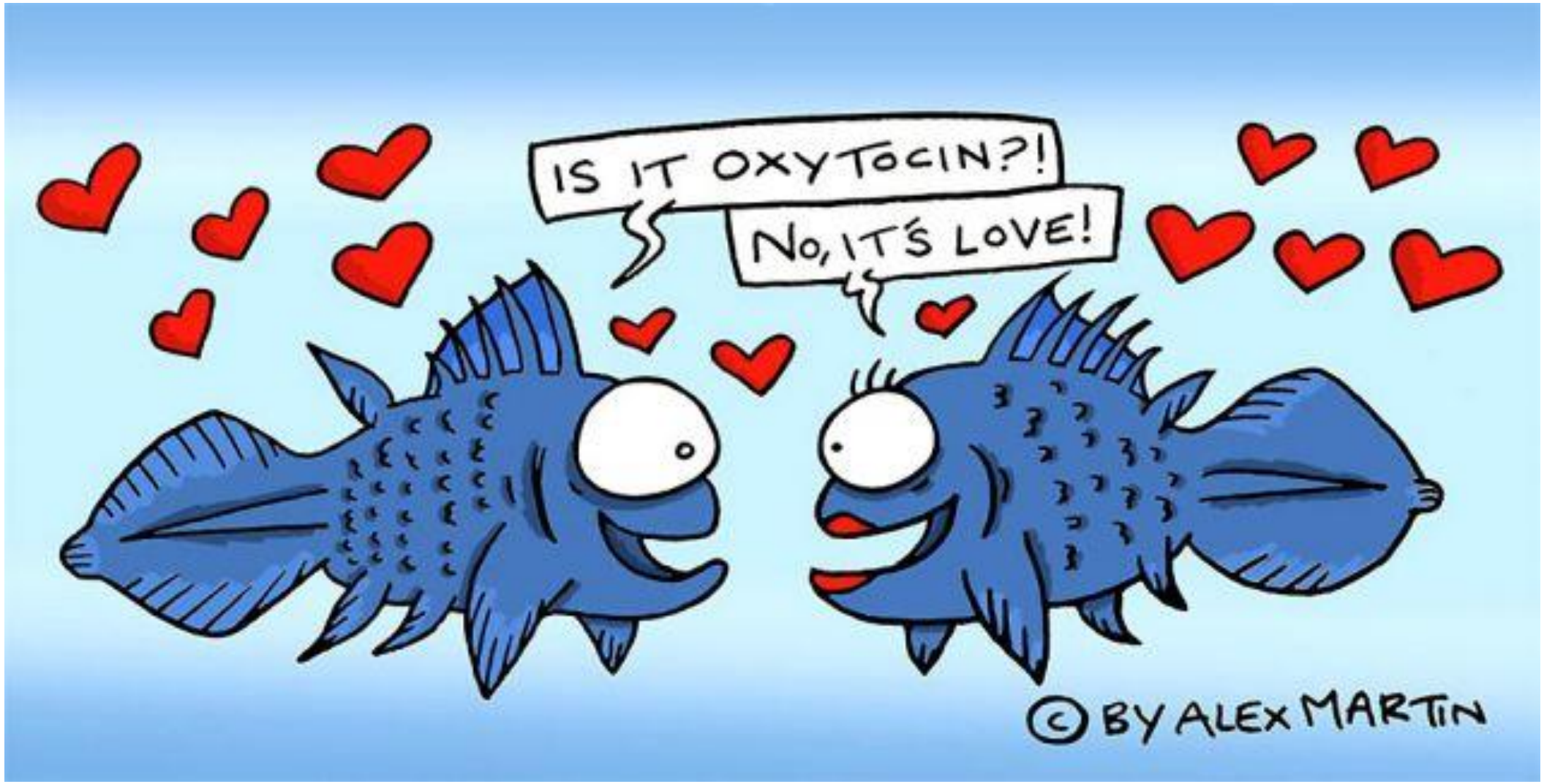
Endocrine system

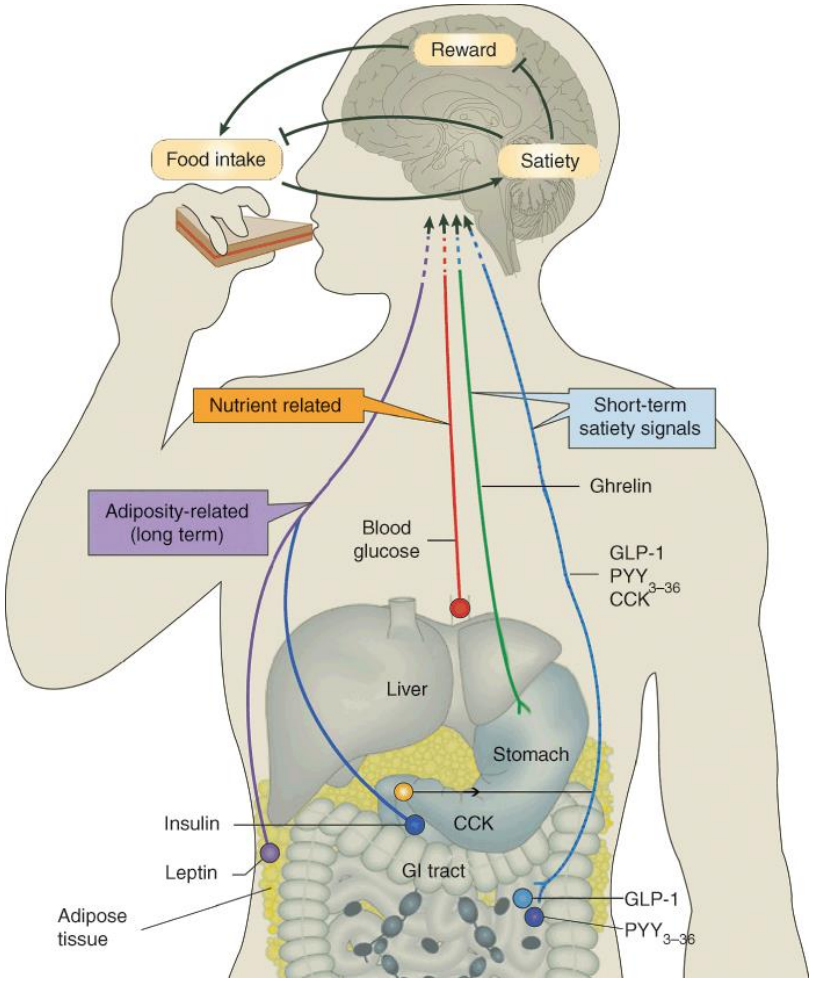


https://www.psychologytoday.com/ca/blog/how-we-do-it/201505/oxytocin-the-multitasking-love-hormone

Endocrine glands - *Glandulae endocrinae*

- One of two regulation systems
- hormon (Greek hormḗ (ὁρμή) – to arise)

- chemical messenger produced by endocrine gland and transported into blood to target organs
  - proteins (polypeptides) – *insuline*
  - amines – *adrenaline*
  - steroids – *estrogenes*



https://www.cambridge.org/core/books/abs/clinical-neuroendocrinology/neuroendocrine-regulation-of-appetite-and-body-weight/475C6860888D1DC8EAA5B36703CDB149

History

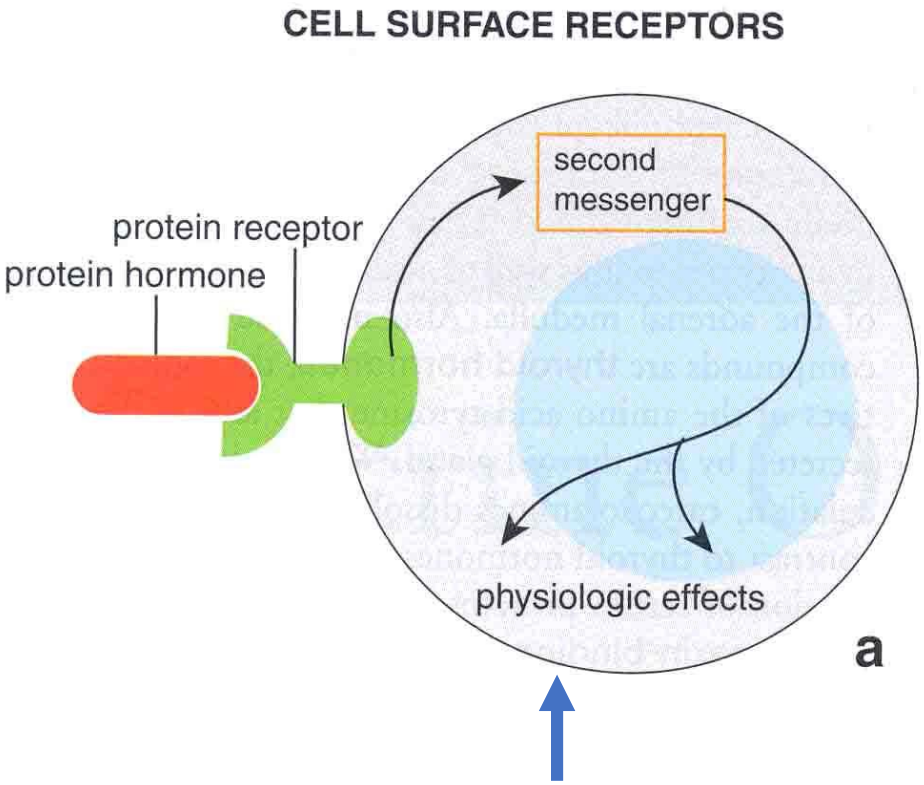
Thomas Wharton
- 1614-1673
- Adenographia
- first detailed description of glands

https://en.wikipedia.org/wiki/Thomas_Wharton_%28anatomist%29

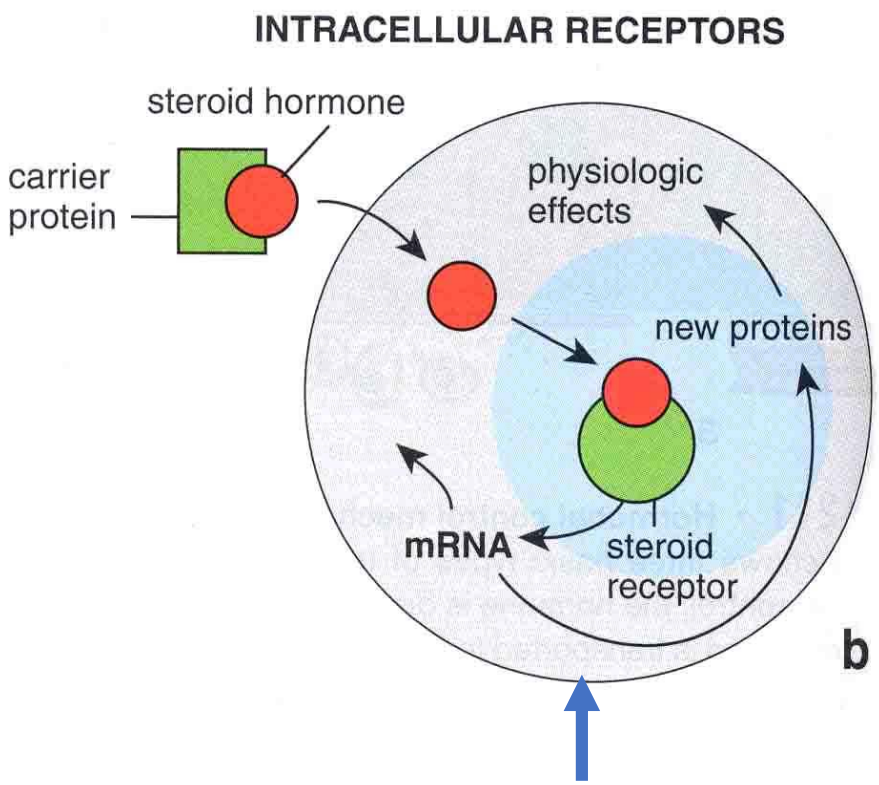
Ernest Henry Starling
- 1866-1927
- general schemes of „endocrine secretion“
- used the already exsiting word „hormones“

https://en.wikipedia.org/wiki/Ernest_Starling

Hormonal signalling

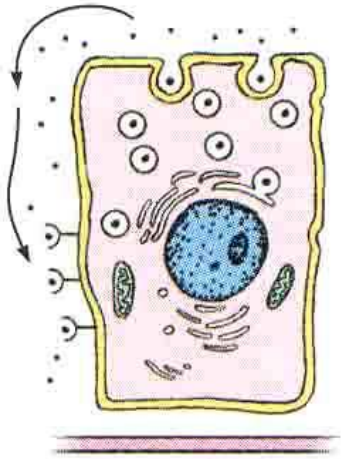


peptids and proteins
amins

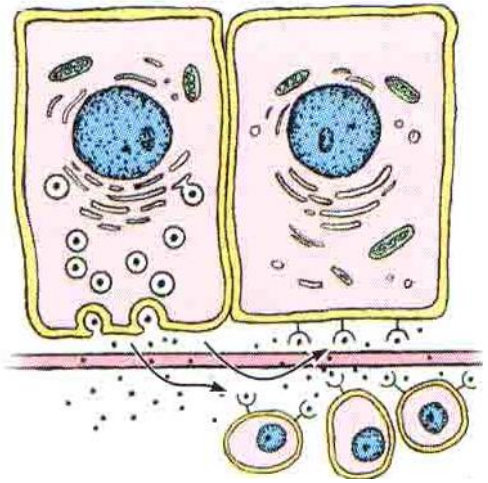


steroids
and other small hydrophobic molecules

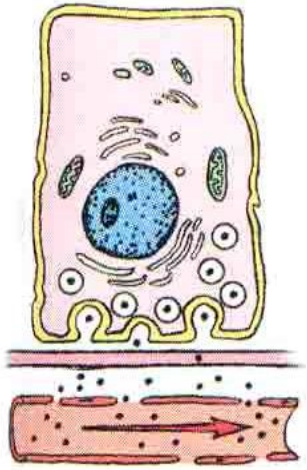
Ways of secretion



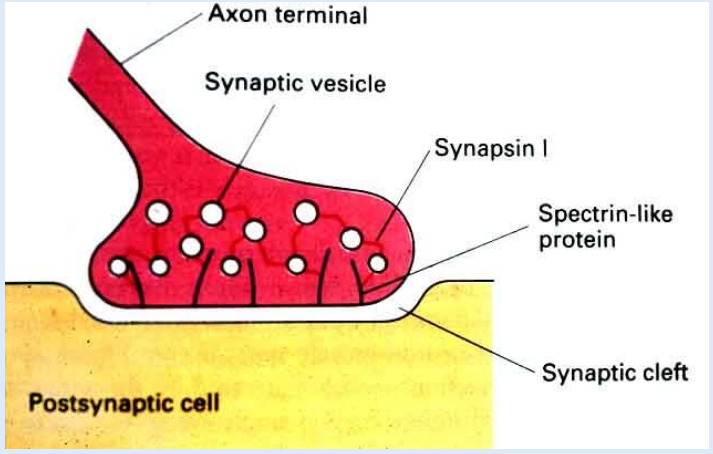
autocrine



paracrine



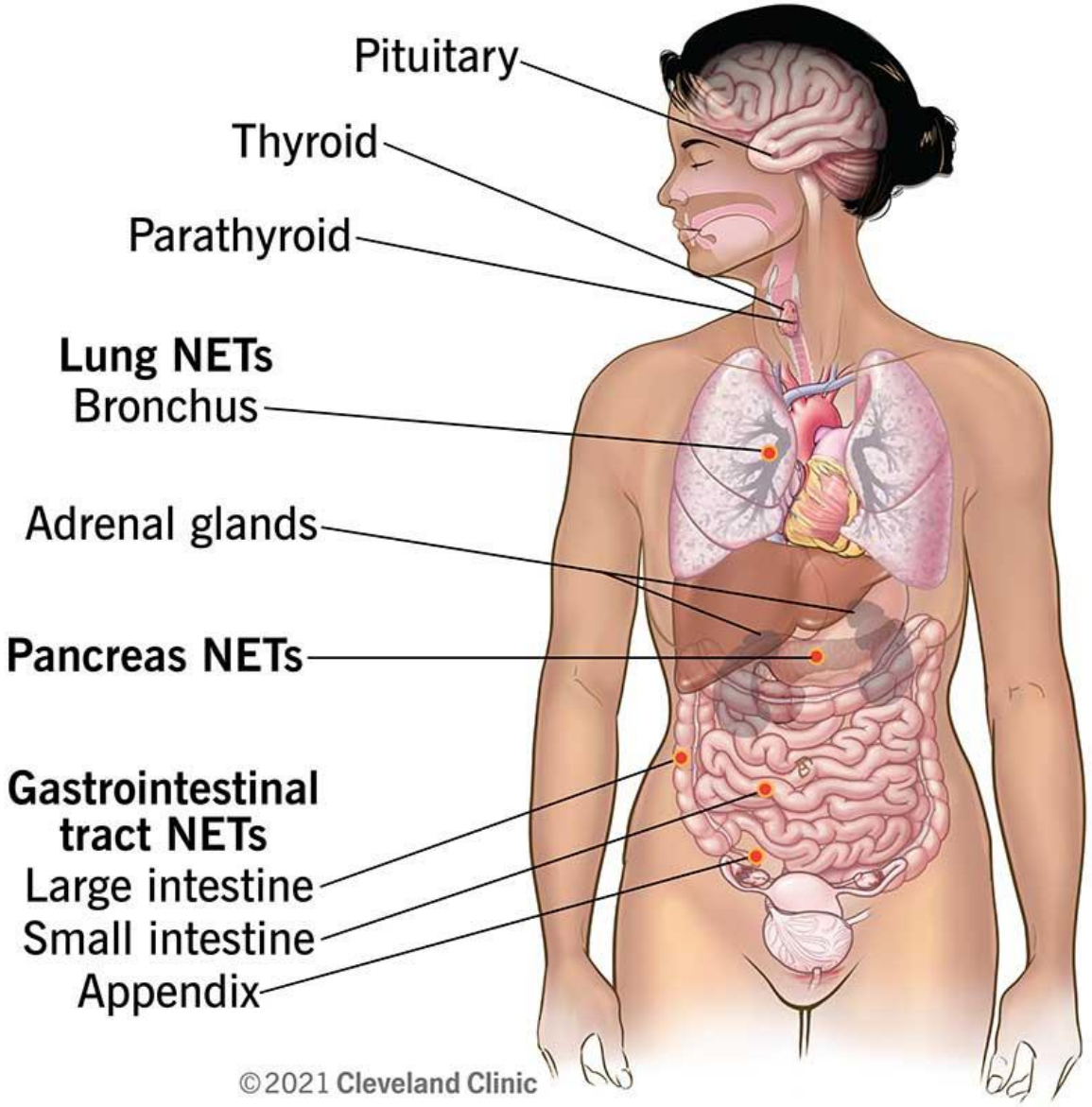
endocrine



synaptic

Endocrine system arrangement

- glands
- disseminated cells
- neuroendocrine cells



https://my.clevelandclinic.org/health/diseases/22006-neuroendocrine-tumors-net

Endocrine glands

- hypothalamus (*hypothalamus*)
- pituitary gland (*hypophysis; gl. pituitaria)*

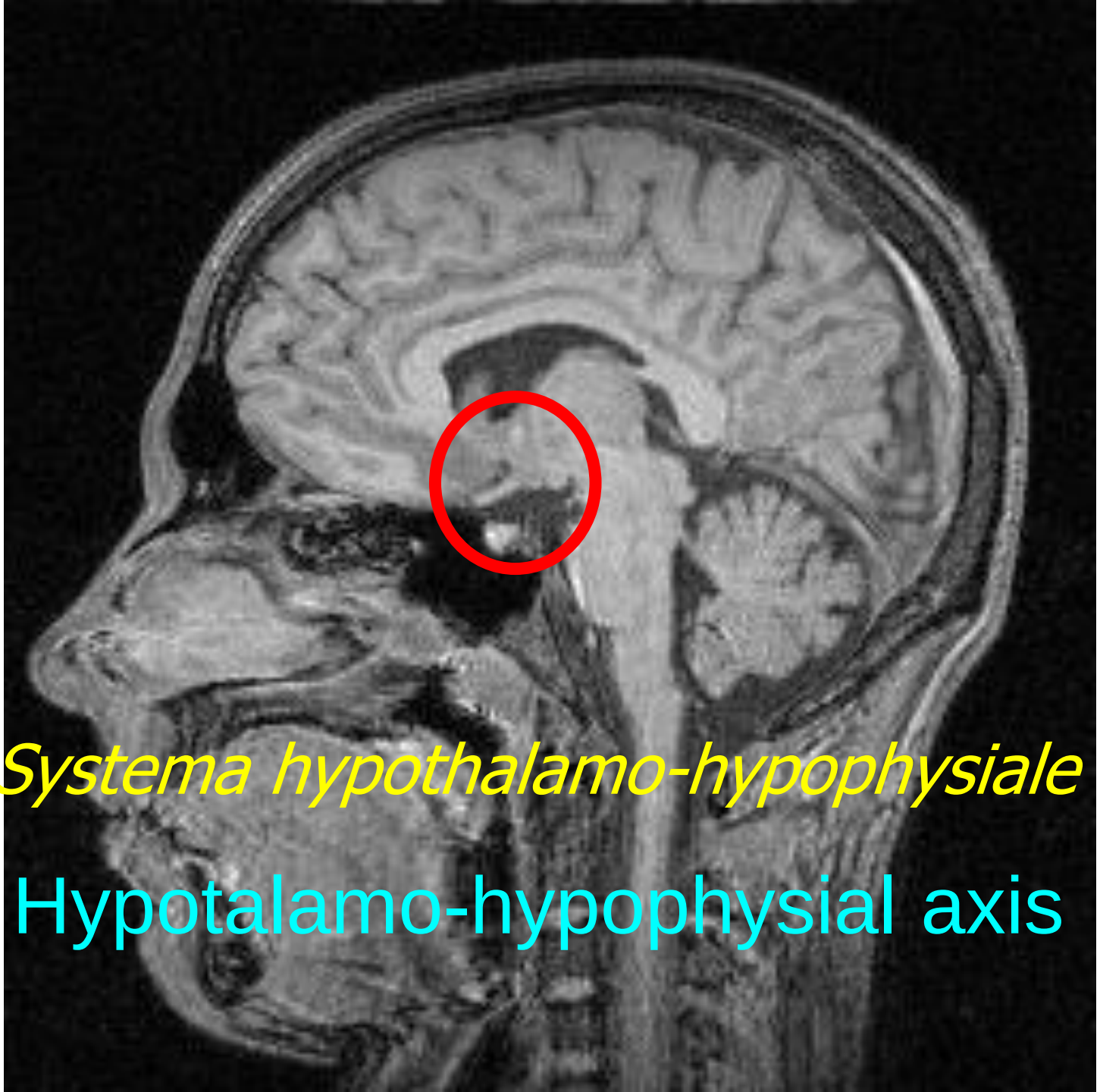
pineal gland (*gl. pinealis; corpus pineale*)

- thyroid gland (*glandula thyroidea*)
- parathyroid bodies(*gll. parathyroideae)*
- suprarenal glands, adrenals (*gll. suprarenales*)
- pancreatic (Langerhans‘) island (*insulae pancreaticae*)

General structure

- stroma – reticular connective tissue
- parenchyme
  - Trabecular epithelium (adenohypophysis, parathyroid glands, adrenal glands, Langerhan´s islets)
  - Sheet epithelium arranged into follicules (thyroid gland)
  - Specialised nerve tissue (neurohypophysis, pineal gland)

Hypothalamo-hypophysial system



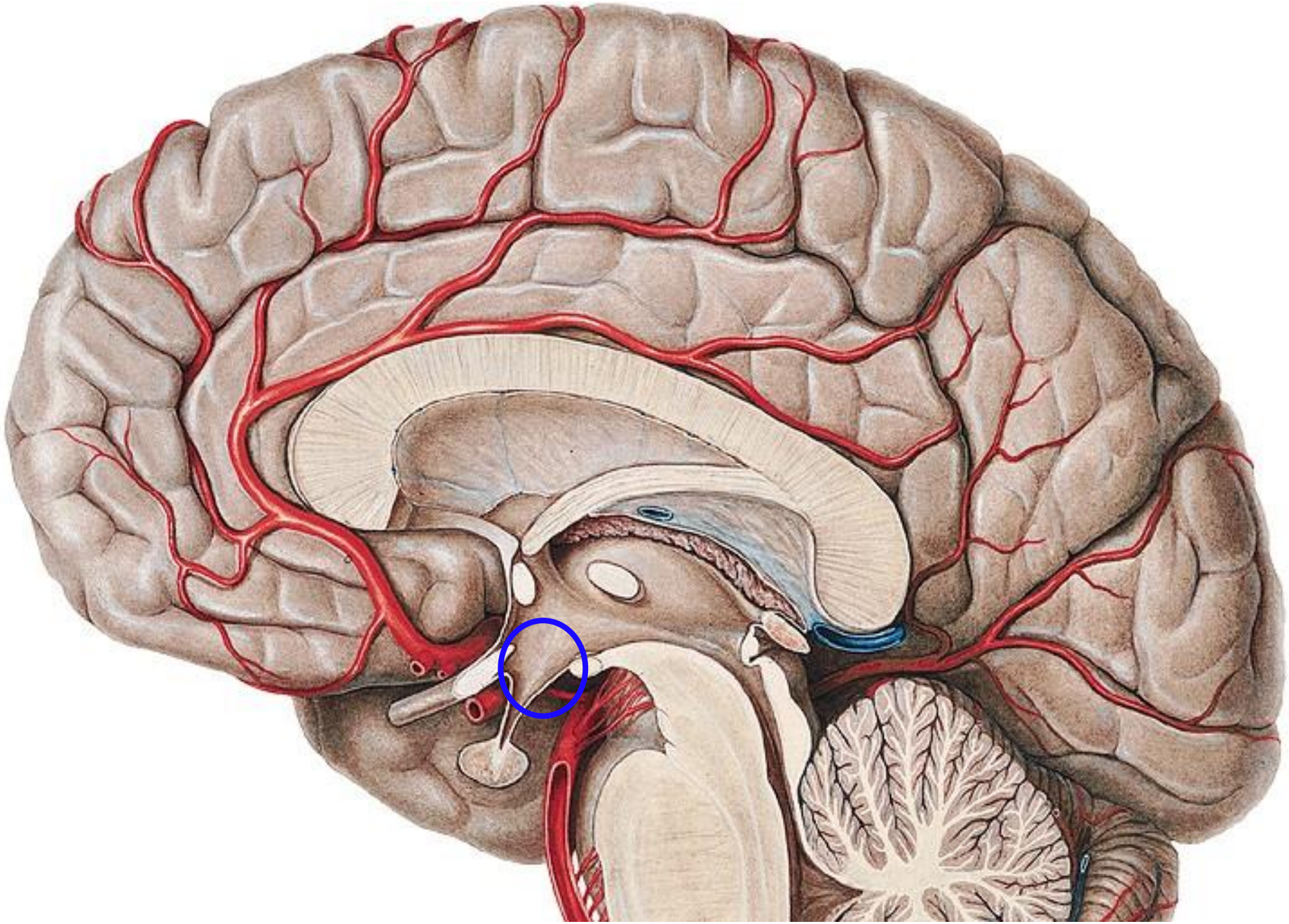
Systema hypothalamo-hypophysiale

Hypotalamo-hypophysial axis

Hypothalamus
+ hypophysis

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



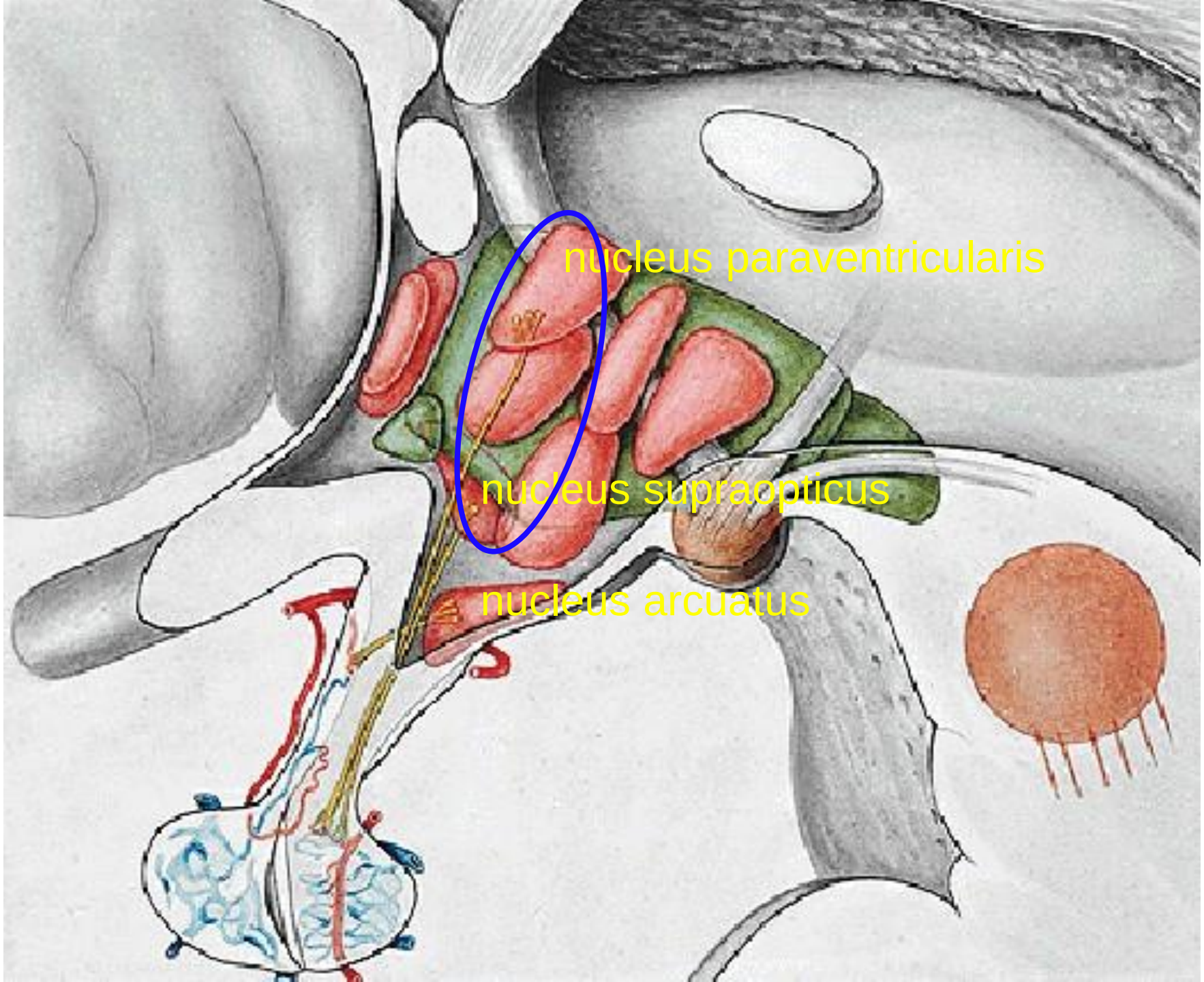
https://www.datart.cz/cestovni-adapter-fixed-eu-pro-zapojeni-uk-us-aus-nabijecek-do-eu-zasuvek-fixct-eu.html?gclid=Cj0KCQjwgYSTBhDKARIsAB8Kuku5-K28uD79GMbRbUx-rDIPcxMdXacp9cgqj2CEGM2sGIgvgc-DtAkaAqOIEALw_wcB

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


nucleus paraventricularis
nucleus supraopticus
nucleus arcuatus

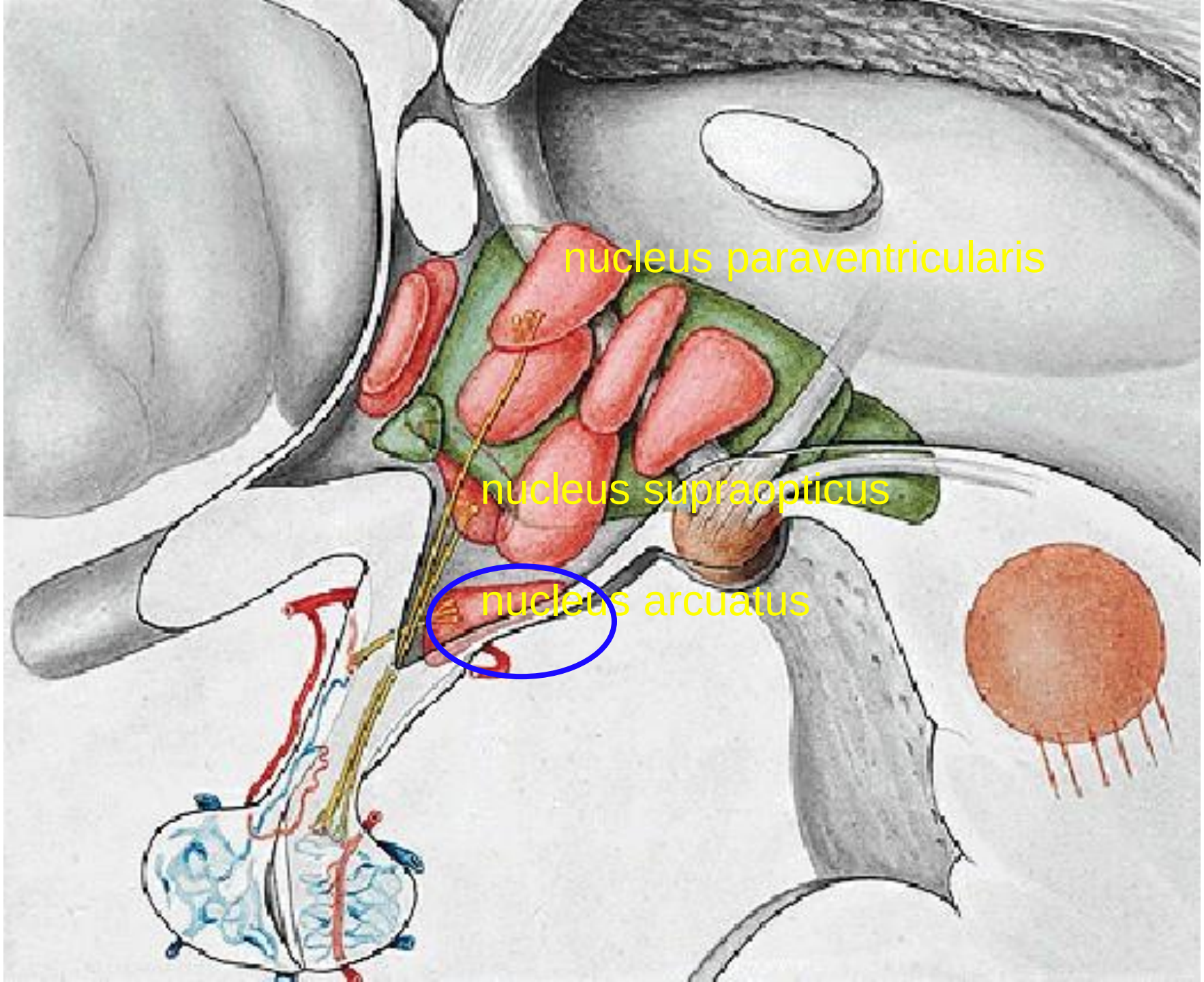
Neuroscience & Biobehavioral Reviews
Volume 55, August 2015, Pages 98-106

Review

Similar effects of intranasal oxytocin administration and acute alcohol consumption on socio-cognitions, emotions and behaviour: Implications for the mechanisms of action

Ian J. Mitchell, Steven M. Gillespie, Ahmad Abu-Akel

Ian J. Mitchell, Steven M. Gillespie, Ahmad Abu-Akel, Similar effects of intranasal oxytocin administration and acute alcohol consumption on socio-cognitions, emotions and behaviour: Implications for the mechanisms of action, Neuroscience & Biobehavioral Reviews, Volume 55, 2015, Pages 98-106, ISSN 0149-7634, https://doi.org/10.1016/j.neubiorev.2015.04.018.


nucleus paraventricularis
nucleus supraopticus
nucleus arcuatus

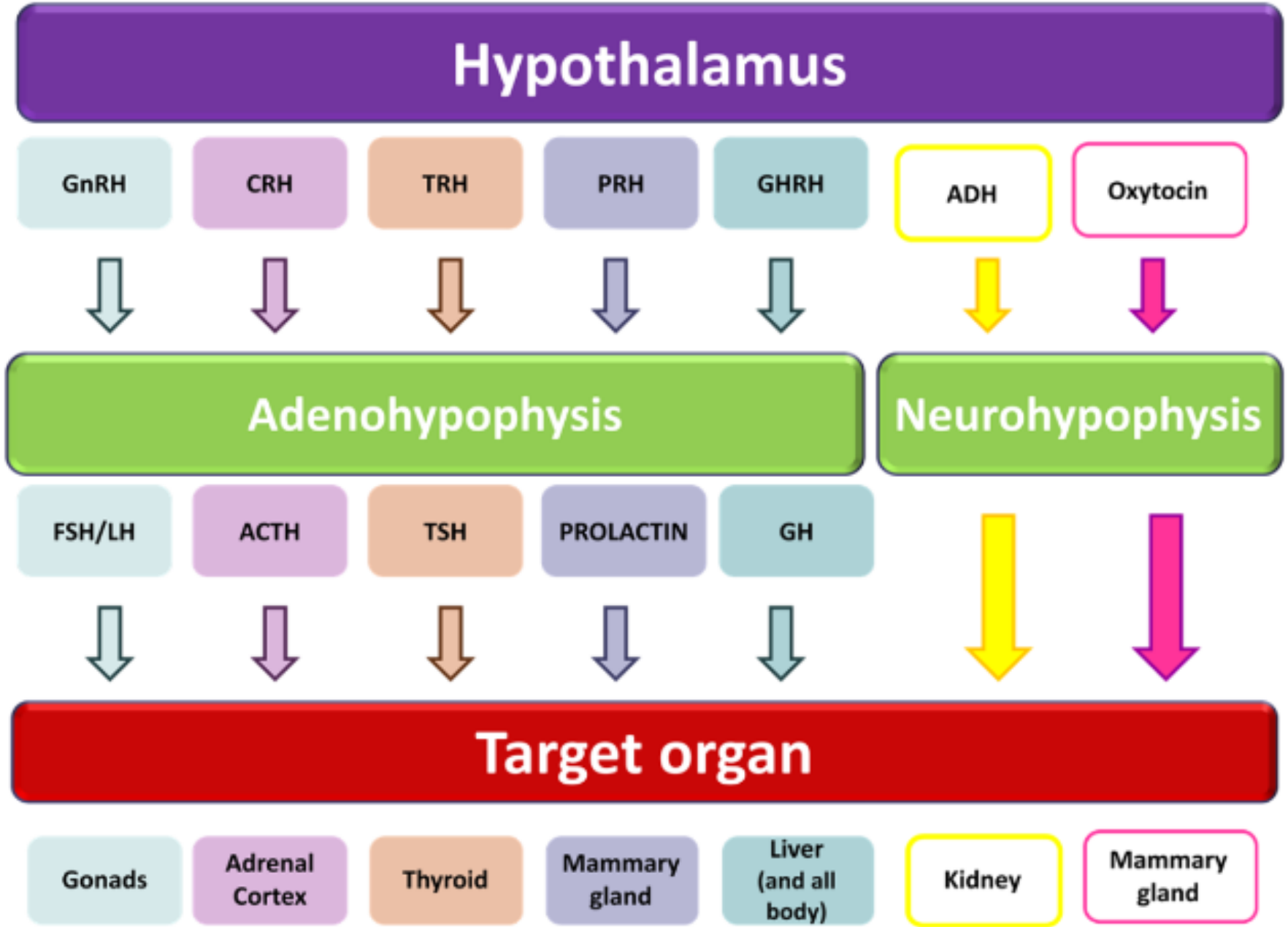
Hypothalamus - hormones

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

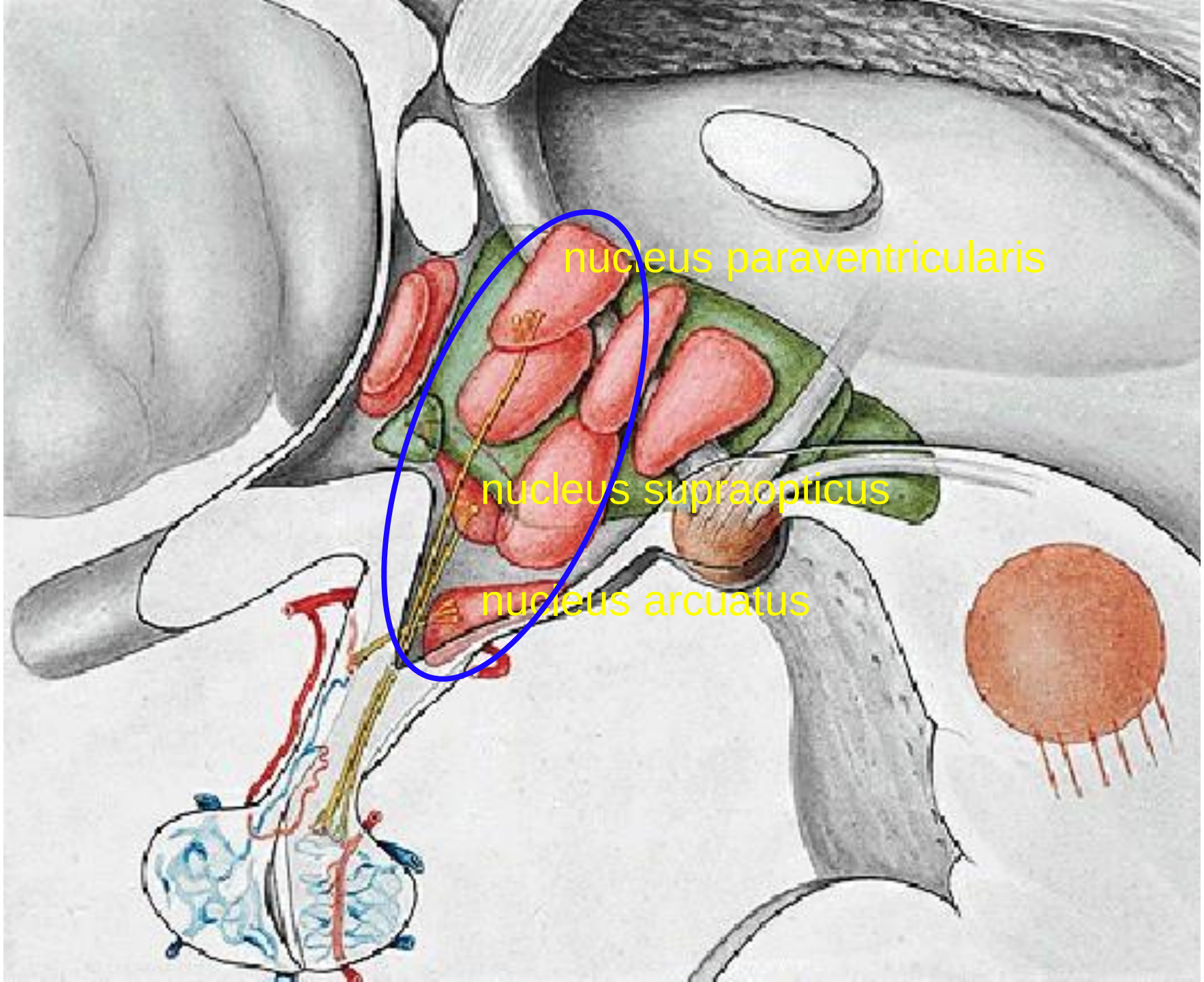
–SRH, PRH, GnRH, TRH, CRH

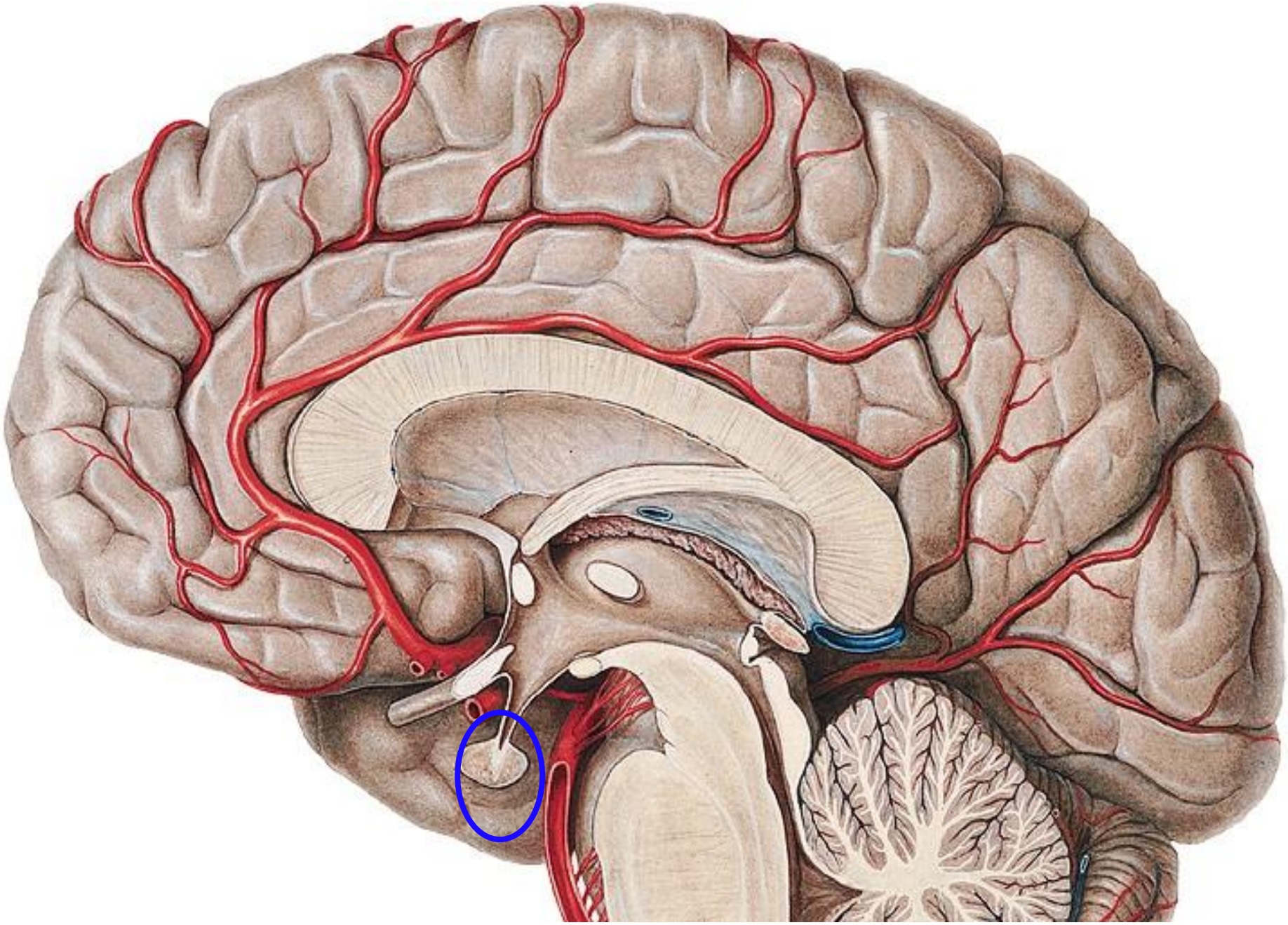
- inhibiting hormones = statins

–somatostatin, PIH (= dopamine)



https://is.muni.cz/el/sci/jaro2017/Bi1100/um/3._Hypothalamo-hypofyzarni_system.pdf


nucleus paraventricularis
nucleus supraopticus
nucleus arcuatus



Pituitary gland, Hypohysis, Glandula pituitaria

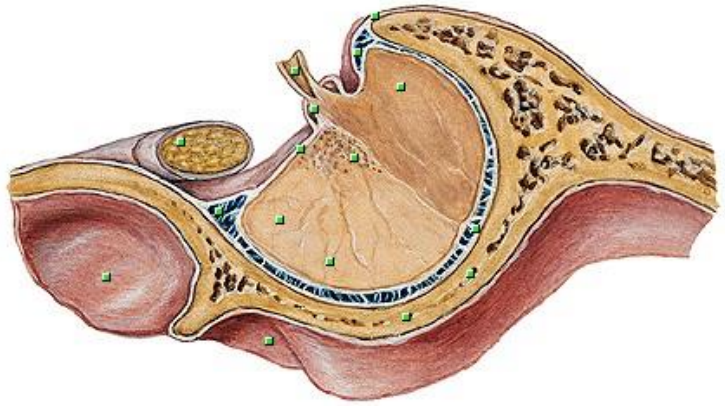
Pituitary gland - history

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

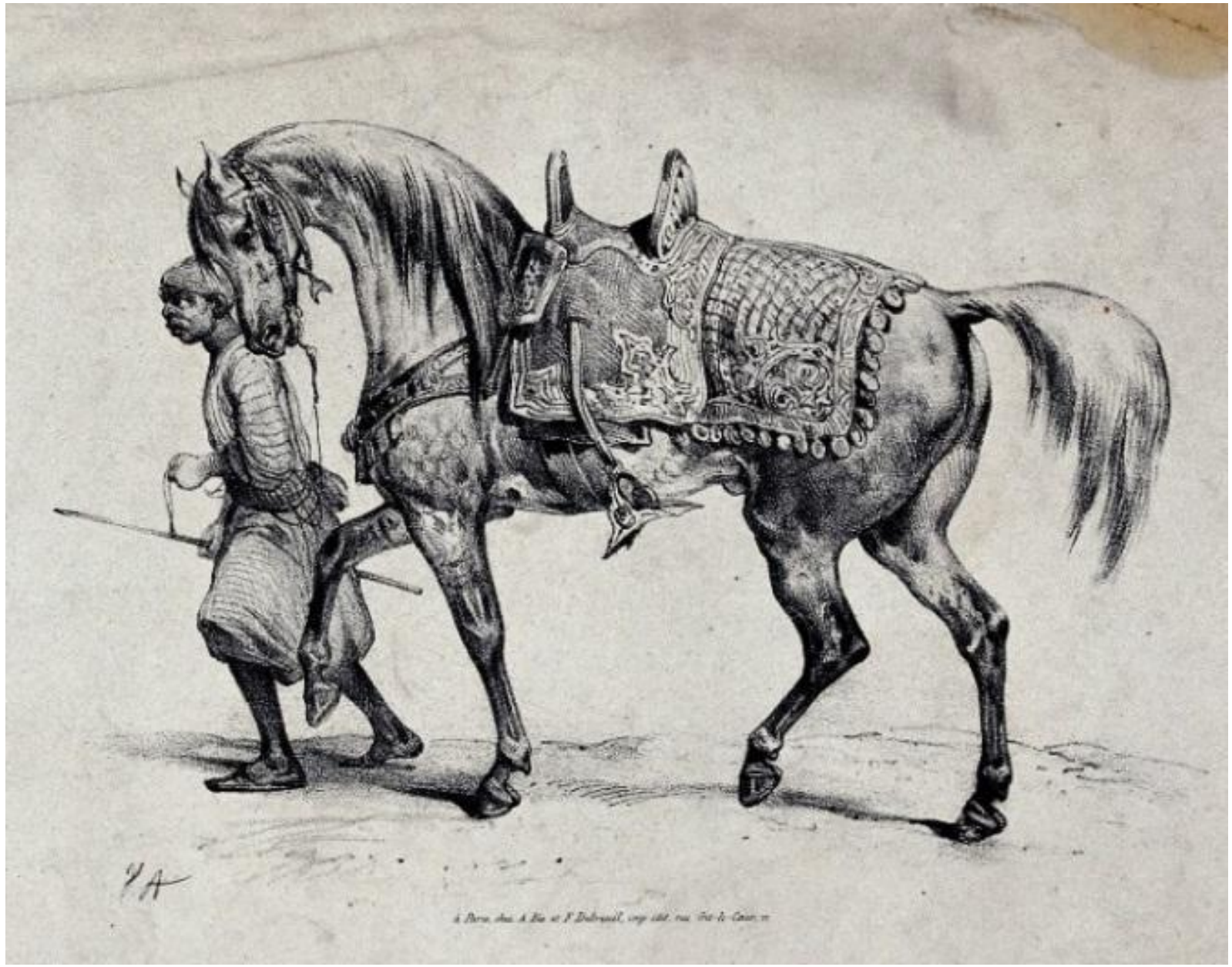
„a conductor of endocrine system, a prime minister “

https://www.researchgate.net/figure/An-animation-illustrating-how-the-pituitary-gland-orchestrates-the-functions-of-other_fig4_6165172

