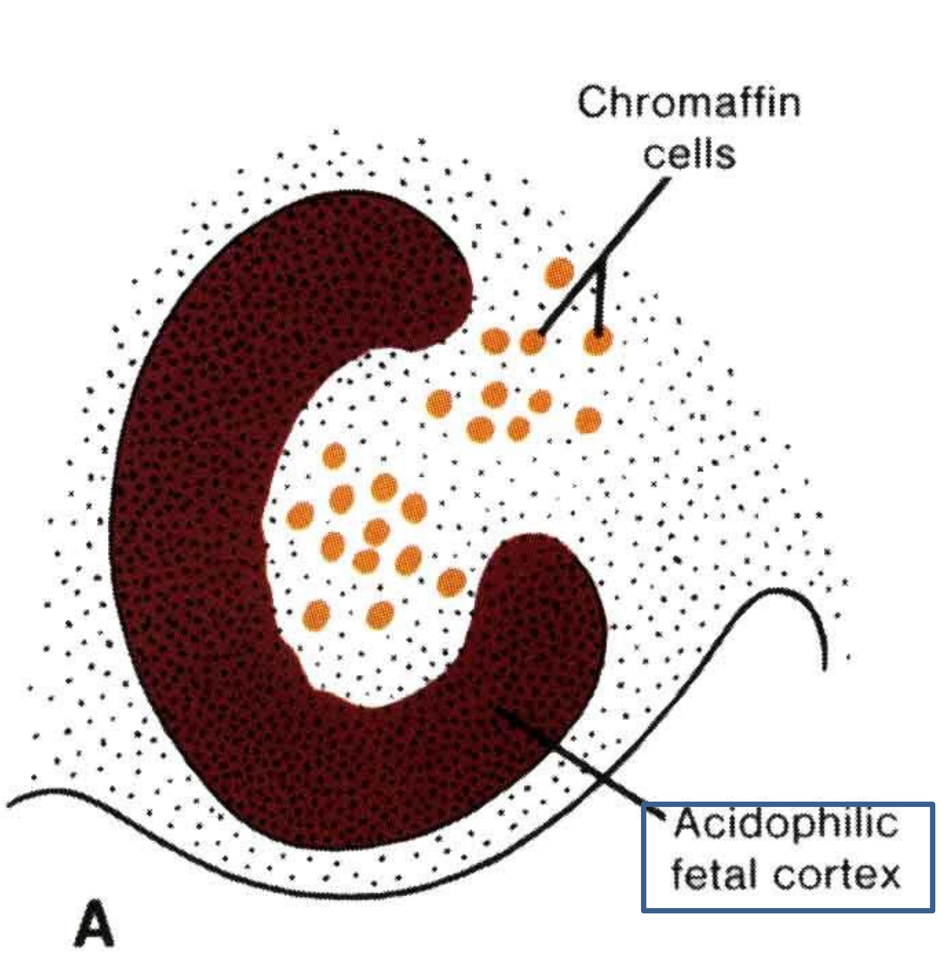
- dřeň
  - původ z **neurální lišty**
  - ze základu ganglion coeliacum -> sympatogonie (neuroblasty a feochromocytoblasty)
  - vcestují do základu kůry

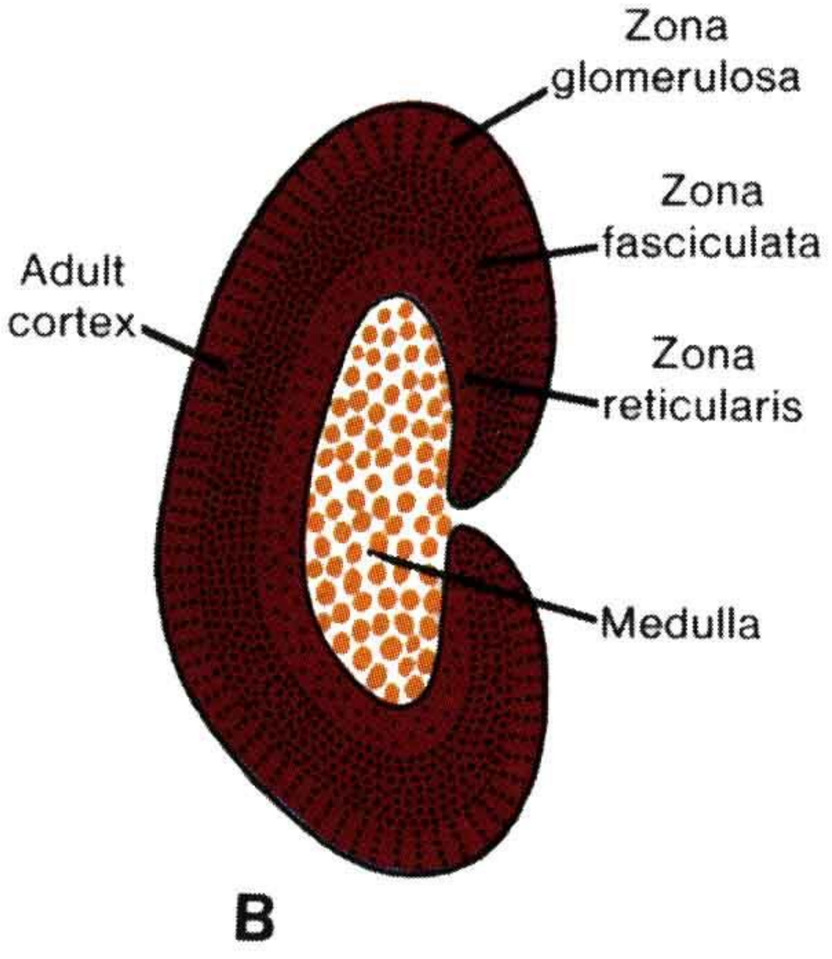

Adrenal gland
Dorsal mesogastrium
Spleen
Omental bursa
Stomach
Lesser omentum
Liver
Falciform lig.

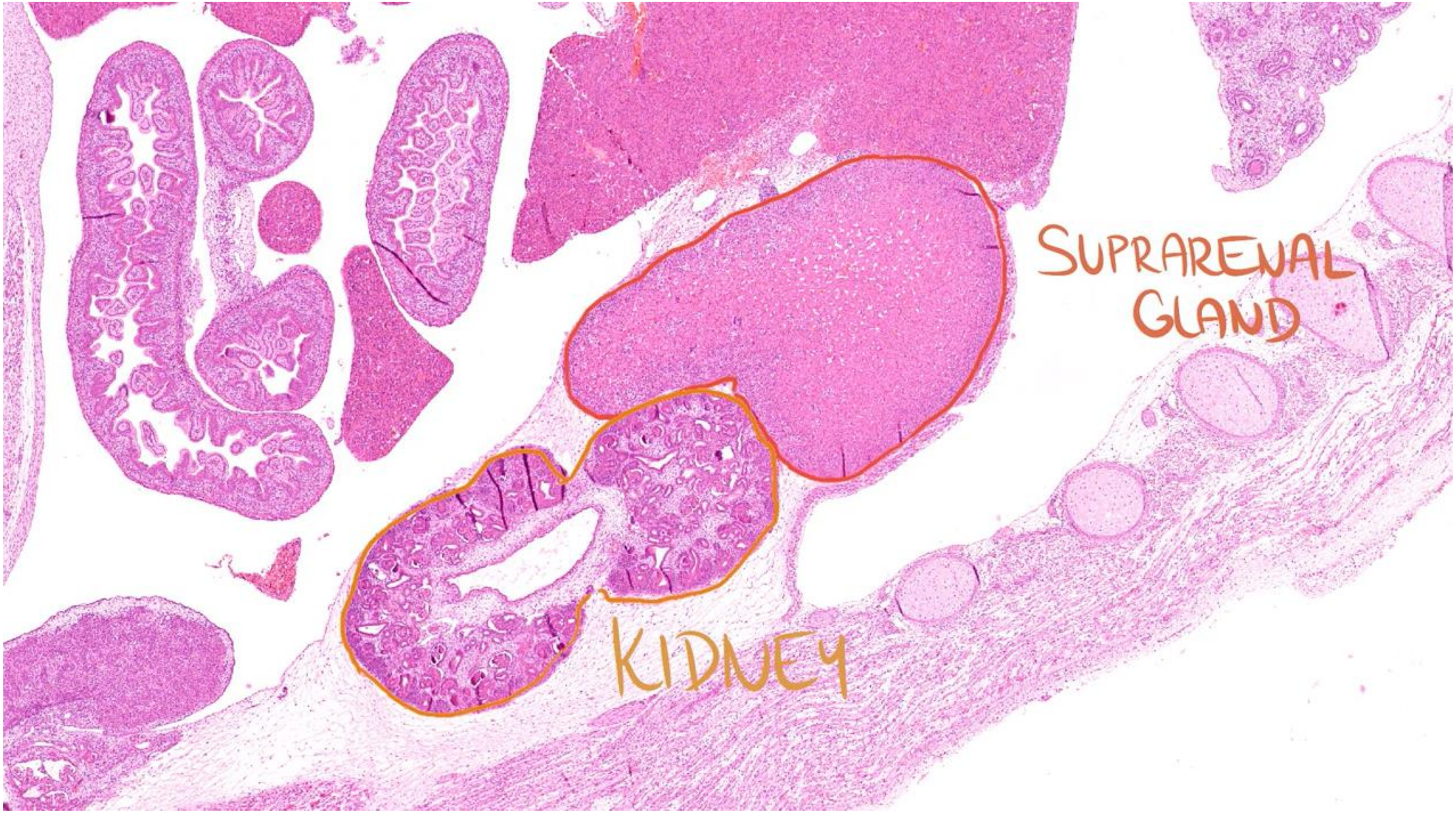

Fetal cortex
Medulla
Primordium of permanent cortex
Zona fasciculata
Zona glomerulosa
Zona reticularis
A
B
C
D
E
F
G
H

