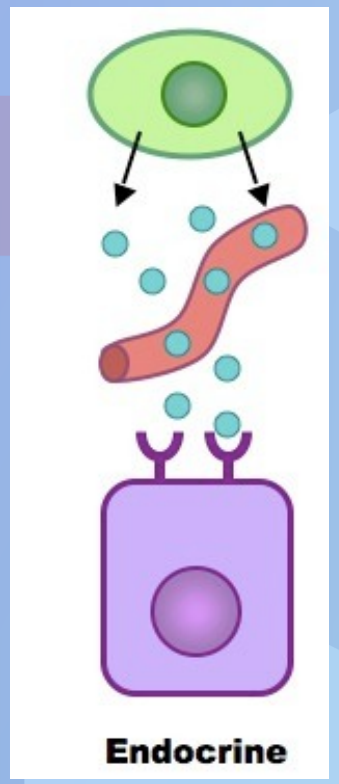
Endocrine System

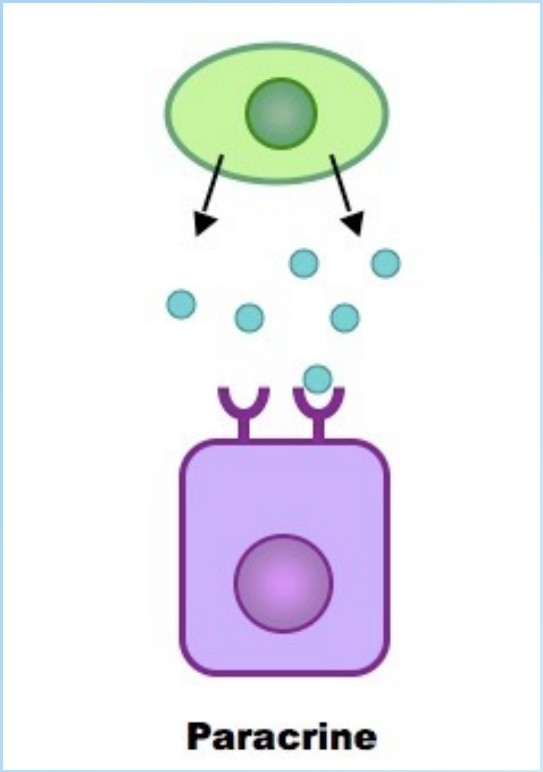
Part 1

Types of hormonal cell signaling

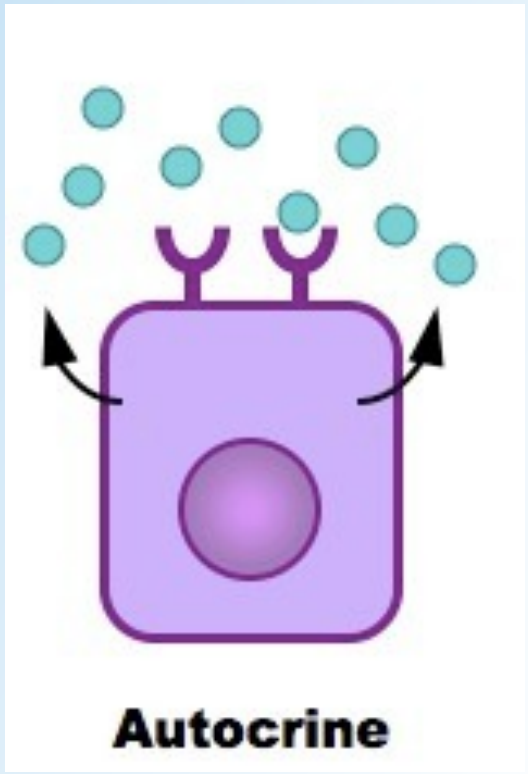
Endocrine



Paracrine

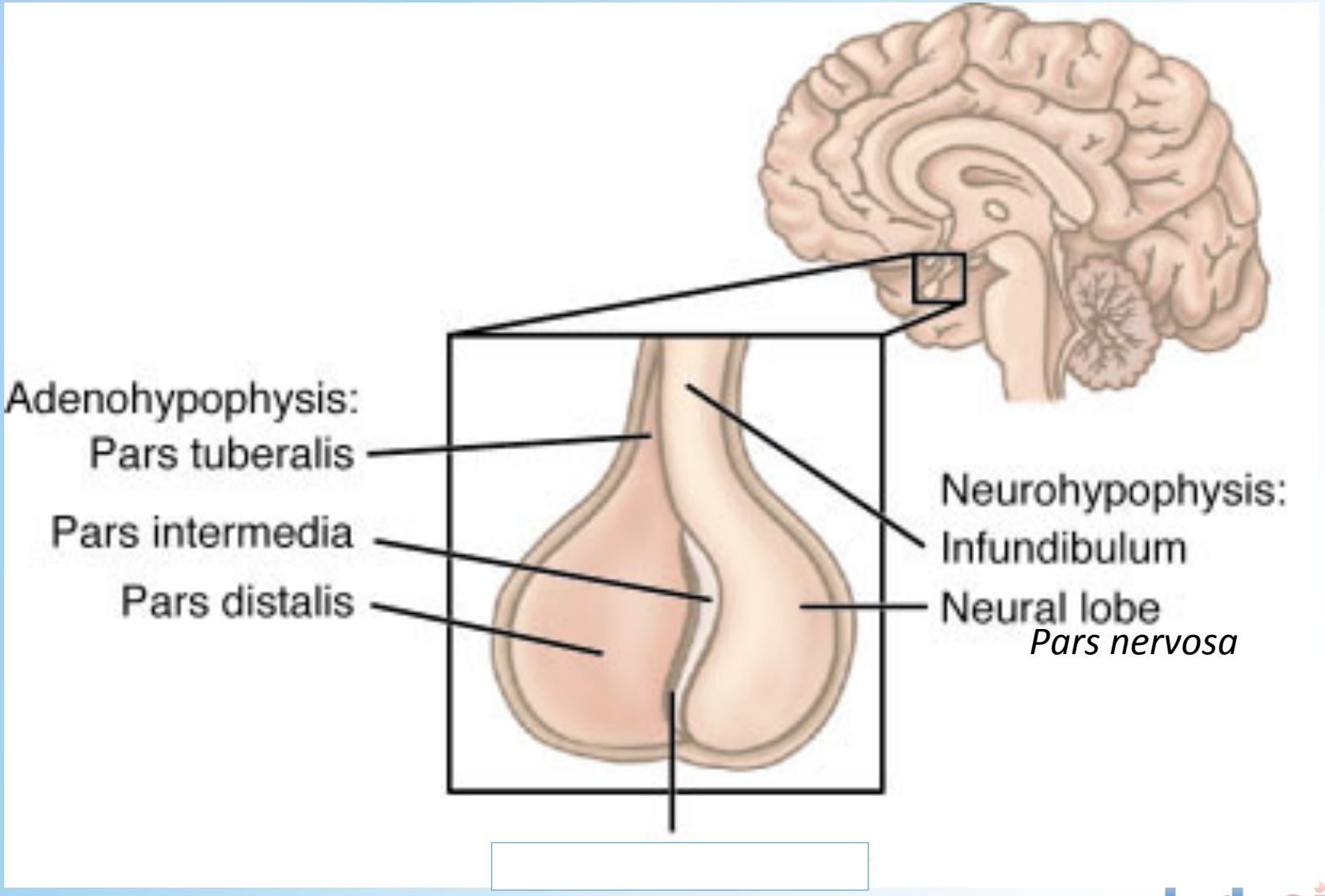


Autocrine



Pituitary gland (*hypophysis*)

- Adenohypophysis
- Neurohypophysis

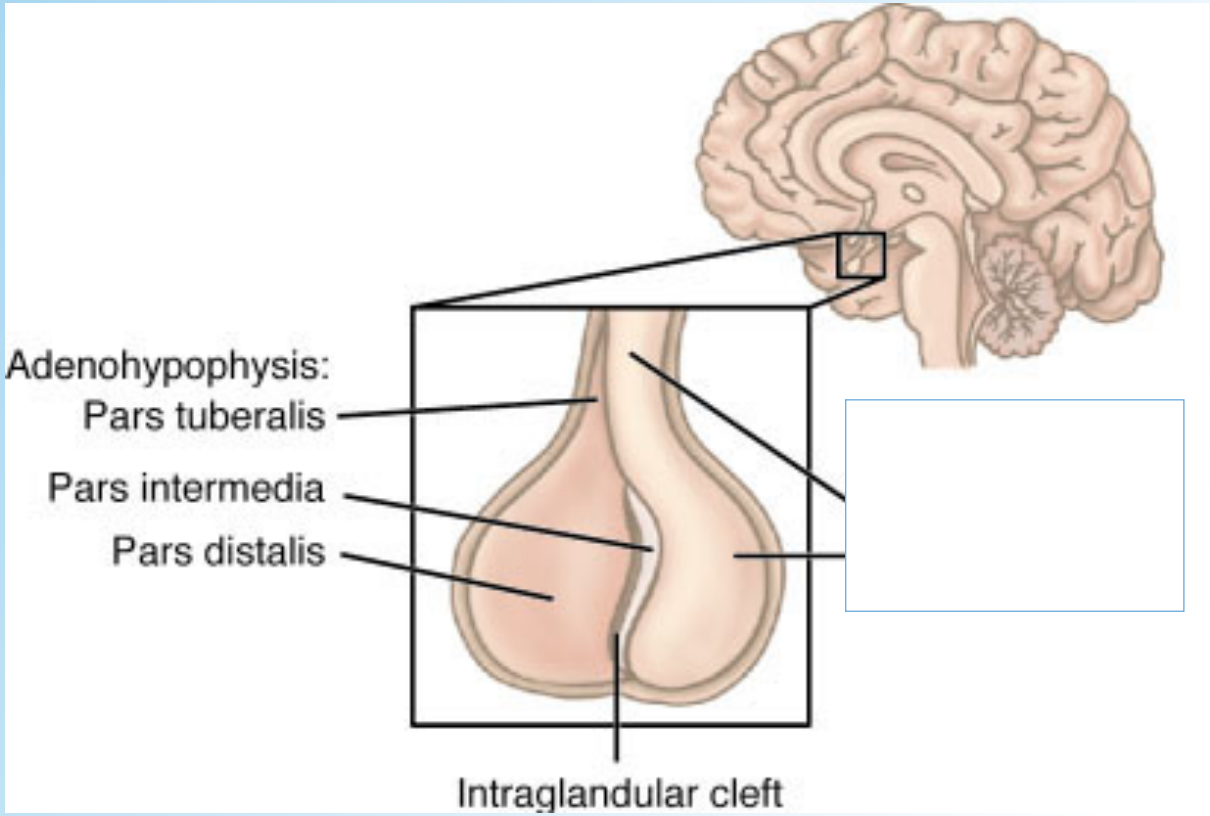


Adenohypophysis

- Produces hormones
- Components:
  - Irregular clusters and cords of cells
  - Fenestrated capillaries

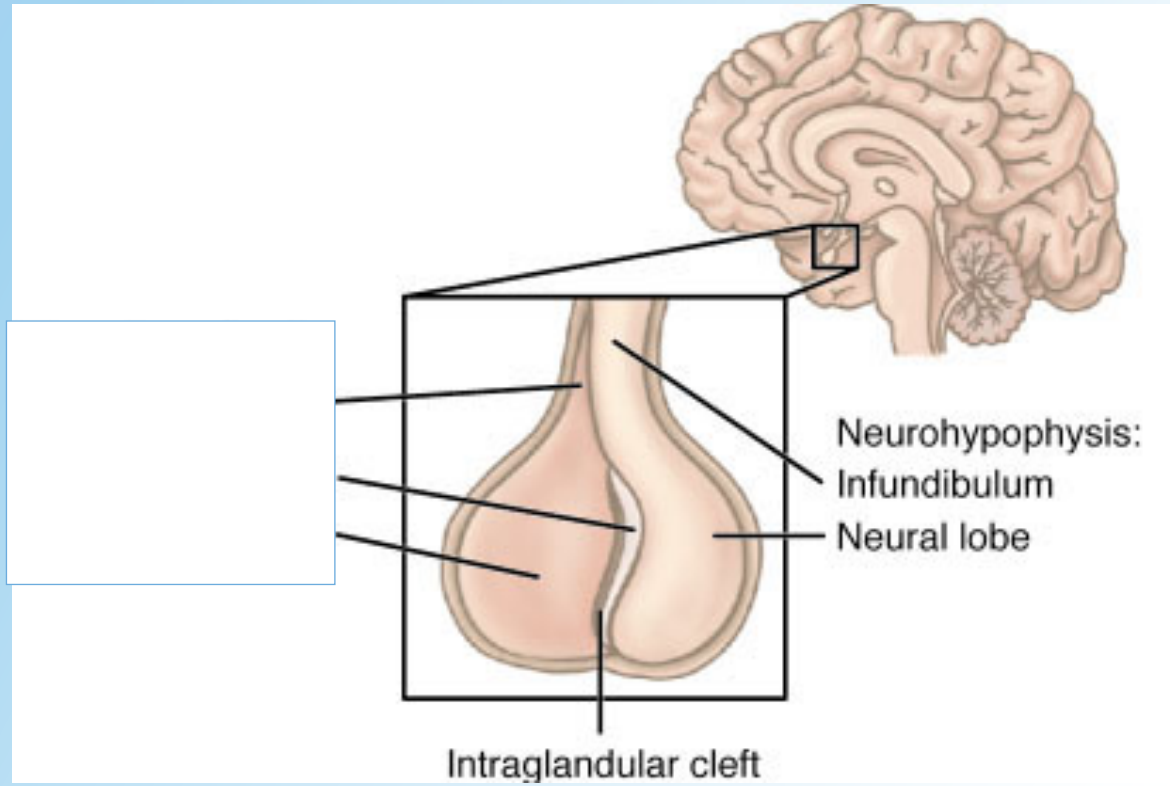
- Cell categorization:

1. Chromophobes
2. Chromophils
   1. Acidophils
   2. Basophils



Neurohypophysis

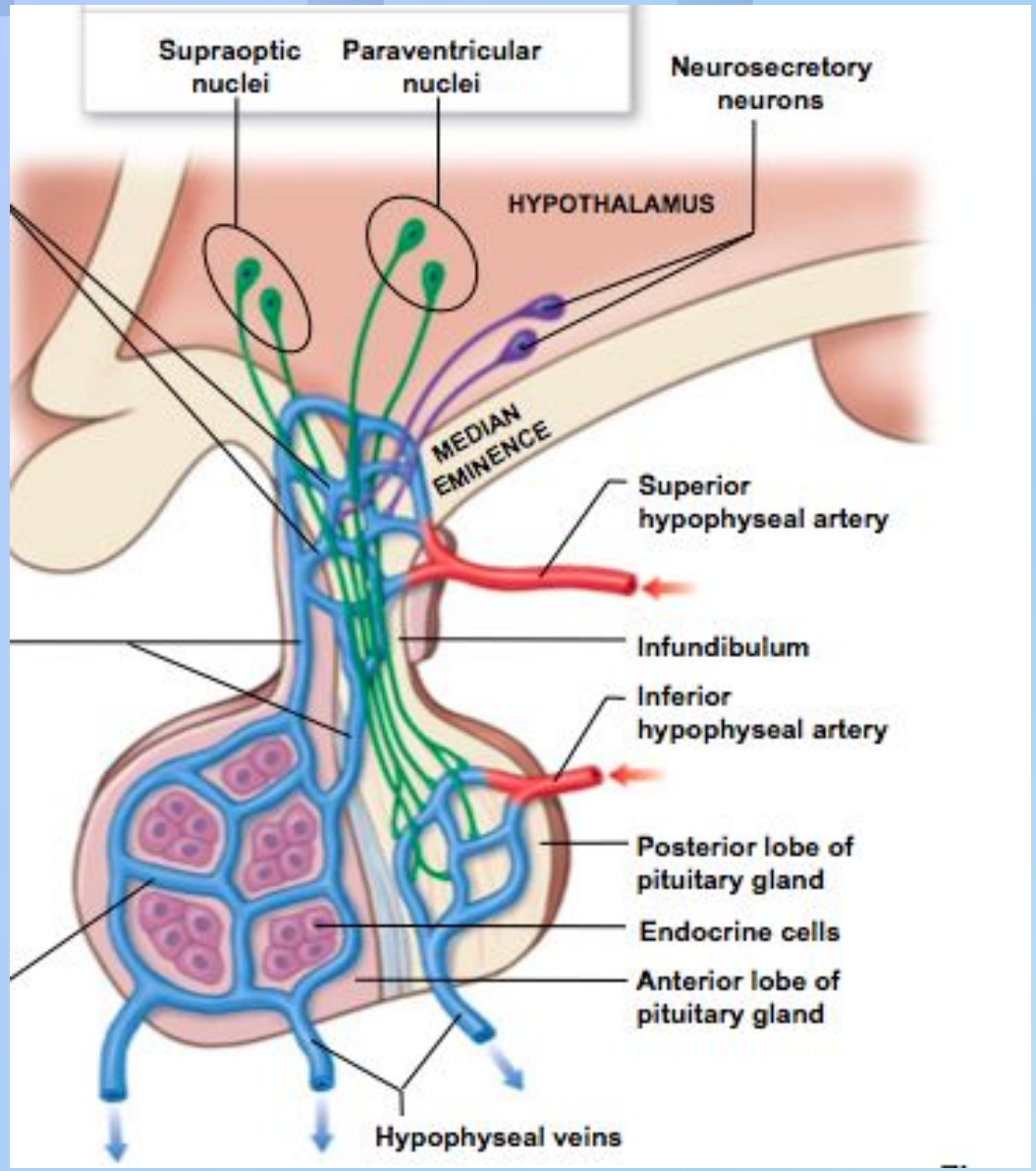
- Does not produce hormones
- Components:
  - Axons of HPA
  - Pituicytes (astrocytes)
  - Capillaries

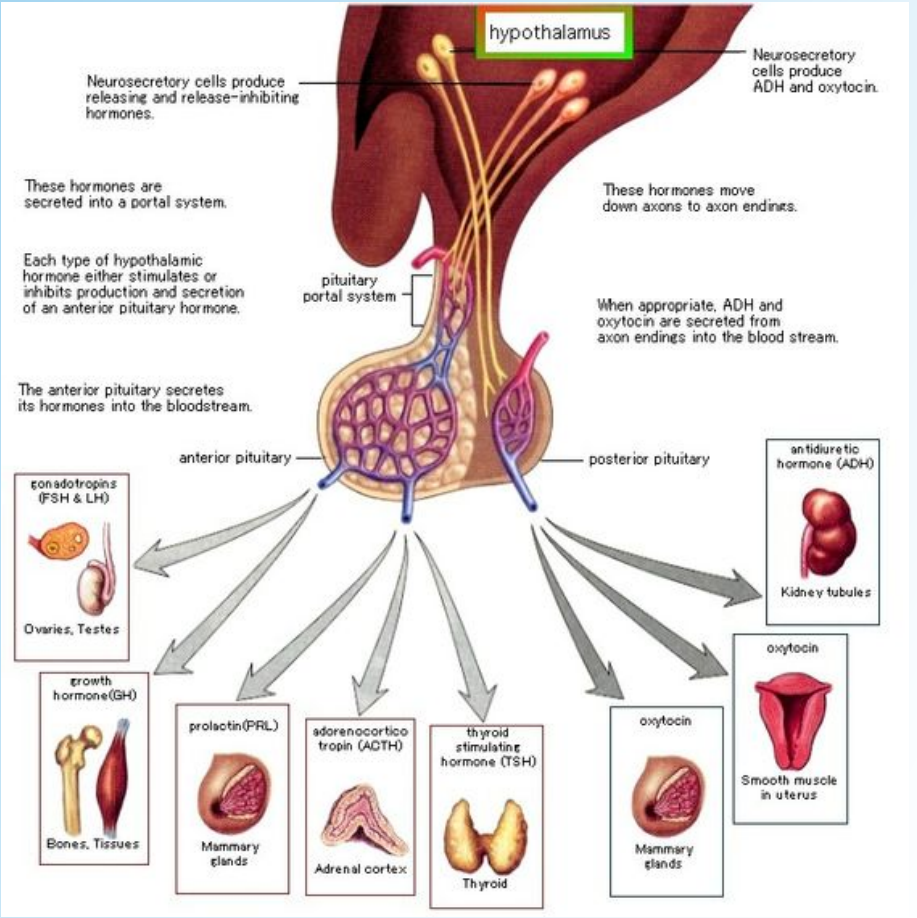


Hypothalamo-pituitary axis

- Neurohemal organ = neurosecretory nerve terminals + capillaries

- Small neurosecretory neurons → adenohypophysis
  - Factors controlling hormone secretion of adenohypoph. cells
    - Mediated by folliculostellate cells
  - Median eminence → capillaries → portal system → pars distalis
- Large neurosecretory neurons → neurohypophysis
  - ADH and oxytocin
  - Supraoptic & paraventricular nuclei → pars nervosa → capillaries


Supraoptic nuclei
Paraventricular nuclei
Neurosecretory neurons
HYPOTHALAMUS
MEDIAN EMINENCE
Superior hypophyseal artery
Infundibulum
Inferior hypophyseal artery
Posterior lobe of pituitary gland
Endocrine cells
Anterior lobe of pituitary gland
Hypophyseal veins


hypothalamus
Neurosecretory cells produce releasing and release-inhibiting hormones.
Neurosecretory cells produce ADH and oxytocin.
These hormones are secreted into a portal system.
These hormones move down axons to axon endings.
Each type of hypothalamic hormone either stimulates or inhibits production and secretion of an anterior pituitary hormone.
pituitary portal system
When appropriate, ADH and oxytocin are secreted from axon endings into the blood stream.
The anterior pituitary secretes its hormones into the bloodstream.
anterior pituitary
posterior pituitary
gonadotropins (FSH & LH)
Ovaries, Testes
antidiuretic hormone (ADH)
Kidney tubules
growth hormone(GH)
Bones, Tissues
prolactin(PRL)
Mammary glands
adrenocorticotropin (ACTH)
Adrenal cortex
thyroid stimulating hormone (TSH)
Thyroid
oxytocin
Mammary glands
oxytocin
Smooth muscle in uterus

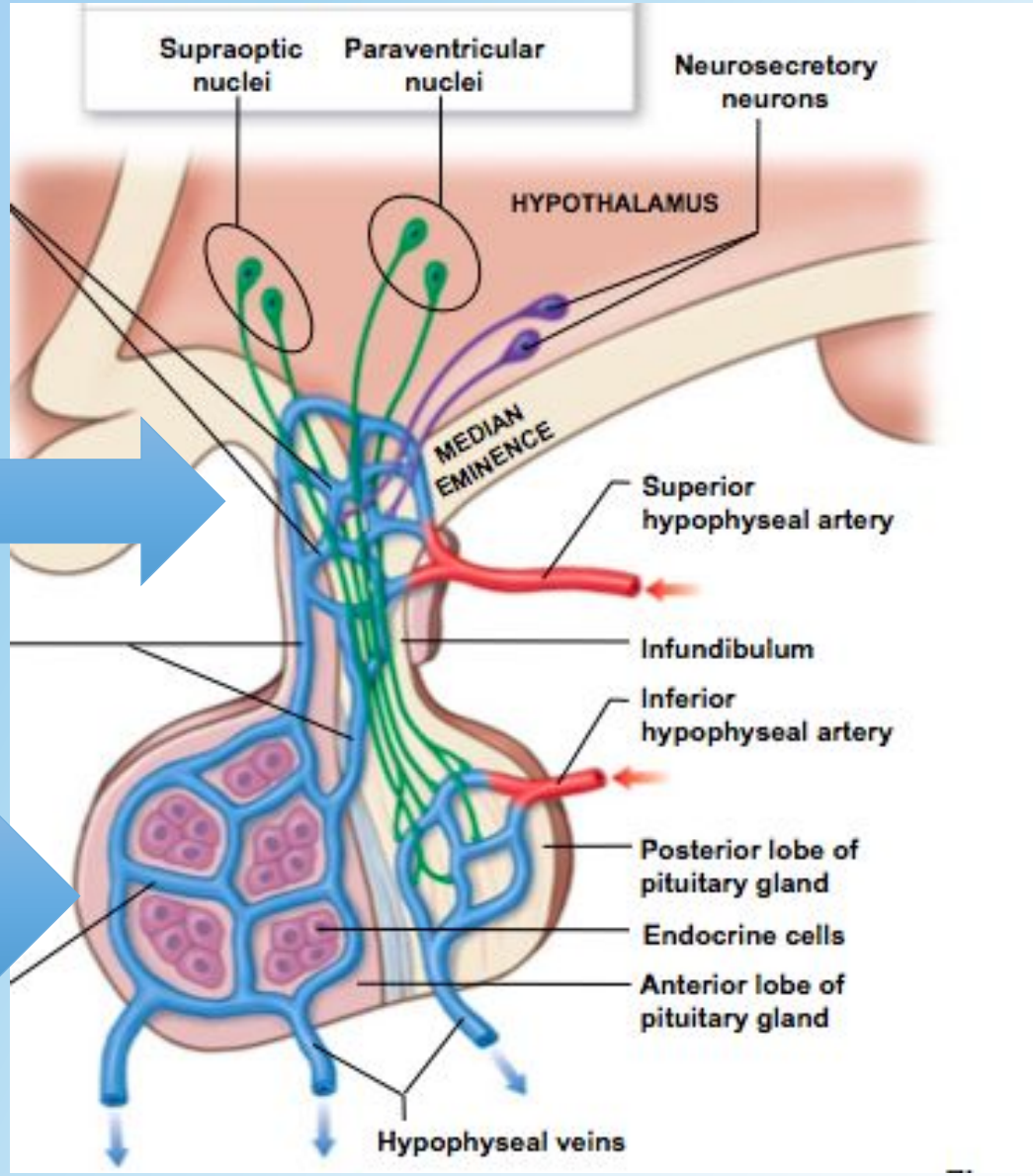
Pituitary portal system

- Links axons of parvocellular nuclei of brainstem and pars distalis (adenohypophysis)

