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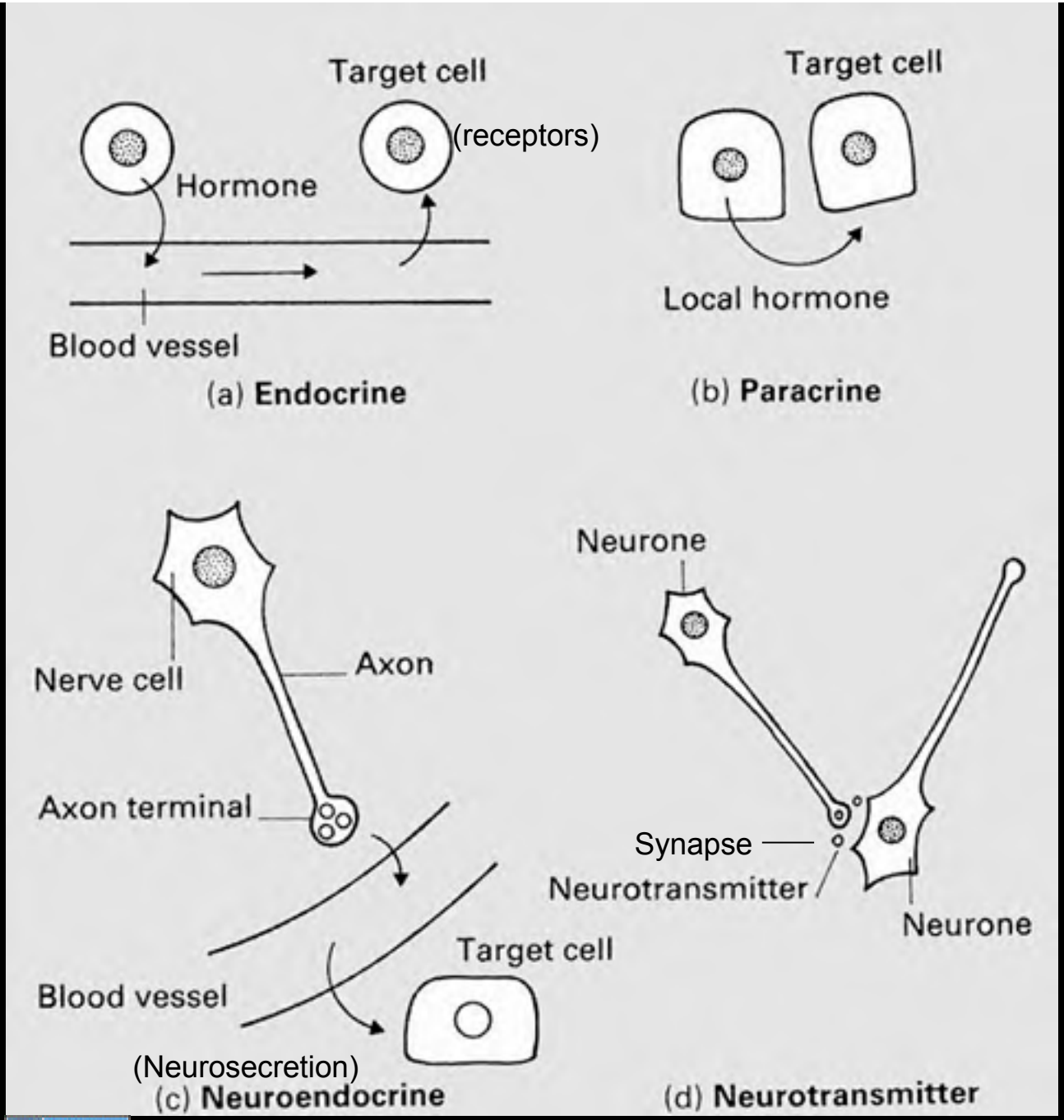
Histology of the Endocrine System

M1 - Endocrine/Reproduction Sequence

A. Kent Christensen
Department of Cell and Developmental Biology
University of Michigan Medical School

Winter, 2009

Hormone delivery



 O'Riordan et al., 2nd ed, page 5

Endocrine system

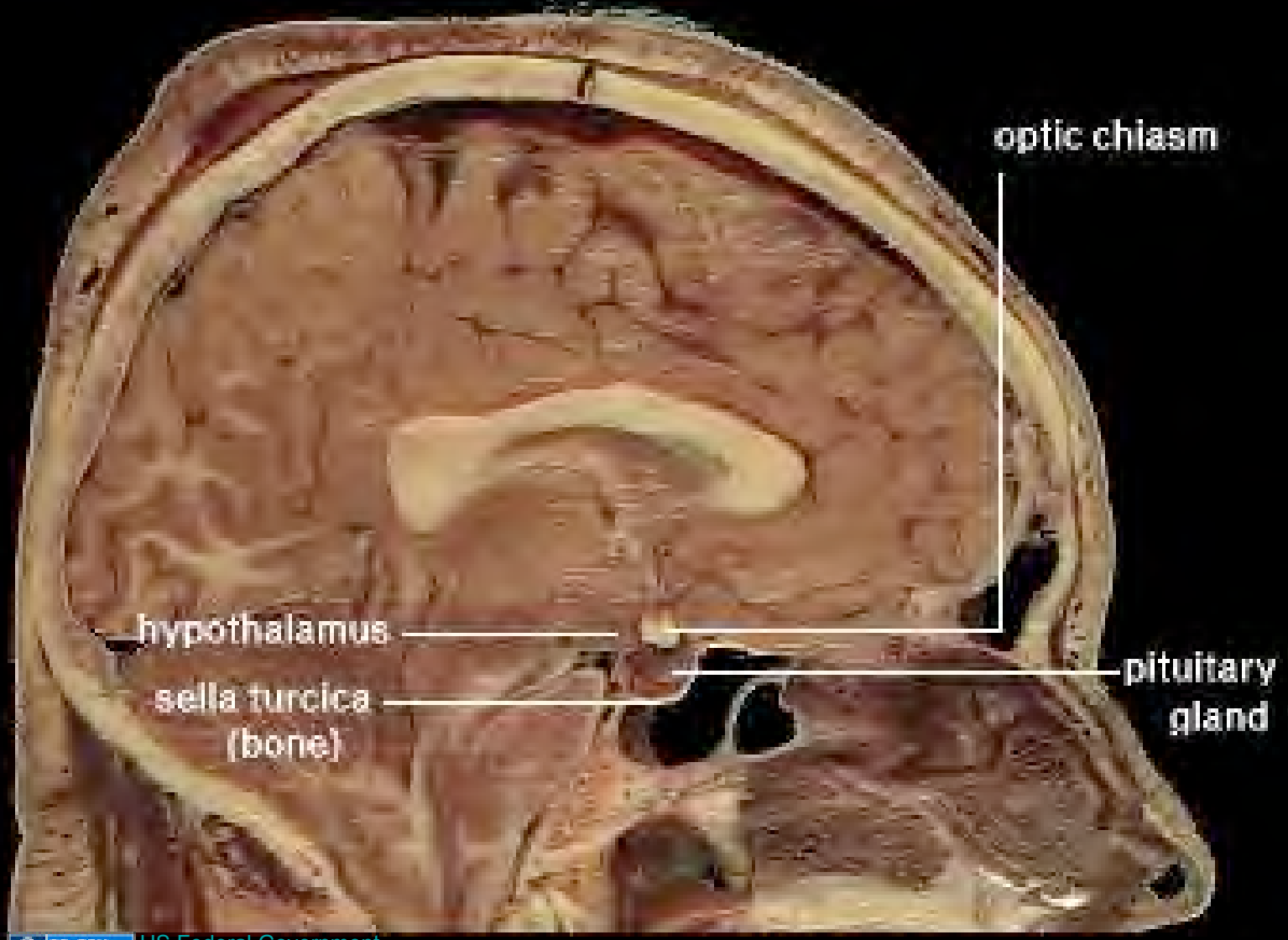
- **Pituitary (hypophysis)**
  - Anterior pituitary
  - Posterior pituitary
- **Adrenal gland (suprarenal)**
  - Adrenal cortex
  - Adrenal medulla
- **Thyroid gland**
  - Follicles
  - Parafollicular cells
- **Parathyroid gland**

Considered in other lectures:

- Endocrine pancreas
- Male
- Female
- Enteroendocrine

PITUITARY

Location of pituitary



Pituitary development

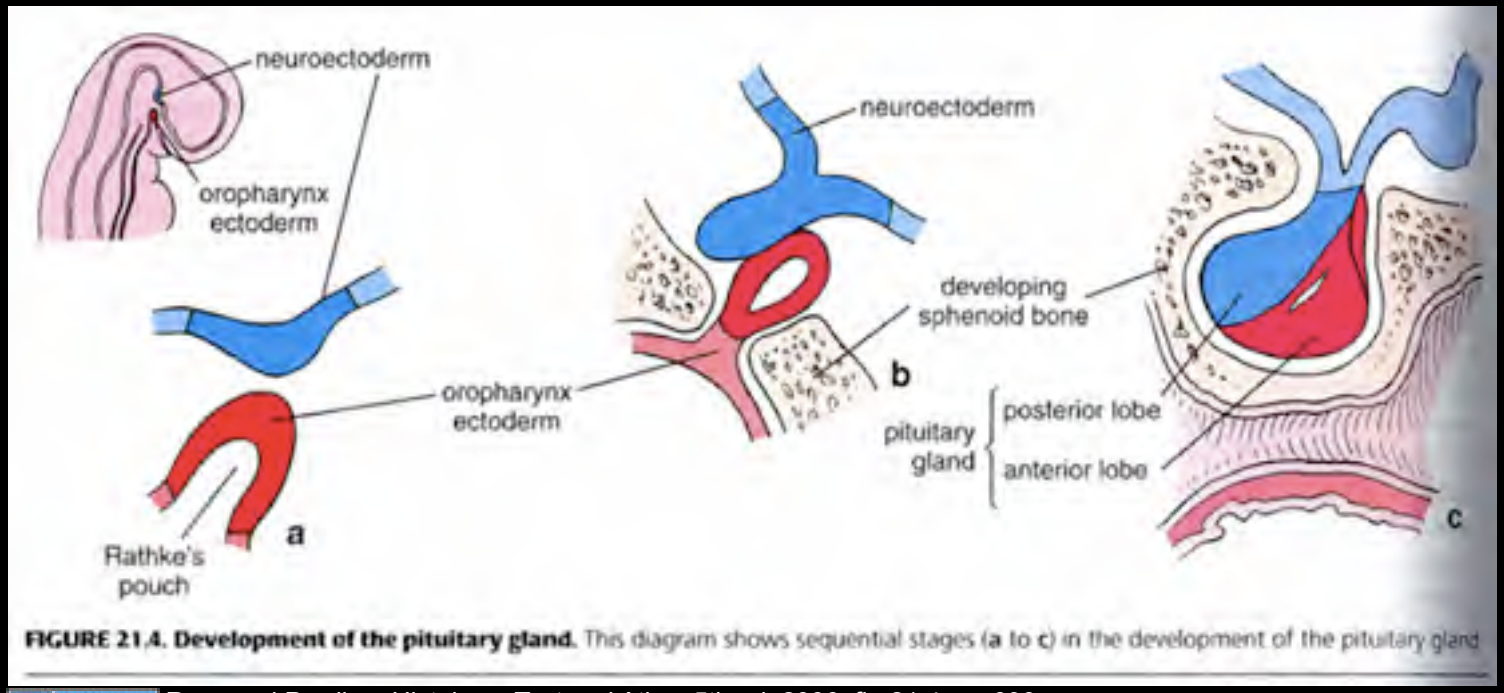
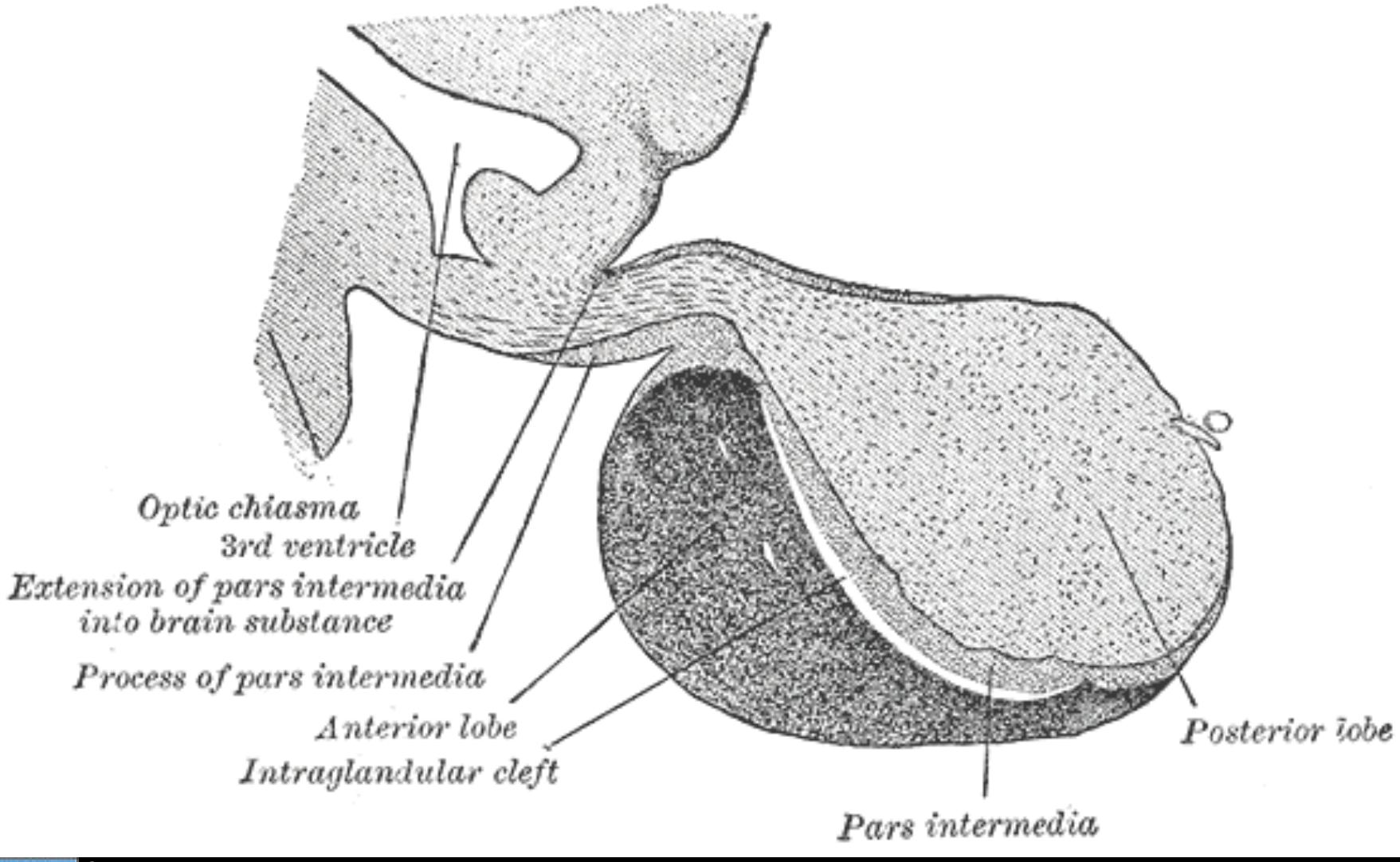


FIGURE 21.4. Development of the pituitary gland. This diagram shows sequential stages (a to c) in the development of the pituitary gland

PD-INEL Ross and Pawlina. Histology: Text and Atlas, 5th ed, 2006, fig 21.4, pg 690



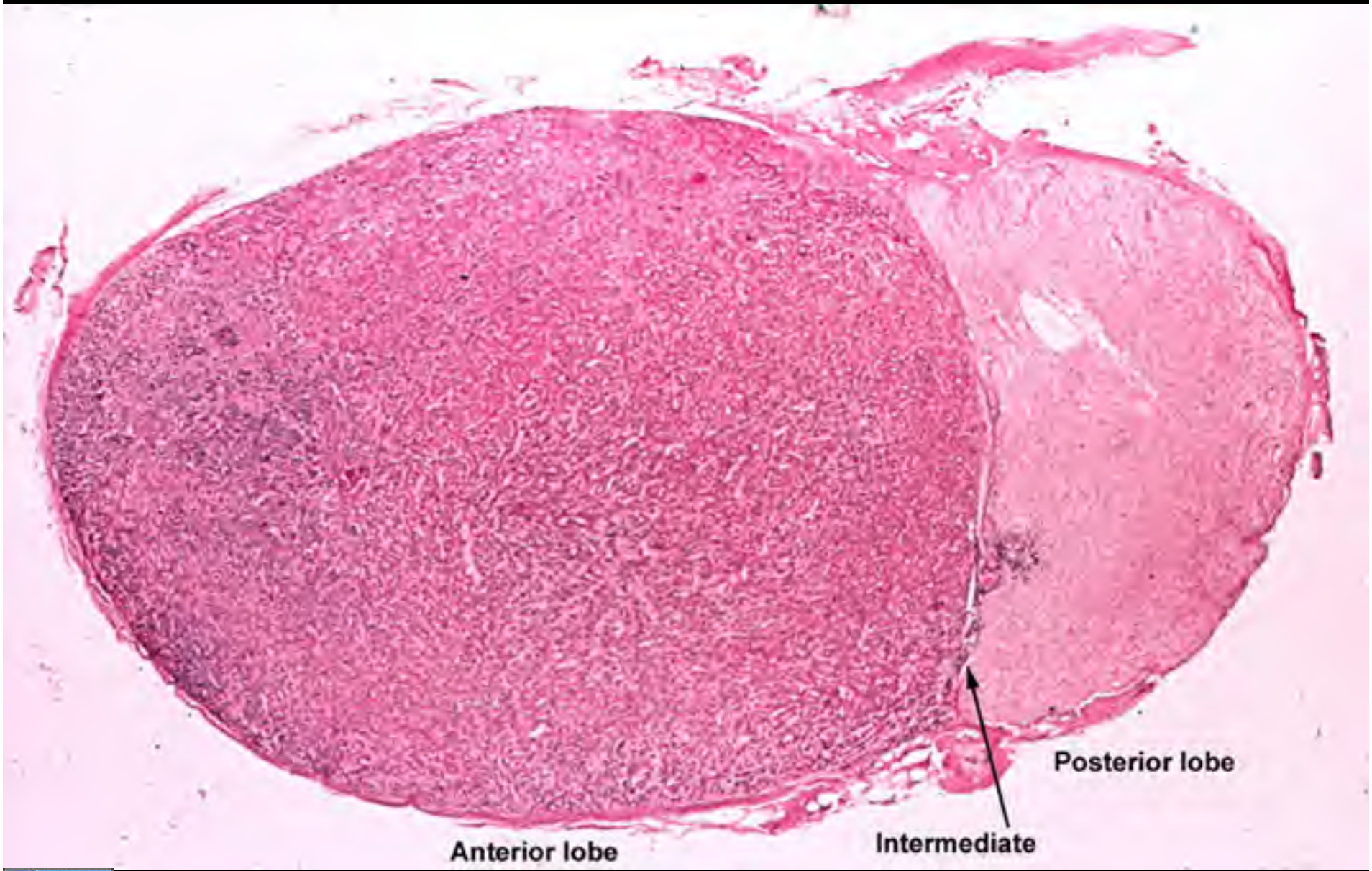
PD-EXP Gray's Anatomy, wikimedia commons

Please also see Ross and Pawlina. Histology: Text and Atlas, 5th ed, 2006, fig 21.3b, pg 689

Cells and hormones of the anterior pituitary

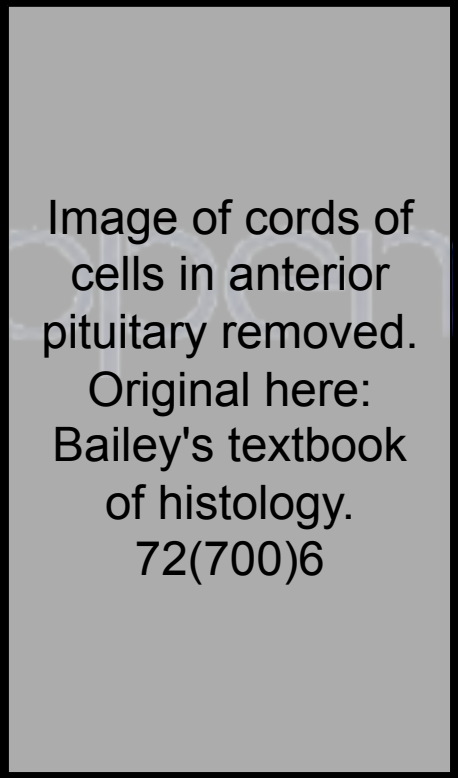
LM staining	Cell type	Hormone	Releasing (+) or inhibiting (-) horm.
Acidophil	Somatotrope	Growth hormone (GH) = somatotropin	GHRH (+) Somatostatin (-)
Acidophil	Mammotrope = lactotrope	Prolactin (PRL)	[Dopamine (-) estrogen (+)]
Basophil	Thyrotrope	Thyroid stimulating hormone (TSH) = thyrotropin	TRH (+)
Basophil	Gonadotrope	Luteinizing hormone (LH), follicle stimulating hormone (FSH); both = gonadotropin	GnRH (+)
Basophil (human)	Corticotrope	Adrenocorticotropin (ACTH) = corticotropin	CRH (+)