Development of adrenal glands




Chromaffin cells
Acidophilic fetal cortex
A

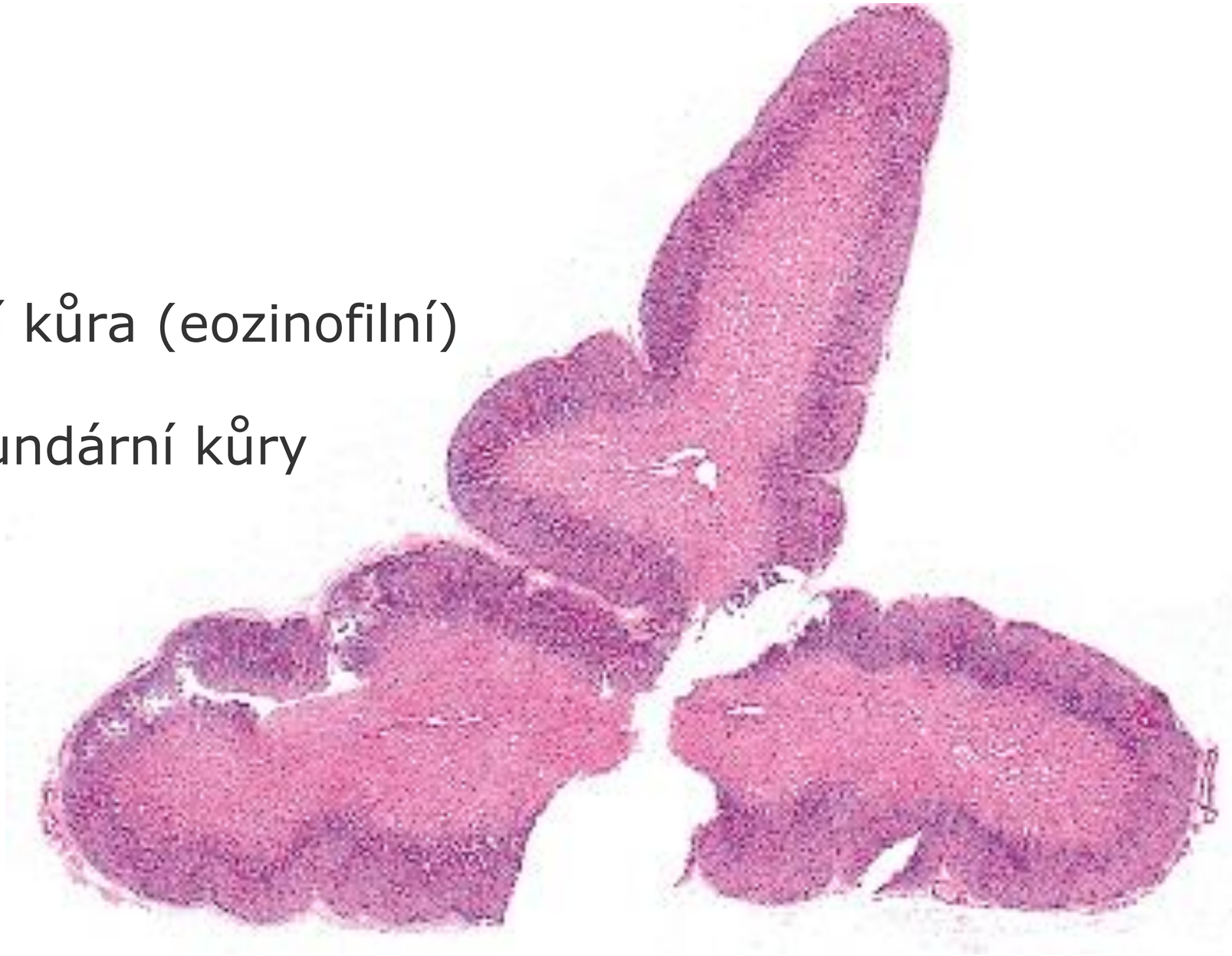

Zona glomerulosa
Zona fasciculata
Adult cortex
Zona reticularis
Medulla
B

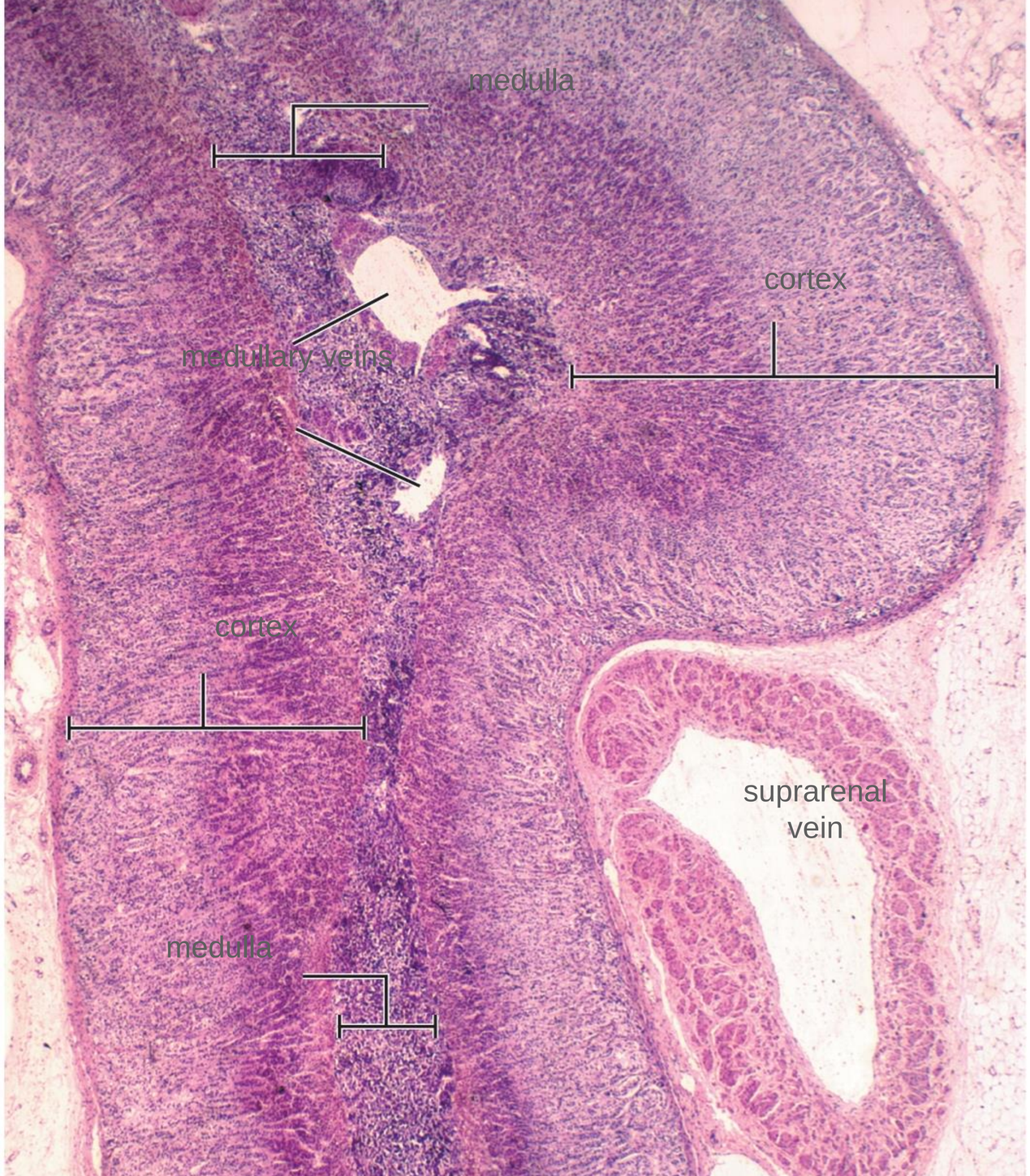

SUPRARENAL
GLAND
KIDNEY


SUPRARENAL GLAND
EOSINOPHILIC CELLS
PRIMITIVE CORTEX
SURROUNDED BY
SECONDARY CORTEX
(DEFINITIVE)

novorozenec, 35t.
centrálně primární kůra (eozinofilní)