Pituitary gland - anatomy



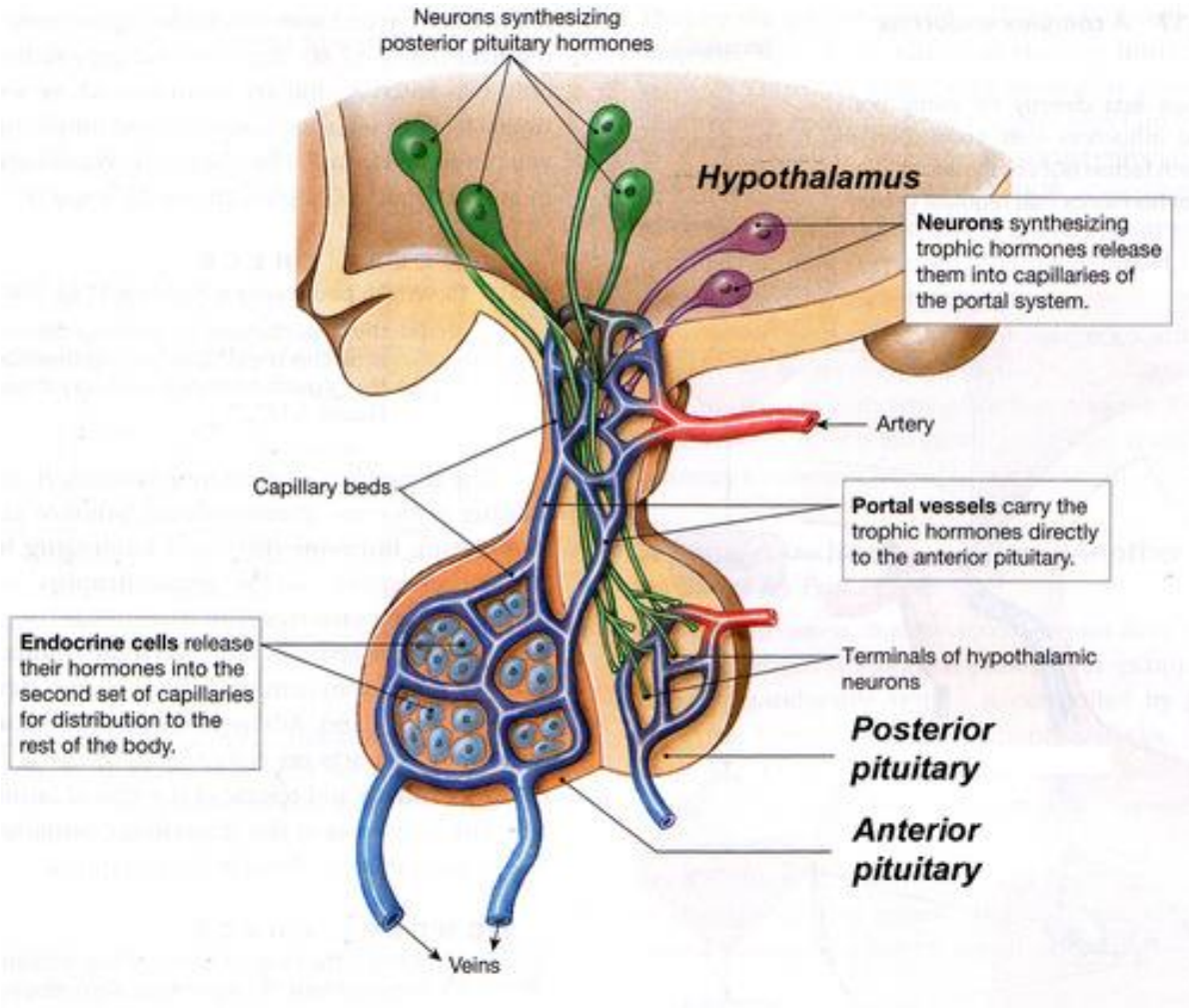
„double glands“
-two different tissues
two lobes
–anterior = adenohypophysis
–posterior = neurohypophysis
located within *sella turcica ossis sphenoidalis*
– covered with dura mater –*diaphragma sellae*
–foramen diaphragmatis *Pacchioni*–transmits *infundibulum*



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

Pituitary gland - anatomy

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



https://quizlet.com/559019365/other-systems-metabolic-and-endocrine-anatomy-flash-cards/

Pituitary gland - development

pouch of Ratke

–ectoderm→ anterior lobe

–3rd week: in the roof of stomodeum

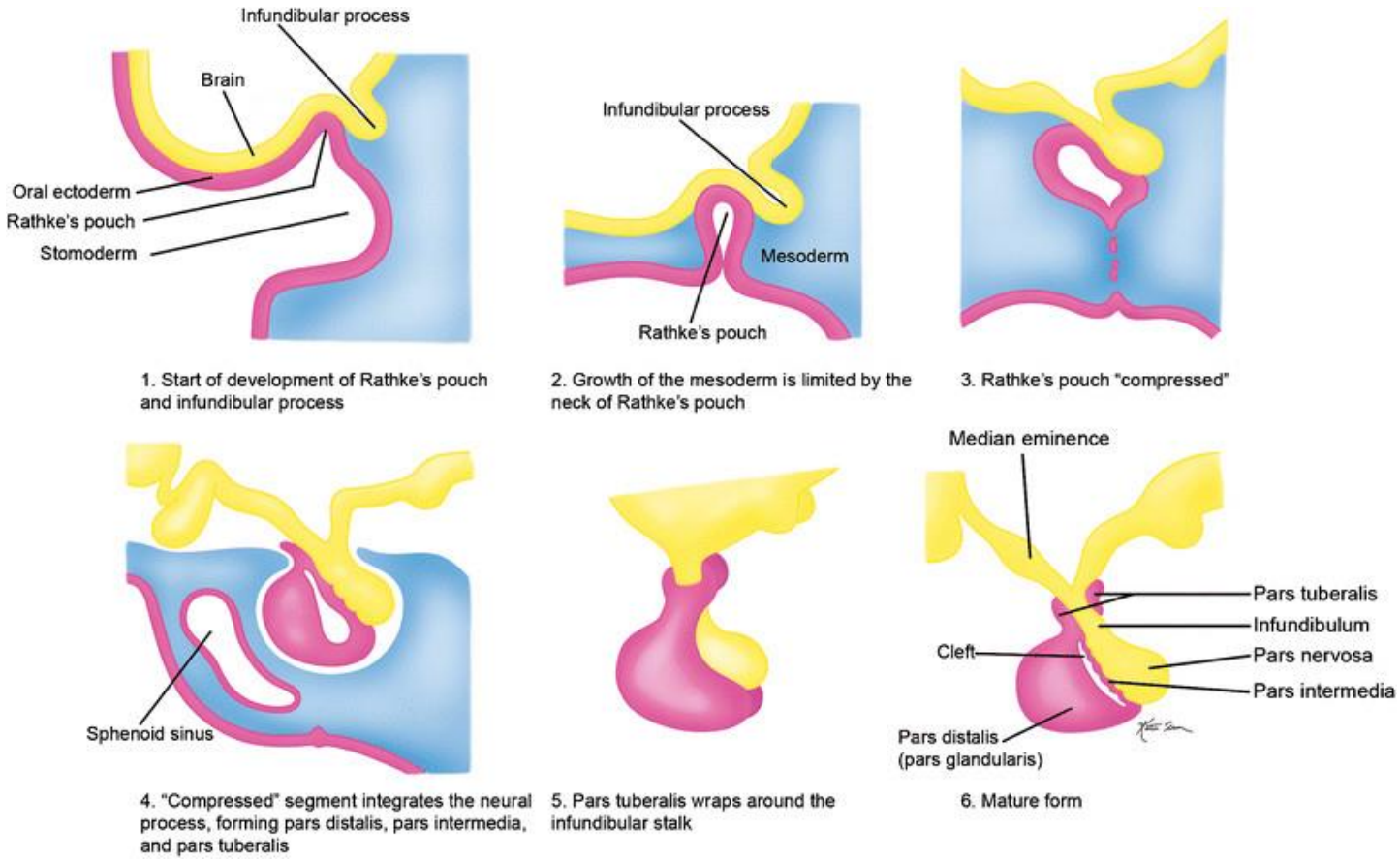
–pouch towards diencephalon

–separation of pouch, proliferation of anterior wall

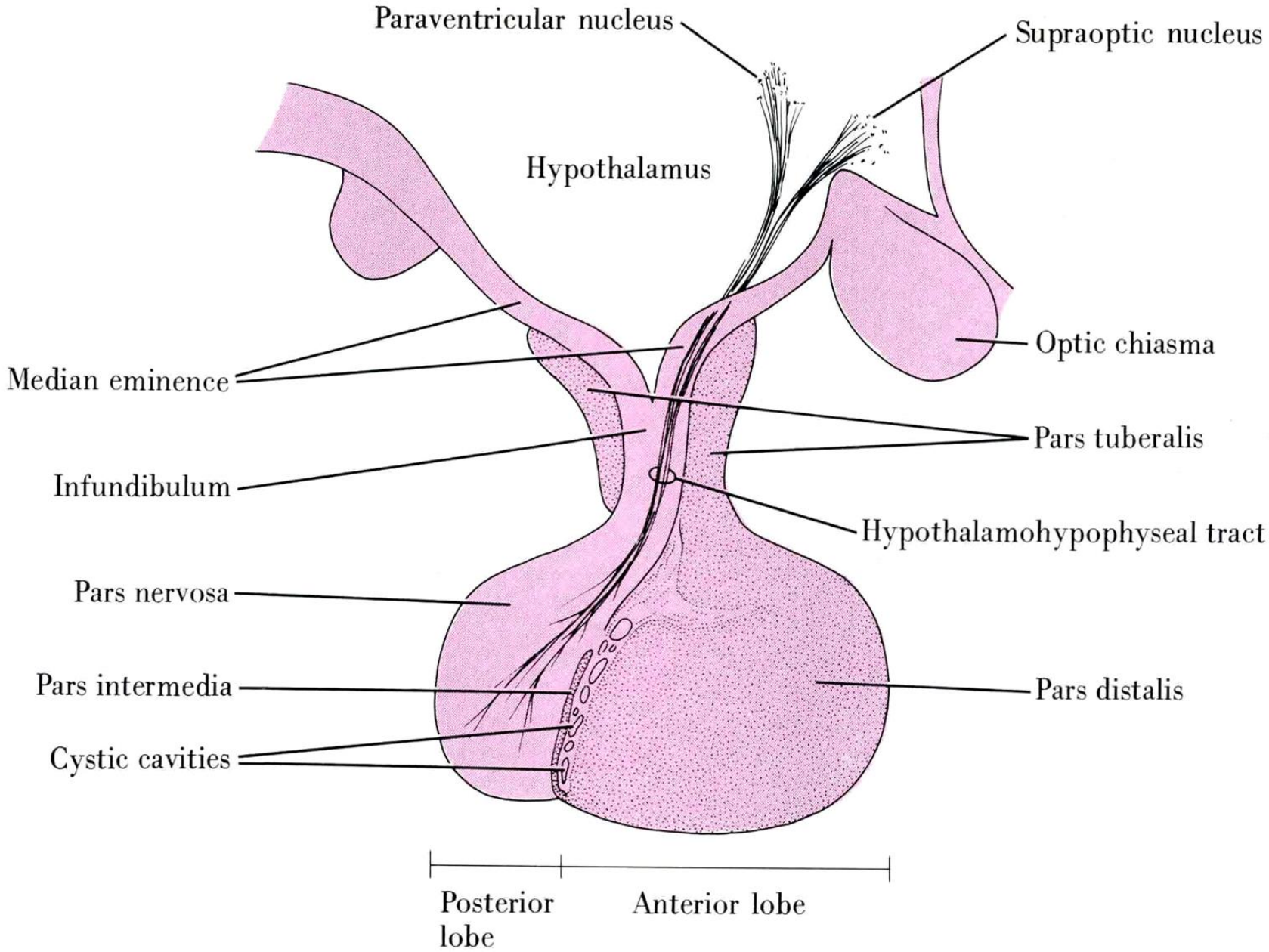
pouch of diencephalic base

–neuroectoderm → posterior lobe

–differentiation into pituicytes (glia)



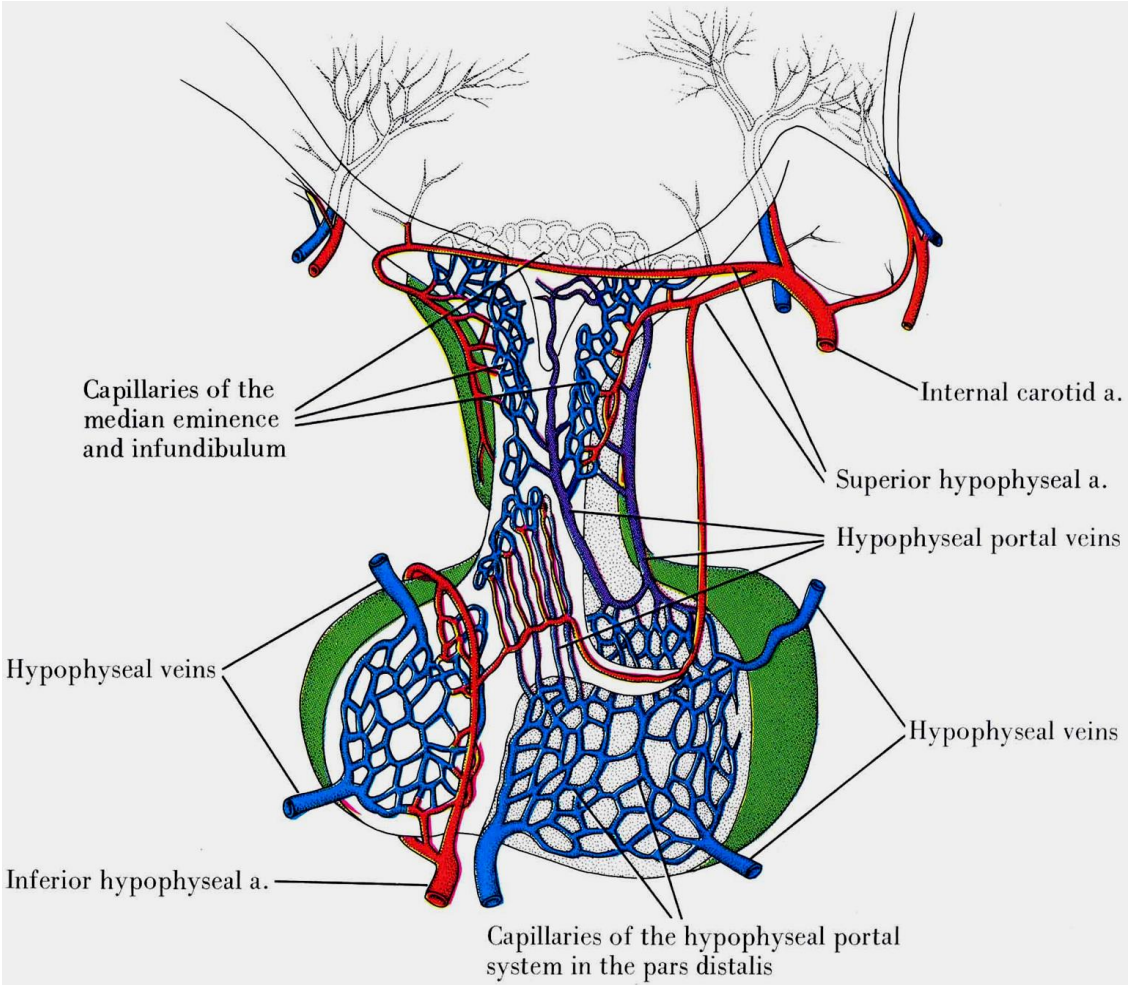
Shields, Rachel & Mangla, Rajiv & Almast, Jeevak & Meyers, Steven. (2015). Magnetic resonance imaging of sellar and juxtasellar abnormalities in the paediatric population: an imaging review. Insights into imaging. 6. 10.1007/s13244-015-0401-5.


Paraventricular nucleus
Supraoptic nucleus
Hypothalamus
Median eminence
Optic chiasma
Pars tuberalis
Infundibulum
Hypothalamohypophyseal tract
Pars nervosa
Pars intermedia
Pars distalis
Cystic cavities
Posterior lobe
Anterior lobe

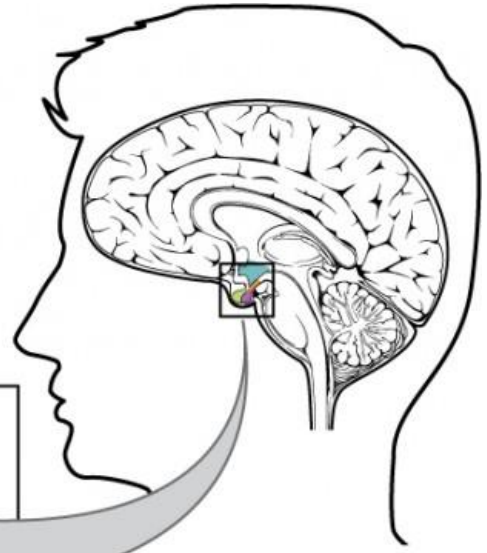
Pituitary gland – blood supply

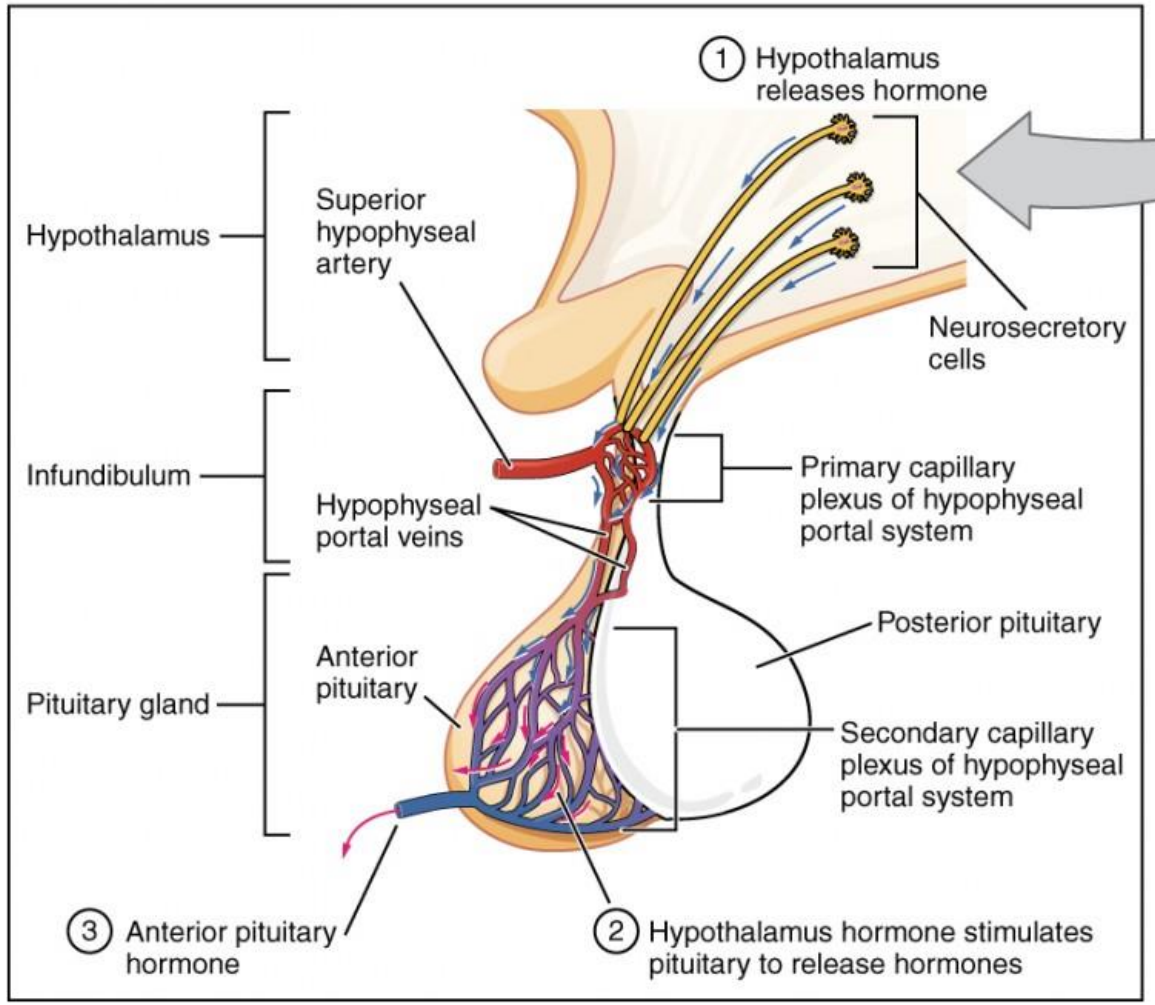
hypophysial portal system

- 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



Pars distalis - adenohypophysis





https://courses.lumenlearning.com/suny-ap2/chapter/the-pituitary-gland-and-hypothalamus/

Pars distalis - adenohypophysis

- cords of cells
- fenestrated capillaries inbetween cords
- 3 types of cells in HE staining:

Chromophil:

- acidophilic
- basophilic

- chromophobe

Pars distalis – acidophilic cells

α –cells = somatotropic

–large granules, GER

–zone without granules around nucleus (GA)

–somatotropin (human growth hormone, GH)

- ε –cells = mammotropic

–usually small, infrequent

–multiplication in gravidity and lactation

–little granules (larger in gravidity)

–prolactin (PRL)

Pars distalis – basophilic cells

β1 –cells = corticotropic

–large granules at cytoplasmatic membrane

–**ACTH, β-MSH**, Met-enkefalin, endorphine

- β2 –cells = thyrotropic

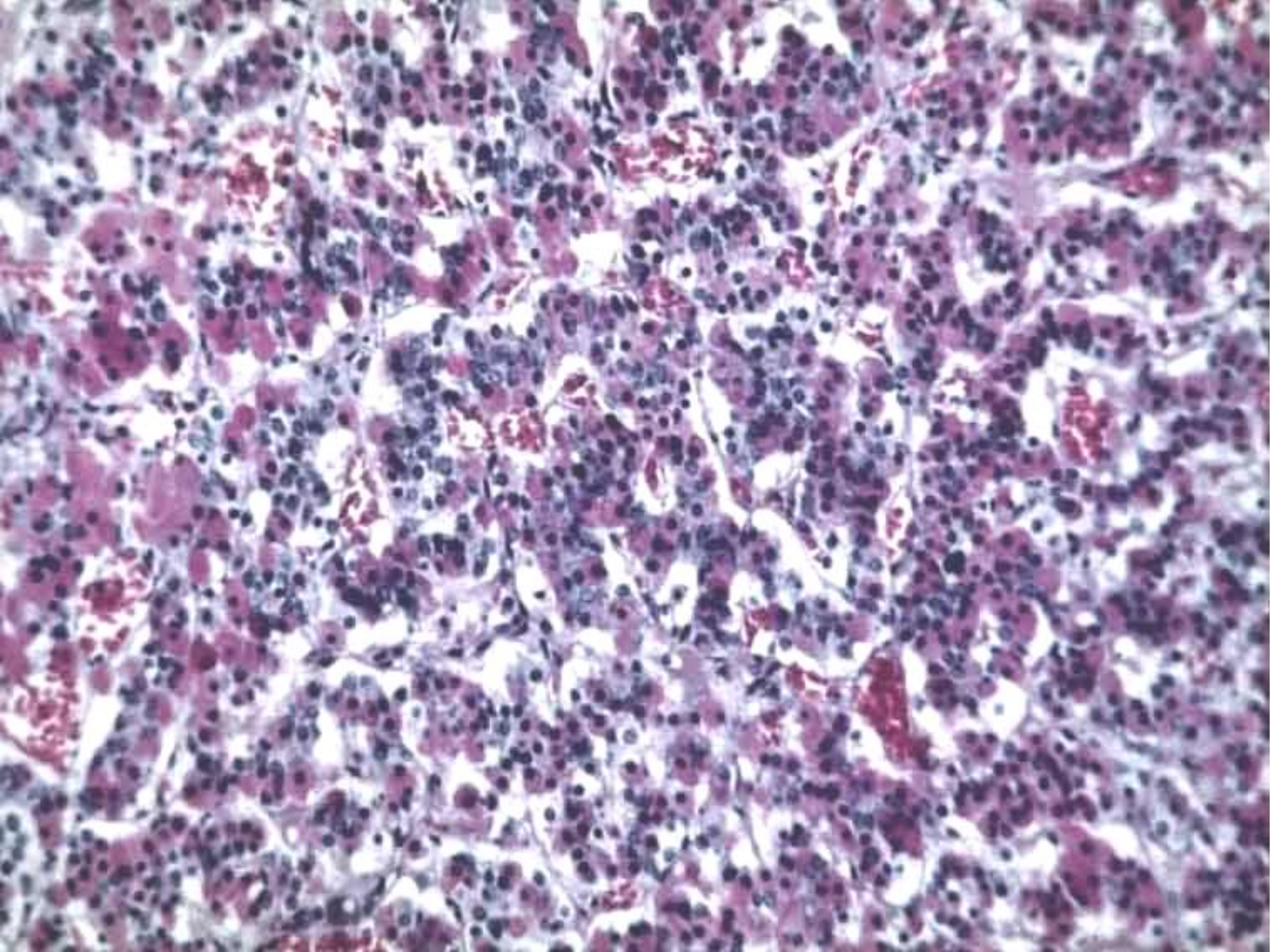
–large cells, small granules at BM

–TSH

- δ –cells = gonadotropic

–large cells, middle granules

–FSH, LH (lutropin)

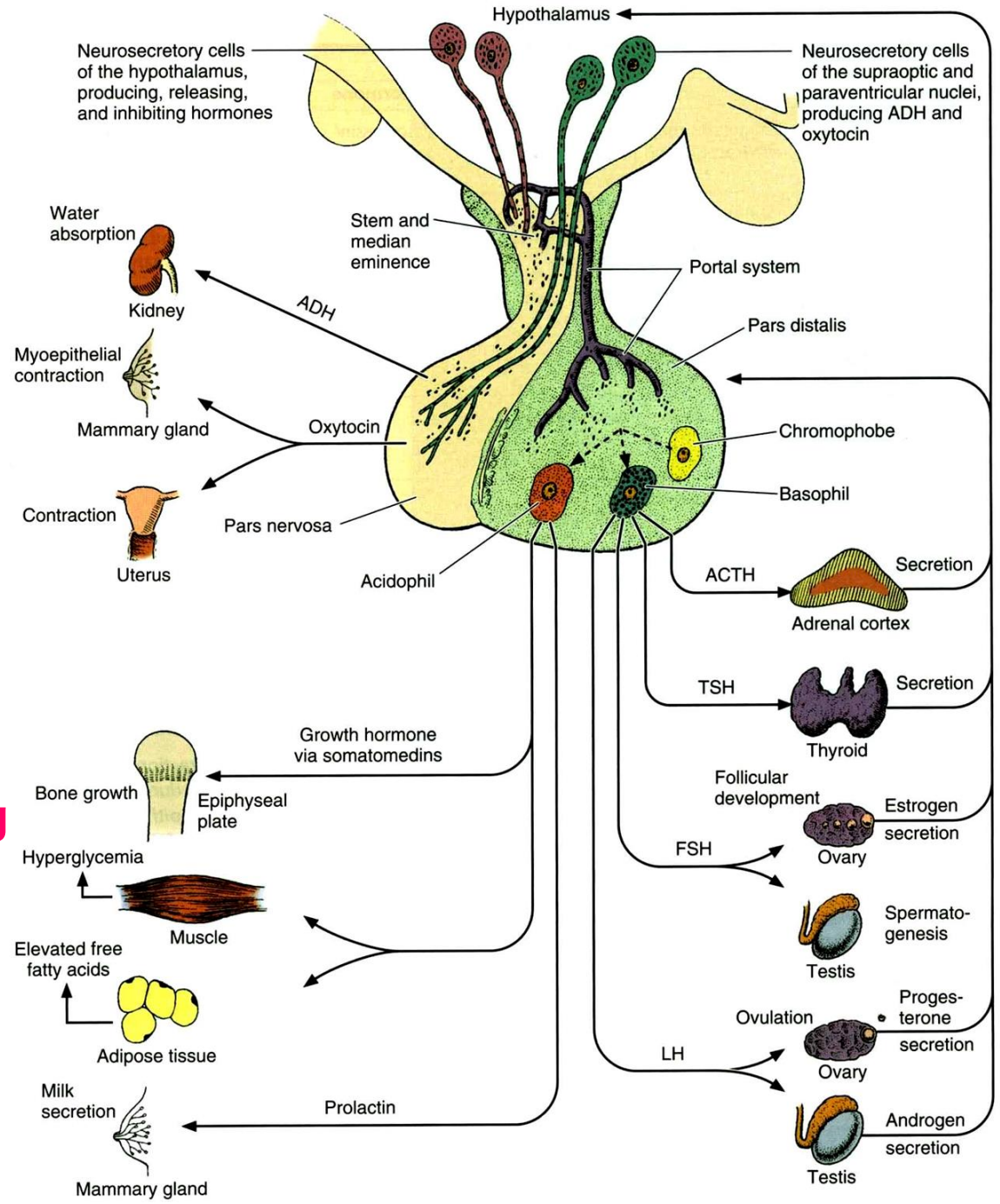


Adenohypophysis – pars distalis

acidophilic

STH
GHRH
ghrelin
somatostatine
NFB

PRL (LTH)
PRH
TRH
GnRH
estrogene
breastfeeding
dopamine



basophilic

TTH
TRH
NFB

FSH / LH
GnRH
FSH-activin
NFB
FSH-inhibin

ACTH
CRH
NFB

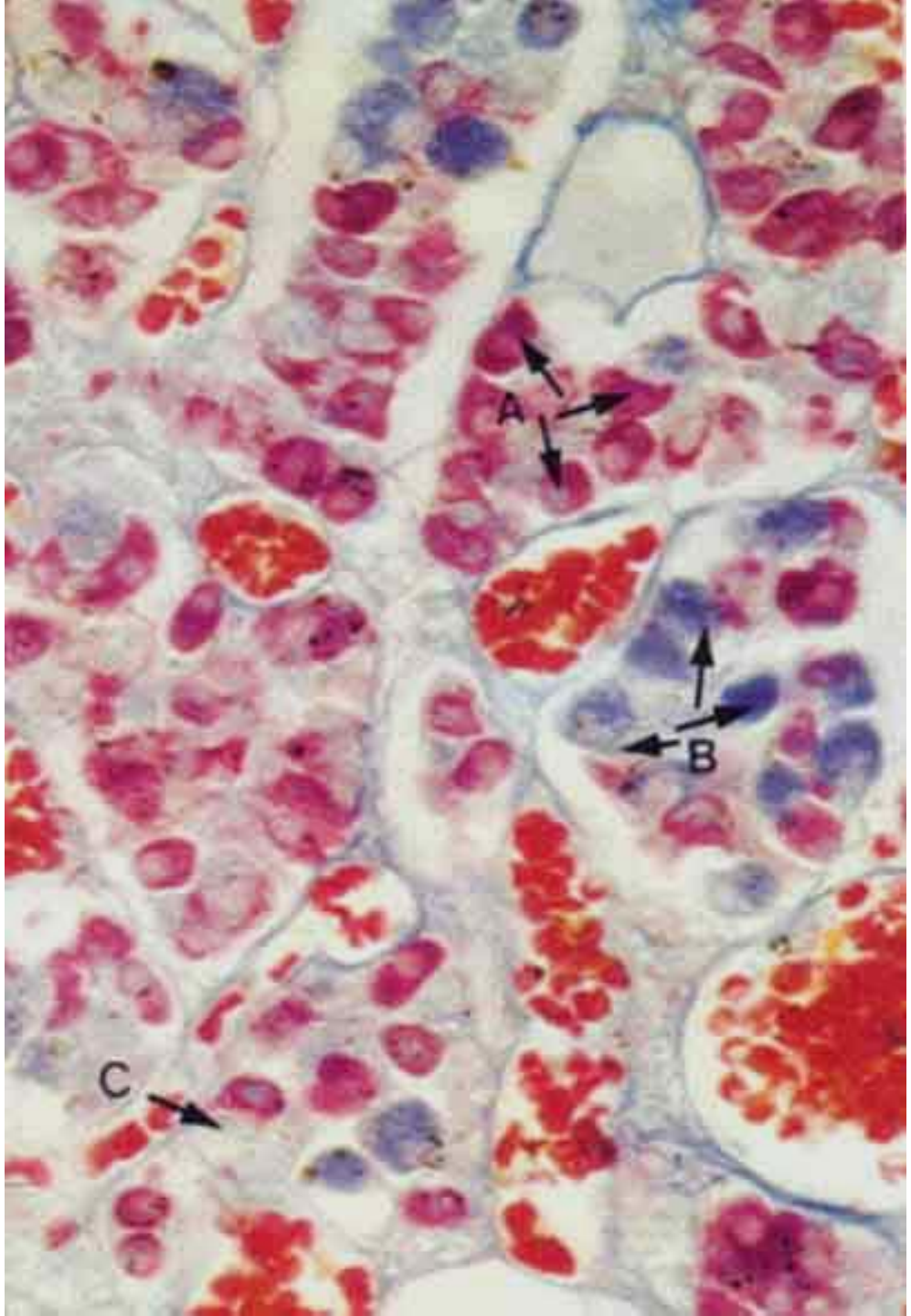
MSH

hormon
stimulation
inhibition
NFB = negative feedback

A = acidophilic cells

B = basophilic cells

C = chromophobic cells

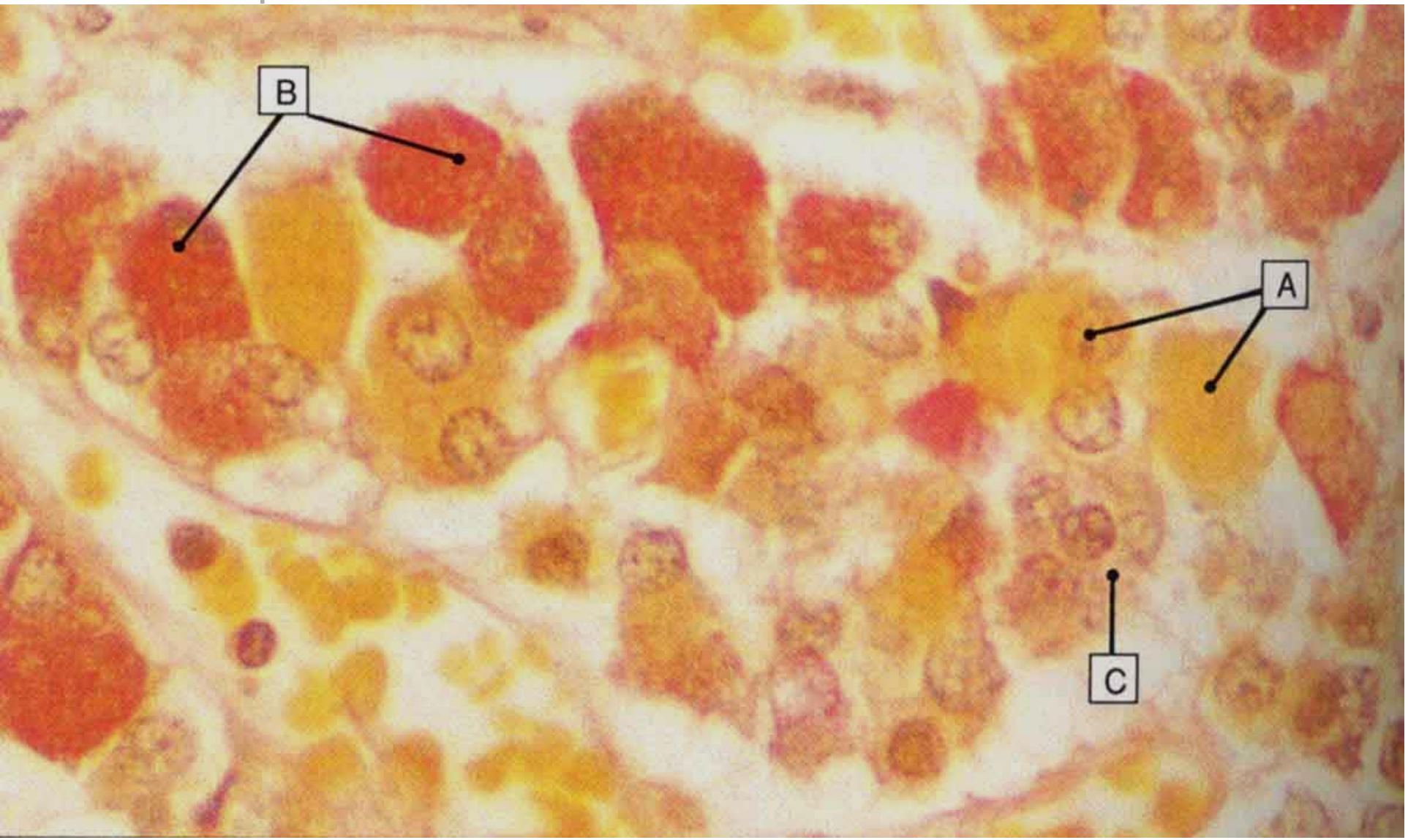


A = acidophilic cells

B = basophilic cells

C = chromophobic cells

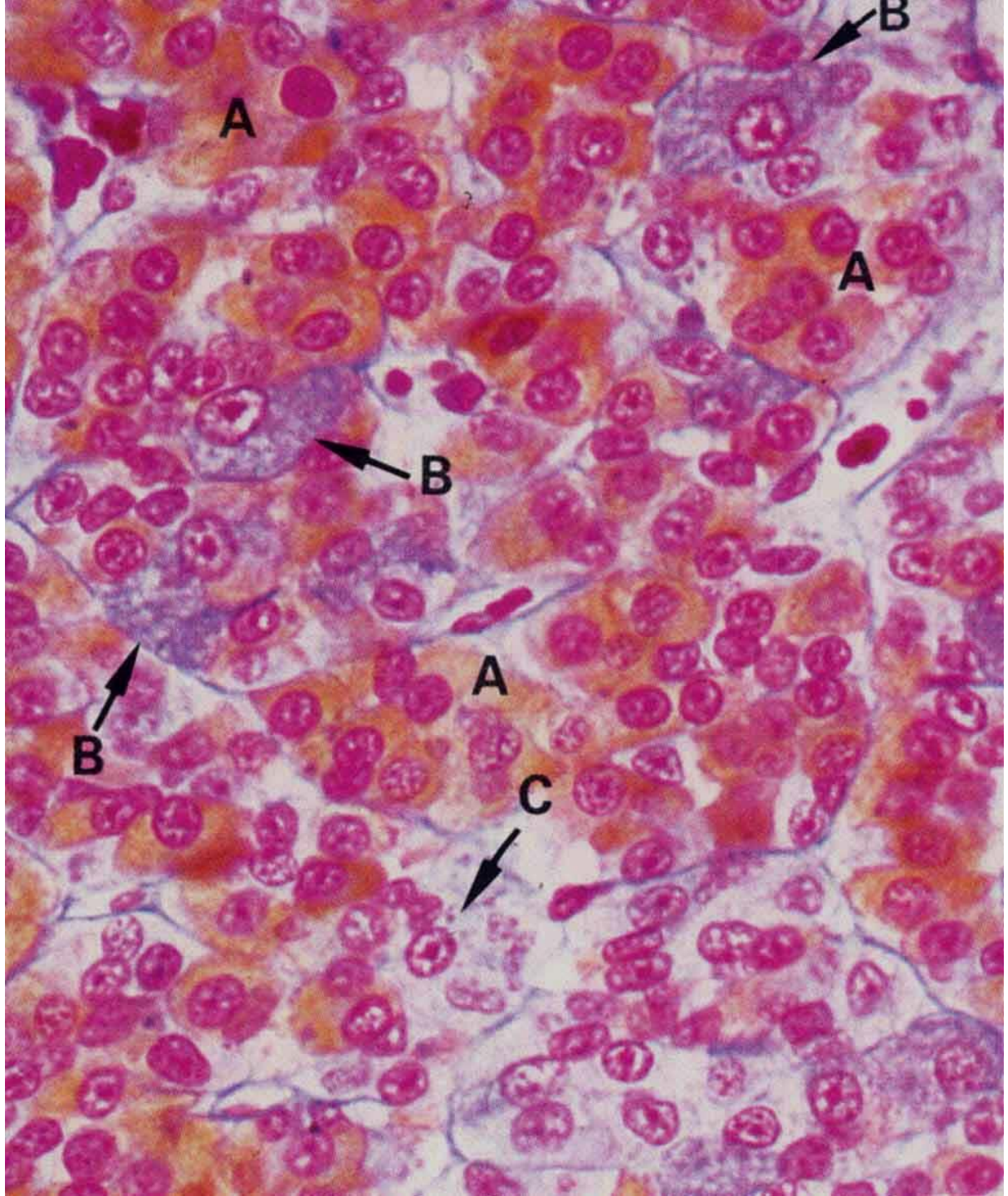
PAS + orange G + hematoxylin



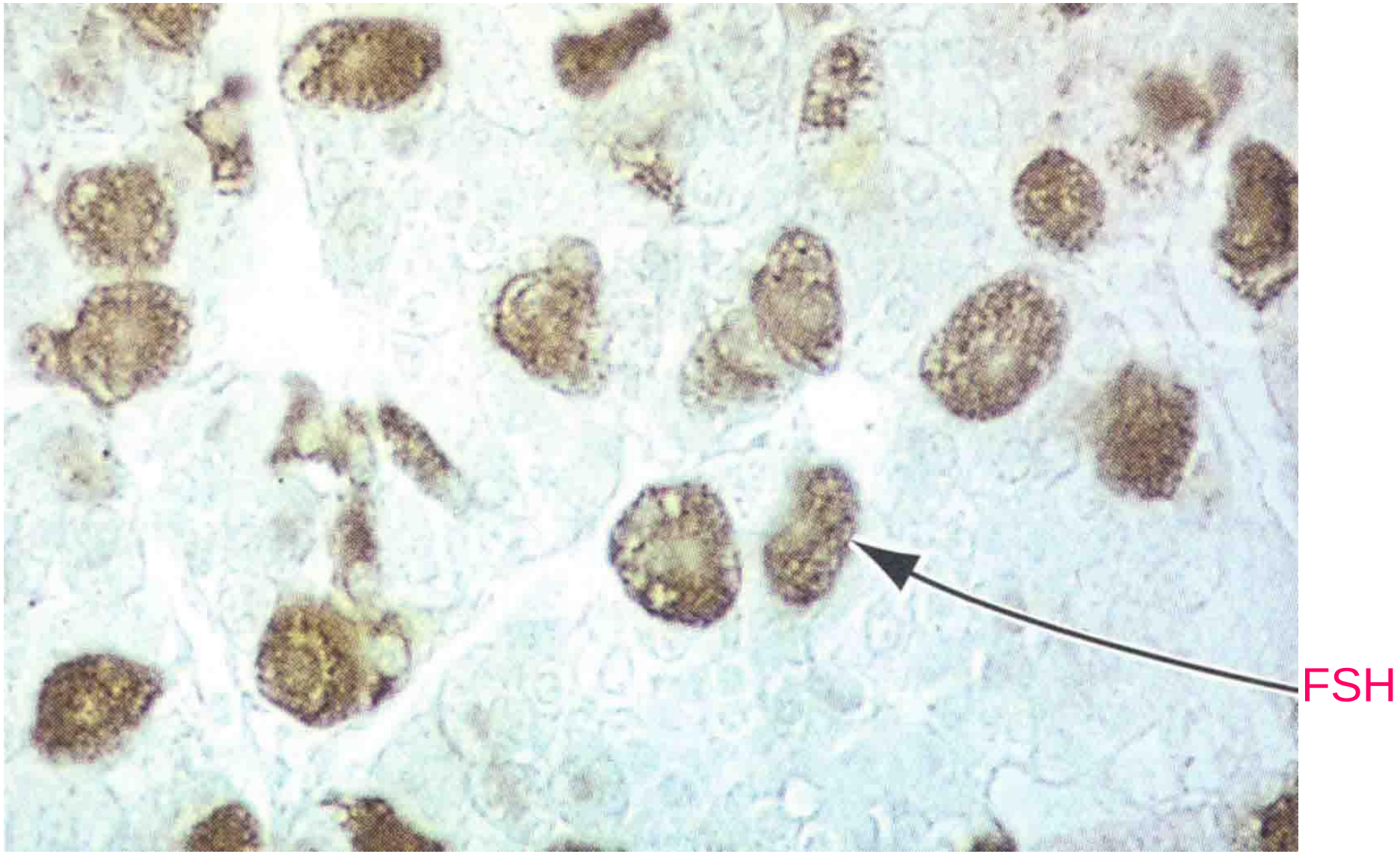
A = acidophilic cells

B = basophilic cells

C = chromophobic cells



Immunohistochemistry

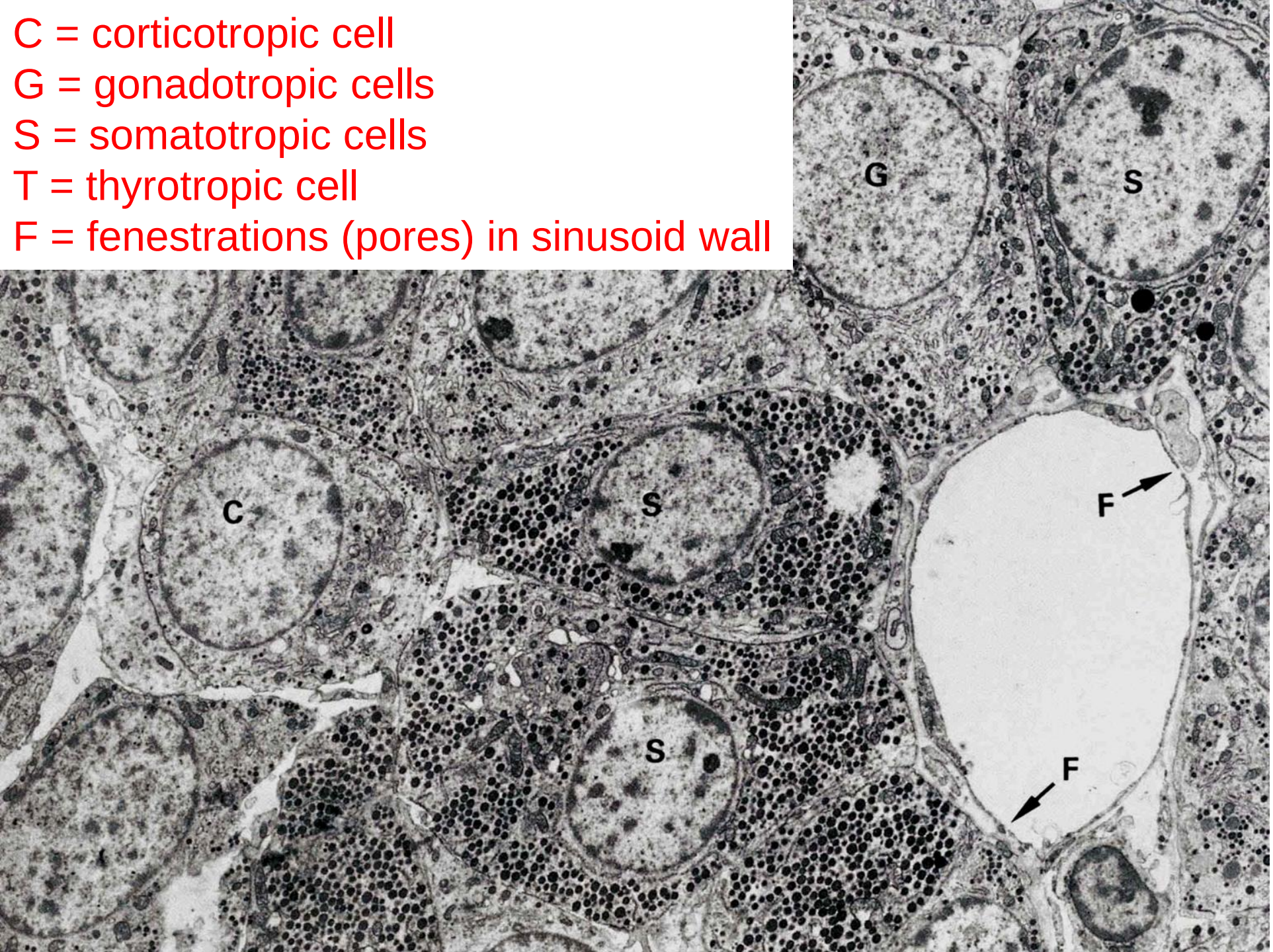


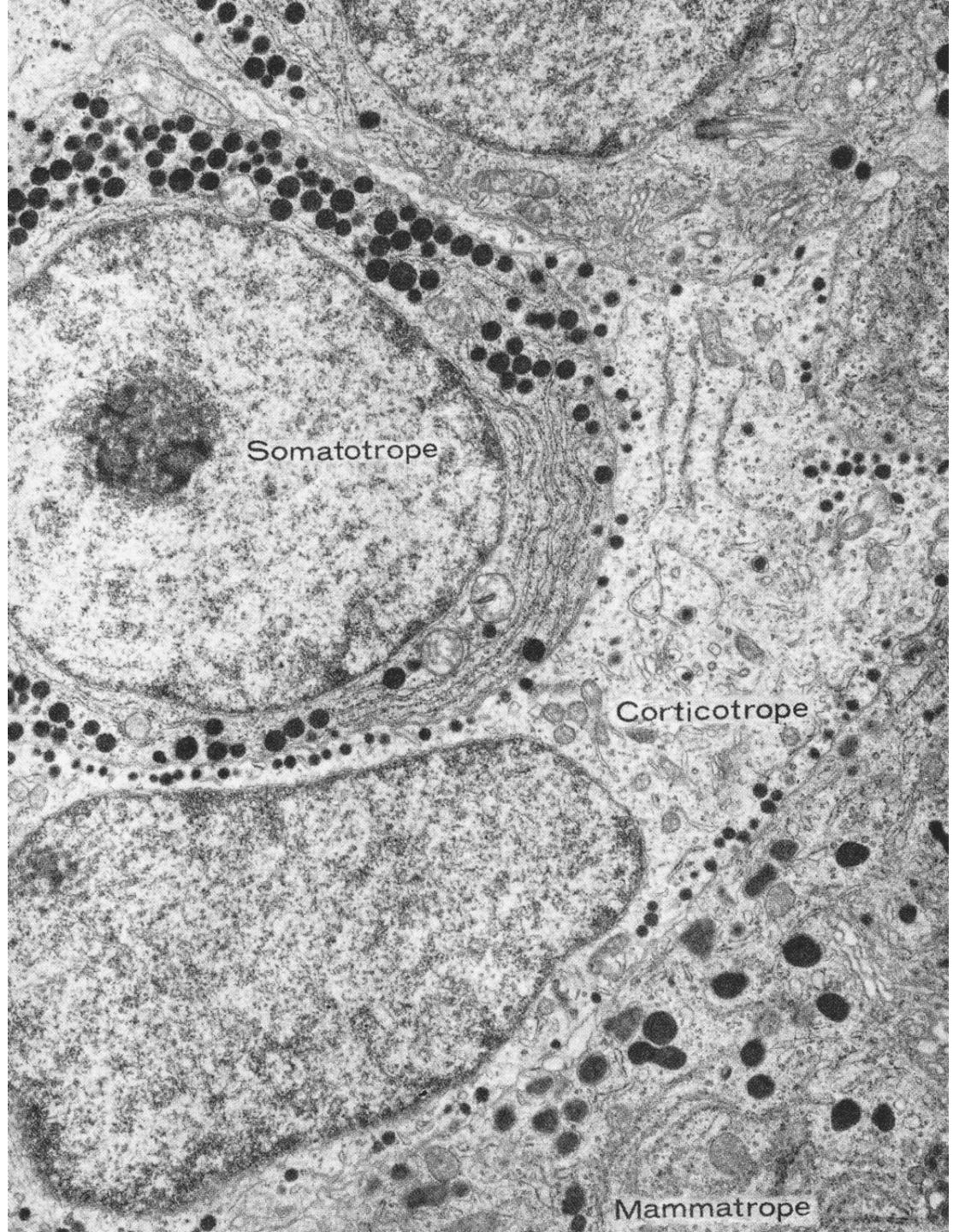
Gonadotropic cell

Folliculostellate cell

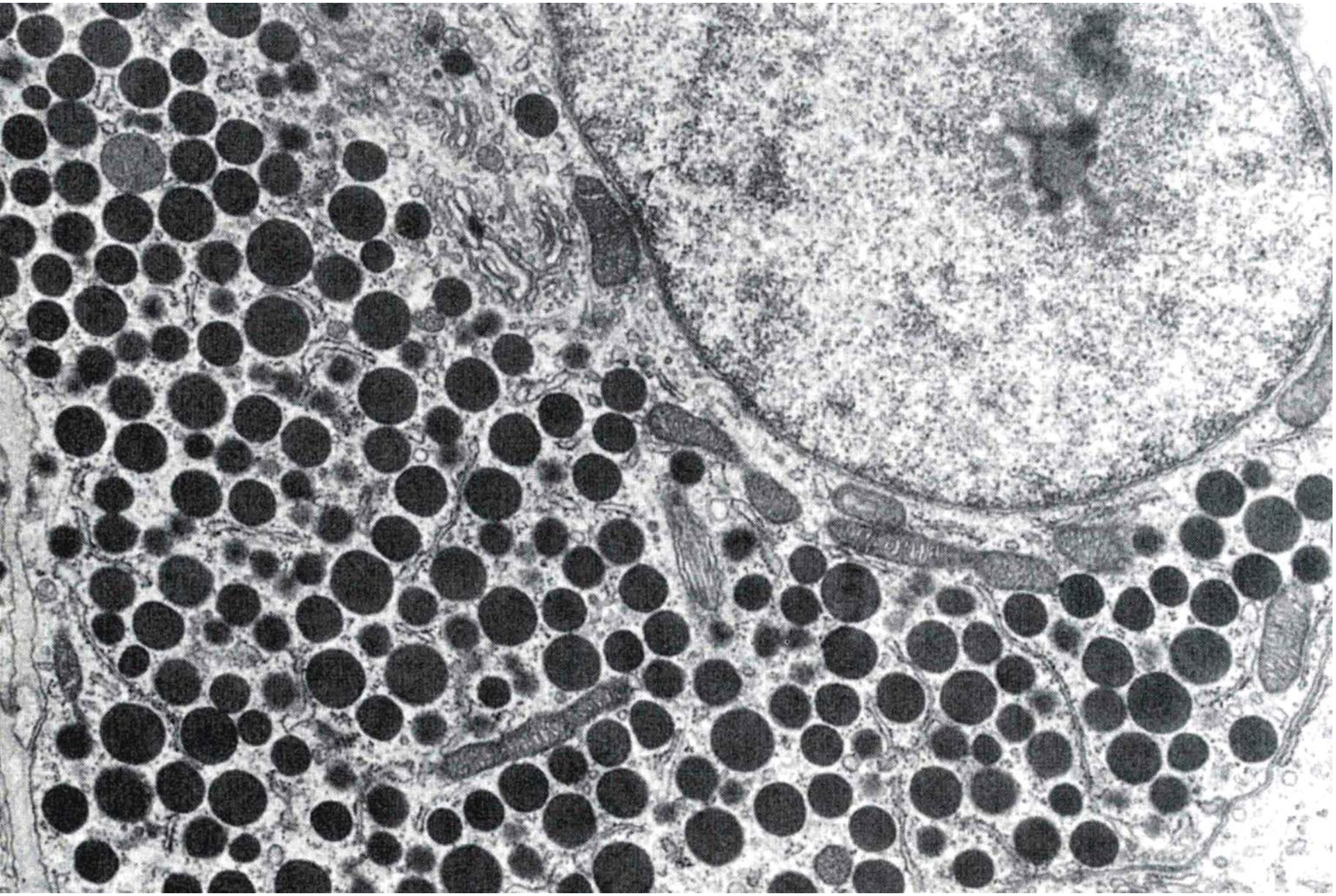
processi of folliculostellate cells

C = corticotropic cell
G = gonadotropic cells
S = somatotropic cells
T = thyrotropic cell
F = fenestrations (pores) in sinusoid wall