Pituitary, low power LM

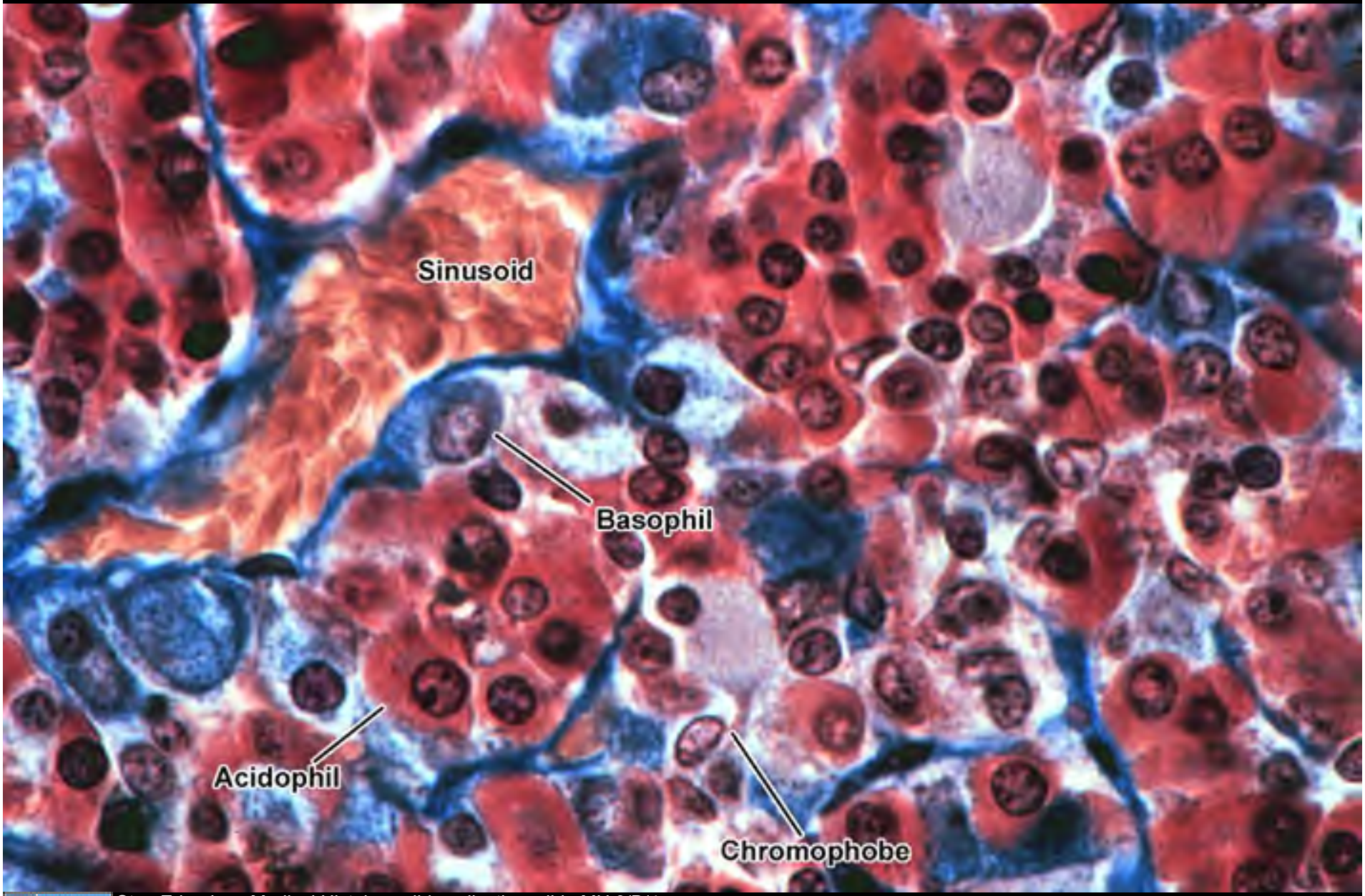


 Humio Mizoguti, Kobe Univ Sch Med, slide 515

Anterior pituitary, LM drawing

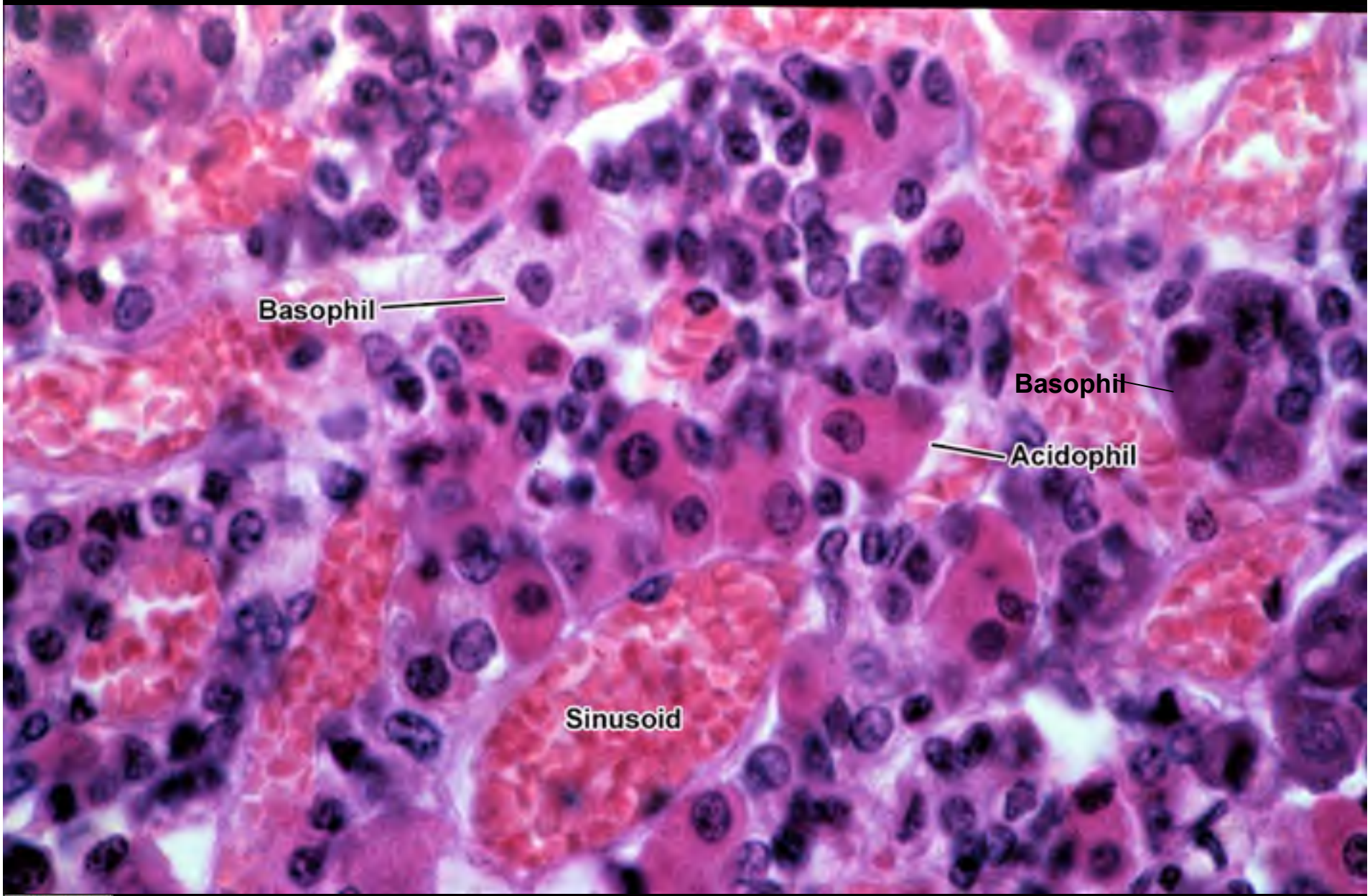


Anterior pituitary, LM, trichrome stain



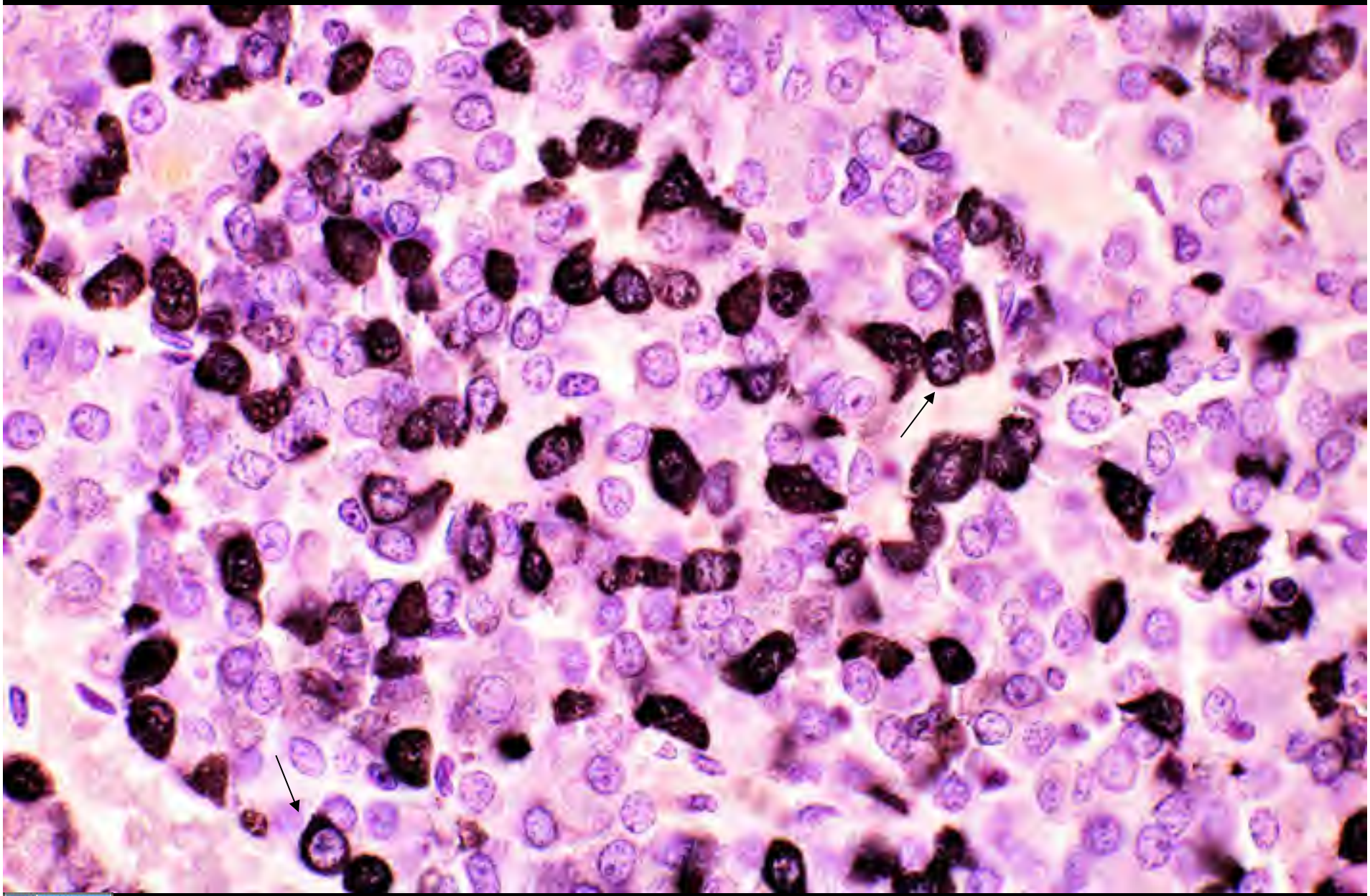
PD-INEL Stan Erlandsen Medical Histology slide collection, slide MH 9/B/4

Anterior pituitary, LM, H&E stain



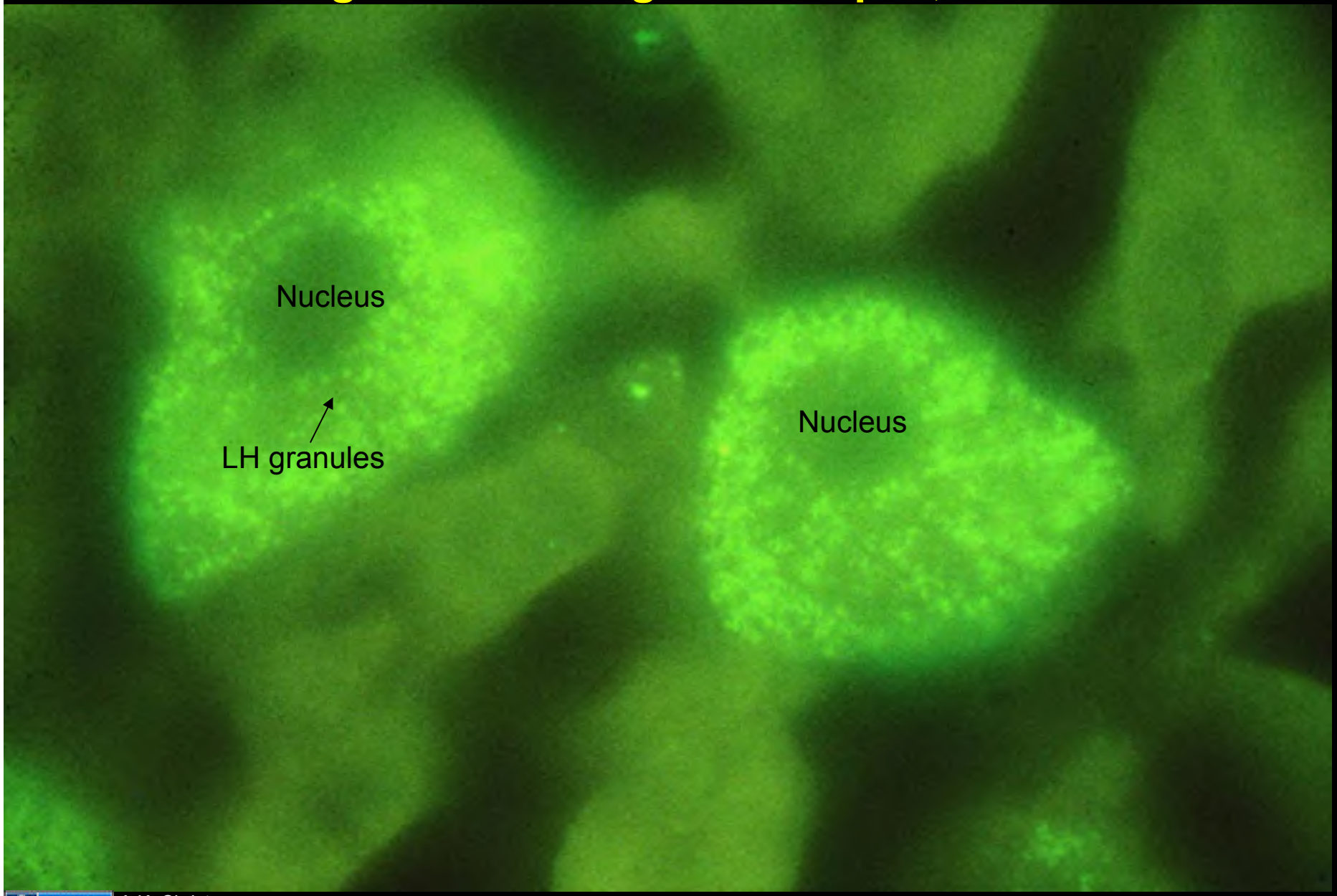
PD-INEL Stan Erlandsen Medical Histology slide collection, slide MH-9B3

Immunocytochemical localization of growth hormone, LM

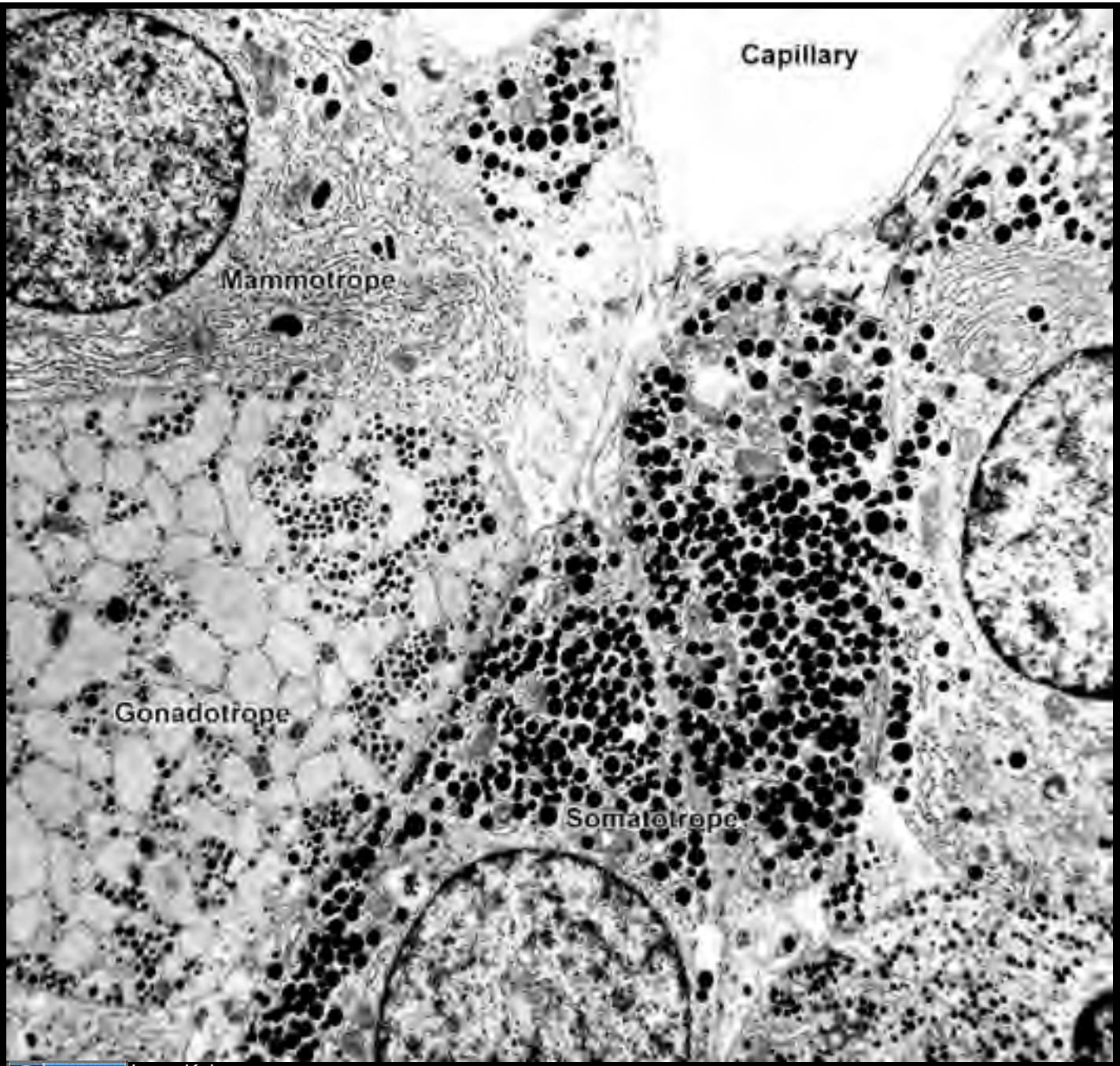


 A.K. Christensen

Immunocytochemical localization of luteinizing hormone in gonadotropes, fluorescence



Anterior pituitary, EM



PD-INEL Larry Kahn

Pathway of hormone secretion

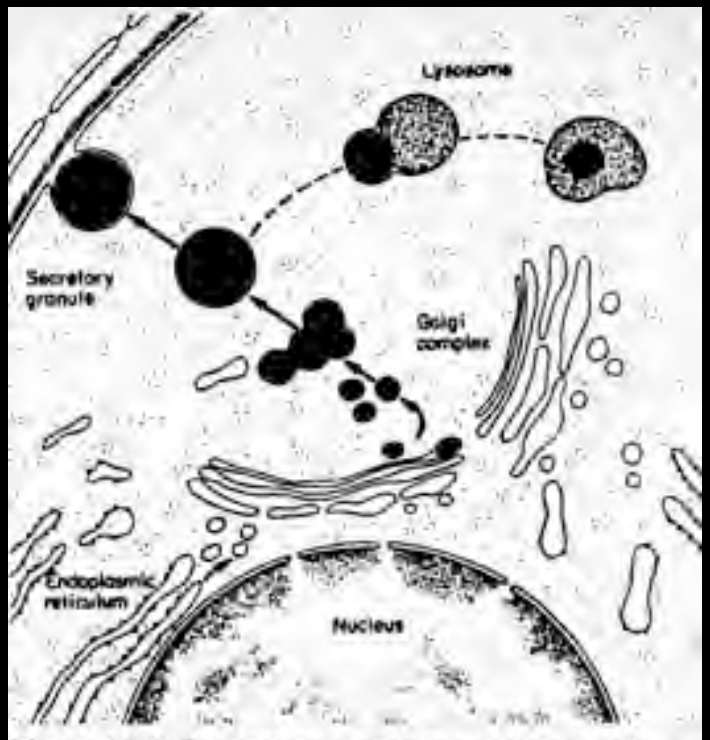
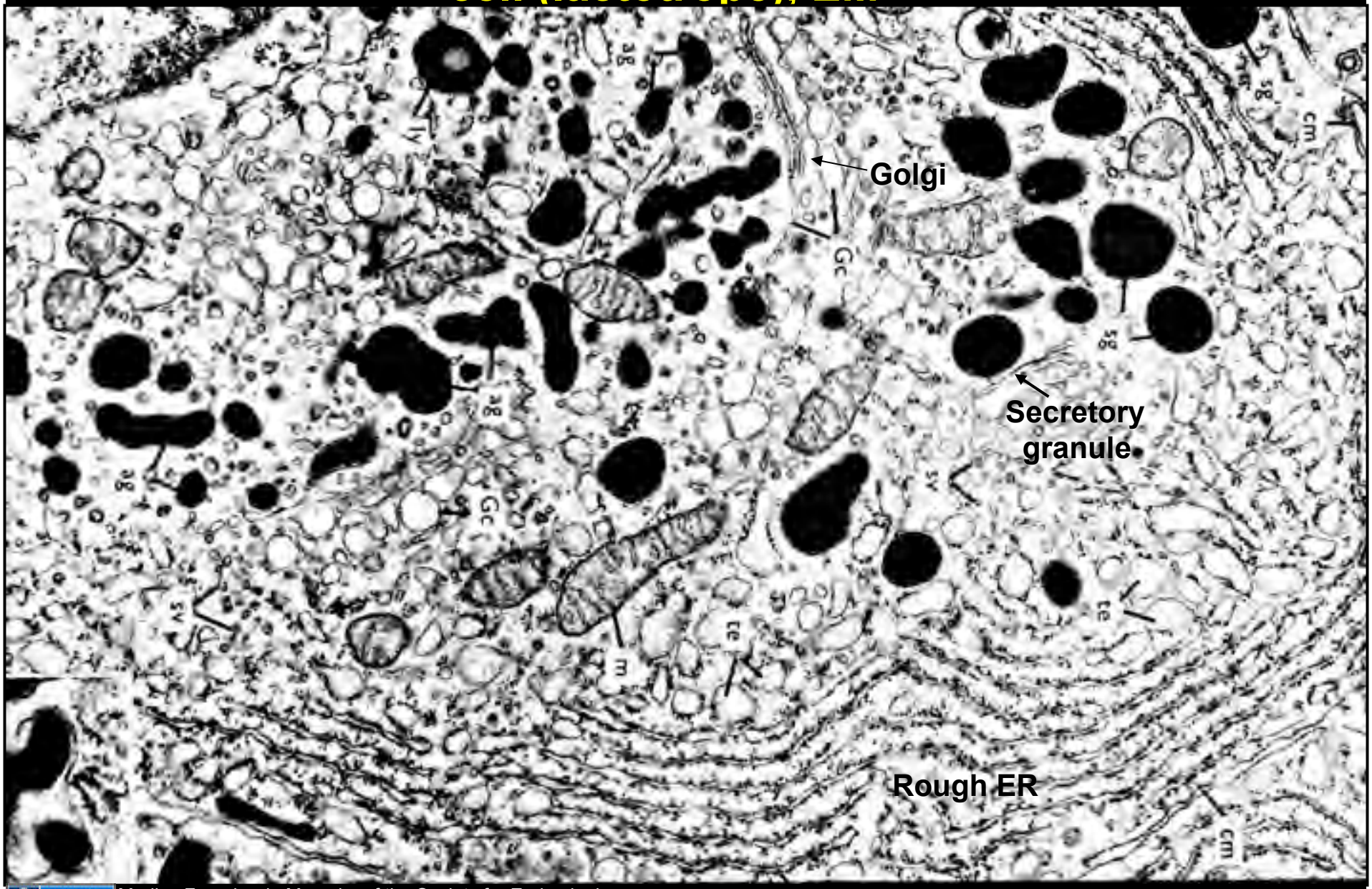


Figure 17–8. Diagram illustrating the secretory pathway of a mammatrope. Small granules are formed in the Golgi complex and subsequently fuse to form larger granules, often of irregular outline. During lactation, they are discharged by exocytosis, but after the young are weaned, excess granules fuse with lysosomes and are destroyed by autophagy. (After Smith, R. E., and M. G. Farquhar. J. Cell Biol. 31:319, 1966.)