periferně lem sekundární kůry



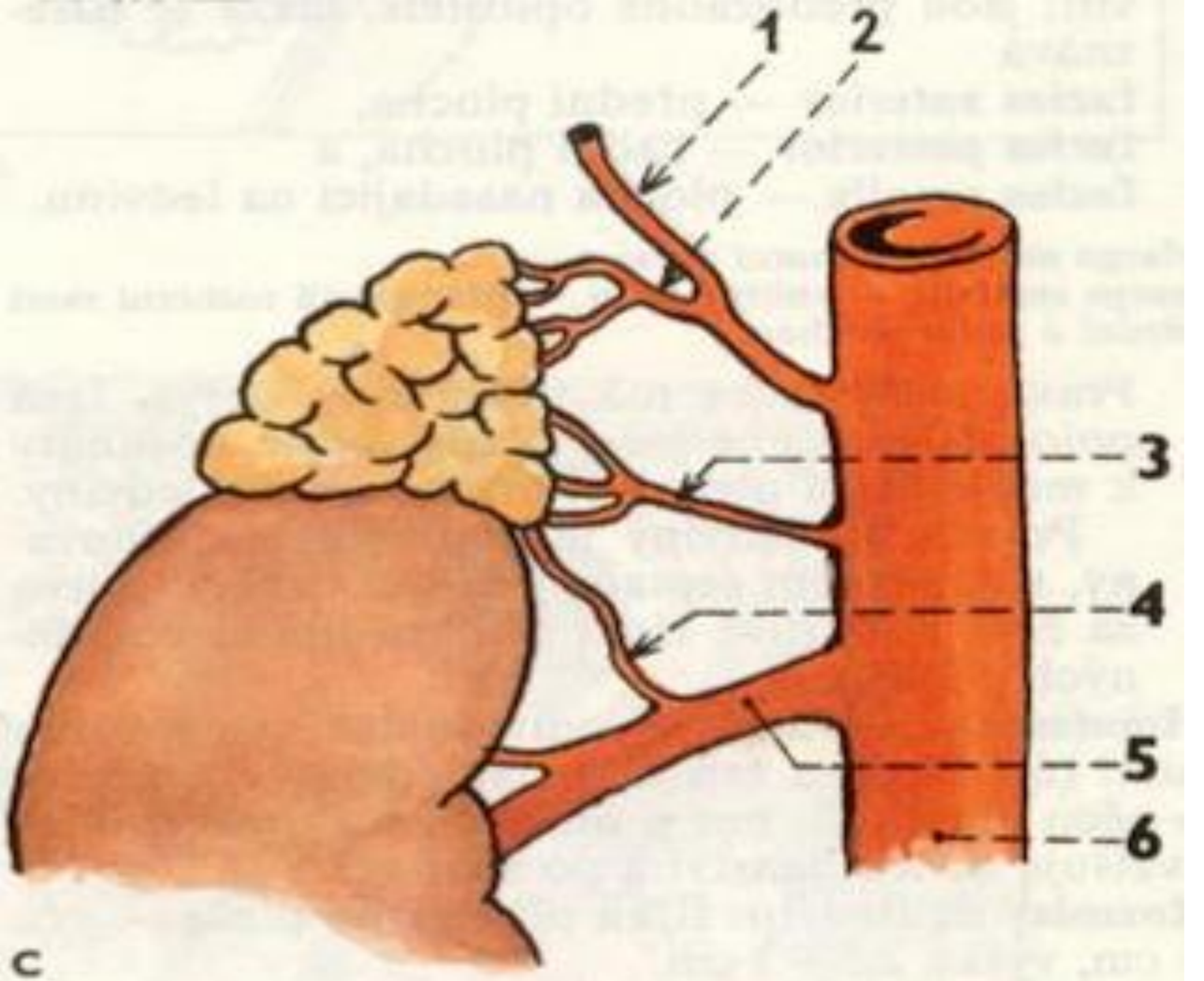

medulla
cortex
medullary veins
cortex
suprarenal
vein
medulla

Nadledviny – krevní cévy

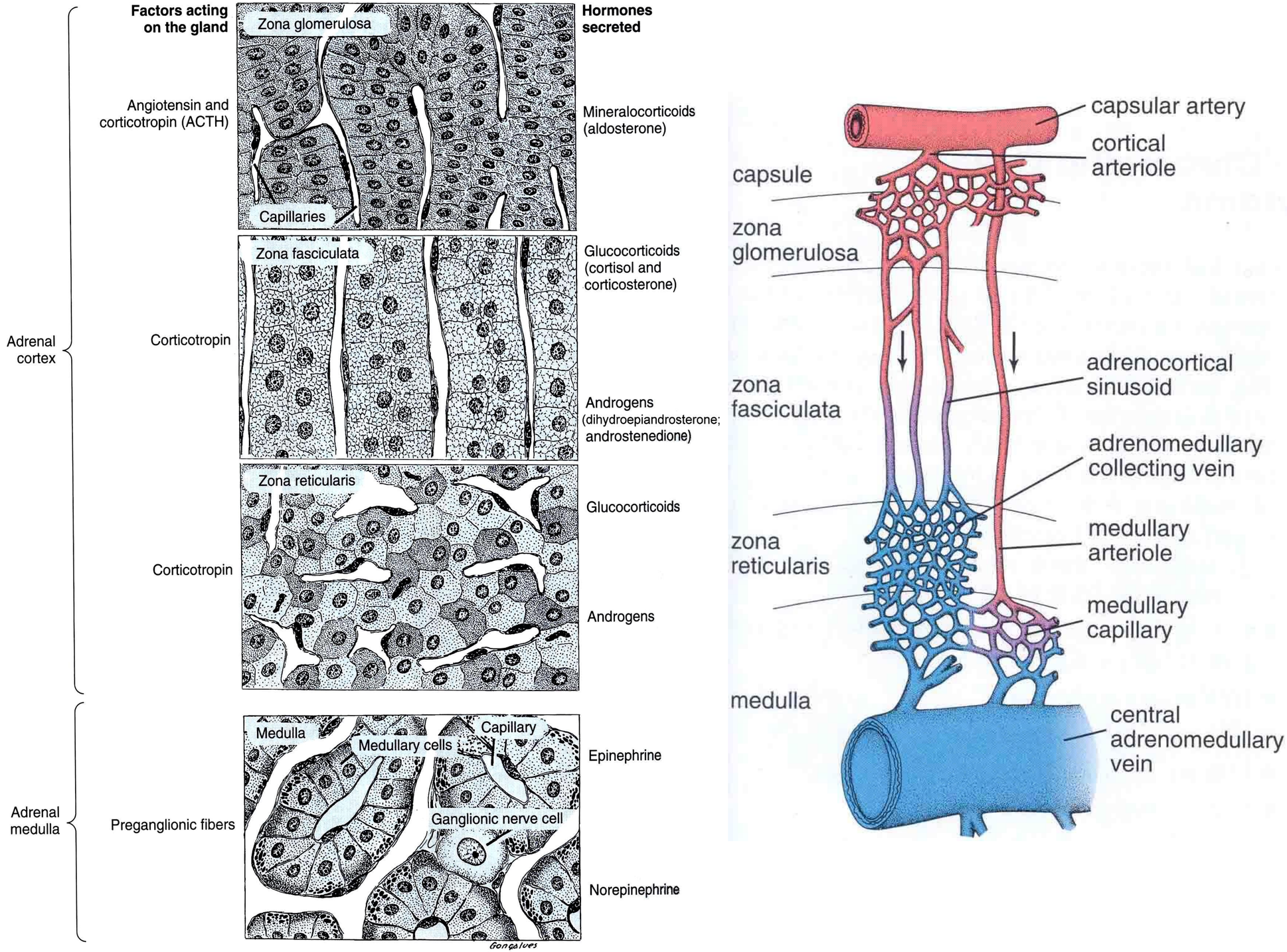
- a. suprarenalis superior (← a. phrenica inferior)
- a. suprarenalis media (← aorta abdominalis)
- a. suprarenalis inferior (← a. renalis)

→ subkapsulární pleteň, kapiláry a sinusoidy skrz kůru →

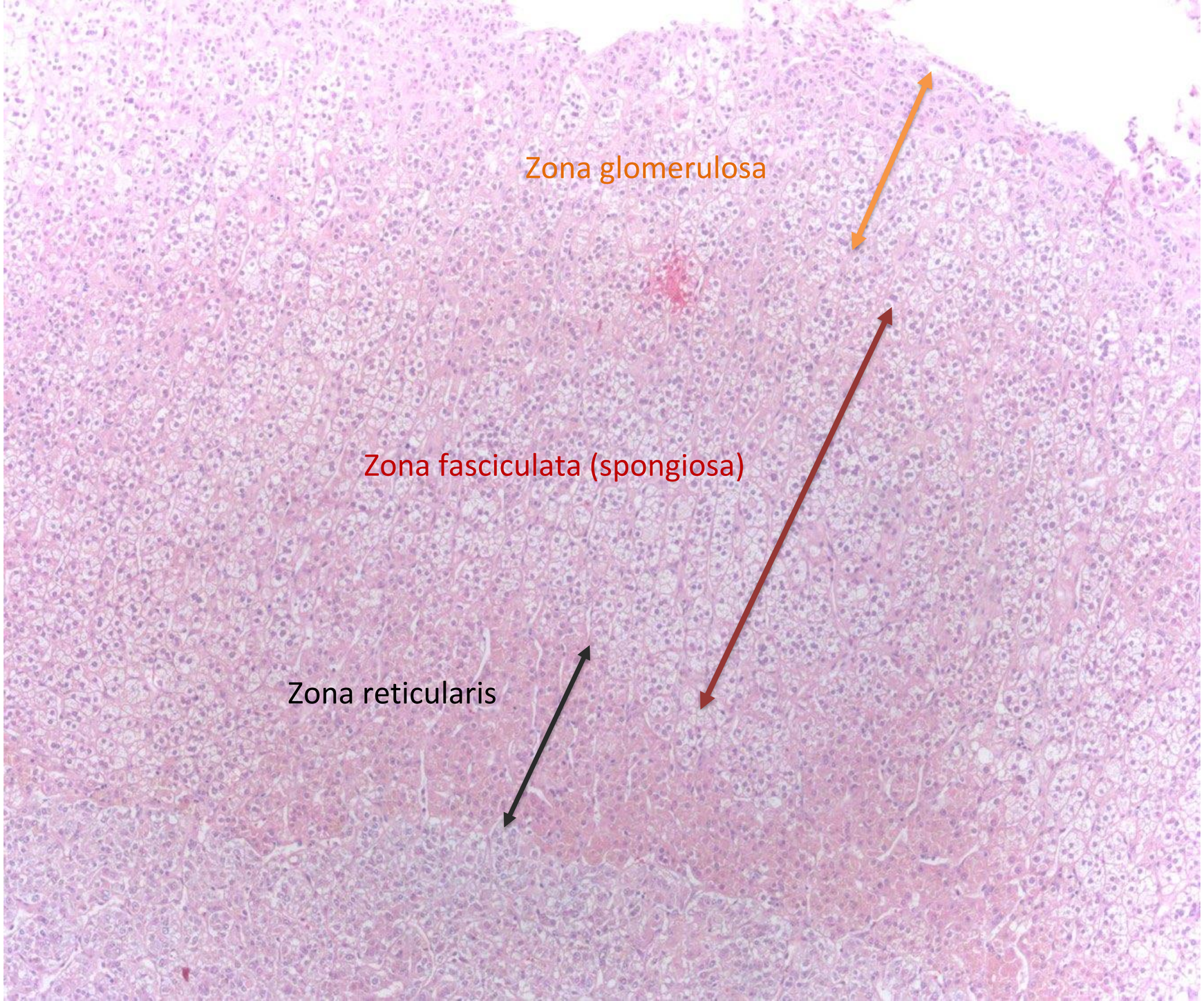
- žíly ze dřeně do v. centralis → v. suprarenalis → v. renalis sinistra / v. cava inferior vpravo

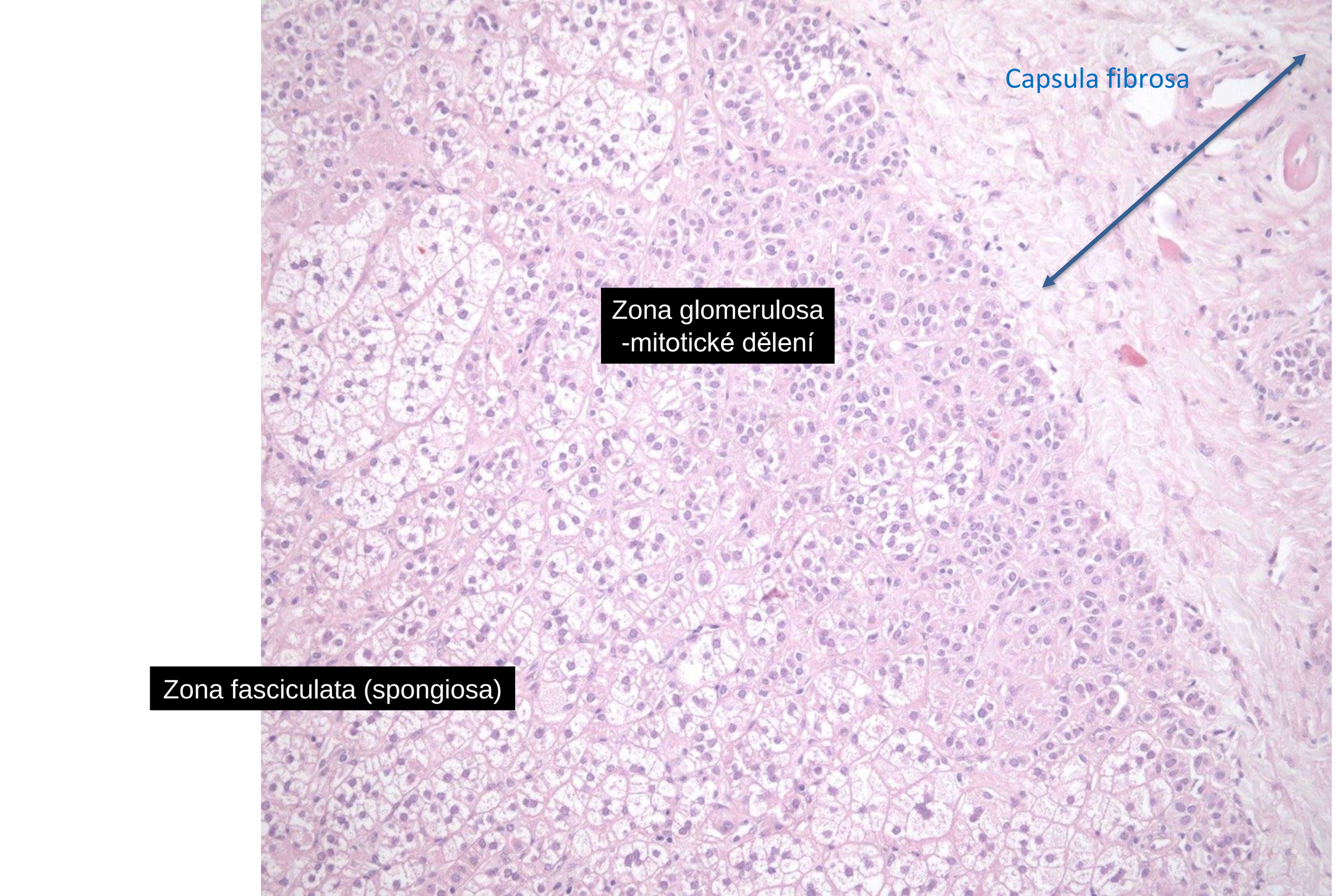


C. CÉVY NADLEDVINY (pravé strany)
1 / a. phrenica inferior (dextra)
2 / a. suprarenalis superior (dextra)
3 / a. suprarenalis media (dextra)
4 / a. suprarenalis inferior (dextra)
5 / a. renalis (dextra)
6 / aorta abdominalis