Somatotrope
Corticotrope
Mammatrope

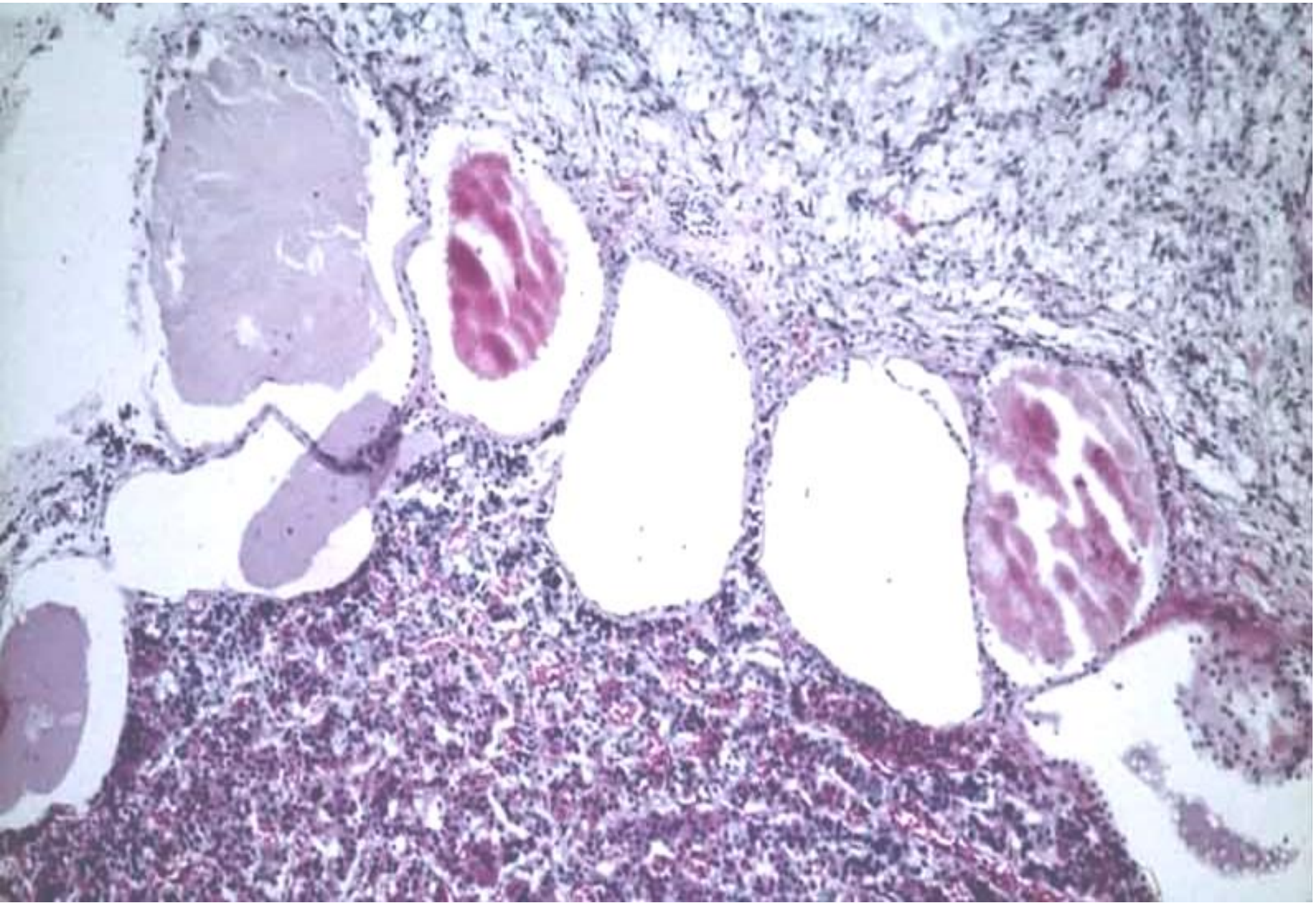
Somatotropic cell



Pars intermedia

- Rathke cysts (single layer epithelium, colloid)
- Chromophobic cells
- Basophilic cells - MSH

Pars intermedia

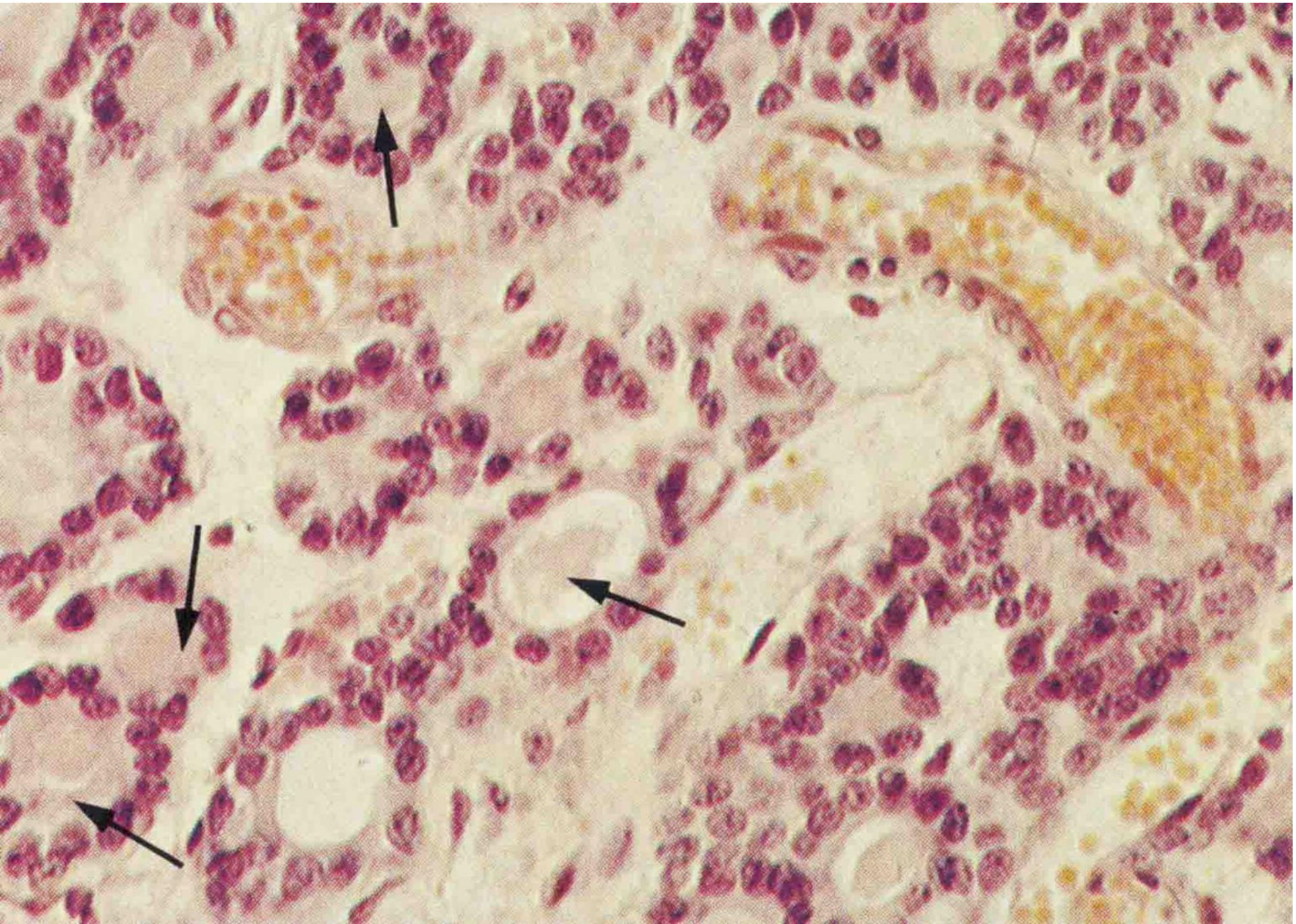



arrows = small follicles in pars intermedia

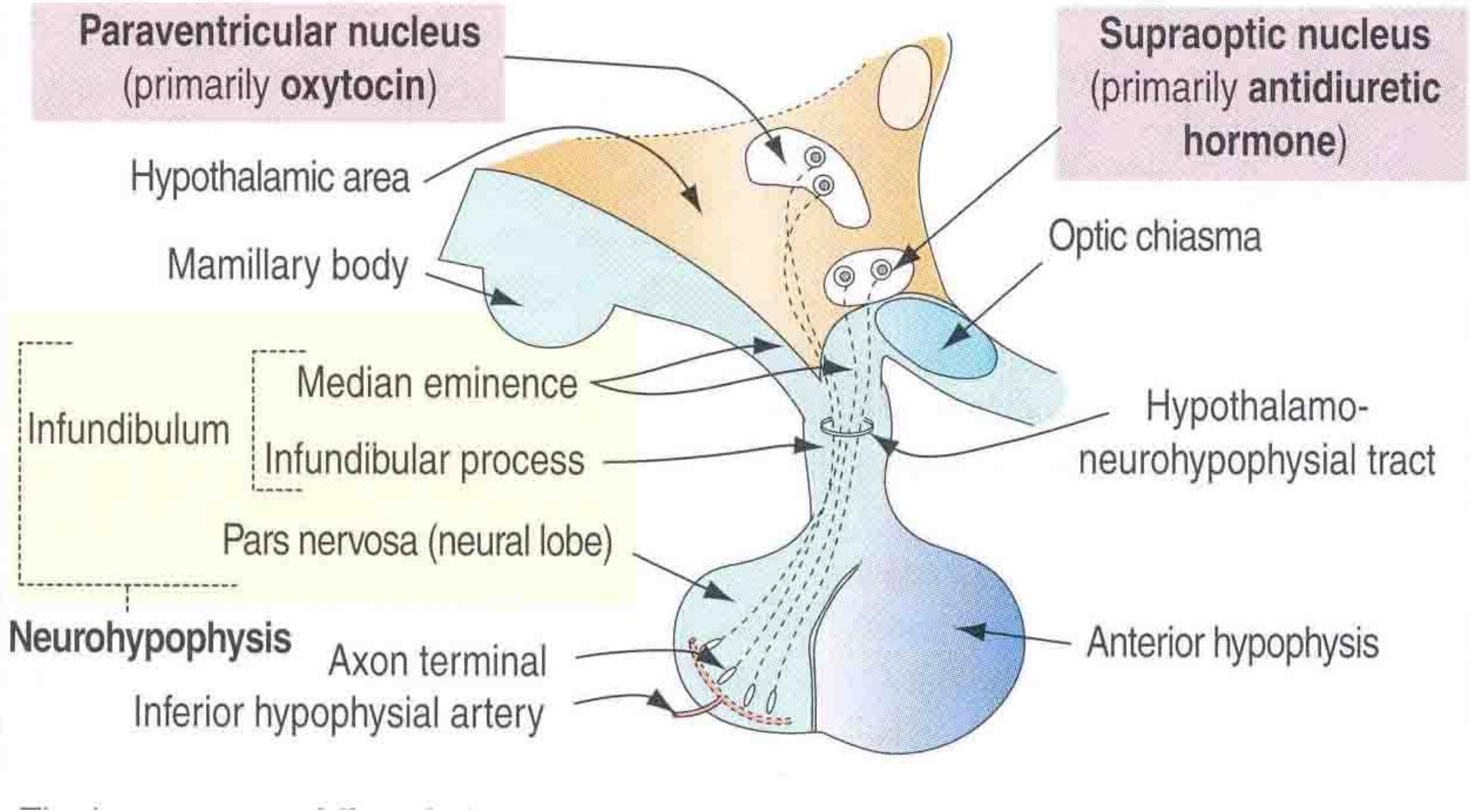
Pars tuberalis

- Upper protrusion of pars distalis, surroundig a part of infundibulum
- Chromophobe cells

Pars tuberalis



Posterior lobe - Neurohypophysis



Posterior lobe = *Neurohypophysis*

eminentia mediana

–floor of the 3rd ventricle

–frequent nonmyelinized nerve fibers

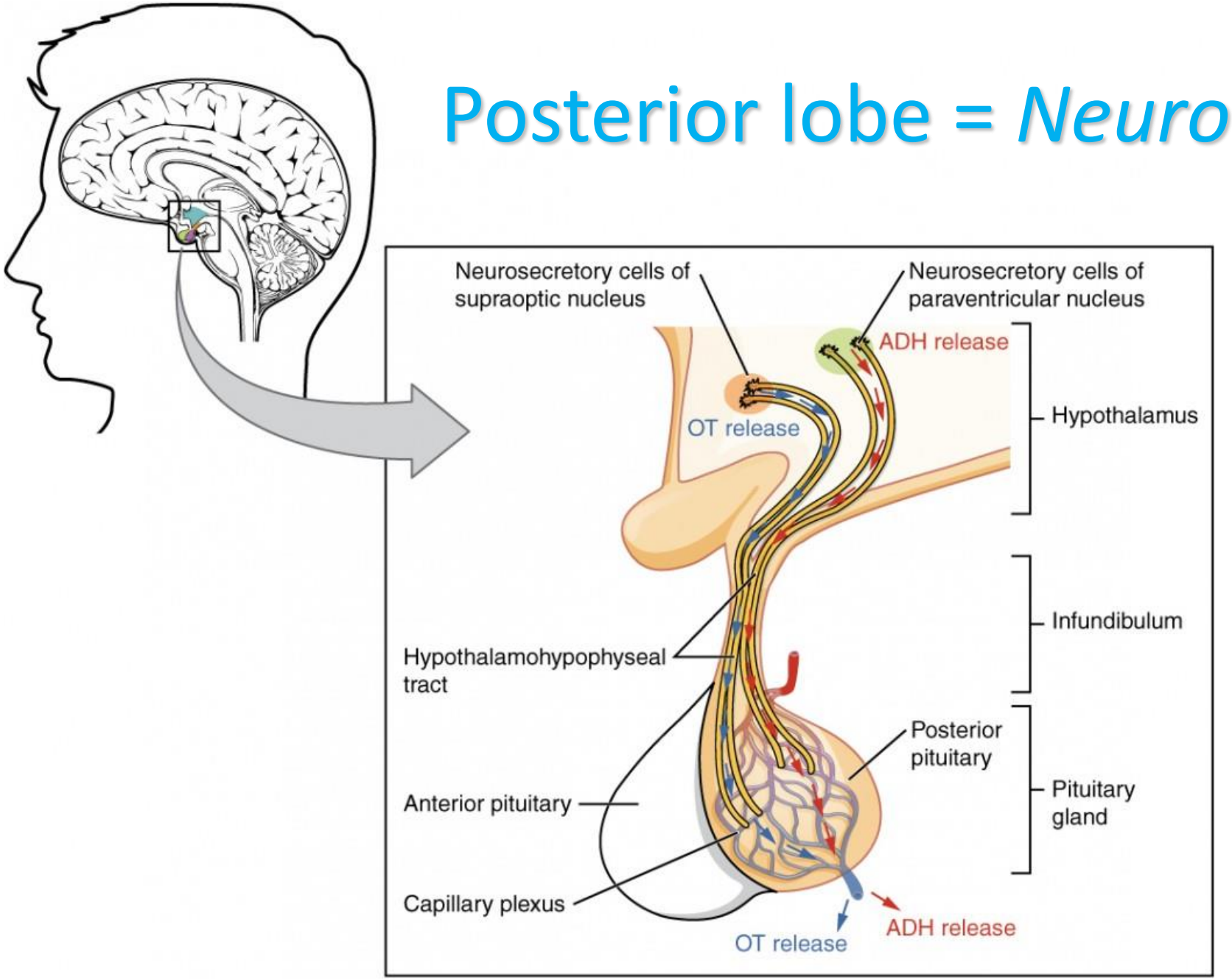
- infundibulum

–tractus hypothalamohypophysialis

–neurofibra neurosecretoria (+ vesicula neurosecretoria) = nonmyelinized nerve fibers

- some terminate at capillaries
- lobus nervosus (pars nervosa)

Posterior lobe = *Neurohypophysis*

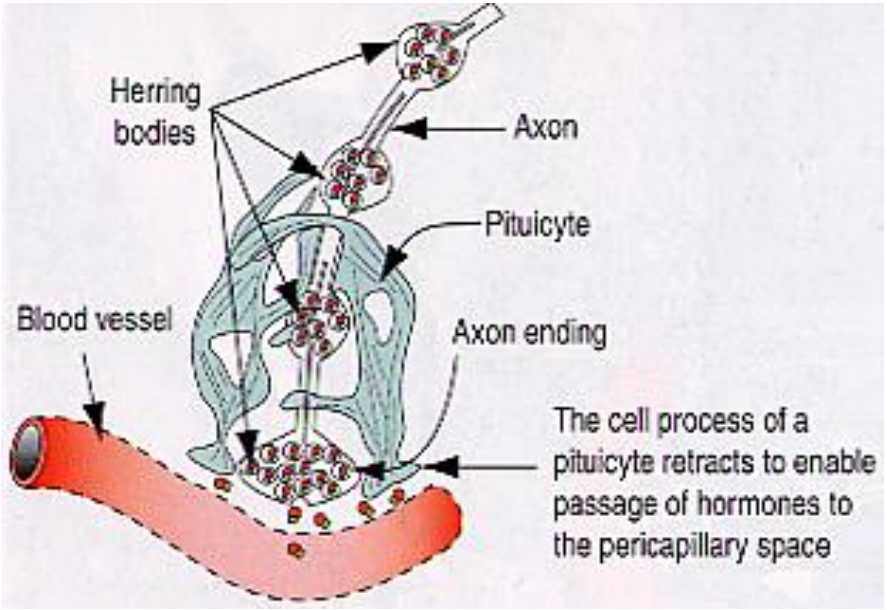


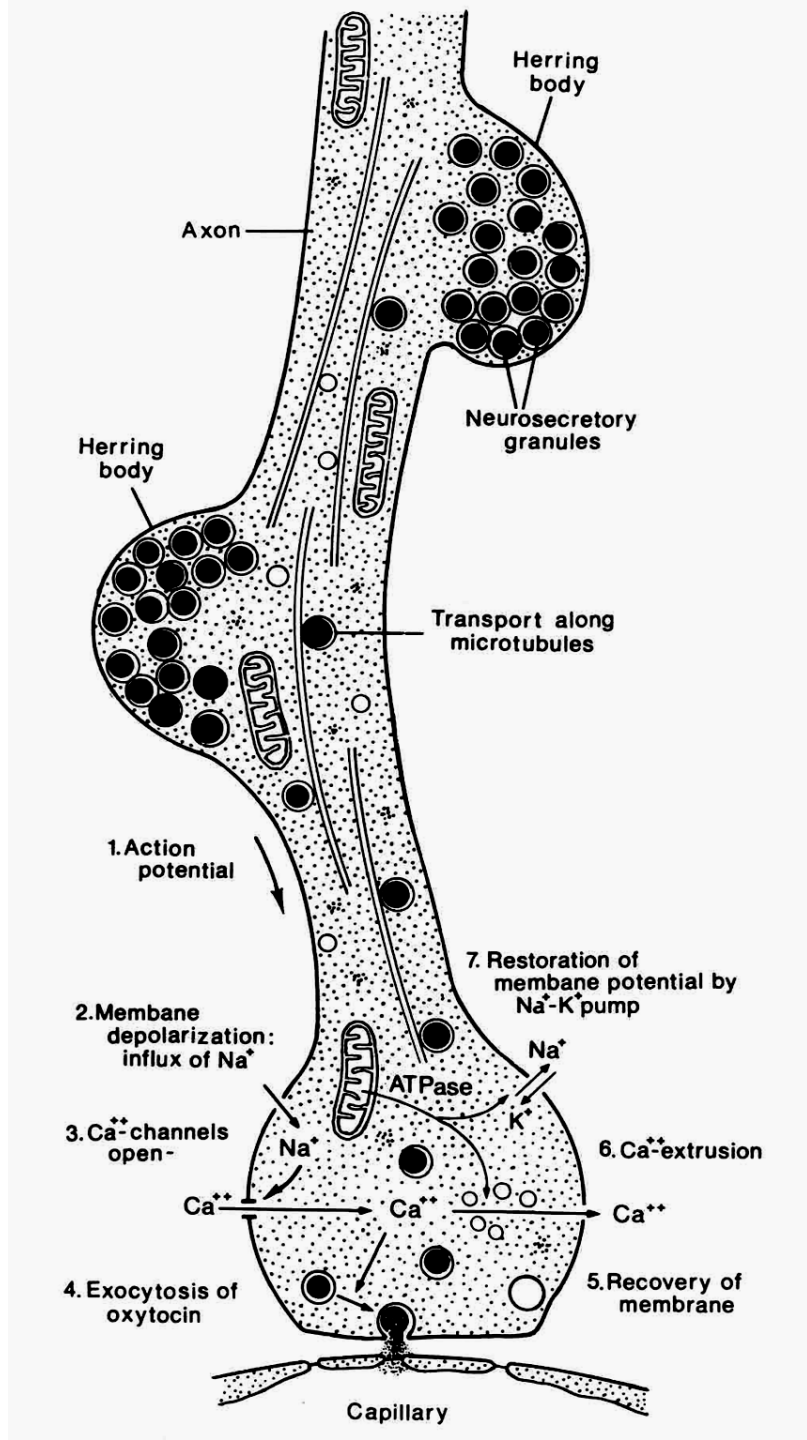
https://courses.lumenlearning.com/suny-ap2/chapter/the-pituitary-gland-and-hypothalamus/

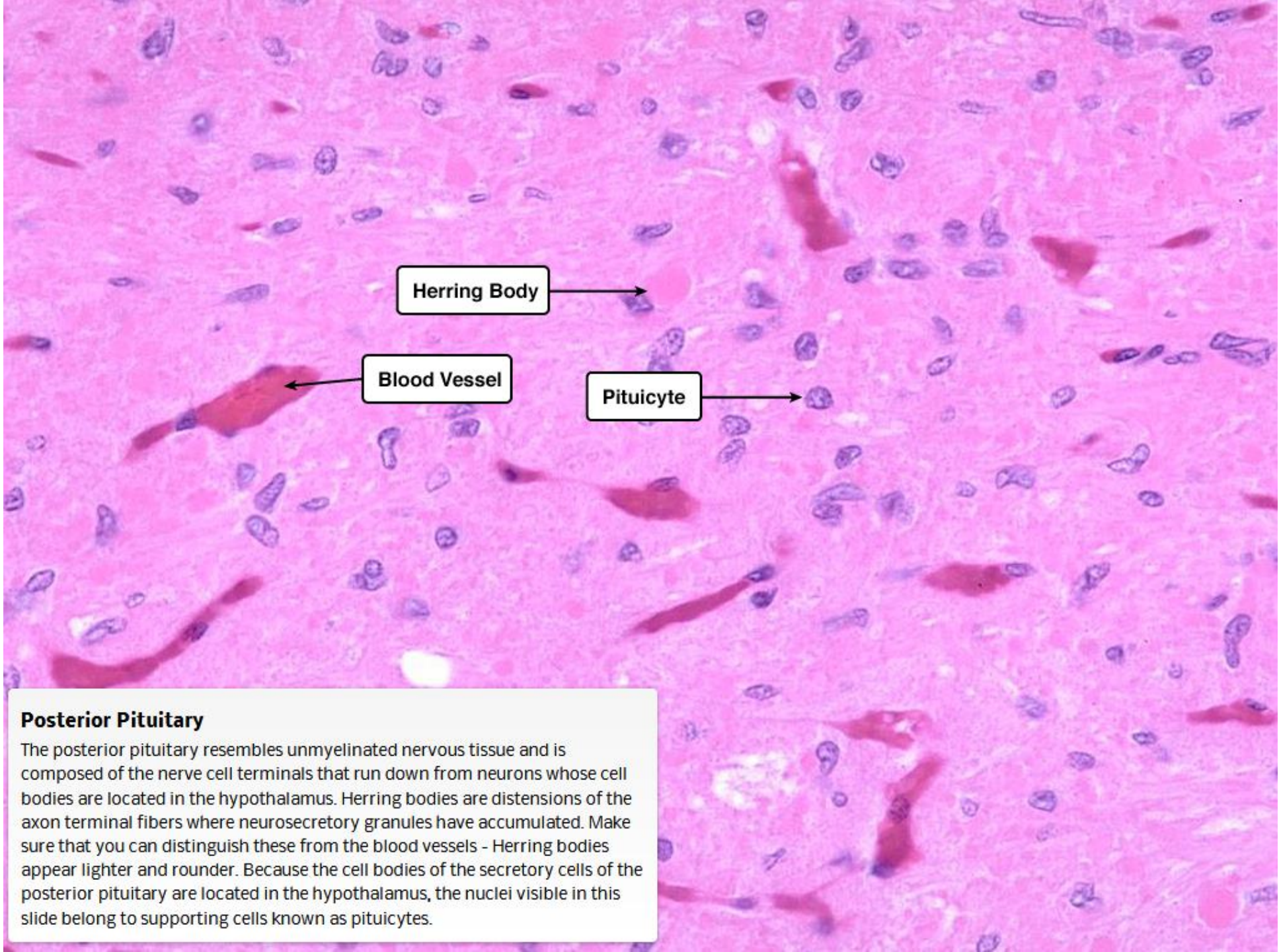
Lobus nervosus neurohypophysis

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*)



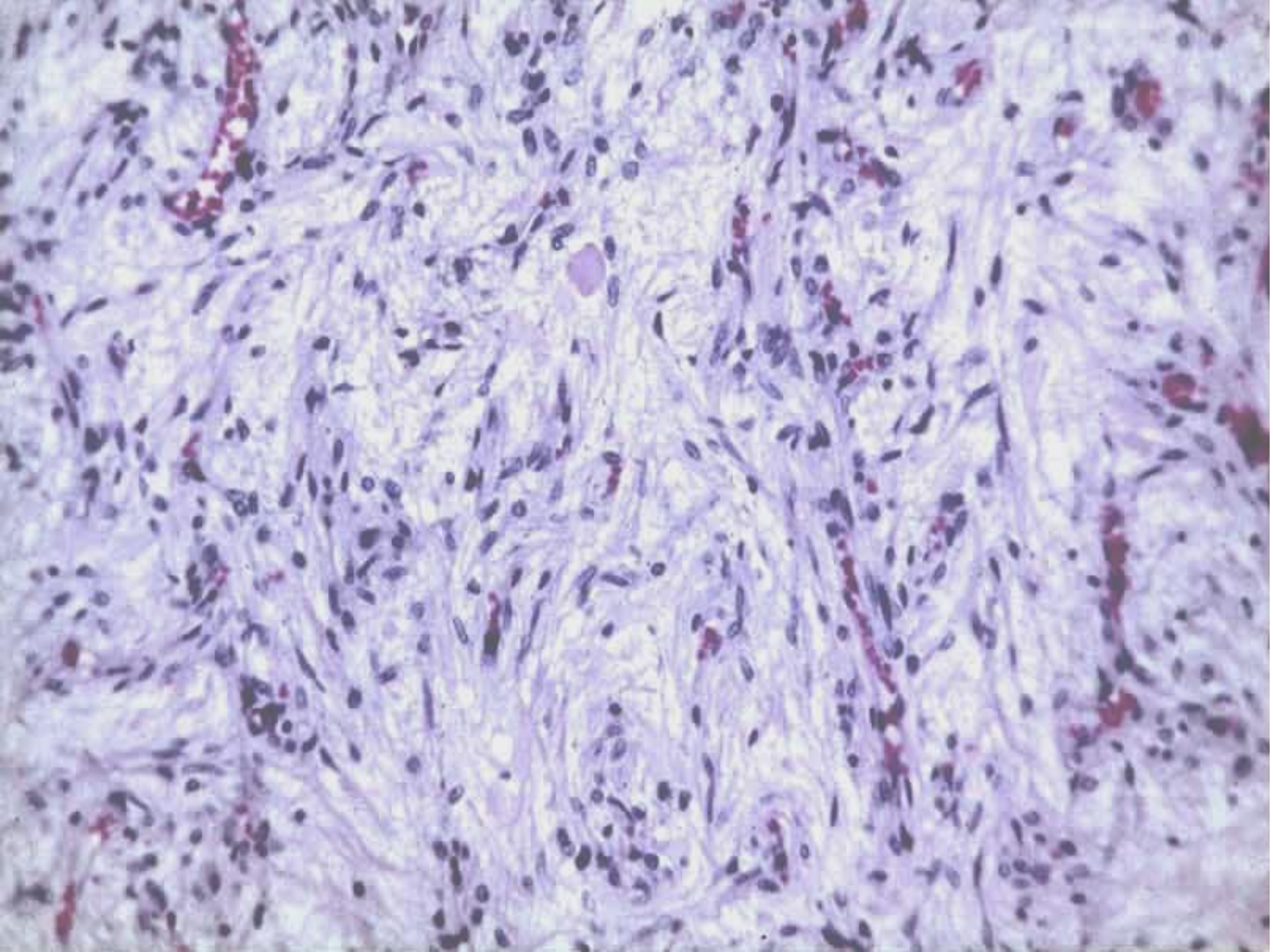

Herring body
Axon
Neurosecretory granules
Herring body
Transport along microtubules
1. Action potential
7. Restoration of membane potential by Na^+-K^+ pump
2. Membane depolarization: influx of Na^+
Na^+
ATPase
K^+
3. Ca^{++}-channels open-
Na^+
6. Ca^{++}-extrusion
Ca^{++}
Ca^{++}
Ca^{++}
4. Exocytosis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

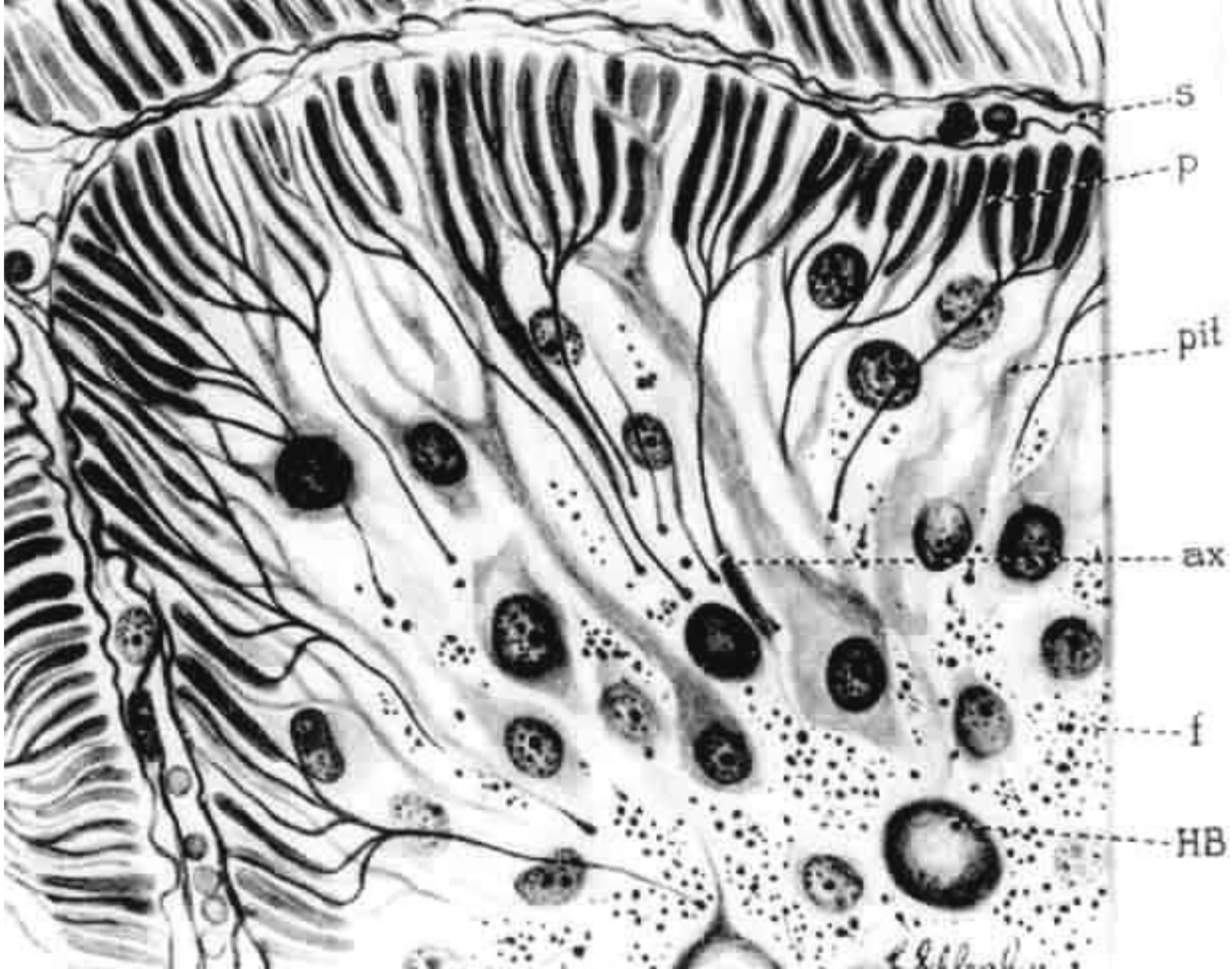


Posterior Pituitary

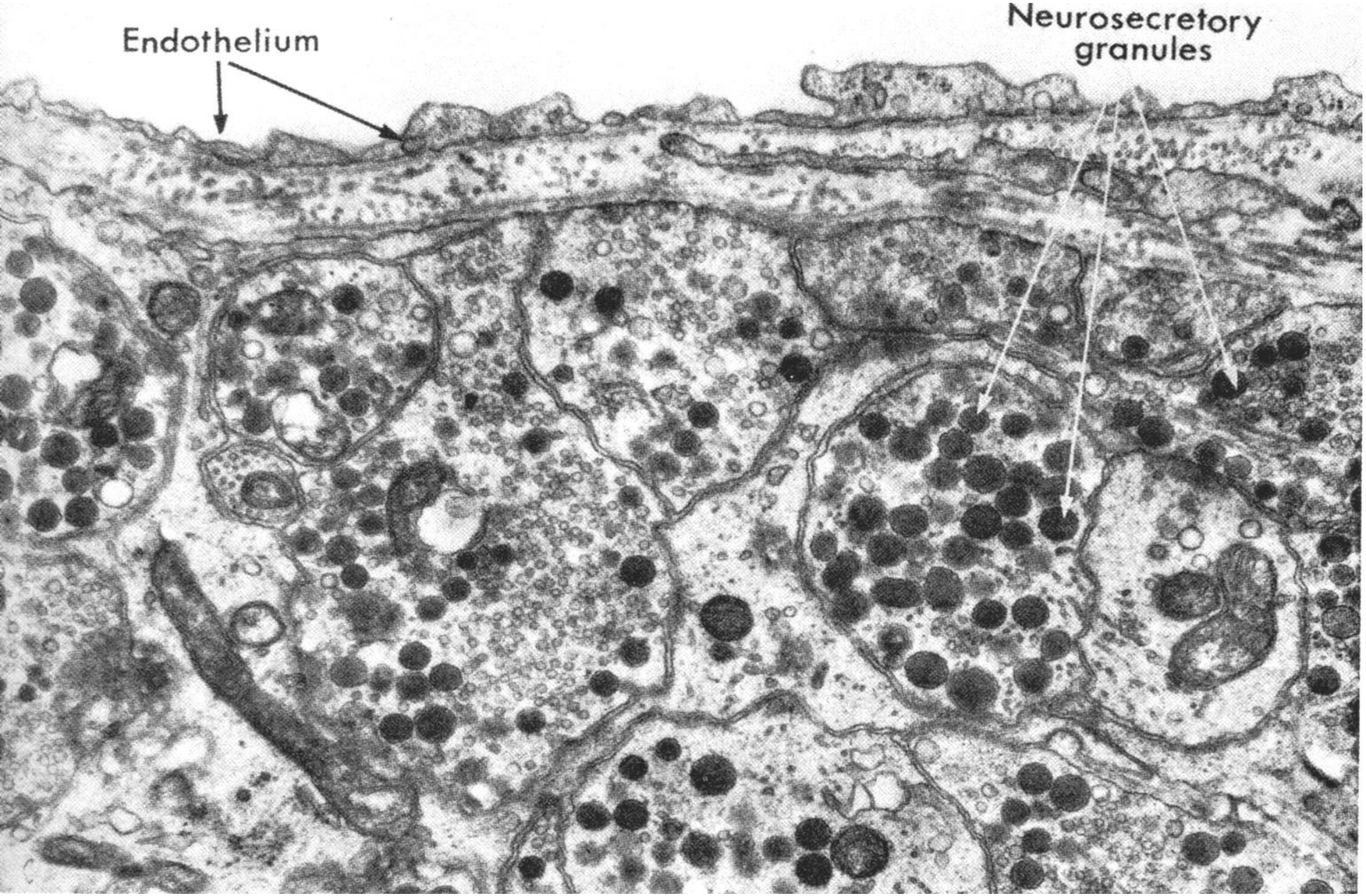
The posterior pituitary resembles unmyelinated nervous tissue and is composed of the nerve cell terminals that run down from neurons whose cell bodies are located in the hypothalamus. Herring bodies are distensions of the axon terminal fibers where neurosecretory granules have accumulated. Make sure that you can distinguish these from the blood vessels - Herring bodies appear lighter and rounder. Because the cell bodies of the secretory cells of the posterior pituitary are located in the hypothalamus, the nuclei visible in this slide belong to supporting cells known as pituicytes.

https://medcell.org/histology/endocrine_systems_lab/posterior_pituitary.php





Pars nervosa

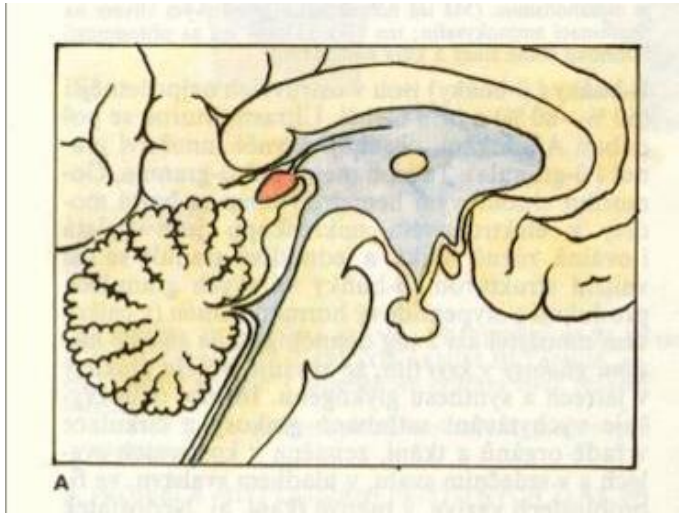

Endothelium
Neurosecretory granules

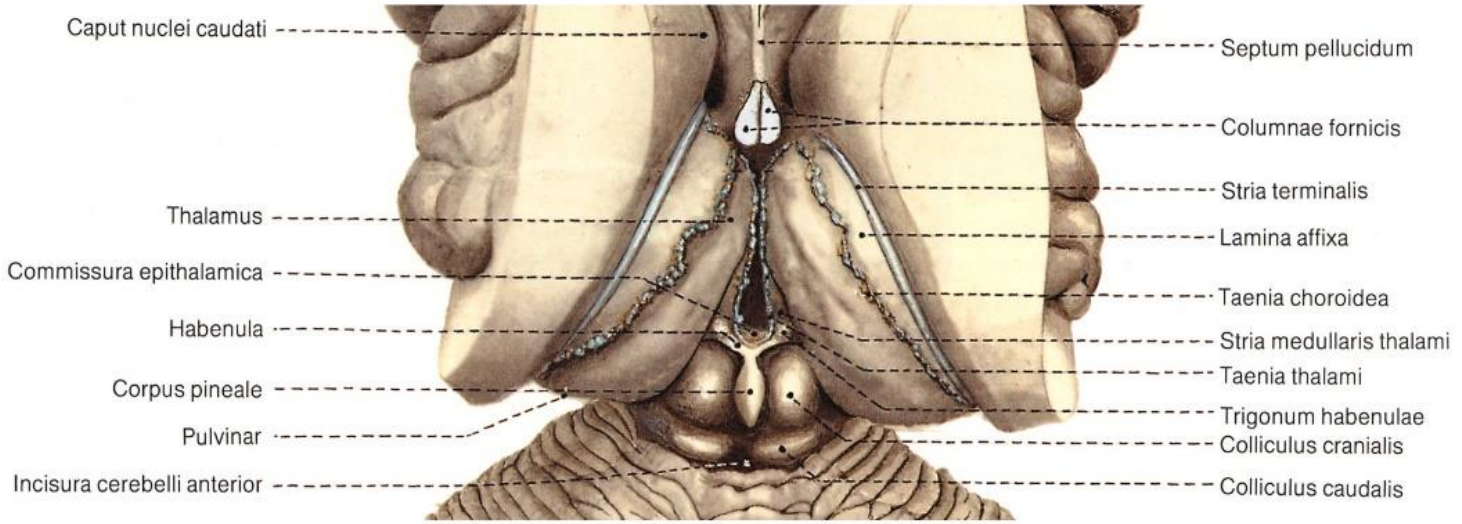
Pineal gland (glandula pinealis)

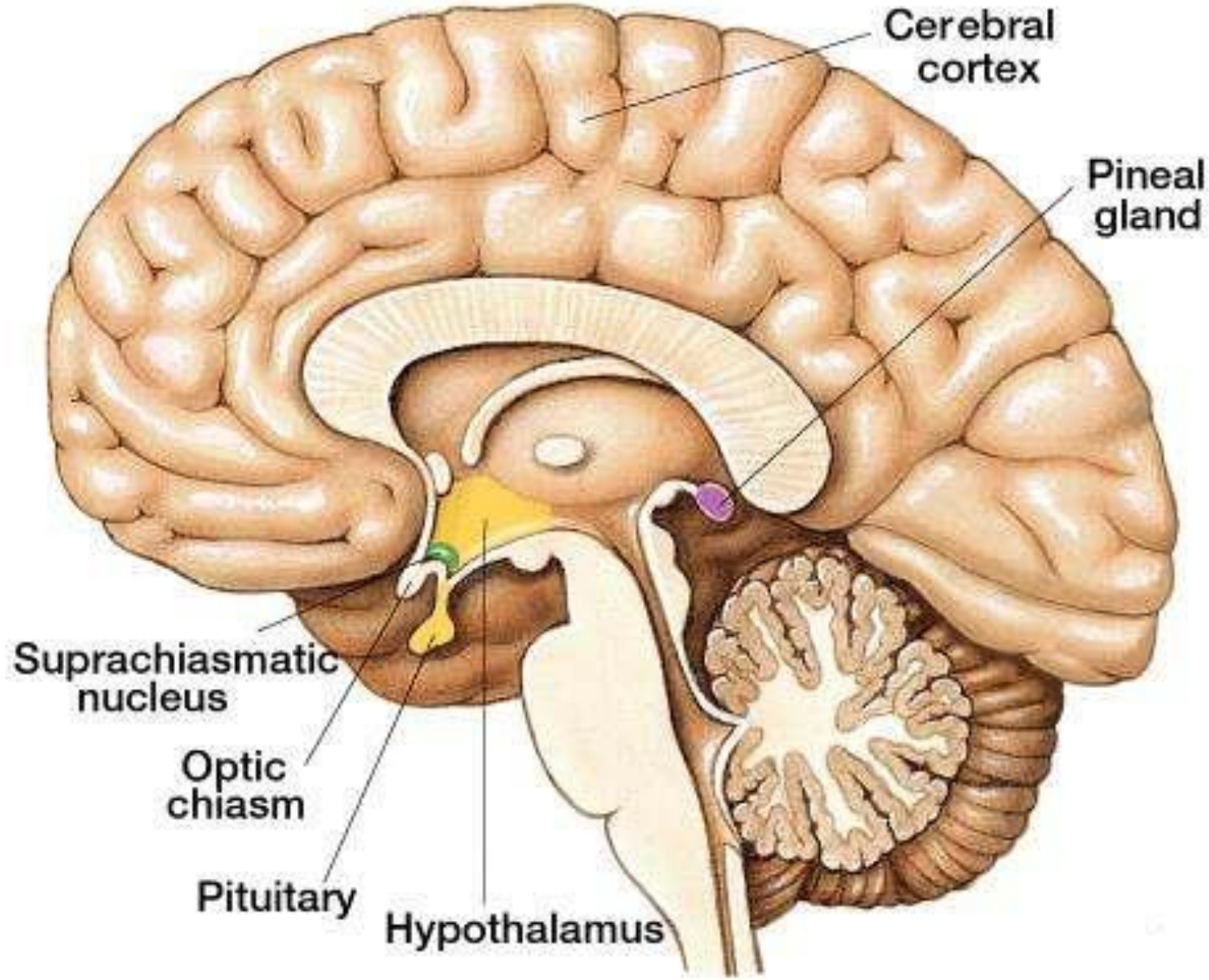
Pineal gland

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







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

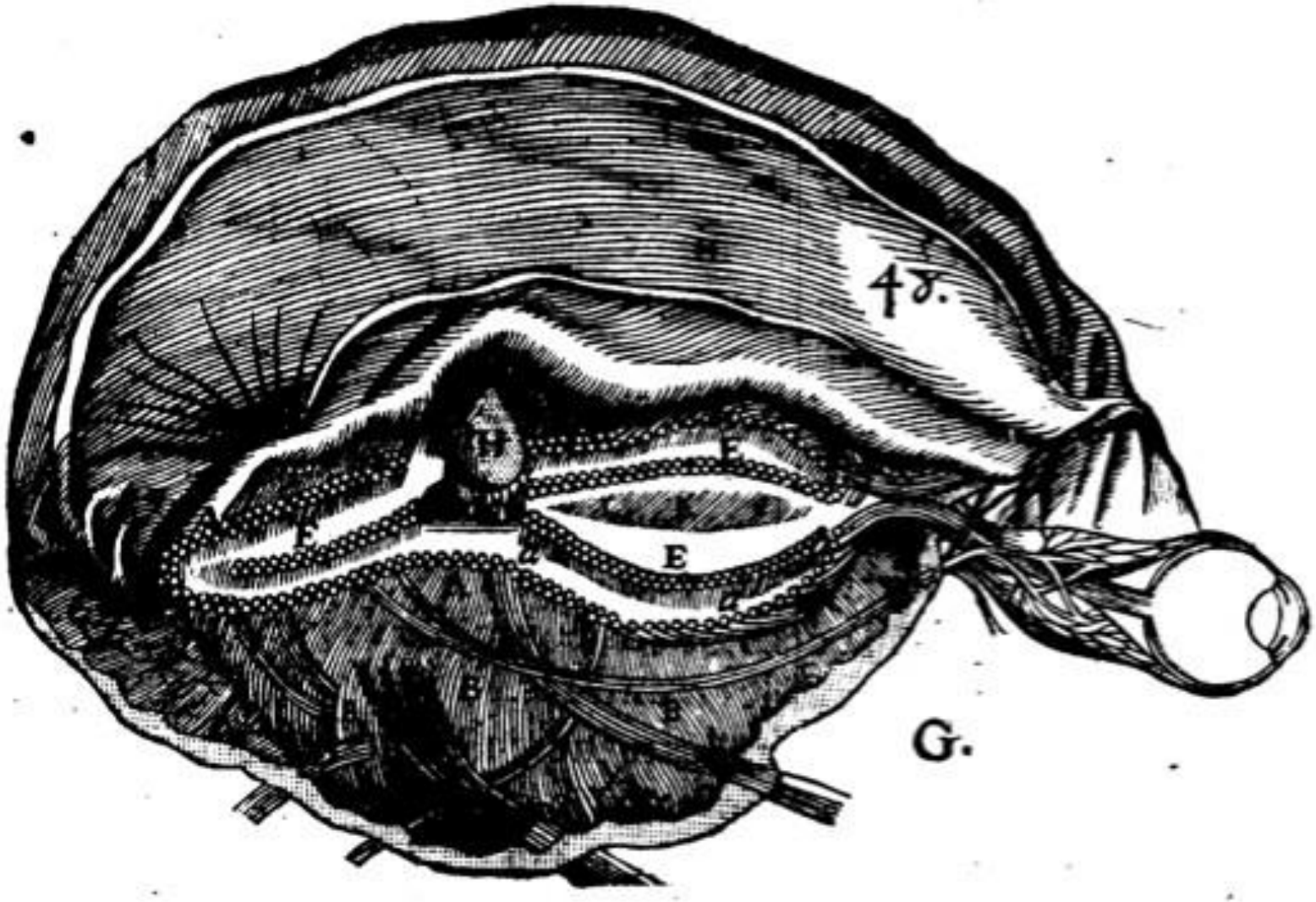
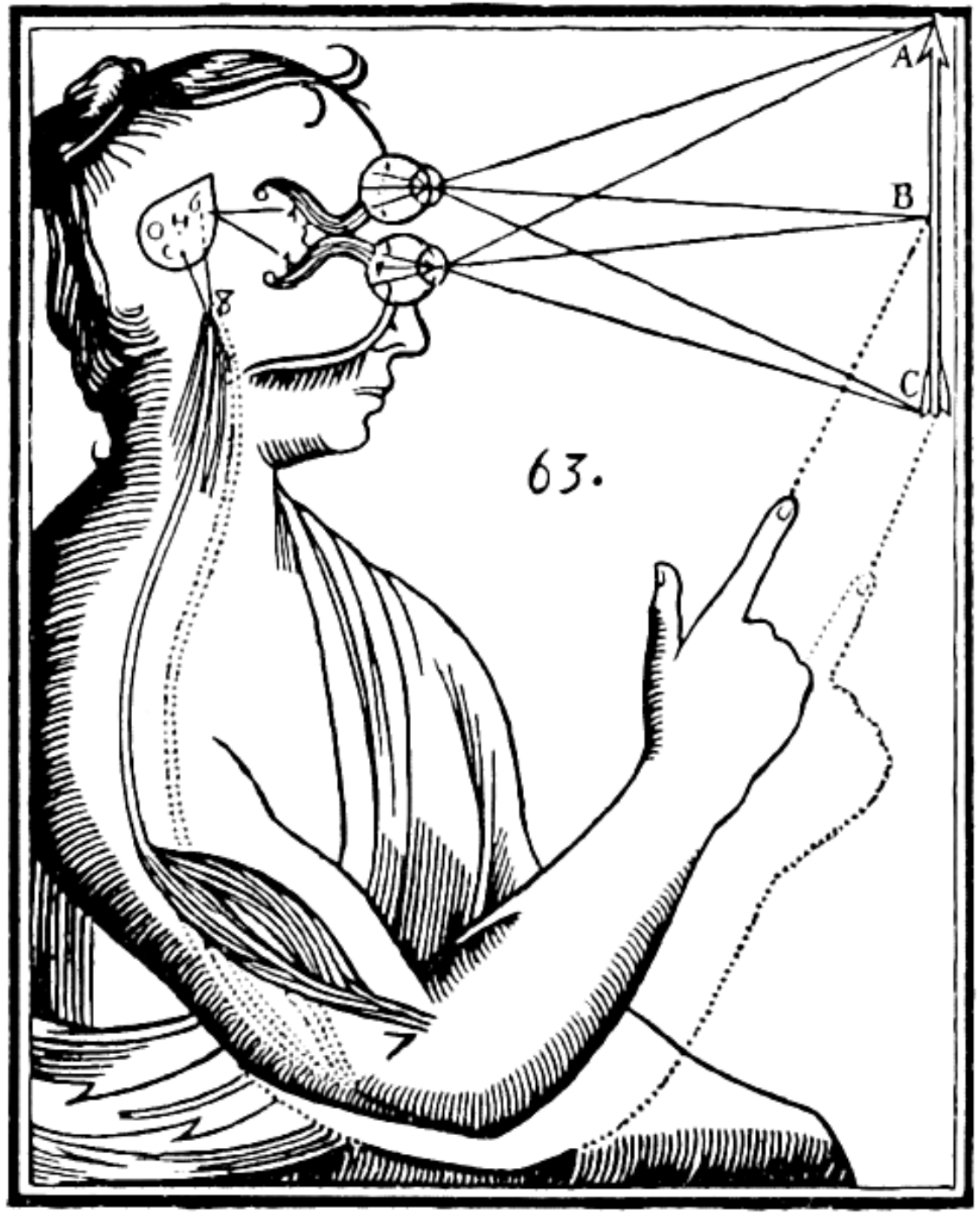


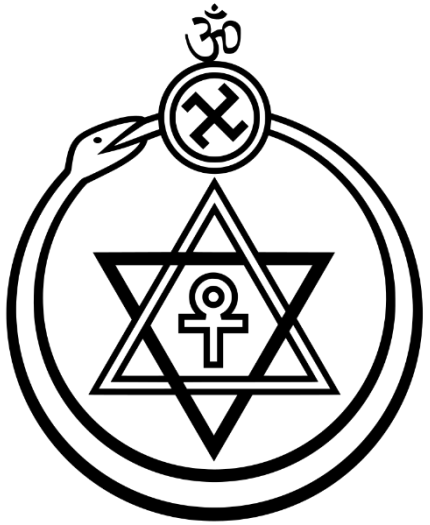
Figure 6. The Pineal Gland According to Descartes. This image from the 1664 edition of the *Treatise of man* illustrates Descartes' view that the pineal gland (H) is suspended in the middle of the ventricles (Descartes 1664, p. 63).