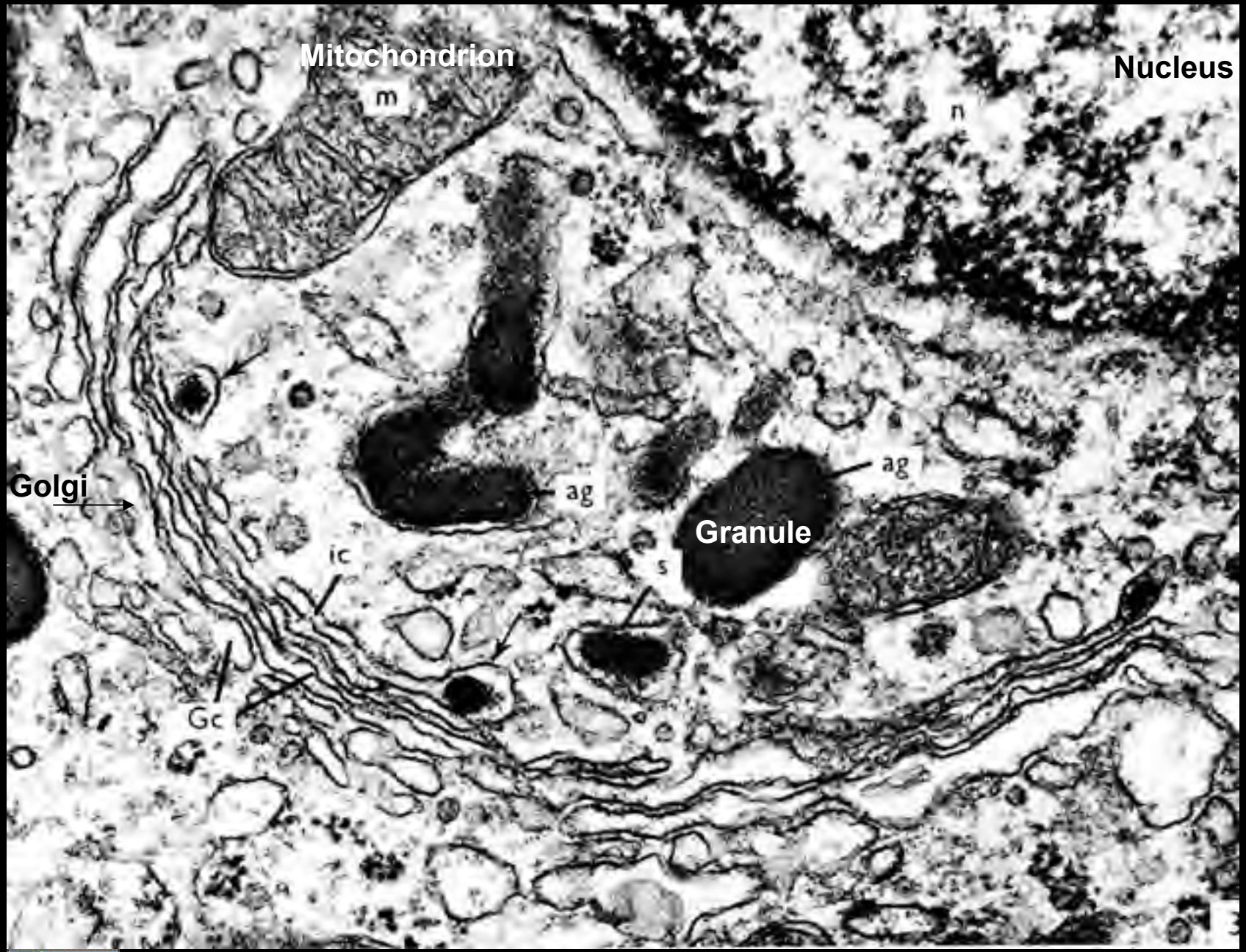
PD-INEL Fawcett. Histology, ed 11, p 486

Cytoplasm of prolactin-secreting cell (lactotrope), EM



 Marilyn Farquhar in Memoirs of the Society for Endocrinology

Golgi and secretory granules, EM



 Marilyn Farquhar in Memoirs of the Society for Endocrinology

Exocytosis of prolactin granules, EM

Fig. 5. Peripheral cytoplasm of a mammotroph from a lactating rat, depicting several secretory granules (sg) lined up facing the perivascular spaces and undergoing discharge by exocytosis. The membranes of several granules are in continuity with the cell membrane at the points indicated by arrows. B, Basement membrane. ×42,000.

 Marilyn Farquhar in Memoirs of the Society for Endocrinology

Cells and hormones of the anterior pituitary

LM staining	Cell type	Hormone	Releasing (+) or inhibiting (-) horm.
Acidophil	Somatotrope	Growth hormone (GH) = somatotropin	GHRH (+) Somatostatin (-)
Acidophil	Mammotrope = lactotrope	Prolactin (PRL)	[Dopamine (-) estrogen (+)]
Basophil	Thyrotrope	Thyroid stimulating hormone (TSH) = thyrotropin	TRH (+)
Basophil	Gonadotrope	Luteinizing hormone (LH), follicle stimulating hormone (FSH); both = gonadotropin	GnRH (+)
Basophil (human)	Corticotrope	Adrenocorticotropin (ACTH) = corticotropin	CRH (+)

Regulation of the anterior pituitary

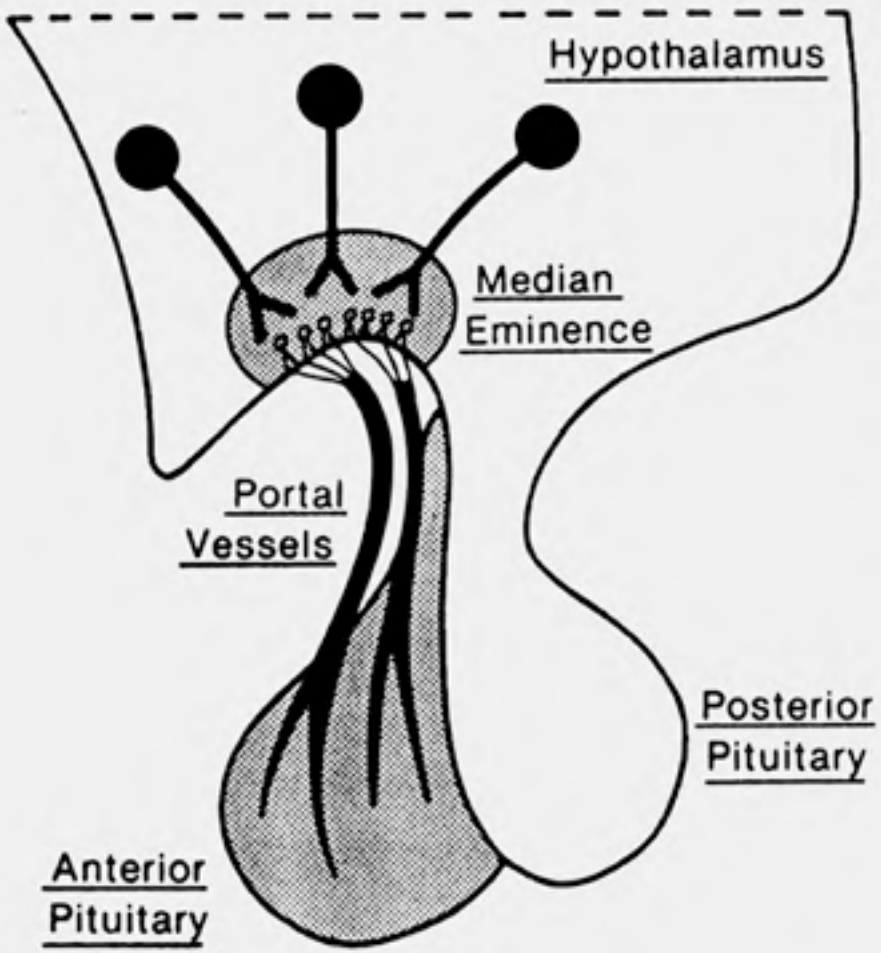
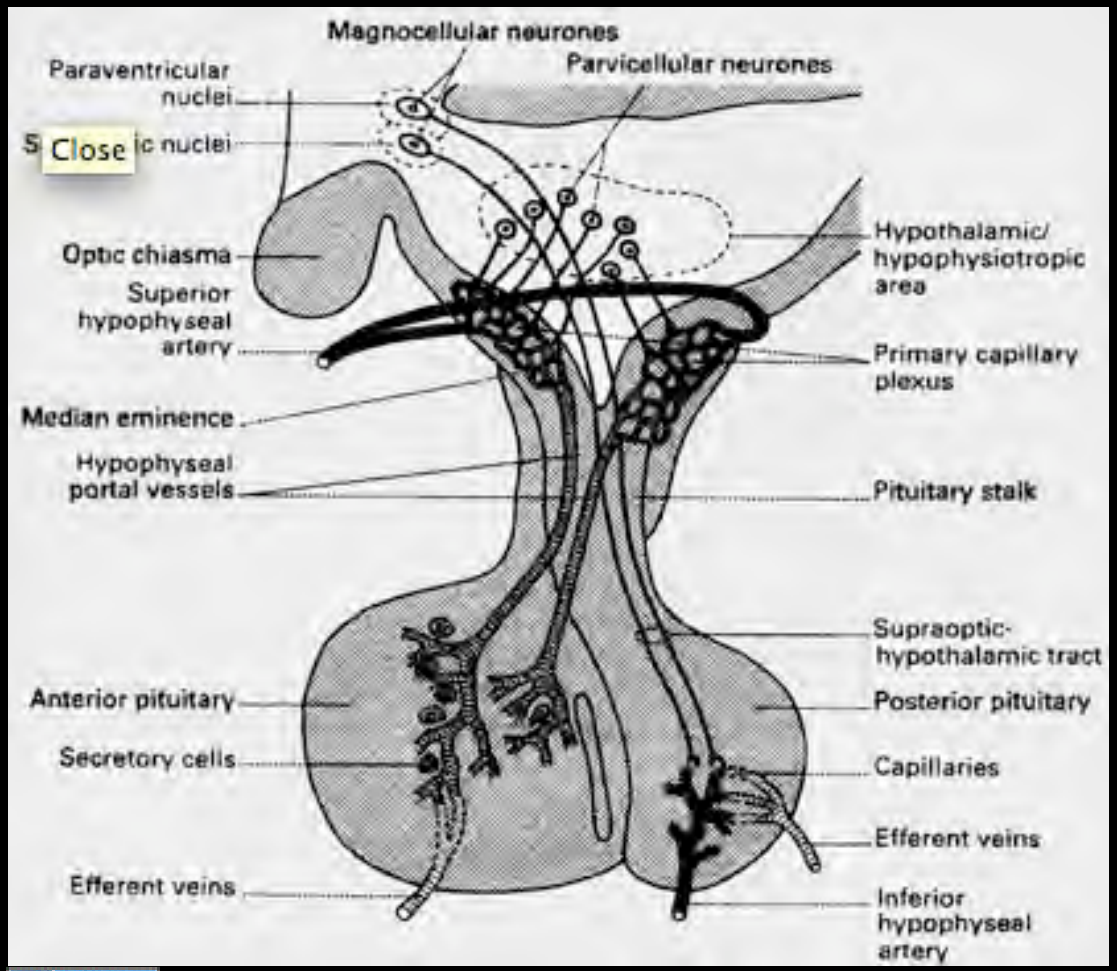


FIGURE 5–1. Hypothalamic neurosecretory neurons and hypothalamo-hypophyseal portal vessels.

 Hedges, 1987

Regulation of anterior pituitary, detail



PD-INEL O'Riordan et al 1988, p 47

SEM of pituitary: portal veins, capillaries, corrosion vascular cast

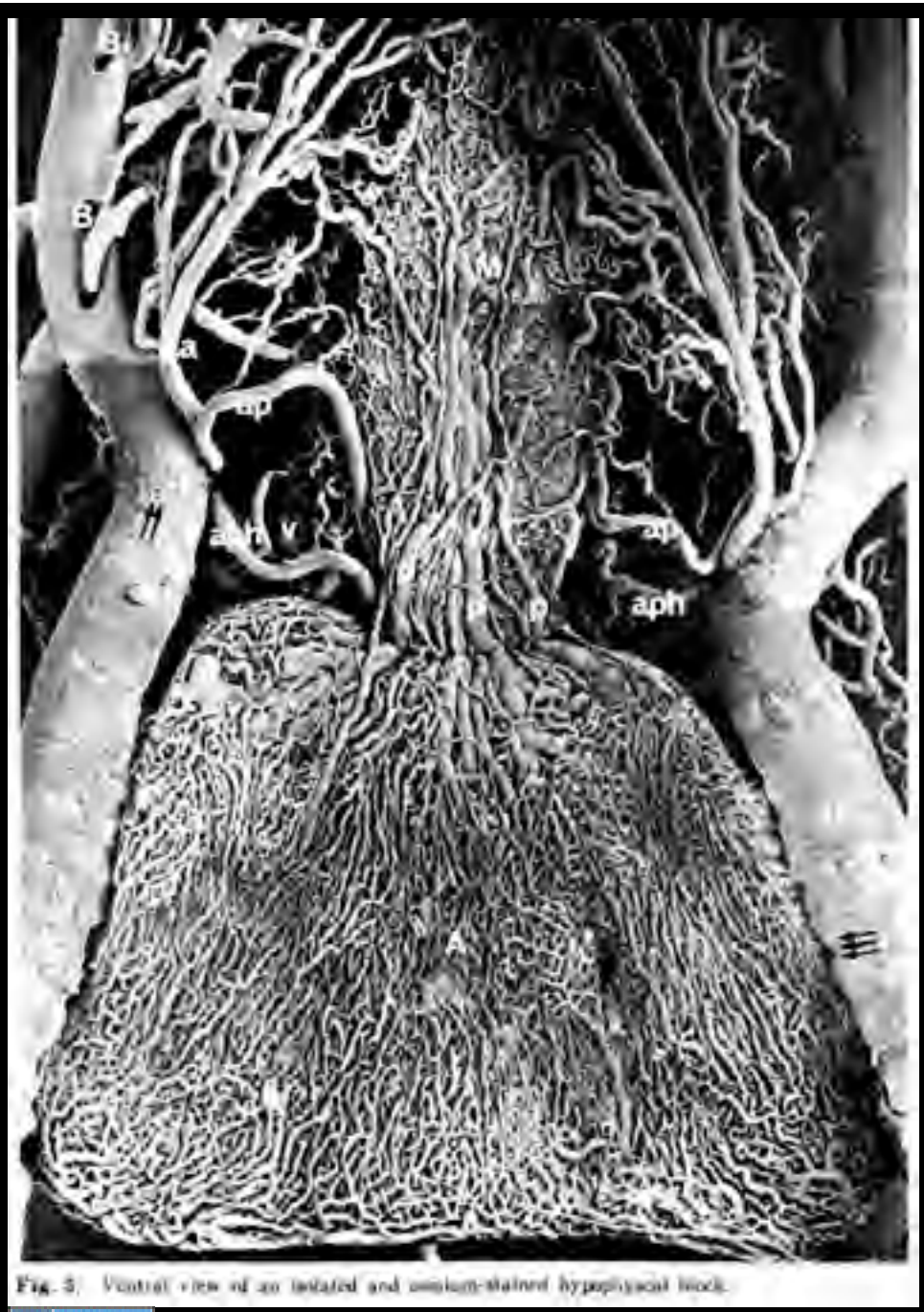


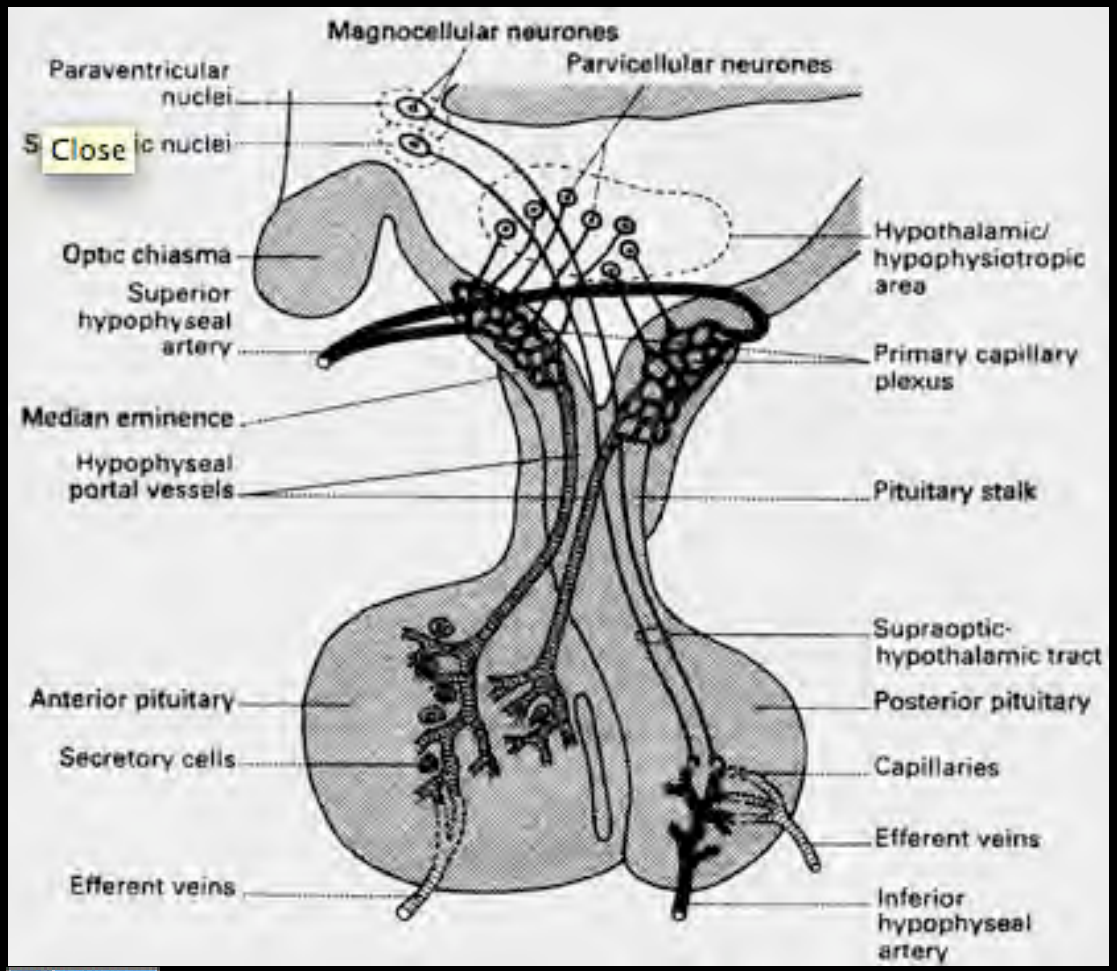
Fig. 3. Ventral view of an isolated and osmium-stained hypophyseal block.

PD-INEL Murakami T, 1975, Archivum Histologicum Japanicum 38:151-168

Posterior pituitary

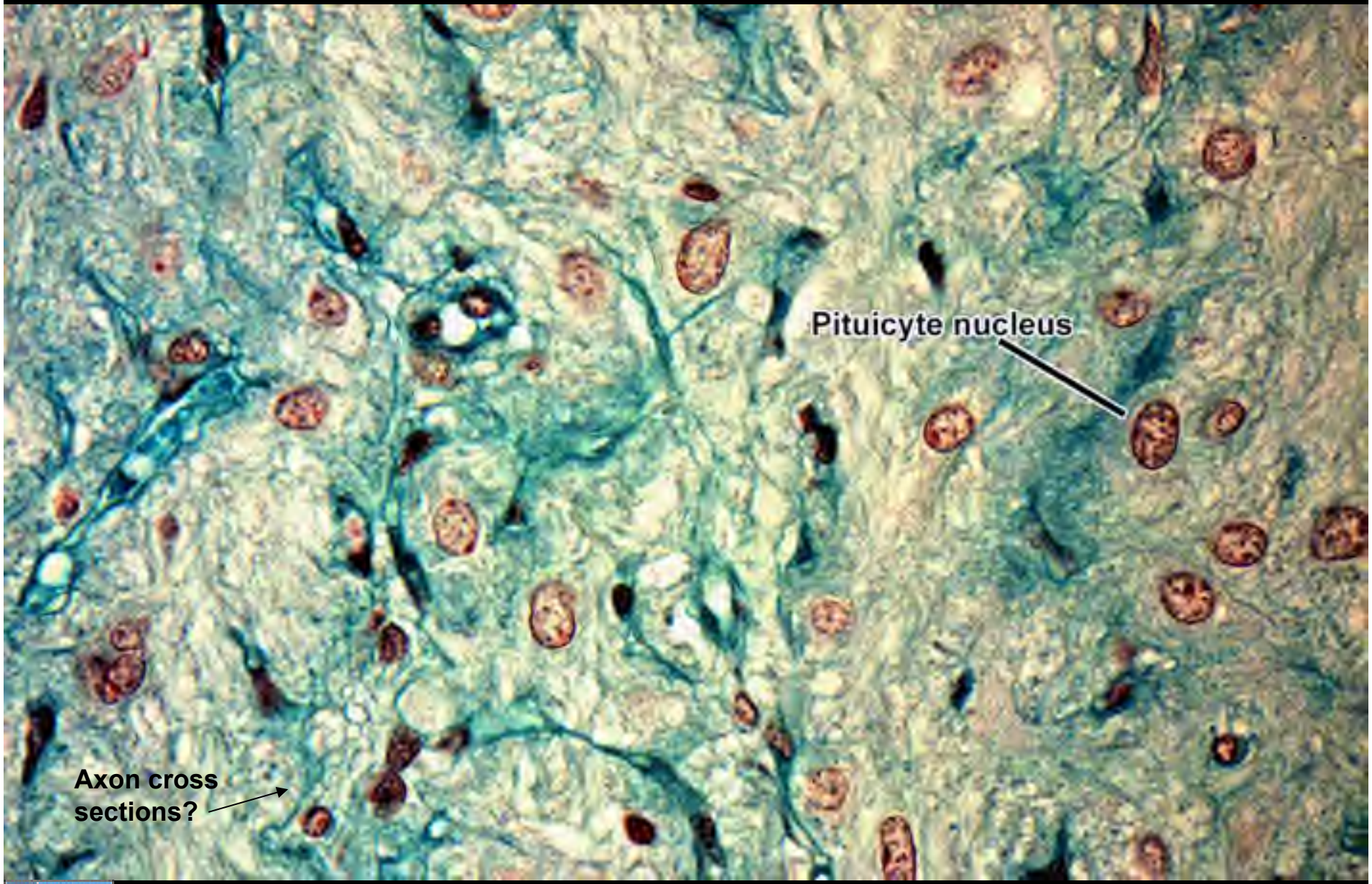
- **Hormones**
  - Antidiuretic hormone (ADH = arginine vasopressin)
  - Oxytocin
- **Neurosecretion**
  - Hormones synthesized as part of larger proteins (neurophysins) in neuron cell bodies of hypothalamus.
  - Transported in axons to pars nervosa (hormone cleaved from neurophysin).
  - Hormone secreted from axon terminals into capillaries.
- **Pituicytes**
  - Specialized glia of pars nervosa.