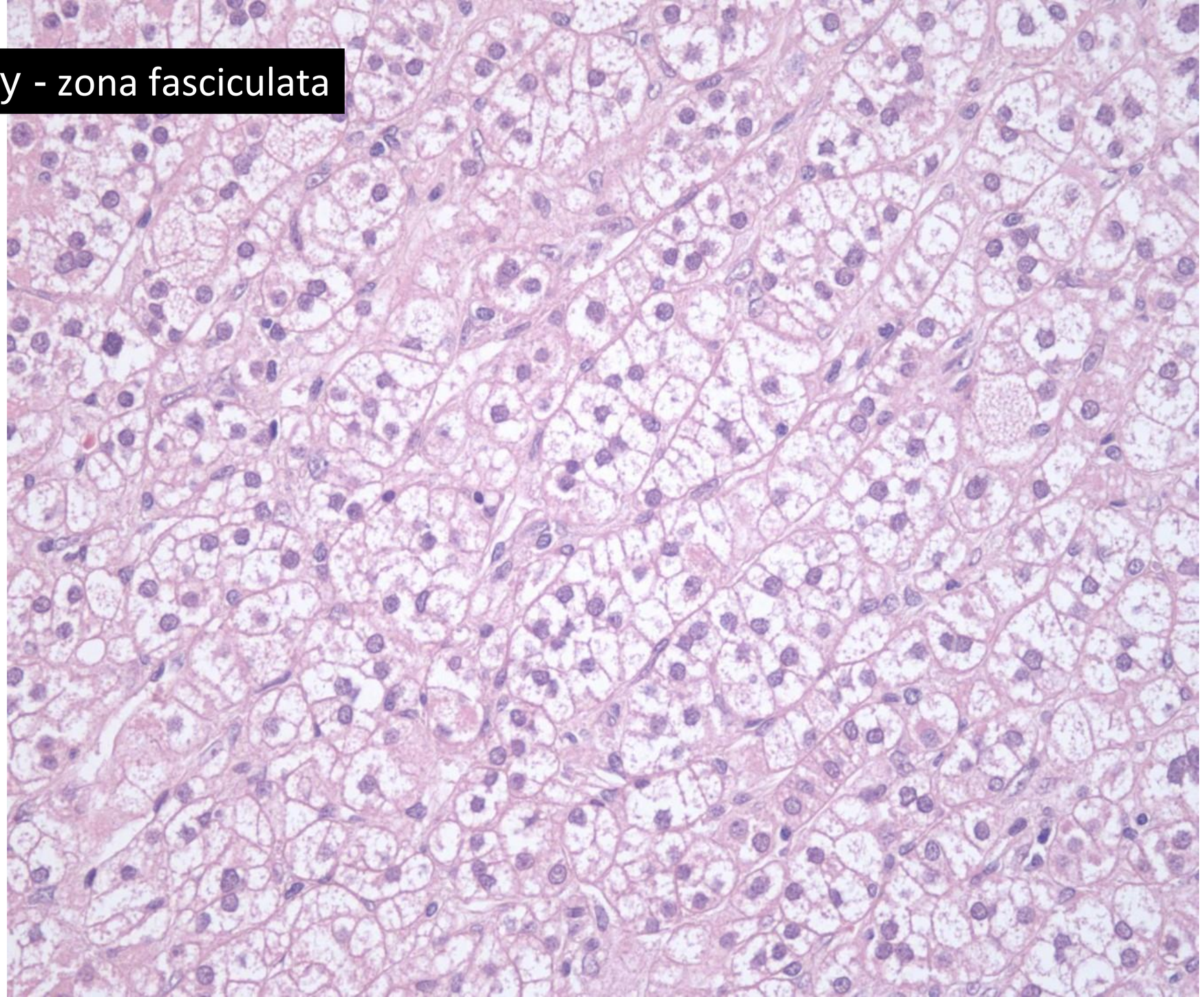

Factors acting on the gland
Hormones secreted
Adrenal cortex
Zona glomerulosa
Angiotensin and corticotropin (ACTH)
Mineralocorticoids (aldosterone)
Capillaries
Zona fasciculata
Corticotropin
Glucocorticoids (cortisol and corticosterone)
Androgens (dihydroepiandrosterone; androstenedione)
Zona reticularis
Corticotropin
Glucocorticoids
Androgens
Adrenal medulla
Medulla
Capillary
Medullary cells
Preganglionic fibers
Epinephrine
Ganglionic nerve cell
Norepinephrine
Gonçalves

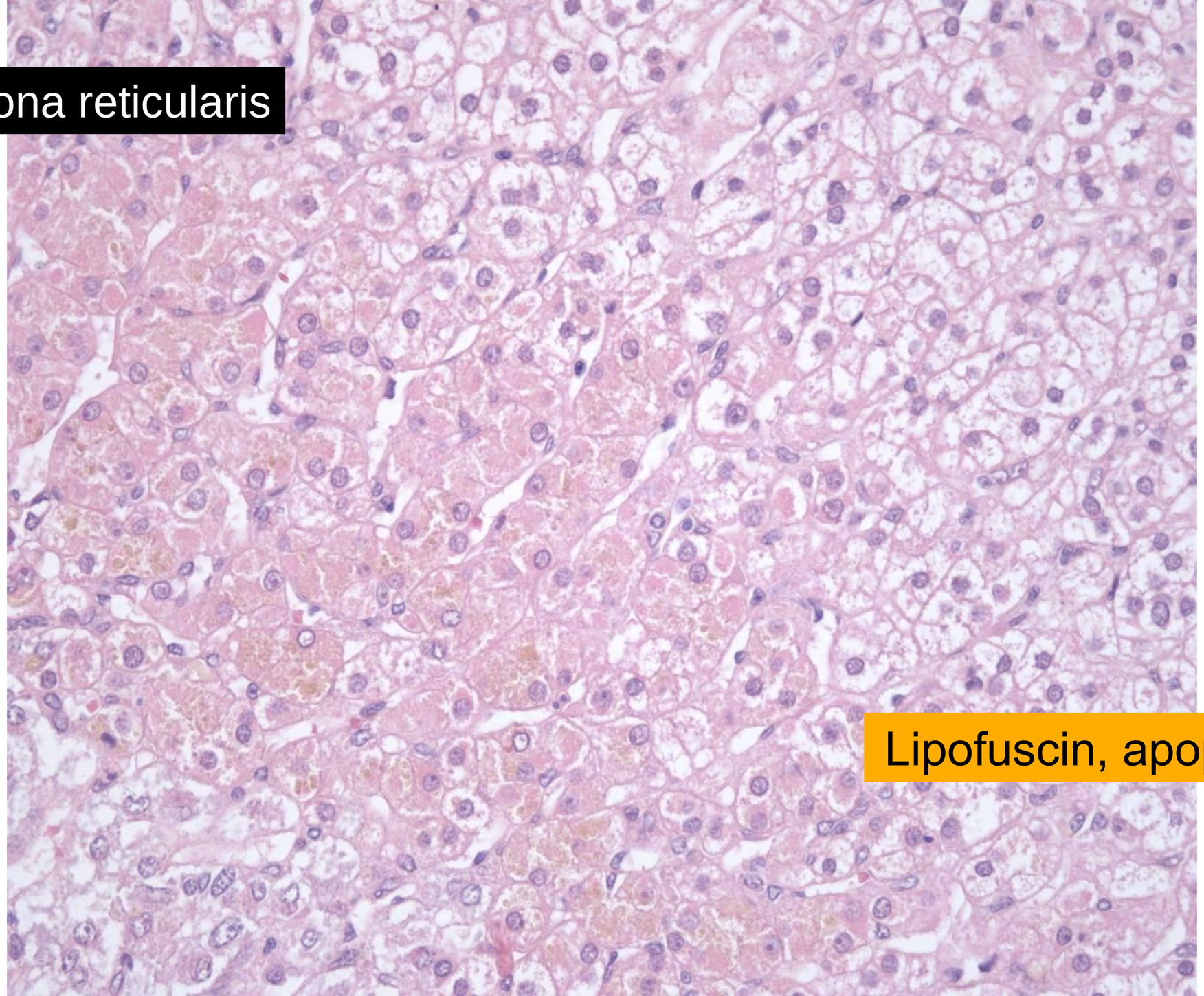
capsular artery
cortical arteriole
capsule
zona glomerulosa
adrenocortical sinusoid
zona fasciculata
adrenomedullary collecting vein
medullary arteriole
zona reticularis
medullary capillary
medulla
central adrenomedullary vein

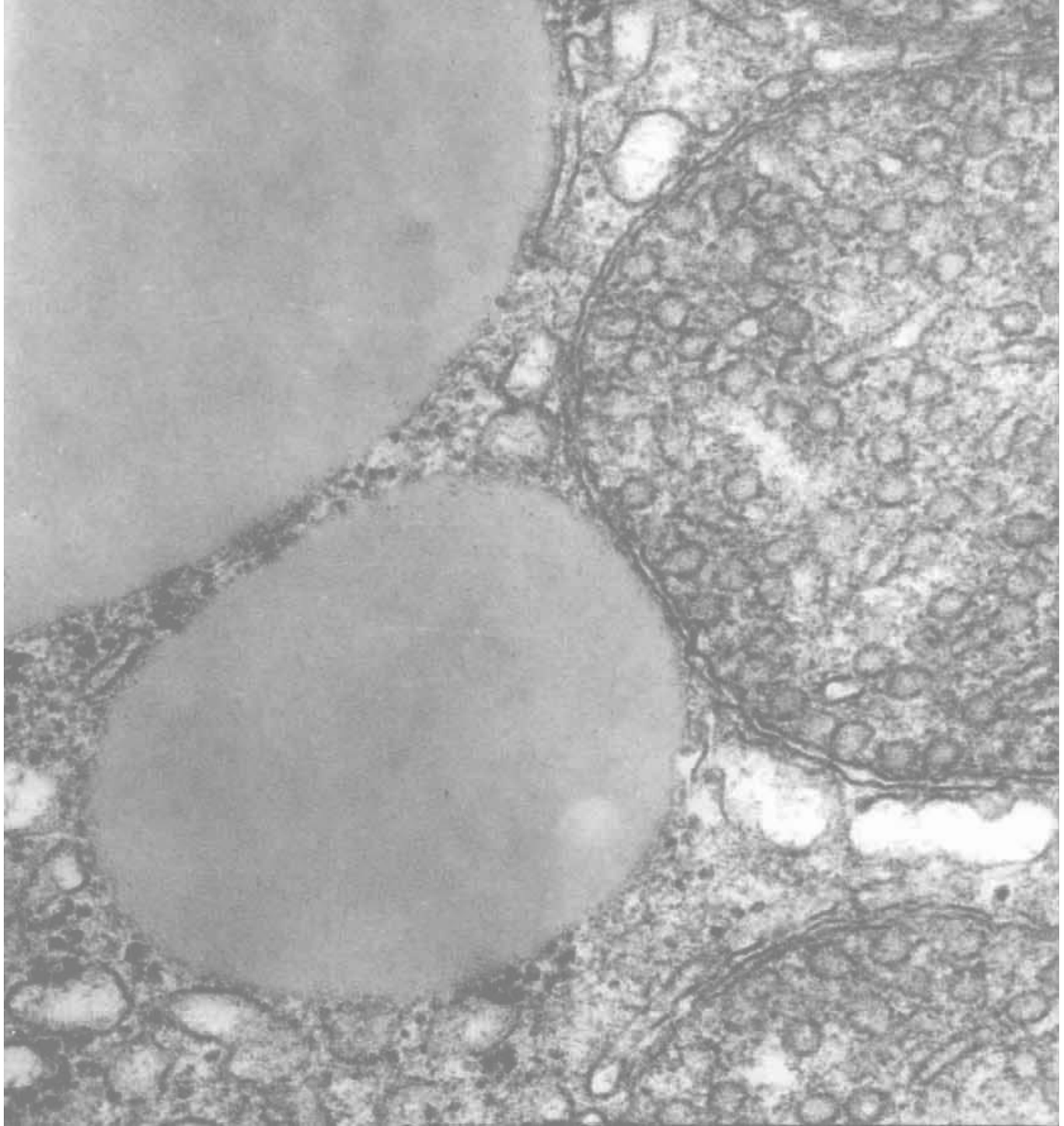

Zona glomerulosa
Zona fasciculata (spongiosa)
Zona reticularis


Capsula fibrosa
Zona glomerulosa
-mitotické dělení
Zona fasciculata (spongiosa)

