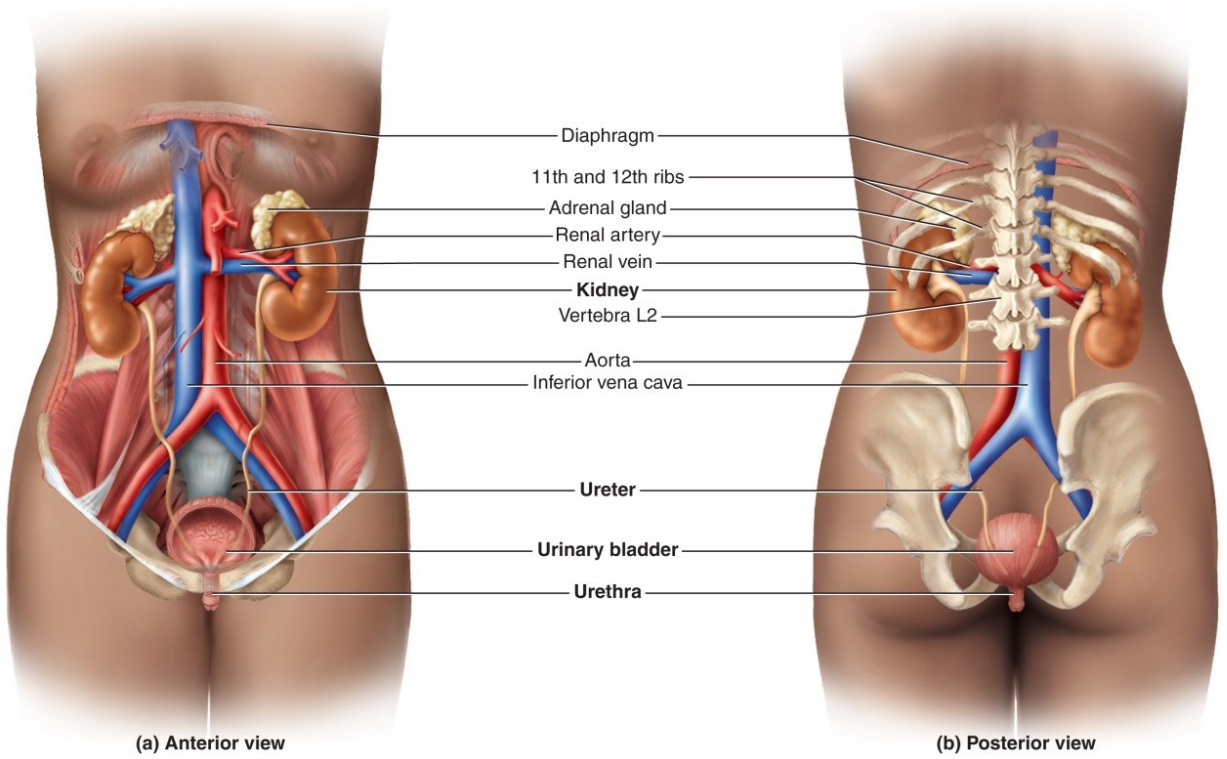
Urinary

BI 455 CHAPTER 19

Urinary system rids the body of waste products

- The urinary system is closely associated with the reproductive system
- Shared embryonic development and adult anatomical relationship
- Collectively called the urogenital (UG) system
- **Urinary system** consists of six organs: two kidneys, two ureters, urinary bladder, and urethra



Chapter 19 Key Points

1. Urinary system function
2. Urinary anatomy
3. Urine formation
    1. Glomerular filtration
    2. Tubular reabsorption
    3. Water conservation
4. Urine function and renal tests
5. Urine storage and elimination

Bozeman Science: http://www.bozemanscience.com/osmoregulation

Crash Course: https://www.khanacademy.org/partner-content/crash-course1/crash-course-biology/v/crash-course-biology-128

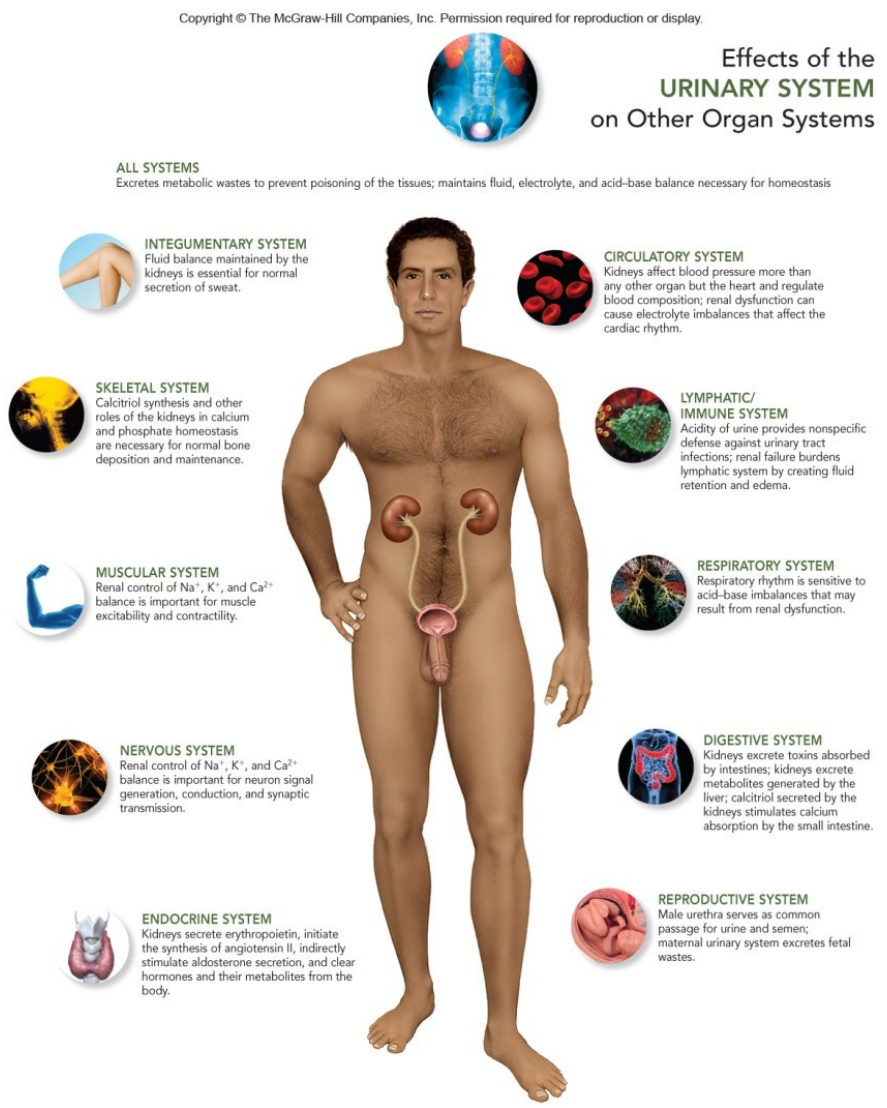
Excretion: separation of wastes from body fluids and the elimination of them

Respiratory system: CO_2, small amounts of other gases, and water

Integumentary system: Water, inorganic salts, lactic acid, urea in sweat

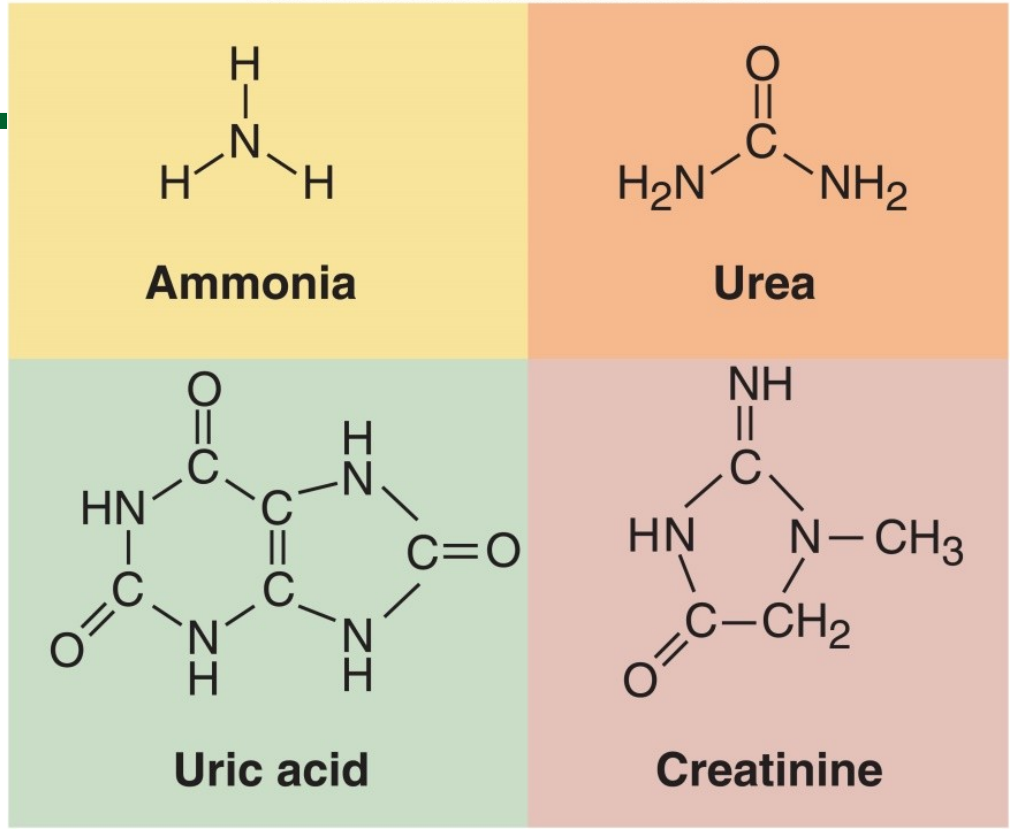
Digestive system: Water, salts, CO_2, lipids, bile pigments, cholesterol, other metabolic waste, and food residue

Urinary system: Many metabolic wastes, toxins, drugs, hormones, salts, H^+, and water



Nitrogenous Wastes

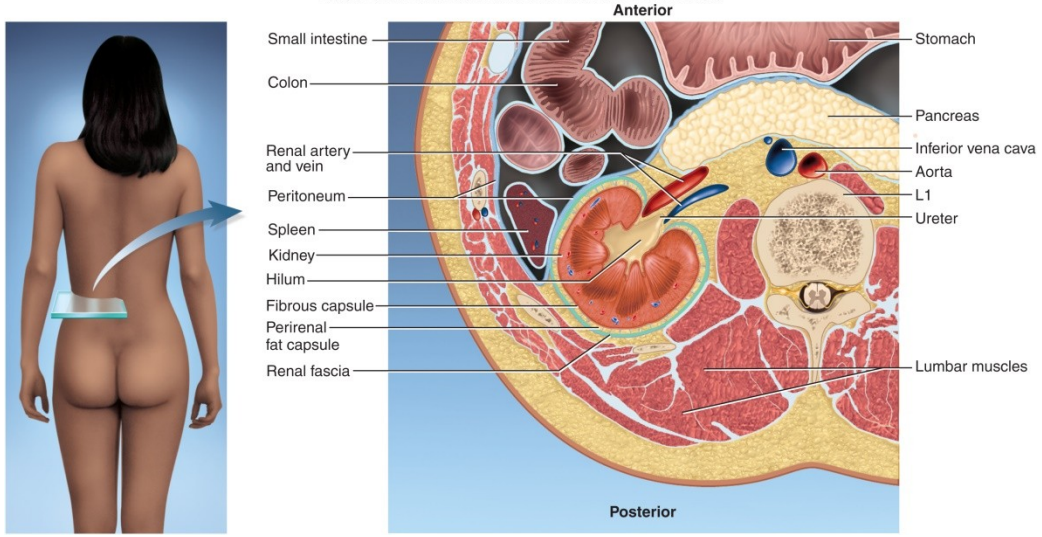
Urea: Proteins→ amino acids → NH_2 removed → forms ammonia, liver converts to urea
Uric acid: Product of nucleic acid catabolism
Creatinine: Product of creatine phosphate catabolism
Blood urea nitrogen (BUN): level of nitrogenous waste in the blood
- Normal BUN: 10 to 20 mg/dL
- **Azotemia**: elevated BUN, indicates renal insufficiency
- **Uremia**: syndrome of diarrhea, vomiting, dyspnea, and cardiac arrhythmia stemming from the toxicity of nitrogenous waste
- Treatment: hemodialysis or organ transplant



Waste: useless or present in excess of the body's needs
Metabolic waste: produced by the body

Functions of the Kidneys

1. **Filters blood plasma**
2. Regulates **blood volume** and **body fluid osmolarity** via elimination of water and solutes
3. Secretes **renin**, controlling blood pressure and electrolyte balance
4. Secretes **erythropoietin**, stimulating RBC production
5. Contributes to **PCO_2** and **acid–base balance** of body fluids
6. Final step in synthesizing hormone, **calcitriol** (Vitamin D)
7. **Gluconeogenesis** in extreme starvation