Posterior pituitary, diagram

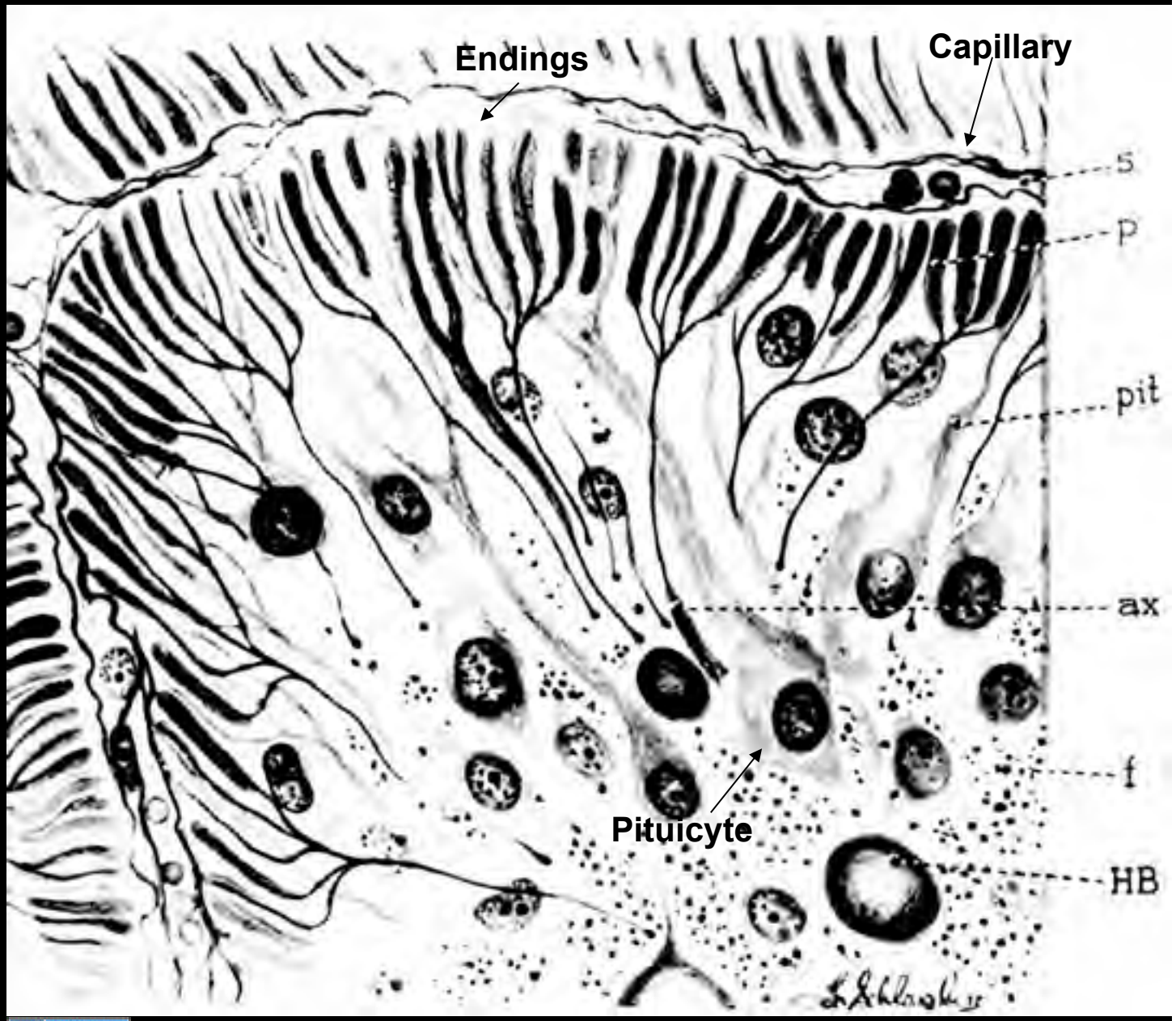


PD-INEL O'Riordan et al 1988, p 47

Posterior pituitary, LM



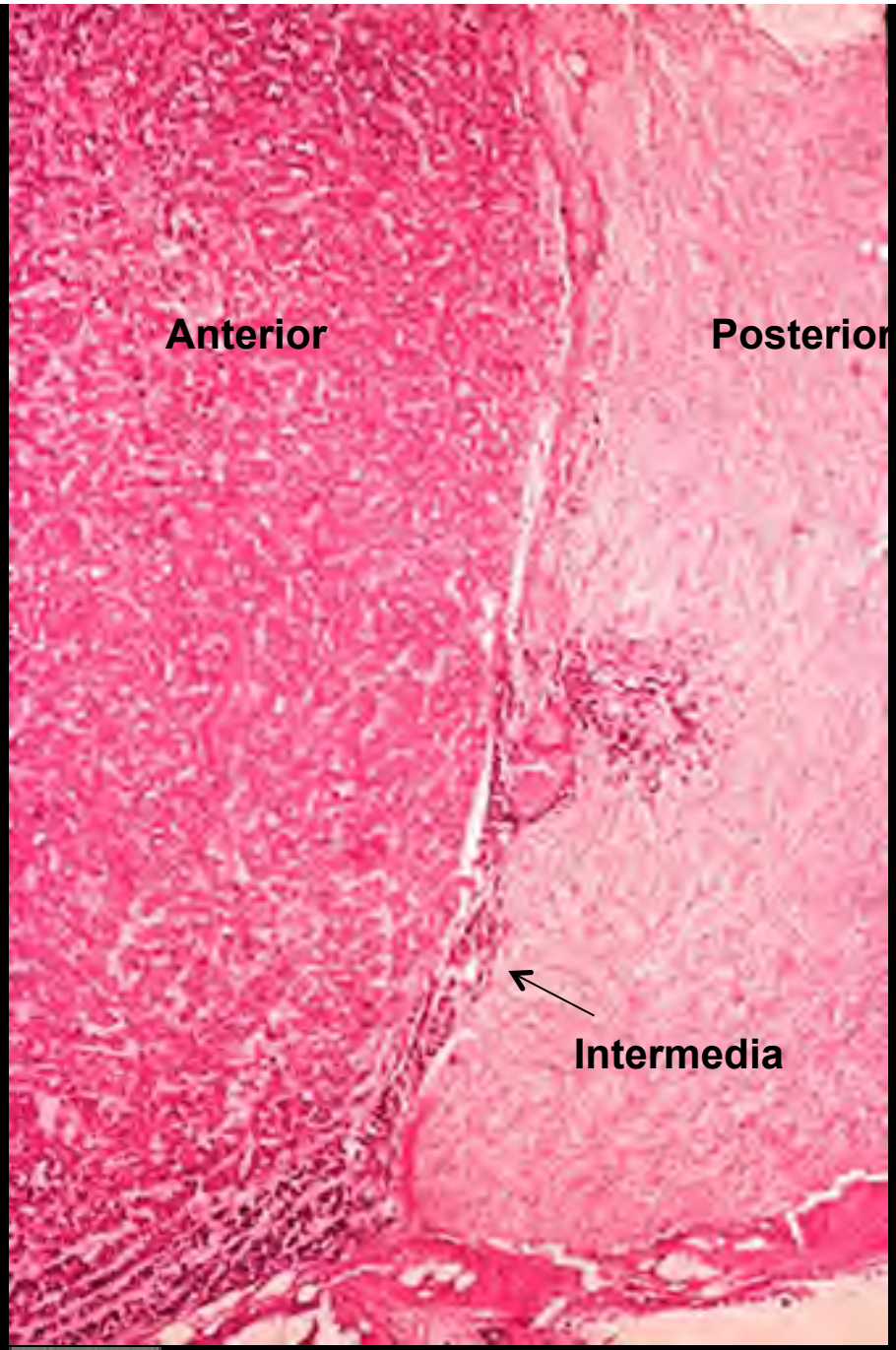
Nerve endings for hormone release, posterior pituitary



PD-INEL Weiss Histology, ed 5

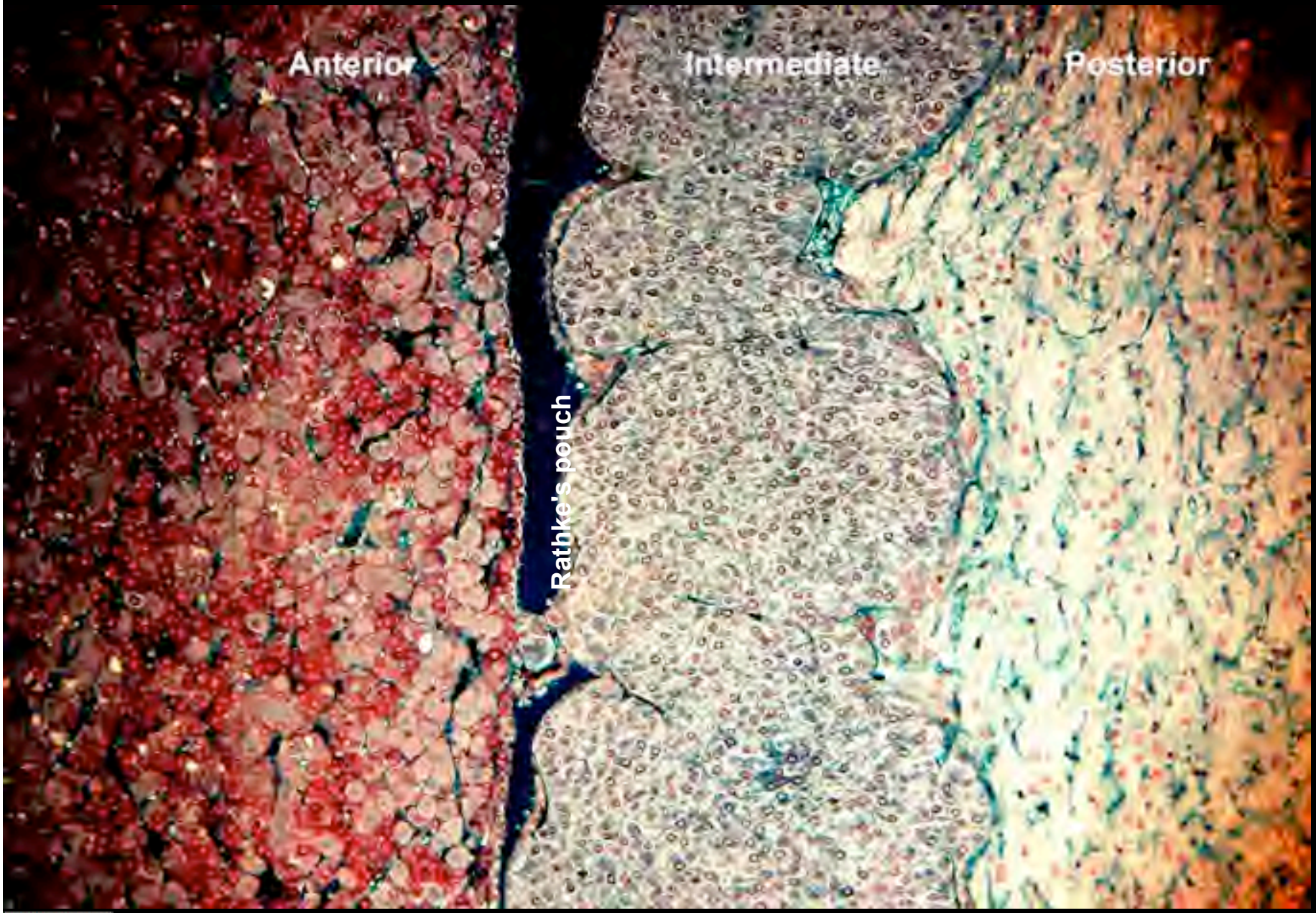
Pars intermedia, between anterior and posterior pituitary, human, LM.

Poorly developed and of doubtful function in humans.



 Humio Mizoguti, Kobe Univ Sch Med, slide 516

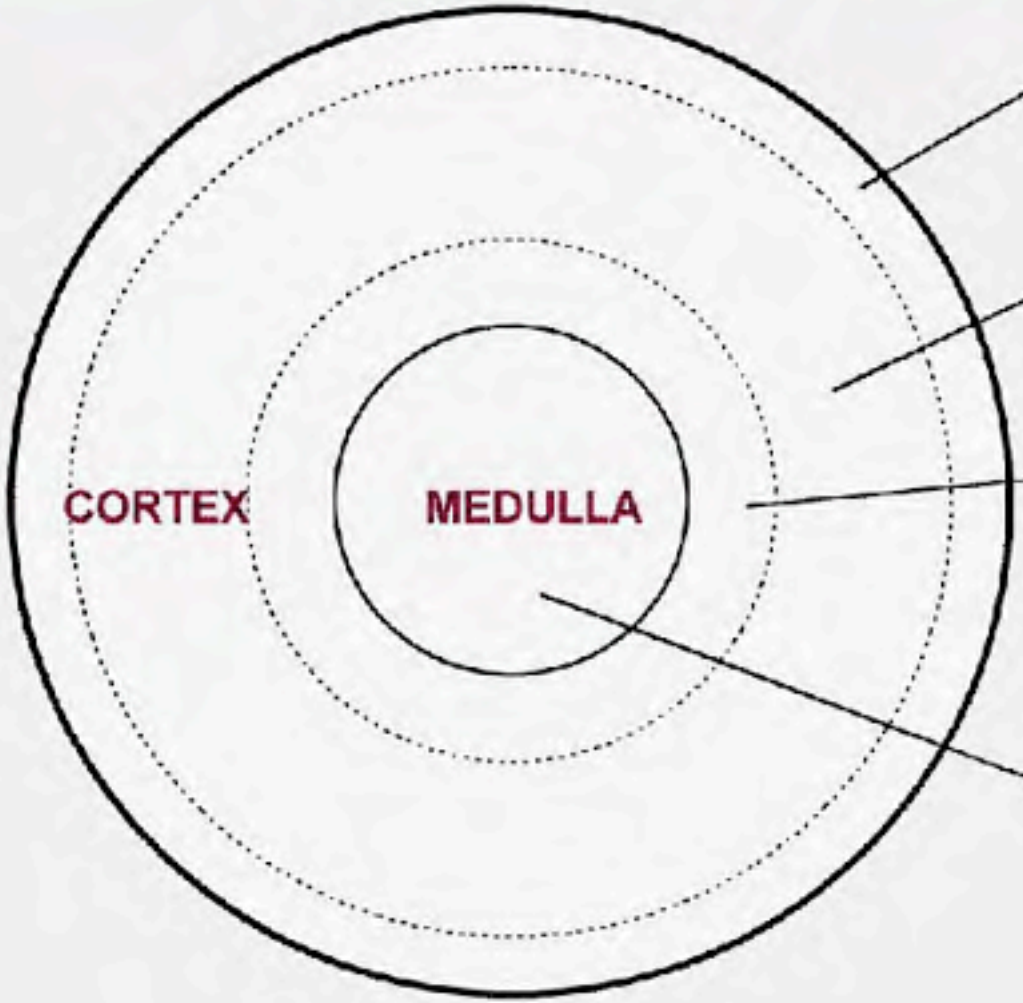
Pars intermedia, rat pituitary, LM



 A.K. Christensen

ADRENAL GLAND

ADRENAL (SUPRARENAL) GLAND



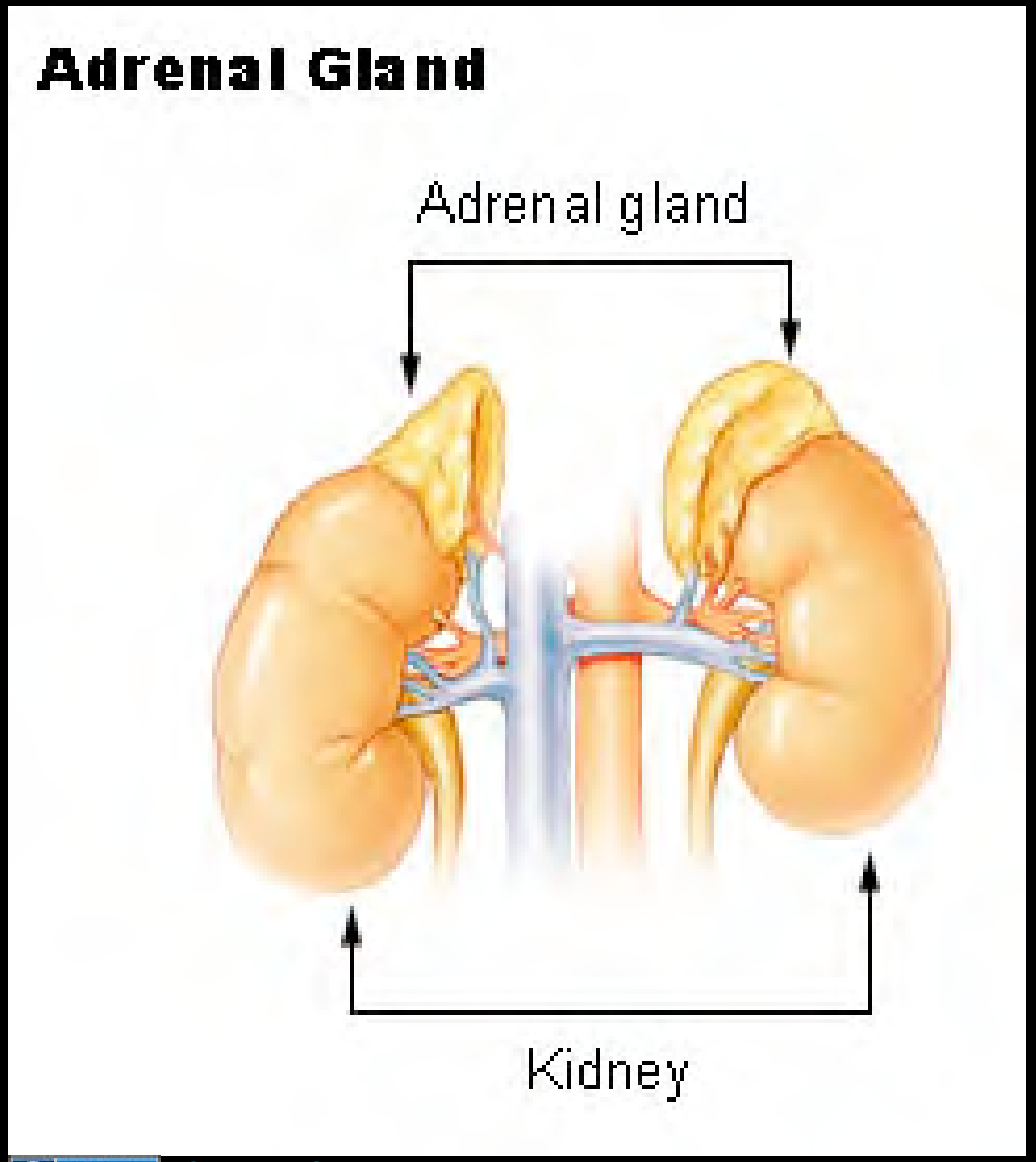
Zona glomerulosa
(→aldosterone)

Zona fasciculata
(→cortisol)

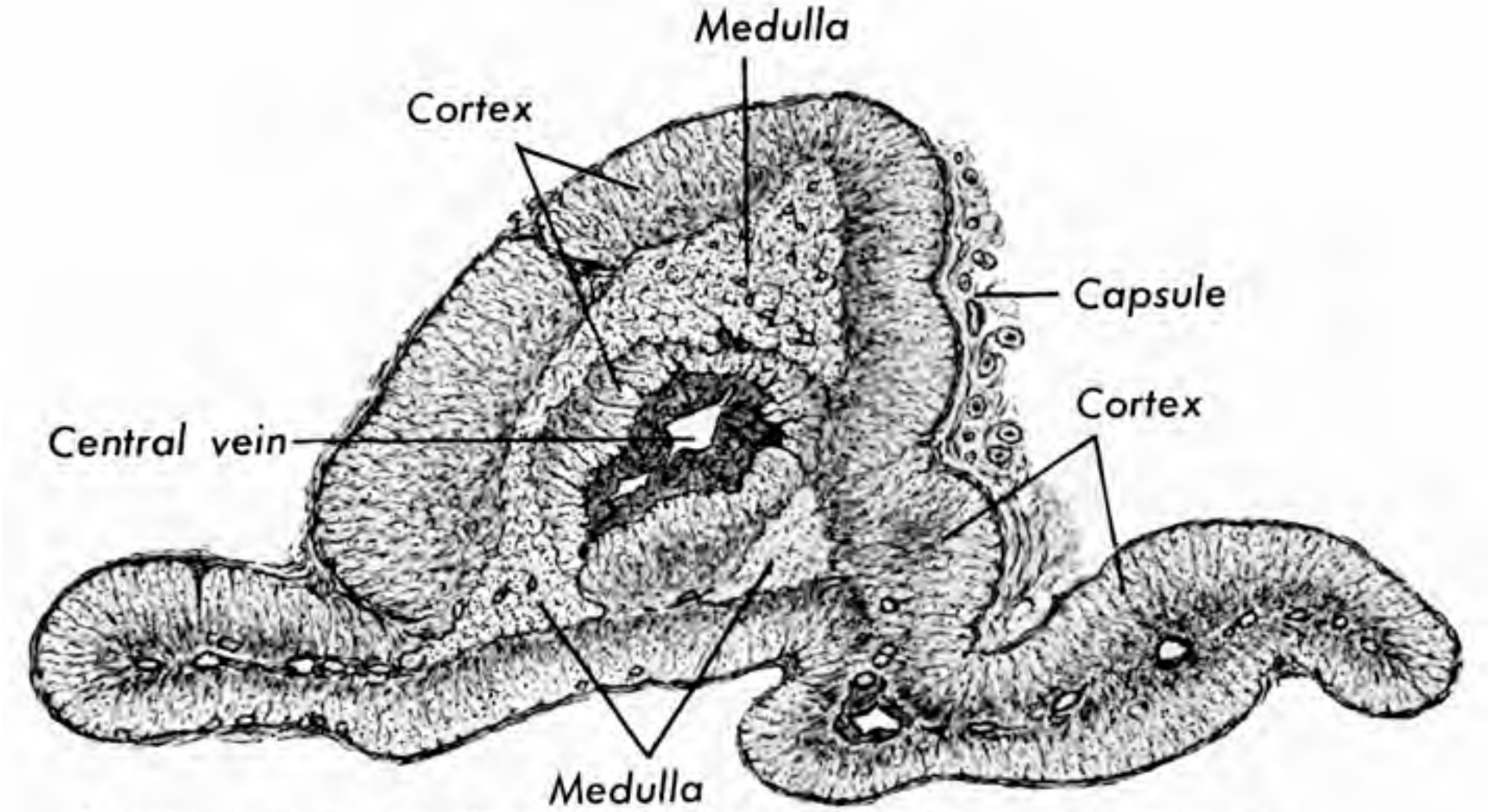
Zona reticularis
(→some cortisol and androgen)

MEDULLA
(→epinephrine and norepinephrine)

Location of the adrenal (suprarenal) gland, human



Human adrenal, low power LM



A transverse section through the left adrenal of a man 72 years old.