Spongiocyty - zona fasciculata

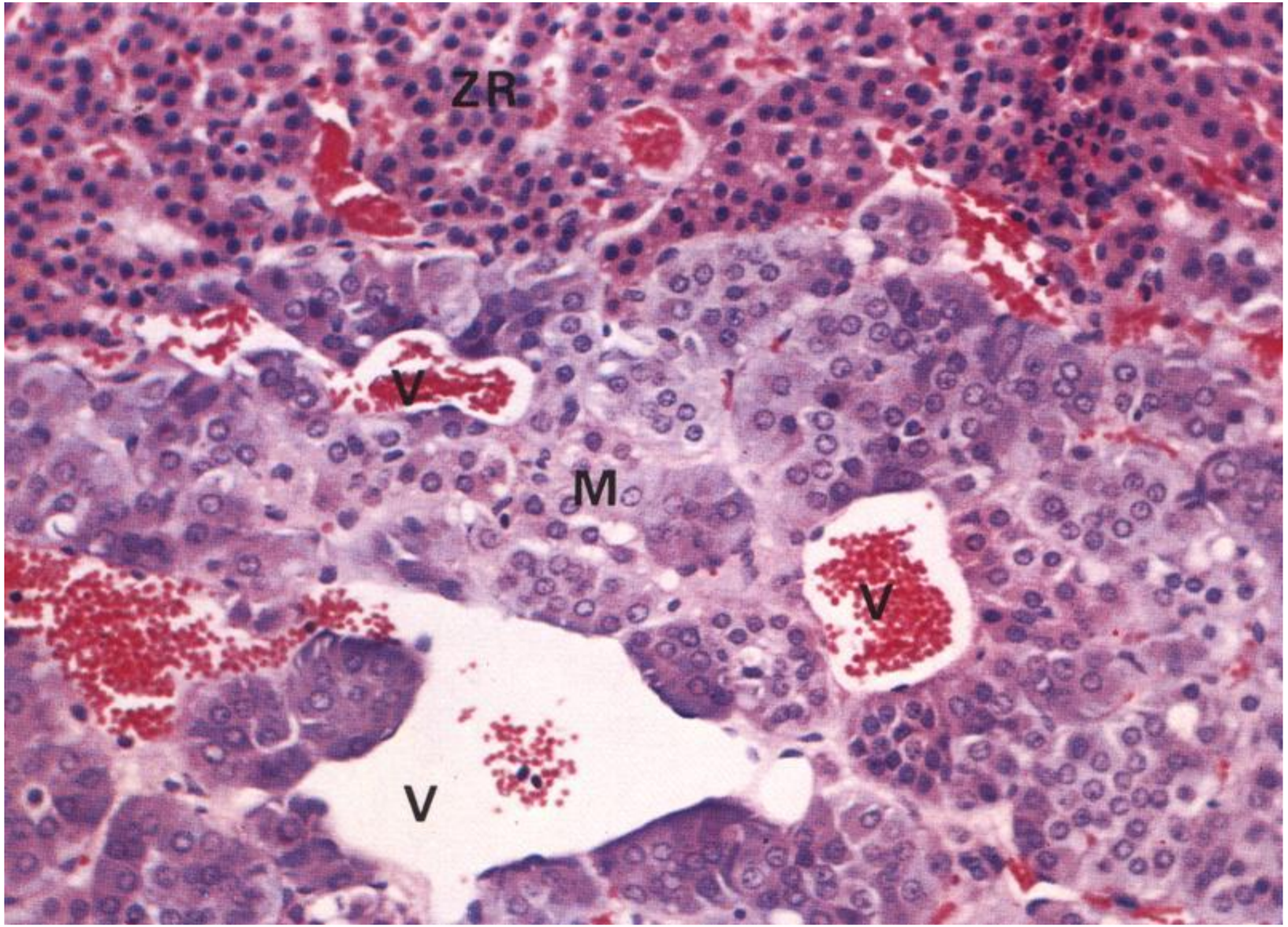


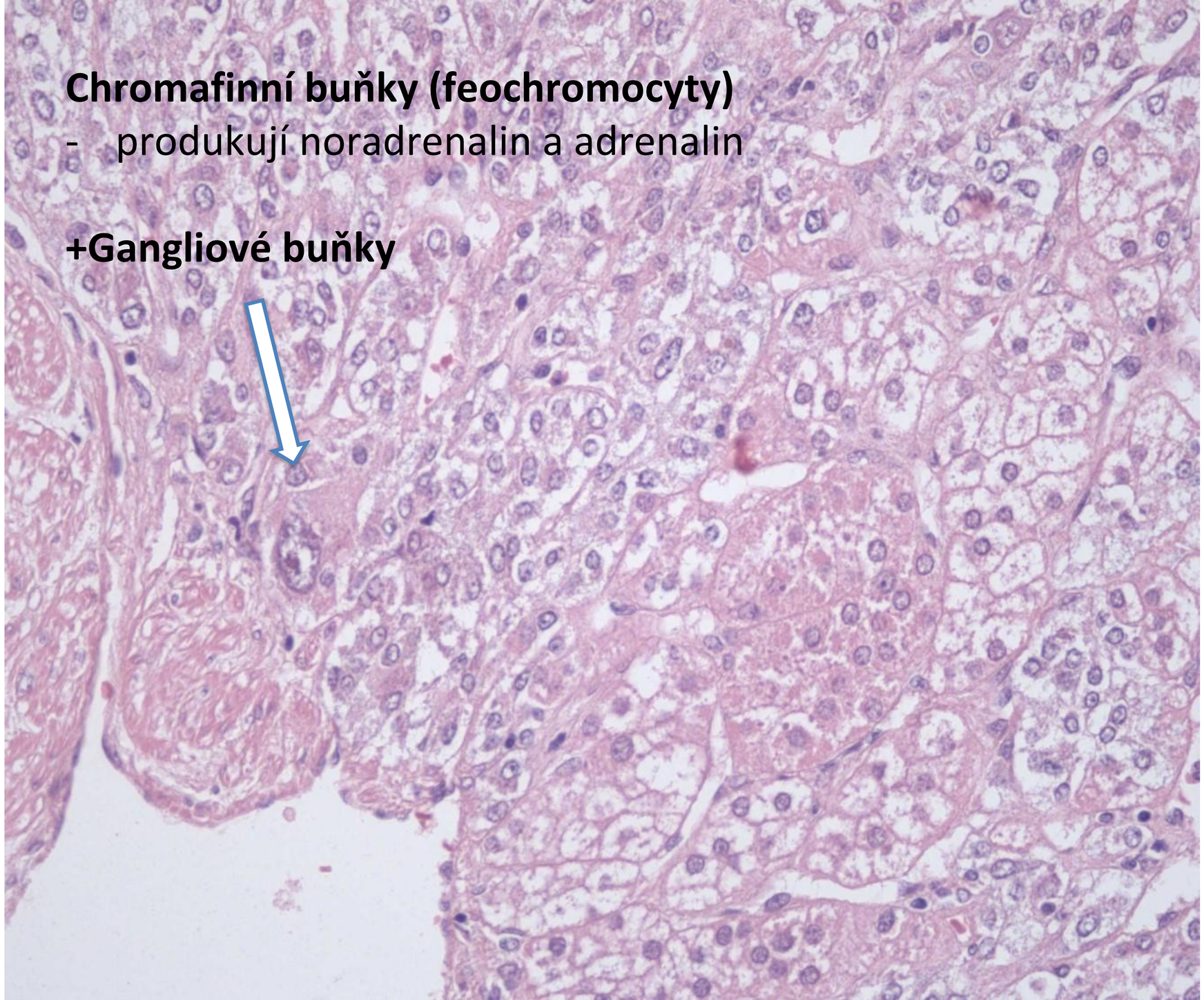

Zona reticularis
Lipofuscin, apoptózy



Nadledvina – dřeň

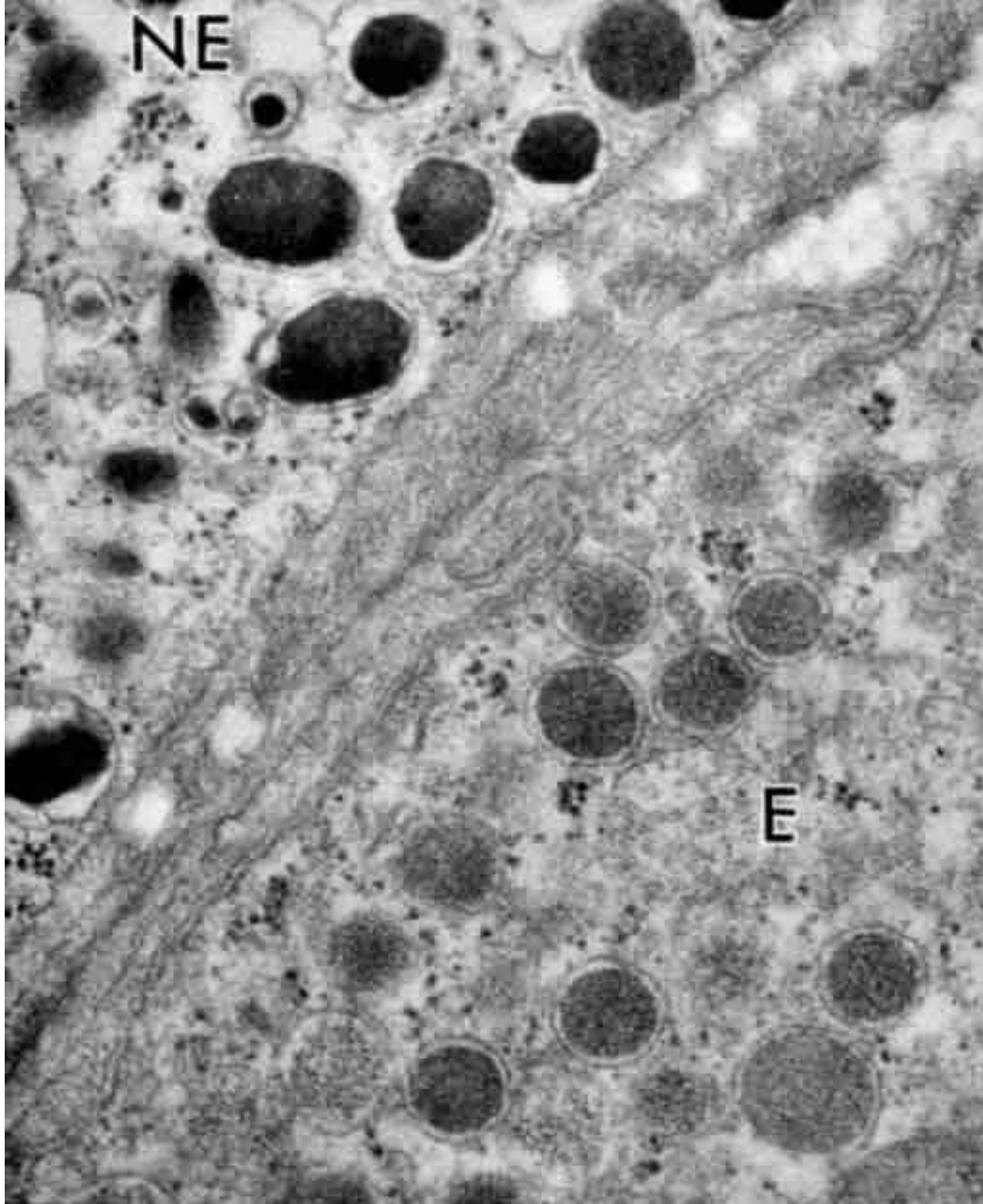
- anastomózující trámce polyedrických buněk (feochromocyty)
  - **adrenalin, noradrenalin**