By René Descartes – Unknown source, Public Domain, https://commons.wikimedia.org/w/index.php?curid=1918592

the pineal gland "is that which the Eastern Occultist calls Devāka, the 'Divine Eye,' or the 'Third Eye.' To this day, it is the chief and foremost organ of spirituality in the human brain."

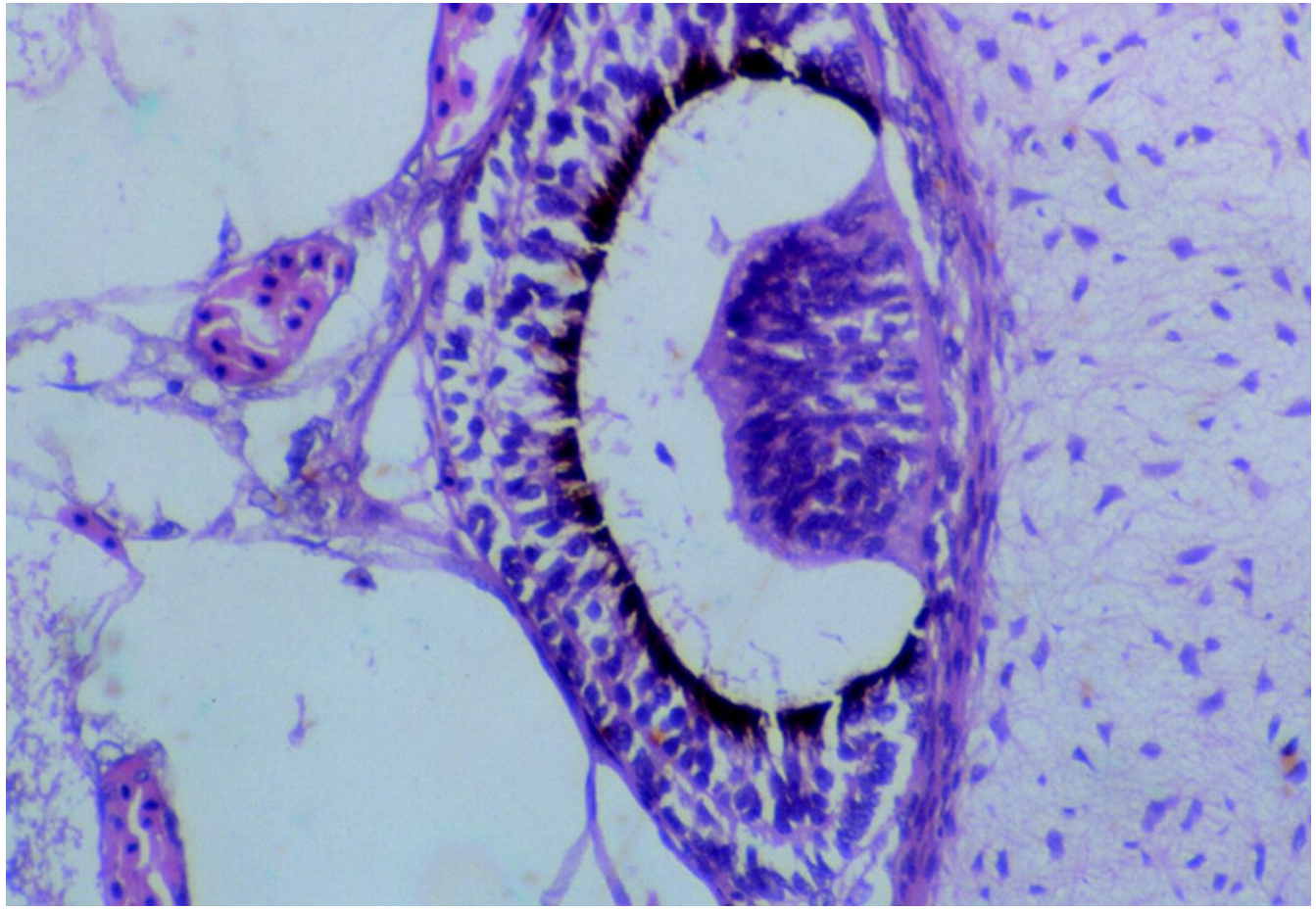
By Unsure – http://www.blavatskyarchives.com/hpbphotos6.htm, Public Domain, https://commons.wikimedia.org/w/index.php?curid=66334



By Frater5 (probable main designer of original emblem, Madame Blavatsky, died 1891) - Own work based on various published documents since 1875, Public Domain, https://commons.wikimedia.org/w/index.php?curid=2214981

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

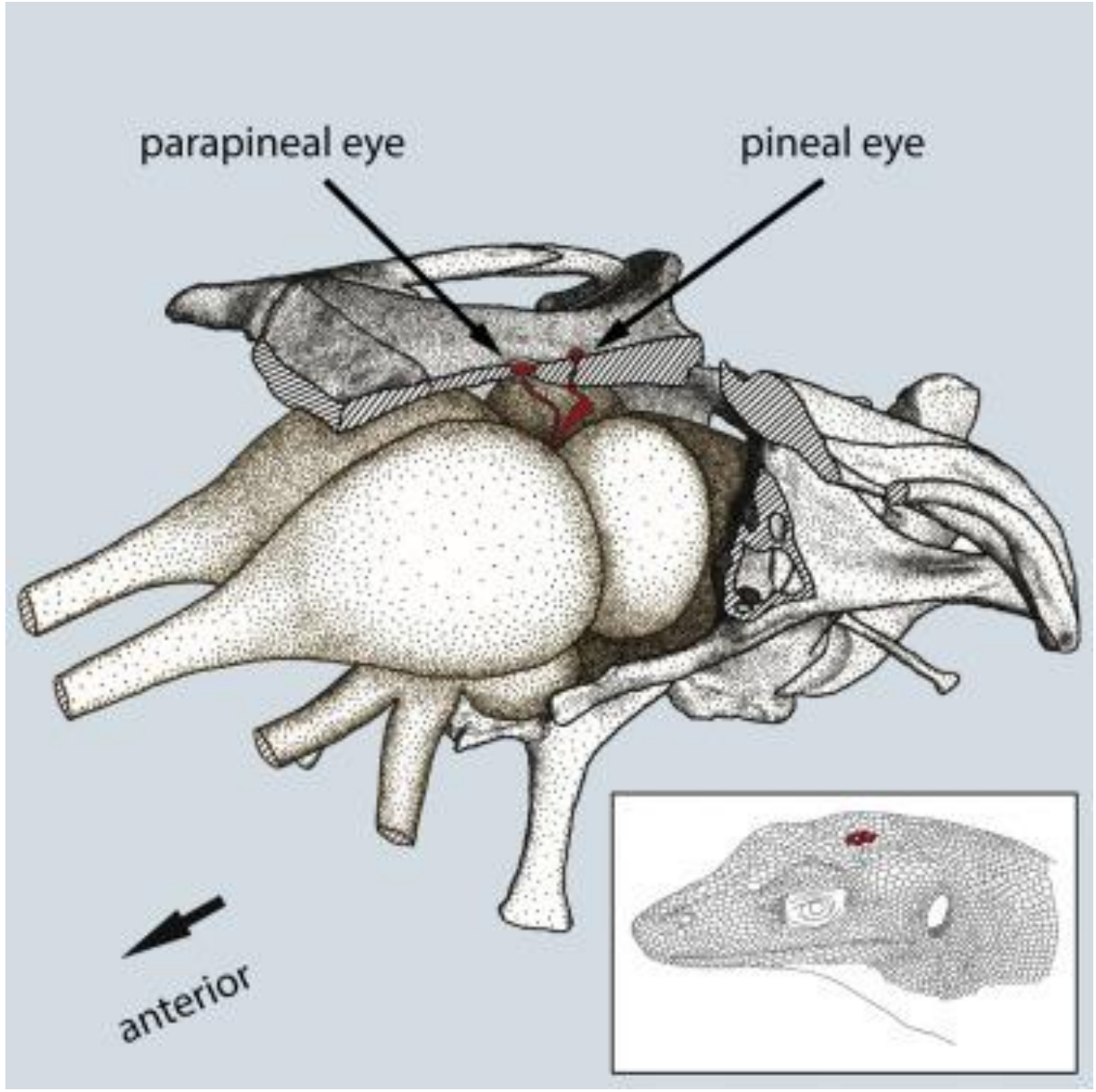
https://www.monaconatureencyclopedia.com/rhynchocephalia/?lang=en



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

•hateria –New Zealand (*Sphenodon punctatus*)
•

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.



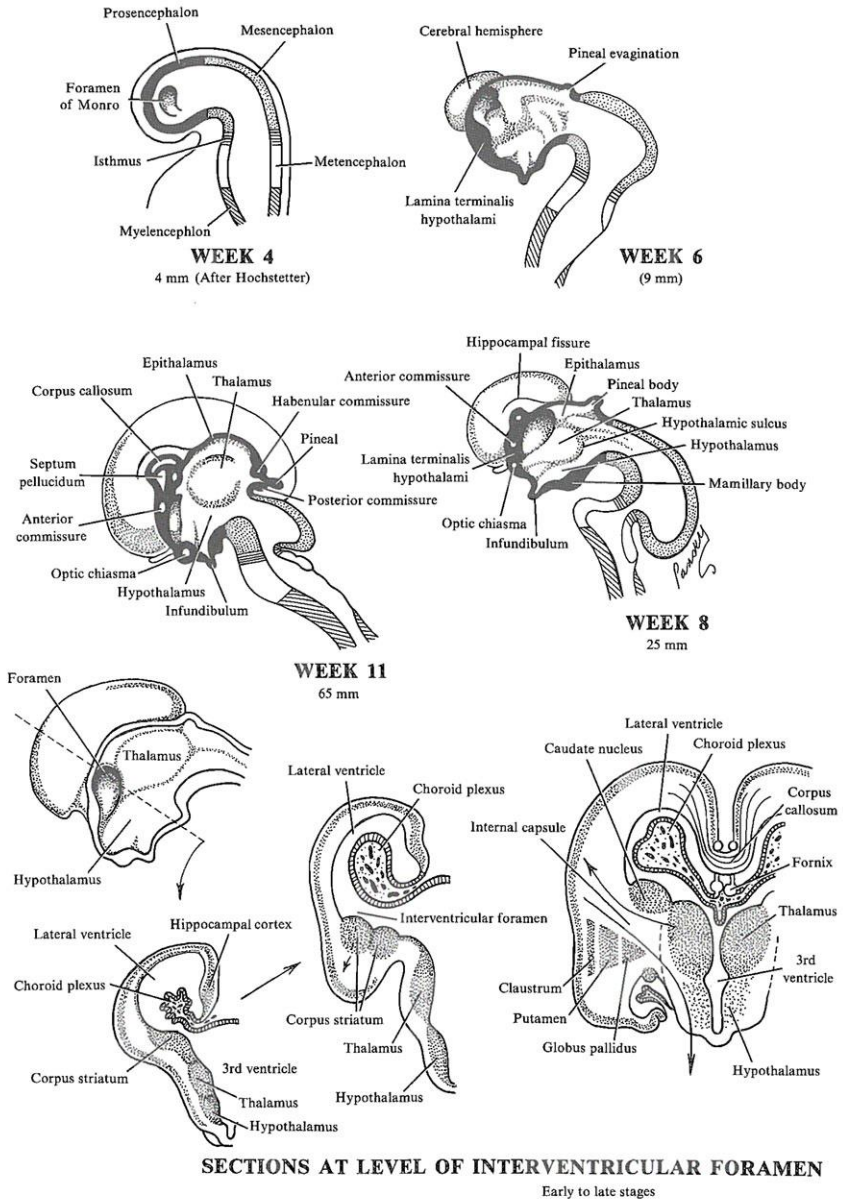
Saniwa ensidens

The Only Known Jawed Vertebrate with Four Eyes and the Bauplan of the Pineal Complex.　Smith, Krister T. et al.　Current Biology, Volume 28, Issue 7, 1101 - 1107.e2

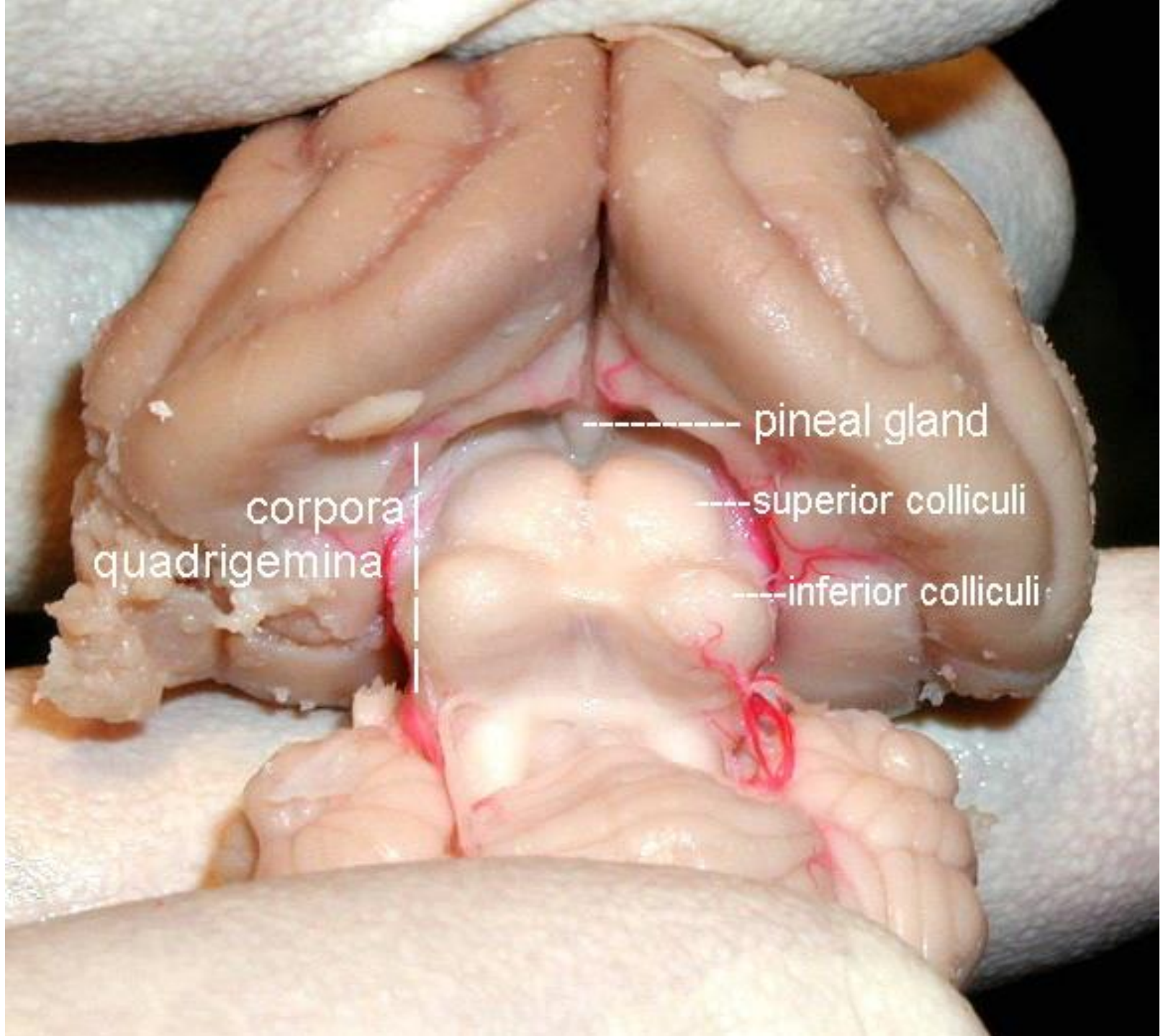
N,N-dimethyltryptamine (DMT), a psychedelic compound identified endogenously in mammals, is biosynthesized by aromatic-*L*-amino acid decarboxylase (AADC) and indolethylamine-*N*-methyltransferase (INMT). Whether DMT is biosynthesized in the mammalian brain is unknown. We investigated brain expression of INMT transcript in rats and humans, co-expression of INMT and AADC mRNA in rat brain and periphery, and brain concentrations of DMT in rats. INMT transcripts were identified in the cerebral cortex, pineal gland, and choroid plexus of both rats and humans via *in situ* hybridization. Notably, INMT mRNA was colocalized with AADC transcript in rat brain tissues, in contrast to rat peripheral tissues where there existed little overlapping expression of INMT with AADC transcripts. Additionally, extracellular concentrations of DMT in the cerebral cortex of normal behaving rats, with or without the pineal gland, were similar to those of canonical monoamine neurotransmitters including serotonin. A significant increase of DMT levels in the rat visual cortex was observed following induction of experimental cardiac arrest, a finding independent of an intact pineal gland. These results show for the first time that the rat brain is capable of synthesizing and releasing DMT at concentrations comparable to known monoamine neurotransmitters and raise the possibility that this phenomenon may occur similarly in human brains.

Dean, J., Liu, T., Huff, S. *et al.* Biosynthesis and Extracellular Concentrations of N,N-dimethyltryptamine (DMT) in Mammalian Brain. *Sci Rep* **9**, 9333 (2019). https://doi.org/10.1038/s41598-019-45812-w

Pineal gland development



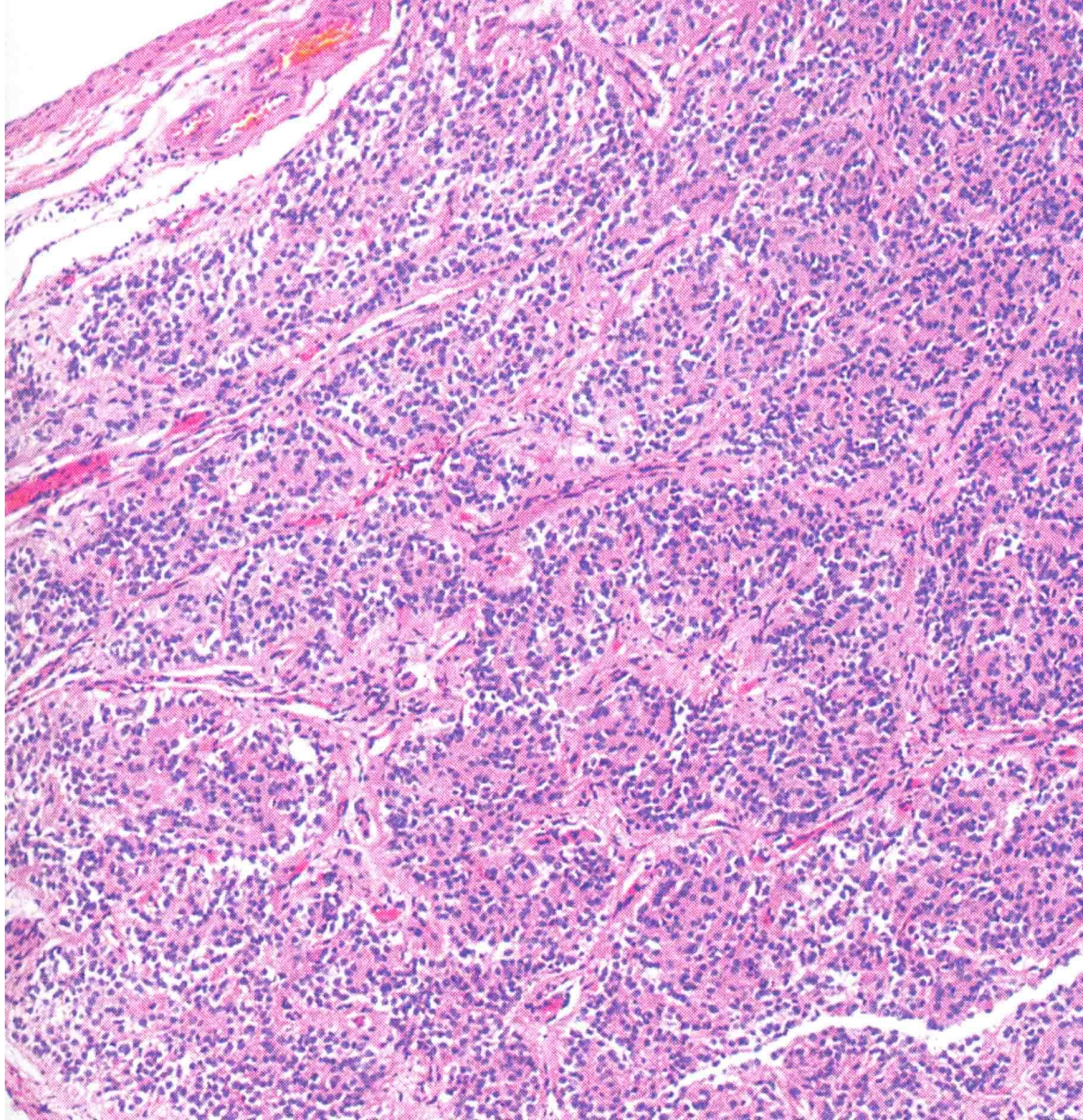
https://discovery.lifemapsc.com/library/review-of-medical-embryology/chapter-153-the-diencephalon-second-vesicle


pineal gland
corpora quadrigemina
superior colliculi
inferior colliculi

Pineal gland - structure

capsule from *pia mater (*septa)

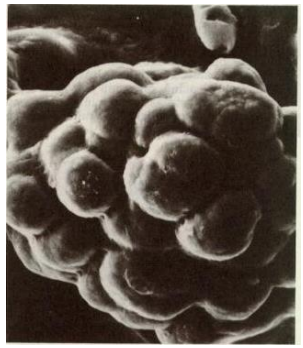
- pinealocytes
  - nucleus with prominent nucleolus, basophillic cytoplasm
  - production of **melatonine**
- level changes during the day
- interstitial/astroglial cells
  - bar-shaped nucleus
- n. pinealis - neurofibra non myelinata

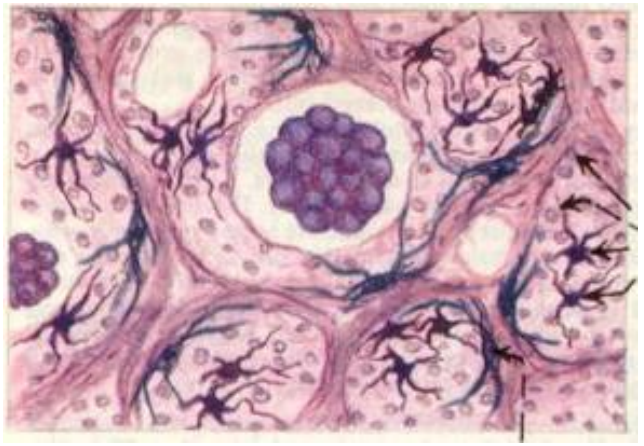


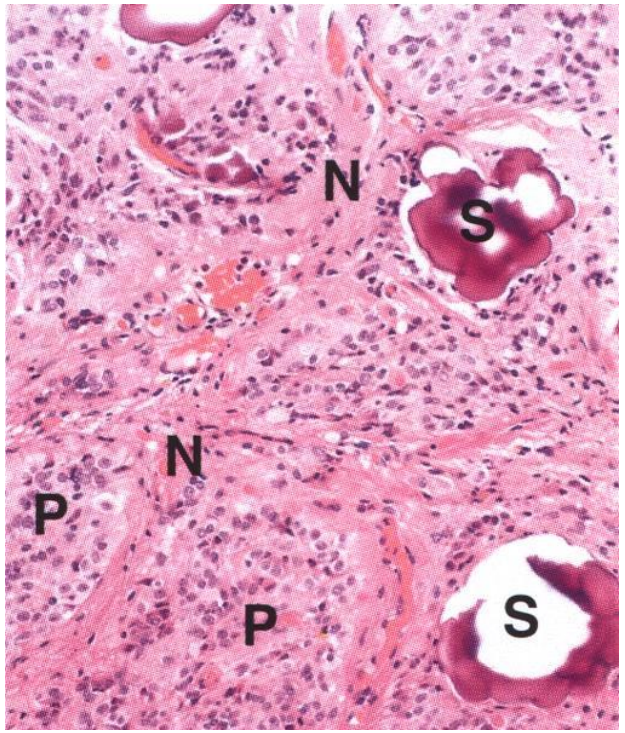
Pineal gland – “brain sand“

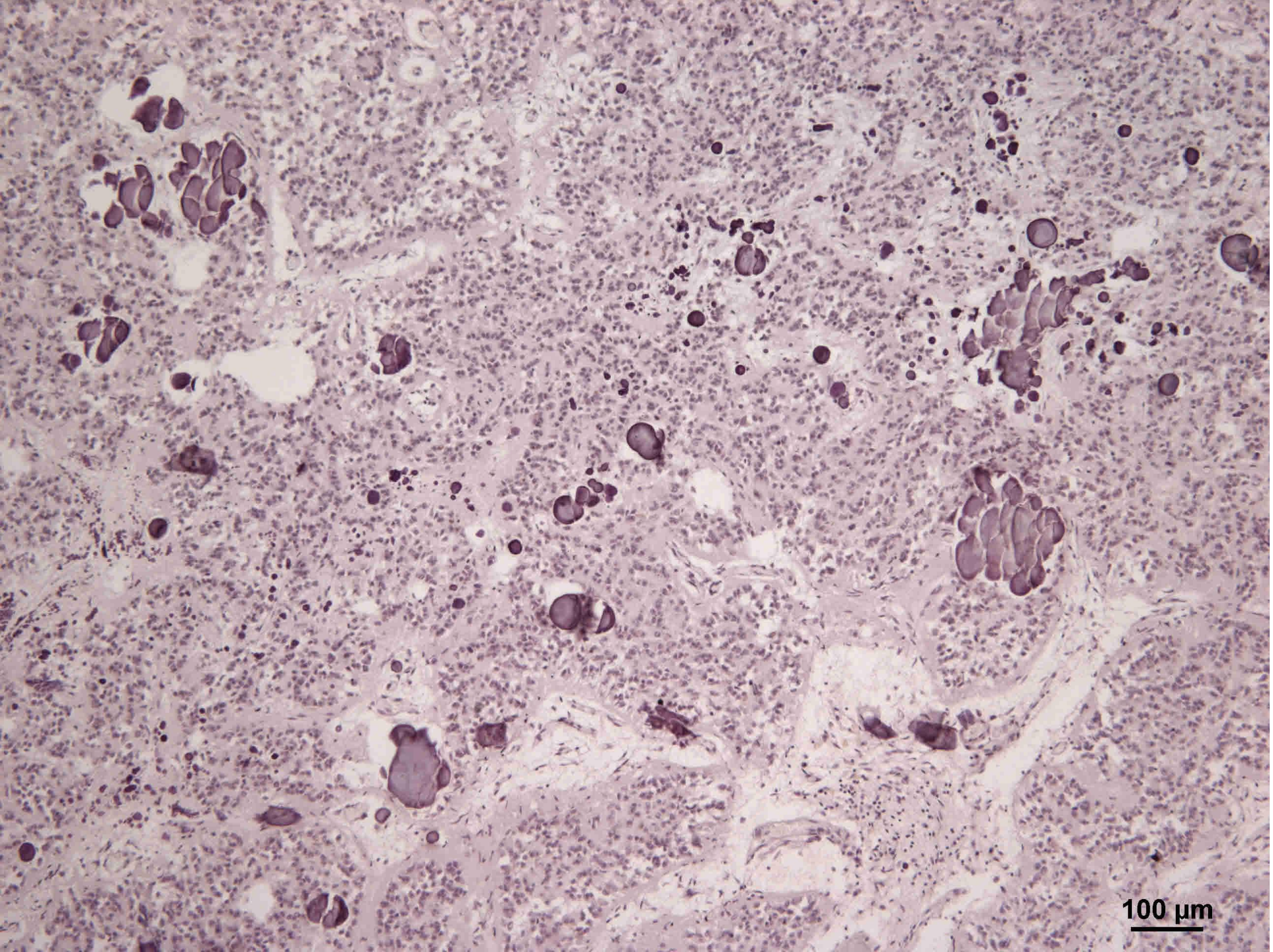
- **acervulus; corpus arenaceum**

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

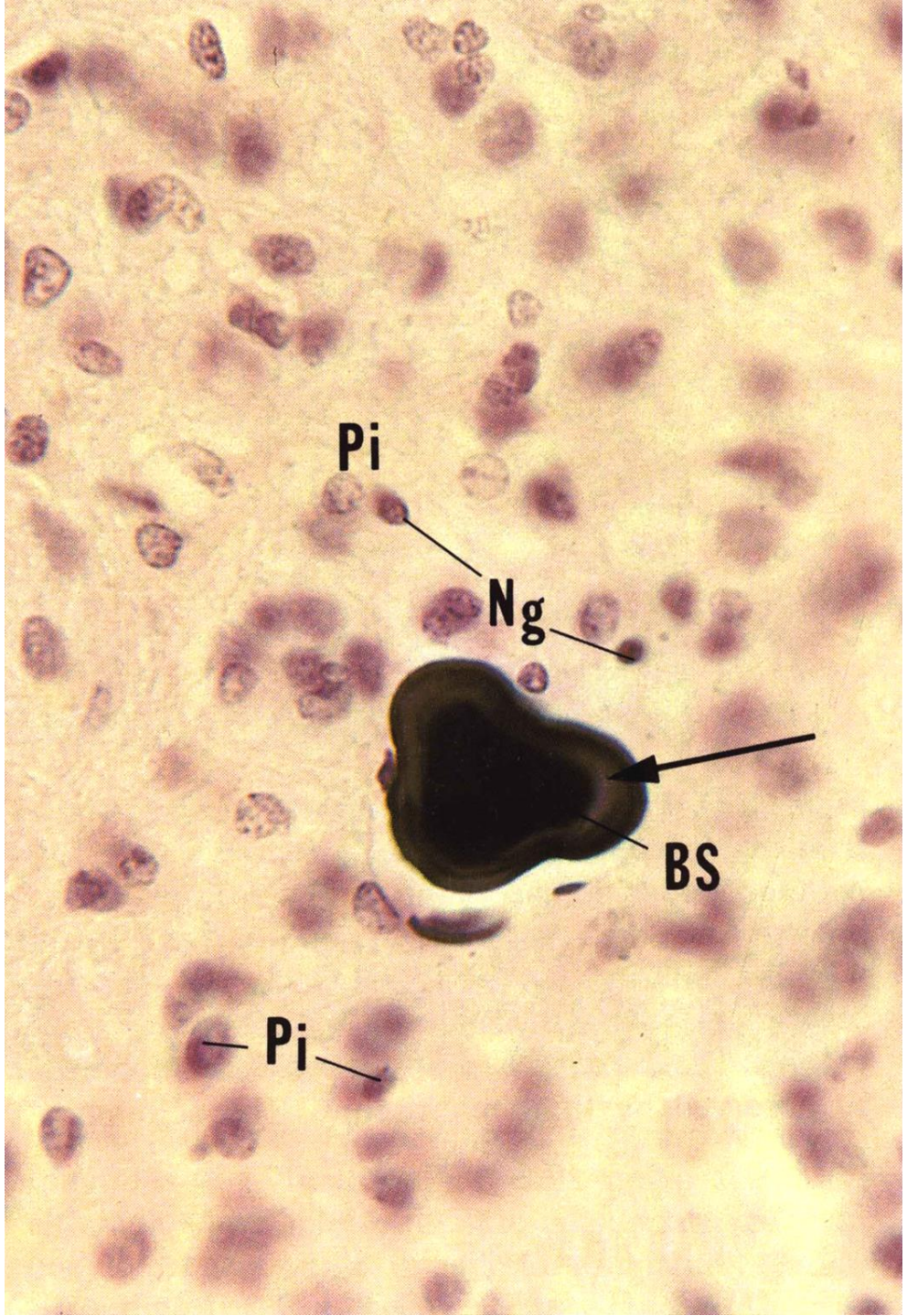


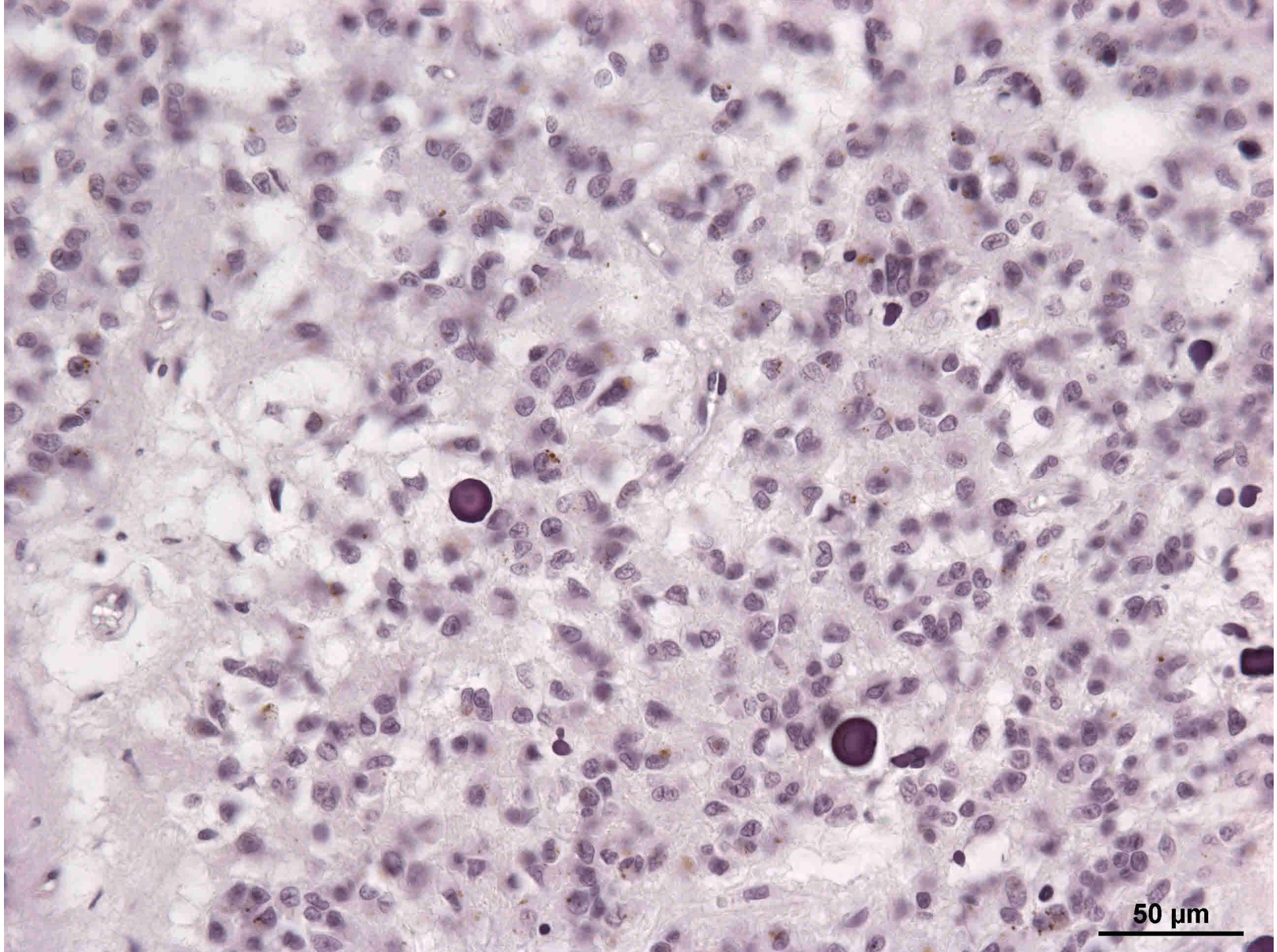


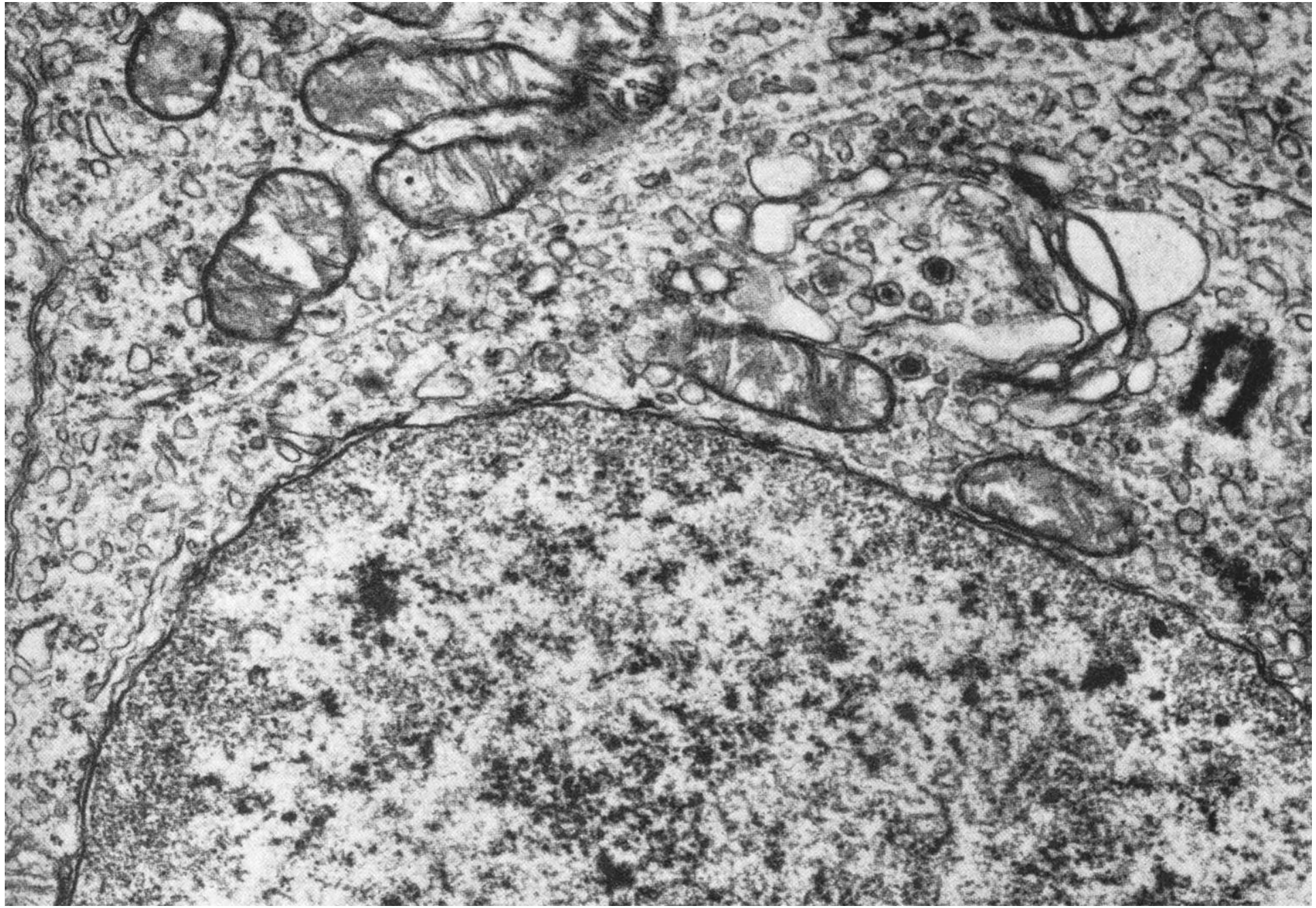



100 µm

Pi = pinealocytes
Ng = neurogliol cells
BS = acervulus cerebri
arrow = lamels




50 µm



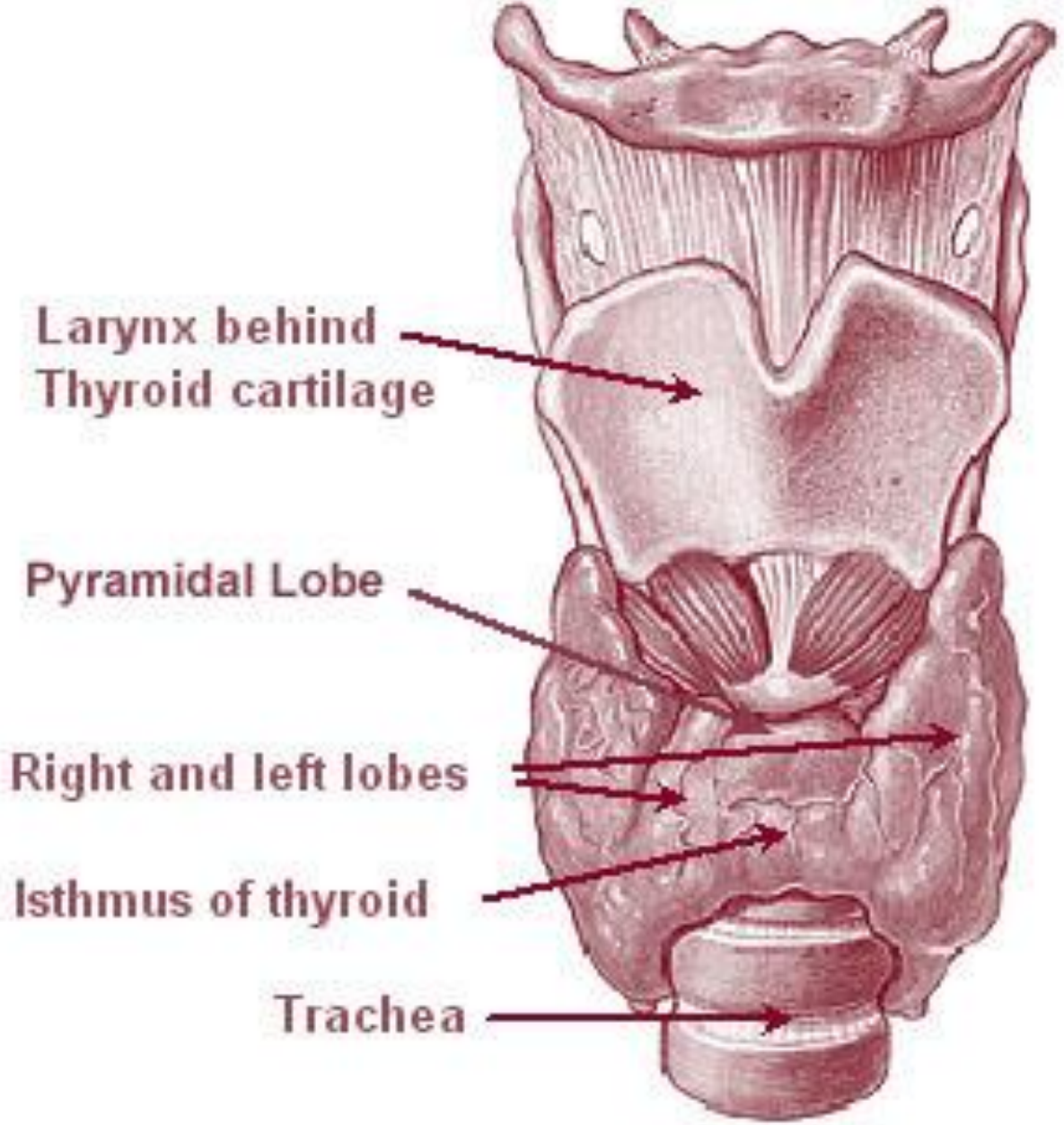
pinealocyte

Thyroid gland (glandula thyroidea)

Thyroid gland – history

Galenos –makes the pharynx wet inside

- 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



C6-C7

isthmus on 2.-4. laryngeal cartillage

located at level of C6-C7

- shape of letter H
- lobus dexter et sinister
- isthmus glandulae thyroideae

–at 2nd-4th tracheal cartilage

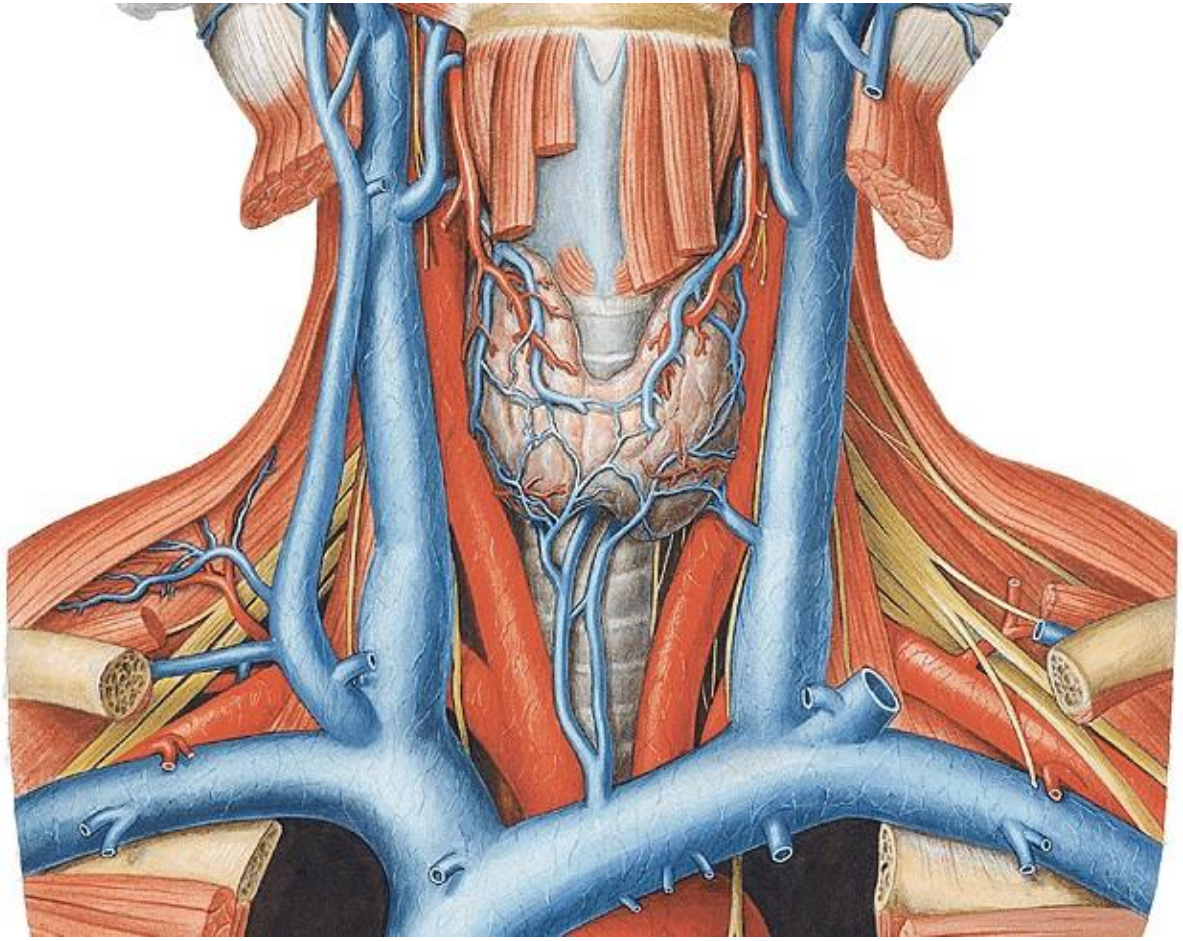
–height of isthmus about 1.5 cm

- lobus pyramidalis (40 %)

–length of lobe 5-8 cm

- 30-40 g (20-60 g)

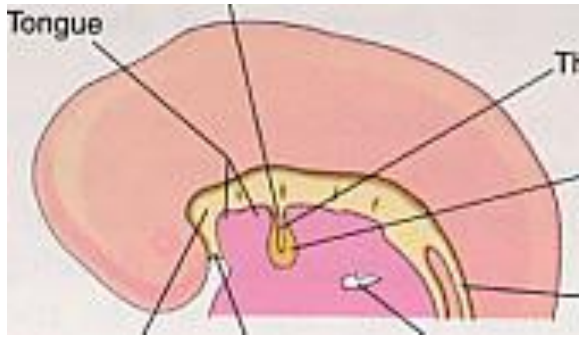
Thyroid gland – blood vessels

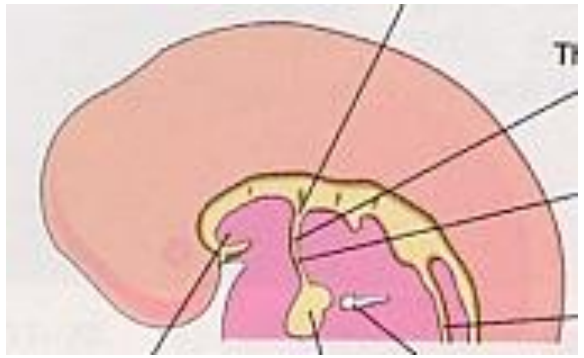


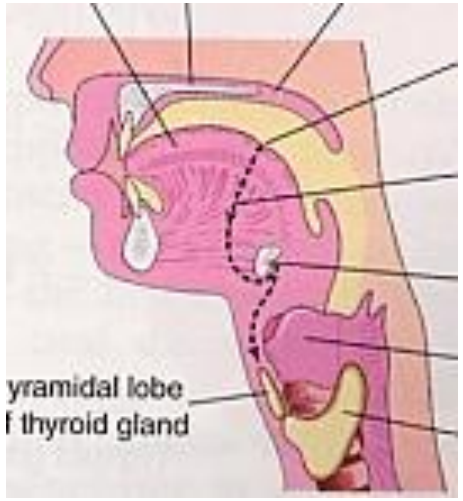
a. thyroidea superior (← a. carotis externa)
•a. thyroidea inferior (← truncus thyrocervicalis)
–crossing with n. laryngeus recurrens
•a. thyroidea ima *Neubaueri* (← arcus aortae)
–2%
•vv. thyroideae superiores
•Vv. thyroideae mediae *Lichačevae-Kocheri*(50%) →vv. jugularis interna
•vv. thyroideae inferiores →plexus thyroideus impar →v. brachiocephalica sinistra