 Bailey's Histology

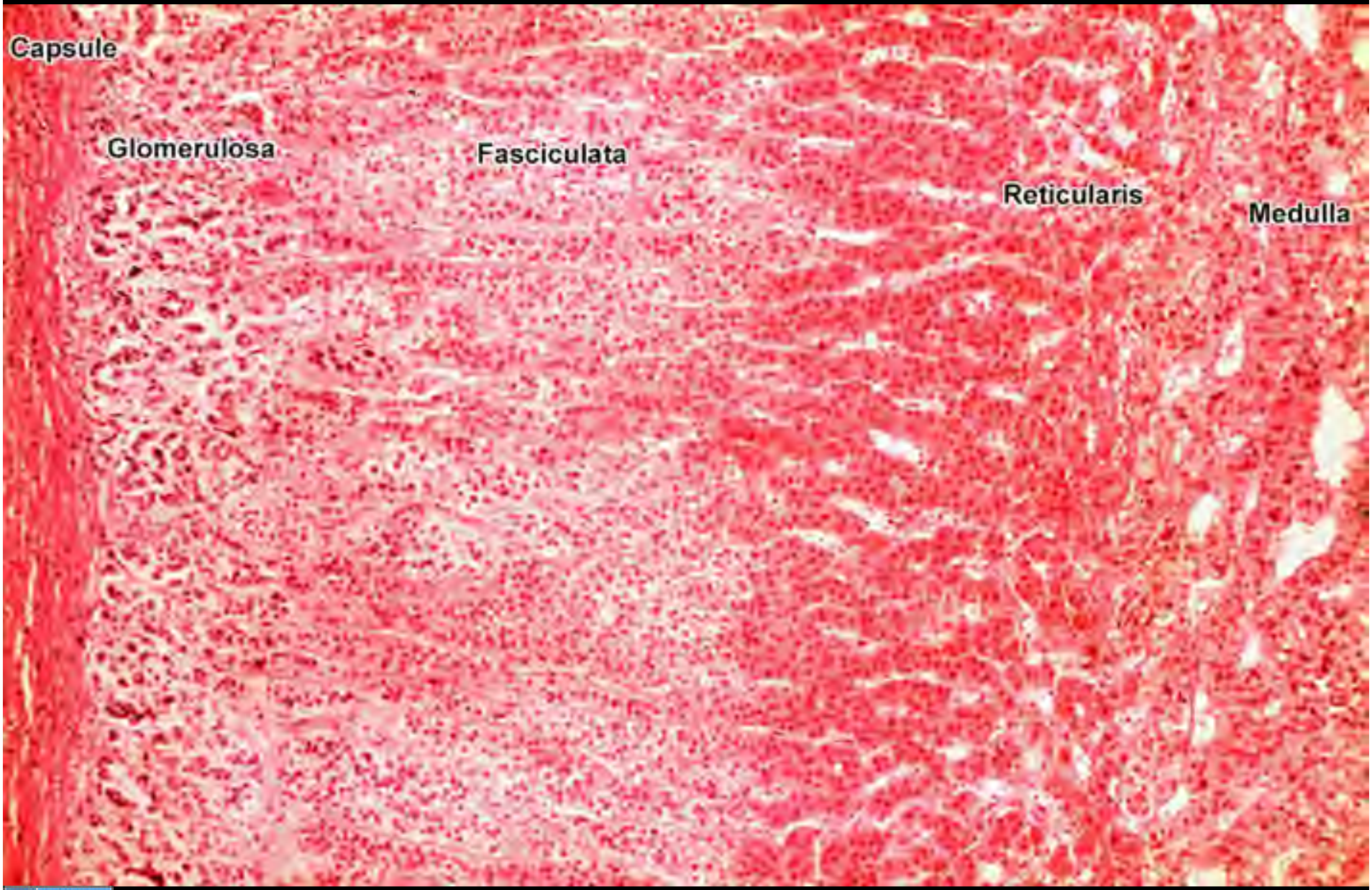
Adrenal cortex

- **Zona glomerulosa**
  - Main hormone: Aldosterone (a mineralocorticoid).
  - General function: Maintain blood electrolyte balance.
  - Main control: Angiotensin II.
- **Zona fasciculata**
  - Main hormone: Cortisol (a glucocorticoid).
  - General function: Includes regulating glucose and fatty acid metabolism, and response to stress.
  - Main control: Pituitary ACTH.
- **Zona reticularis**
  - Hormones: Some cortisol and androgens.
  - Function and control: Similar to zona fasciculata.

Adrenal cortex, human, LM

PD-INEL Hadley Kirkman slide collection, slide K285

Adrenal cortex, human, H&E, LM



 Humio Mizoguti, Kobe Univ Sch Med, slide 547

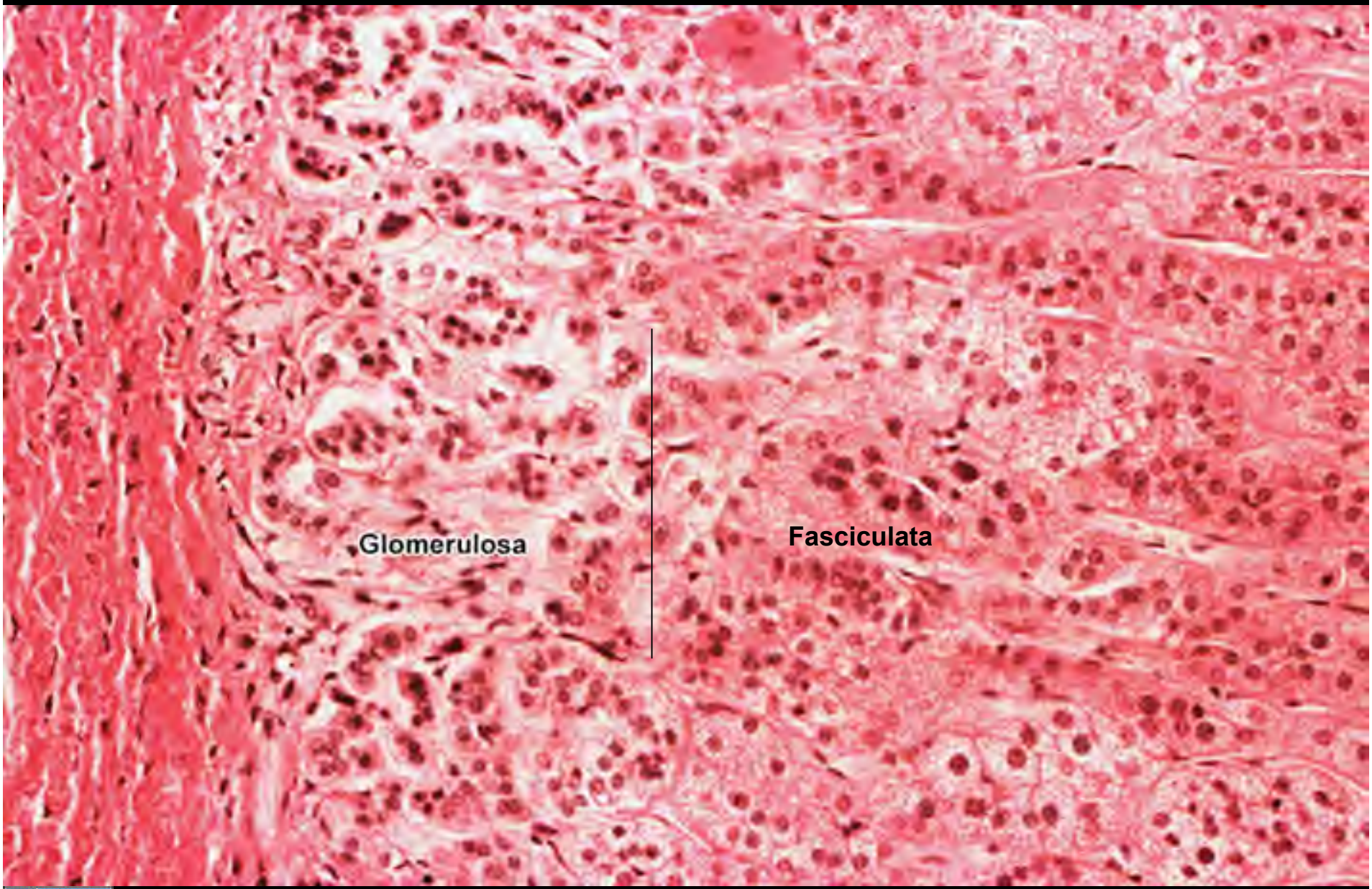
Adrenal blood vessels

Image of adrenal gland vasculature removed. Original here: Junqueira and Carneiro, 10th ed., 2003, page 414, fig 21-2.

Adrenal blood vessels, corrosion vascular cast, SEM

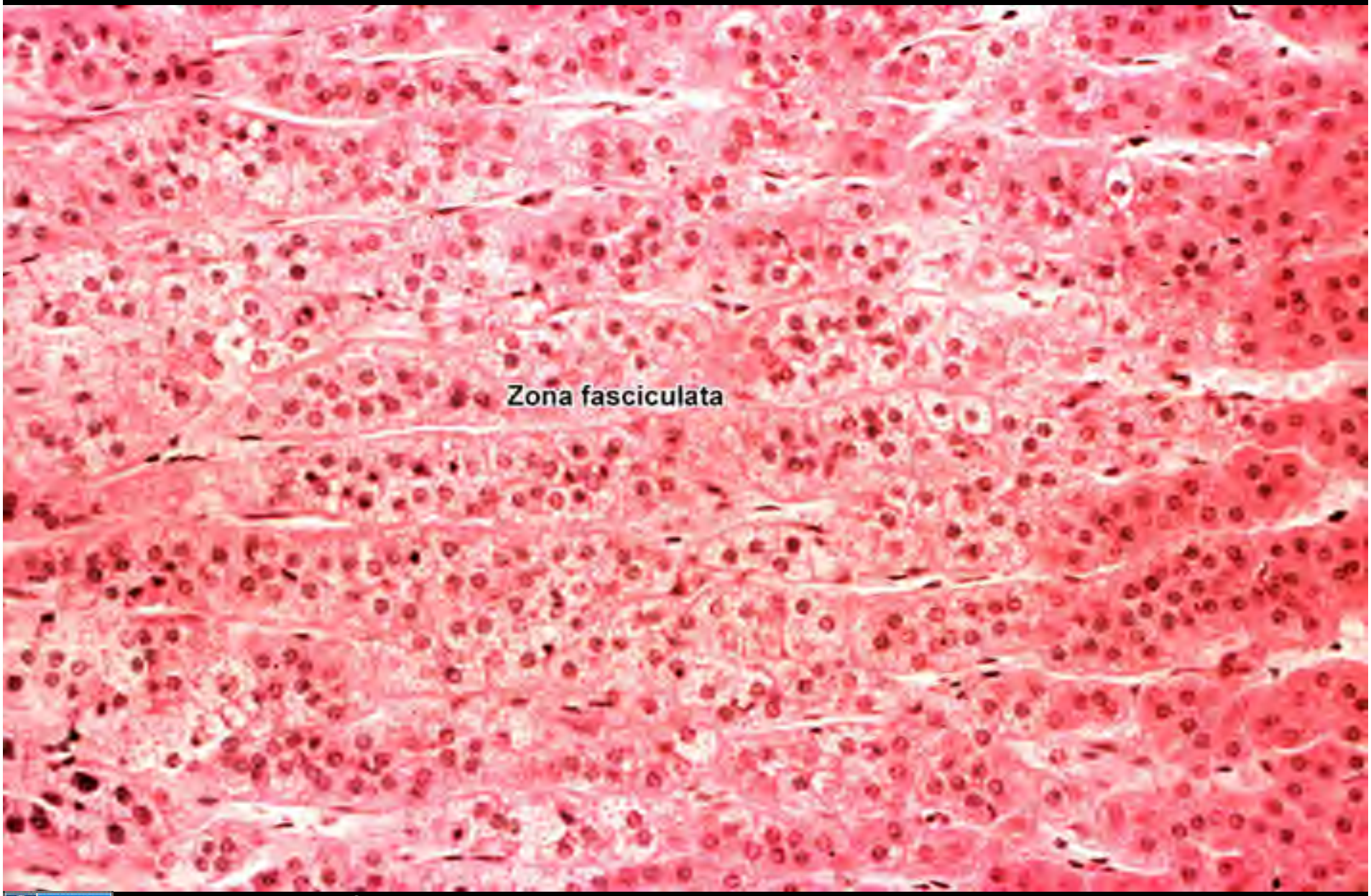
PD-INEL Virginia Black chapter, in Weiss Histology, 6th ed

Zona glomerulosa (source of aldosterone), LM



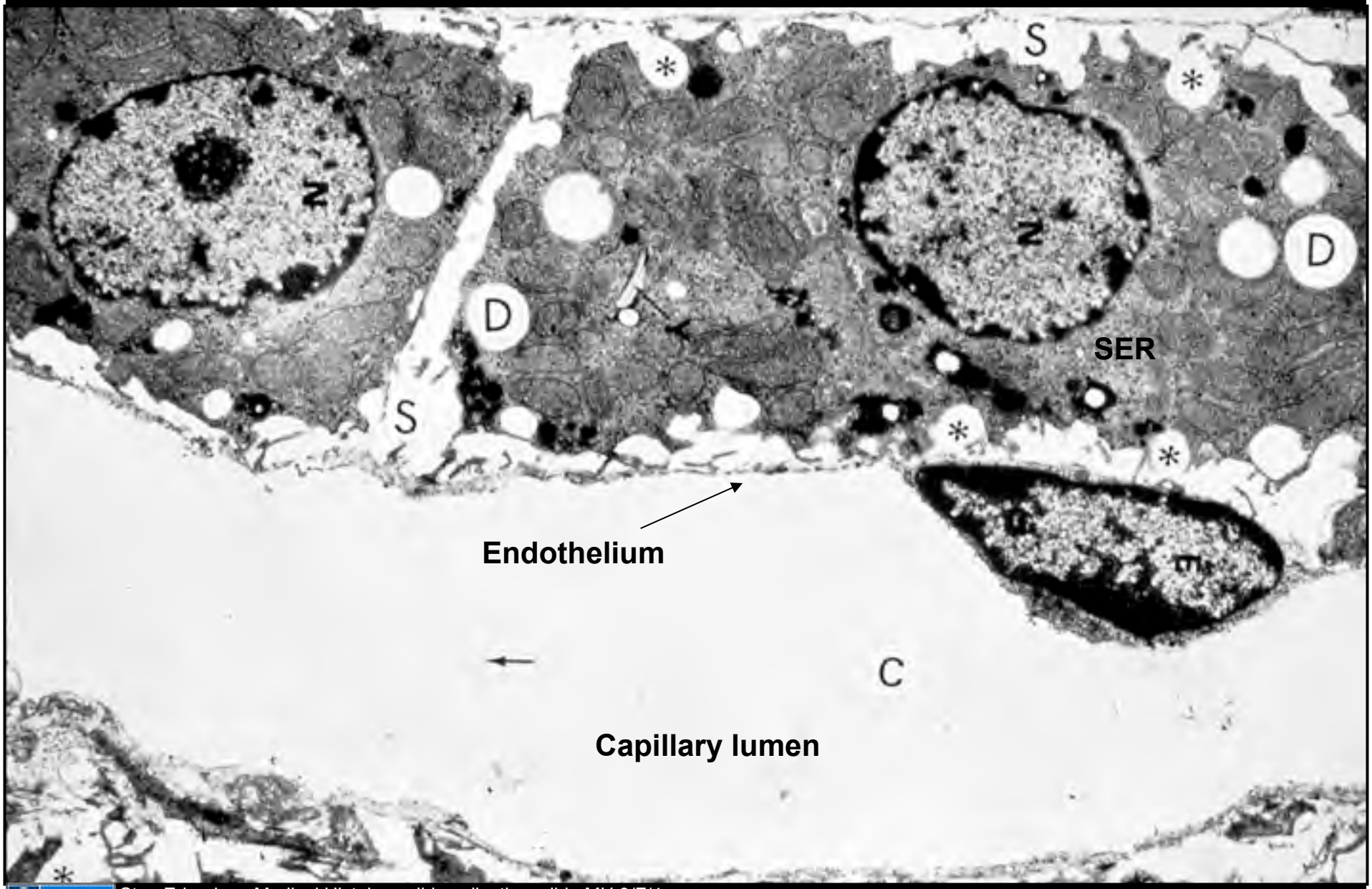
 Humio Mizoguti, Kobe Univ Sch Med, slide 548

Zona fasciculata (source of cortisol), LM



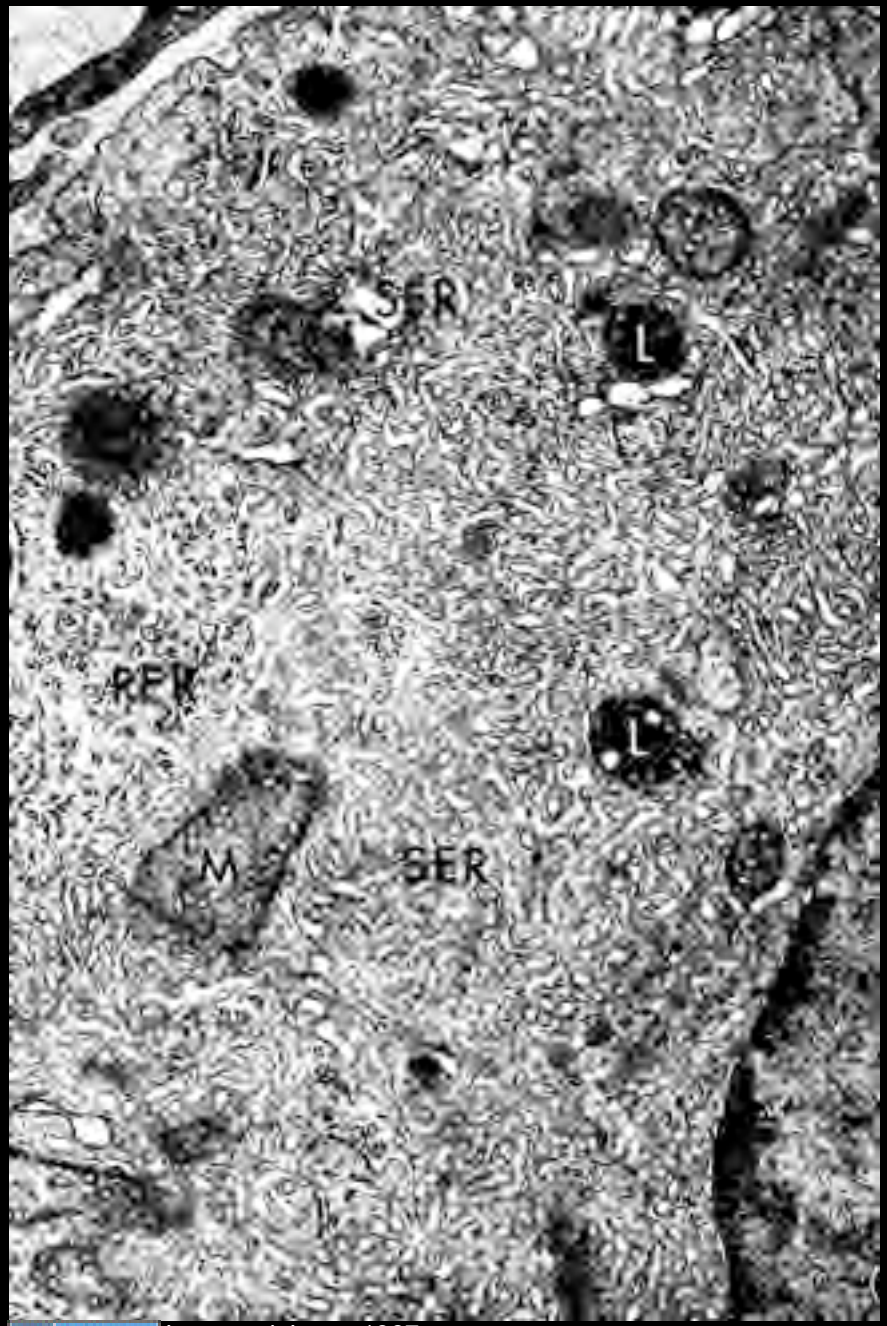
 Humio Mizoguti, Kobe Univ Sch Med, slide 549

Zona fasciculata, EM



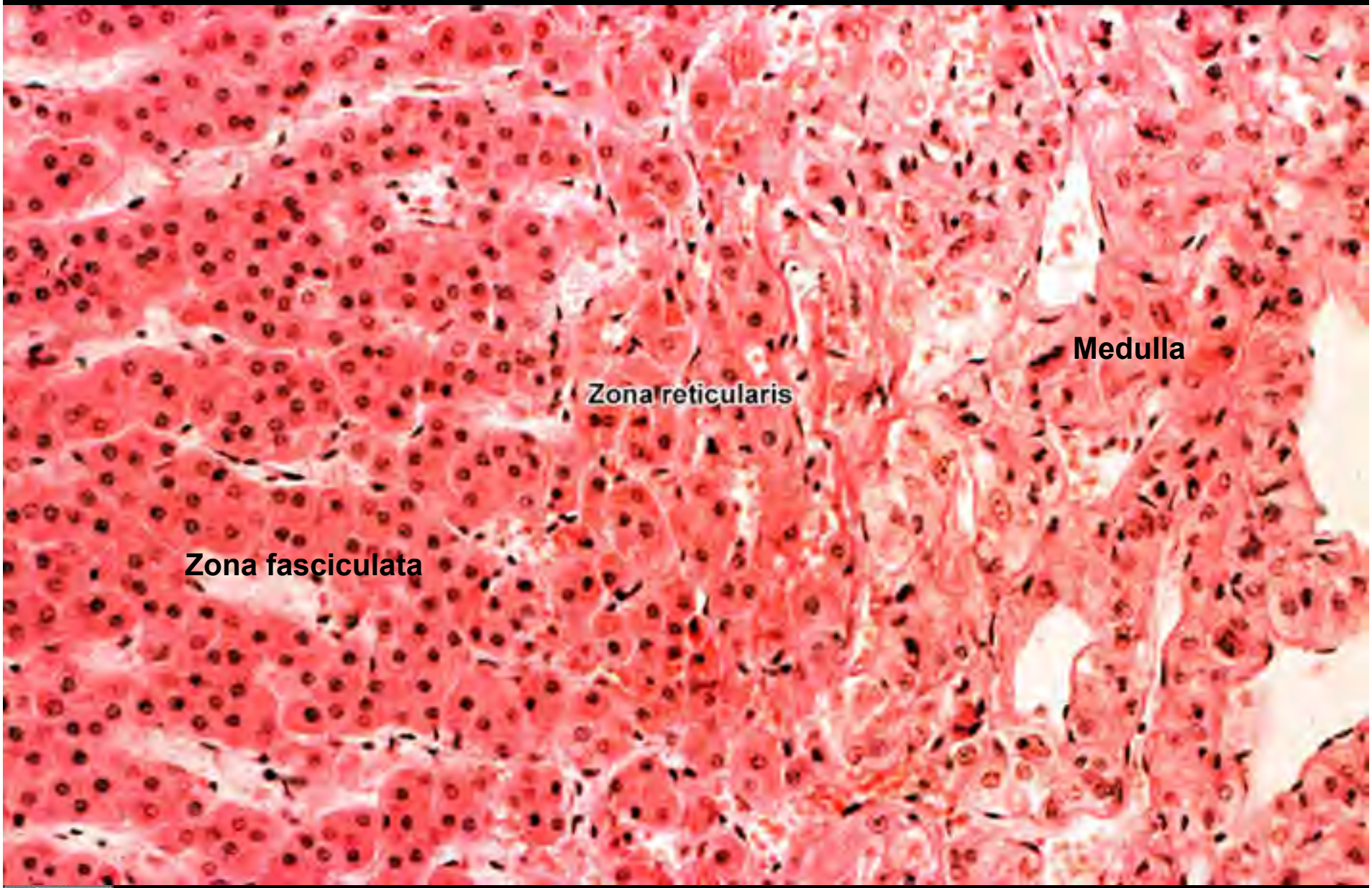
 Stan Erlandsen Medical Histology slide collection, slide MH 9/F/4