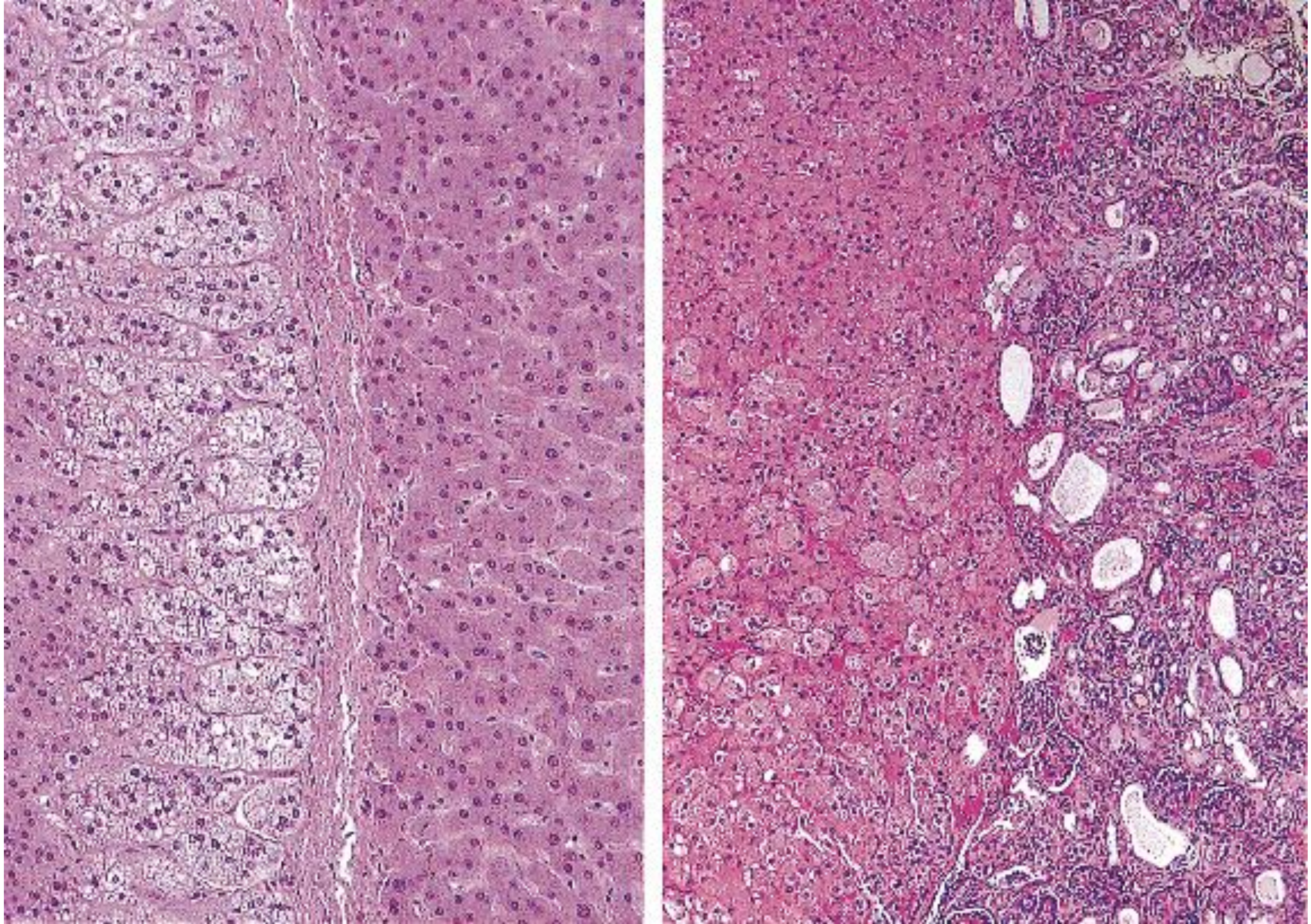


inervace cestou g.coeliacum

E = buňka produkující adrenalin
NE = buňka produkující noradrenalin

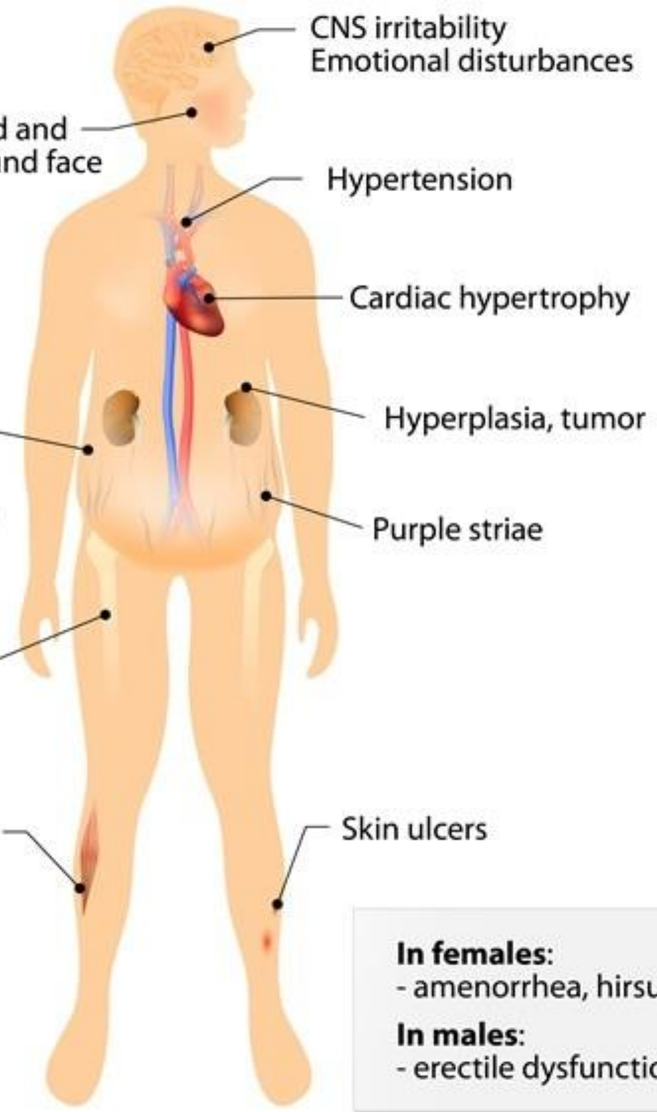


?



?

SYMPTOMS
of Cushing's syndrome



CNS irritability
Emotional disturbances

Red and round face

Hypertension

Cardiac hypertrophy

Obesity (fat deposition on abdomen and back of neck)

Hyperplasia, tumor

Purple striae

Osteoporosis

Muscle wasting

Skin ulcers

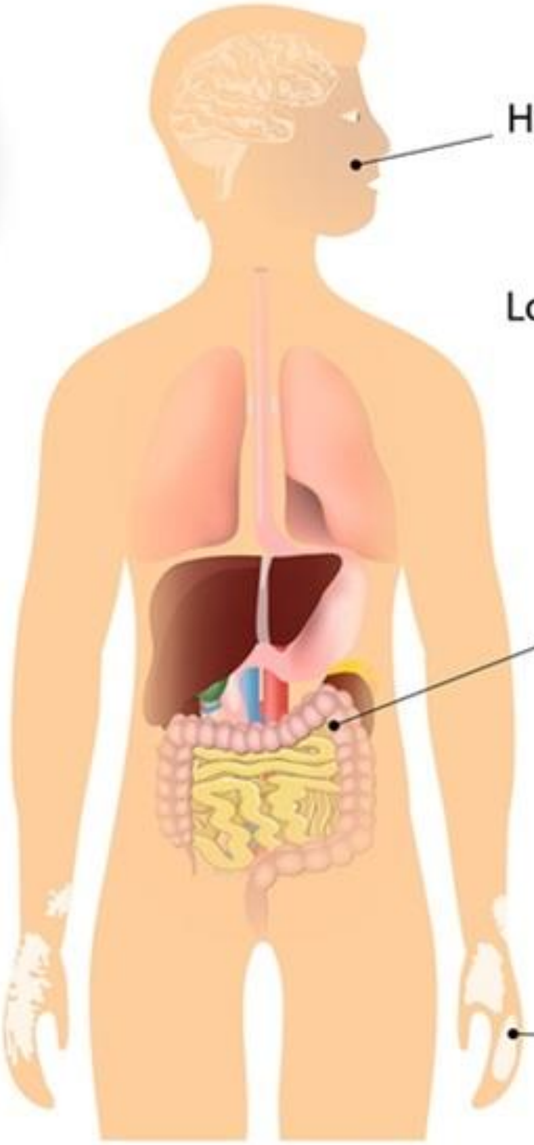
In females:
- amenorrhea, hirsutism

In males:
- erectile dysfunction

Addison's disease

Adrenal glands not produce sufficient steroid hormones

Adrenal crisis:
- fever;
- syncope;
- convulsions;
- hypoglycemia;
- hyponatremia;
- severe vomiting and diarrhea.