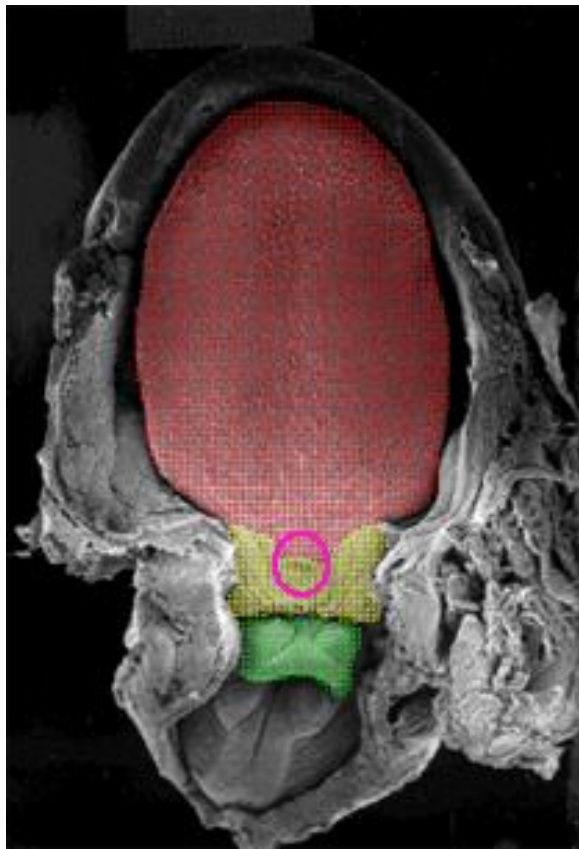
Thyroid gland – development

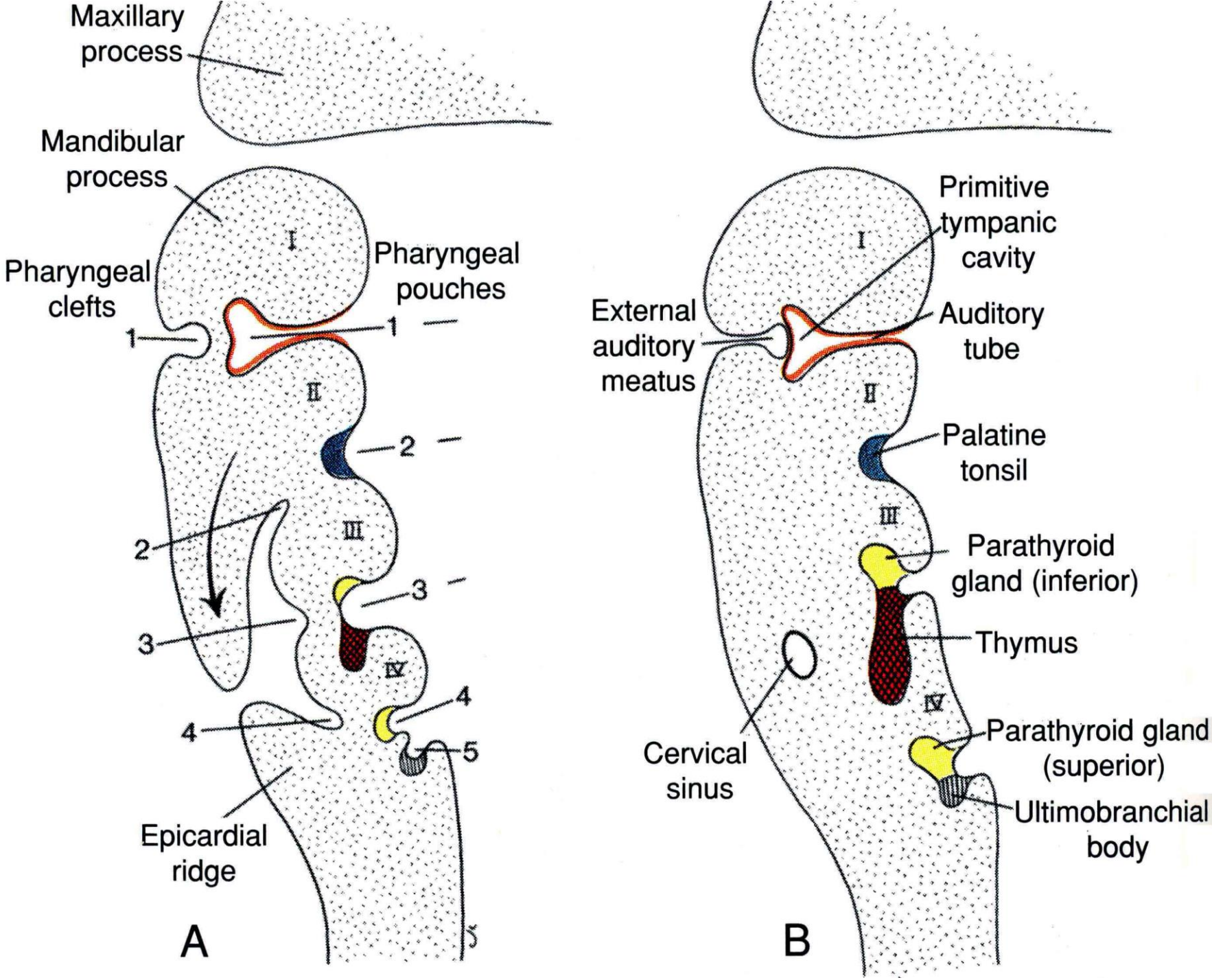
- from 24th day
- pouch of primitive pharynx endoderm
- both relative and absolute descent →*ductus thyroglossus*
- foramen caecum
- gll. thyroideae accessoriae
- lobes formation
- lobus pyramidalis
- *ligamentum suspensorium gl. thyroideae /musculus levator glandulae thyroideae* (smooth)










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

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

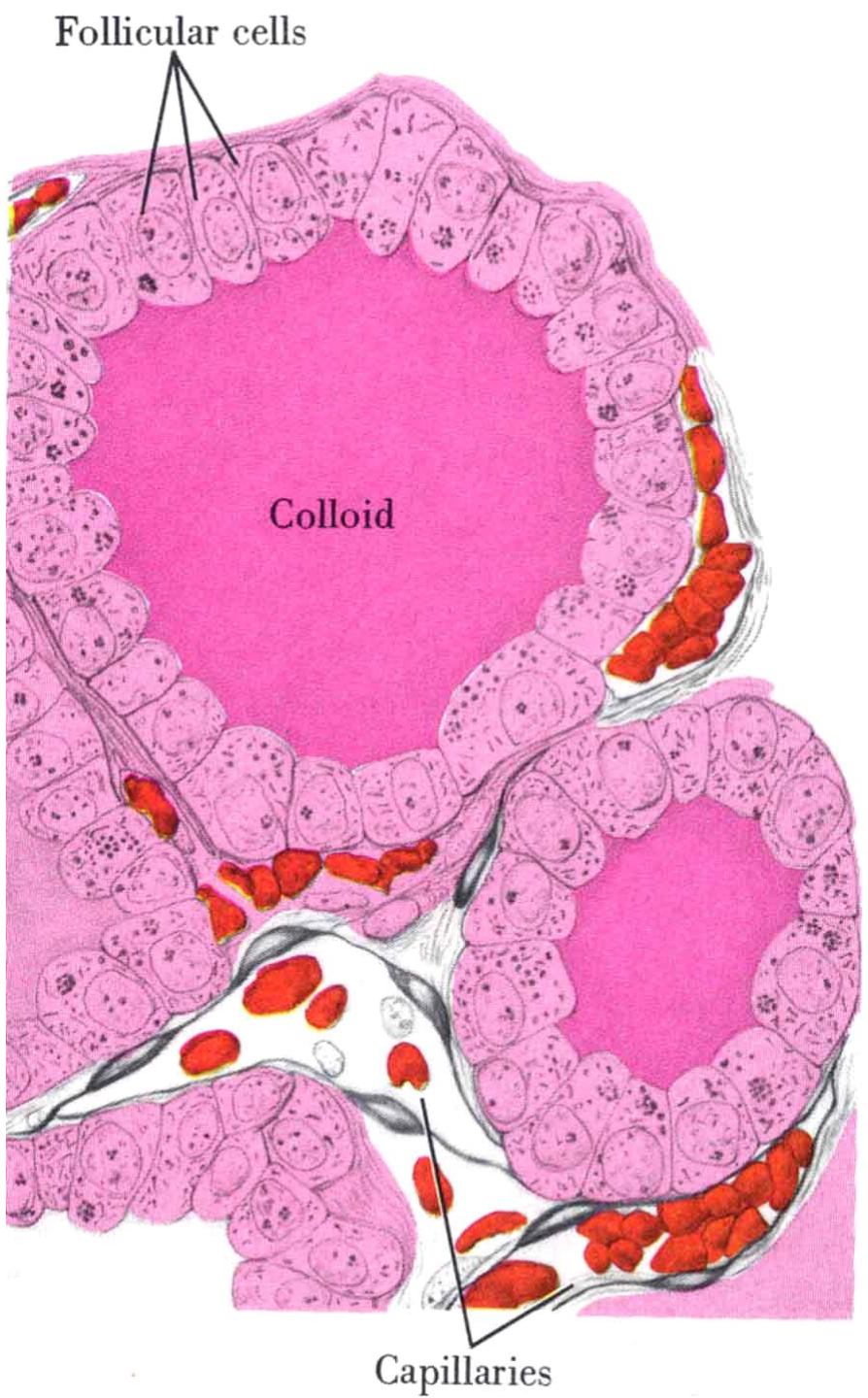
- capsula fibrosa
- stroma
- septa (between lobules)
- lobus – lobulus - folliculus
- follicles (50–900 µm)

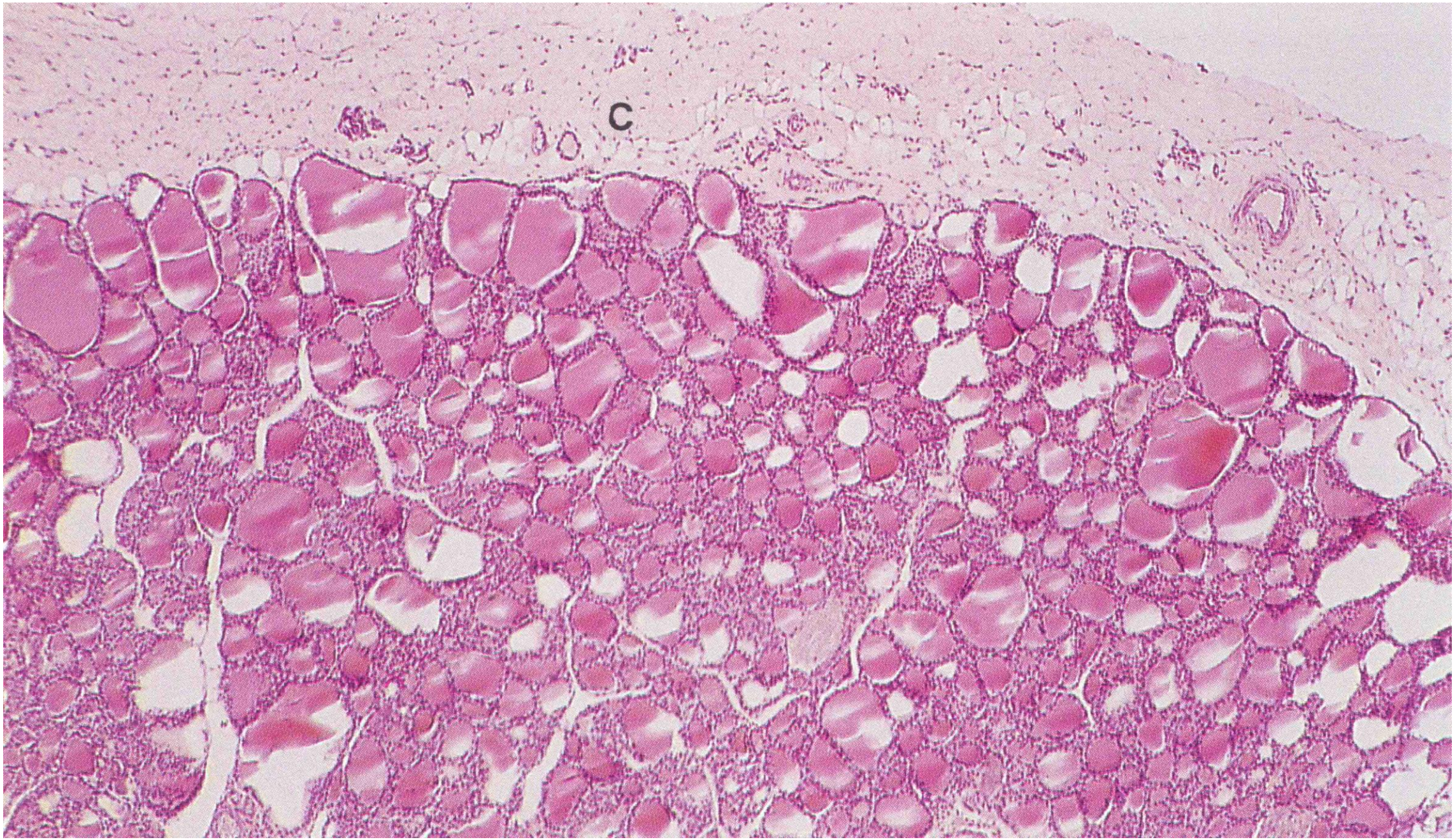
–spheric

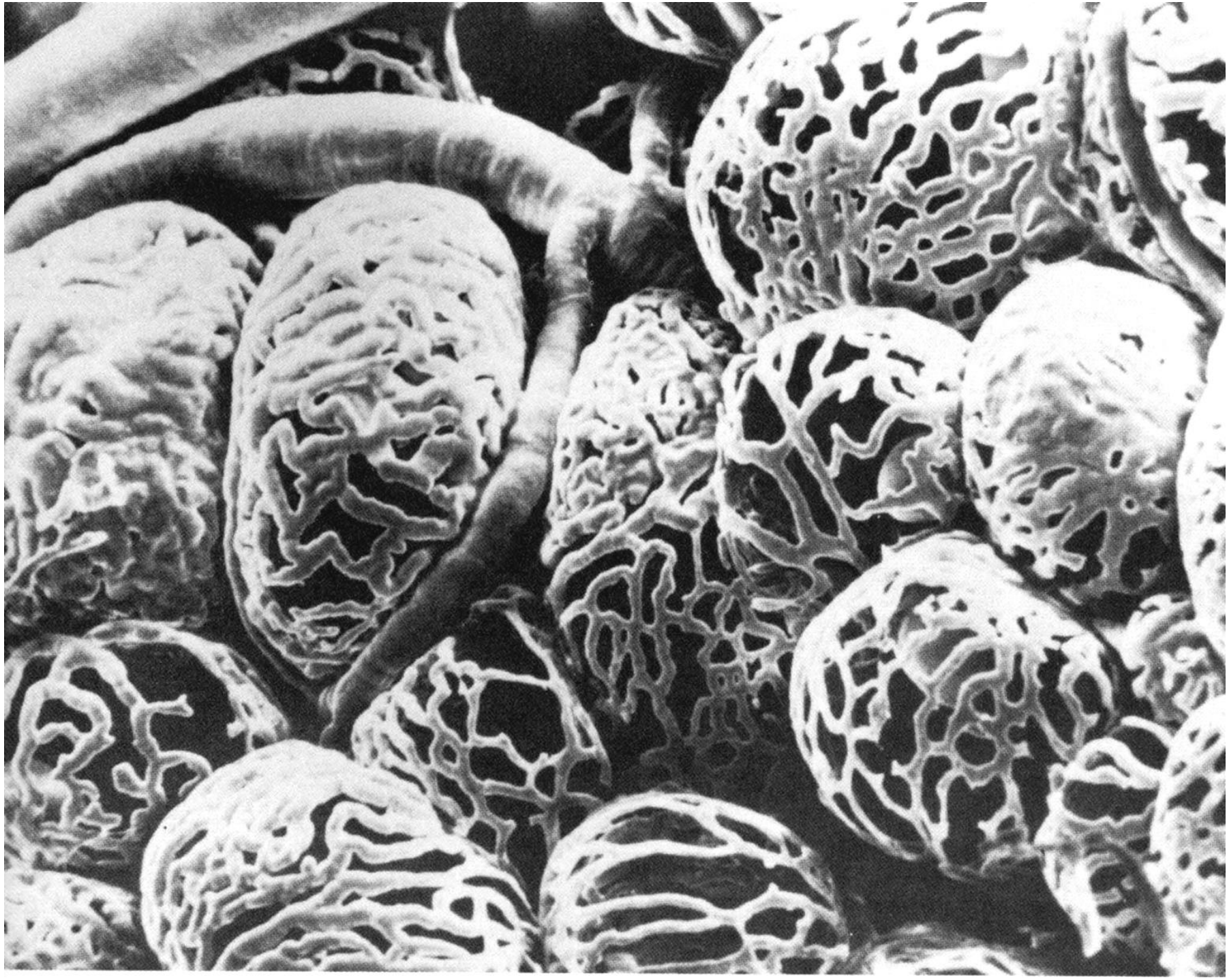
–simple epithelium of follicular cells

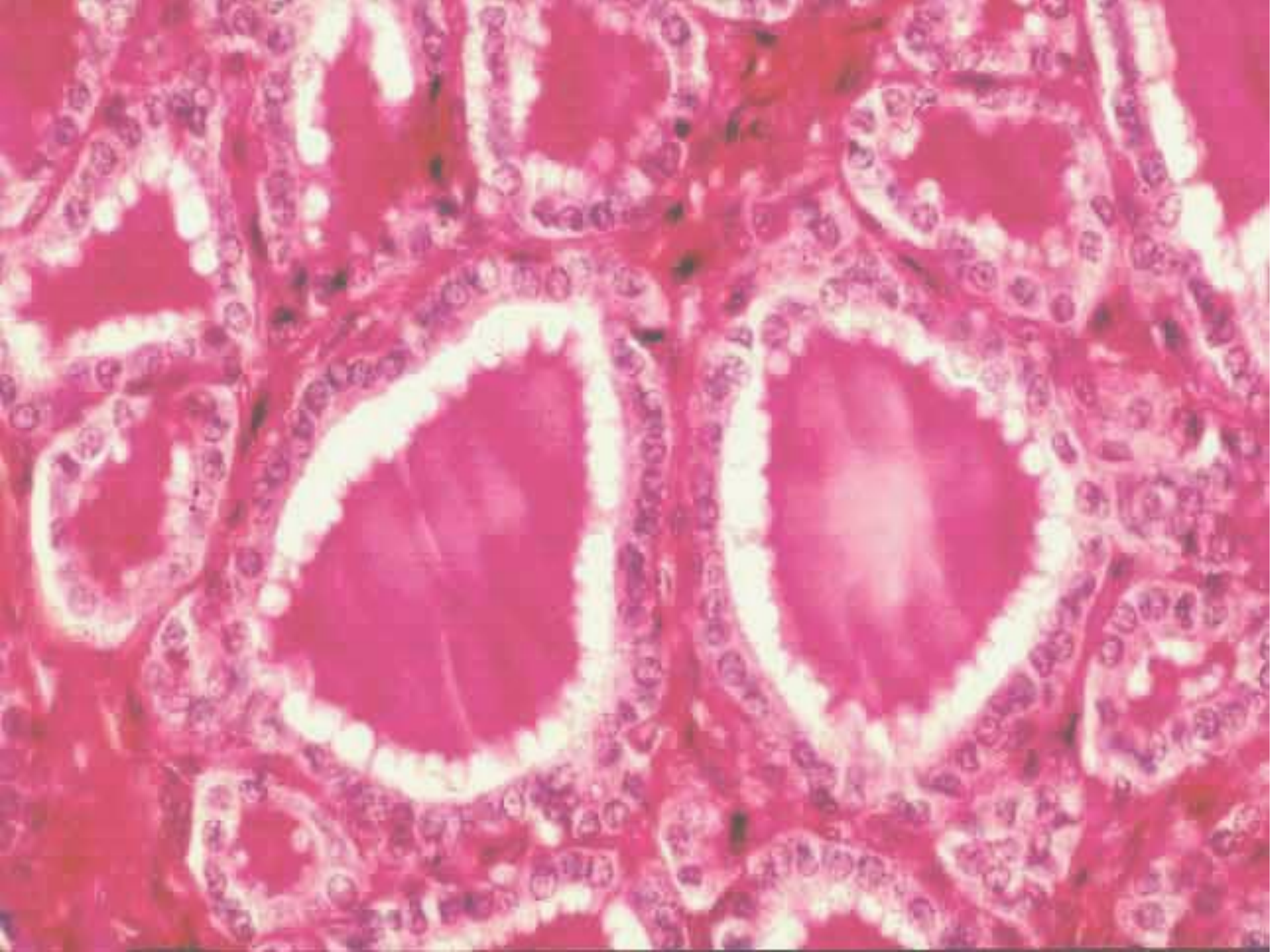
–contains *colloidum* (colloid) –thyreoglobulin

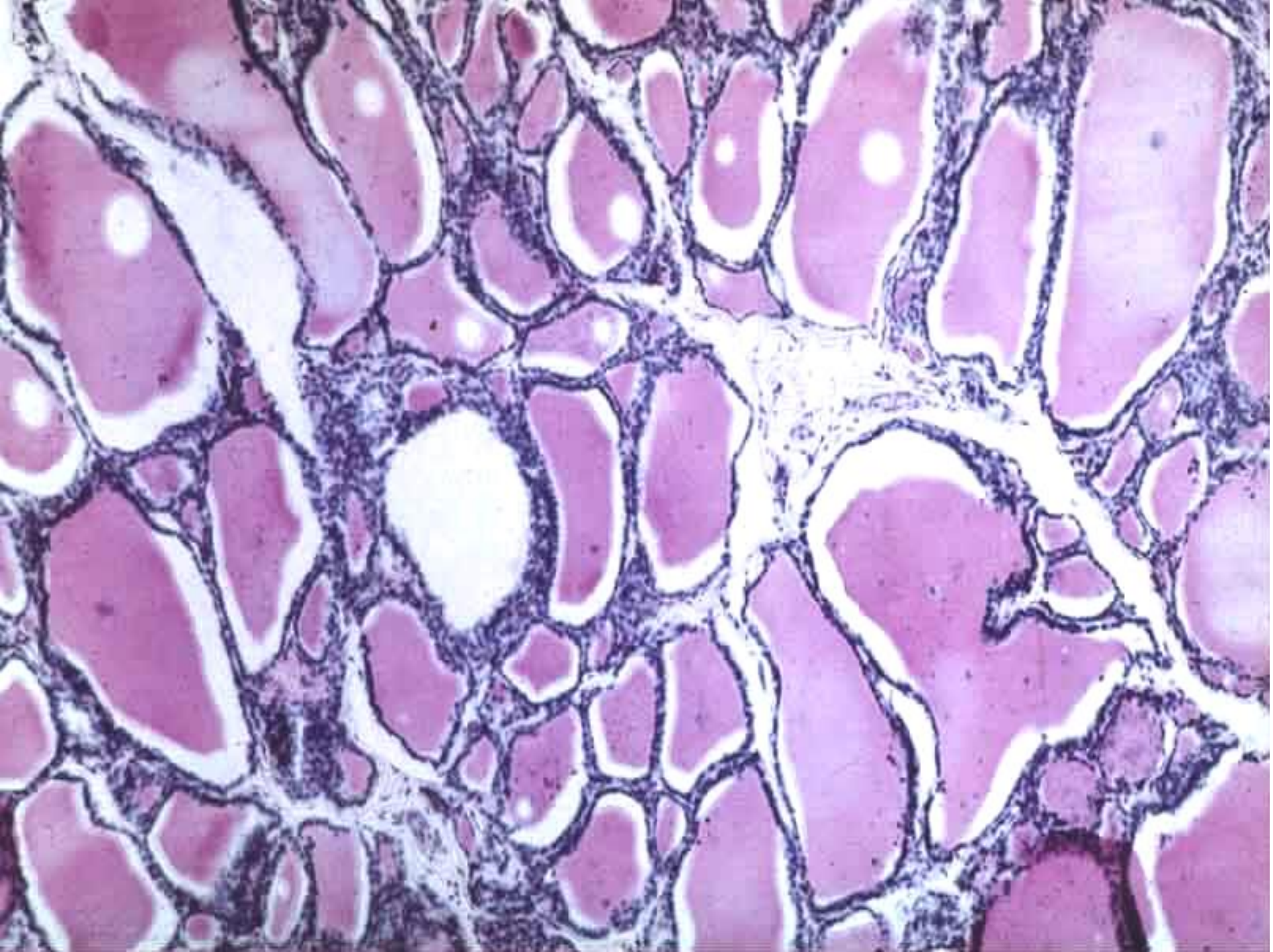
- follicular cell
- parafollicular cell (*C*)



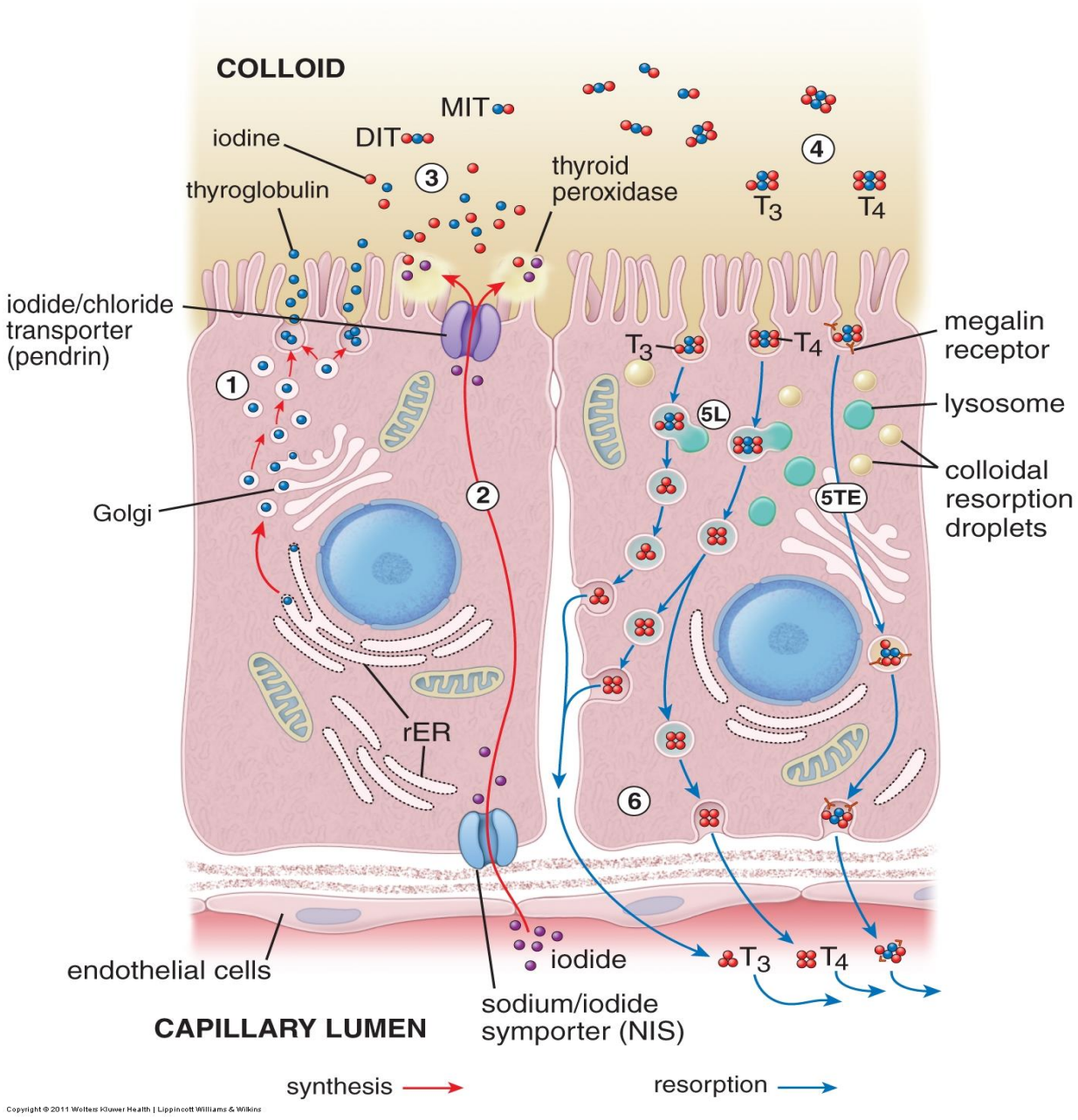

C





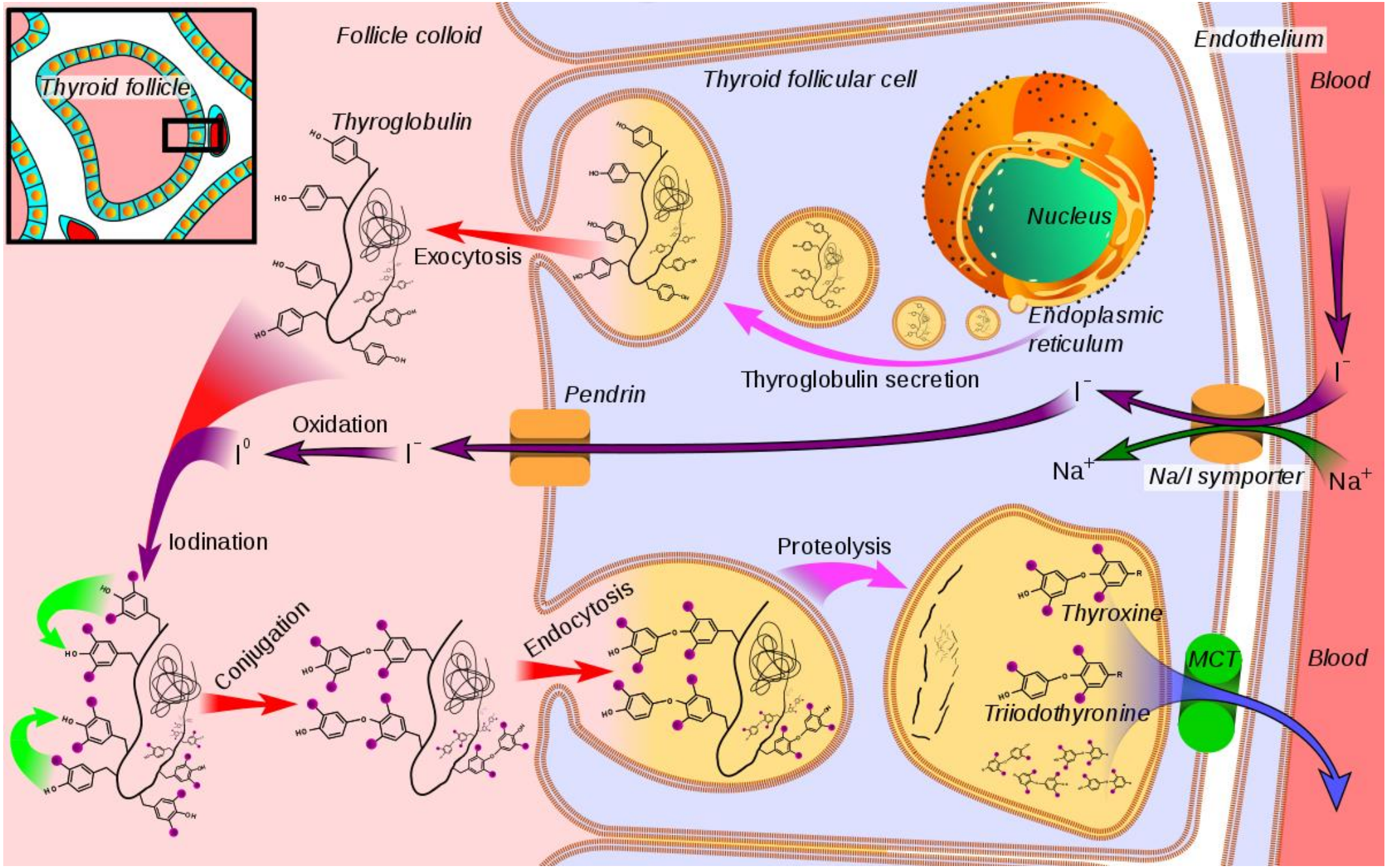


TE = follicle epithelium
BM = basal membrane
TC = colloid
C = capillary



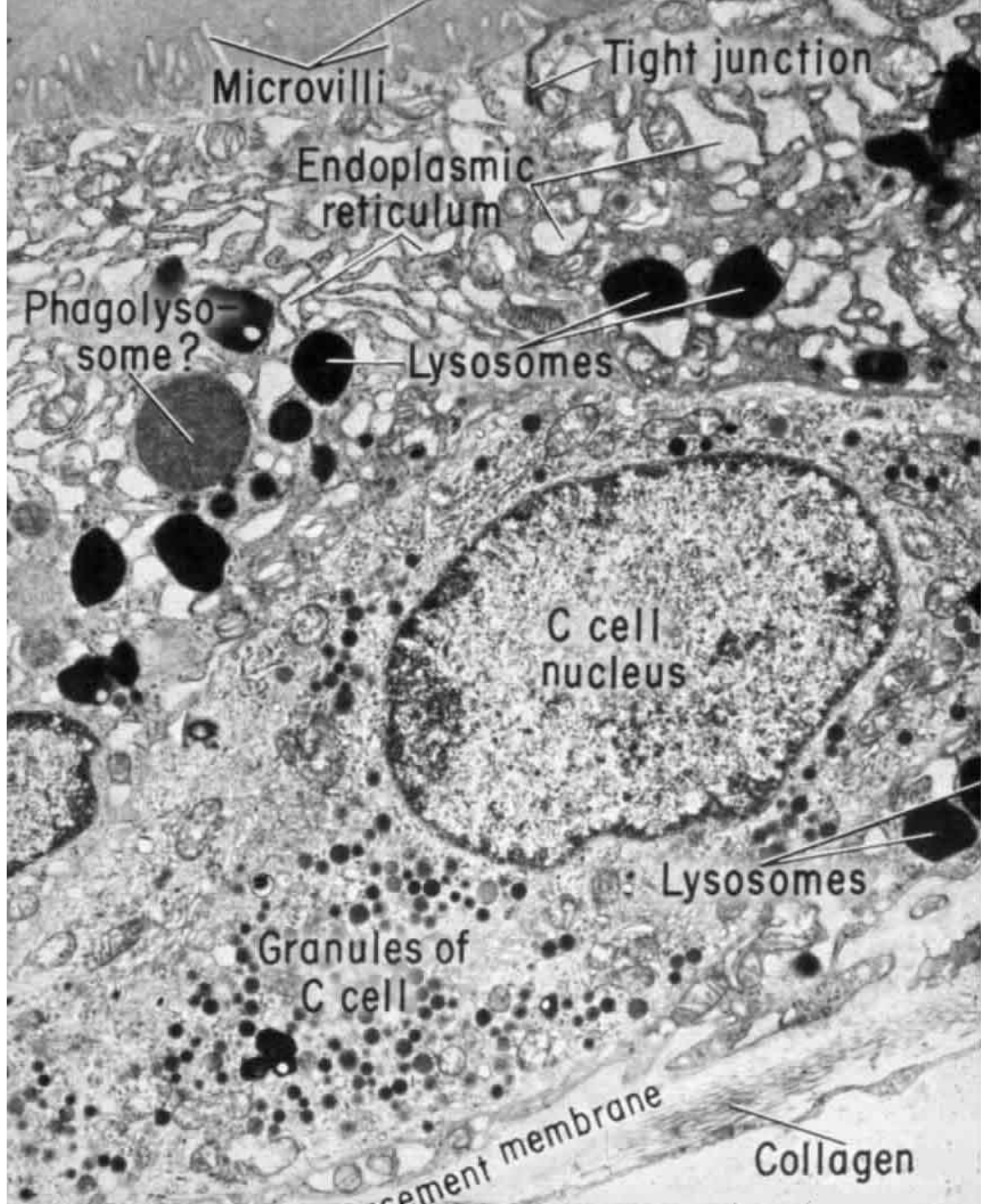
1. iodine pump using ATP transport the iodine form blood to colloid
- 2. + 3. synthesis of thyreoglobulin and peroxidase, storage in one secretory vesicle and their release into the colloid by exocytosis
- 4. iodination of thyreoglobulin by peroxidase within the colloid and formation of iodinethyreoglobulin

- 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)

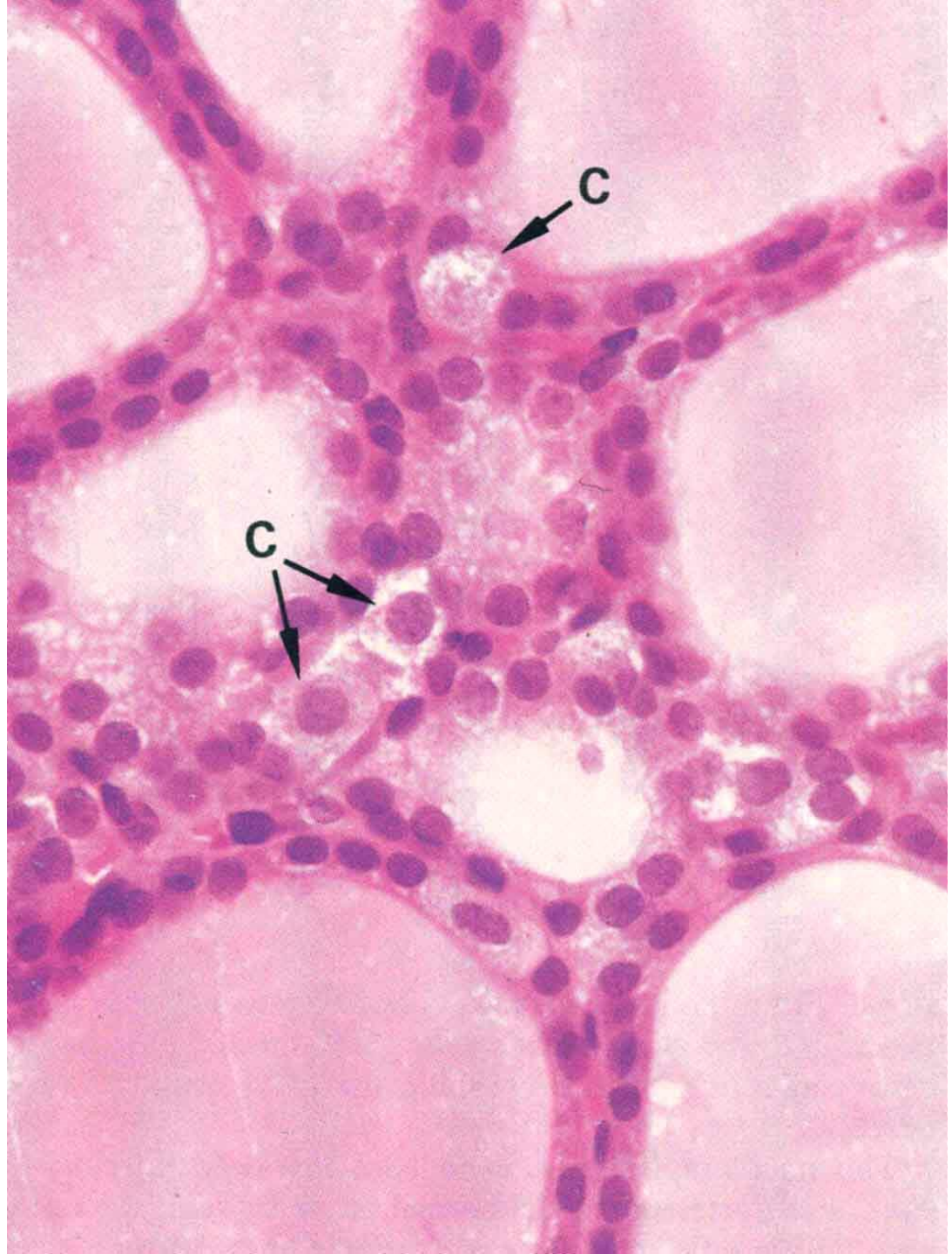


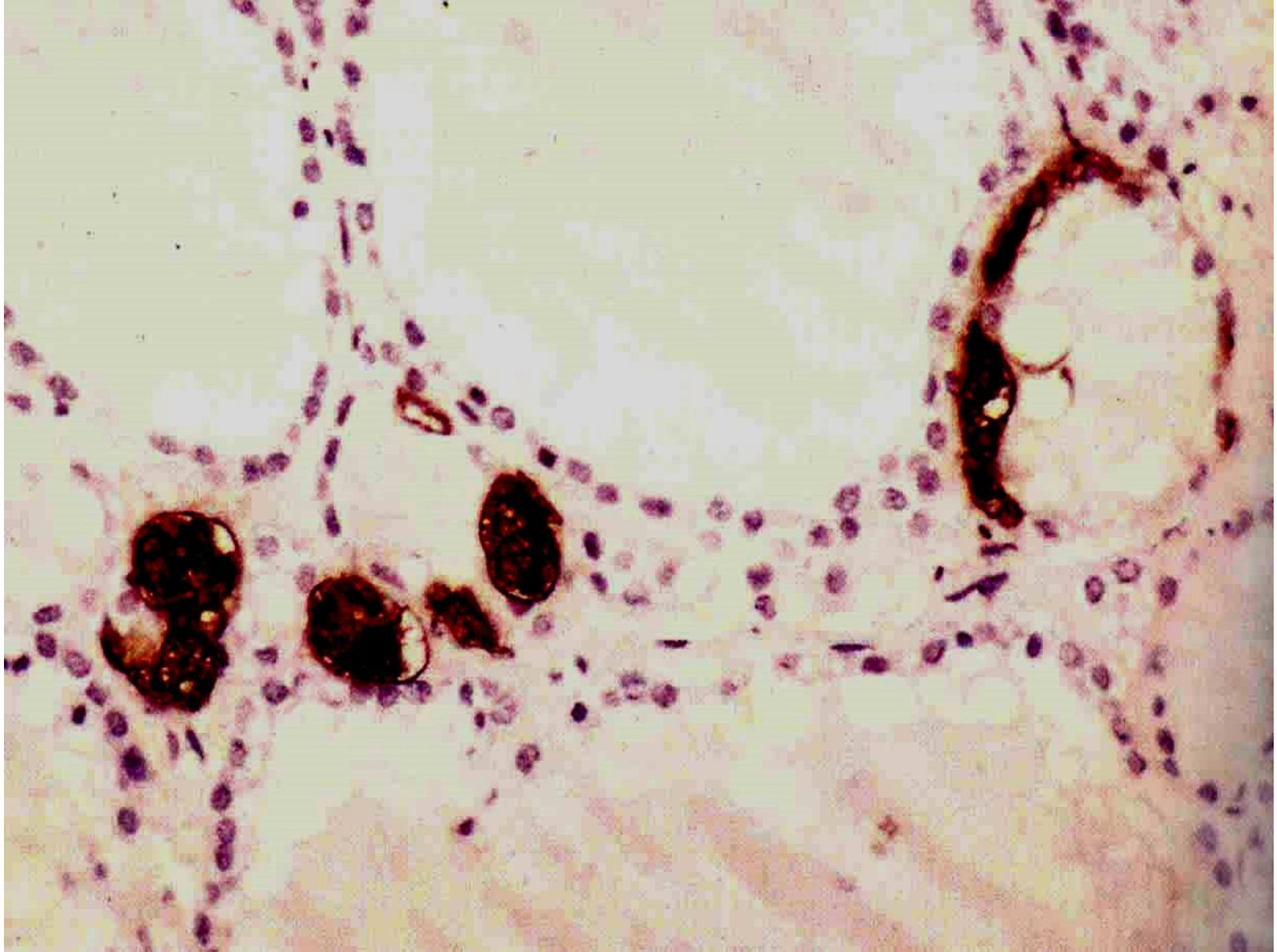
https://cs.m.wikipedia.org/wiki/Soubor:Thyroid_hormone_synthesis.svg

F = follicular cells
T = colloid
C = parafollicular cells
BM = basal membrane
Cap = capillary
G = Golgi complex
V = vesicle containing colloid
L = lysosome fusing with vesicule
rER = granular ER in follicular cell of neighboring follicle
M = part of mast cell

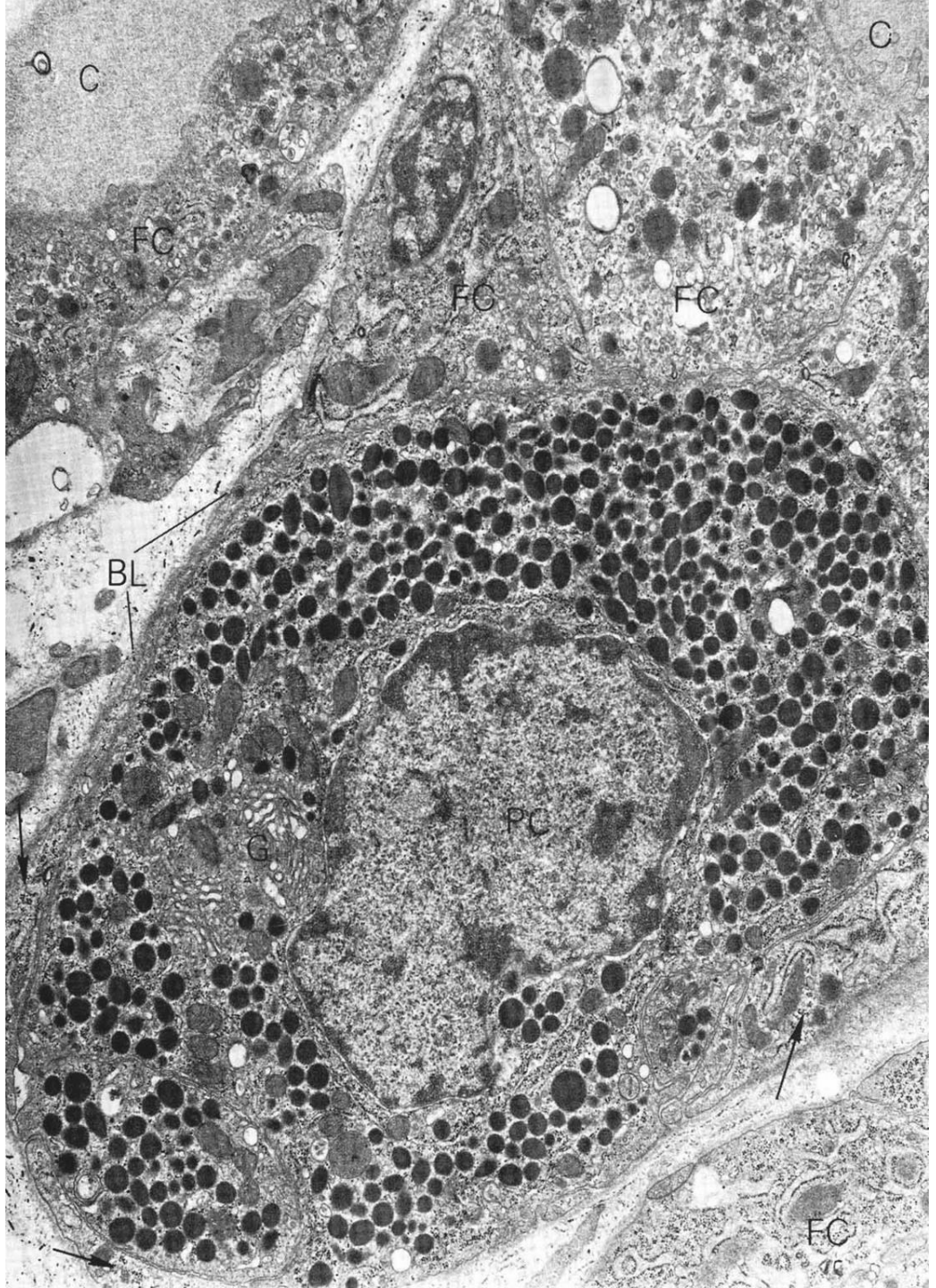

Microvilli
Tight junction
Endoplasmic reticulum
Phagolyso-some?
Lysosomes
C cell nucleus
Lysosomes
Granules of C cell
Collagen

Parafollicular (C) cells


C
C

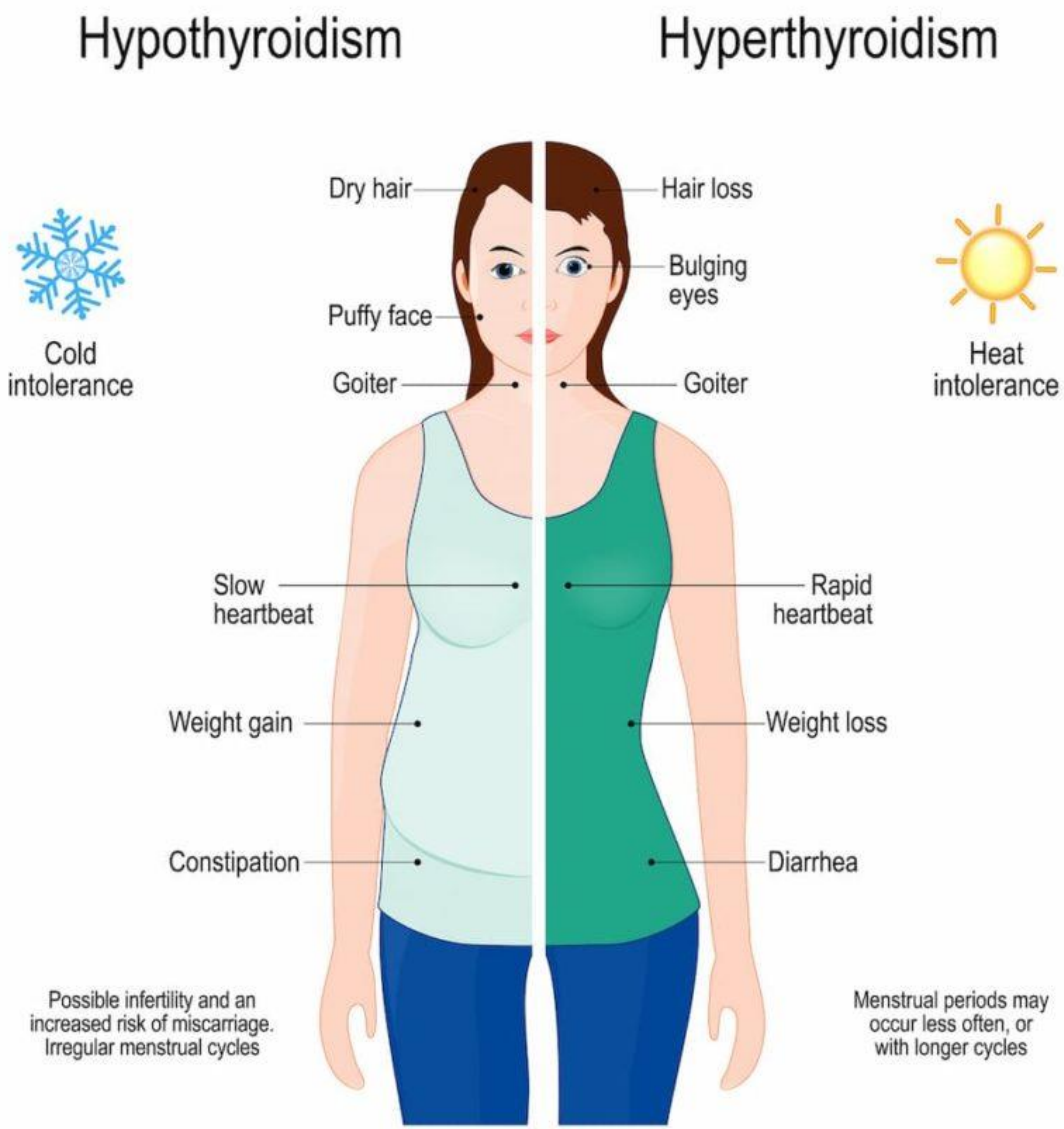


FC = follicular cells
C = colloid
PC = parafollicular cells
BL = basal lamina
G = Golgi complex
arrows = processi of follicular cells