Smooth ER in the cytoplasm of a zona fasciculata cell, EM



PD-INEL Long and Jones 1967

Zona reticularis, LM

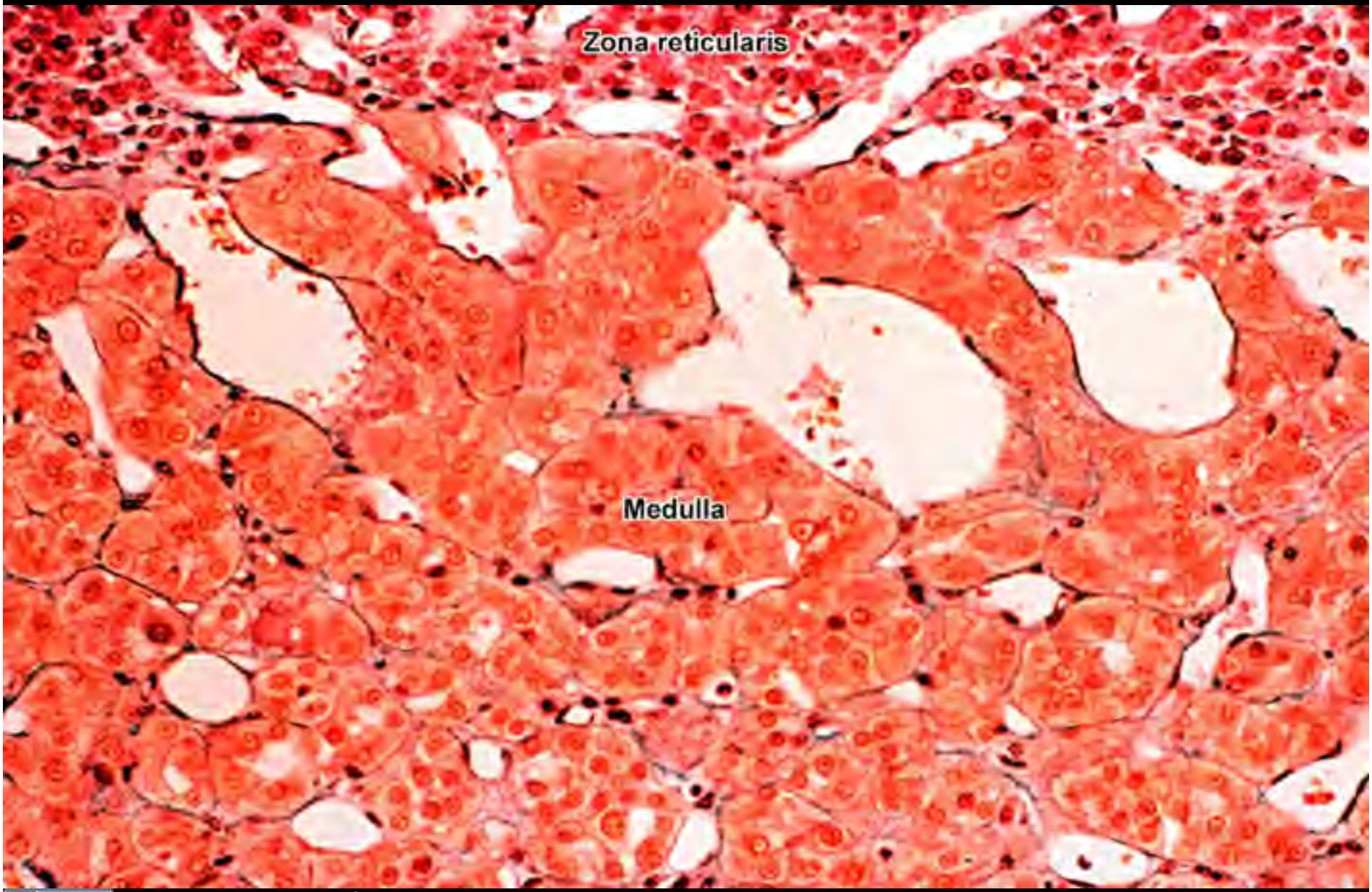


 Humio Mizoguti, Kobe Univ Sch Med, slide 550

Adrenal medulla

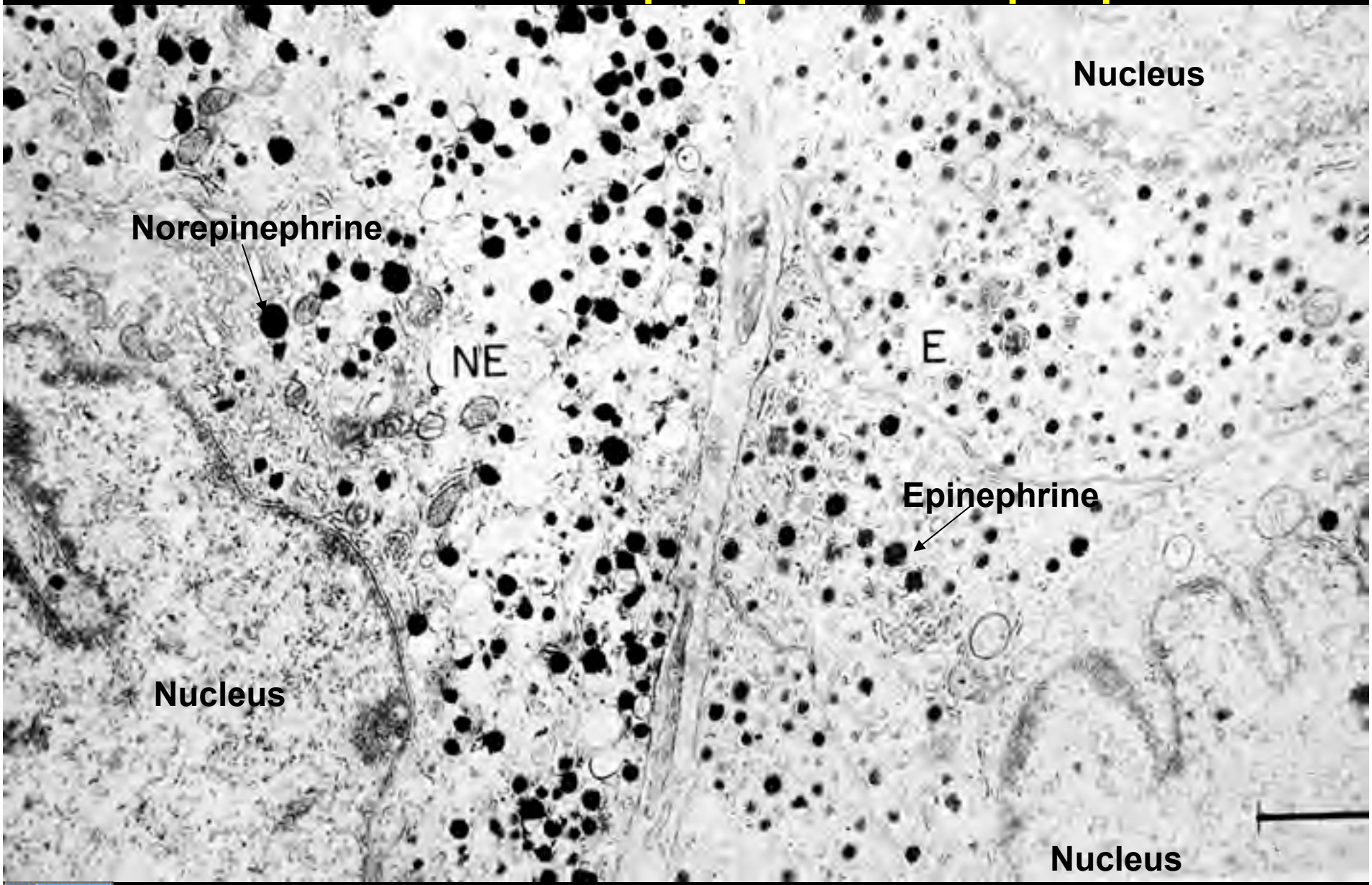
- **Hormones**
  - Epinephrine (adrenalin) and norepinephrine (noradrenalin), both catecholamines. Two cell types, one for E and one for N.
  - General function: Acute response to stress.
  - Main control: Preganglionic sympathetic innervation.
- **Embryonic source**
  - From neural crest cells, same as postganglionic sympathetic neurons. Although adrenal medulla cells do not have dendrites or axons, they behave like postganglionic sympathetic neurons, releasing norepinephrine/epinephrine in response to preganglionic sympathetic stimulation.
- **Also called "chromaffin cells"**
  - Cells of the adrenal medulla are examples of "chromaffin cells," containing catecholamine granules that stain brown with potassium dichromate. Neurons of sympathetic ganglia are also chromaffin cells. The term is used in pathology.

Adrenal medulla, LM



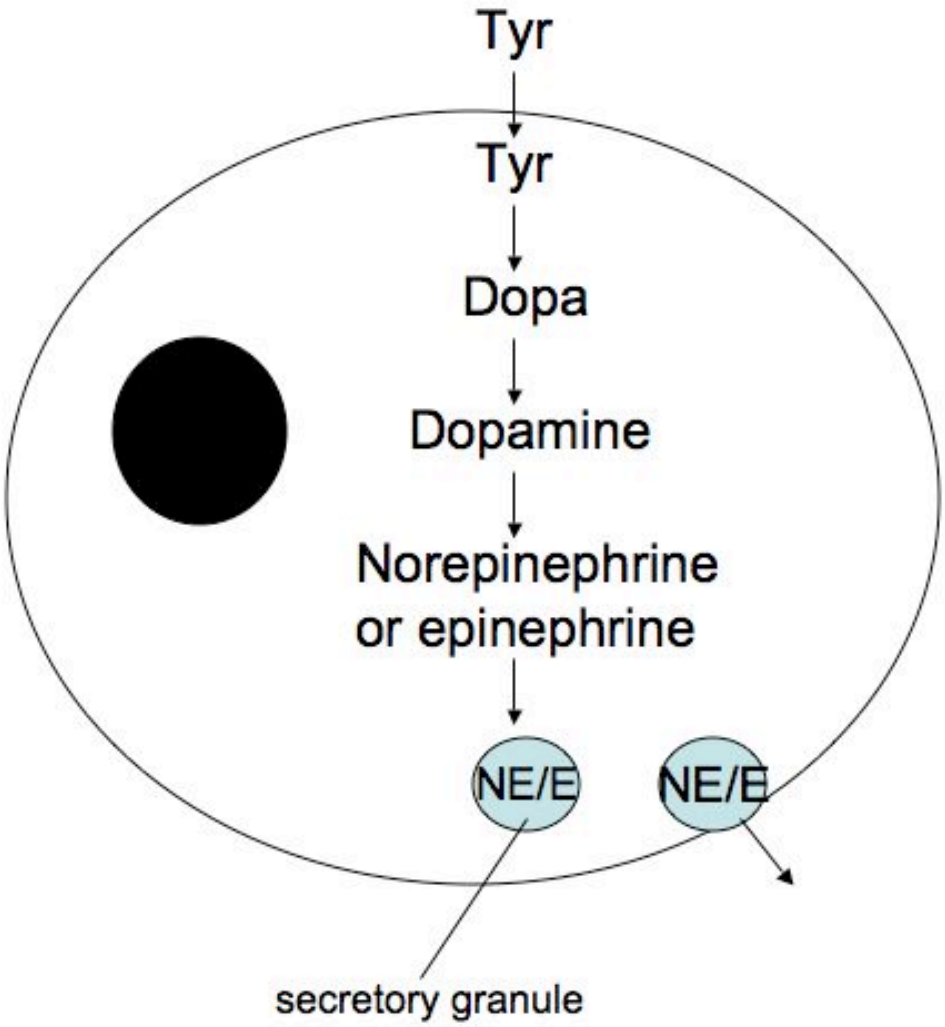
 Humio Mizoguti, Kobe Univ Sch Med, slide 565

EM of adrenal medulla: norepinephrine and epinephrine cells



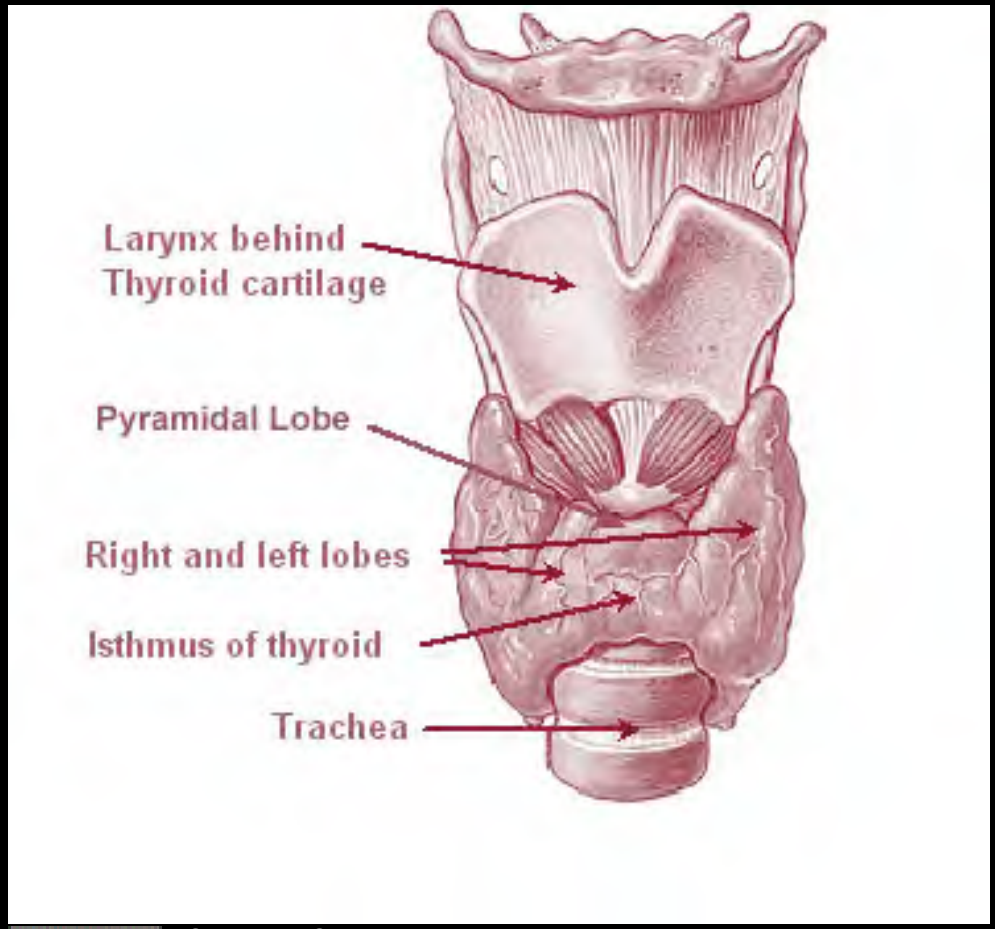
 Stan Erlandsen Medical Histology Slide Collection, slide MH 9/G/2-P

Production of norepinephrine and epinephrine in the cytosol



THYROID GLAND

Location of thyroid gland

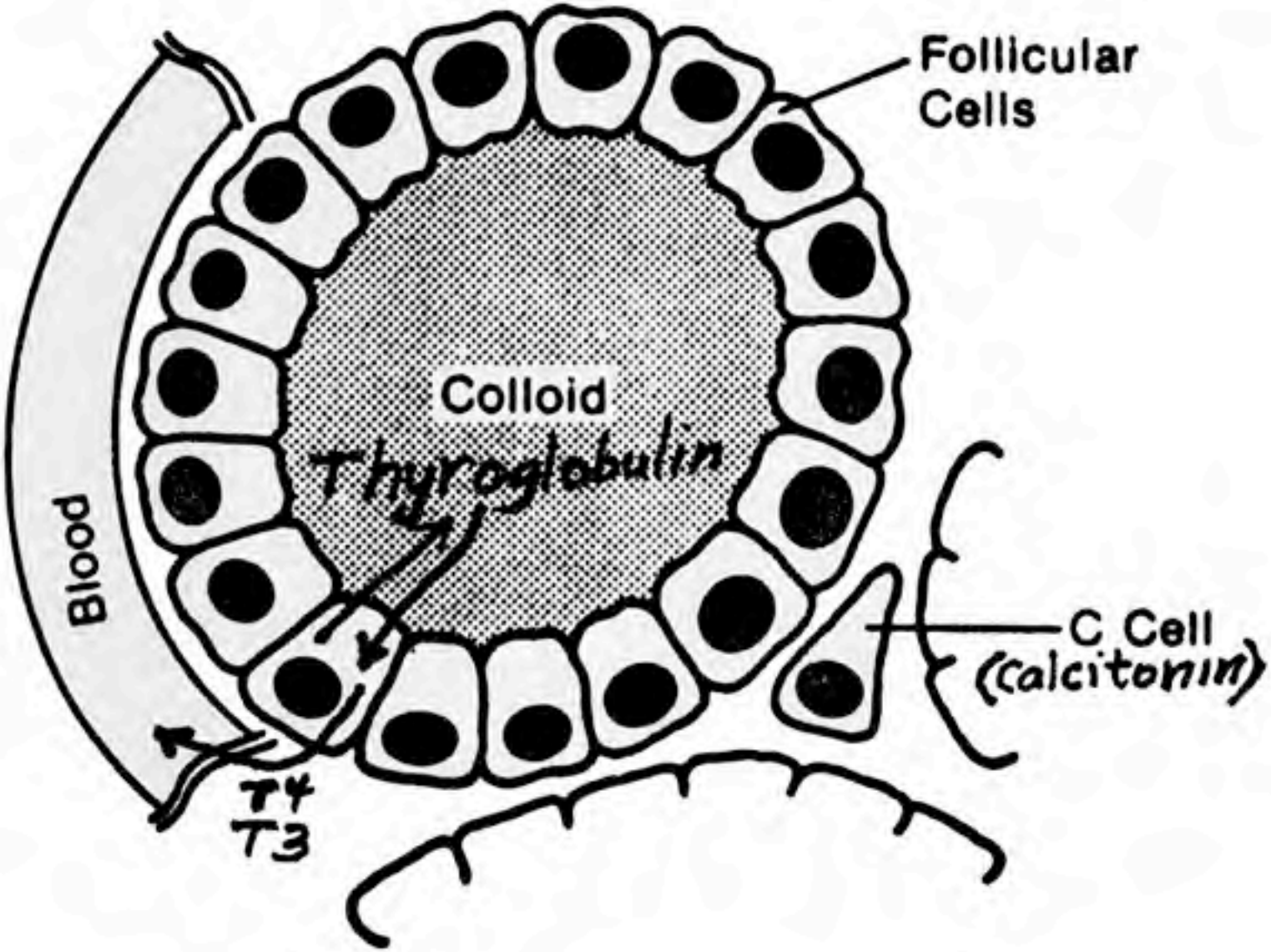


Thyroid gland

- **Thyroid follicles**
  - Thyroid hormones: thyroxine (T4), triiodothyronine (T3).
  - Synthesis: A very large protein, thyroglobulin (660 kDa), is synthesized and then secreted into the follicle lumen. It is later taken up and broken down (with lysosomes) to yield T4 and T3.
  - General function: To increase the body's metabolic rate.
  - Main control: Pituitary TSH.

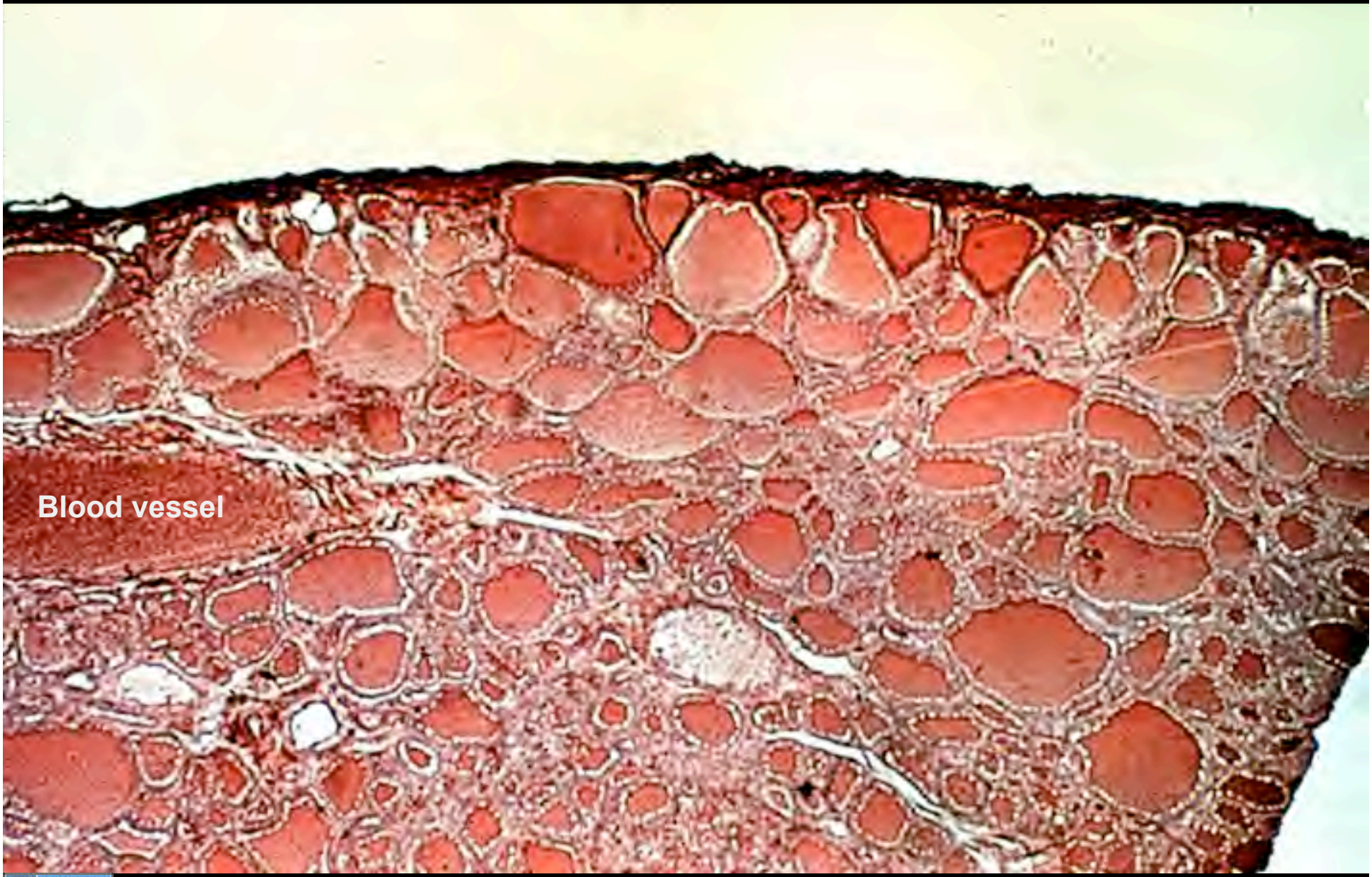
- **Parafollicular cells (= C-cells)**
  - Hormone: Calcitonin.
  - General function: Lower serum calcium.
  - Main control: Serum calcium level.