Gross Anatomy of the kidney

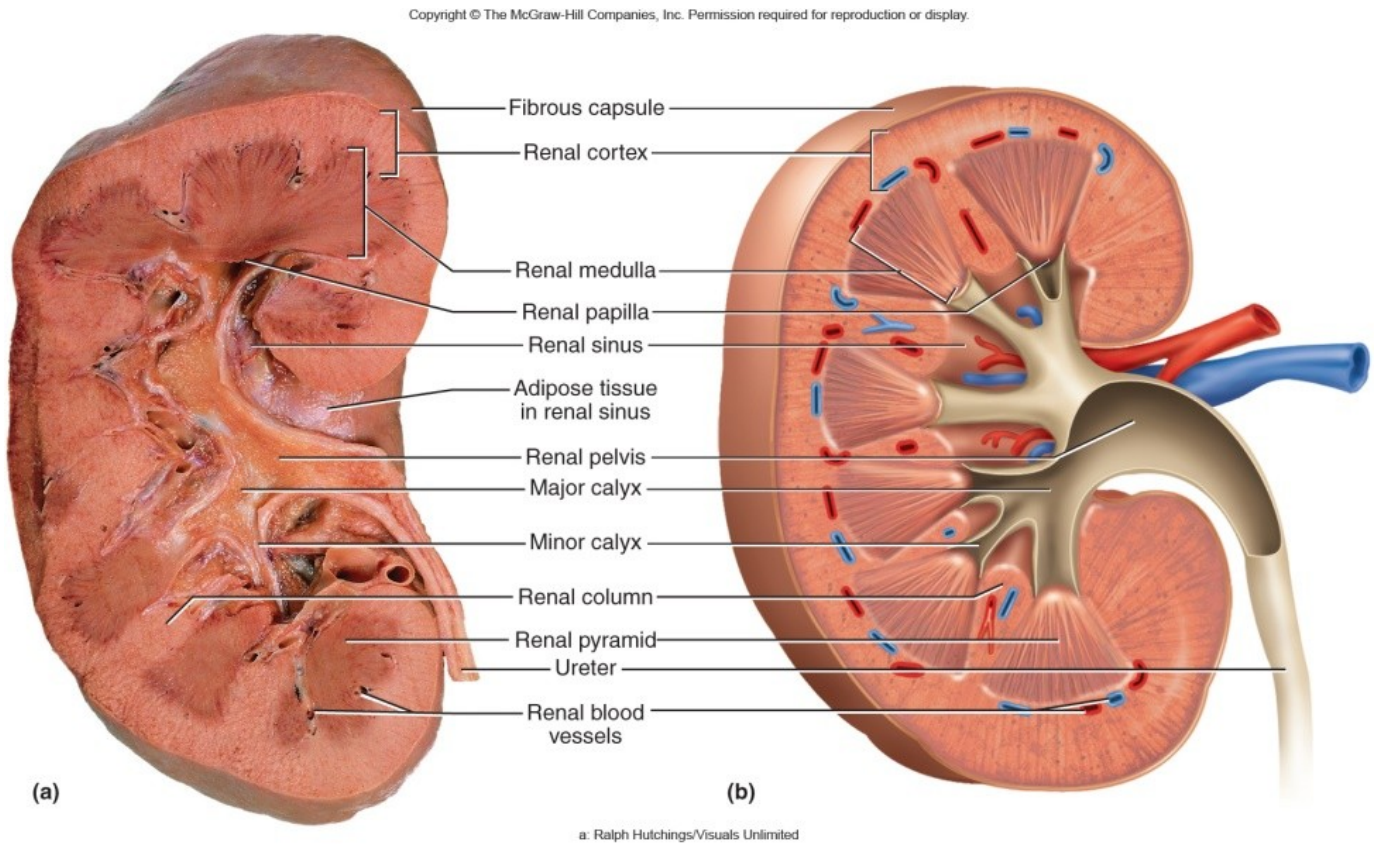
Renal sinus: blood lymphatic vessels, nerves, and urine-collecting structures

Renal parenchyma: glandular tissue that forms urine, Encircles the renal sinus

Two zones of renal parenchyma

- **Outer renal cortex**
- **Inner renal medulla**: **Renal columns** & Renal pyramids:

Lobe of the kidney: one pyramid and its overlying cortex



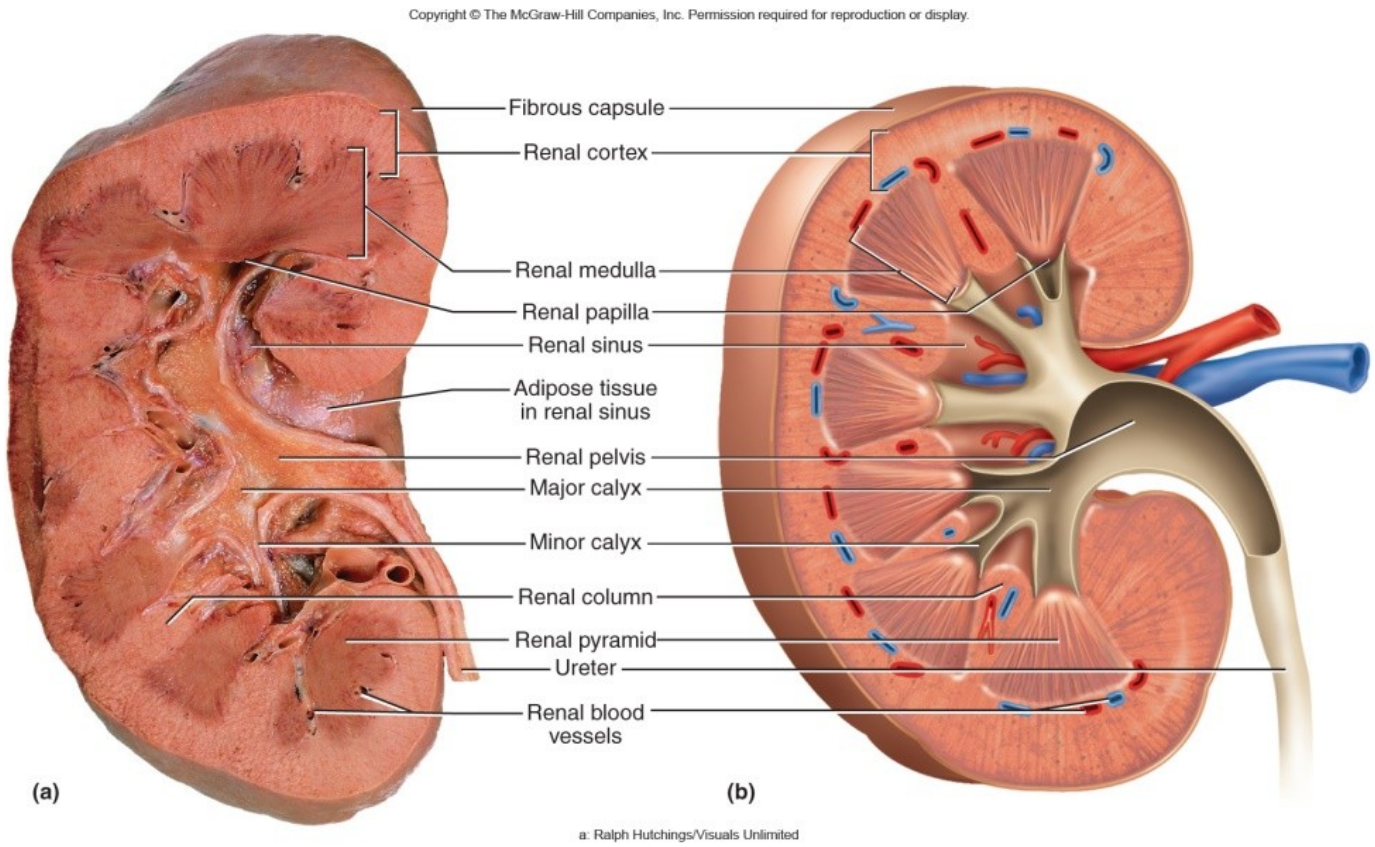
Gross Anatomy of the kidney

Minor calyx: cup nestled in papilla of each pyramid; collects it urine

Major calyces: convergence of two or three minor calyces

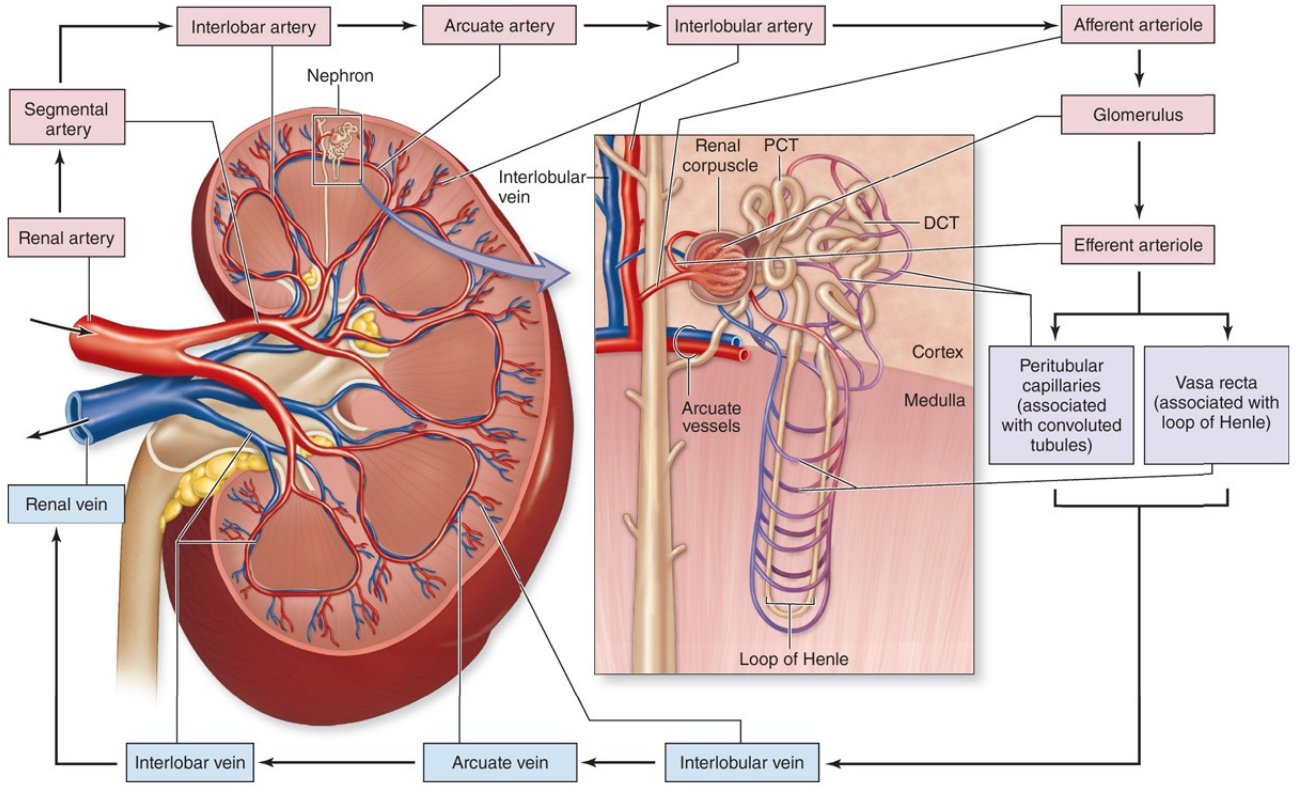
Renal pelvis: convergence of two or three major calyces

Ureter: tubular continuation of the pelvis that drains the urine down to the urinary bladder



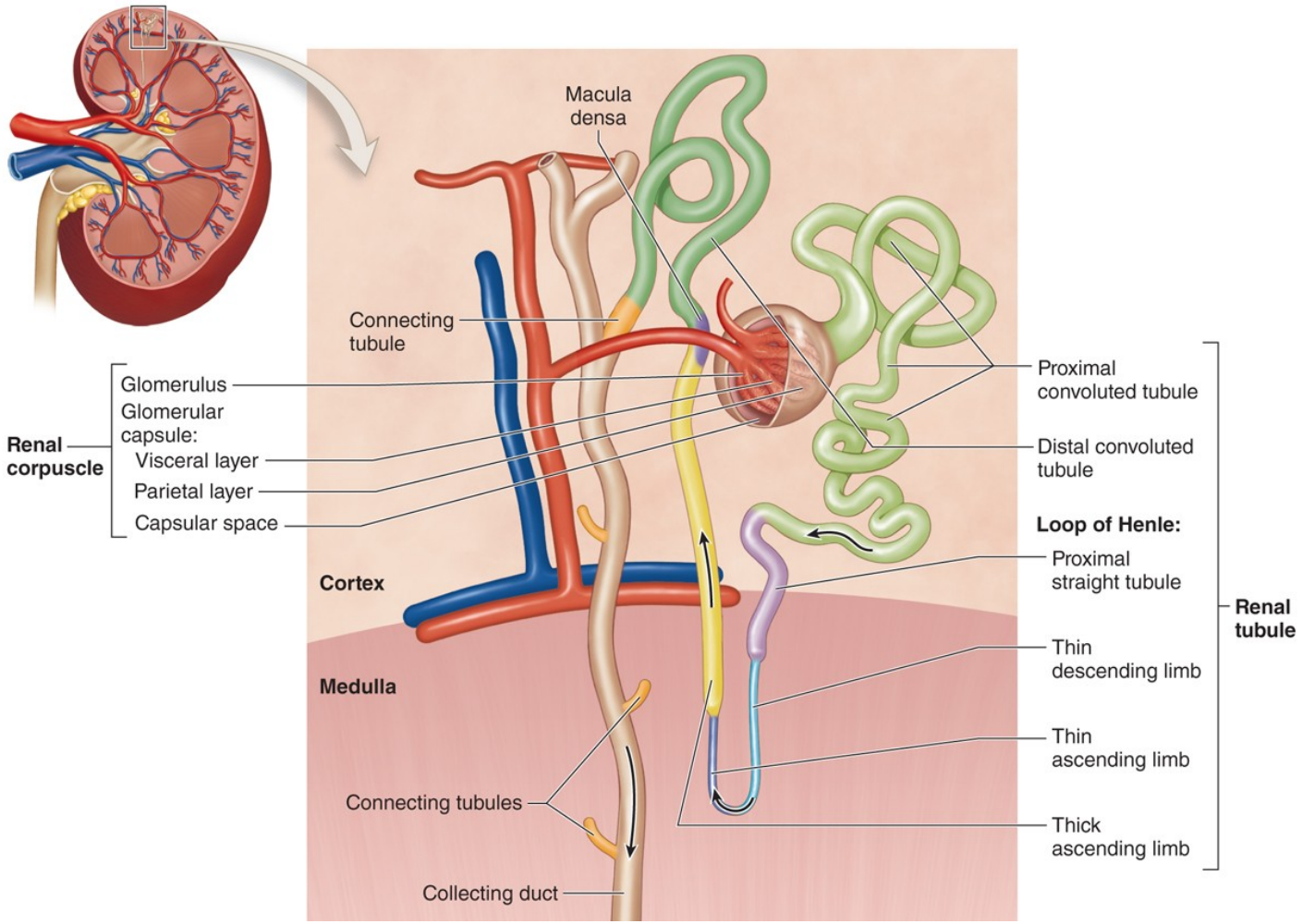
Renal Circulation: 0.4% of body weight, 21% of cardiac output