- Primary capillary plexus
  - Capillary plexus associated with axon terminals
  - Median eminence
- Secondary capillary plexus
  - Portal venules
  - Connects primary capillary plexus with pars distalis

PRIMARY
CAPILLARY PLEXUS

SECONDARY
CAPILLARY PLEXUS



RECAP

Adenohypophysis

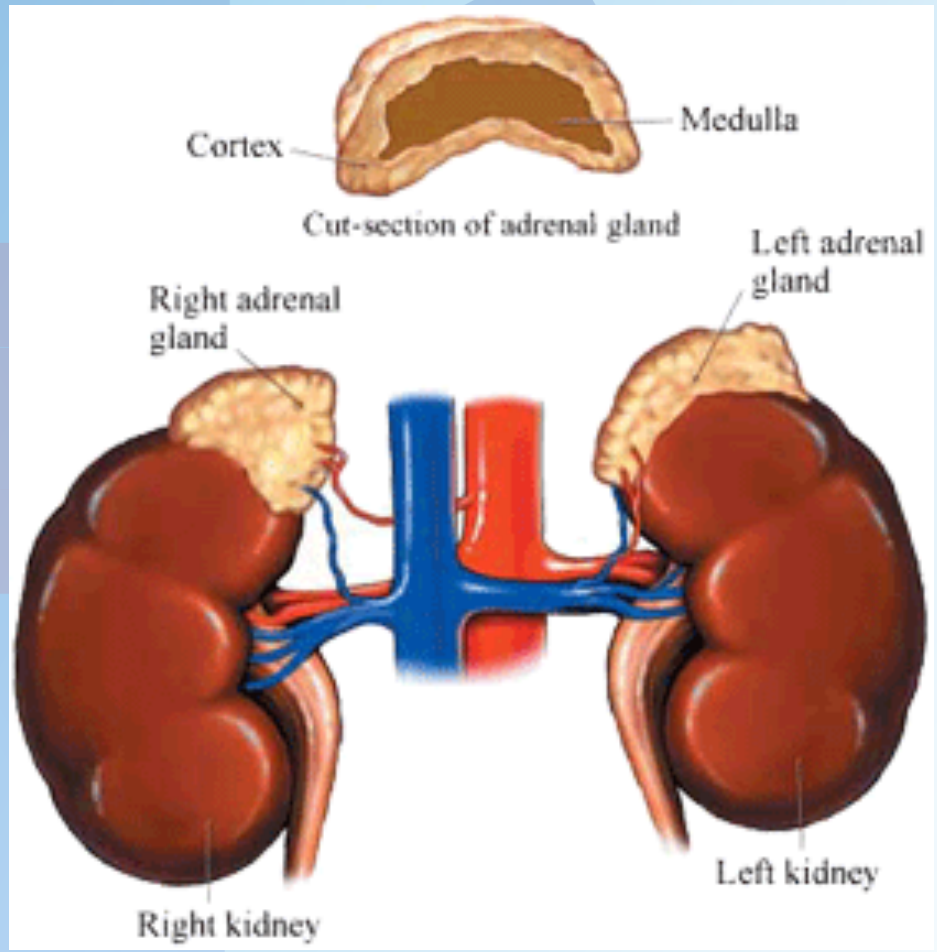
- Pars distalis, tuberalis, intermedia
- HPA: small neurosecretory neurons
- Pituitary portal system
- Produces hormones

Neurohypophysis

- Infundibulum, pars nervosa
- HPA: large neurosecretory neurons
- Does not use pituitary portal system
- Does not produce hormones

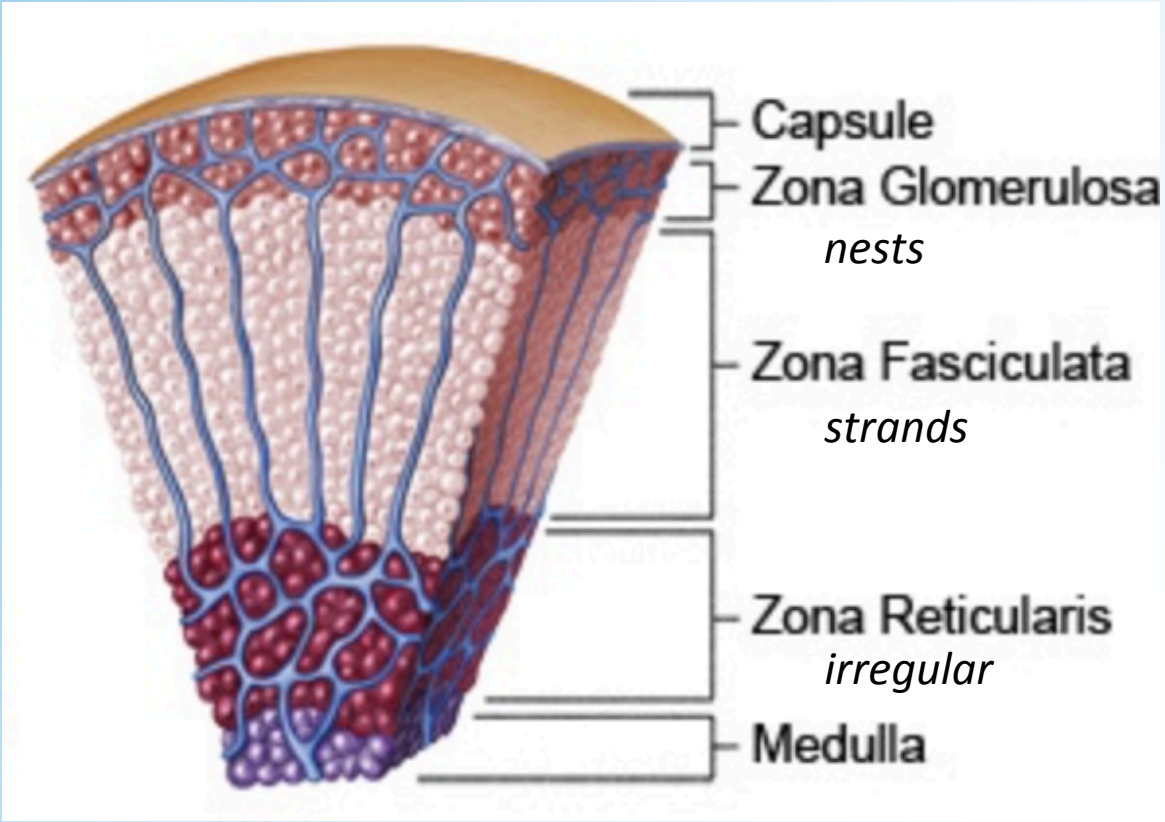
Adrenal gland

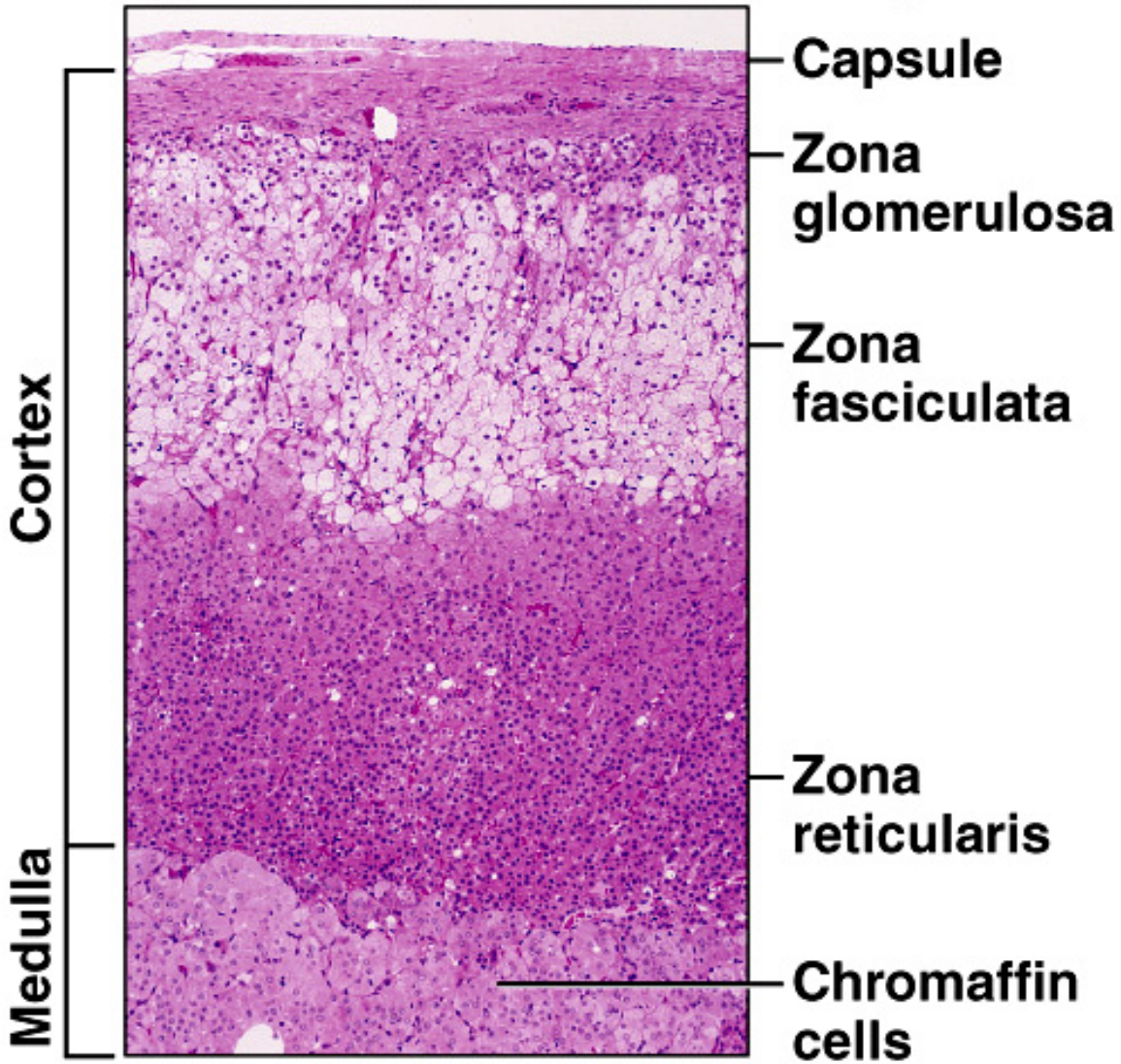
- Cortex
- Medulla



Adrenal cortex

- Produces steroid hormones
- All steroidogenic cells have:
  - Abundant SER
  - Mitochondria with tubular cristae
  - Lipid droplets





Small cells with sparse lipid droplets

Large pale cells with numerous lipid droplets

Small cells with lipofuscin granules

Adrenal medulla

- Communicates with cortex via blood vessels
- Produces catecholamines
  - Adrenaline (*epinephrine*), noradrenaline (*norepinephrine*)
- Contains:
  - Chromaffin cells
  - Ganglionic nerve cells (sympathetic)
  - Blood vessels (veins + capillaries)

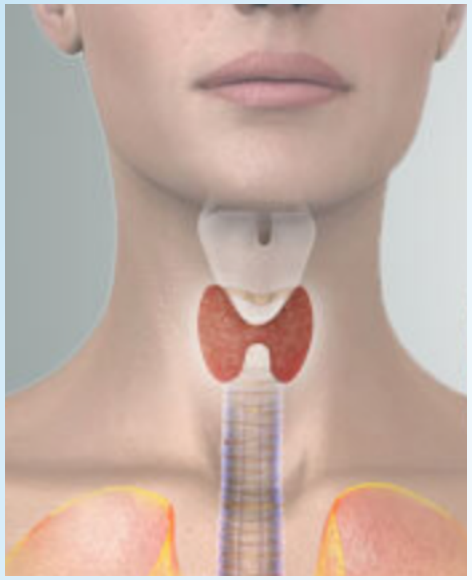
Chromaffin cells

1. Convert tyrosine into noradrenaline
   - Tyrosine hydroxylase, dopa decarboxylase, dopamine β-hydroxylase
2. Noradrenaline can be converted to adrenaline by phenylethanolamine N-methyltransferase (**PNMT**)
3. The catecholamines are bound to chomogranins in secretory granules and then exocytosed