Thyroid follicle



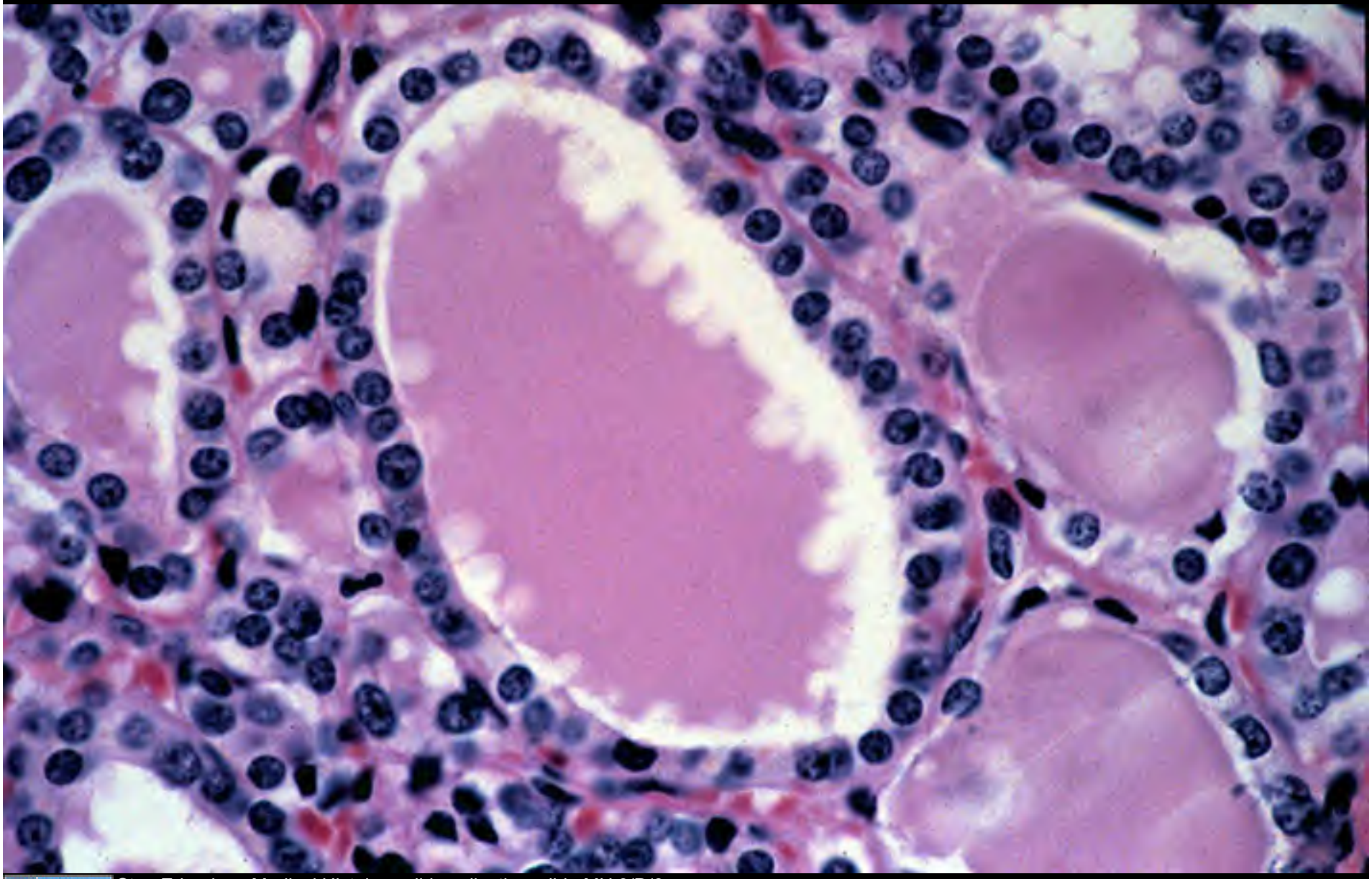
 Modified from Hedge 1987

Thyroid, low power LM



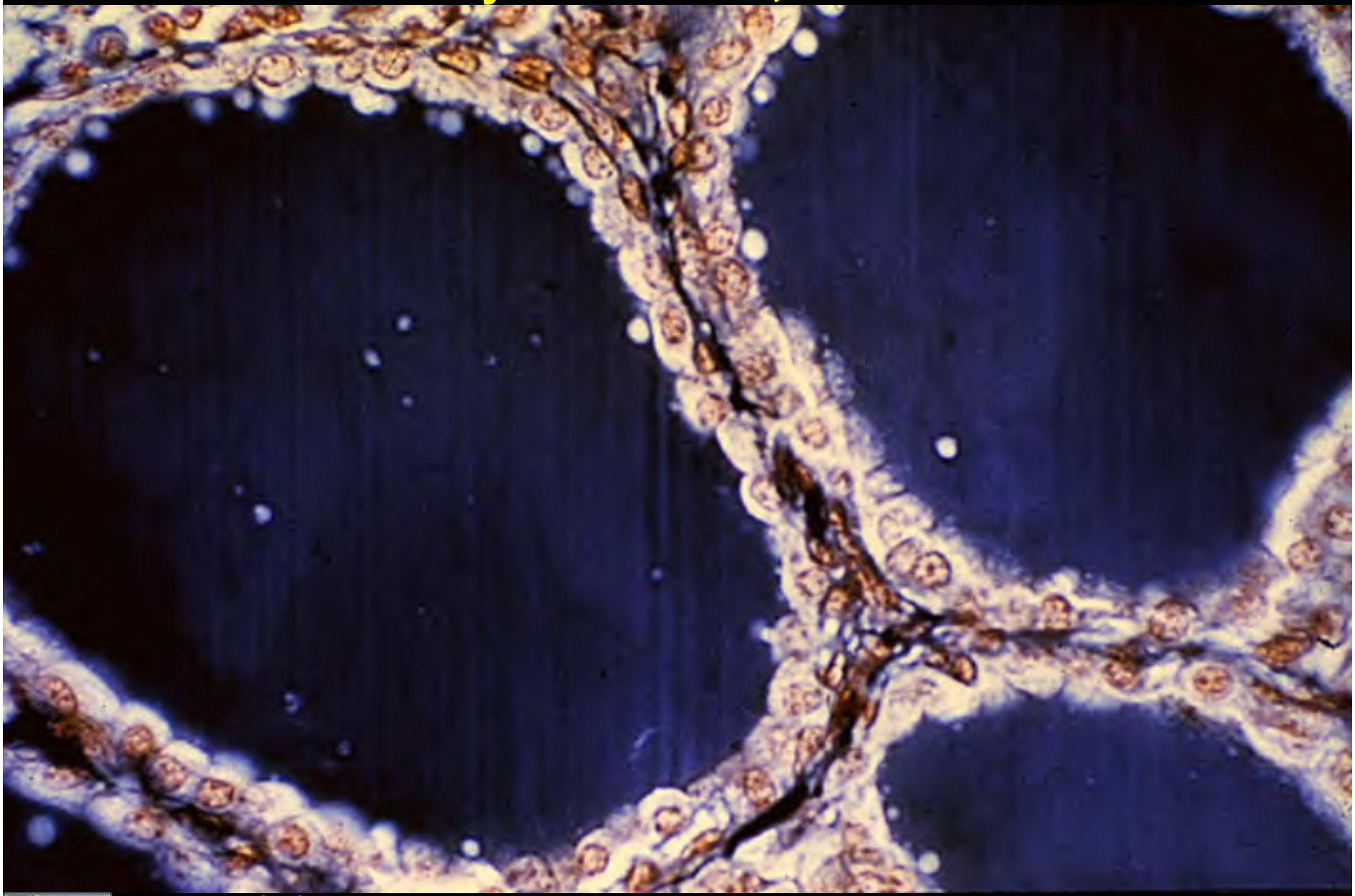
 Hadley Kirkman (Stanford) slide collection, slide 18

Thyroid follicles, LM



 Stan Erlandsen Medical Histology slide collection, slide MH 9/D/6

Thyroid follicles, LM



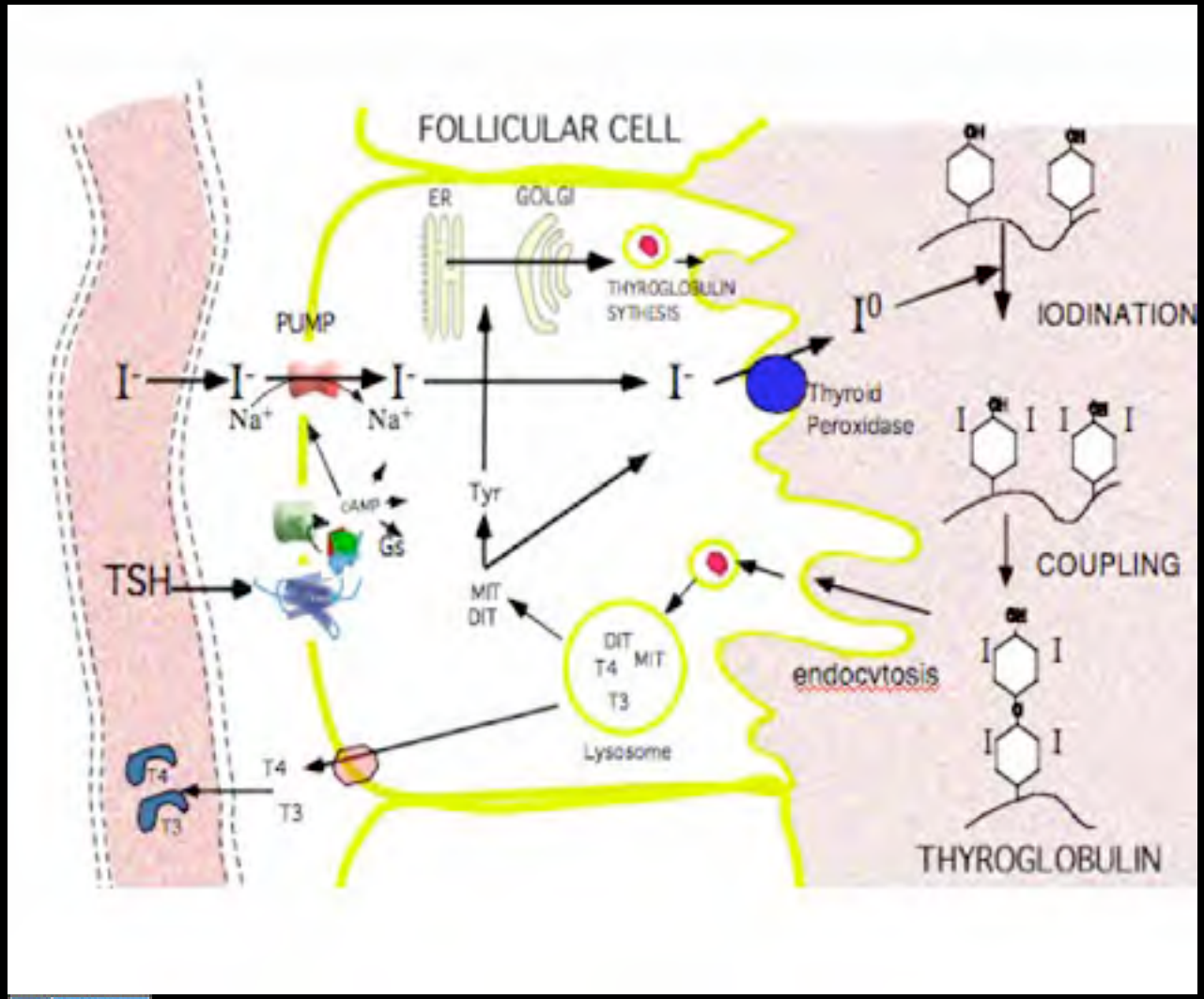
 Hadley Kirkman (Stanford) slide collection, slide K27

Thyroid capillary beds, corrosion vascular cast, SEM

 Stan Erlandsen Medical Histology slide set, slide MH 9/D/5

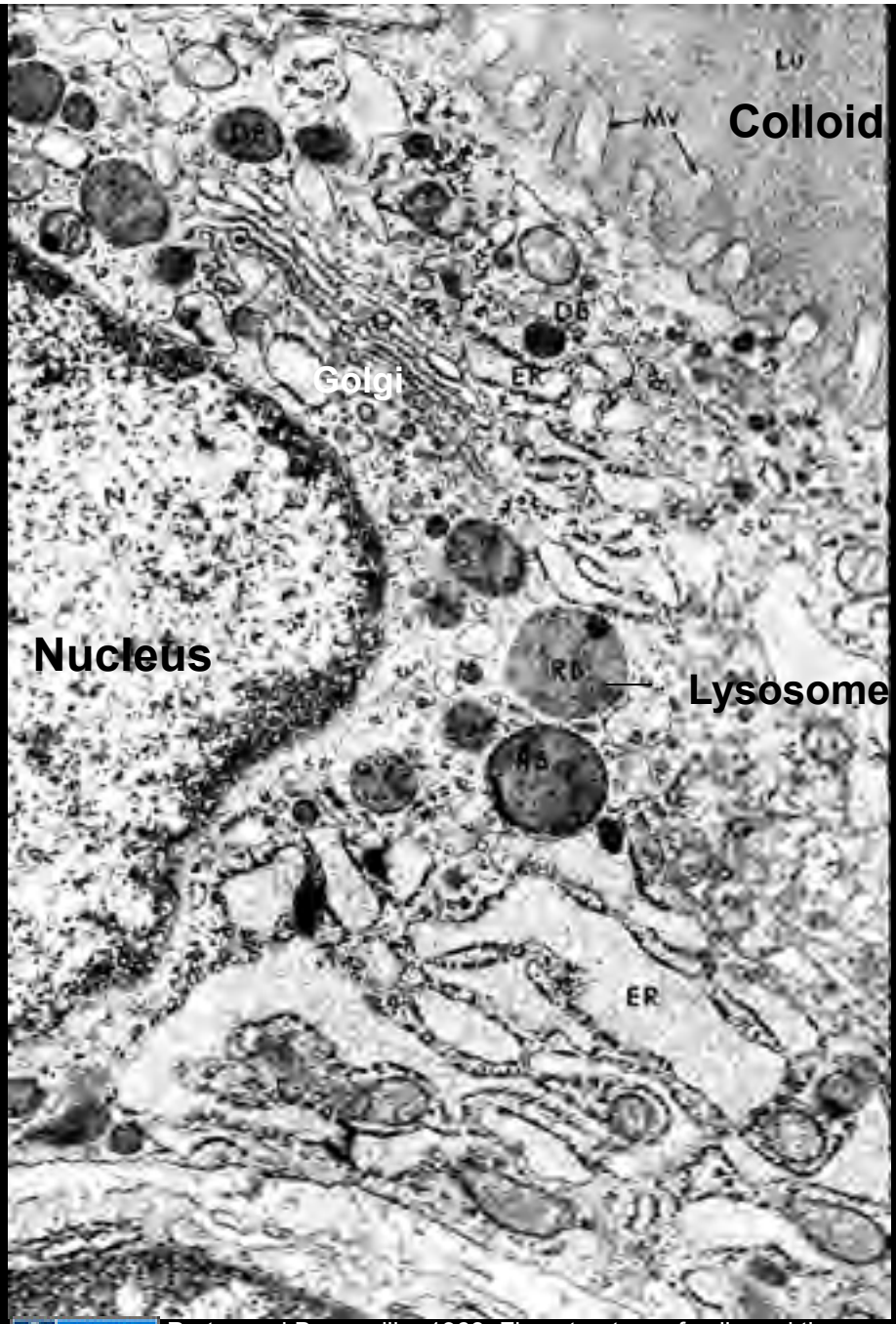
Production of thyroid hormones by a follicular cell

Synthesize thyroglobulin and then secrete it into the colloid. Iodinate tyrosine residues on thyroglobulin. When stimulated by pituitary TSH, take up the thyroglobulin and break it down in lysosomes to release thyroid hormones T3 and T4.



PD-INEL Modified from Junqueira and Carneiro, 10th ed., 2003, page 426, fig. 21-19 by R. Mortensen

Thyroid follicular cell, EM



PD-INEL Porter and Bonneville, 1968, Fine structure of cells and tissues, 3rd ed

TABLE 5. *Causes of Goiter* **(increase in thyroid size)**

A. Iodine deficiency
B. Excessive intake of goitrogen
    1. Natural goitrogens
    2. Iatrogenic goitrogens
    3. Industrial goitrogens
C. Hereditary defect in thyroid hormone synthesis
    1. Iodide-trapping defect
    2. Iodide-organification defect
    3. Iodotyrosyl-coupling defect
    4. Thyroid hormone release defect
    5. Iodotyrosine dehalogenase defect
    6. Defect associated with abnormal serum iodoprotein
D. Increased need for thyroid hormone
    1. Puberty
    2. Pregnancy
    3. Menstruation
    4. Lactation
E. Pituitary or hypothalamic dysfunction
F. Primary thyroid disease

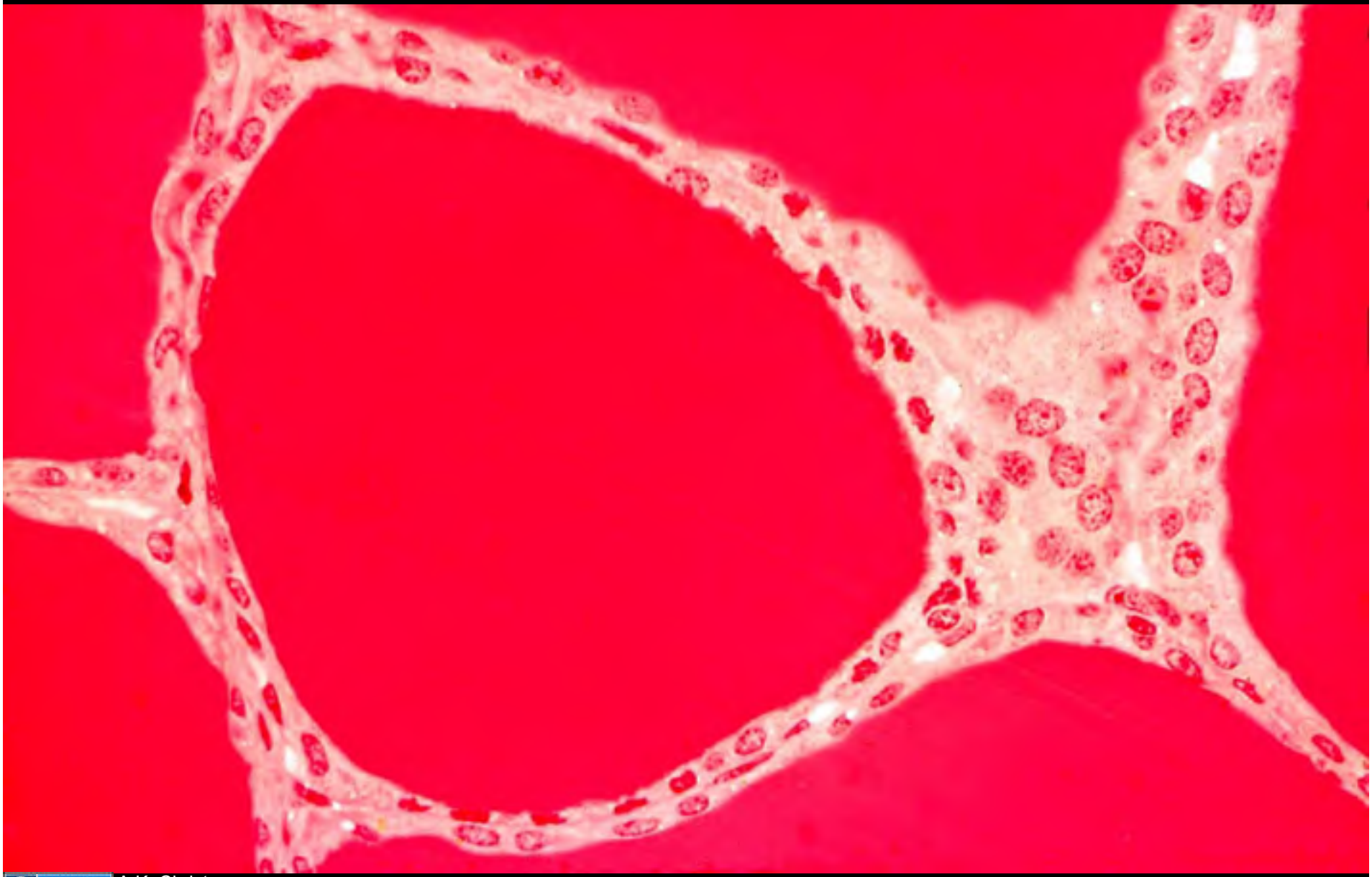
 Rugh and Patton 1965, Physiology and biophysics, 19th ed

Functional states of thyroid follicles

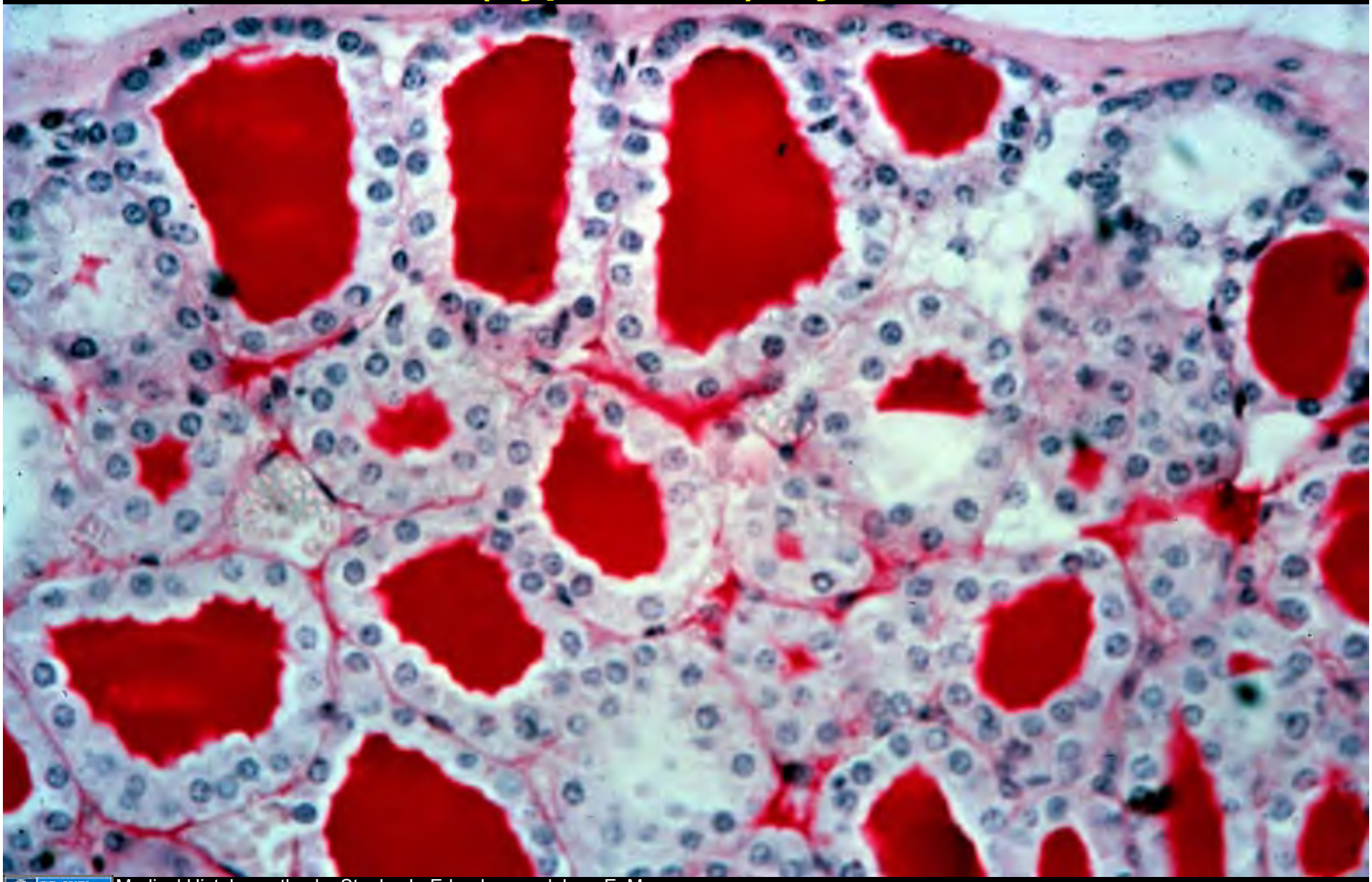
Normal
Underactive = hypoactive
Overactive = hyperactive

Image of thyroid follicles removed. Original here: 0'Riordan, 2nd ed, p 160.