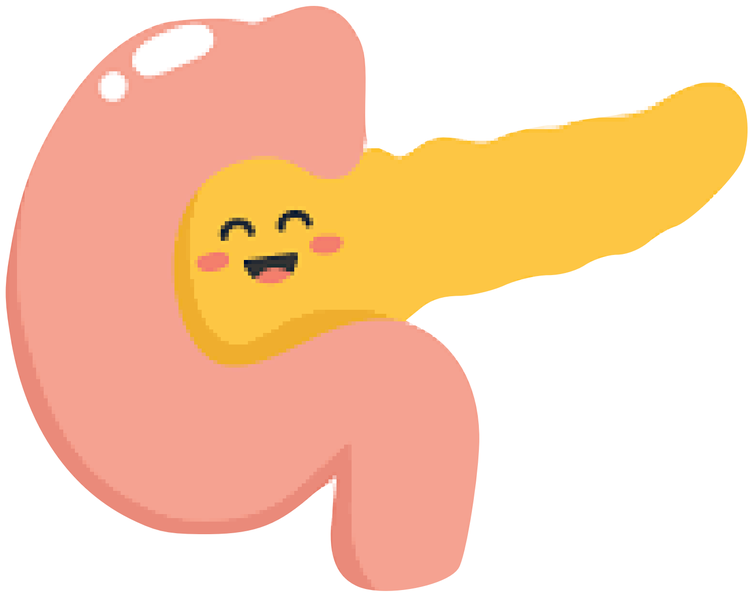
Skin
Hyperpigmentation

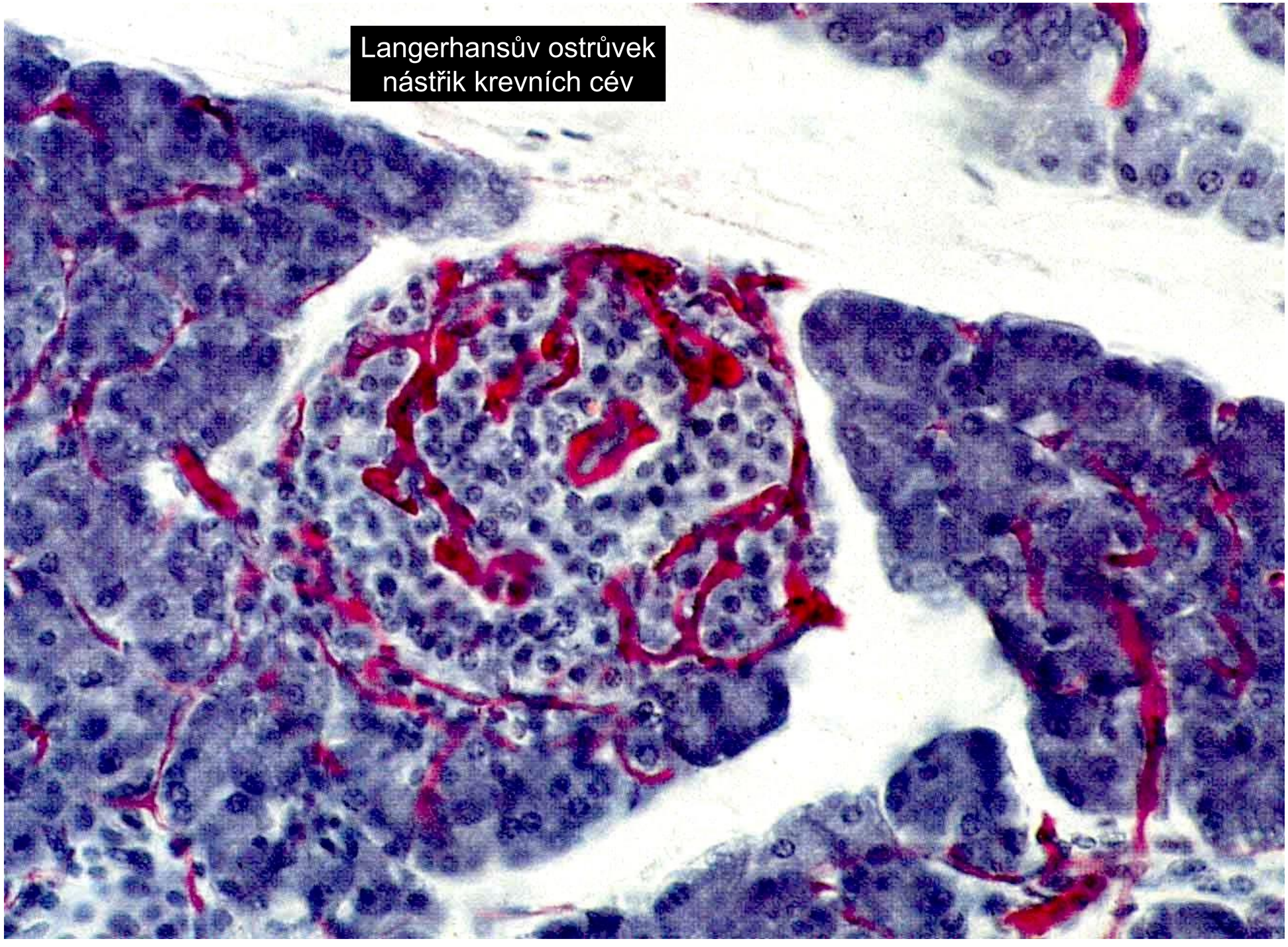
Low blood pressure
Weakness
Weight loss

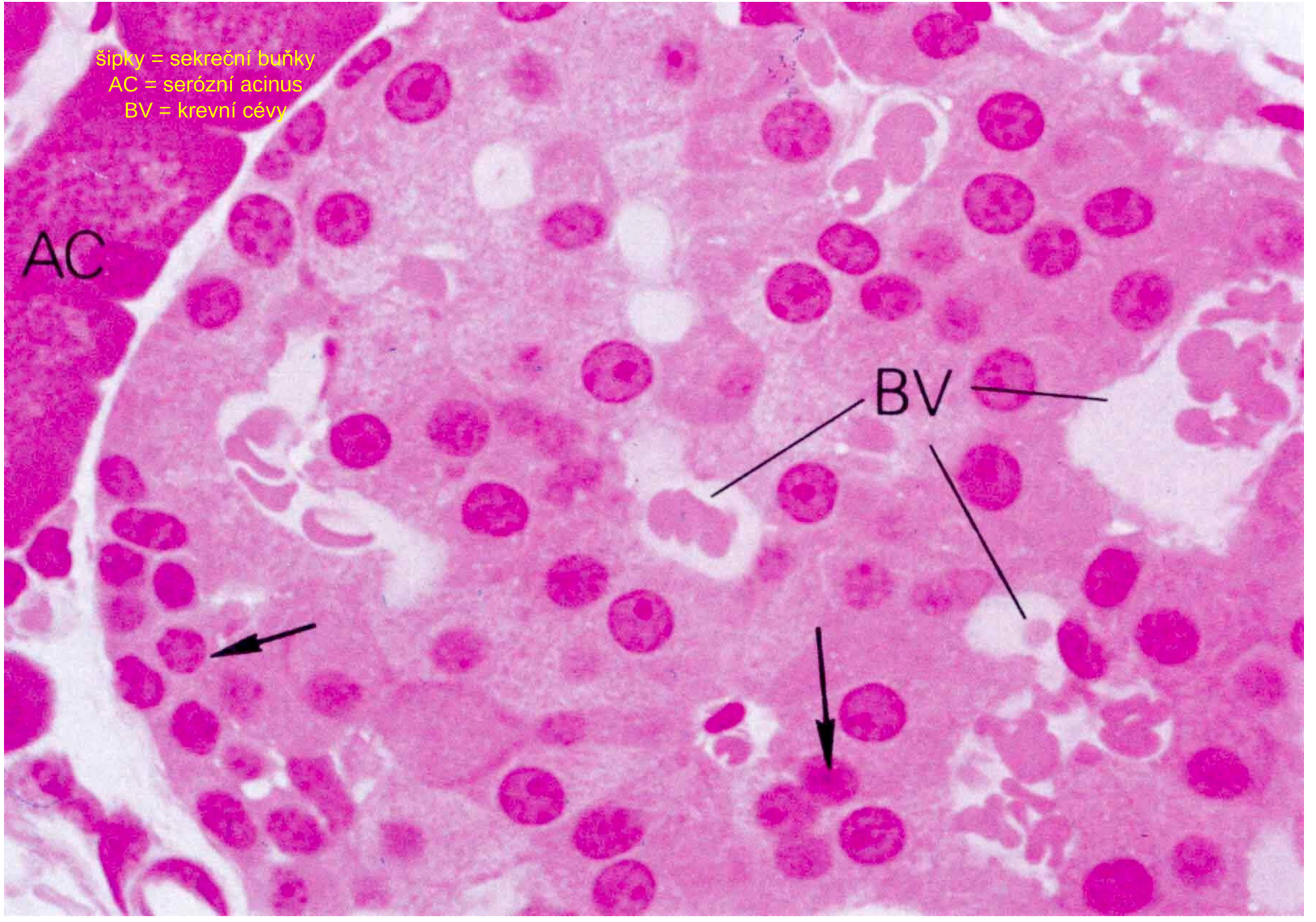
Gastrointestinal
Nausea
Diarrhea
Vomiting
Constipation
Abdominal pain

Skin
Vitiligo

Pankreas – endokrinní část



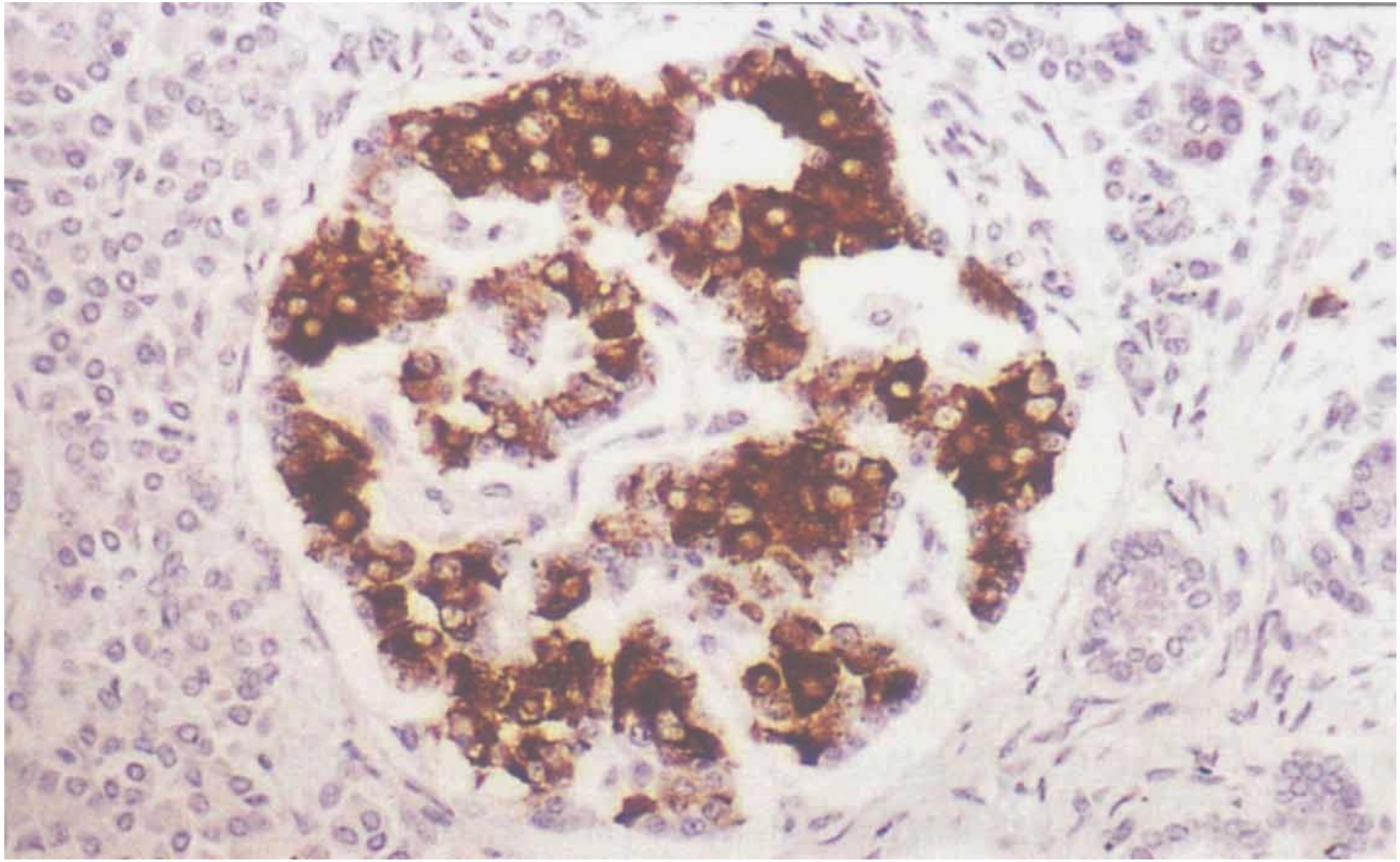

Langerhansův ostrůvek
nástřik krevních cév


šipky = sekreční buňky
AC = serózní acinus
BV = krevní cévy
AC
BV

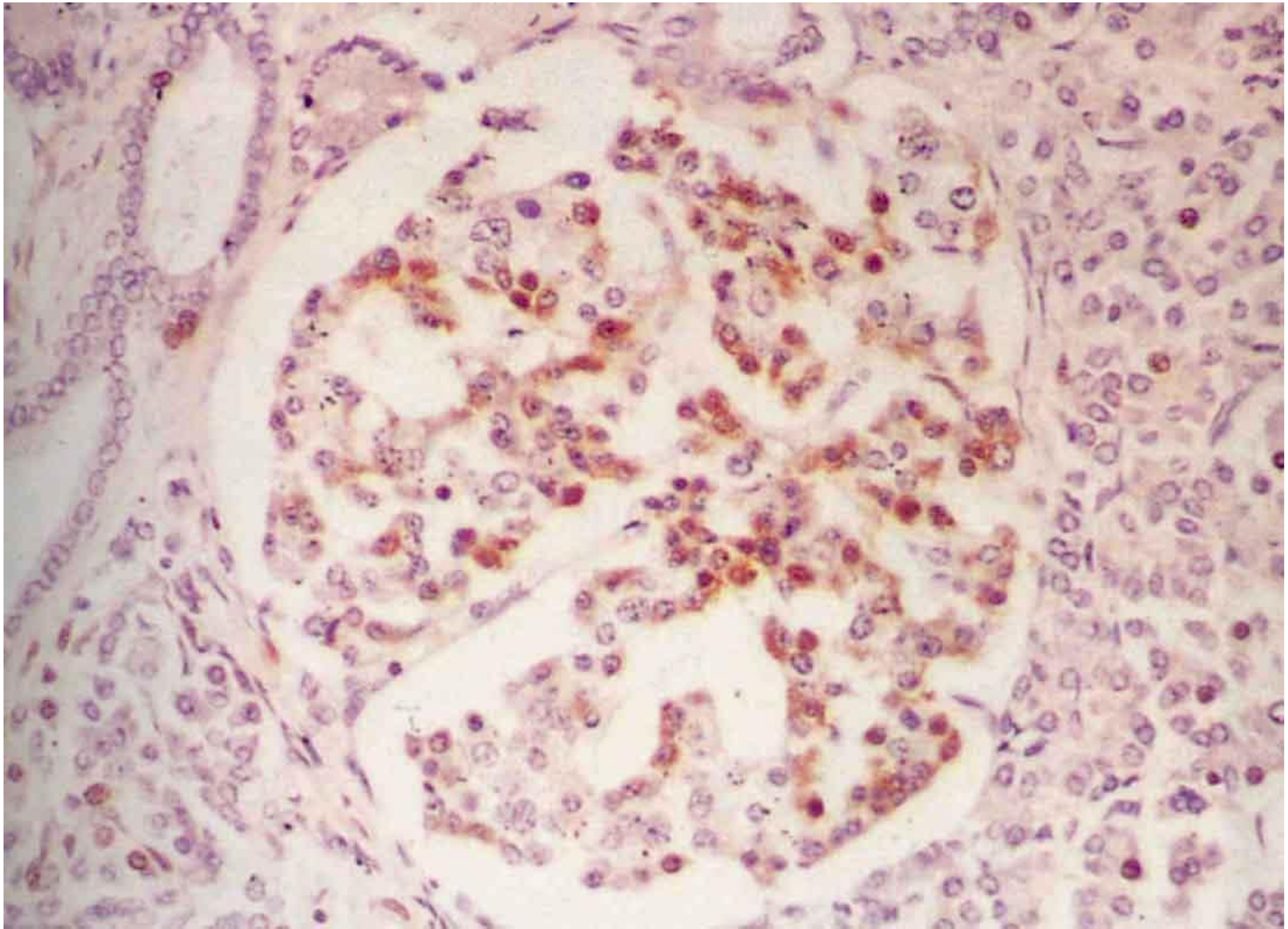
Slinivkové (Langerhansovy) ostrůvky
typy buněk