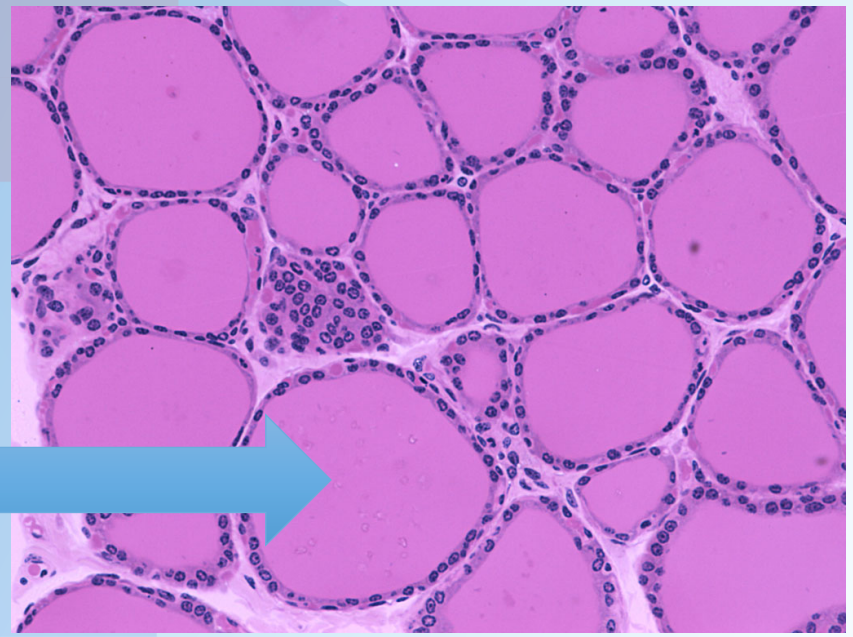
- *PNMT is stimulated by the glucocorticoids produced by the cortex*

Thyroid

- Only endocrine gland with subunits
- Lobular structure composed of thyroid follicles



HORMONE SYNTHESIS OCCURS HERE

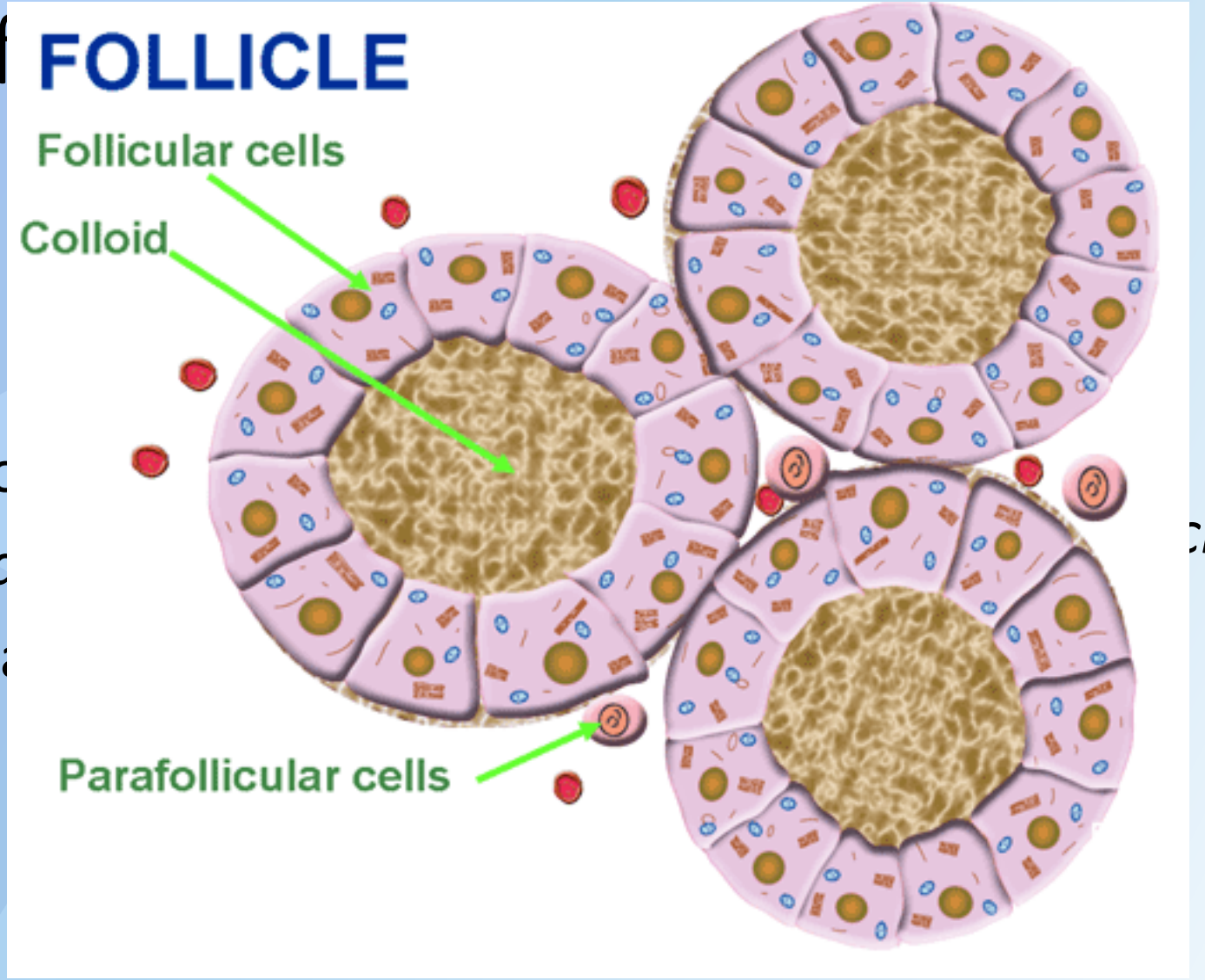


Thyroid f

Components

- Colloid
- Simple cubo
- C cells (*paro*
- Basal lamin

citonin



Thyroid hormone synthesis

1. Follicular cells synthesize thyroglobulin and thyroid peroxidase, take up iodide
   i. Secrete it to the colloid
2. In the colloid iodide is oxidized and bound to tyrosine residues of thyroglobulin
   i. Catalyzed by thyroid peroxidase
3. Follicular cells take up iodinated thyroglobulin and digest it in lysosomes
   i. Releases active iodinated dityrosine molecules (T_3 and T_4)
   ii. T_3 and T_4 diffuse through membranes and enter capillaries

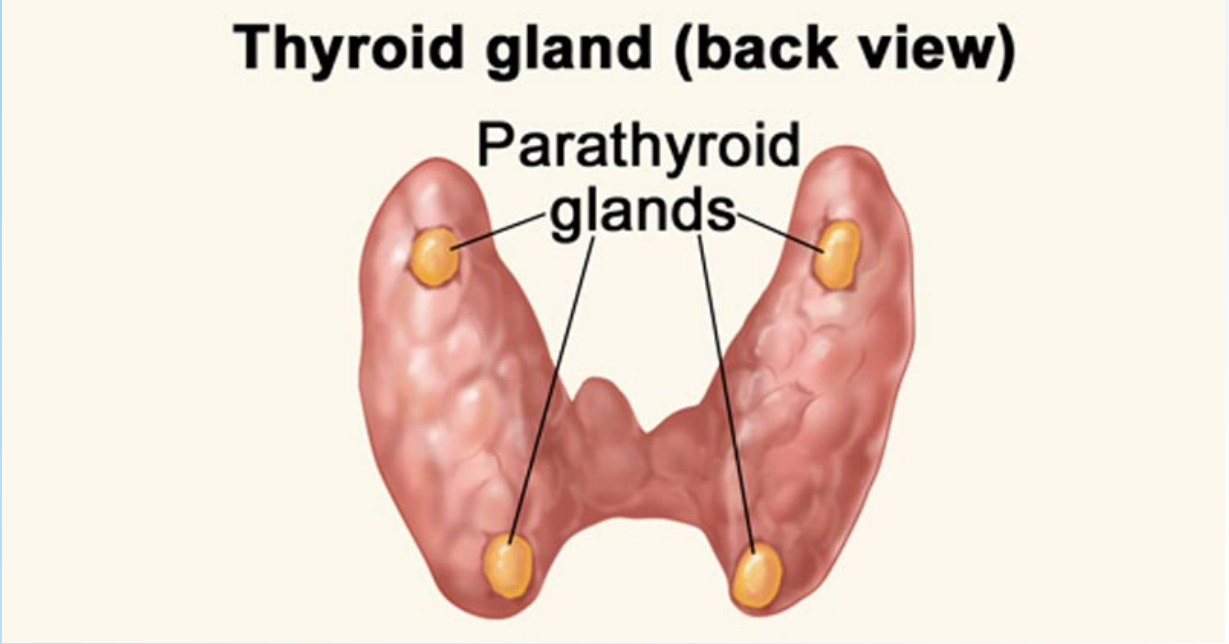
Endocrine System

Part 2

Thyroid continued! (sort of)

Parathyroid glands

- Located in the capsule surrounding the thyroid gland (4)
- Contains
  - Chief cells
  - Oxyphil cells
  - Adipocytes
  - Fenestrated capillaries



Chief cells

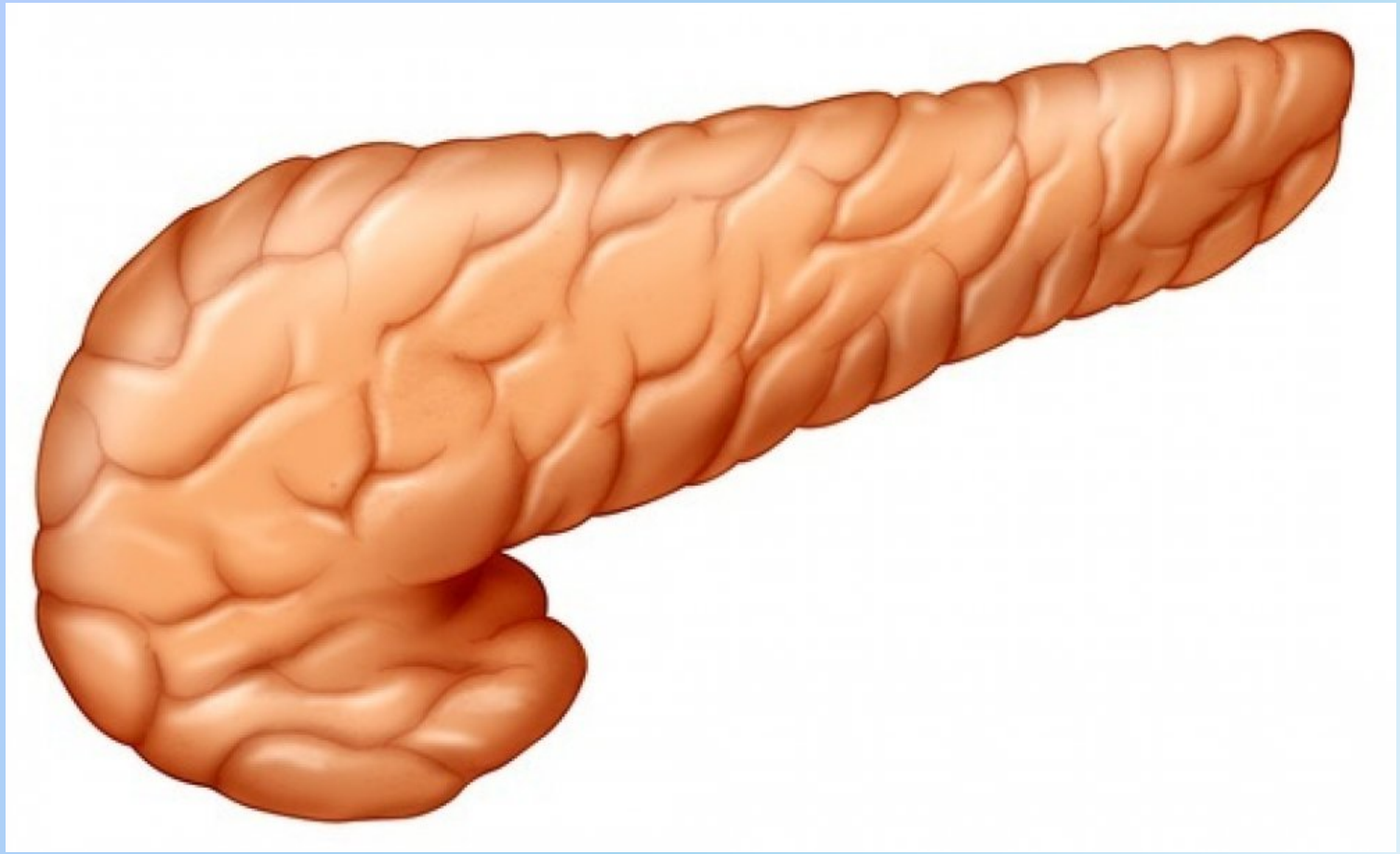
Dark

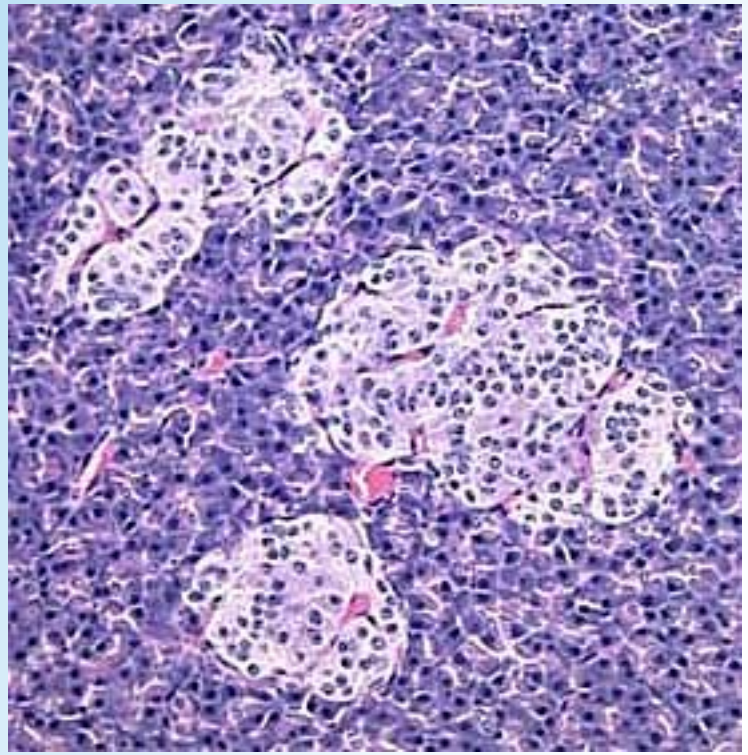
- Active
  - Produce parathormone (PTH)
- Lots of RER, Golgi, secretory granules
- Lipofuscin granules