Renal artery → Interlobar arteries → Arcuate arteries: over pyramids → Interlobular (cortical radiate) arteries → afferent arterioles → 1 nephron → efferent arterioles → peritubular capillaries or vasa recta → Interlobular veins (cortical radiate) → arcuate veins → interlobar veins → Renal vein → inferior vena cava



Medical Application: Distance runners and swimmers often experience temporary proteinuria or hematuria (protein or blood in urine). Prolonged, strenuous exercise greatly reduces perfusion of kidney Glomerulus deteriorates under prolonged hypoxia

Each kidney contains approximately 1 million functional units called nephrons, which carry waste from blood to calyx



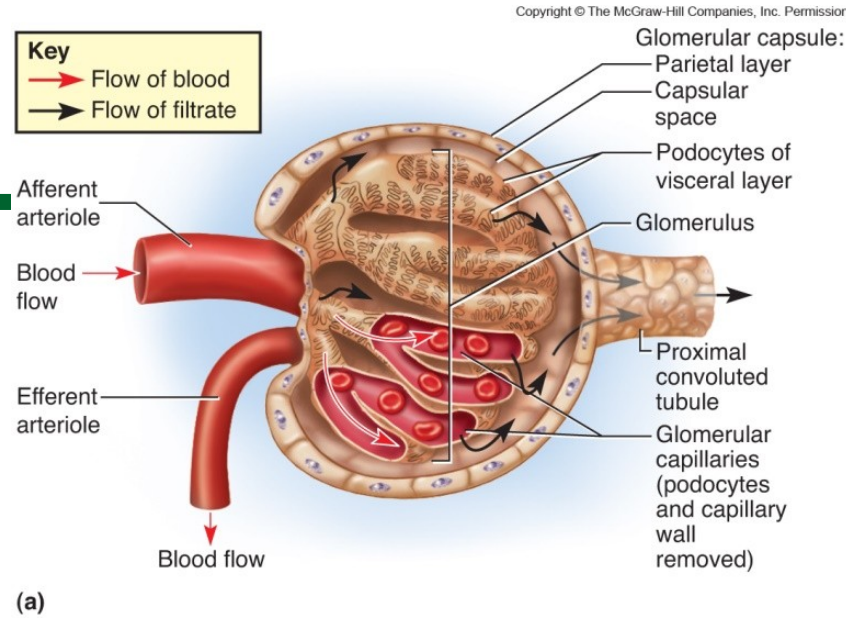
renal corpuscle → proximal convoluted tubule → loop of Henle (proximal straight tubule → thin descending limb → thin ascending limb → thick ascending limb → macula densa → distal convoluted tubule → connecting tubule → collecting duct → calyx

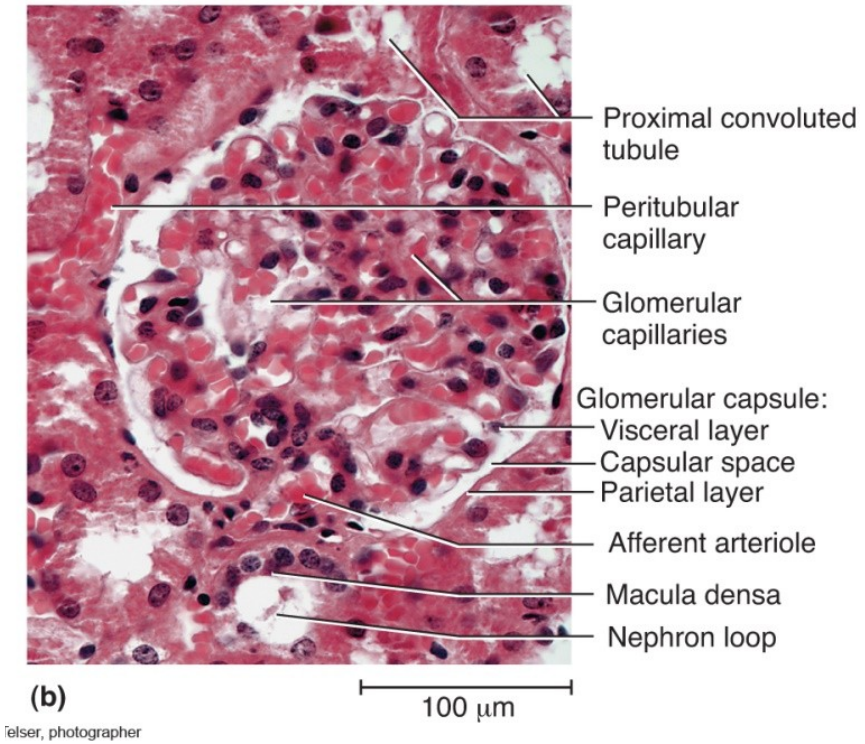
The Nephron

Glomerular filtrate: fluid exits glomulerular capillary → capsular space → convoluted tubule.
Note the afferent arteriole is larger than the efferent arteriole.

- **Vascular pole**: the side of the corpuscle where the afferent arterial enters the corpuscle and the efferent arteriole leaves
- **Urinary (Tubular) pole**: the opposite side of the corpuscle where the renal tubule begins

MEDICAL APPLICATION: In diseases such as diabetes mellitus and glomerulonephritis, the glomerular filter is altered and becomes much more permeable to proteins, with the subsequent release of protein into the urine (**proteinuria**). Proteinuria is an indicator of many potential kidney disorders.





Renal corpuscle is small mass of capillaries called the glomerulus housed within a bulbous glomerular capsule: filters the blood plasma

Parietal (outer) layer of capsule: simple squamous epithelium

Visceral (inner) layer of capsule

- **podocytes** surround capillaries and create barrier against escape of large molecules
- **pedicels:** foot processes of podocytes

Capsular space separates the two layers of Bowman capsule

Blood enters and leaves the glomerulus through the afferent and efferent arterioles, respectively.

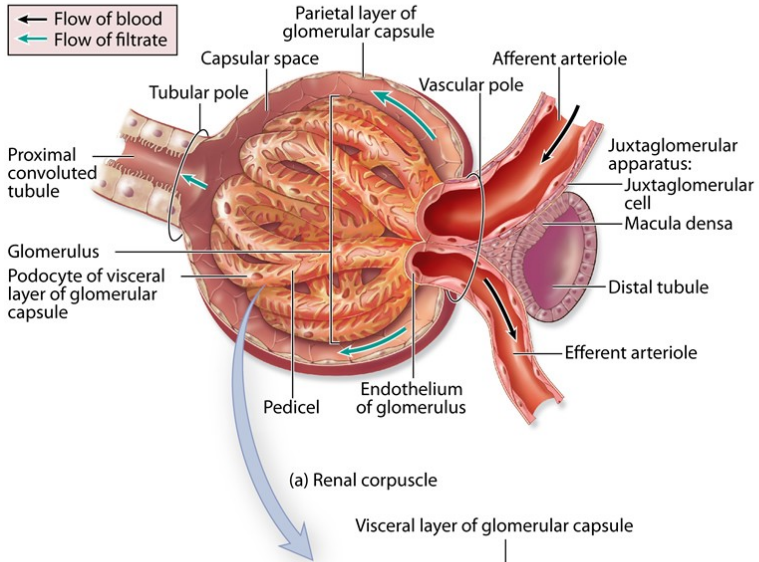
G glomerulus

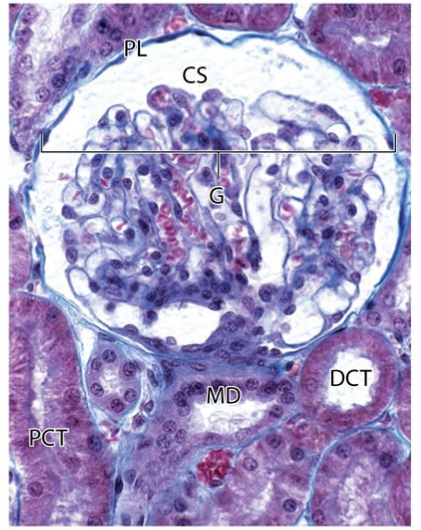
CS capsular space

PL: simple squamous parietal layer of Bowman capsule. **MD** macula densa

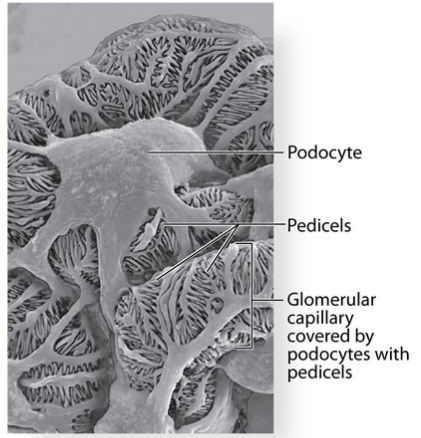
PCT proximal convoluted tubules

DCT distal convoluted tubules





(b) Histology of renal corpuscle



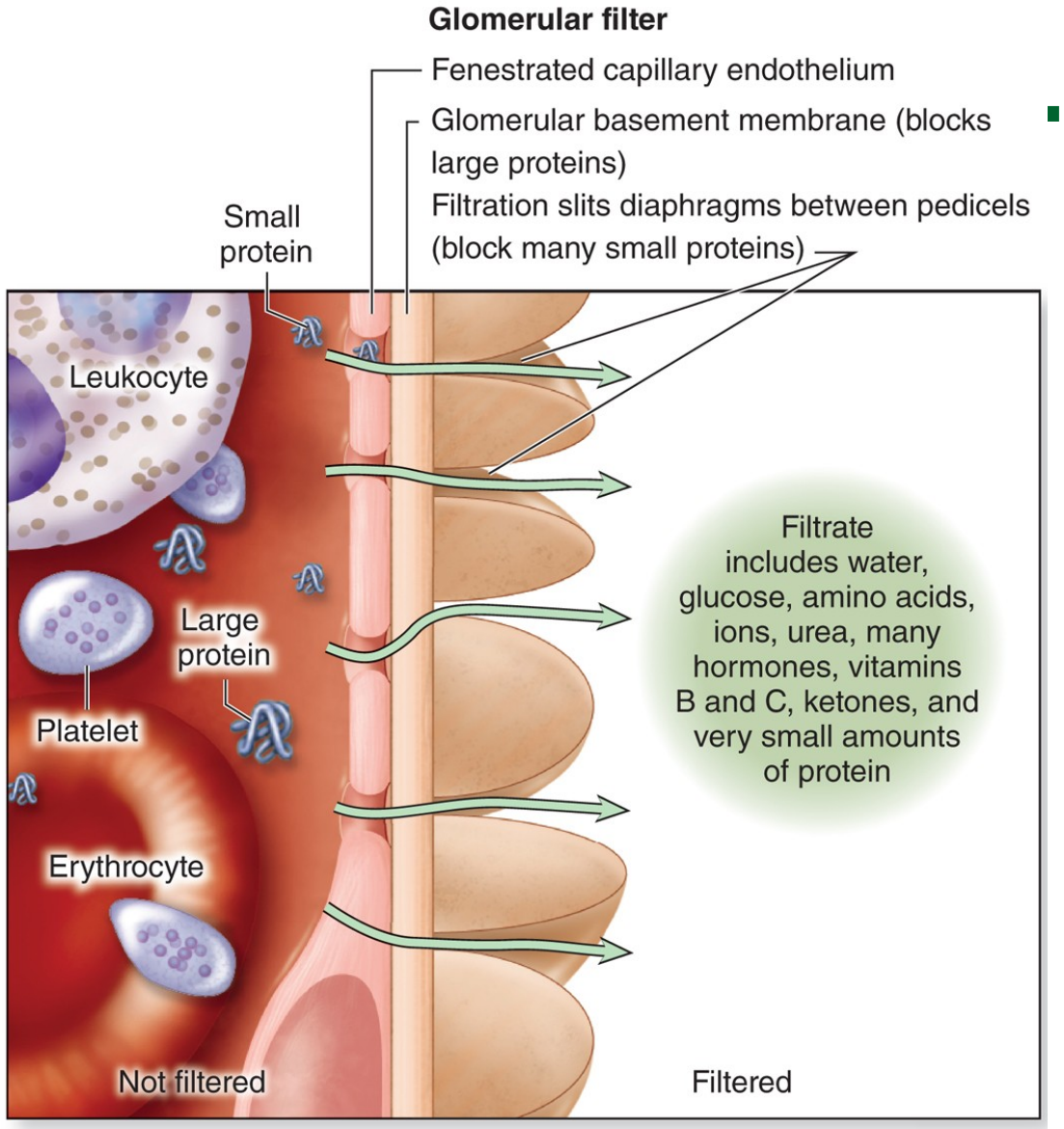
(d) Podocytes

Glomerular Filter

Filtrate is produced in the corpuscle when blood plasma is forced under pressure through the **capillary fenestrations**, across the filtration **membrane** or surrounding the capillary, and through the **filtration slit** diaphragms located between the podocyte pedicels

The glomerular filtration barrier = fenestrated **capillary endothelium**, the **glomerular basement membrane (GBM)**, and **filtration slit**

MEDICAL APPLICATION Diabetic glomerulosclerosis, the thickening and loss of function in the GBM produced as part of the systemic microvascular sclerosis in diabetes mellitus, is the leading cause of (irreversible) end-stage kidney disease in the United States. Treatment requires either a kidney transplant or regular artificial hemodialysis.