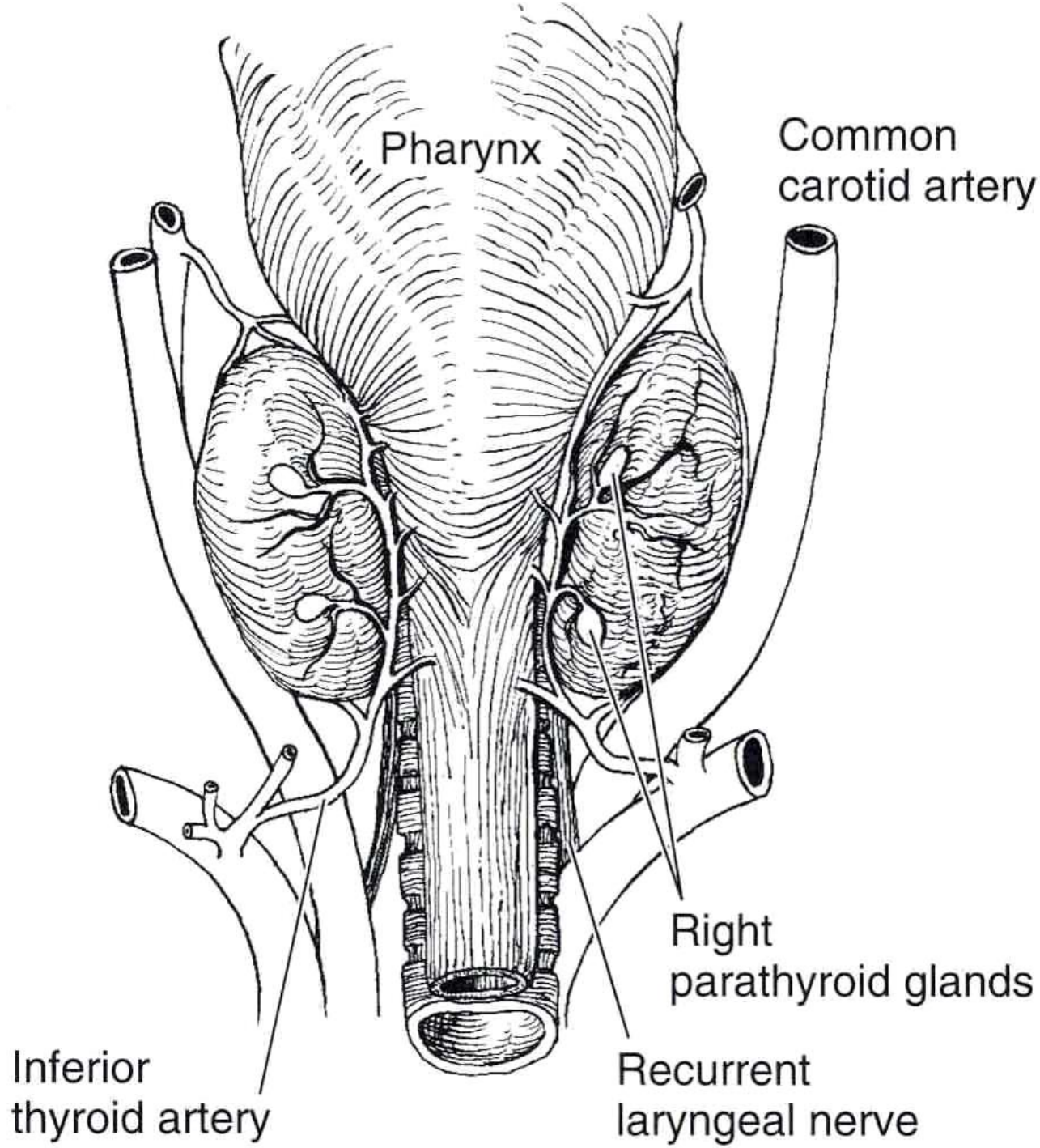
Ross, M.H., Romrell, L.J.: Histology: a text and atlas, 2nd ed., Williams & Wilkins, 1989

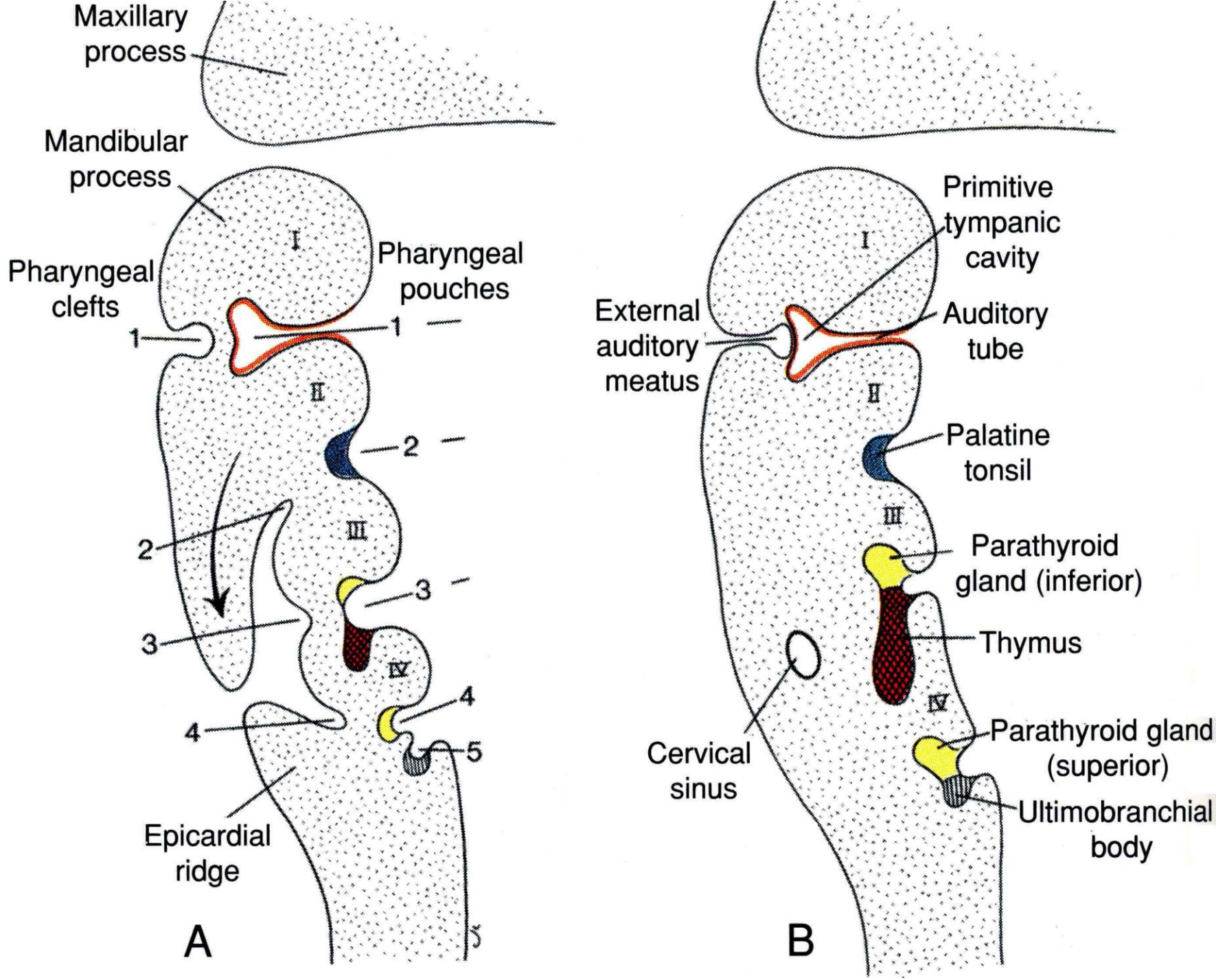
Disorder of the thyroid gland



https://rockymountaindiabetes.com/idaho-falls-diabetes-doctor-medical-services/thyroid-diseases/

Parathyroid gands (glandulae parathyroideae)


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


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

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

Parathyroid glands - structure

- function in bone metabolism
- parathormone (PTH)
- capsule + septa
- parenchyma divided into cords
- **principal cells**

–relatively small (4-8 µm)

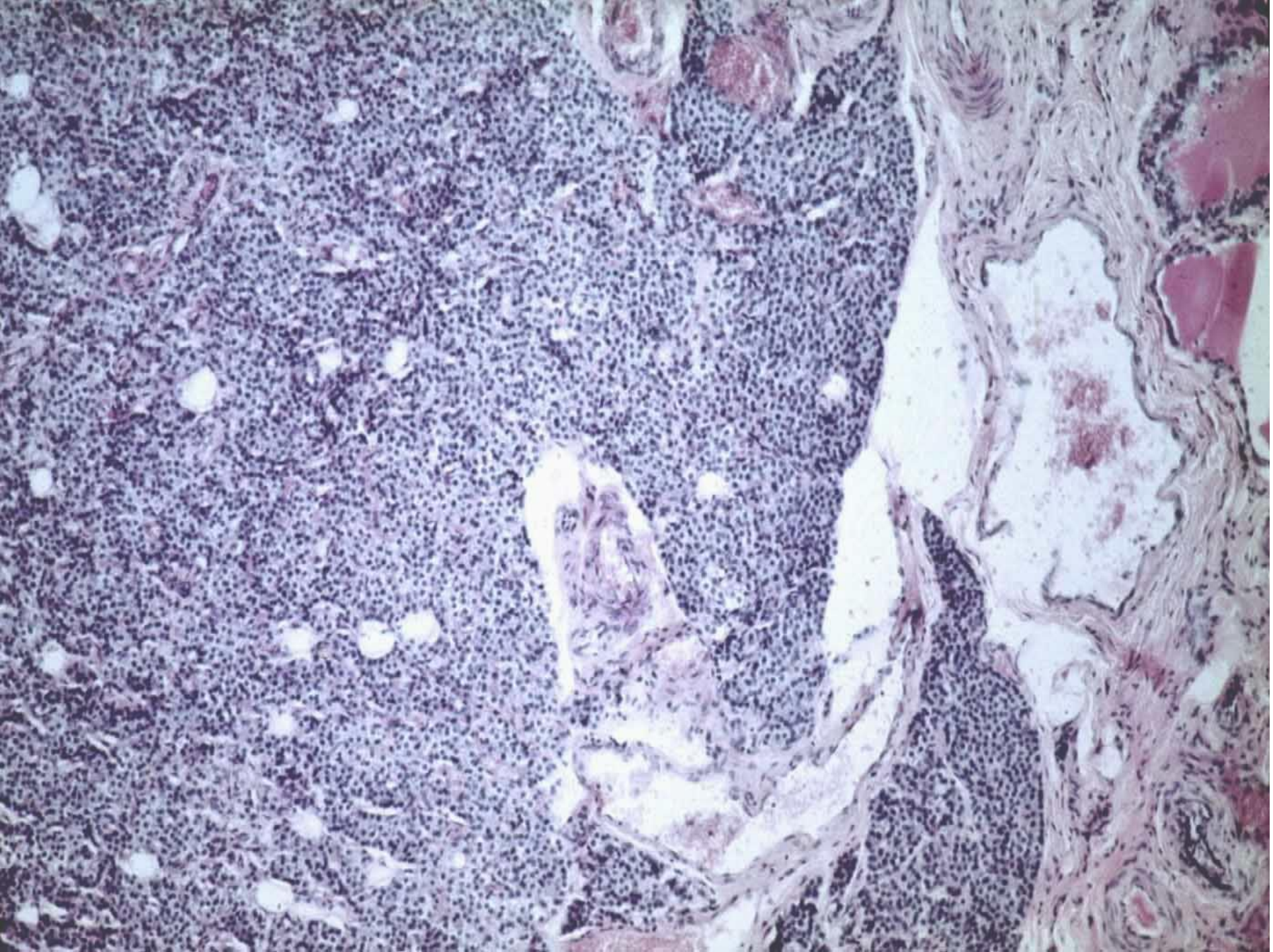
–light cytoplasm, granule containing PTH

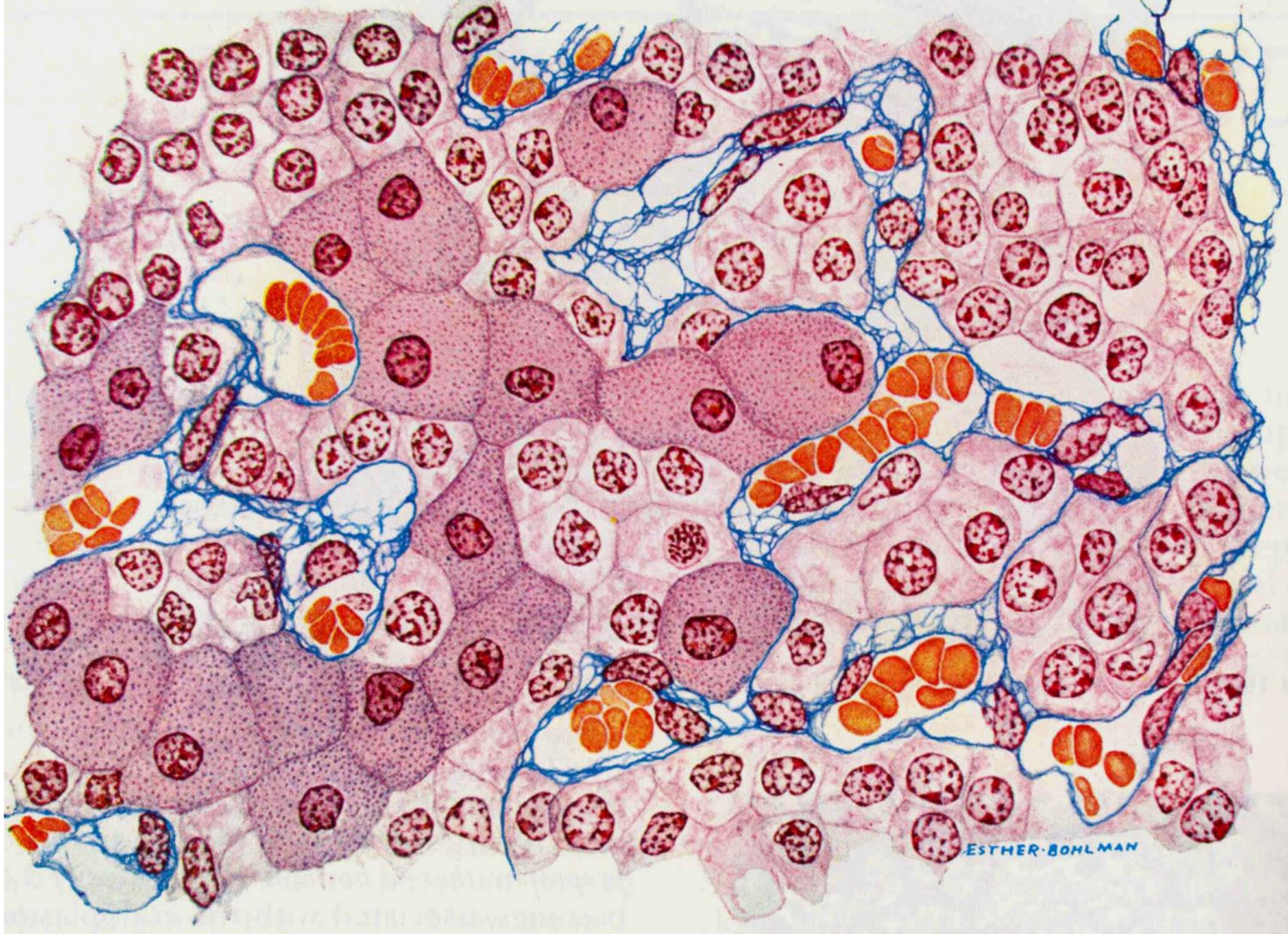
- oxyphilic cells

–fewer, larger

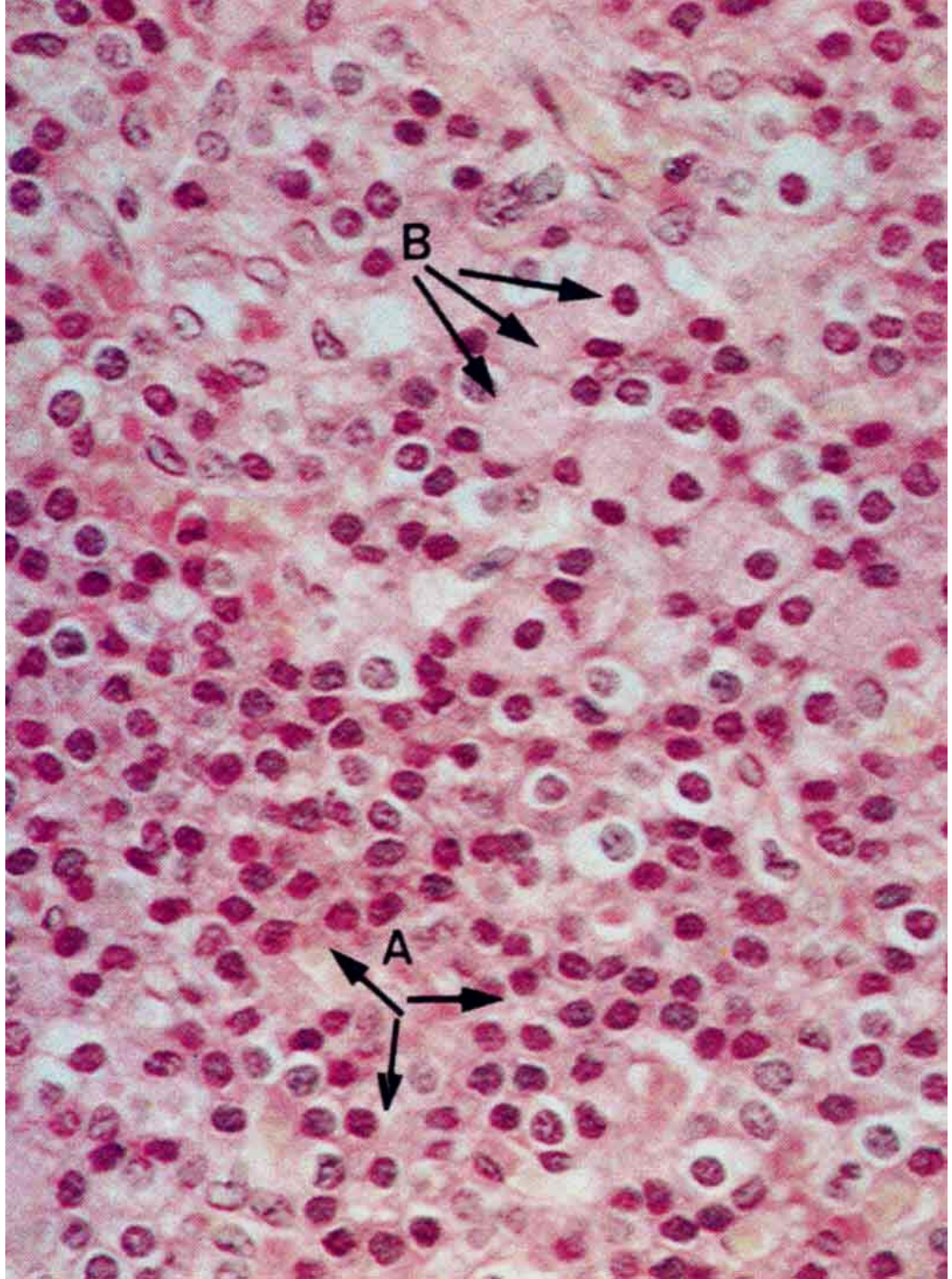
–darker cytoplasm, no granules, numerous MIT

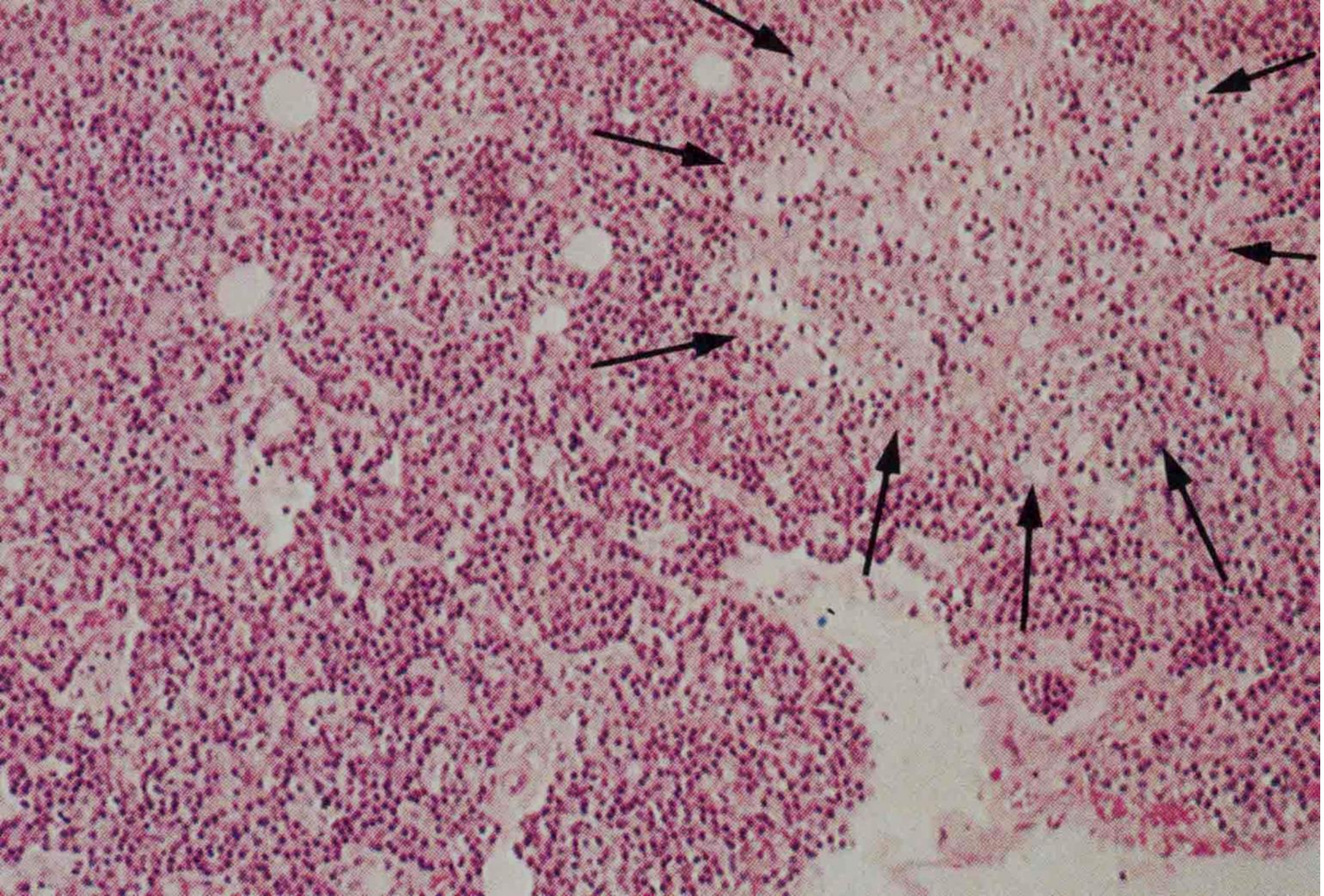
–unclear function, appear as late as 7th year



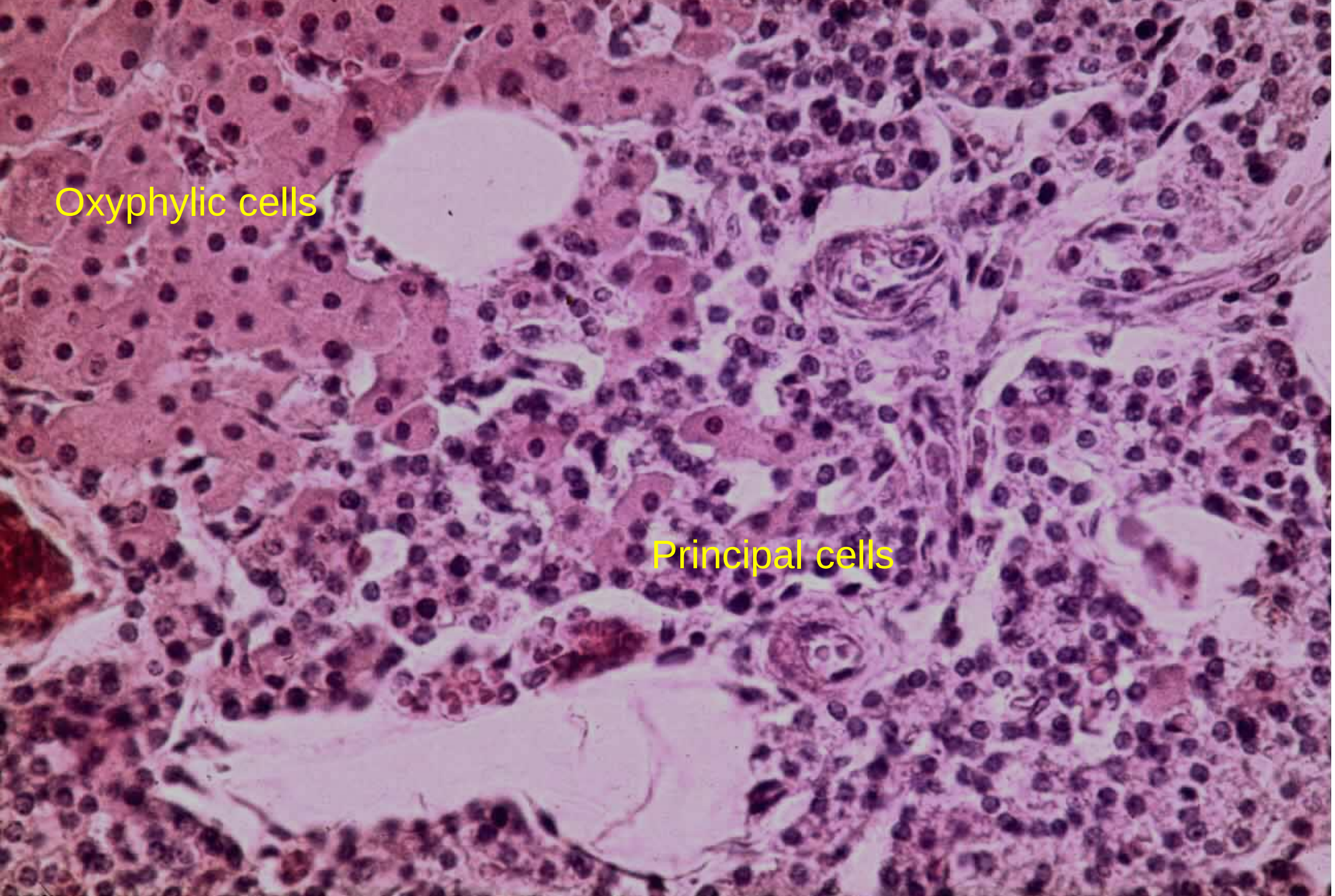

ESTHER·BOHLMAN

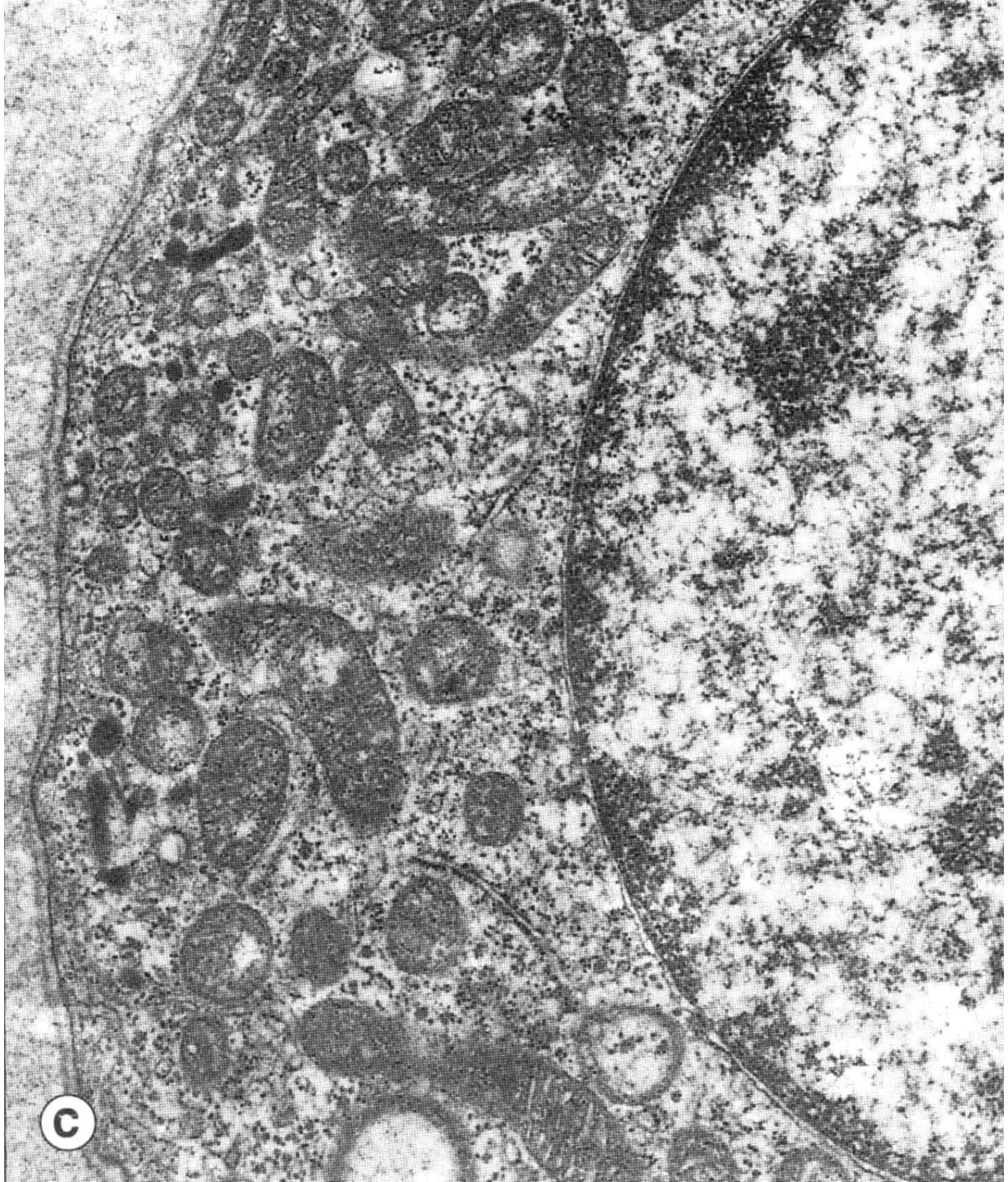
A = principal cells
B = oxyphylic cels





arrows = islet of oxyphylic cells


Oxyphylic cells
Principal cells



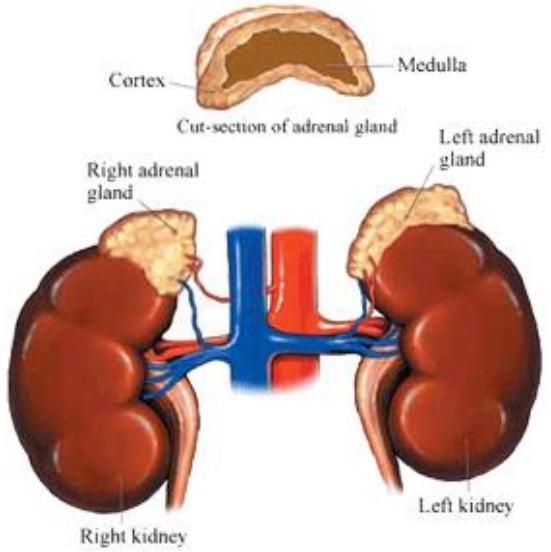
Oxyphyllic cells

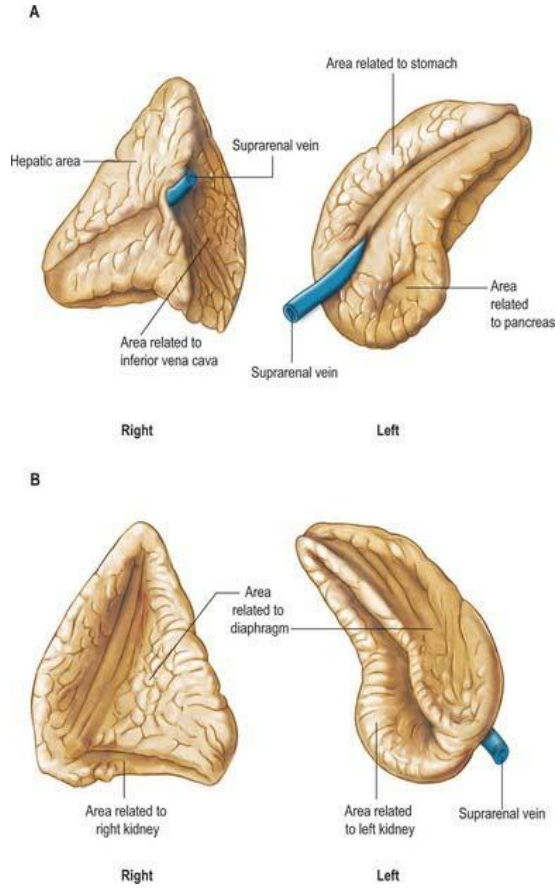
Stevens, A., Lowe, J.: Histology,
Gower Medical Publishing, 1992

Adrenal glands (glandulae suprarenales)

Adrenal glands - 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

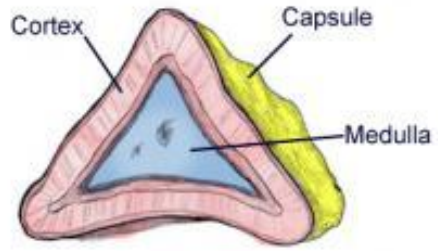




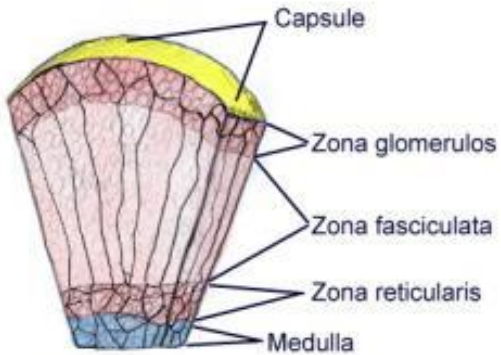
Adrenal gland, suprarenal gland, glandula suprarenalis

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

- cortex
  - **mineralocorticoids**–aldosterone
  - **glucocorticoids**–cortisol, corticosterone
  - androgenes–DEAS=dihydroepiandrosterone
- medulla
  - **catecholamines**–adrenaline, noradrenaline



Transverse section



Microscopic section

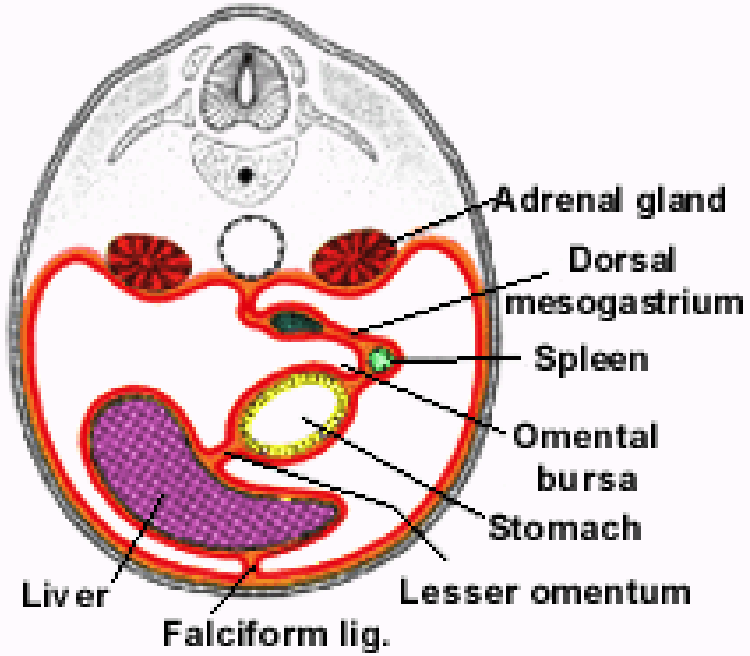
Adrenal gland - development

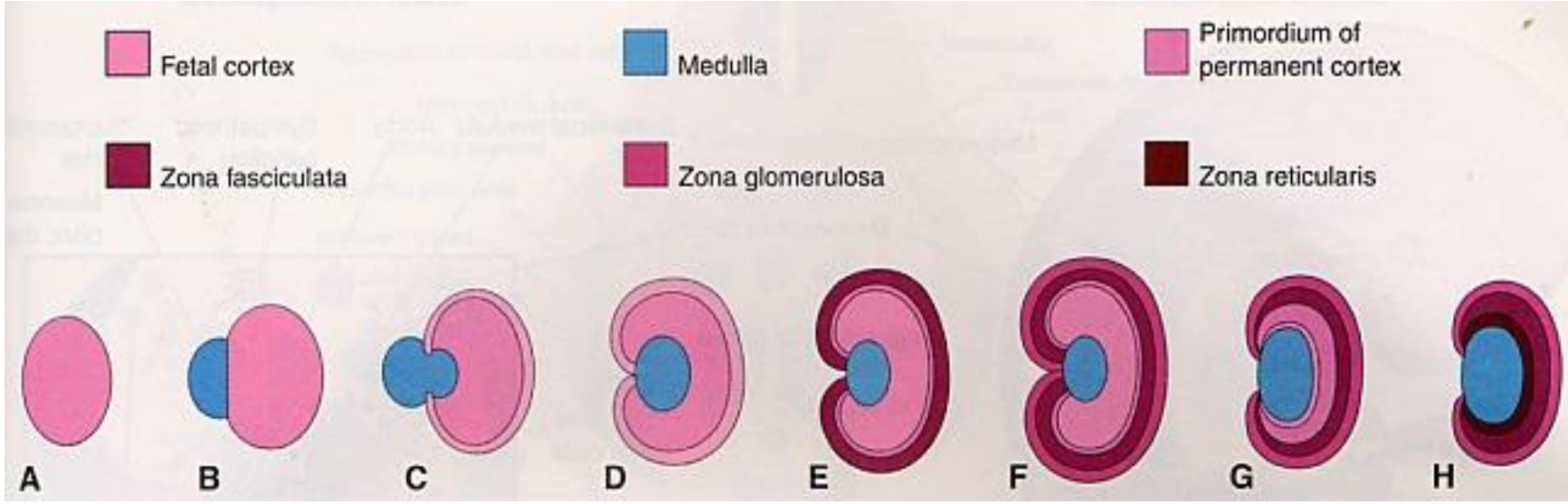
- cortex

–from coelomic epithelium laterally to dorsal mesenterium
–proliferation and migrate towards aorta
–secondary proliferation of cortex - arise of definitive cortex

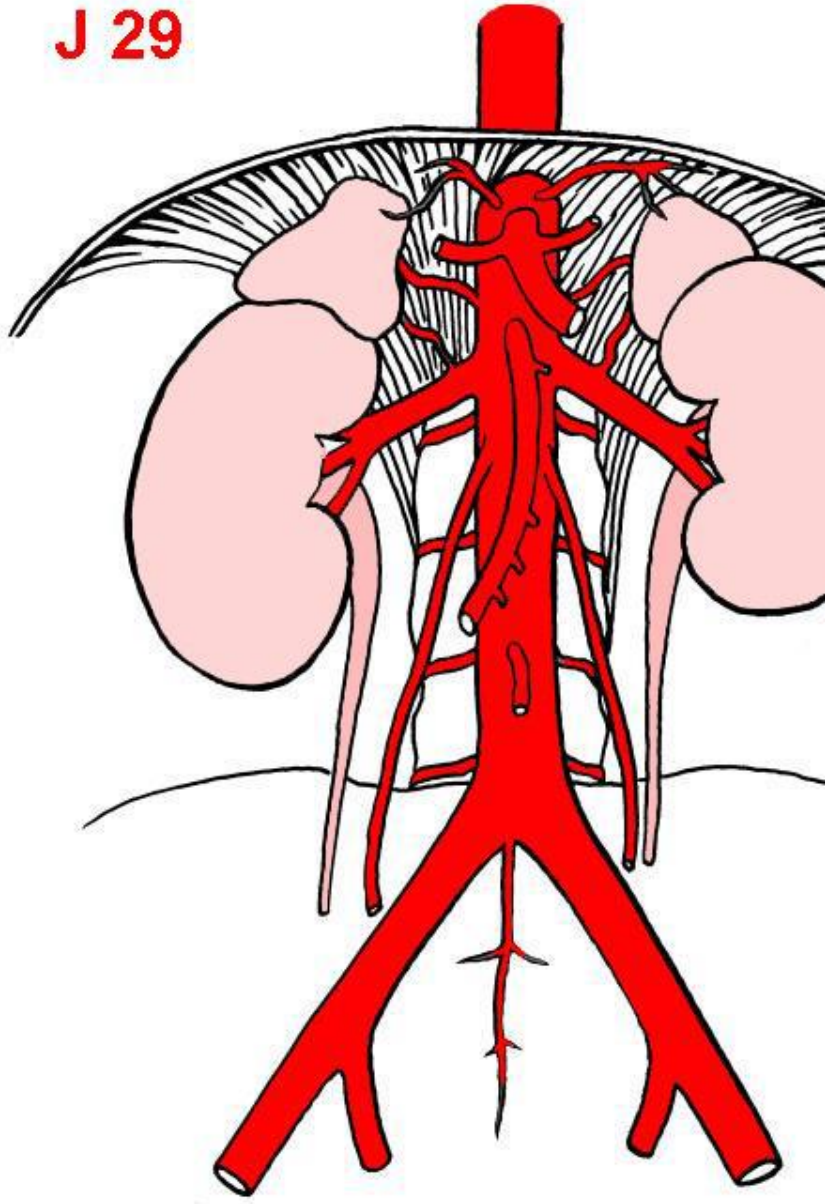
- medulla

–from base of ganglion coeliacum
–sympatoblasts
–migrates to base of cortex





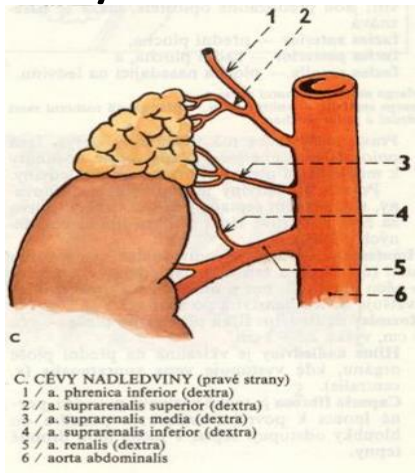
Adrenal glands – blood vessels

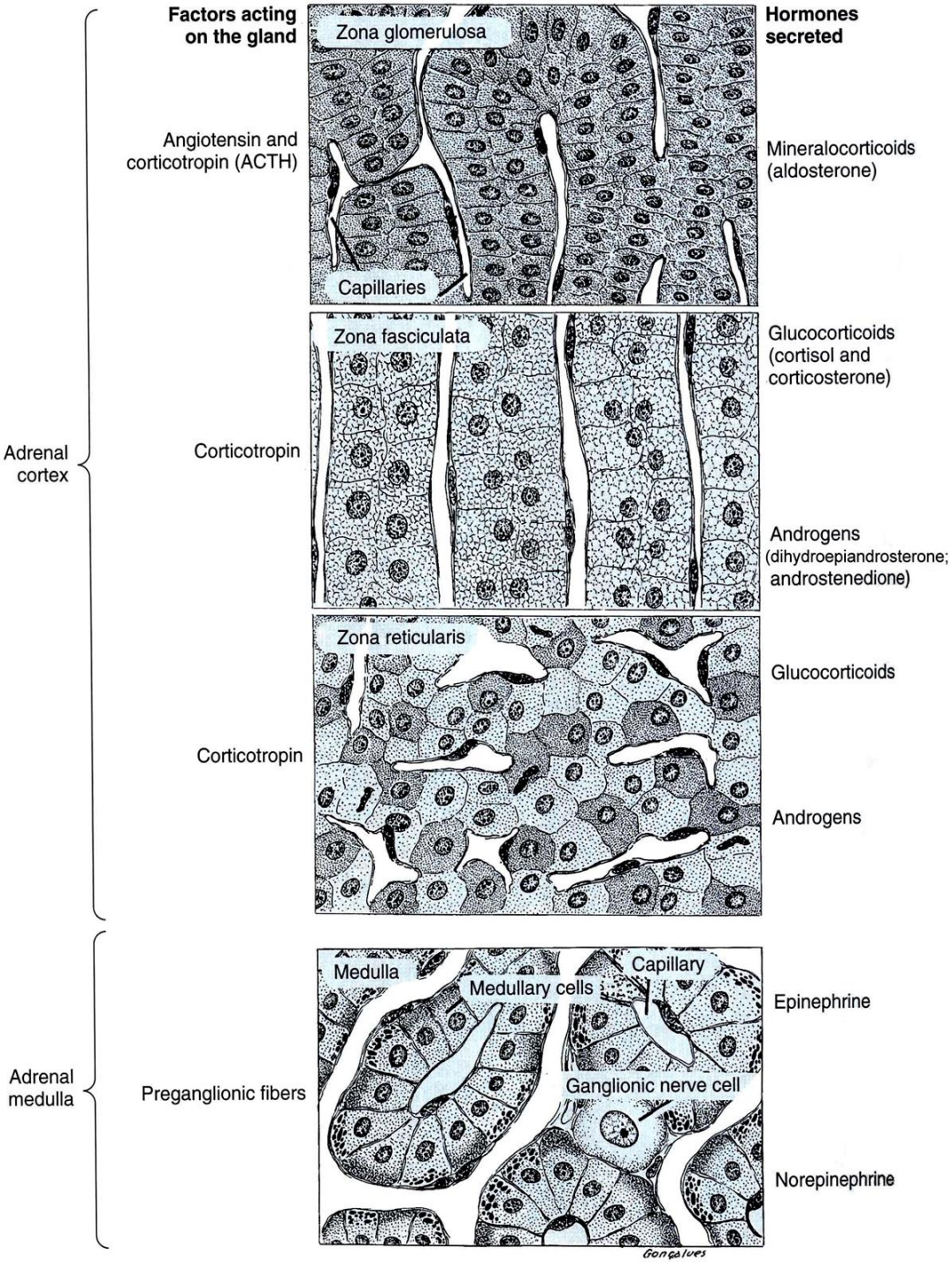


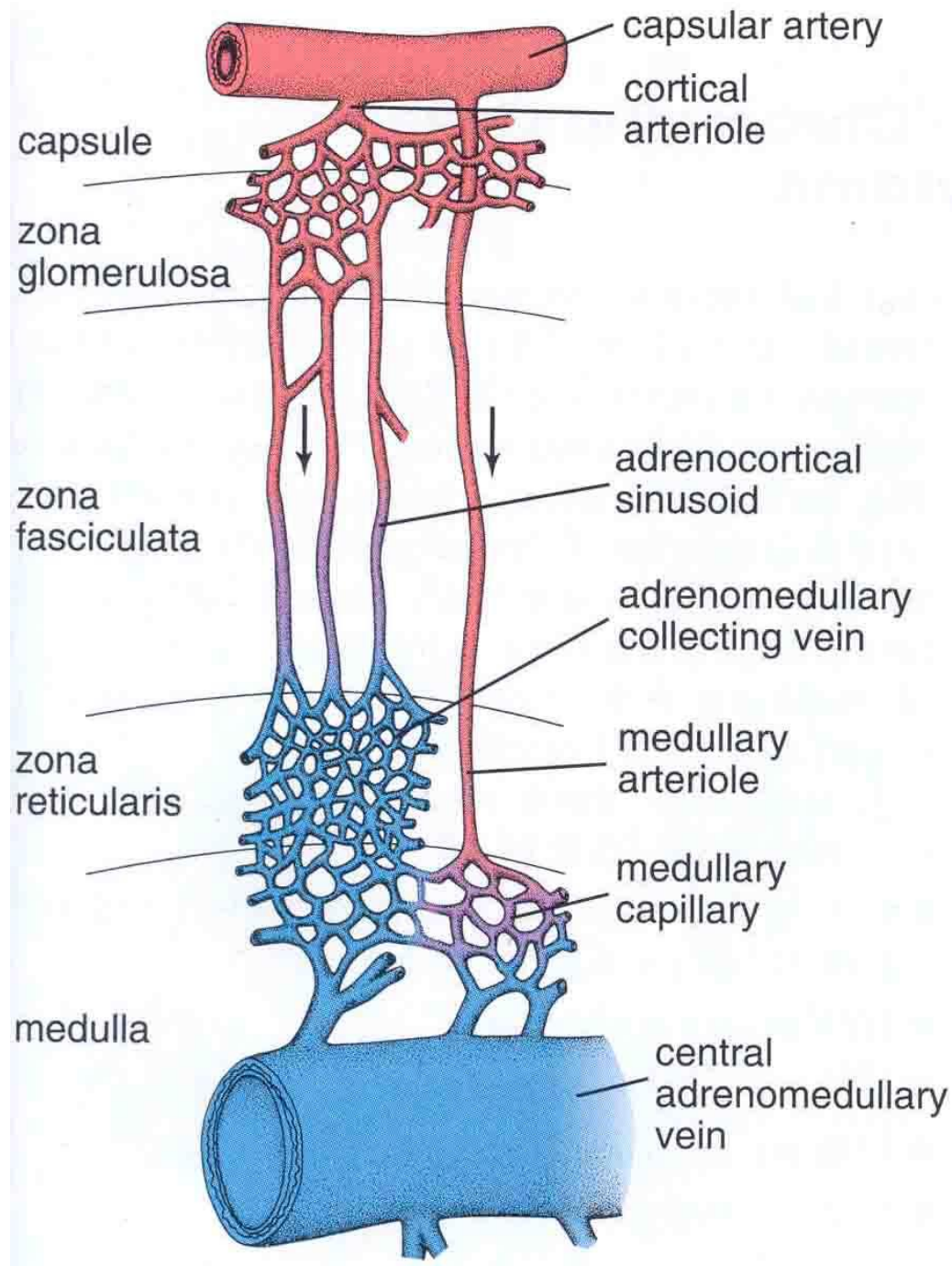
a. suprarenalis superior (← a. phrenica inferior)
- a. suprarenalis media (← aorta abdominalis)
- a. suprarenalis inferior (← a. renalis)

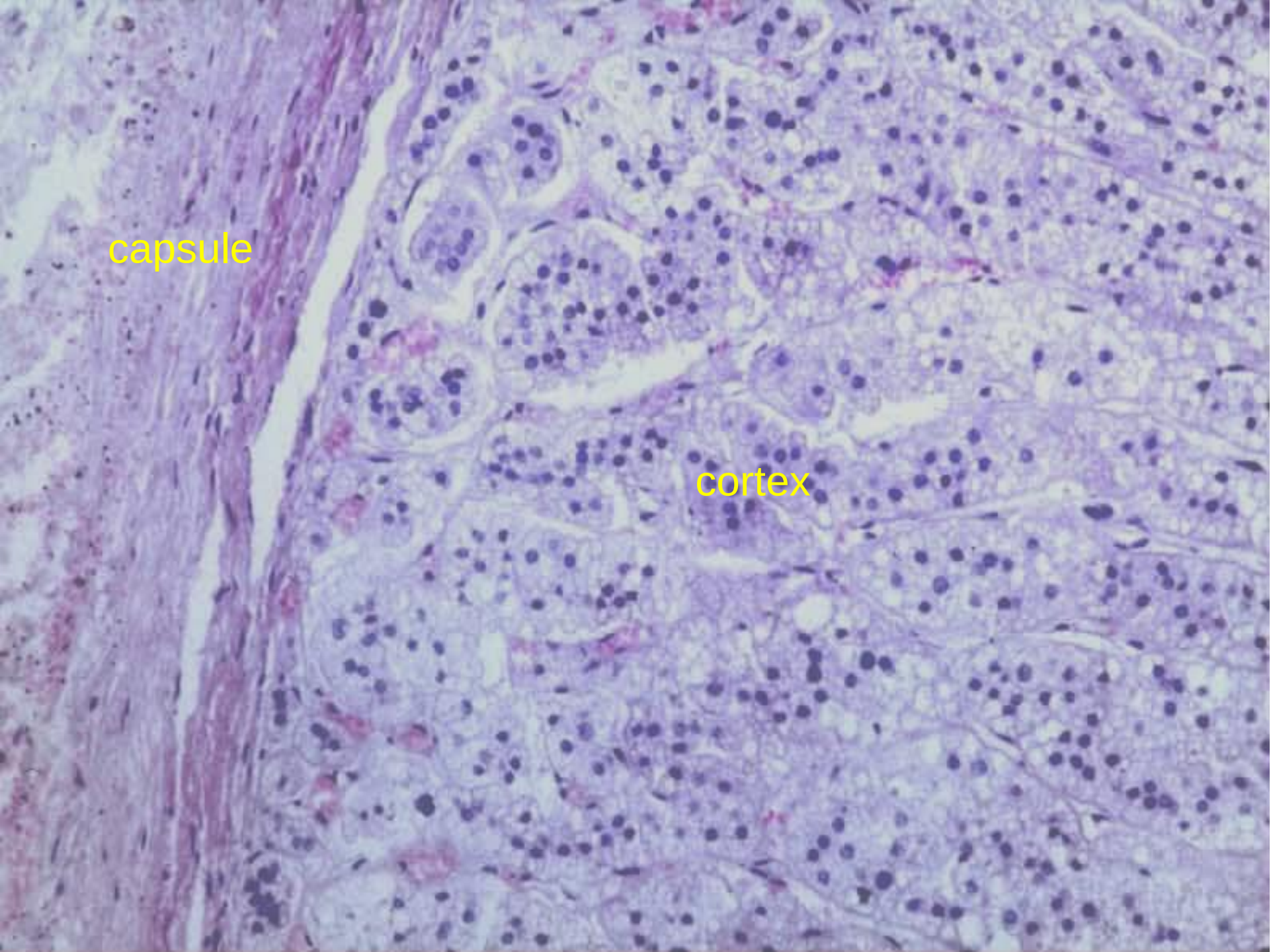
→subcapsular plexus, capillaries + sinusoids pass through cortex →
- vein from medulla → v. centralis →v. suprarenalis