Pale

- Inactive
- Less RER, Golgi
- Glycogen aggregates

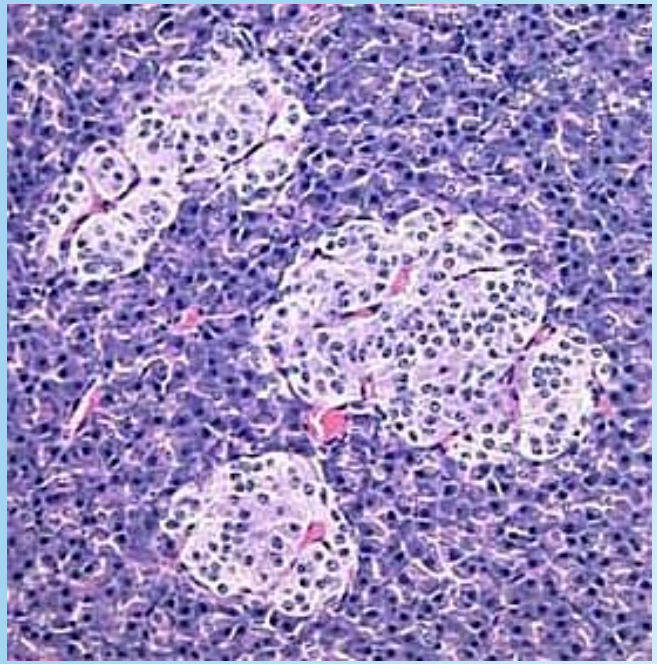
Pancreas

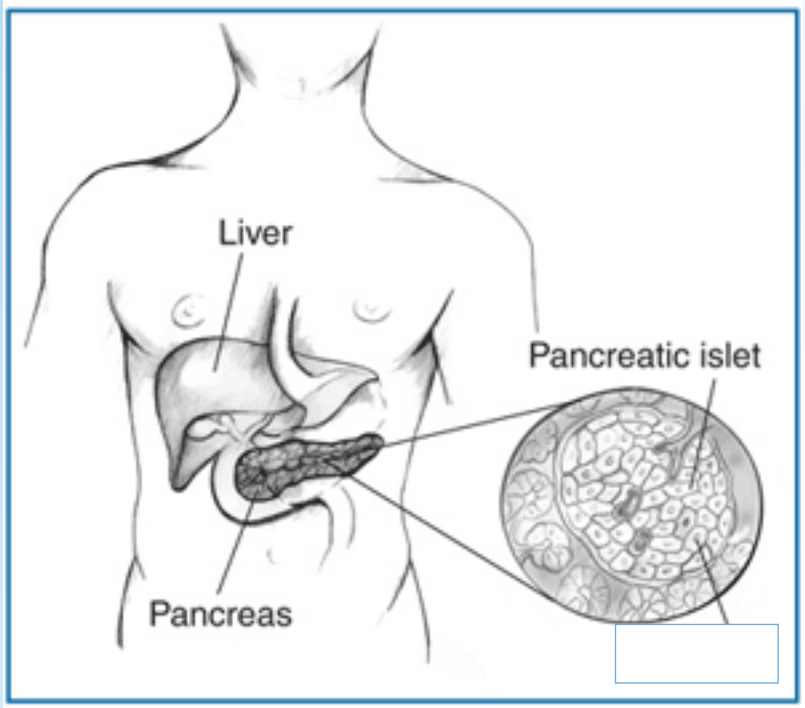




Pancreatic islets of Langerhans

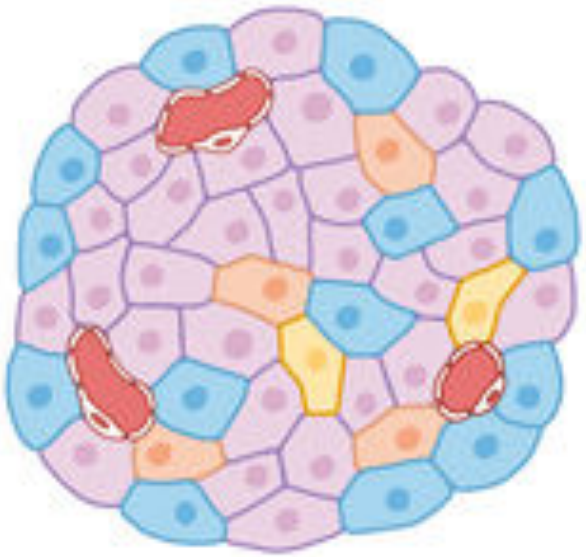
- Clusters of protein-producing endocrine cells with fenestrated capillaries
- Located in exocrine pancreas



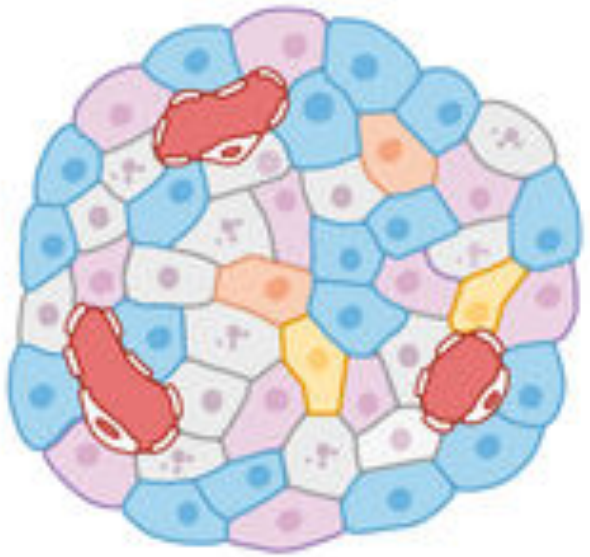


Endocrine cell types

Type	%	Location in islet	Hormone produce
A	20	Peripheral	GLUCAGON
B	70	Central	INSULIN
D	5	Scattered	SOMATOSTATIN
PP	1	Scattered	PANCREATIC POLYPEPTIDE



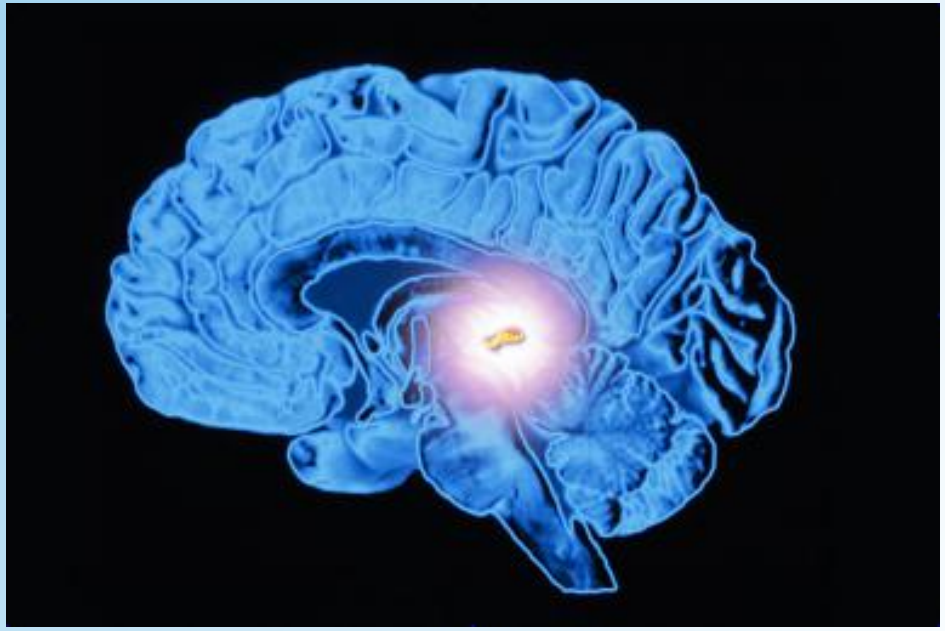
Pancreatic Islet
(healthy)



Pancreatic Islet
(diabetic)

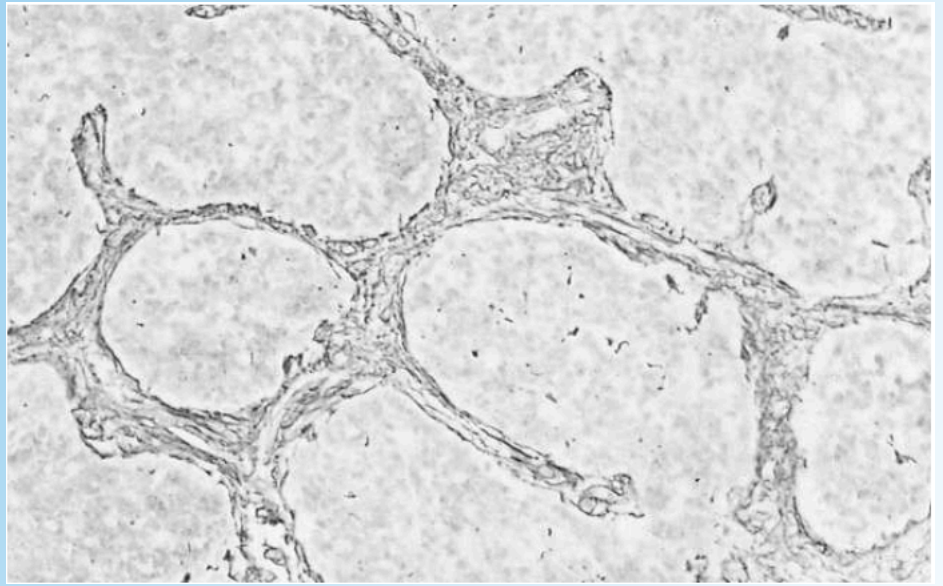
Pineal gland

- Develops from CNS
  - Cells are either modified nerve cells or modified neuroglial cells



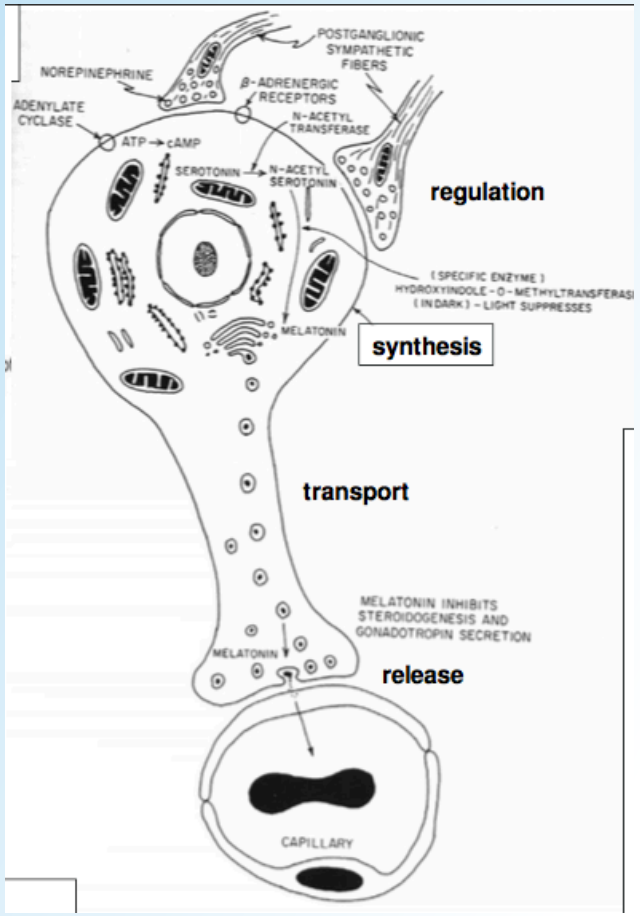
Pineal gland lobules

- Pia matter forms capsules and septa that form incomplete lobules
- Lobules contain:
  - Pinealocytes
  - Interstitial cells
  - Capillaries
  - Brain sand