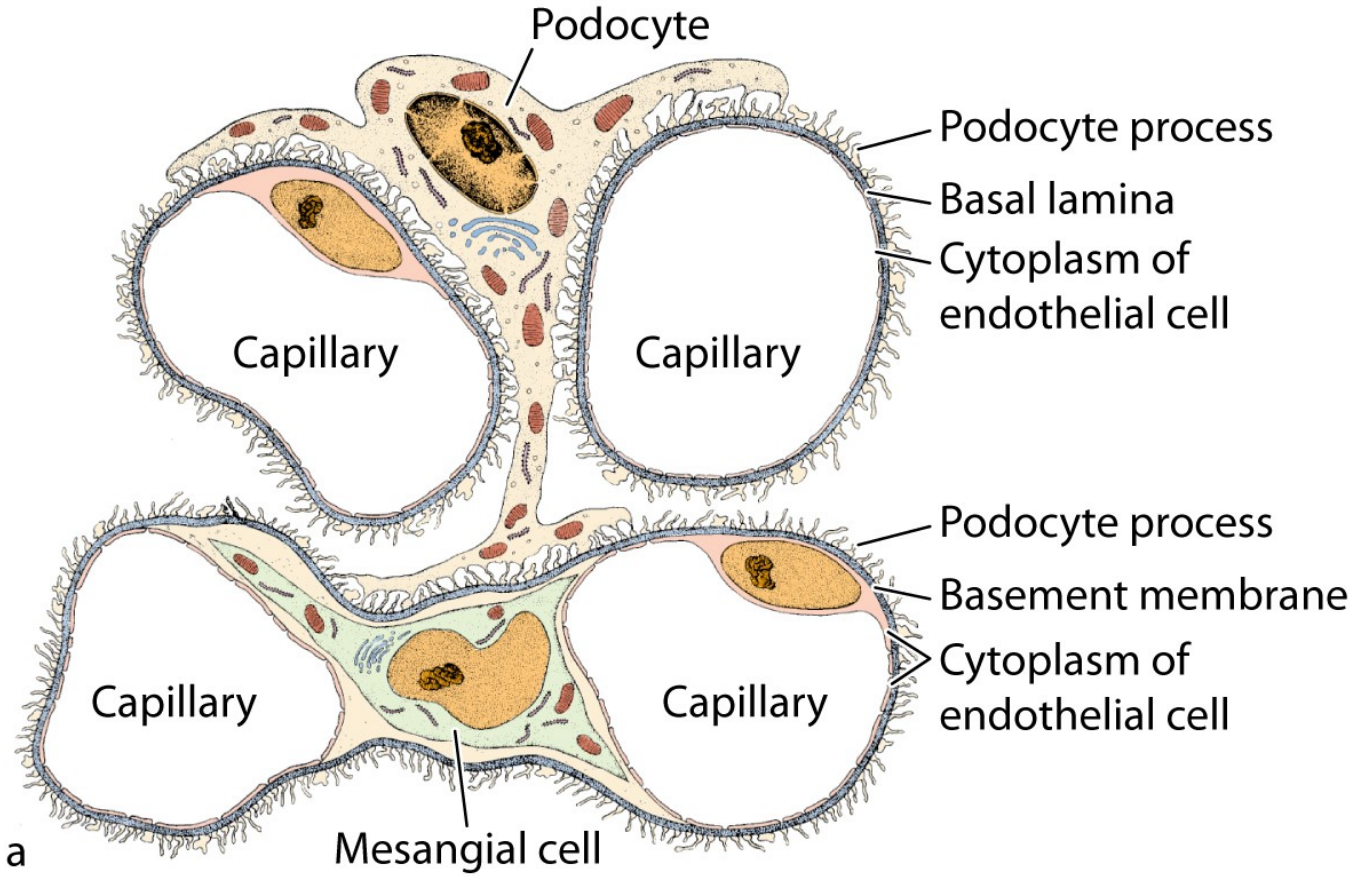
(c) Substances filtered by filtration membrane

Mesangial cells in renal corpuscles are located between capillaries and cover those capillary surface not covered by podocyte processes.

Some mesangial processes appear to pass between endothelial cells into the capillary lumen where they may help remove or endocytose adherent protein aggregates.

Podocytes and their pedicels open to the urinary space and associate with the capillary surfaces not covered by mesangial cells

Mesangial cells extend contractile processes (arrows) along capillaries that help regulate blood flow in the glomerulus



The Renal (Uriniferous) Tubule: glomerular capsule → tip of medullary pyramid

4 regions of renal tubule:

1. Proximal convoluted tubule (PCT): most coiled , Simple cuboidal epithelium with prominent microvilli for majority of absorption

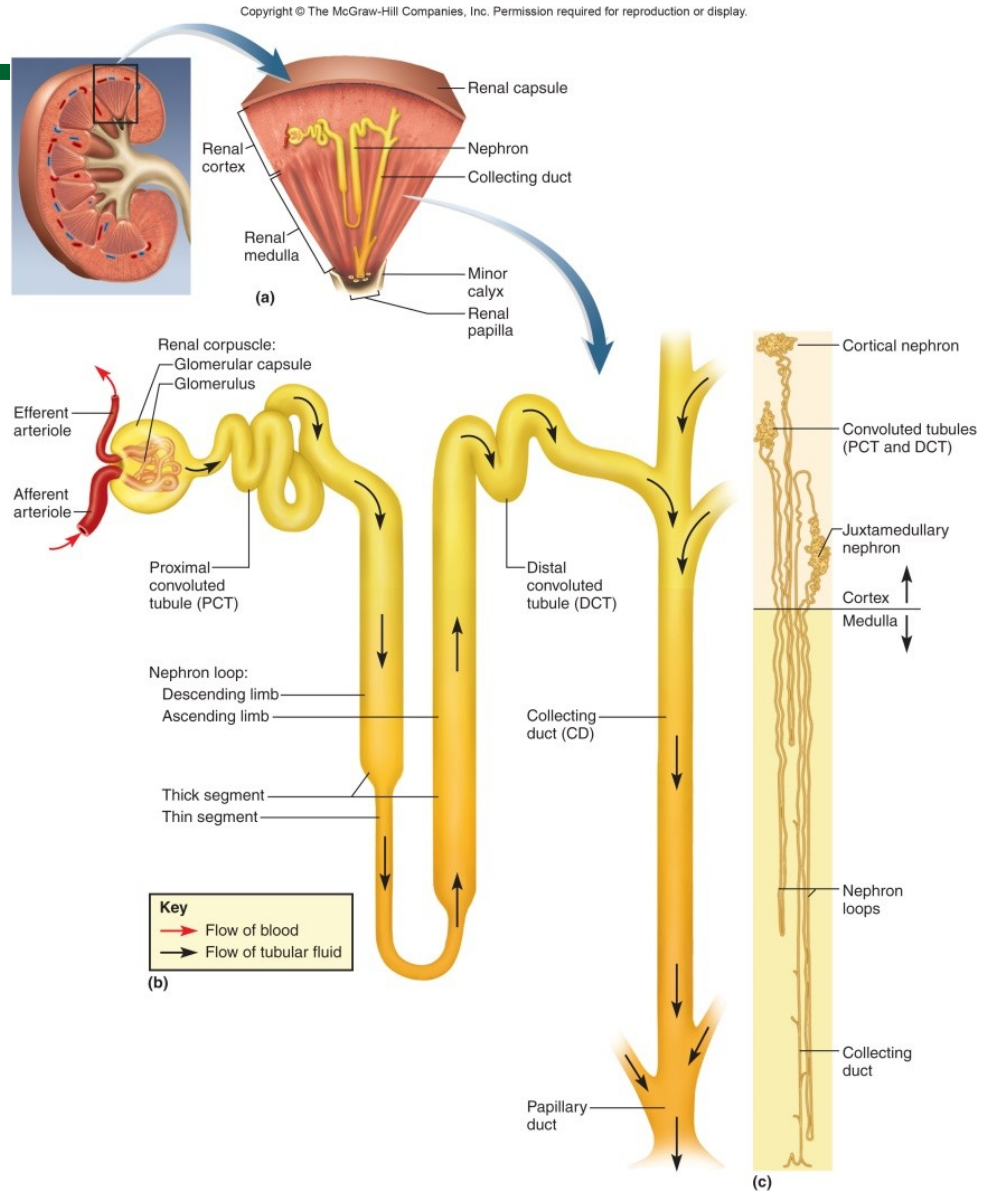
2. Nephron loop (loop of Henle): long U-shaped portion of renal tubule

- Thick segments: simple cuboidal epithelium, active transport of salts, many mitochondria
- Thin segment: simple squamous epithelium, very permeable to water

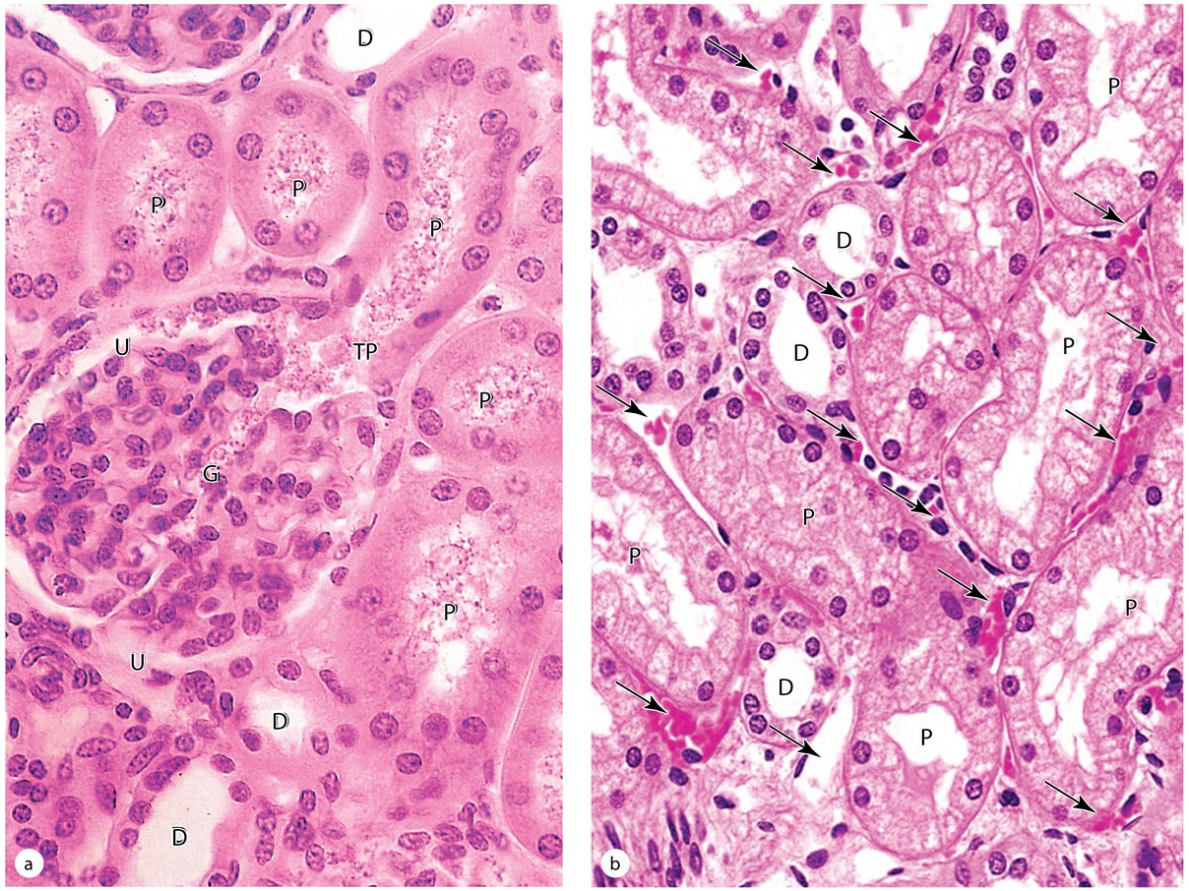
3. **Distal convoluted tubule (DCT, end of nephron**): Cuboidal epithelium without microvilli

4. **Collecting duct**: receives from several DCTs, simple cuboidal ep.

collecting duct → papillary duct → minor calyx → major calyx → renal pelvis → ureter → urinary bladder → urethra



Renal cortex: proximal and distal convoluted tubules

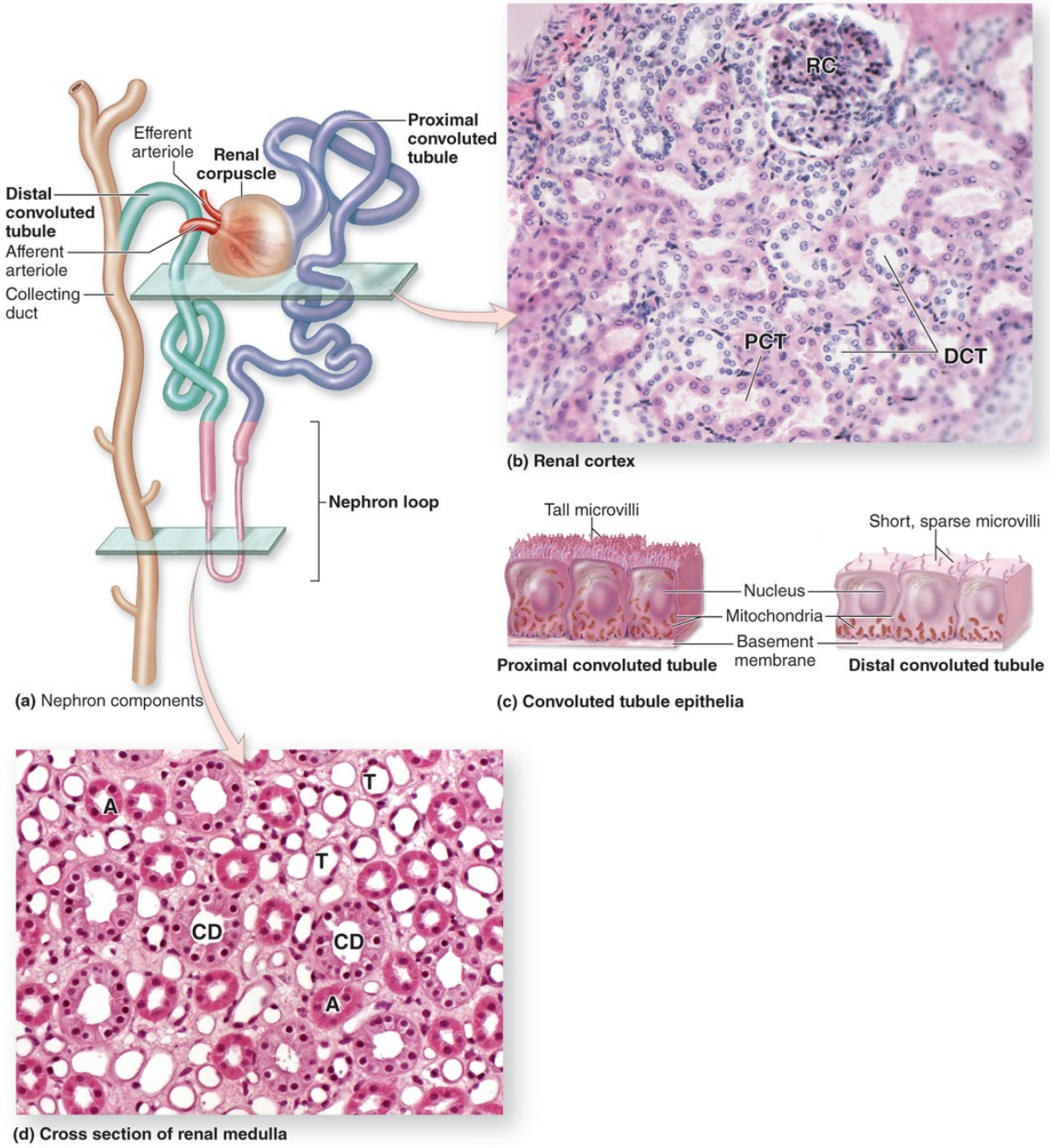


Note the **continuity at a renal corpuscle's tubular pole** (**TP**) between the simple cuboidal epithelium of a **proximal convoluted tubule** (**P**) and the simple squamous epithelium of the **capsule's parietal layer**.