- A-buňky
  - **glukagon** – hyperglykemicko-glykogenolytický faktor
- B-buňky
  - **inzulín** – hypoglykemický faktor
- D-buňky
  - jeden dlouhý výběžek buněk → parakrinní sekrece
  - **somatostatin**
- PP-buňky
  - **pankreatický polypeptid** → řízení exokrinní části slinivky

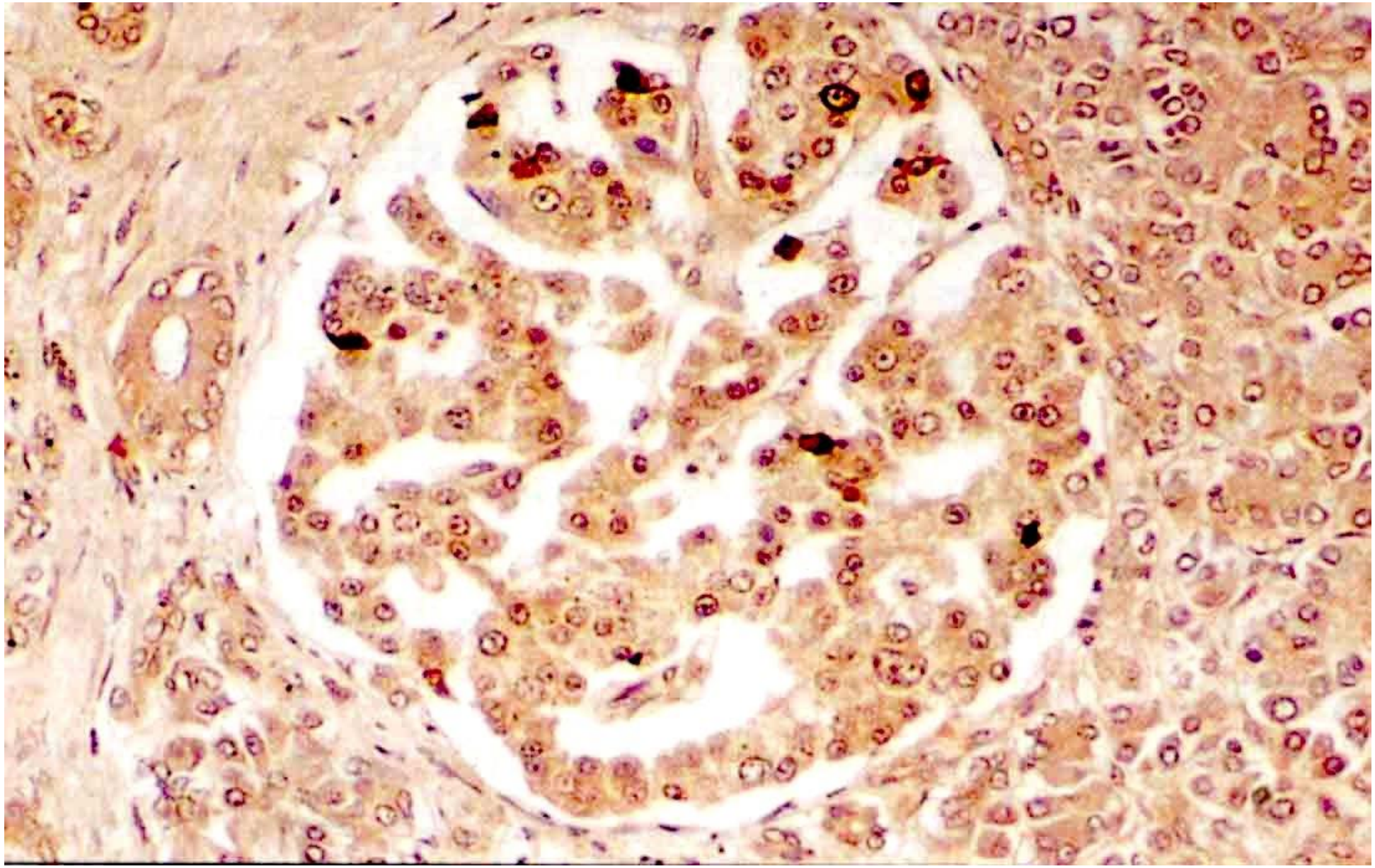
B buňky, asi 70 %, centrum, shluky

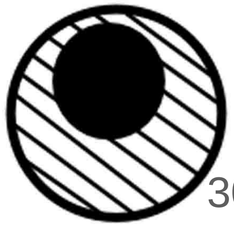
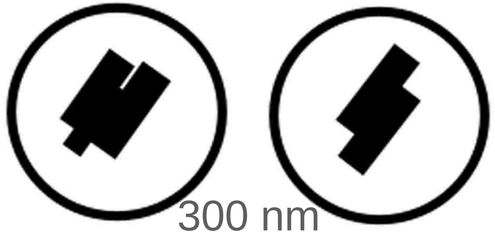
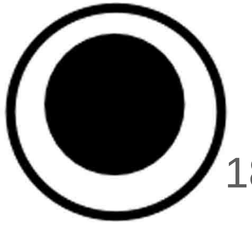


A buňky, do 20 %, periferie, ve vrstvách



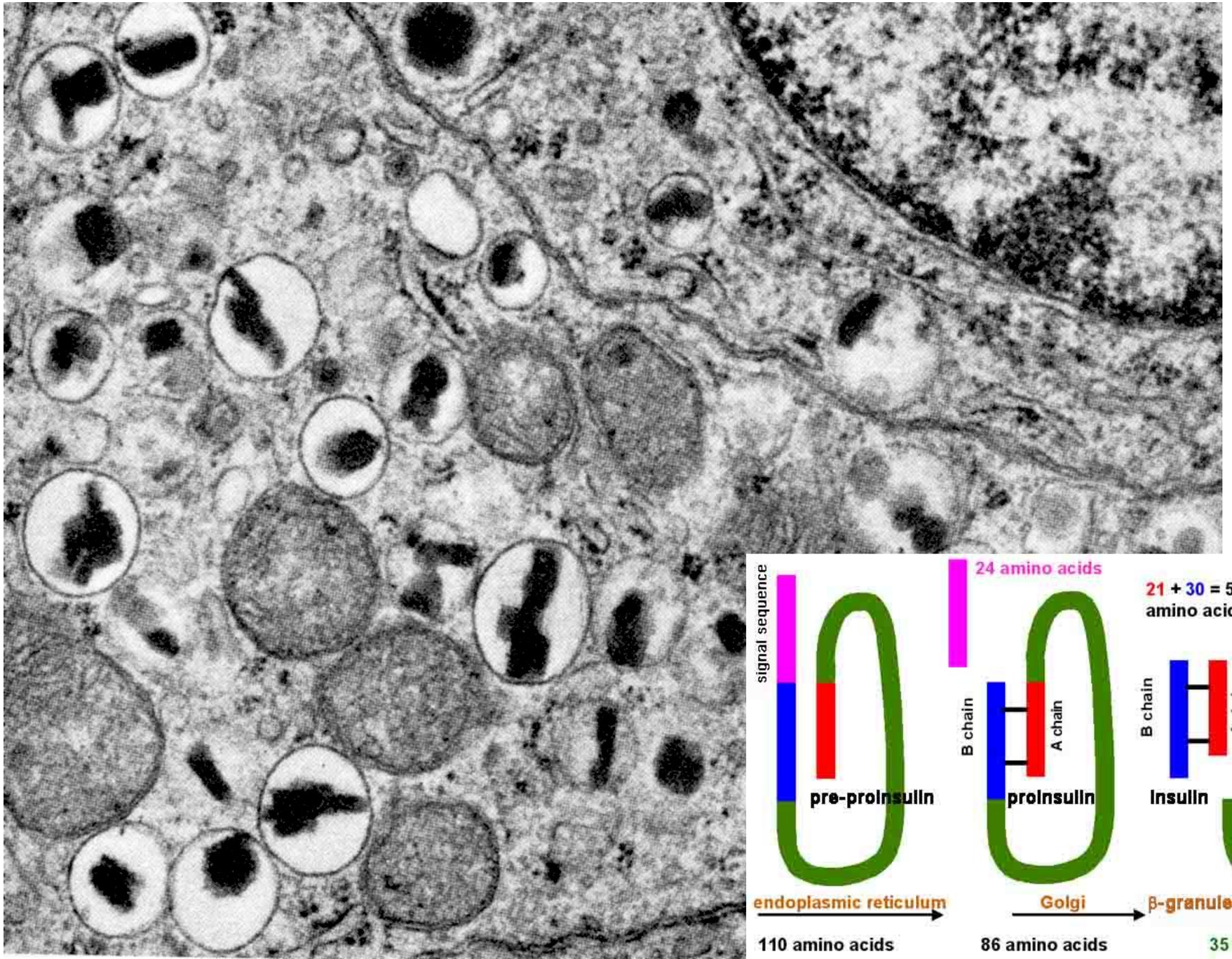
D buňky, do 5 %, roztroušeně

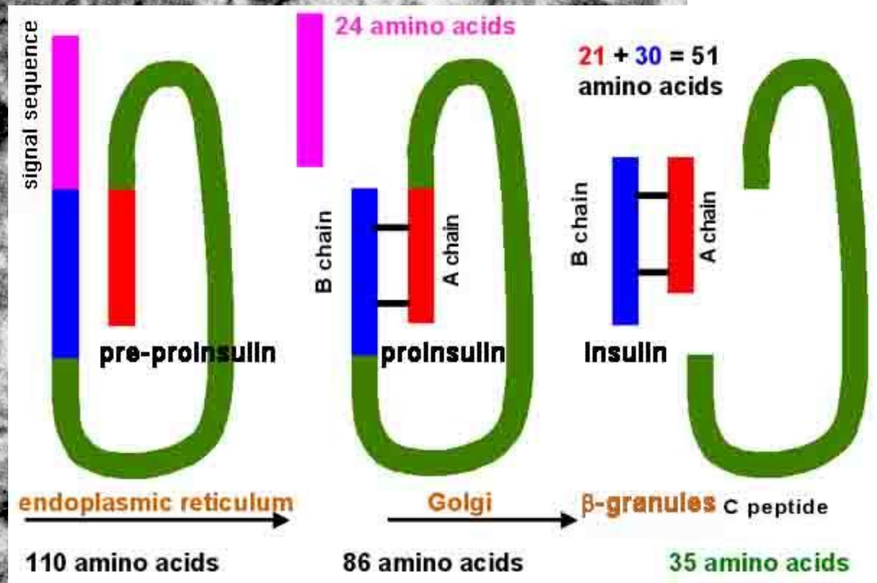


typ buňky	struktura granul	hormon
A	 300 nm	glukagon
B	 300 nm	insulin
D	 250 nm	somatostatin
F	 180 nm	pankreatický polypeptid

E (ghrelin), EC (substance P), D_1 (VIP), G (gastrin)

B buňka




signal sequence
pre-proinsulin
endoplasmic reticulum
110 amino acids
24 amino acids
B chain
A chain
proinsulin
Golgi
86 amino acids
21 + 30 = 51
amino acids
B chain
A chain
insulin
β-granules
C peptide
35 amino acids