Pinealocytes

- Have processes that reach capillaries; make contact with SANS nerve terminals
- Membrane proteins typical of photoreceptors
- Produce
  - Melatonin
  - Serotonin
  - Peptides (somatostatin, VIP)



Pineal hormones

- **Melatonin**, serotonin, somatostatin, VIP
- Control our rhythms
  - Diurnal rhythm
  - Annual rhythm
- Synthesis is controlled by NA

- Melatonin is produced at night
  - Light (daytime) triggers sympathetic nerve stimulation of the pinealocytes

Diffuse Neuroendocrine System cells

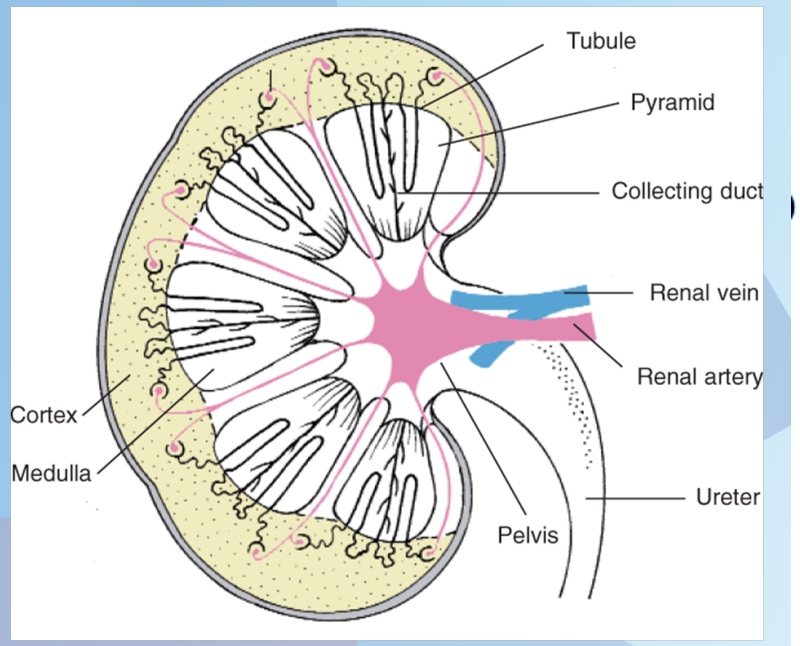
- Originate from neurally programmed ectoderm
- DNES cells produce hormones with similar
  - Origin
  - Structure
  - Chemical character
  - Metabolism
    - Produce amines (e.g dopamine, NA, melatonin) by decarboxylating their precursors (e.g serotonin)
    - Synthesize peptide hormones

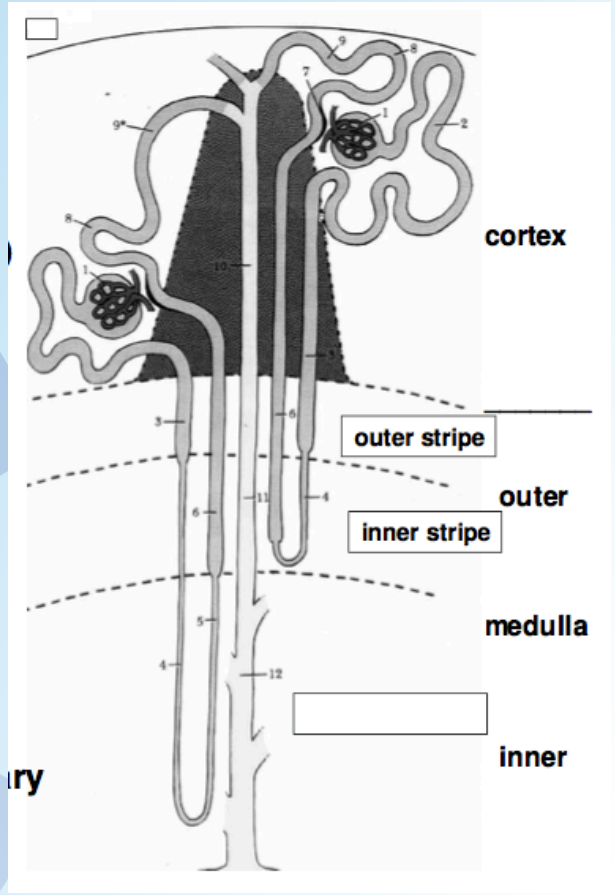
- Also called APUD cells
  - APUD = Amine Precursor Uptake, Decarboxylase

Urinary System

Kidney

- Cortex
  - Labyrinth
  - Medullary rays
- Medulla
  - Outer
  - Inner

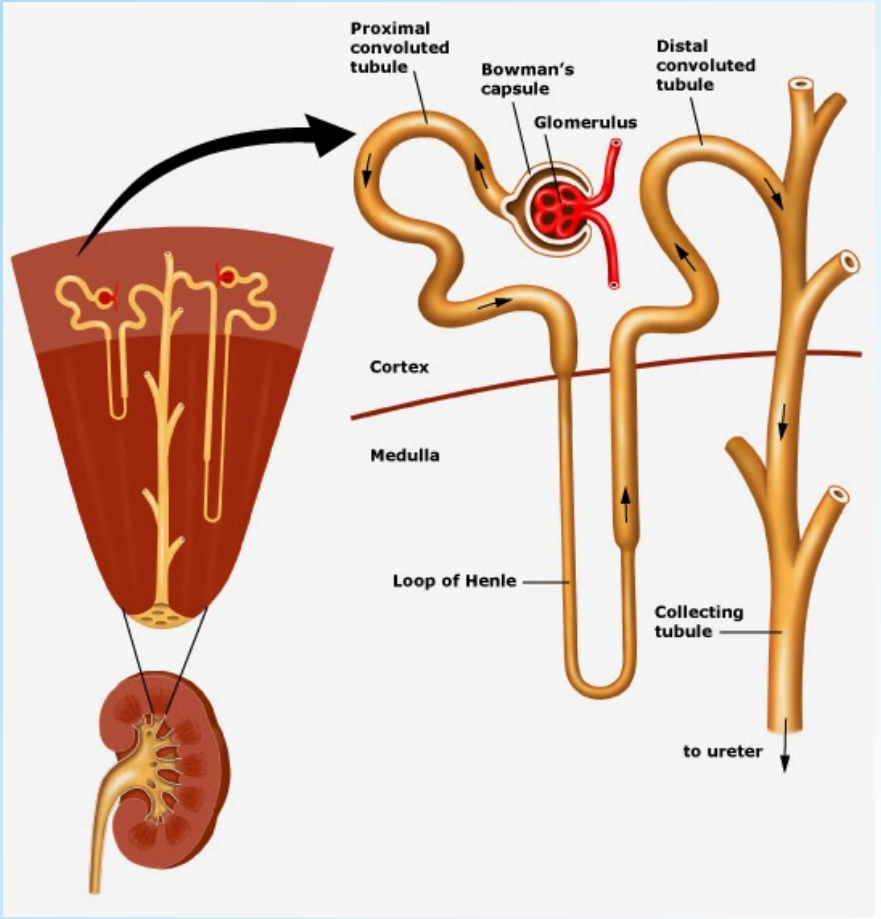




- Differentiation is due to uriniferous tubule arrangement

Nephron

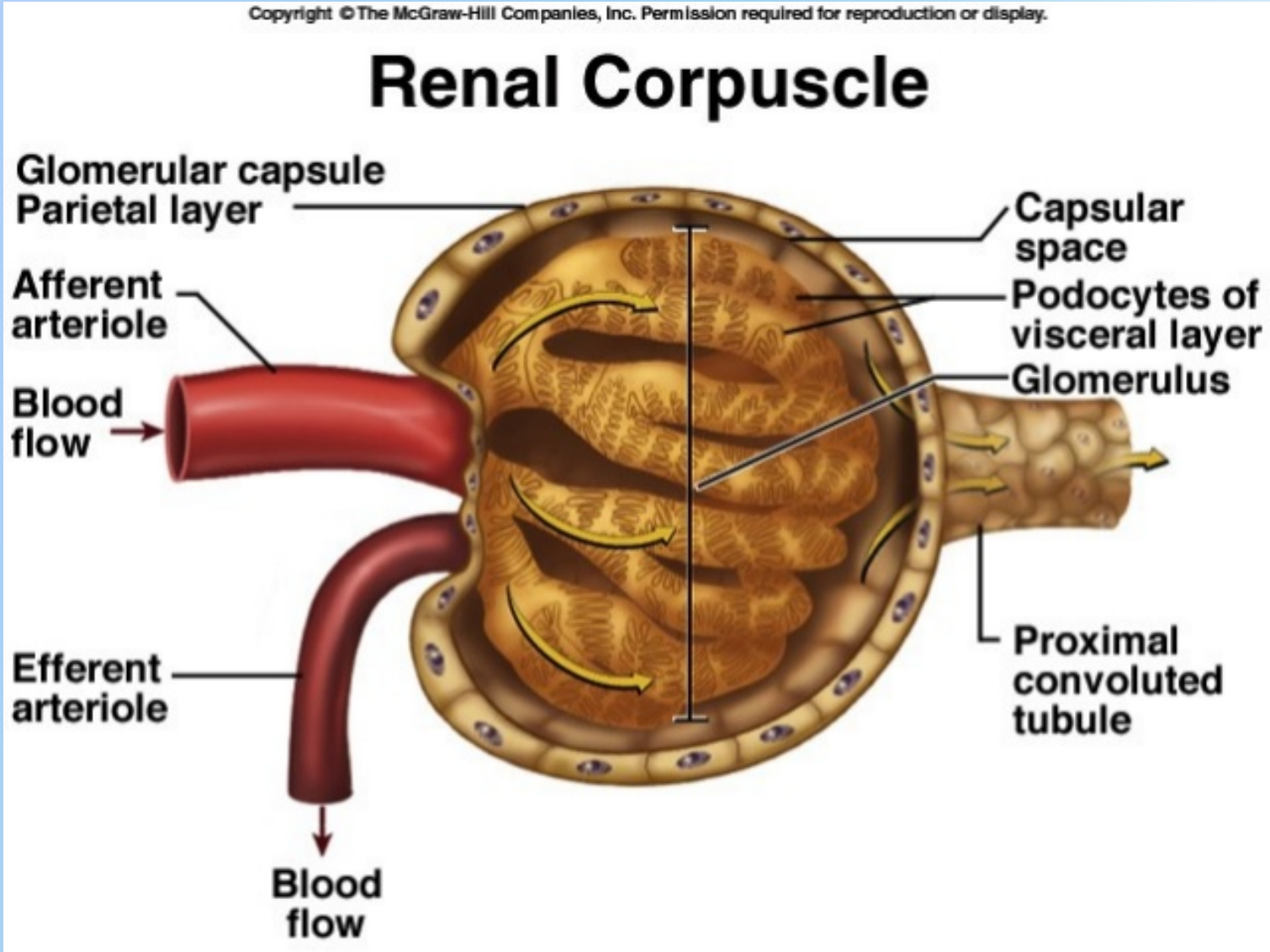
- Unbranched uriniferous tubule
- Segmented
    1. Renal corpuscle
    2. Proximal tubule
        1. Proximal convoluted tubule
        2. Thick descending limb
    3. Thin limb
    4. Distal tubule
        1. Thick ascending limb
        2. Distal convoluted tubule
- Loop of Henle



Renal corpuscle

- Filtrates blood plasma into the Bowman's space (*ultrafiltration*)
- Glomerulus
  - Capillary loops (within Bowman's capsule)
  - In between mesangial cells
- Bowman's capsule
  - Surrounds glomerulus
  - Inner visceral layer + outer parietal layer
  - Composed of podocytes