The urinary space (**U**) between the parietal layer and the glomerulus (**G**) drains into the lumen of the proximal tubule. The lumens of the proximal tubules appear filled, because of the long microvilli of the brush border and aggregates of small plasma proteins bound to this structure. By contrast, the lumens of distal convoluted tubules (**D**) appear empty, lacking a brush border and protein.

Abundant **peritubular capillaries** and **draining venules** (arrows) that surround the proximal (**P**) and distal (**D**) convoluted tubules are clearly seen.

Convoluted tubules, nephron loops, and collecting ducts



RC: renal corpuscle
PCT: eosinophilic proximal convoluted tubules smaller
DCT: Less well-stained distal convoluted tubules.

Cuboidal cells of proximal and distal tubules have structural differences.

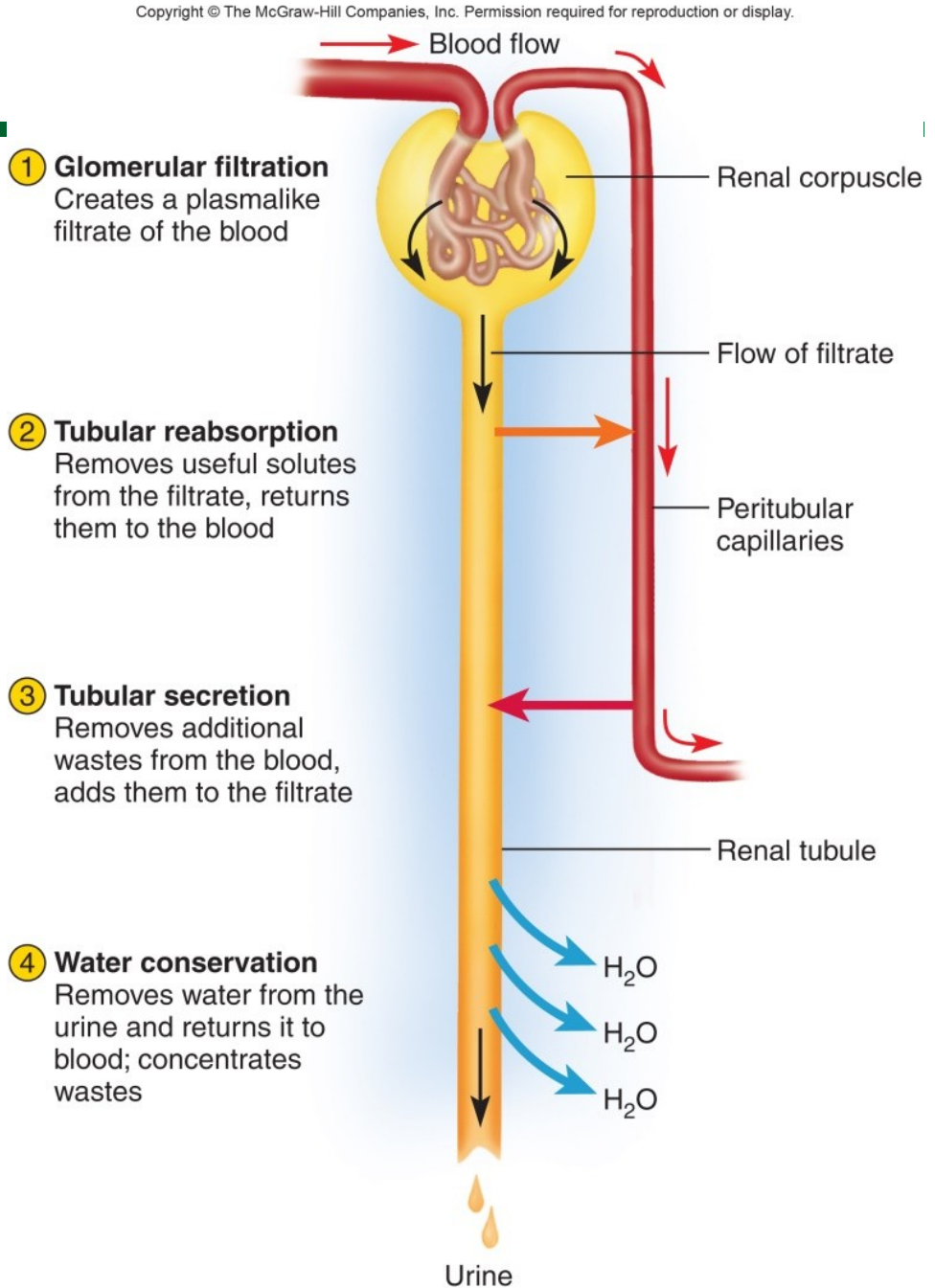
T: loops of Henle in cross section through a medullary pyramid. Simple squamous epithelium of the thin descending and ascending limbs of and its thick ascending limbs (**A**), as well as the pale columnar cells of collecting ducts (**CD**).

Urine Formation I: Glomerular Filtration

Kidneys convert blood plasma to urine in three stages

1. Glomerular filtration
   Glomerular filtrate: fluid in the capsular space, like blood plasma but almost no protein.
2. Tubular reabsorption and secretion
3. Water conservation

Urine: fluid that enters the collecting duct, little alteration beyond this point except for changes in water content



Juxtaglomerular apparatus

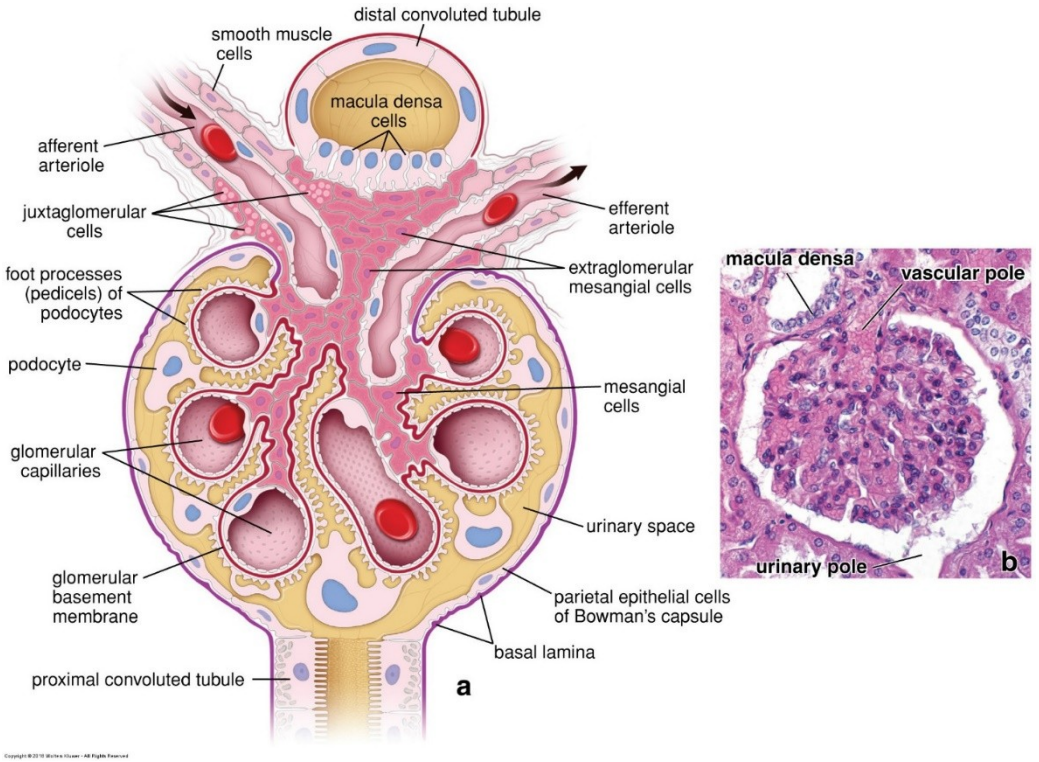
Macula densa: epithelial cells at end of the nephron facing the arterioles

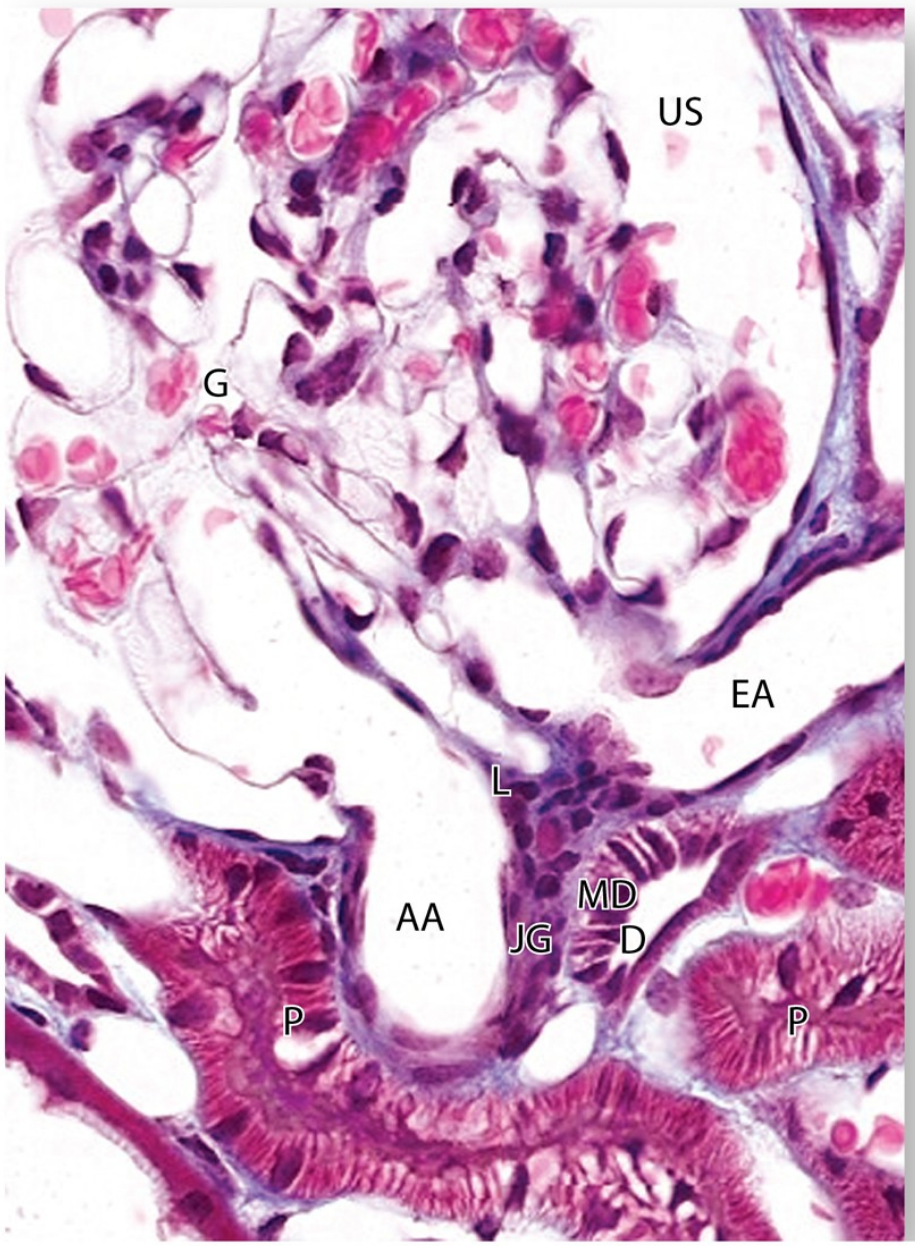
- Senses flow or fluid composition, secretes a paracrine signal that stimulates JG cells

Juxtaglomerular (JG) cells: smooth muscle cells of afferent arteriole across from macula dens, control arteriole diameter.

- Secrete in renin in response to drop in blood pressure
- Renin activates the renin-angiotensin system

angiotensinogen → angiotensin I → angiotensin II → constricts blood vessels, increases the secretion of ADH and aldosterone (to decrease urine volume), and stimulates the hypothalamus to activate the thirst reflex → increase in blood pressure





JGA forms at the point of contact between a nephron's distal tubule (D) and the vascular pole of its glomerulus (G).

Cells of the distal tubule become columnar as a thickened region called the macula densa (**MD**).

Smooth muscle cells of the afferent arteriole's (**AA**) tunica media are converted from a contractile to a secretory morphology as juxtaglomerular granule cells (**JG**).

Also present are lacis cells (**L**), which are extraglomerular mesangial cells adjacent to the macula densa, the afferent arteriole, and the efferent arteriole (**EA**).

TABLE 19–1 Histologic features and major functions of regions within renal tubules.