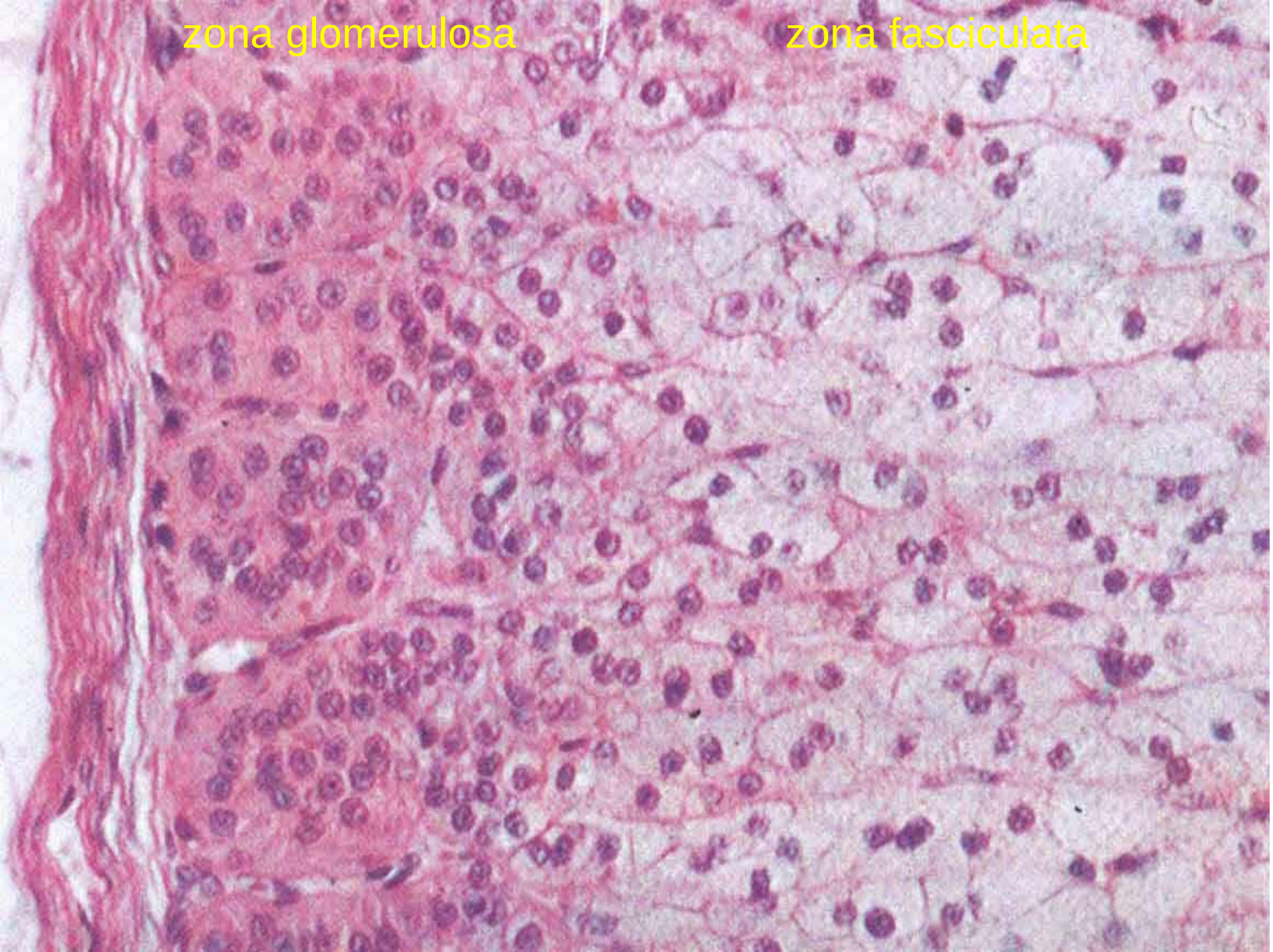
→v. renalis sinistra/ v. cava inferioron the right side

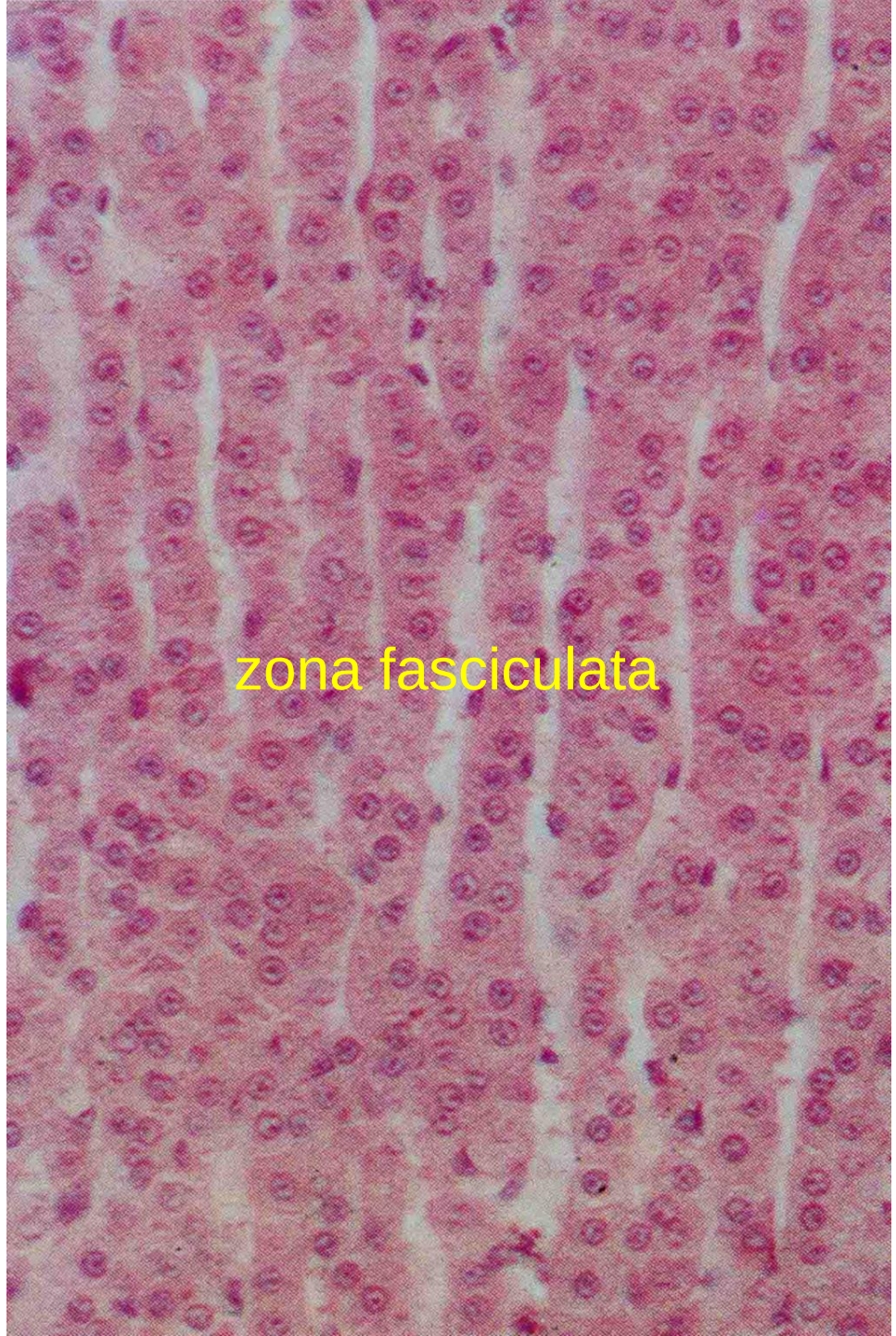


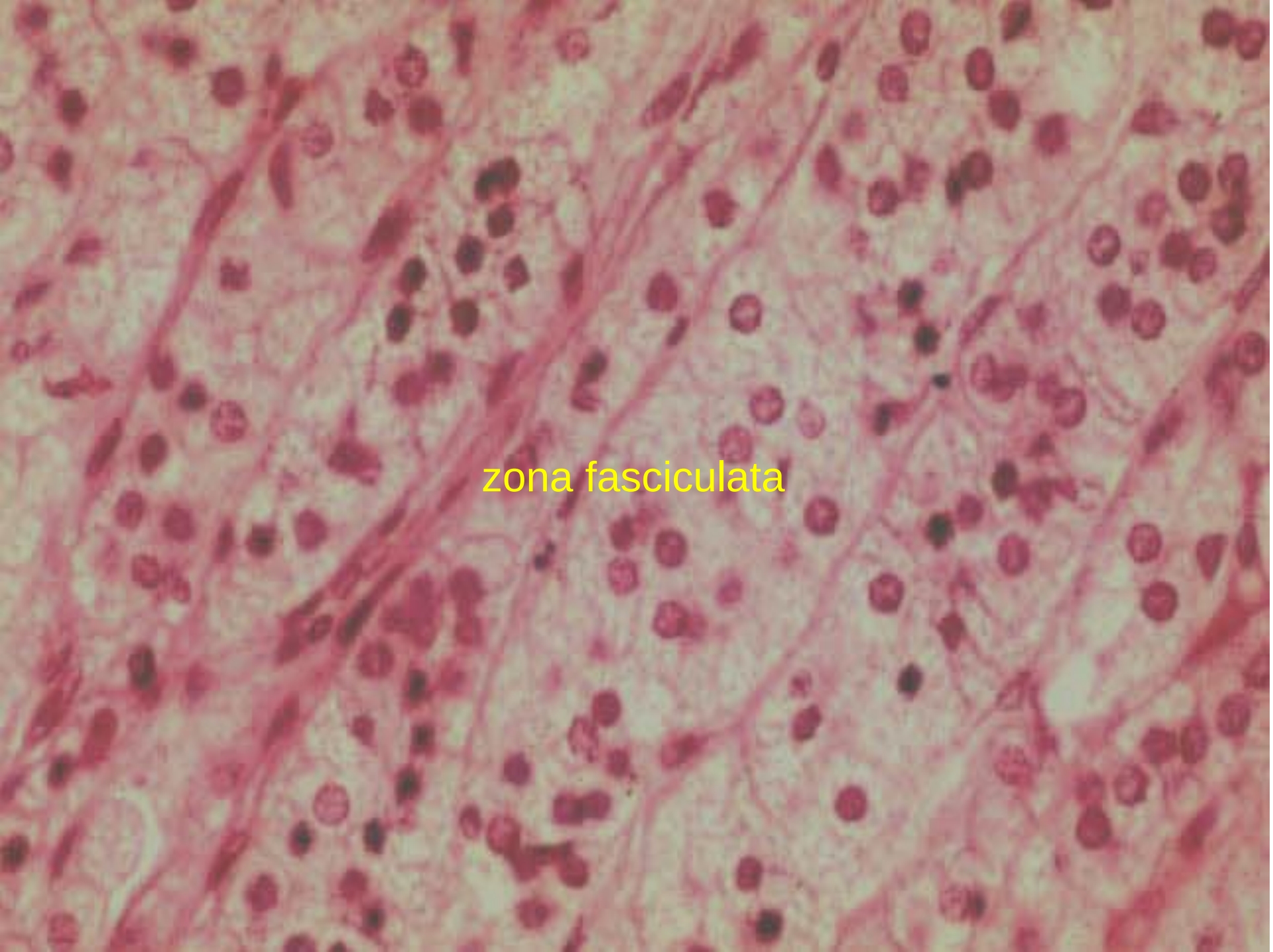

Factors acting on the gland
Hormones secreted
Zona glomerulosa
Angiotensin and corticotropin (ACTH)
Mineralocorticoids (aldosterone)
Capillaries
Zona fasciculata
Glucocorticoids (cortisol and corticosterone)
Corticotropin
Androgens (dihydroepiandrosterone; androstenedione)
Adrenal cortex
Zona reticularis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

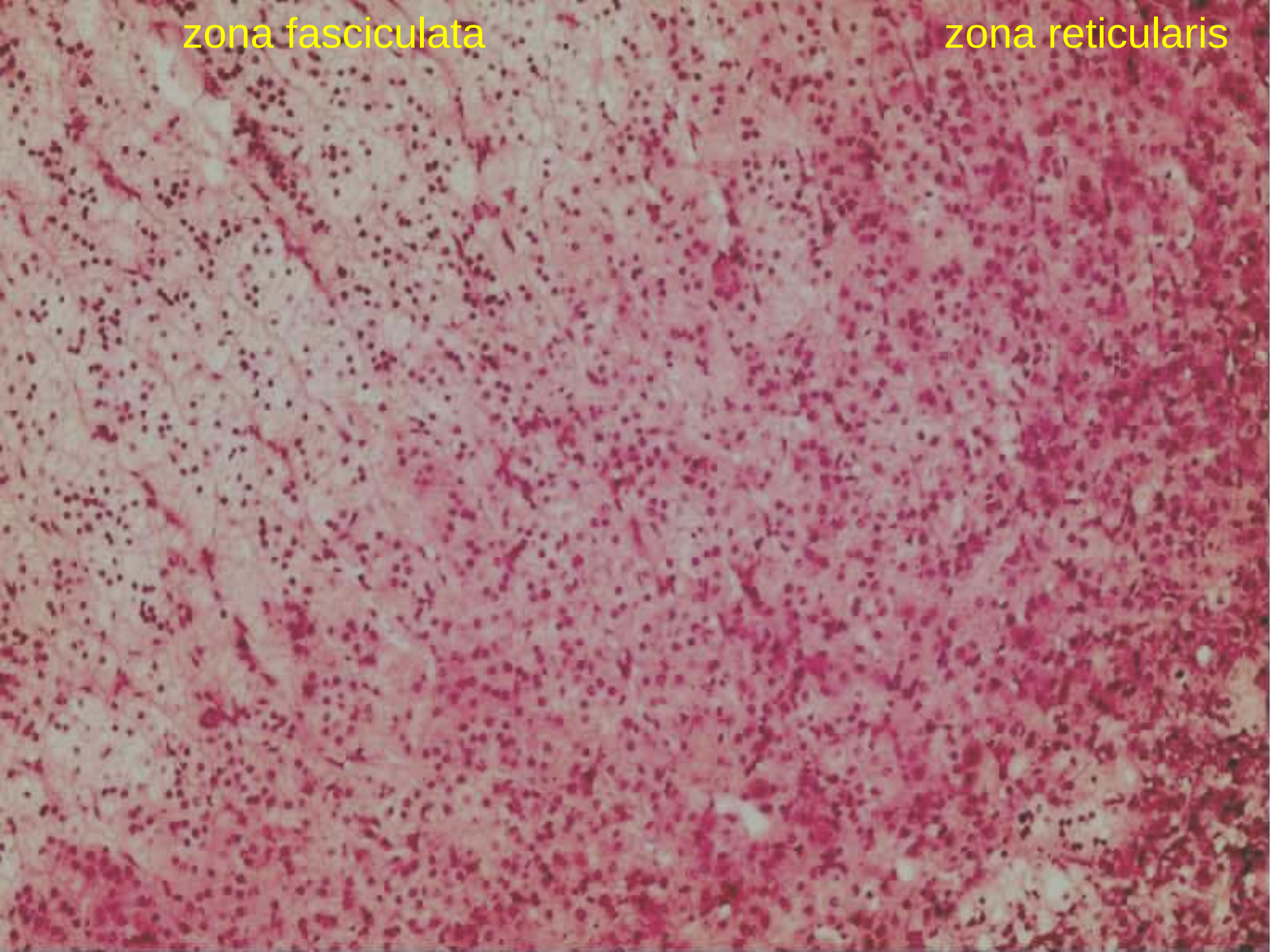

capsular artery
cortical arteriole
capsule
zona glomerulosa
adrenocortical sinusoid
zona fasciculata
adrenomedullary collecting vein
medullary arteriole
zona reticularis
medullary capillary
medulla
central adrenomedullary vein

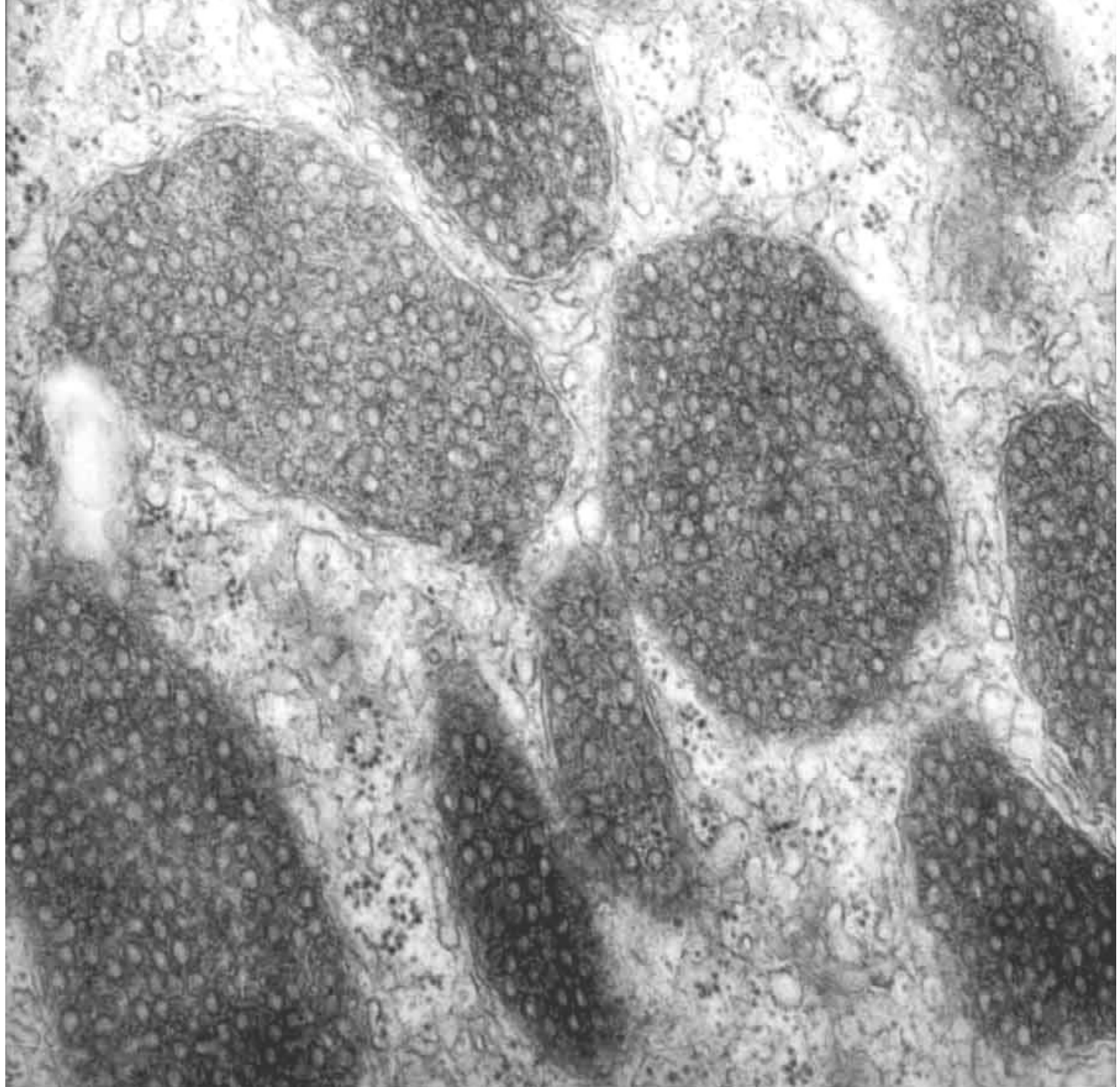

capsule
cortex

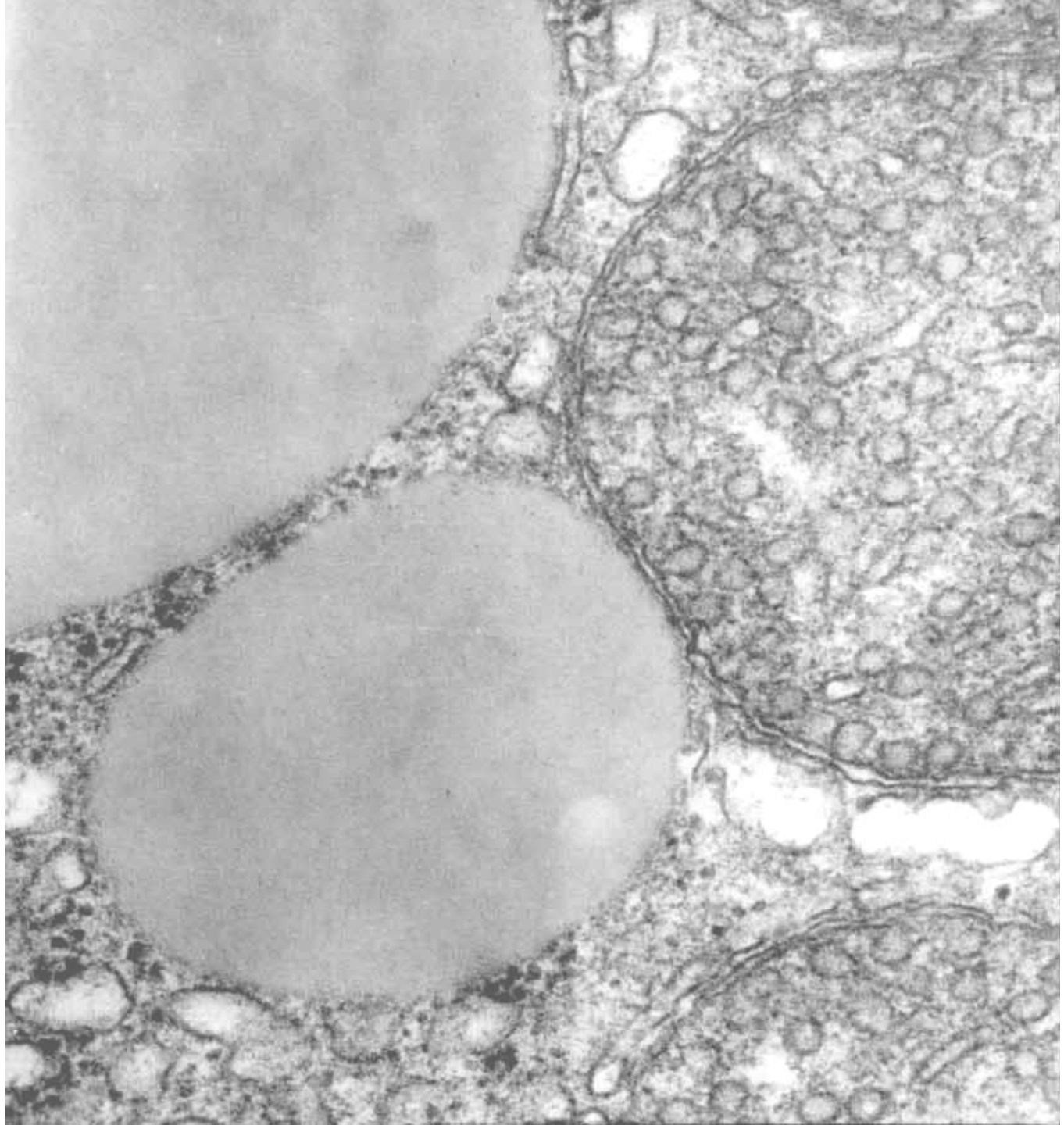

zona glomerulosa
zona fasciculata

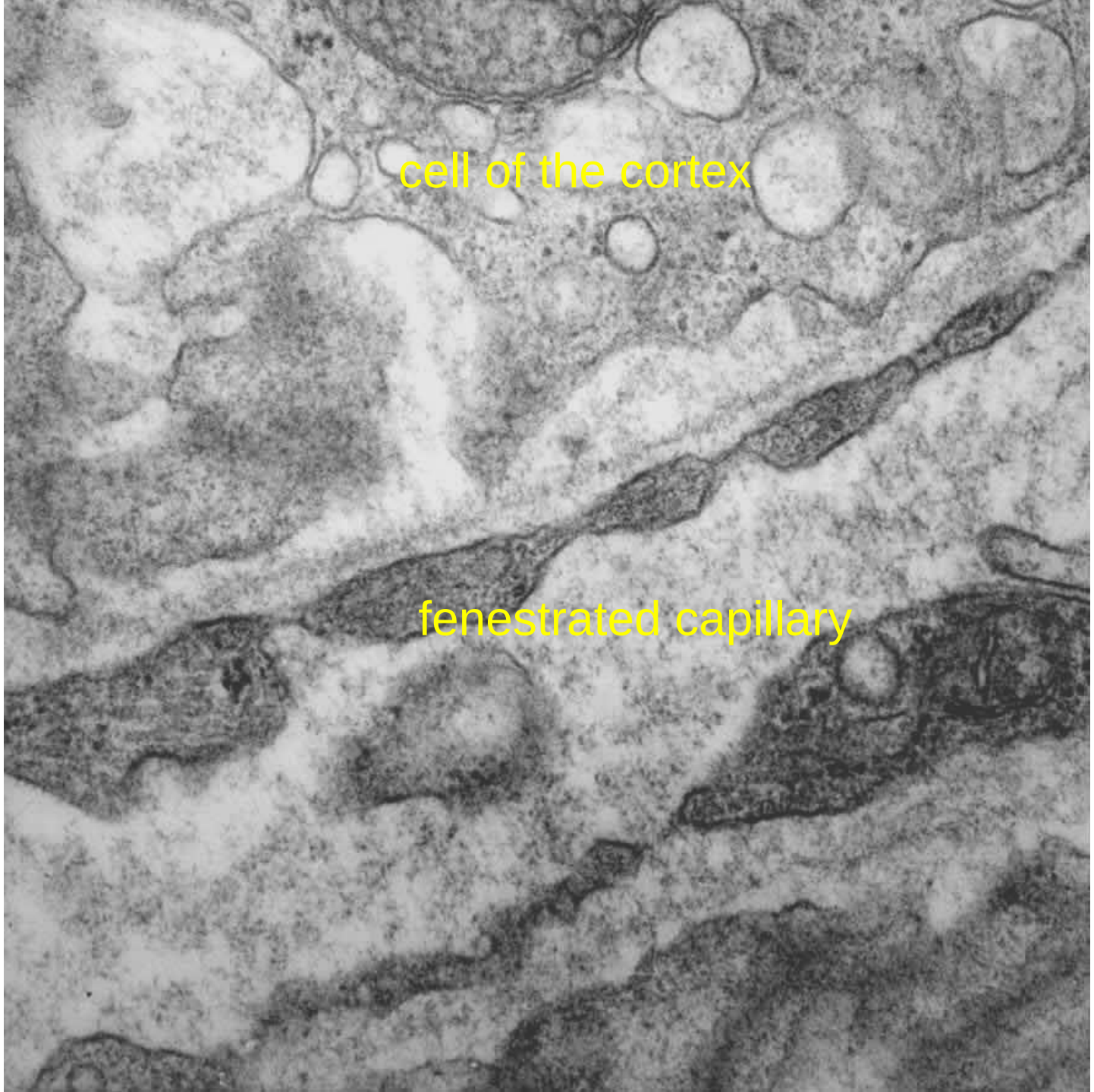

zona fasciculata

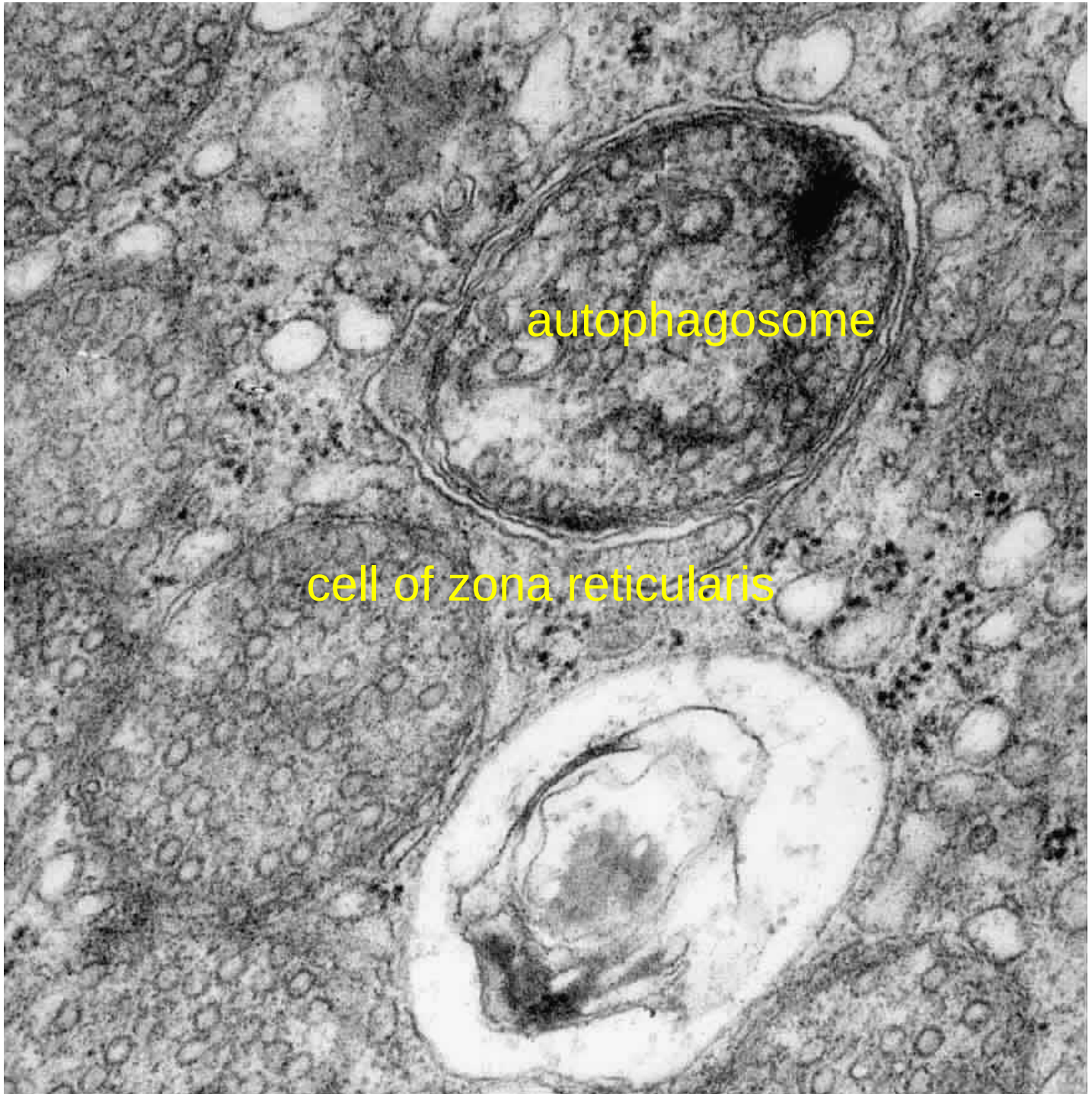

zona fasciculata

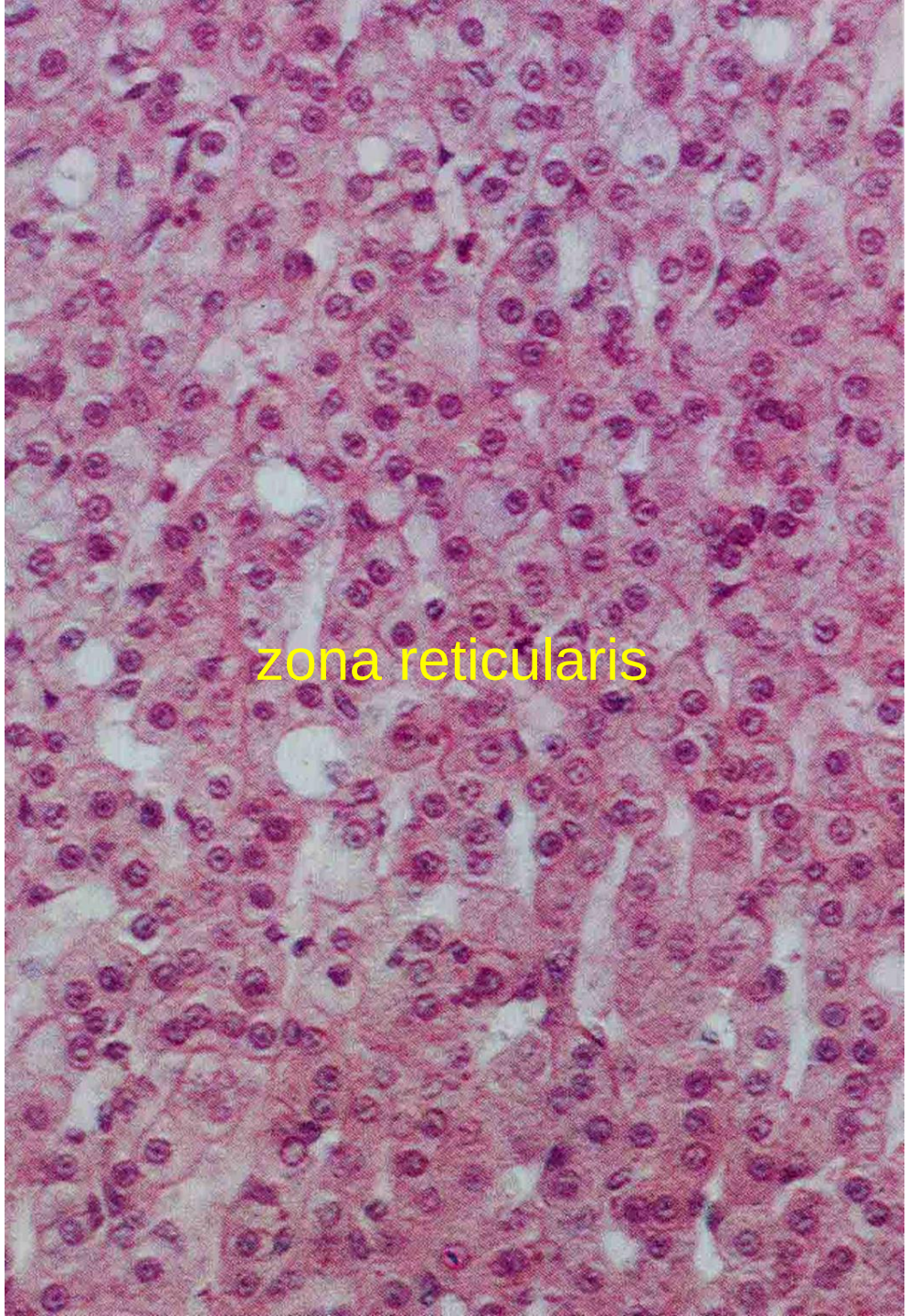

zona fasciculata
zona reticularis

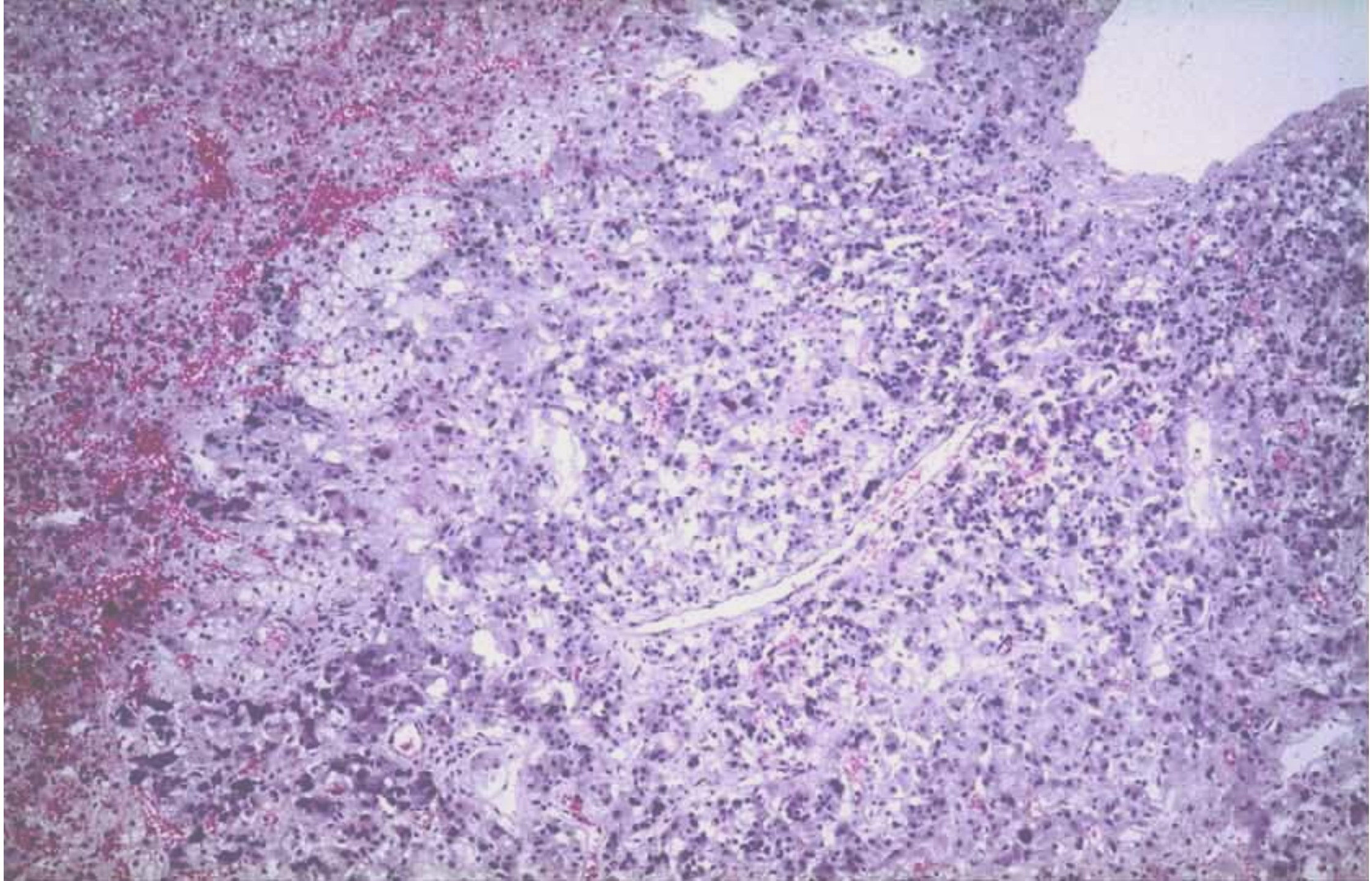





cell of the cortex
fenestrated capillary

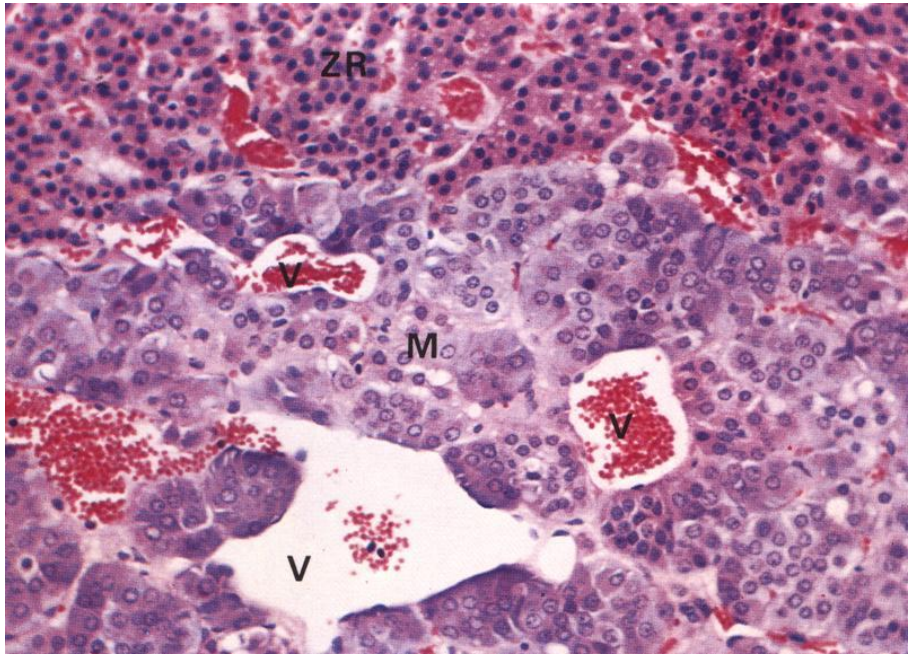

autophagosome
cell of zona reticularis

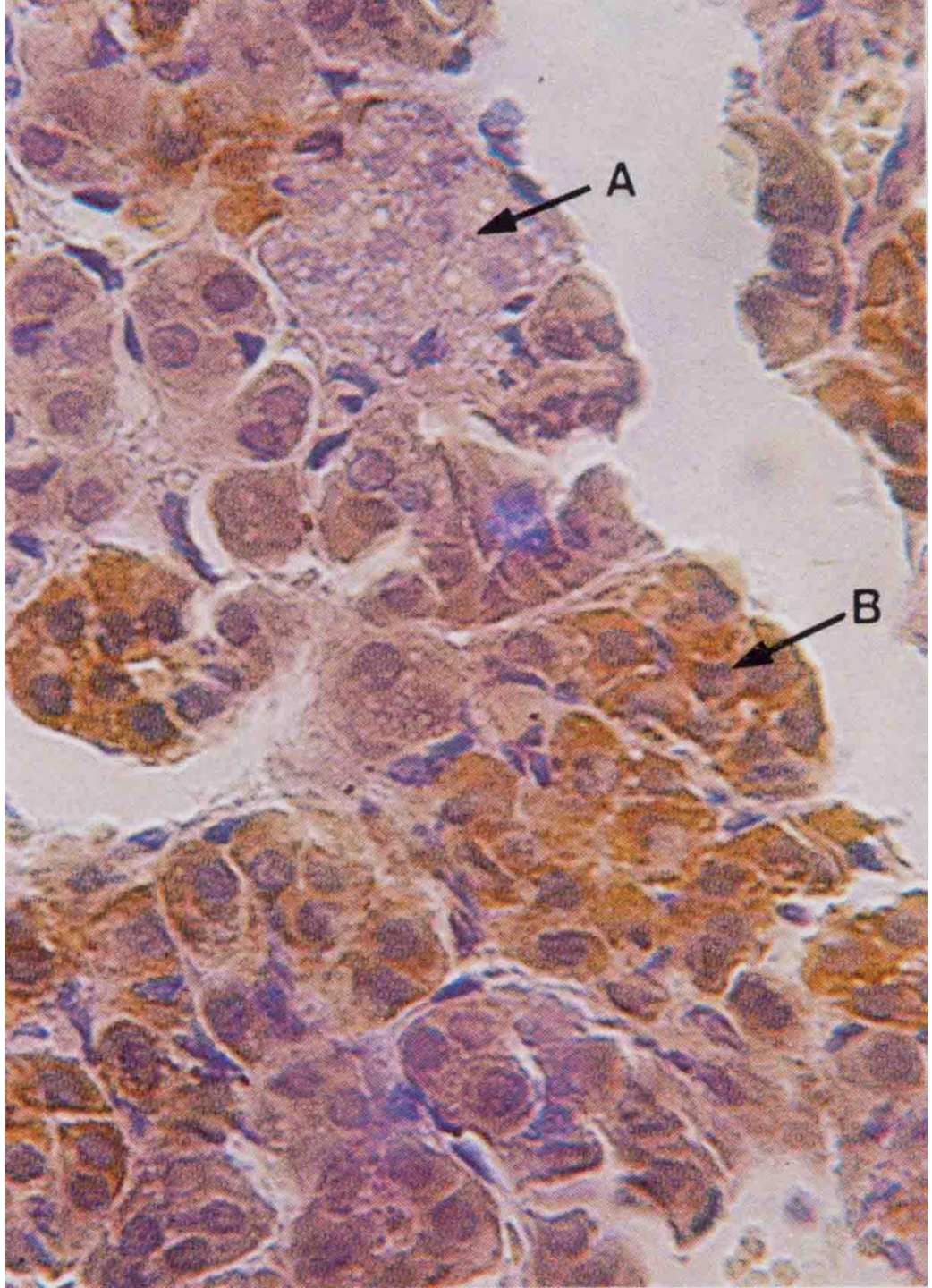

zona reticularis



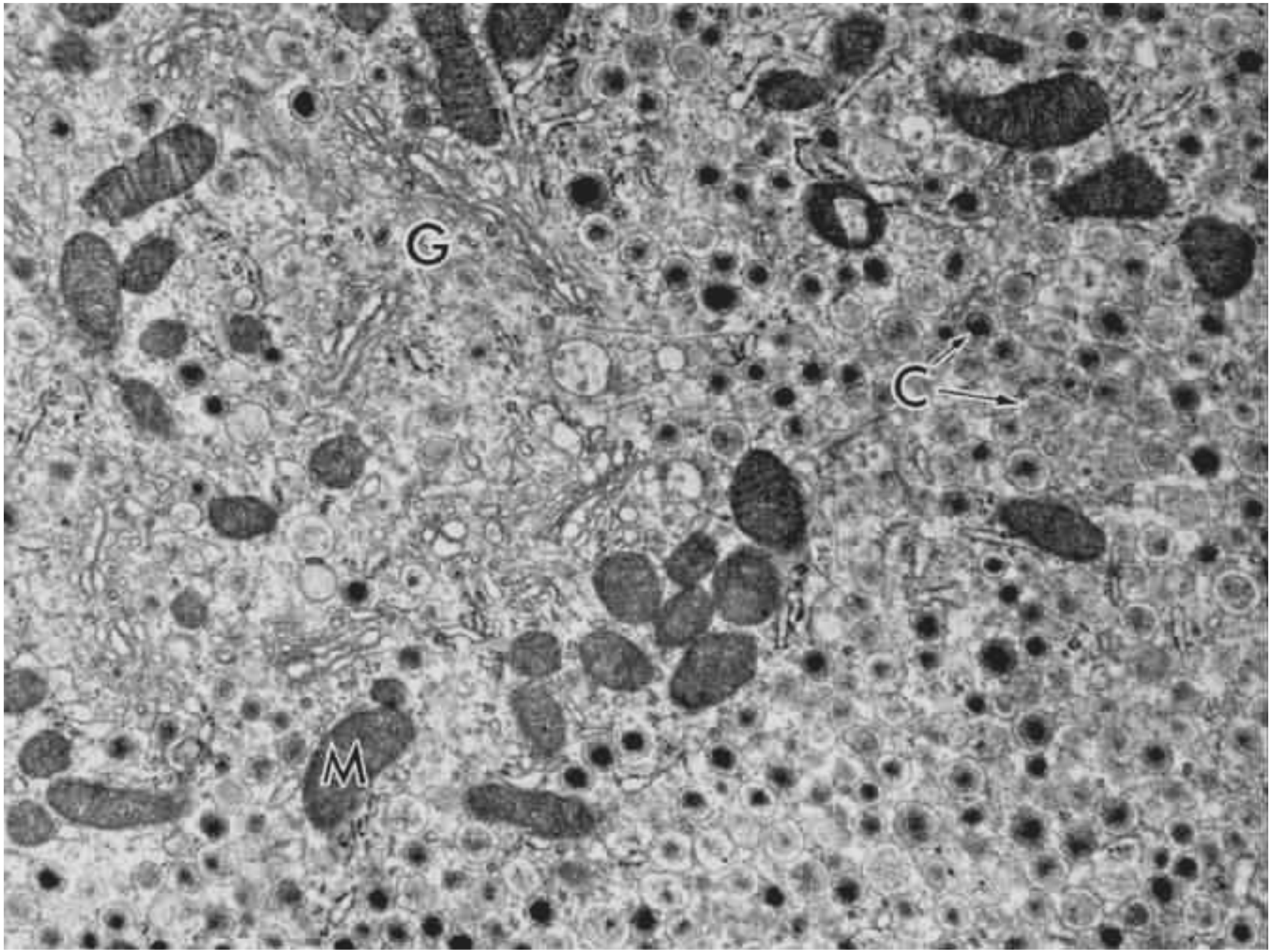
Adrenal glands – medulla

- anastomosing columns of polyhedric cells
- large cells
  - –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





fixation glutaraldehyde + dichromate
A = cells producing adrenaline
B = cells producing noradrenaline