VASCULAR POLE



URINARY POLE

Renal corpuscle filtration barrier

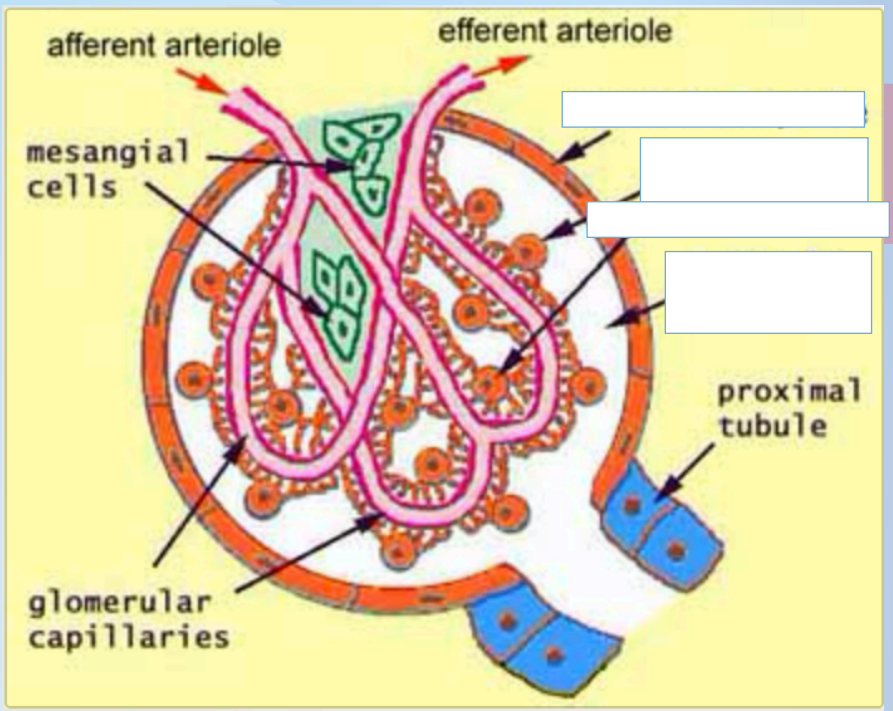
- Capillary walls + basement membrane + podocyte processes
- Fenestrated endothelium:
  - Stops blood cells
- Basement membrane:
  - Slows down large/ electrically charged molecules
- Podocytes:
  - Stop all molecules > 70 kDa

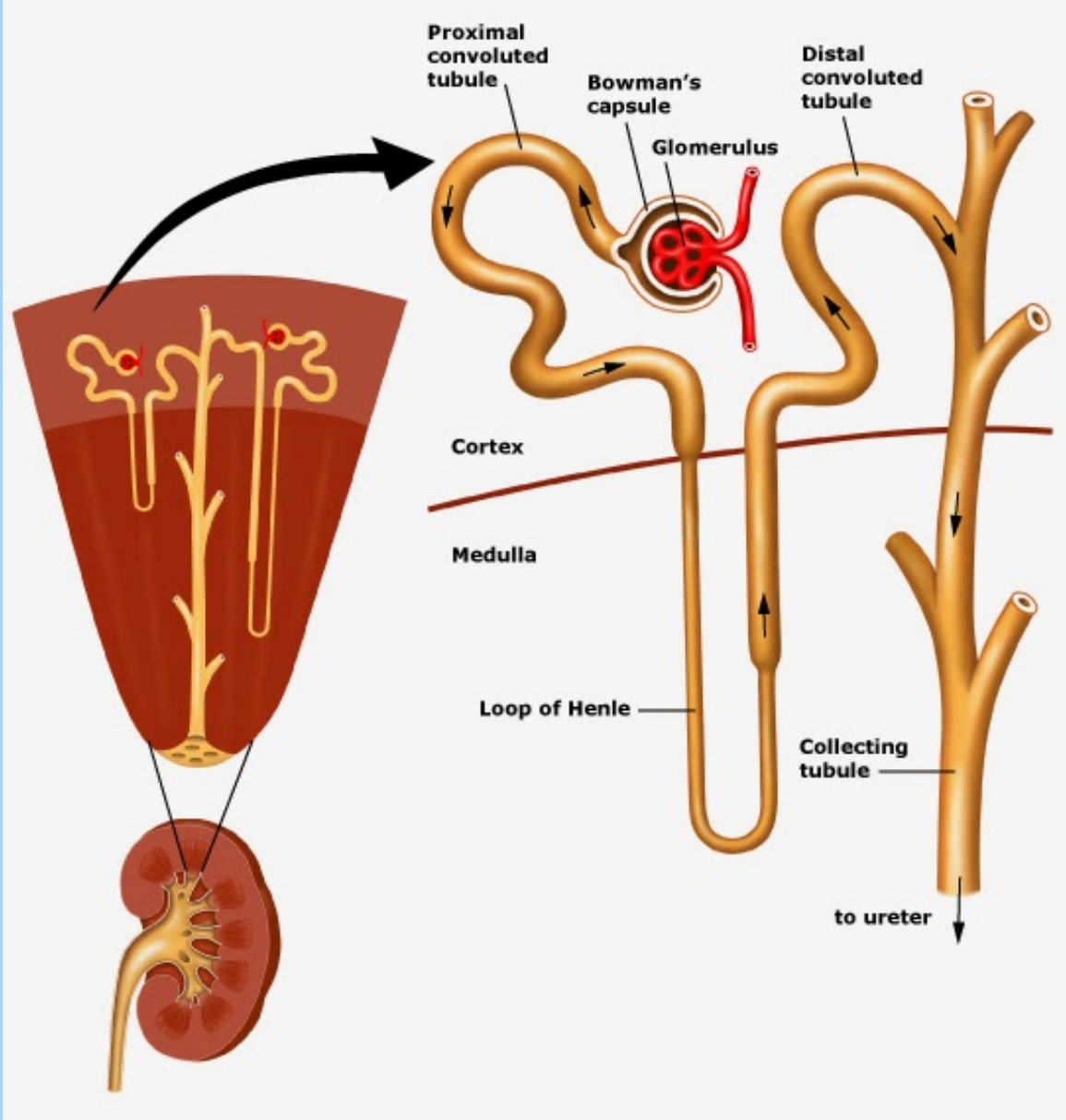
Ultrafiltrate contains all plasma components except for large proteins

Mesangial cells

- Clear away the basement membrane containing trapped molecules

- Phagocytose basement membrane
- Produce factors facilitating regeneration of renal corpuscles
- Have contractile properties

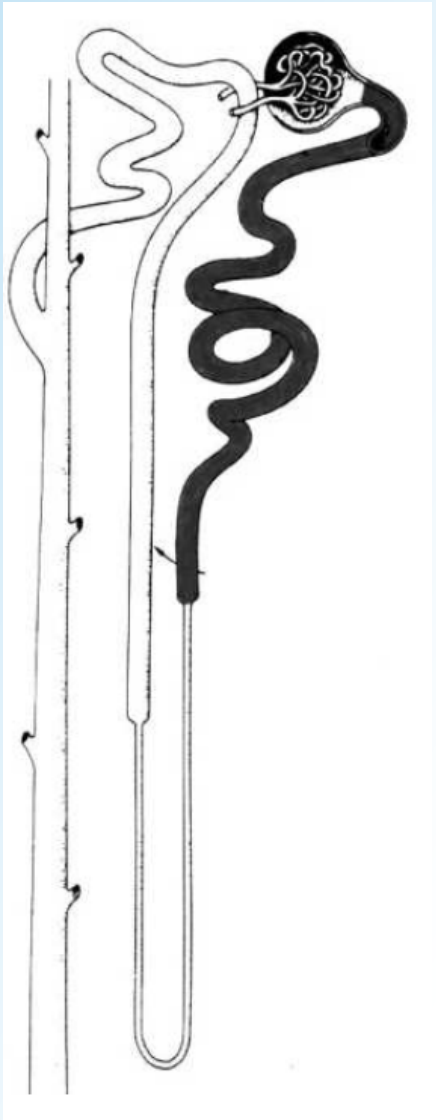



Proximal convoluted tubule
Bowman's capsule
Glomerulus
Distal convoluted tubule
Cortex
Medulla
Loop of Henle
Collecting tubule
to ureter

Proximal tubule

Simple cuboidal epithelium

1. Resorption of water (70-80%)
2. Resorption of ions (Na^+, Cl^-), glucose, amino acids
   - Membrane transporters
3. Resorption of proteins
   - Endocytosis
4. Resorption of some metabolites and drugs
5. Secretion of ammonia, urea, exogenous compounds

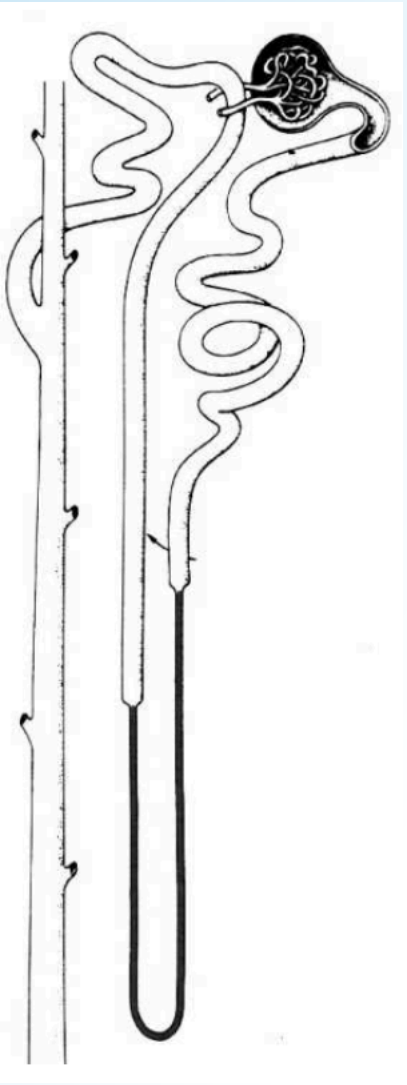


Thin limb

Simple squamous epithelium

1. Resorption of water

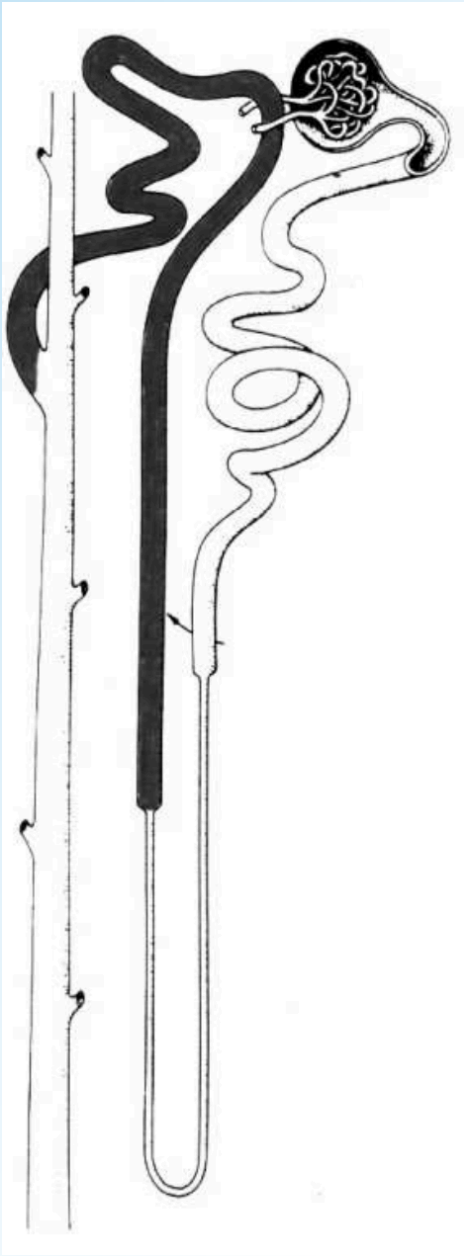
The resorption of water makes urine more concentrated



Distal tubule

Low cuboidal epithelium

1. Resorption of Na^+, Cl^-
   - Controlled by aldosterone
2. Secretion of K^+, H^+
   - Acidifies urine
3. Resorption of water