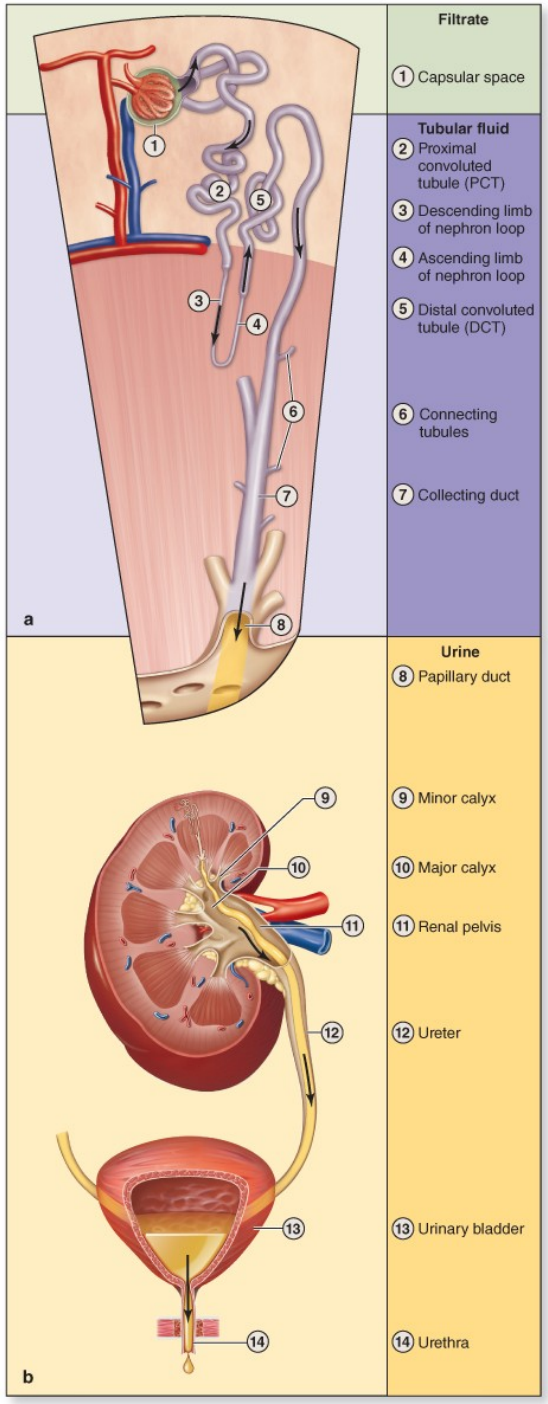
Region of Tubule	Histological Features	Locations	Major Functions
PCT	Simple cuboidal epithelium; cells well-stained, with numerous mitochondria, prominent basal folds and lateral interdigitations; long microvilli, lumens often occluded	Cortex	Reabsorption of all organic nutrients, all proteins, most water and electrolytes; secretion of organic anions and cations, H^+, and NH_4^+
Loop of Henle			
Thin limbs	Simple squamous epithelium; few mitochondria	Medulla	Passive reabsorption of Na^+ and Cl^-
TAL	Simple cuboidal epithelium; no microvilli	Medulla and medullary rays	Active reabsorption of various electrolytes
DCT	Simple cuboidal epithelium; cells smaller than in PCT, short microvilli and basolateral folds, more empty lumens	Cortex	Reabsorption of electrolytes
Collecting system			
Principal cells	Most abundant, cuboidal to columnar; pale-staining, distinct cell membranes	Medullary rays and medulla	Regulated reabsorption of water & electrolytes; regulated secretion of K^+
Intercalated cells	Few and scattered; slightly darker staining	Medullary rays	Reabsorption of K^+ (low-K^+ diet); help maintain acid-base balance

DCT, distal convoluted tubule; PCT, proximal convoluted tubule; TAL, thick ascending limb.

Fluid transport in the urinary system

Upon delivery at a minor calyx, filtrate is no longer modified by reabsorption or secretion and is called **urine**. It flows passively into the renal pelvis but moves by peristalsis along the ureters for temporary storage in the urinary bladder, which is emptied through the urethra.

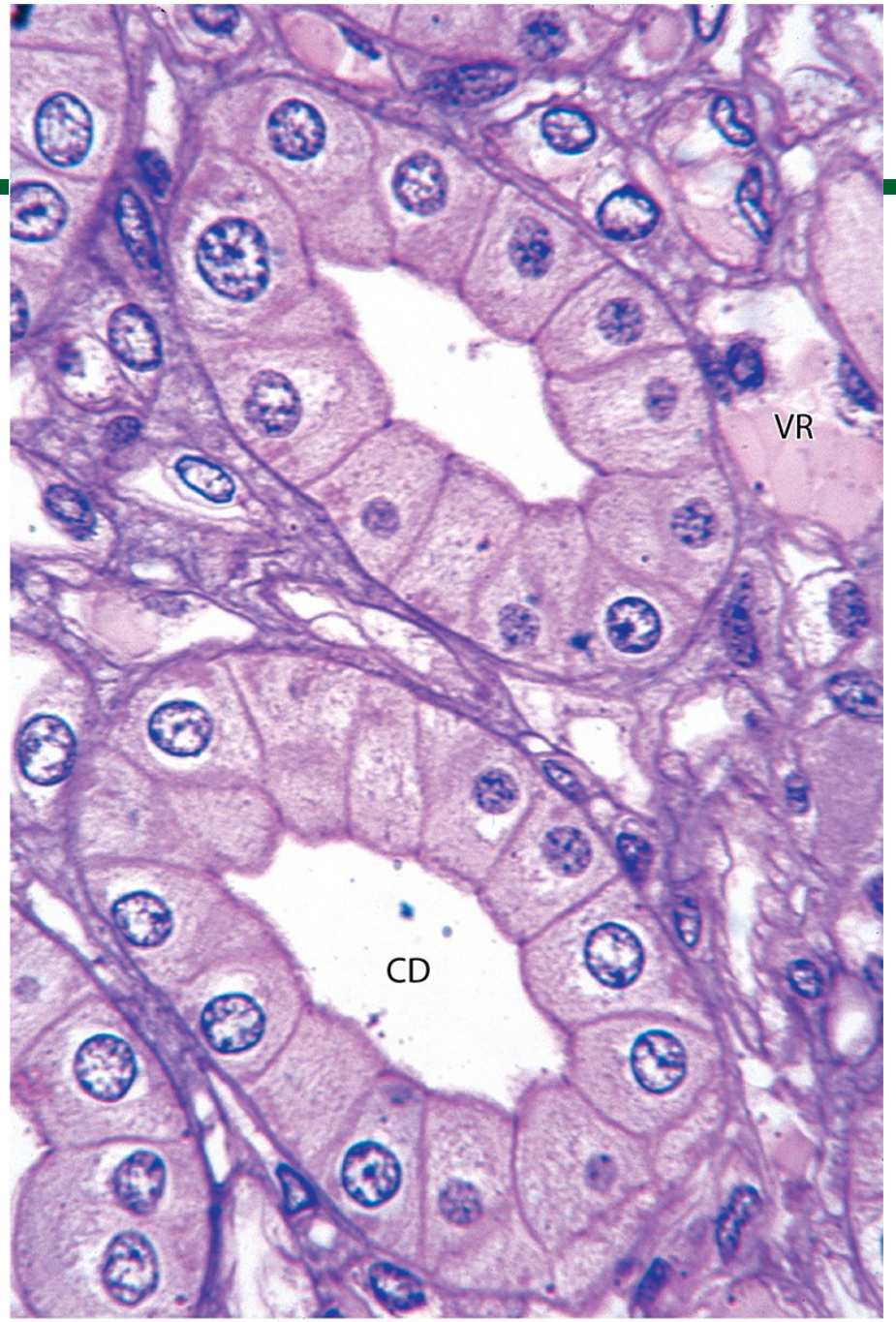
MEDICAL APPLICATION: A common problem involving the ureters is their obstruction by renal calculi (**kidney stones**) formed in the renal pelvis or calyces, usually from calcium salts (oxalate or phosphate) or uric acid. While urate stones are usually smooth and small, calcium stones can become large and irritate the mucosa. Problems caused by such stones can be corrected by either surgical removal of the stone or its disintegration using focused ultrasonic shock waves in a procedure called **lithotripsy** (https://www.youtube.com/watch?v=fR_CjlVXhzw)



Collecting Ducts

Pale-staining columnar **principal cells**, in which ADH-regulated aquaporins of the cell membrane allow more water reabsorption, are clearly seen in these transversely sectioned collecting ducts (**CD**), surrounded by interstitium with vasa recta (**VR**)

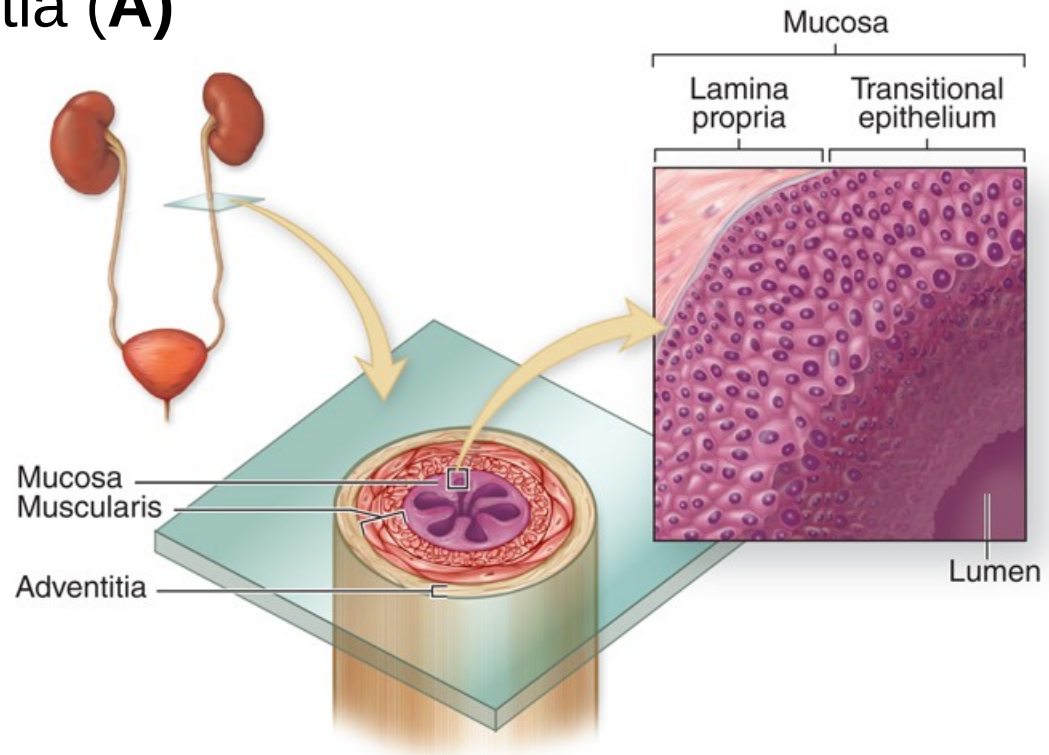
MEDICAL APPLICATION:
Bacterial infections of the urinary tract can lead to inflammation of the renal pelvis and calyces, or pyelonephritis In acute pyelonephritis bacteria often move from one or more minor calyx into the associated renal papilla, causing accumulation of neutrophils in the collecting ducts.



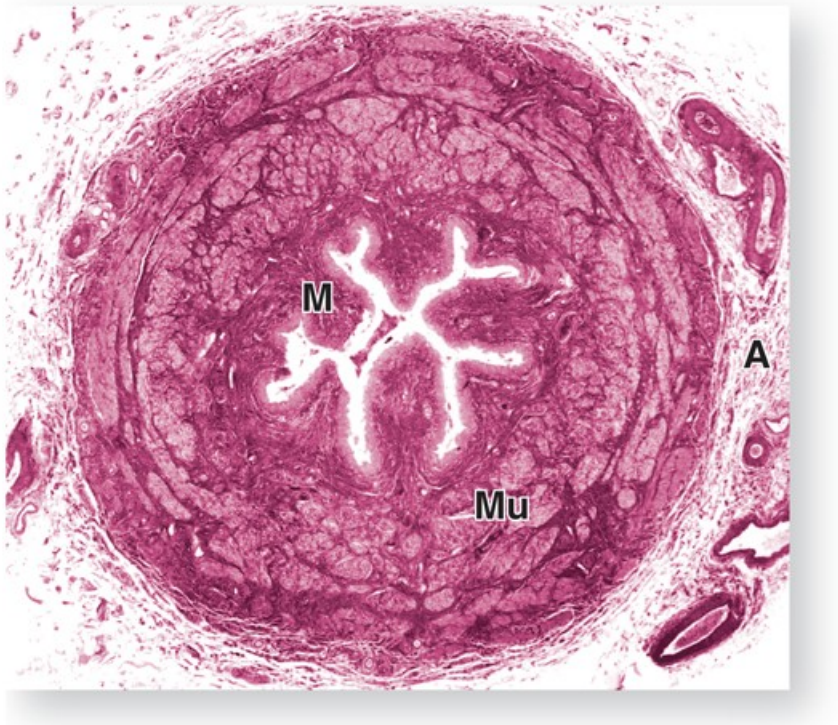
Ureter in cross section shows a characteristic pattern of longitudinally folded mucosa, surrounded by a thick muscularis that moves urine by regular waves of peristalsis.

The lamina propria is lined by a unique stratified epithelium called **transitional epithelium** or **urothelium** that is resistant to the potentially deleterious effects of contact with hypertonic urine.