Underactive (hypoactive) thyroid follicles, LM



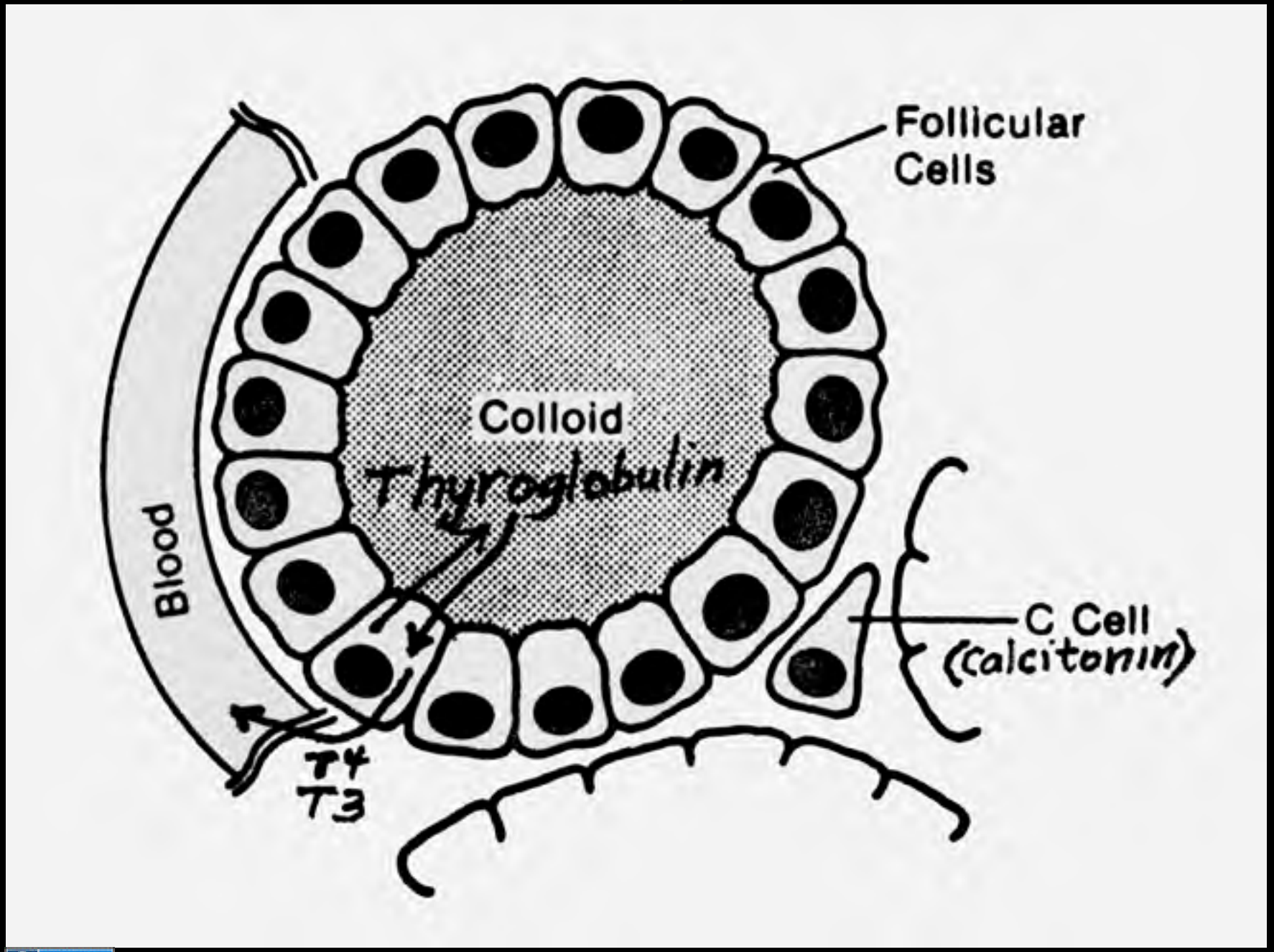
Overactive (hyperactive) thyroid follicles



Thyroid gland

- **Parafollicular cells (= C-cells)**
  - **Hormone: Calcitonin.**
  - **General function: Lowers serum calcium.**
  - **Main control: Serum calcium level.**

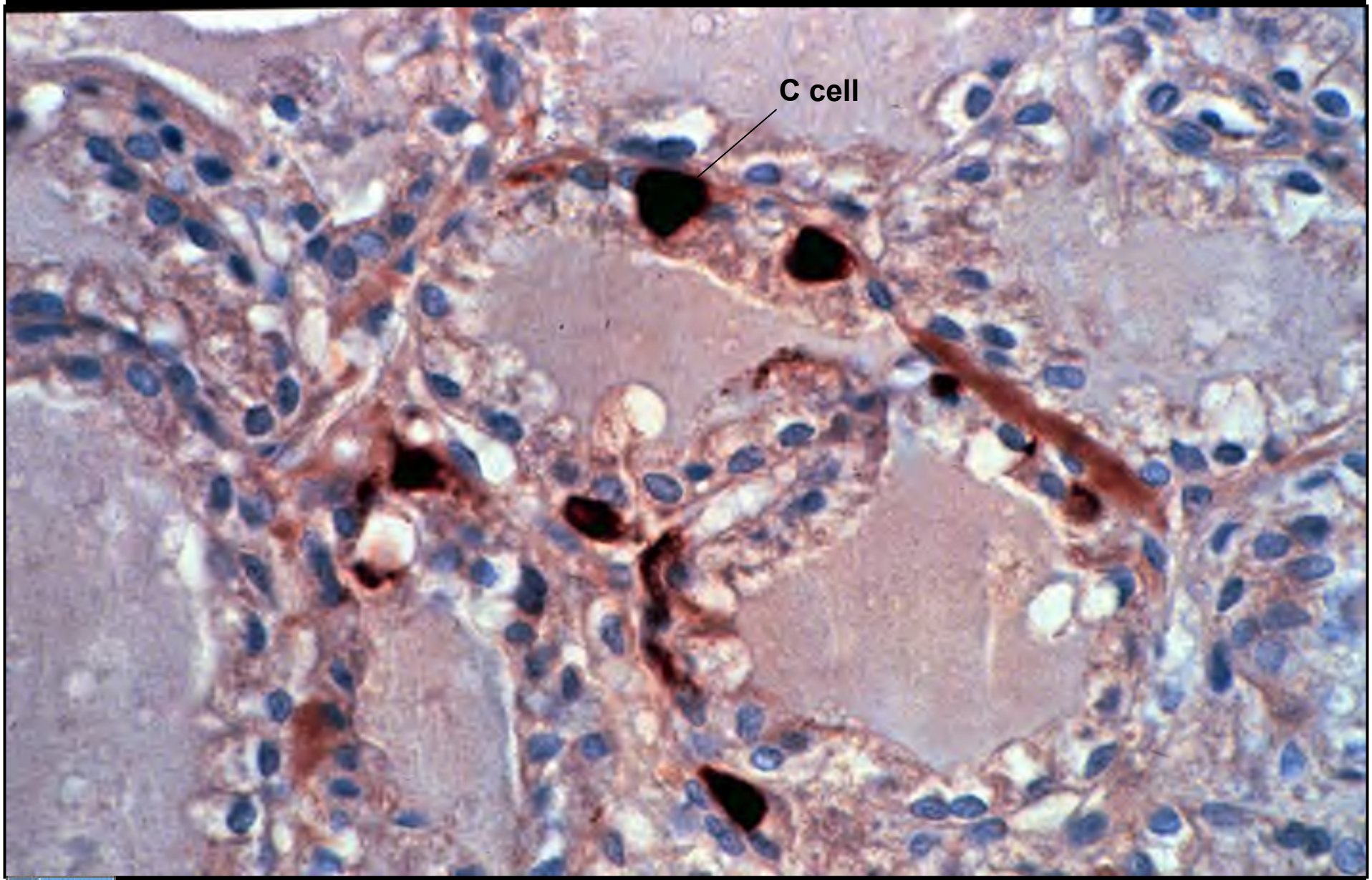
C cell location in thyroid



 Hedge 1987

C-cell in thyroid follicular epithelium, LM

Immunocytochemical localization of calcitonin in C cells, LM



 Stan Erlandsen Medical Histology slide collection, slide MH 9/D/8

Parafollicular cell (C cell), EM

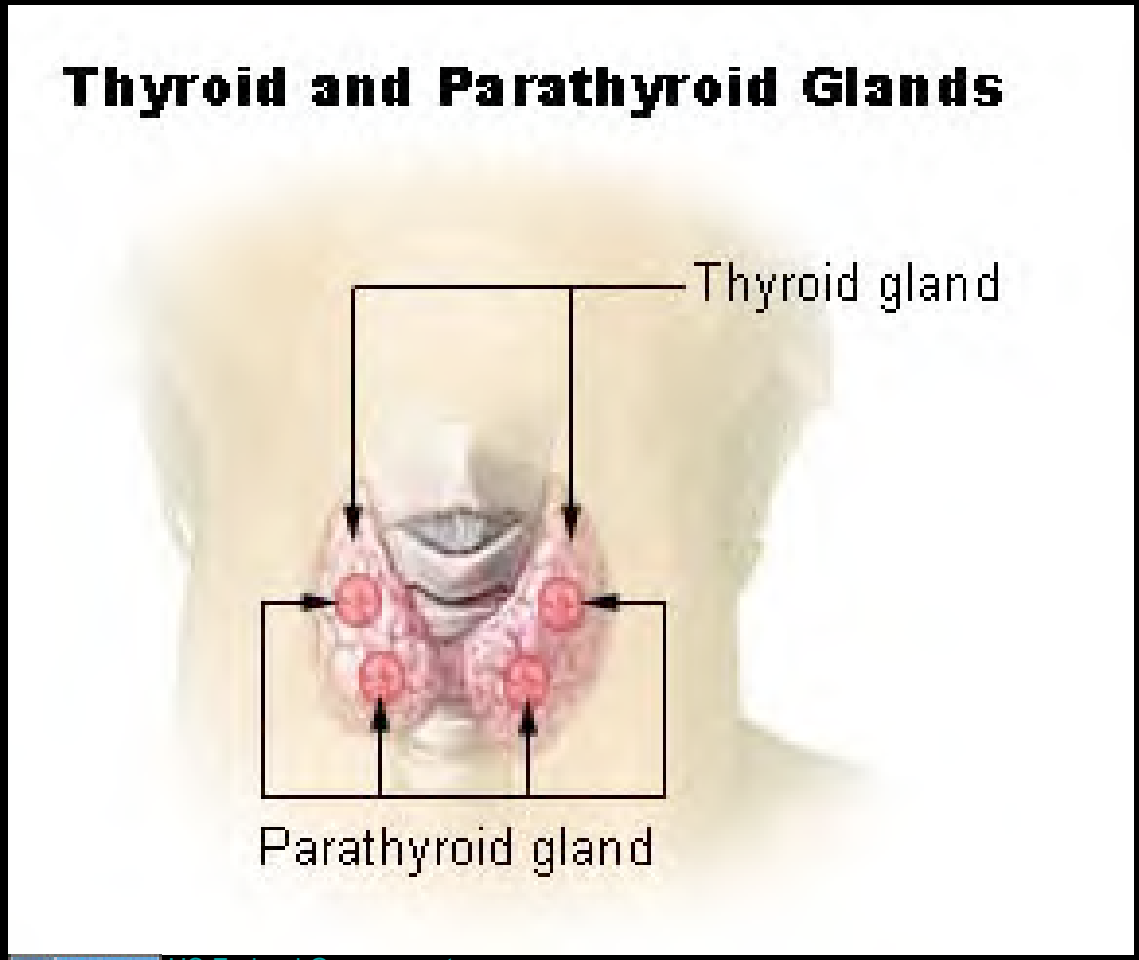
PD-INEL Junqueira histology textbook

Regulation of serum calcium

Parathyroid hormone (from parathyroid)	$Ca^{++}\uparrow$
Calcitonin (thyroid parafollicular cells)	$Ca^{++}\downarrow$

PARATHYROID GLAND

Location of the four parathyroid glands on the back of the thyroid



Parathyroid gland

- **Chief (or principal) cells**
  - Hormone: Parathyroid hormone (PTH).
  - Main function: Raises serum calcium, lowers serum phosphate.
  - Main control: Serum calcium level.
- **Oxyphil cells**
  - Occasional cells or small clusters.
  - Function unknown.
  - Name means "acid [stain] loving" (Greek).

Parathyroid gland (mostly chief cells) , low power LM

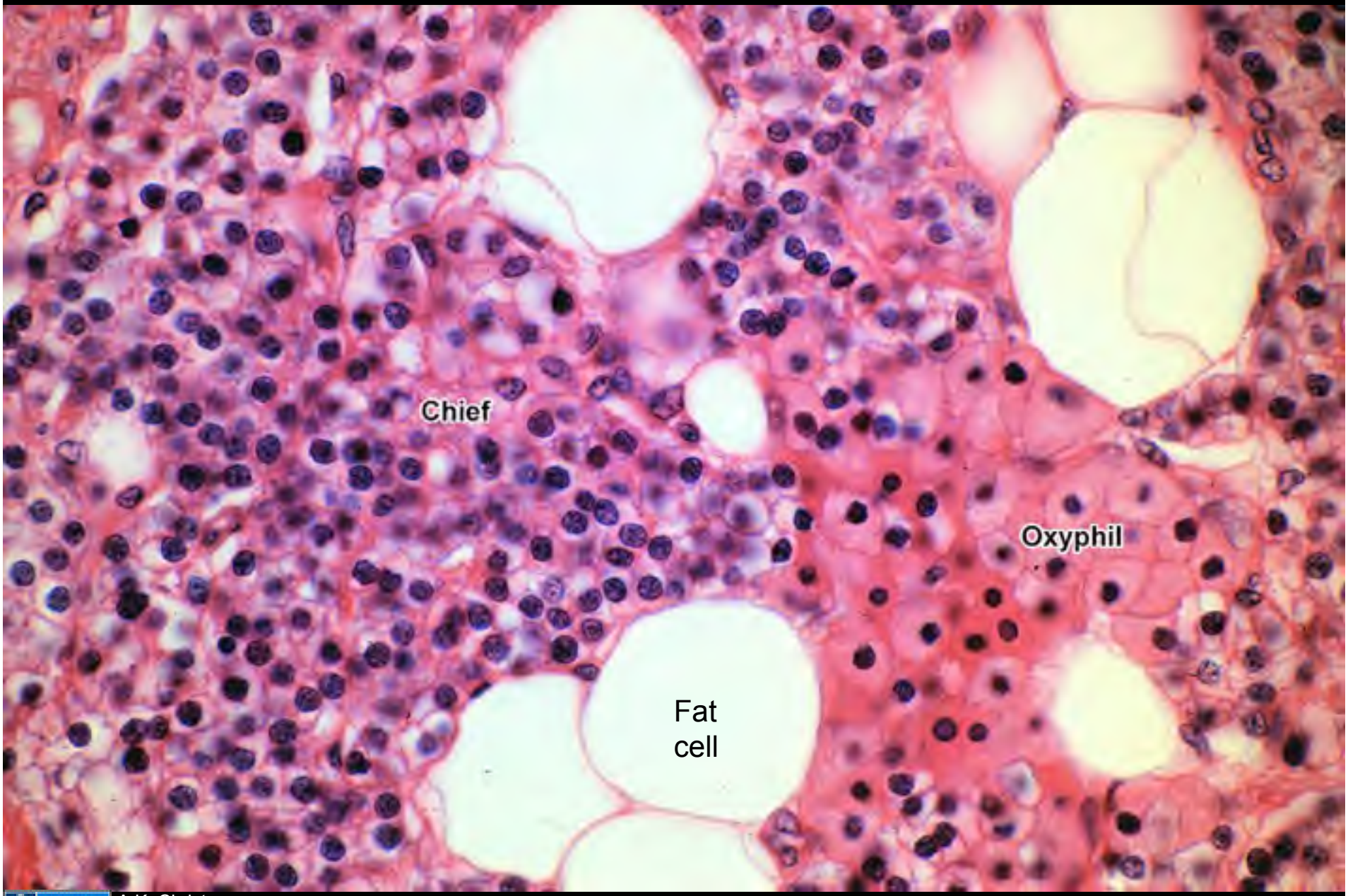
 Humio Mizoguti, Kobe Univ Sch Med, slide 542

Parathyroid, chief cells, one oxyphil (arrow), LM

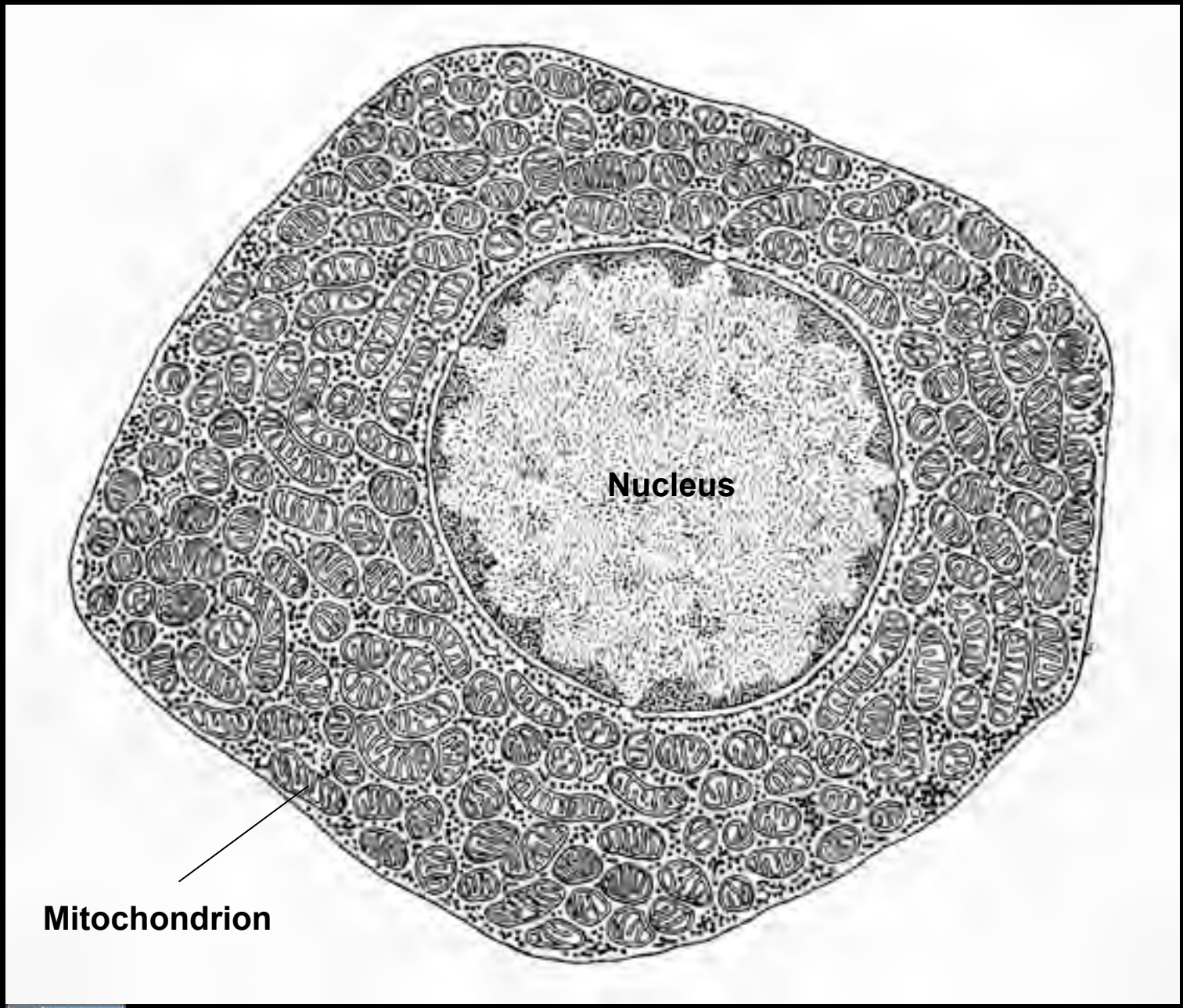
Parathyroid capillary bed, corrosion vascular cast, SEM

PD-INEL Murakami et al 1987, Arch Hist Jap 50:495, fig 2

Oxyphil cell cluster, LM



Oxyphil cell, EM diagram



PD-INEL Thomas Lentz atlas

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