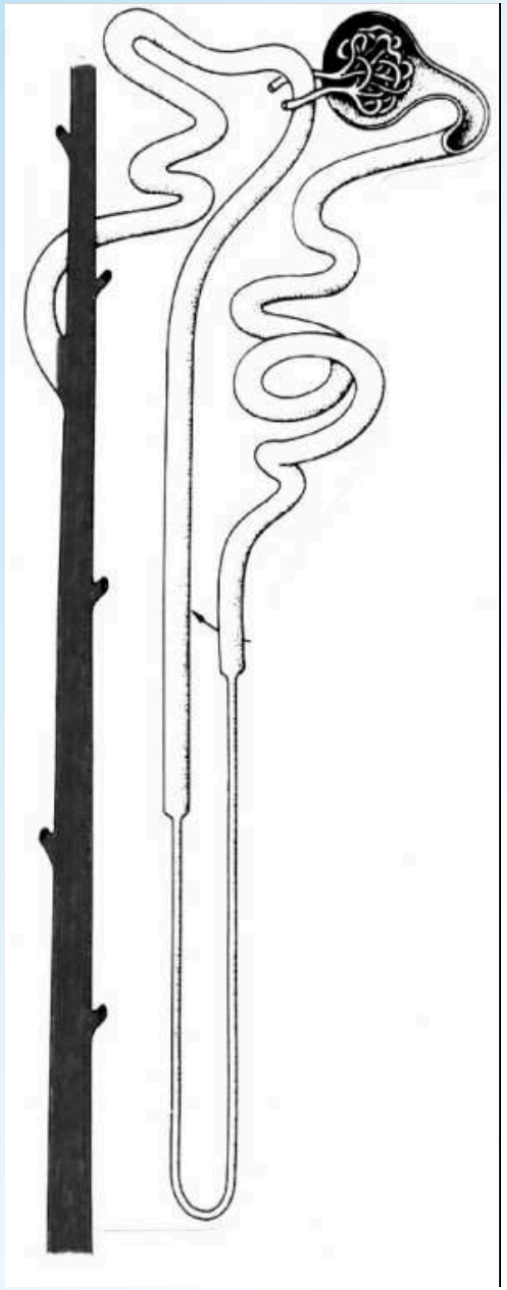


Collecting tubule

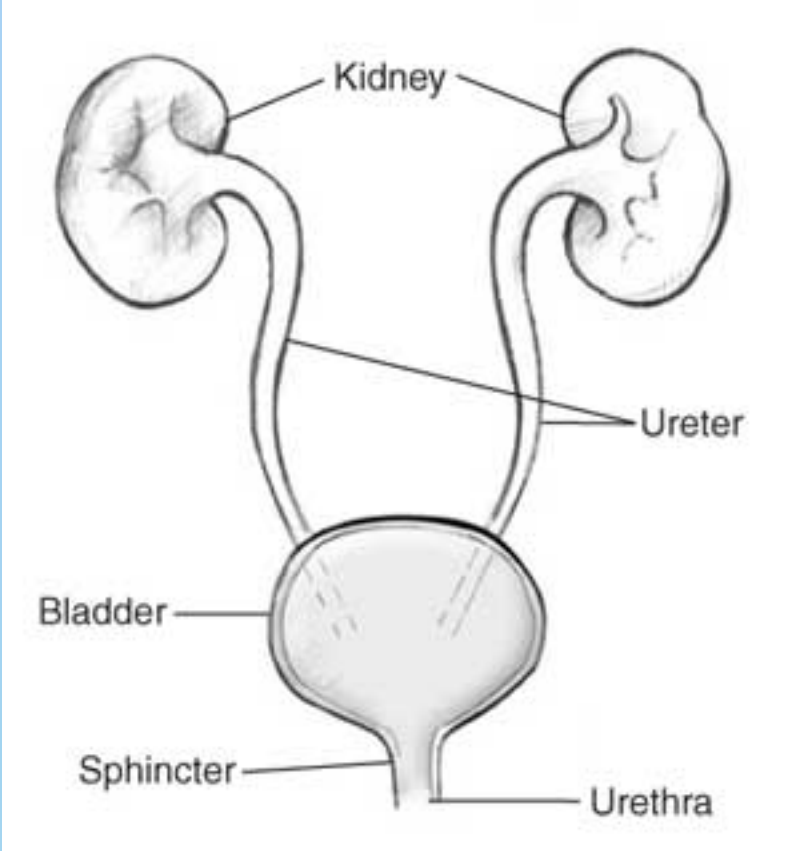
Cuboidal → columnar epithelium

- Branched
- Several nephrons empty into one collecting tubule

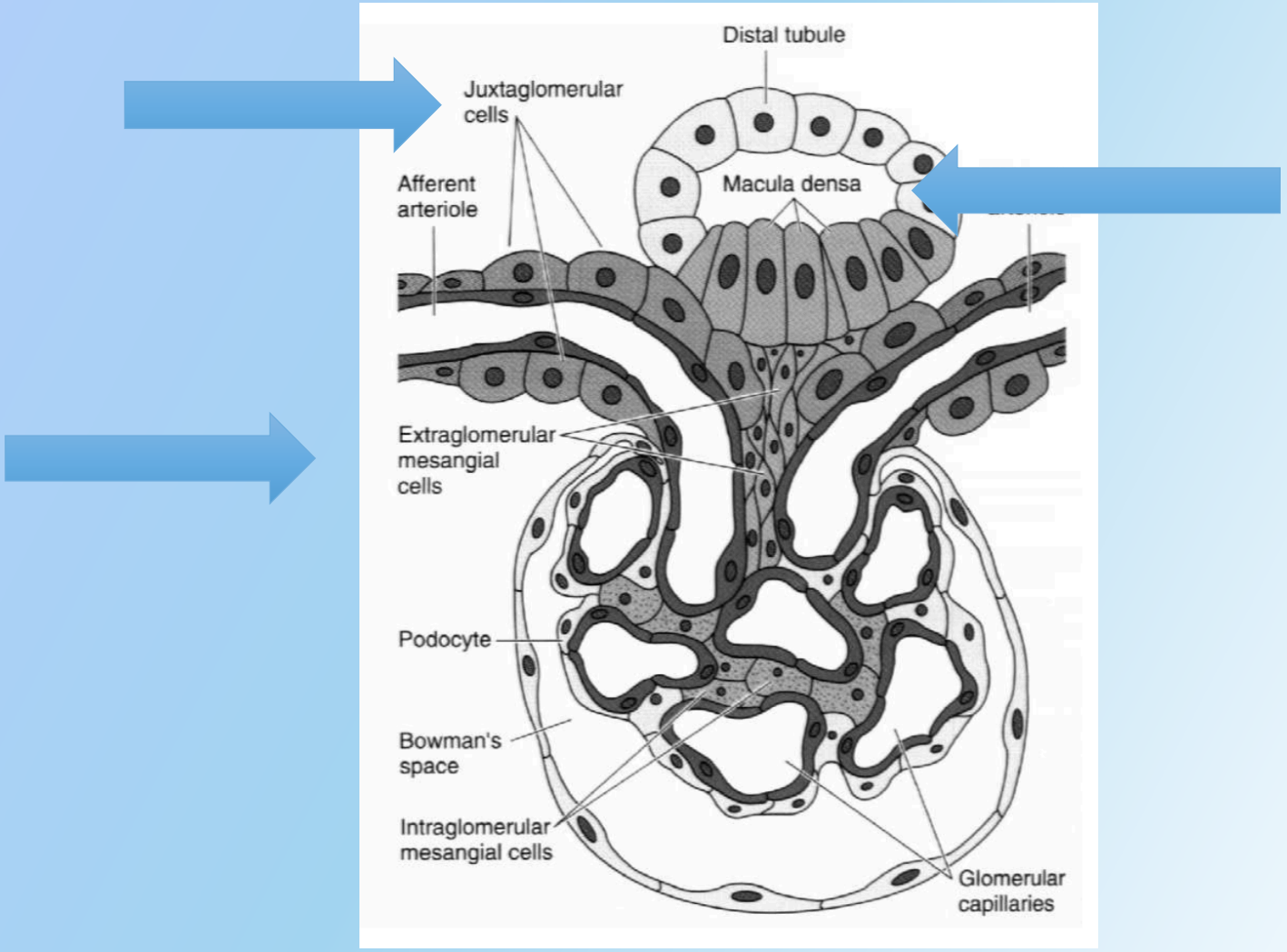
1. Resorption of water
   - Membrane channels (*aquaporins*), mediated by ADH



Collecting tubule → ureter → bladder → urethra → toilet

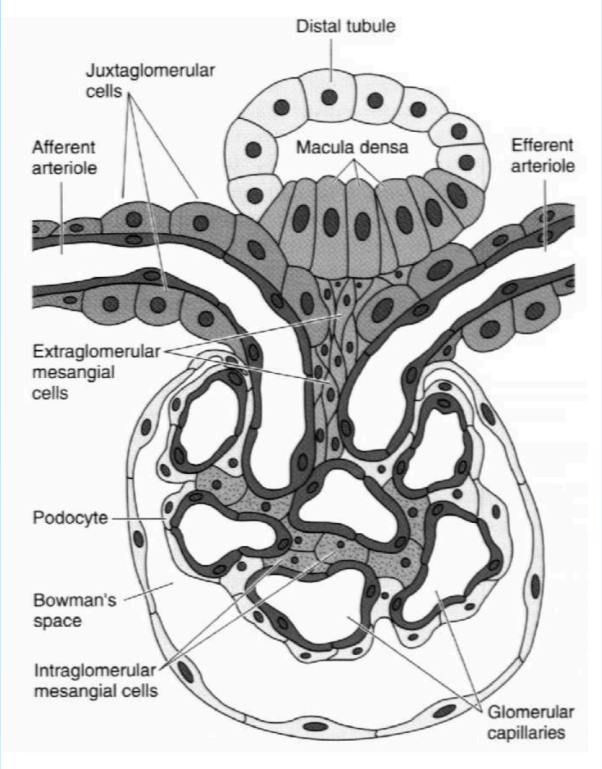


Juxtaglomerular apparatus



Juxtaglomerular apparatus

- Juxtaglomerular (JG) cells
  - Modified smooth muscle cells of afferent arteriole
  - Produce and secrete **RENIN**
- Macula densa
  - Modified part of the distal tubule; adjacent to arterioles
  - Monitors volume of urine and [Na^+]
- Extraglomerular mesangial cells
  - Mediate signaling between JG cells and MD cells



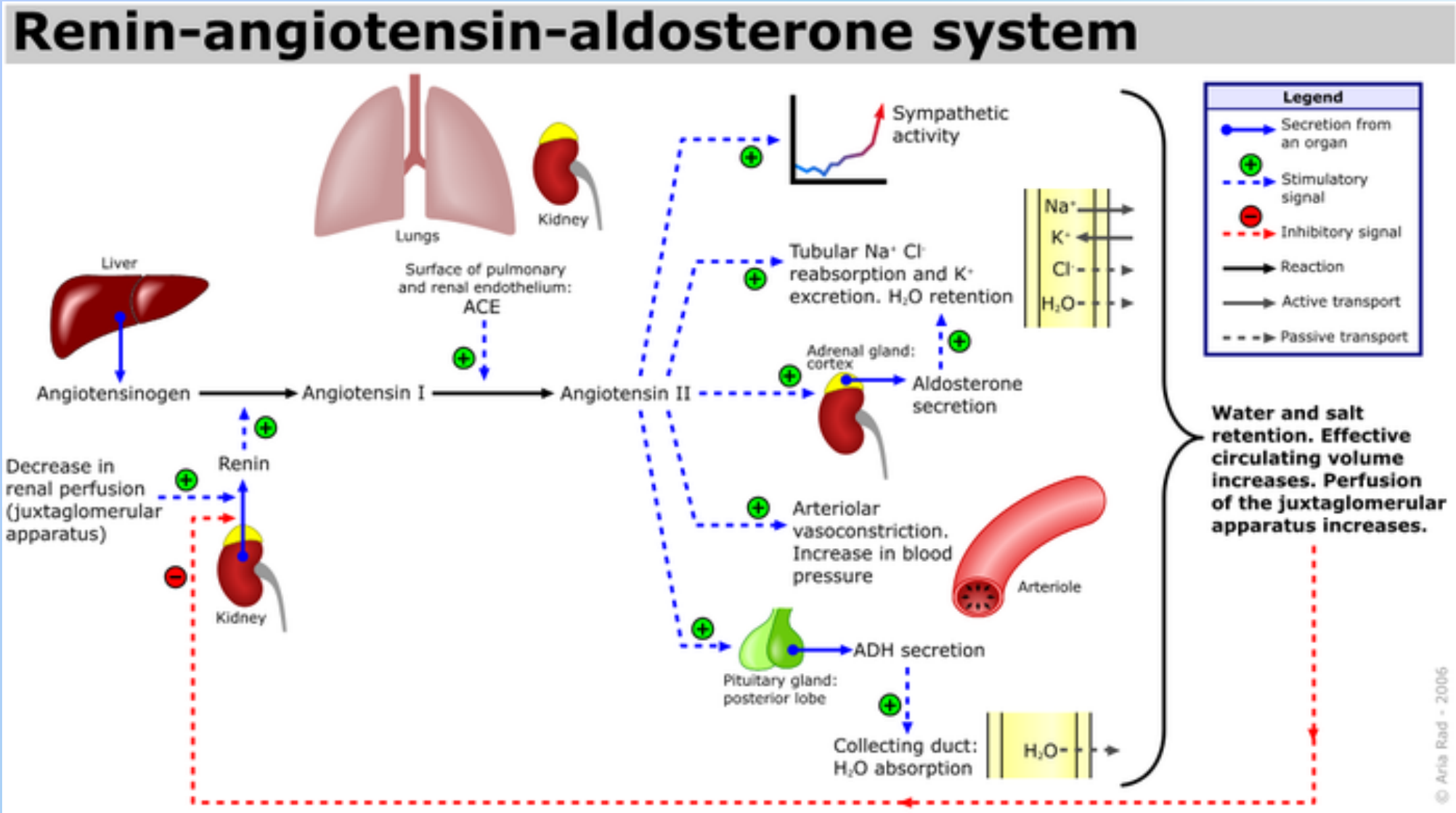
RENIN increases blood pressure in cases of decreased urine volume or [Na^+]

RAAS

Vasoconstriction + increased blood volume = increased blood pressure ☺

1. Macula densa detect decreased BV, $[Na^+]$
2. MD signal JG cells with PGE_2 and PGF_{2a}
3. JG secrete **renin**
4. Renin stimulates the conversion of **angiotensinogen** to **angiotensin I**
5. ACE converts angiotensin I to **angiotensin II** in the lungs
6. Angiotensin II:
    1. Vasoconstricts
    2. Stimulates **aldosterone** secretion from adrenal cortex
7. Aldosterone causes resorption of water and Na^+ in distal tubules

Renin-angiotensin-aldosterone system

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