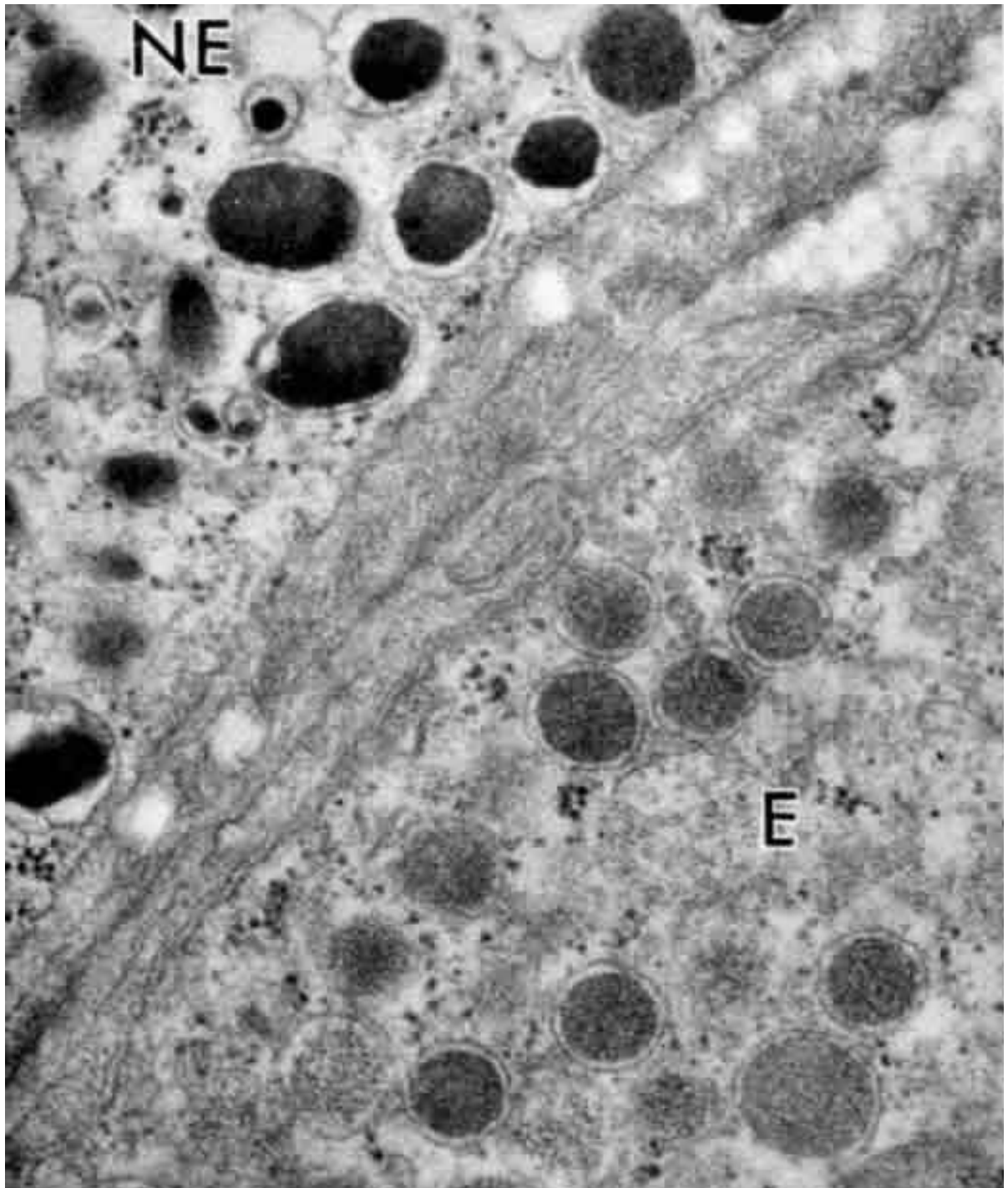
cell producing adrenaline

C = secretion granules

G = Golgi complex

M = mitochondria

E = cell producing adrenaline
NE = cell producng noradrenaline

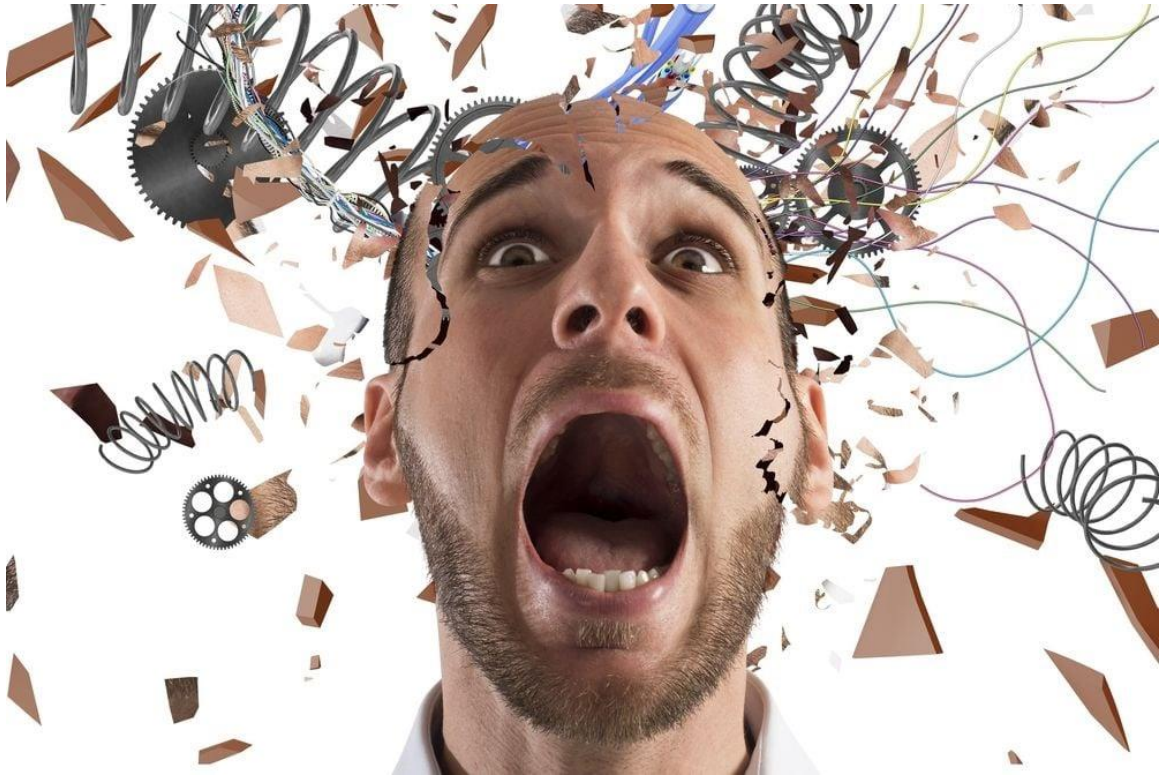


Stress reaction (fight or flight or fright)

sympathetic activation (suprarenal cortex and medulla)

- effect on vascular smooth muscle ➡ vasodilatation in skeletal 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



https://www.smithsonianmag.com/science-nature/what-happens-your-body-when-youre-stressed-180964357/

Pancreas – endocrine part

Pancreas – 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)

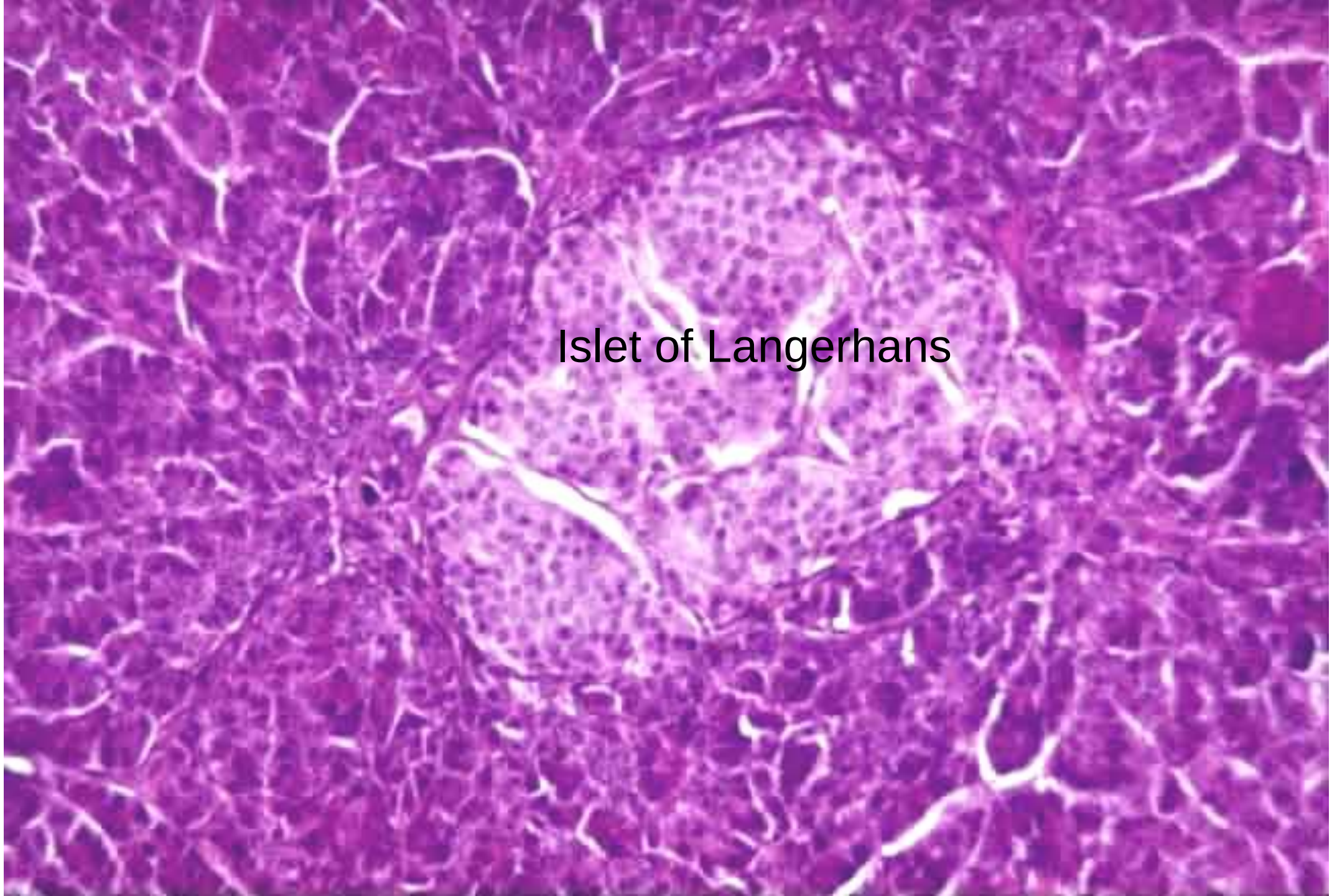
–extract from canine pancreas → treatment of dogs with diabetes

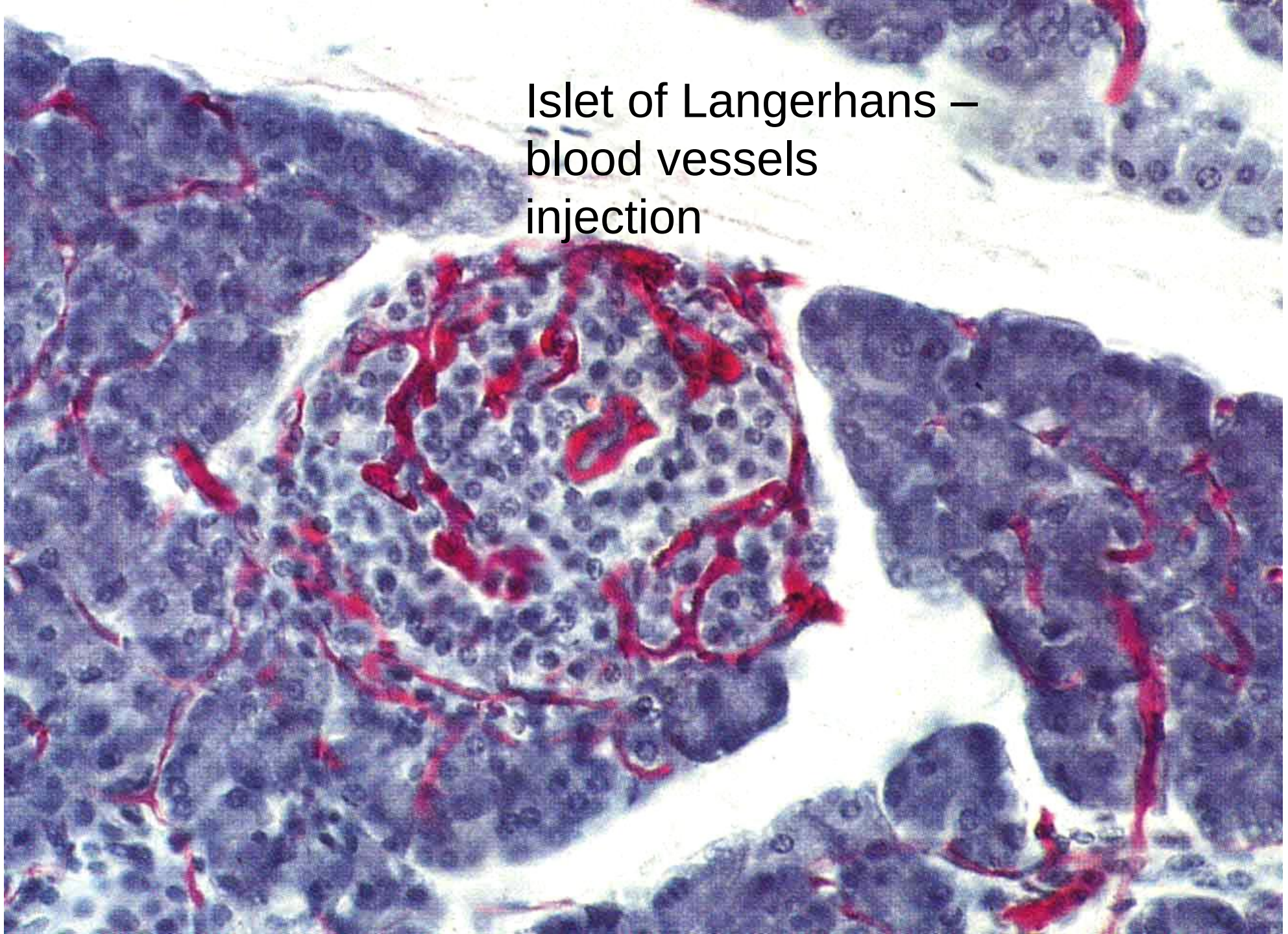
–treatment of patients

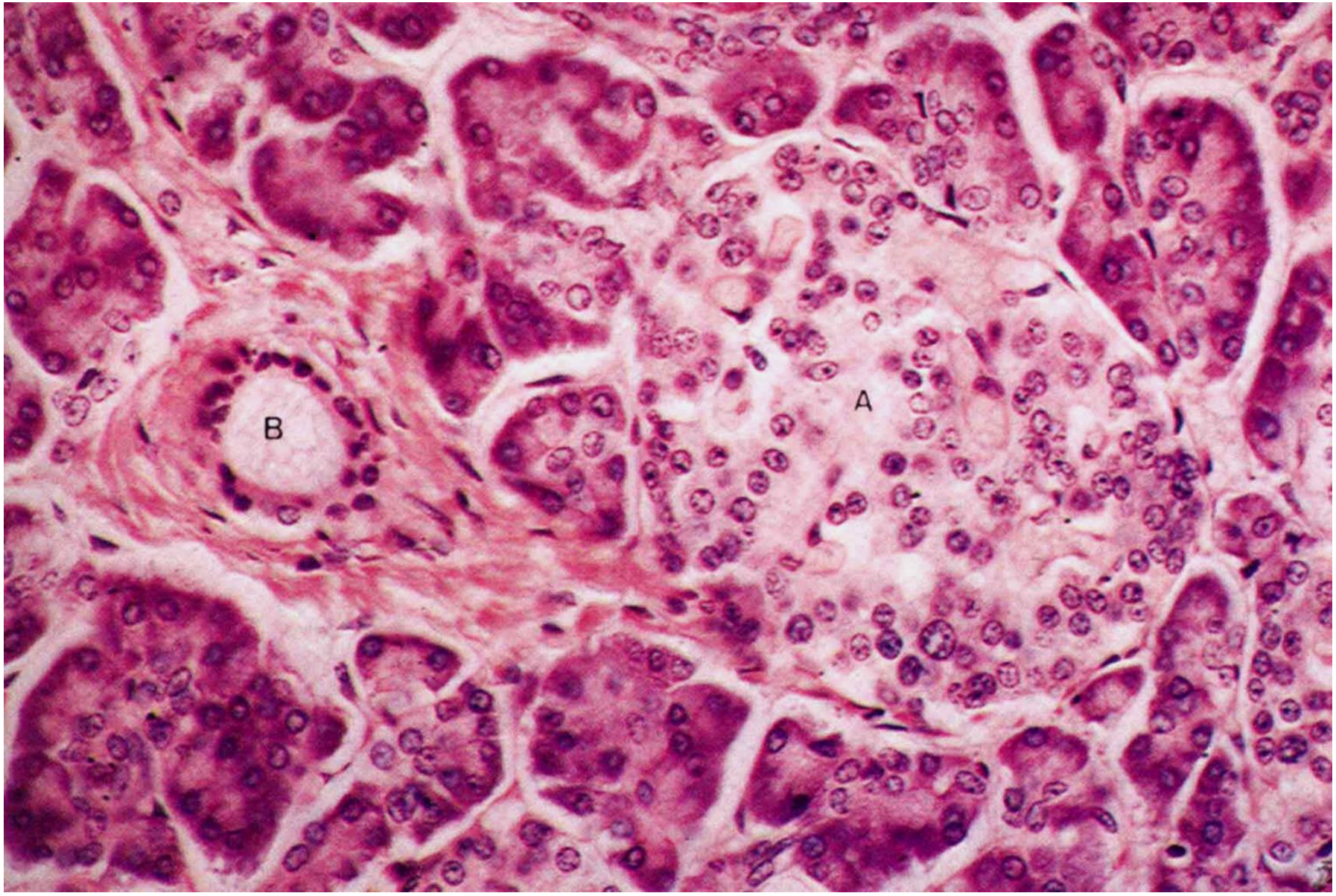
- 1929 –Nobel prize for Banting and Macleod

Pancreas – Islets of Langerhans (*Insulae pancreaticae)*

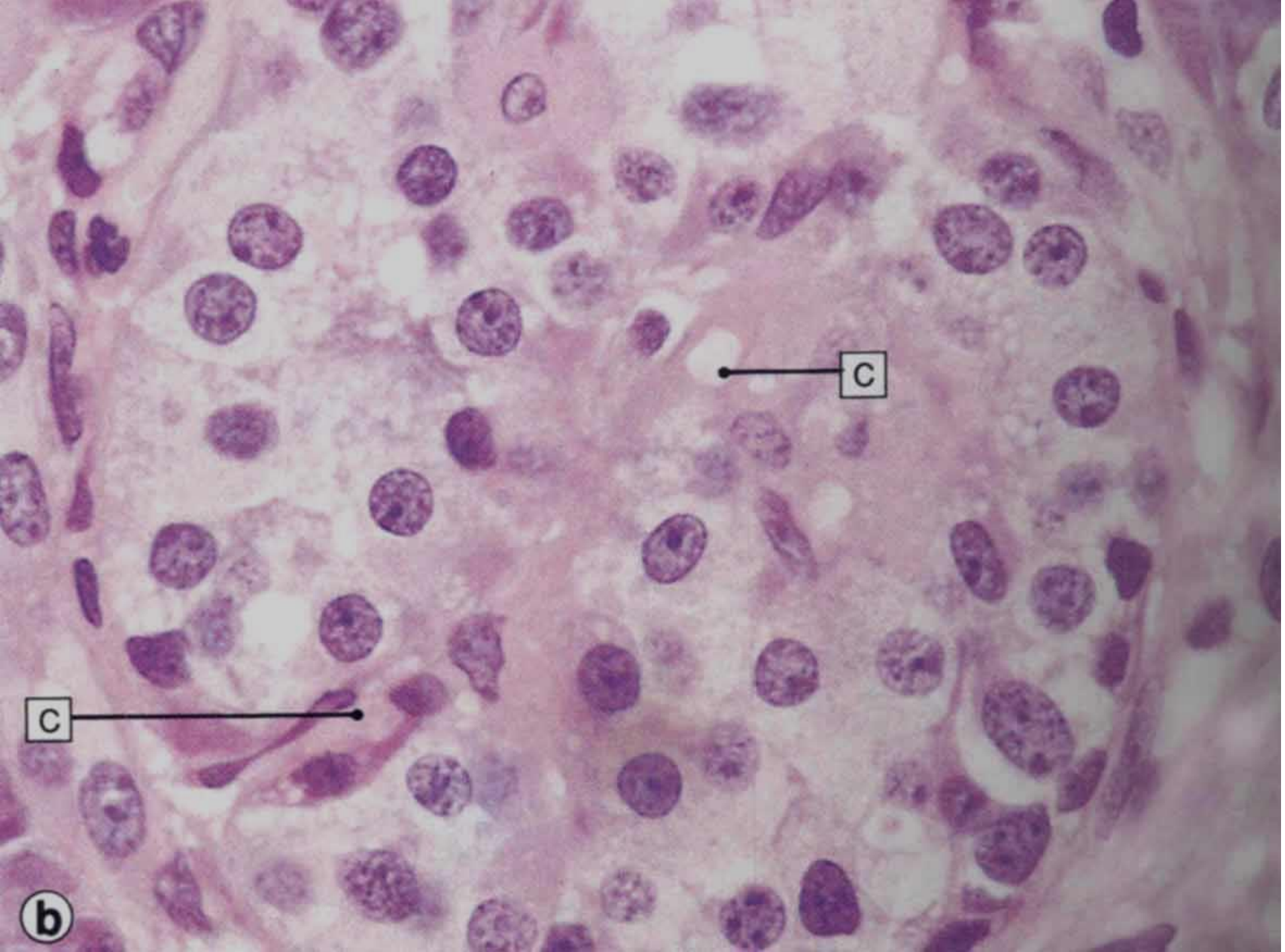
- endocrine part of pancreas
- 0,1–0,2 mm large
- totally 1–1.5 million
- various type of cells: A, B, D, PP (G)
- hormones:
  - insulin
  - glucagon
  - somatostatine
  - pancreatic polypeptide


Islet of Langerhans

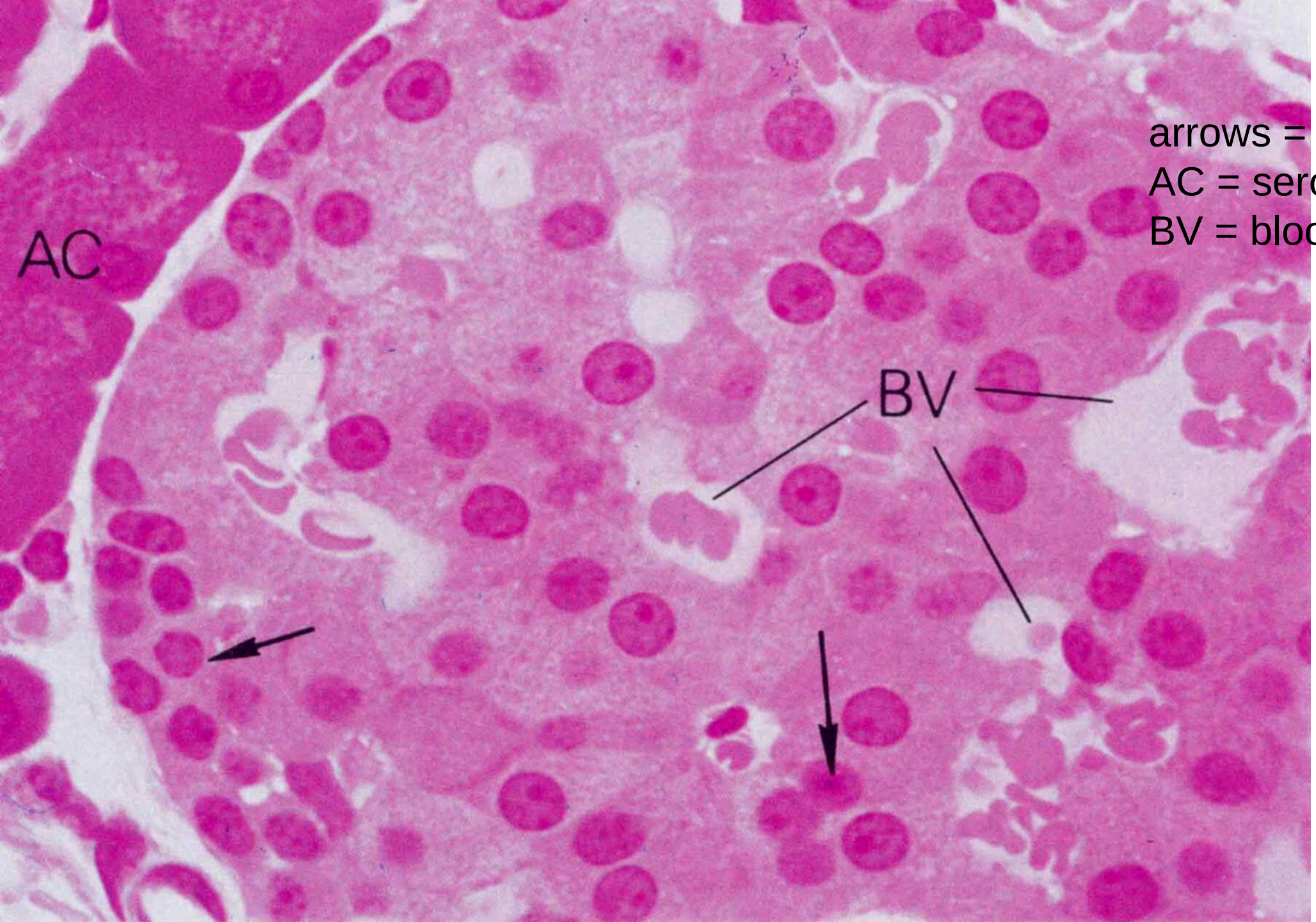

Islet of Langerhans –
blood vessels
injection



A = Islet of Langerhans
B = interlobular duct



C = capillaries



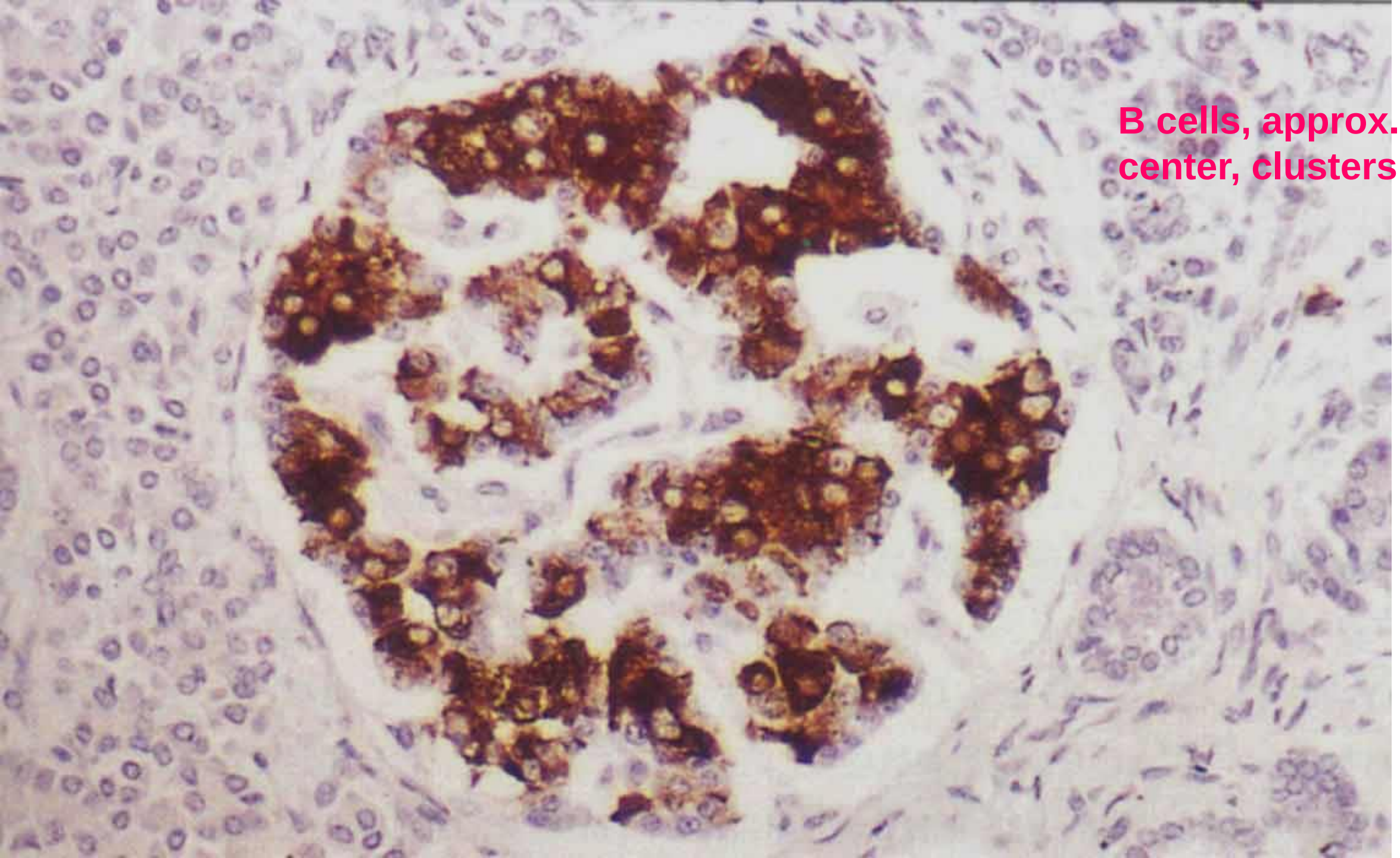
arrows = secretion cells
AC = serous acinus
BV = blood vessels

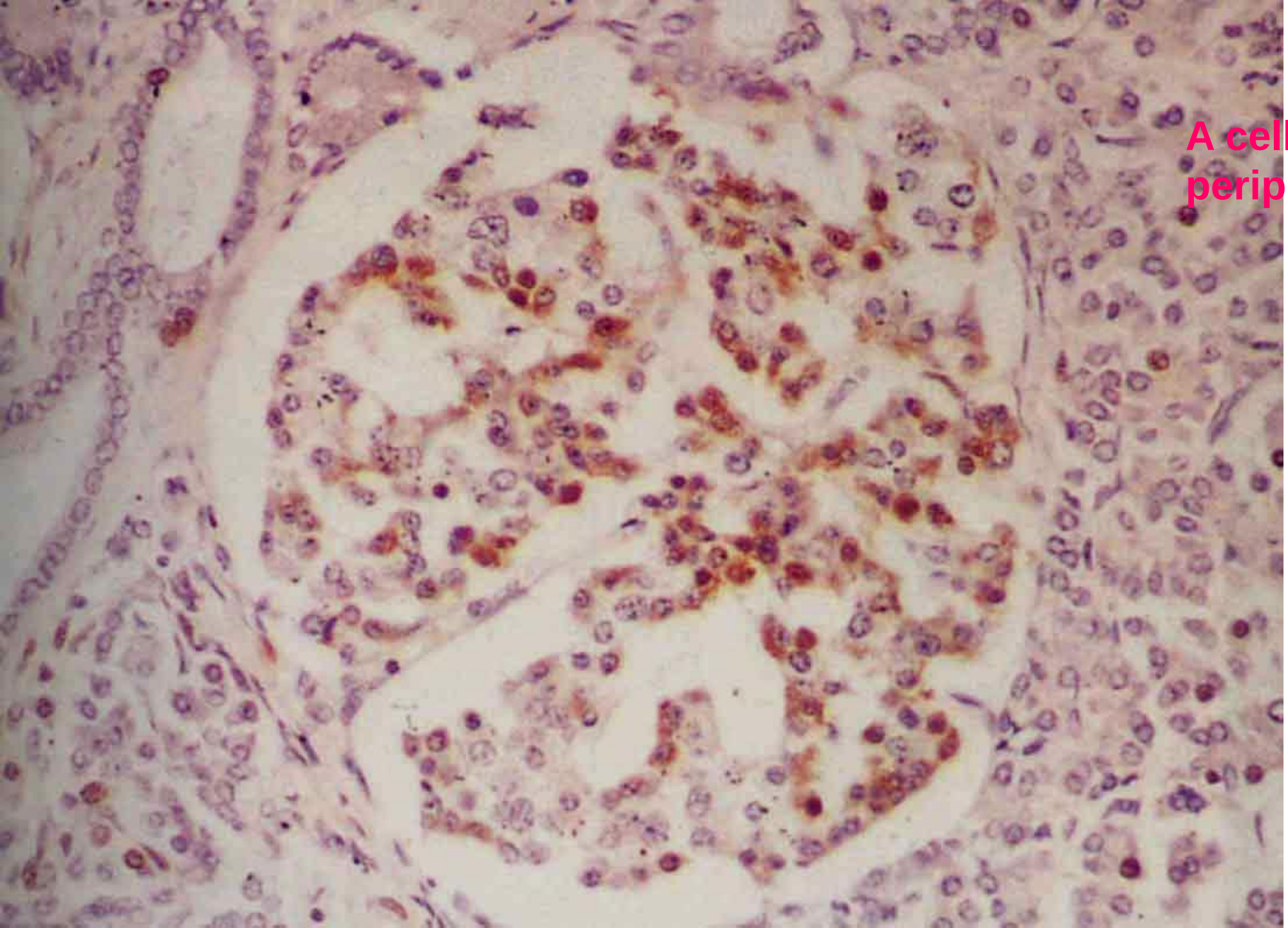
Pancreas – Islets of Langerhans (*Insulae pancreaticae*) – *cell types*

- A-cells
  - **glucagon** – hyperglycemic-glycogenolytic factor
- B-cells
  - **insulin** – hypoglycemic faktor
- D-cells
  - one long cellular processus → paracrine secretion
  - **somatostatin**
- PP-cells
  - **pankreatic polypeptide** → control of exocrine part of pancreas

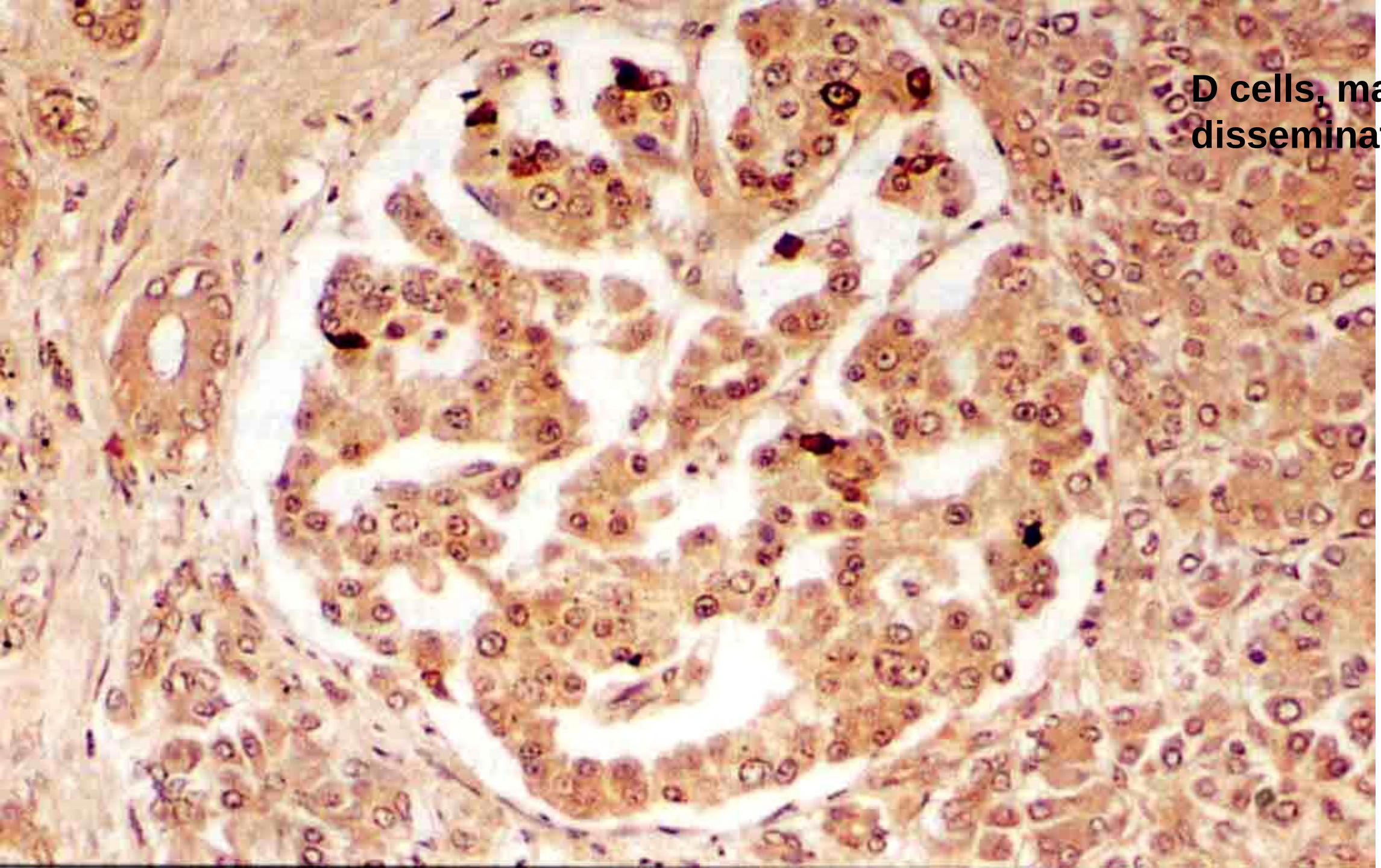
Pancreas – Islets of Langerhans (*Insulae pancreaticae)* – *cell types*

- (G - cells)
  - **gastrin**
- (other)
  - cells secreting ghrelin, PYY, D1, EC)


B cells, approx. 70 %,
center, clusters



A cells, approx. 20 %, periphery, layers

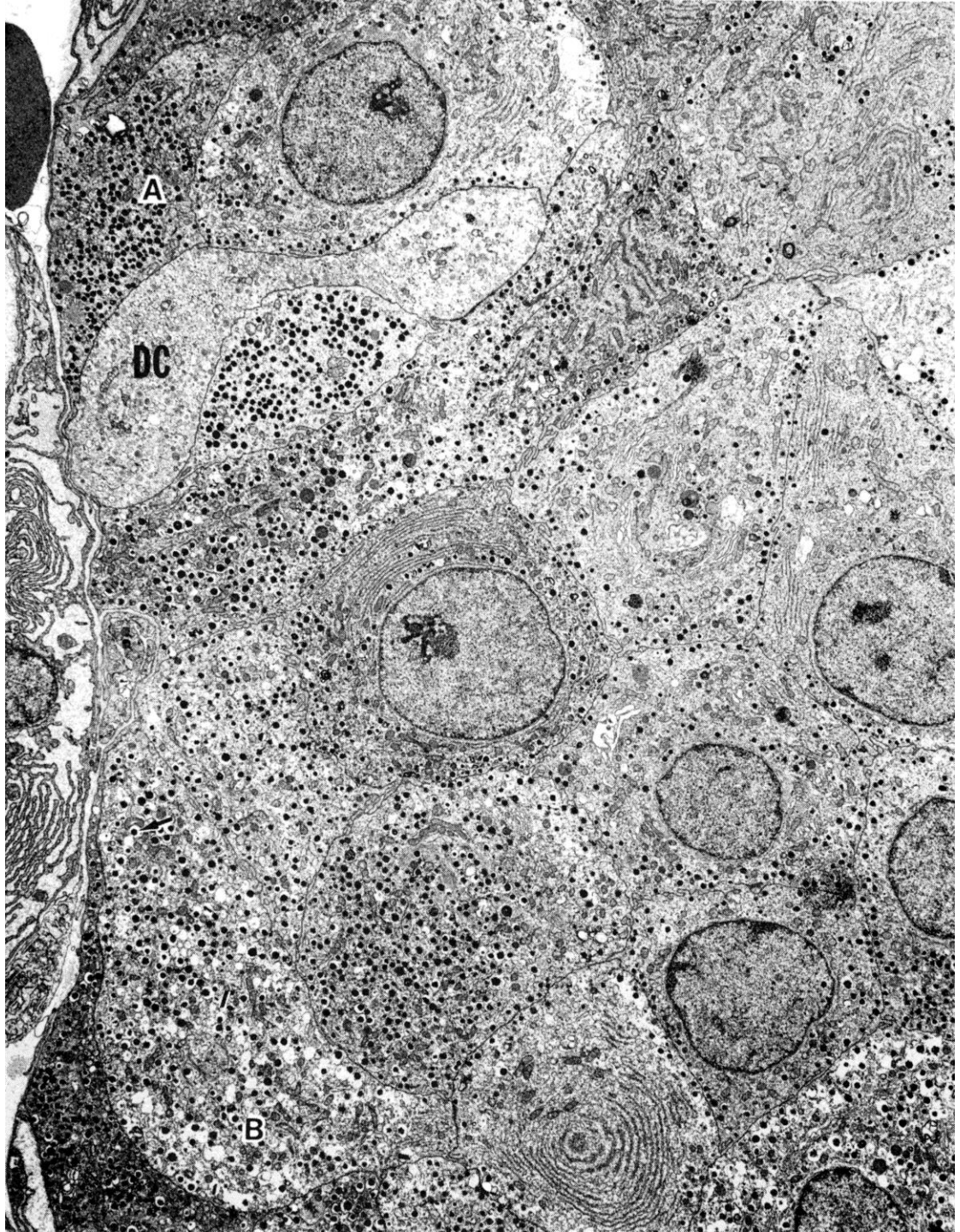


D cells, max. 5 %, disseminated

ISLETS OF LANGERHANS

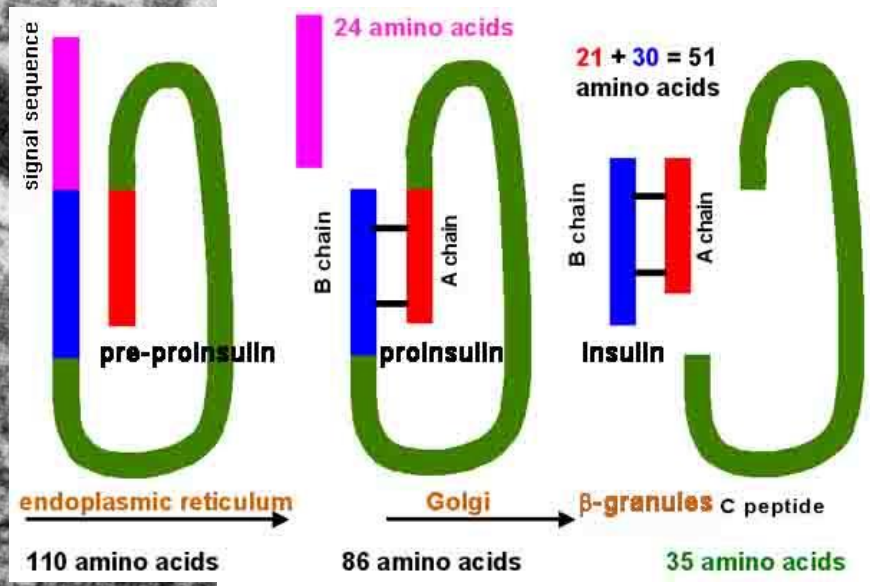
cell type	structure of granules	hormon
A		glukagon
B		insulin
D		somatostatin
F		pankreatický polypeptid

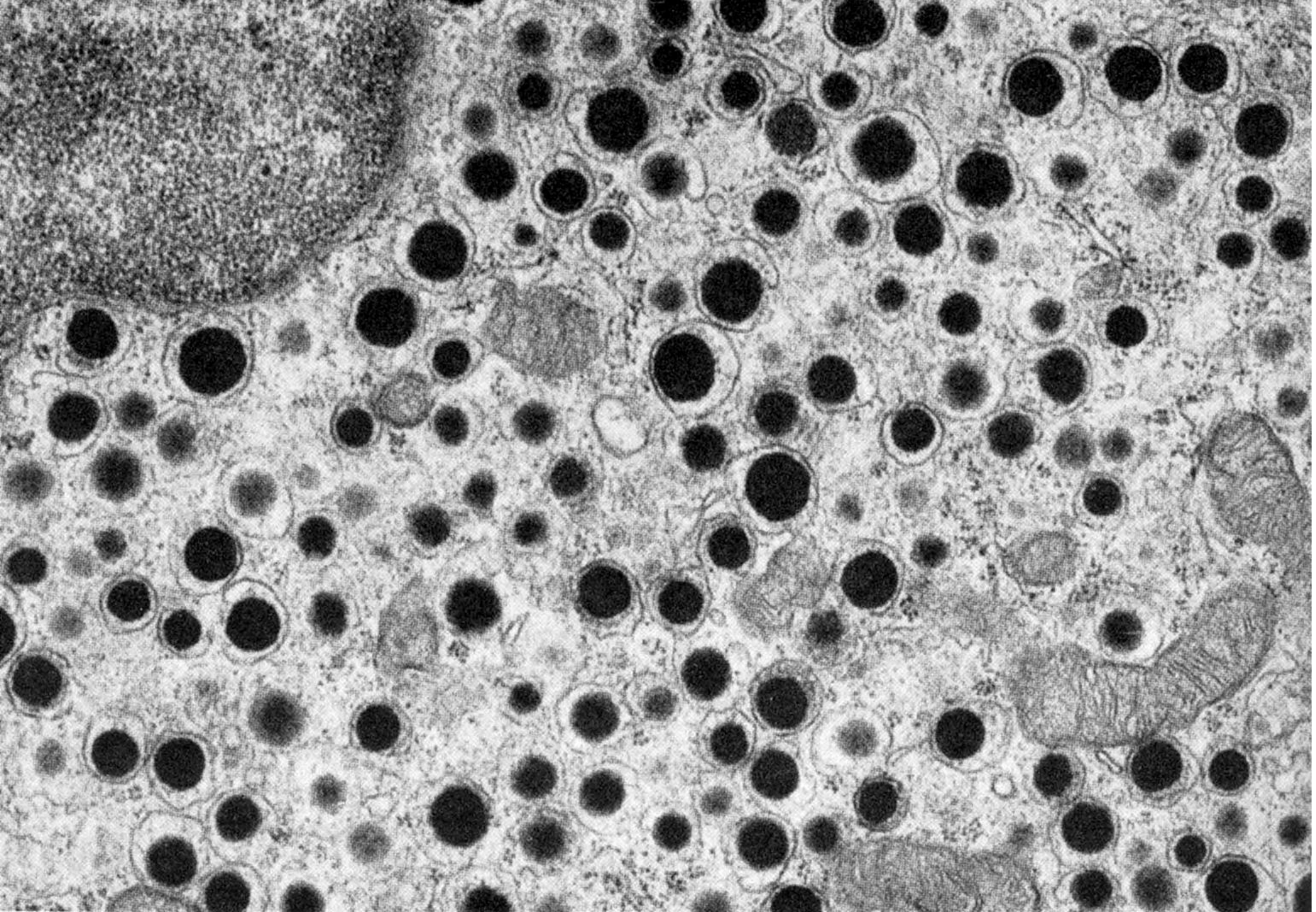
E (ghrelin), EC (substance P), D_1 (VIP)



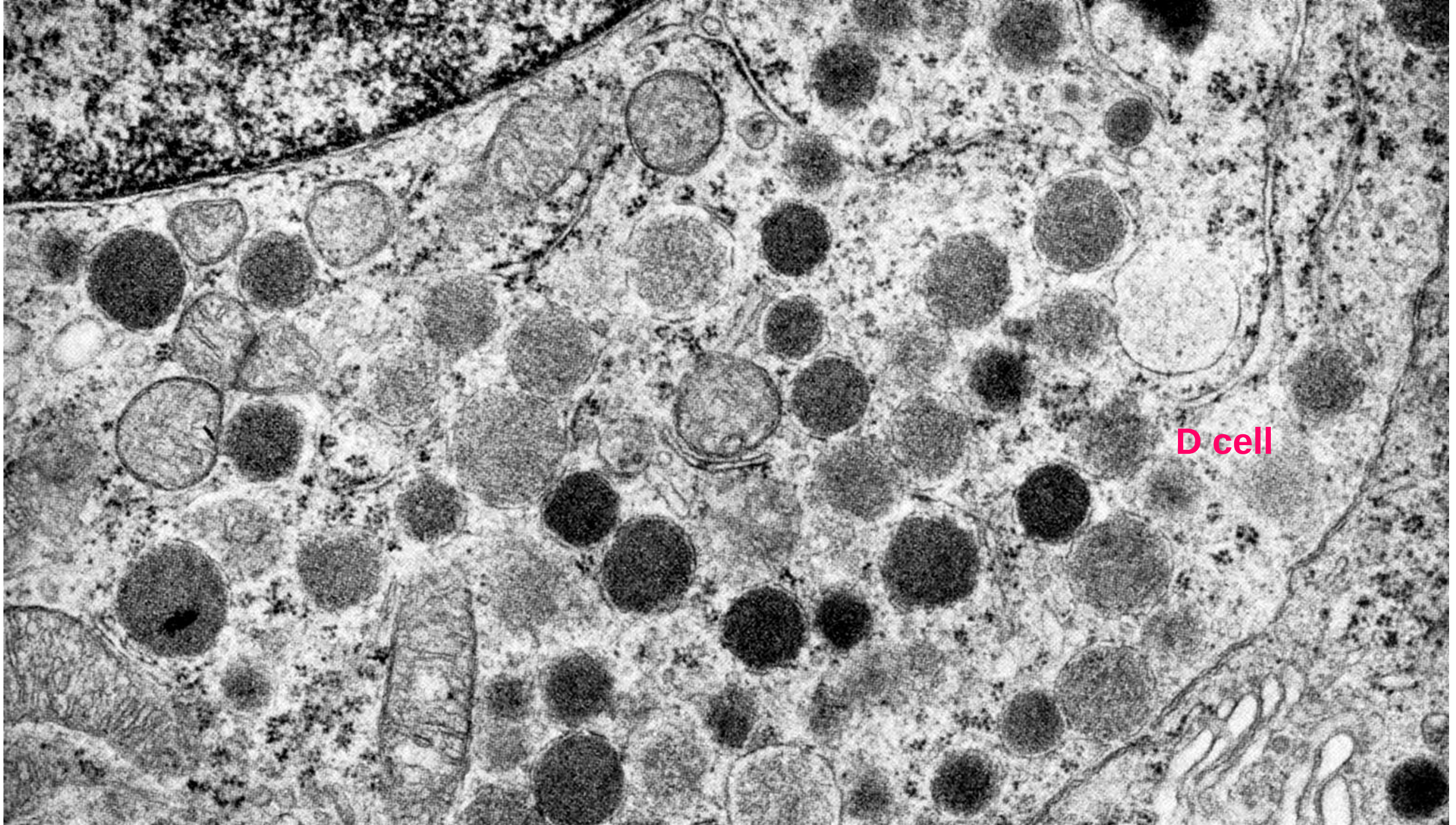
A = A cell
B = B cell
DC = D cell

B cell


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



A cell


D cell

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

https://en.wikipedia.org/wiki/Heart_symbol

Kidneys

- 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

Kidneys – RAA axis – juxtaglomerular apparatus

- regulation of blood pressure
- system **renin-angiotensin-aldosterone** (RAA)
- granular cells of arteriola afferens + efferens

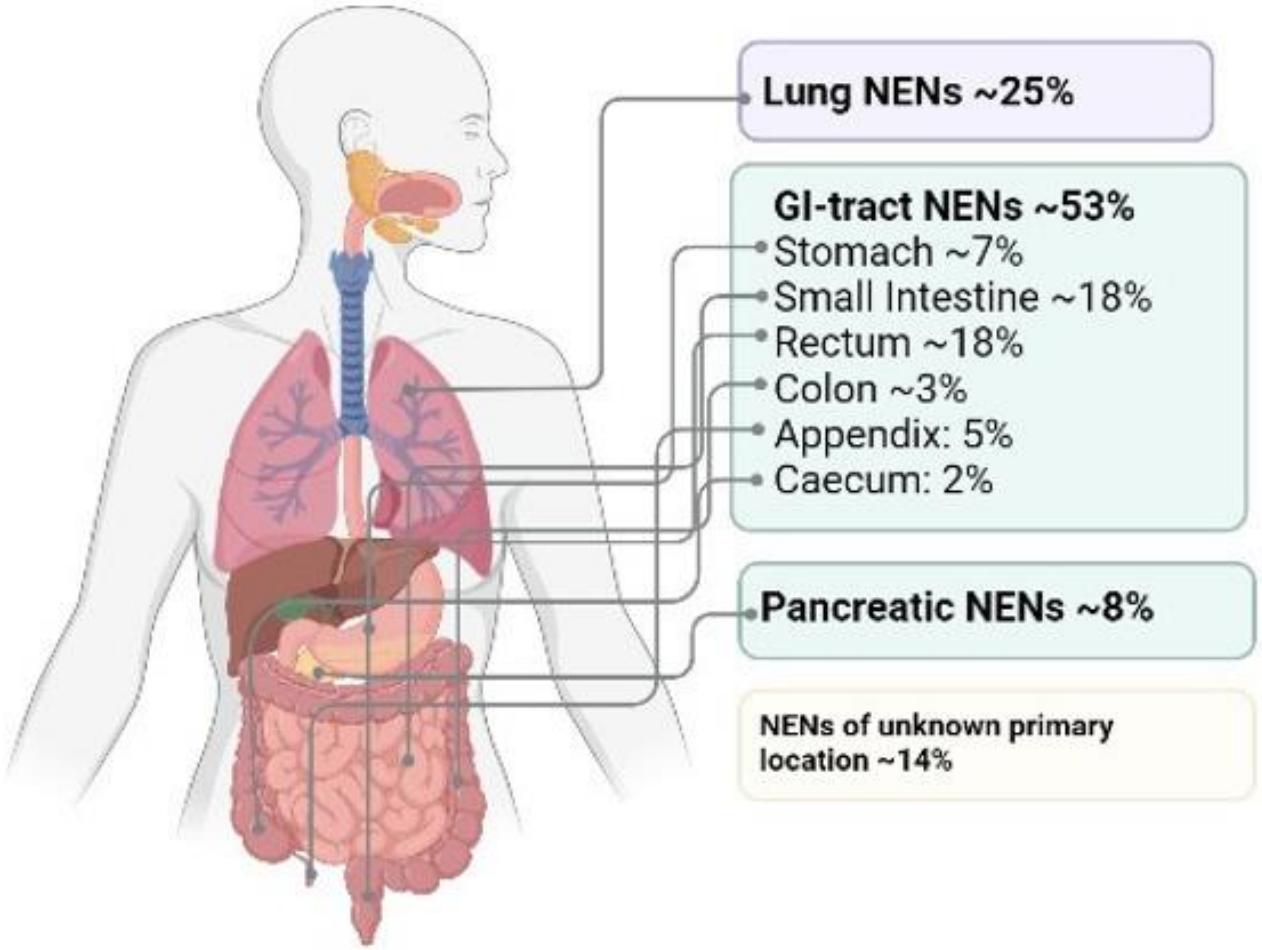
= juxtaglomerular cells

– transformed muscle cells of tunica media
– mechanoreceptors
– produce renin

- macula densa of distal tubule - chemoreceptor
- extraglomerual mesangial cells

Disseminated endocrine cells

- endocrine cells of digestive and respiratory tract (DNES)
- many types = plenty of hormones regulating functions of digestive and respiratory tracts



https://www.ncbi.nlm.nih.gov/books/NBK279025/