Histologically the muscularis (**Mu**) is much thicker than the mucosa (**M**) and adventitia (**A)**



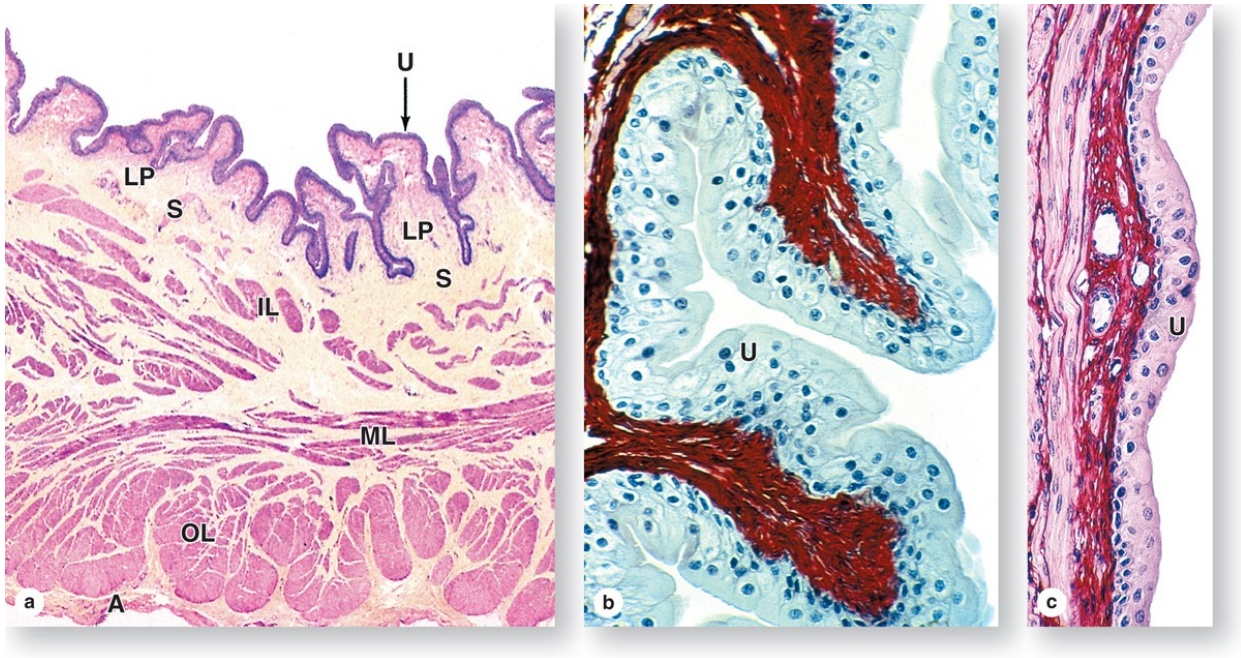
(a) Ureter cross section



(b)

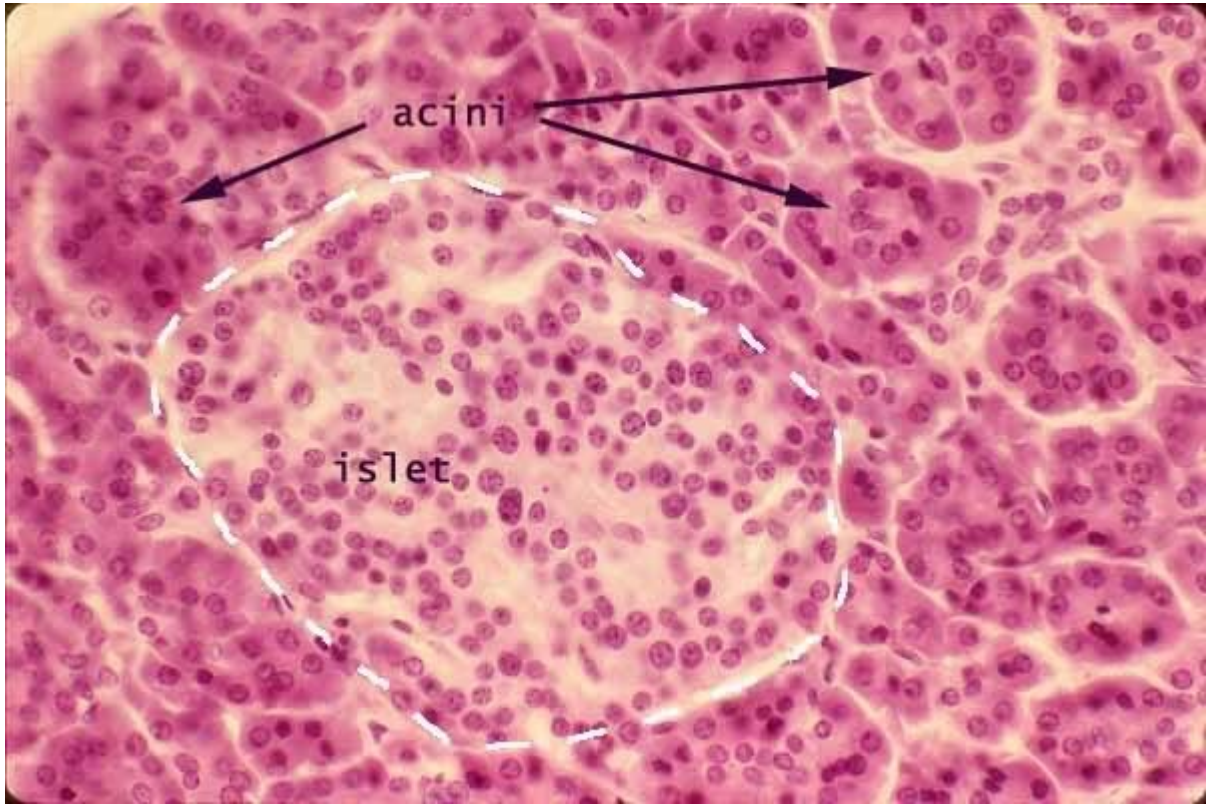
Bladder

(a) In the neck of the bladder, near the urethra, the wall shows four layers: the mucosa with urothelium (**U**) and lamina propria (**LP**); the thin submucosa (**S**); inner, middle, and outer layers of smooth muscle (**IL**, **ML**, and **OL**); and the adventitia (**A**). **(b)** When the bladder is empty, the mucosa is highly folded and the urothelium (**U**) has bulbous umbrella cells. **(c)** When the bladder is full, the mucosa is pulled smooth, the urothelium (**U**) is thinner, and the umbrella cells are flatter.



MEDICAL APPLICATION Cystitis, or inflammation of the bladder mucosa, is the most frequent problem involving this organ. Such inflammation is common during urinary tract infections, but it can also be caused by immunodeficiency, urinary catheterization, radiation, or chemotherapy.

Bladder cancer is usually some form of transitional cell carcinoma arising from unstable urothelium.



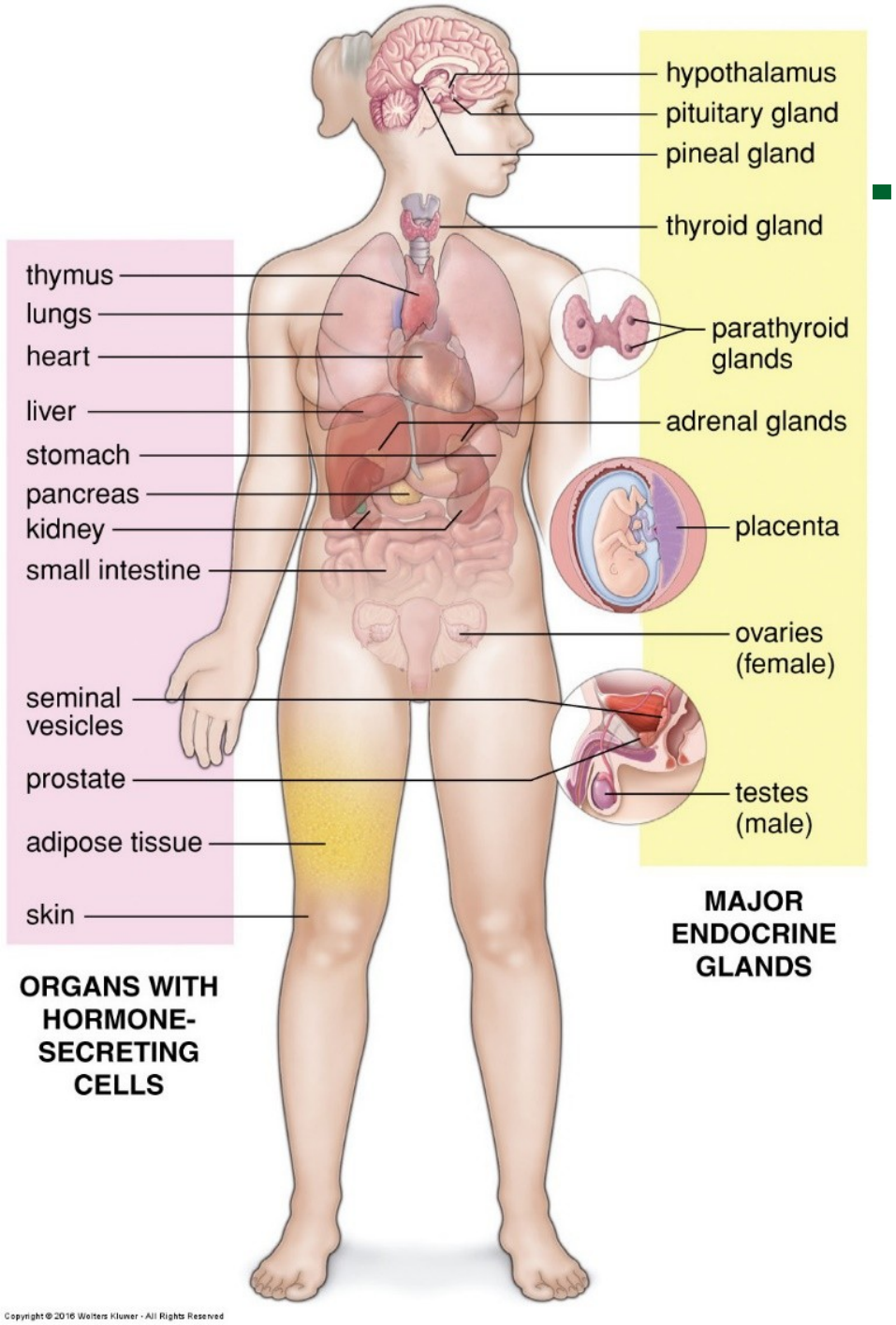
Endocrine

BI 455 CHAPTER 20

Crash Course Endocrine
https://www.khanacademy.org/partner-content/crash-course1/partner-topic-crash-course-bio-ecology/crash-course-biology/v/crash-course-biology-132

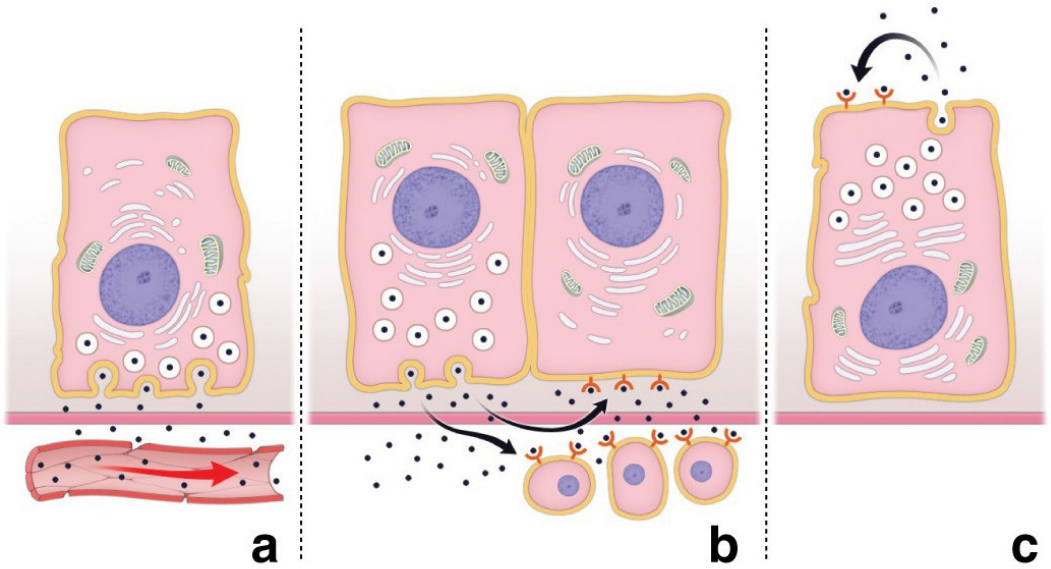
Overview of the Endocrine System

- **Endocrine system:** glands, tissues, and cells that secrete hormones
- **Endocrinology**: the study of this system and the diagnosis and treatment of its disorders
- **Endocrine glands**: organs that are traditional sources of hormones
- **Hormones**: chemical messengers that are transported by the bloodstream and stimulate physiological responses in cells of another tissue or organ, often a considerable distance away



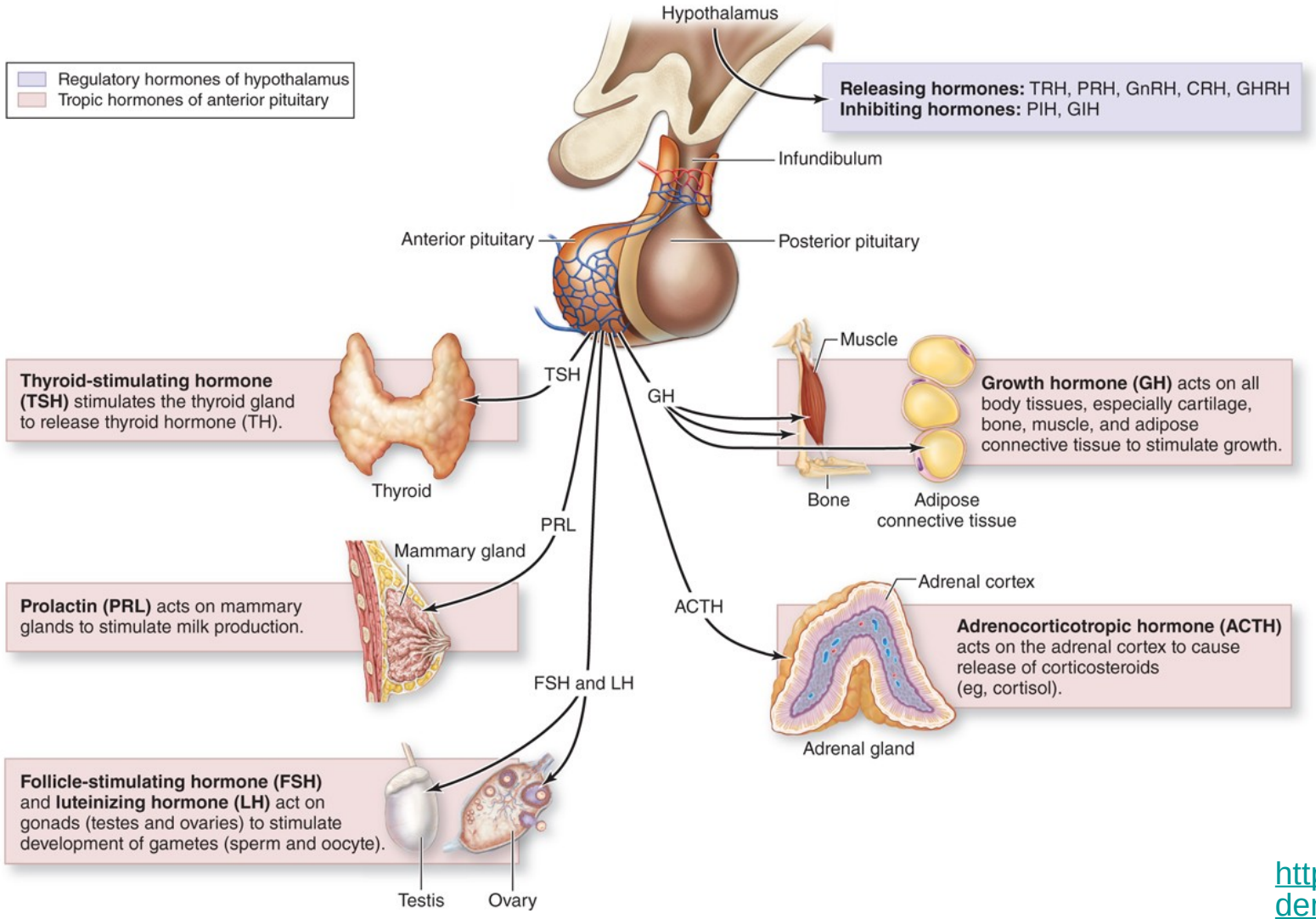
Comparison of Endocrine and Exocrine Glands

- **Exocrine glands**: Have ducts carry secretion to an epithelial surface or the mucosa of the digestive tract: “external secretions”
- **Endocrine glands**: No ducts, Contain dense, fenestrated capillary networks which allow easy uptake of hormones into bloodstream
  - “Internal secretions”, Intracellular effects such as altering target cell metabolism



Endocrine: hormone is discharged from a cell into the bloodstream and is transported to the effector cells.
Paracrine: hormone is secreted from one cell and acts on adjacent cells that express specific receptors.
Autocrine: hormone responds to the receptors located on the cell that produces it

Hormones of the Hypothalamus and Pituitary Gland are the Master Regulators of the Endocrine System



http://highered.mheducation.com/sites/0072495855/student_view0/chapter20/animation__hormonal_communication.html

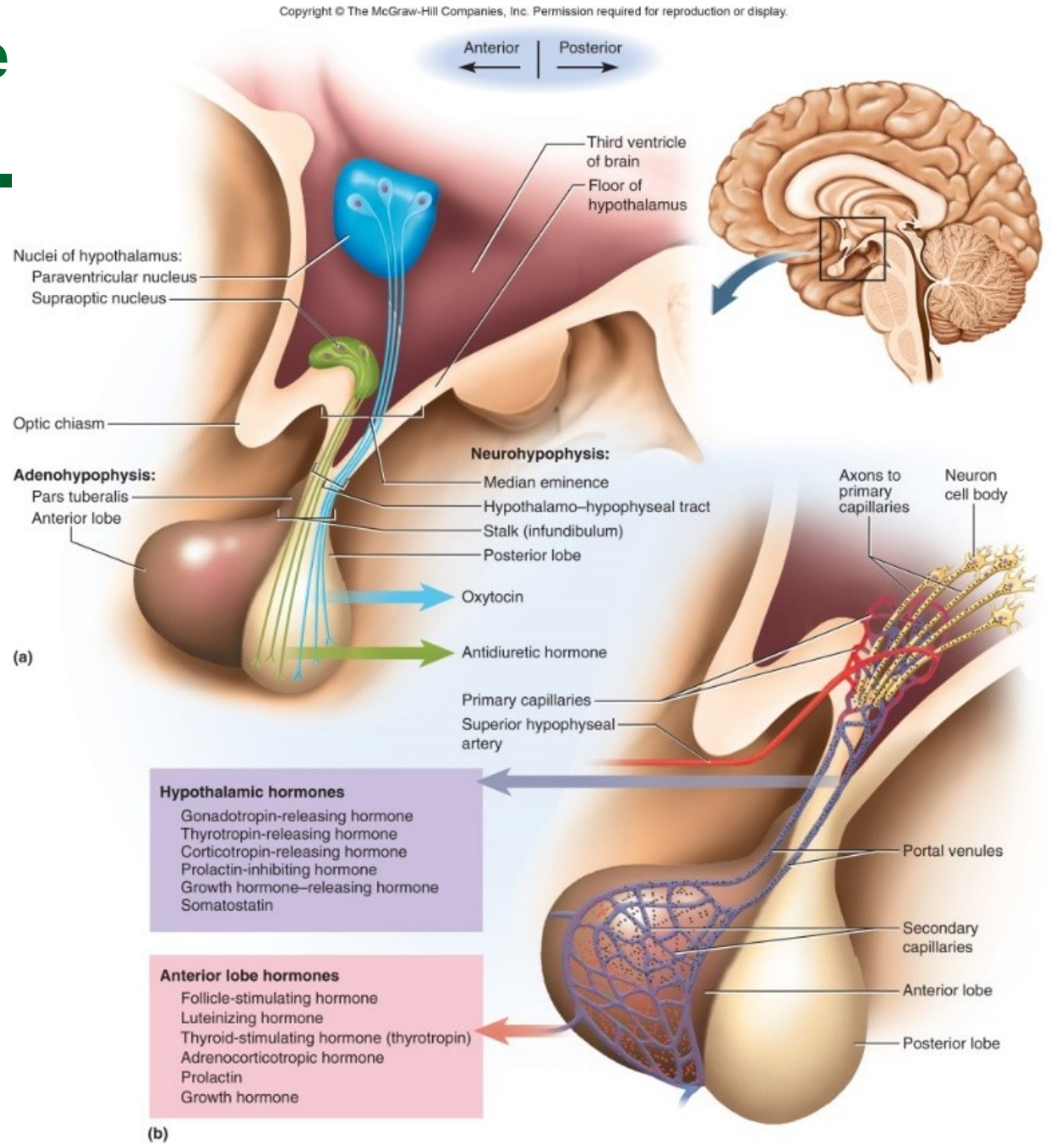
Hypothalamus is attached to poste pituitary by infundibulum stalk

Hypothalamo-hypophyseal tract: Hypothalamic nuclei (NOT posterior pituitary) synthesize oxytocin and antidiuretic hormone

- transport down fibers for storage in posterior pituitary

Hypophyseal portal system:
hypothalamus → anterior pituitary gland

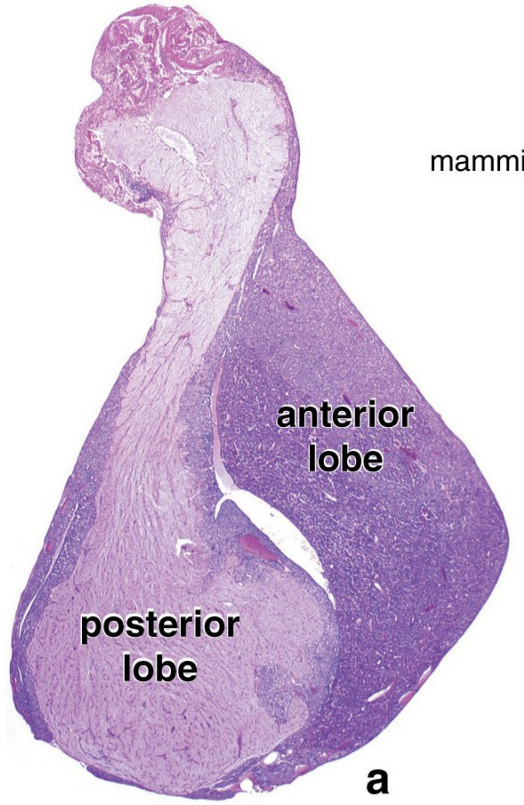
- **Portal system**: blood flows from one capillary bed to another
- **Hypothalamic Hormones** stimulate anterior pituitary via portal system

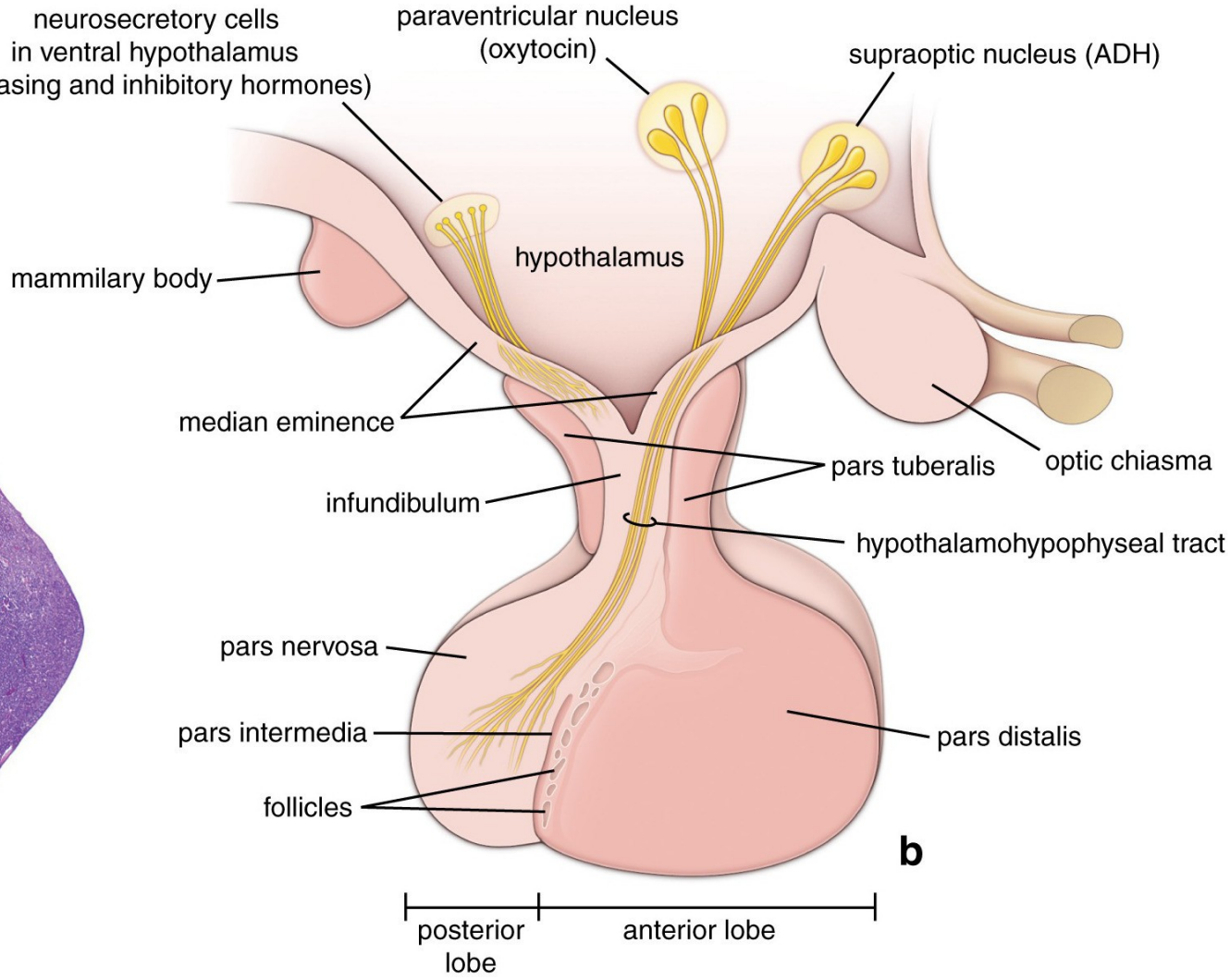


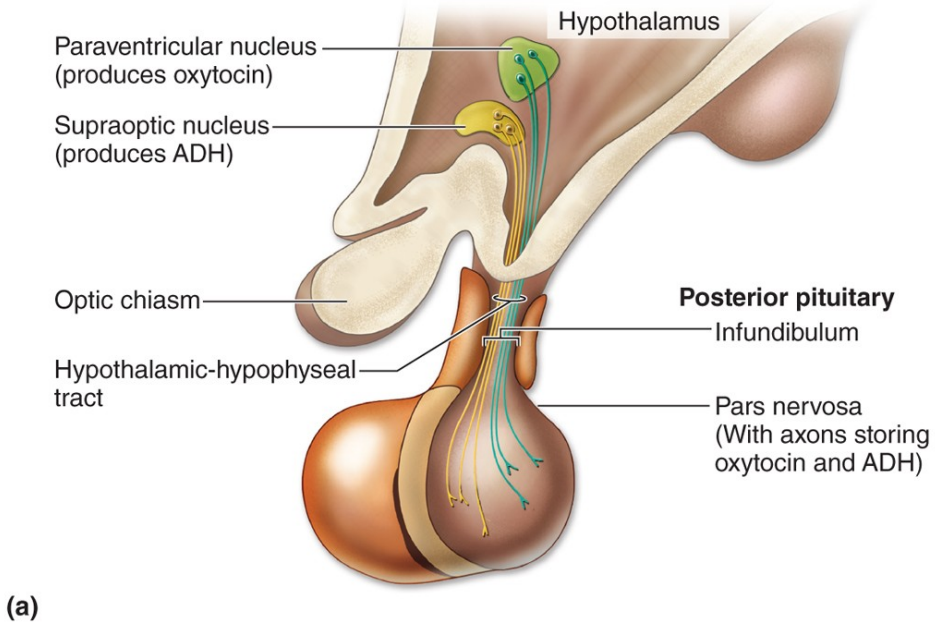
Pituitary gland (hypophysis) is sheltered in sella turcica, of sphenoid bone

Anterior pituitary (adenohypophysis): develops from pouch in roof of embryonic pharynx. Tissue looks glandular.

Posterior pituitary (neurohypophysis): Down growth from hypothalamus, retains connection to brain. Tissue looks nervous.







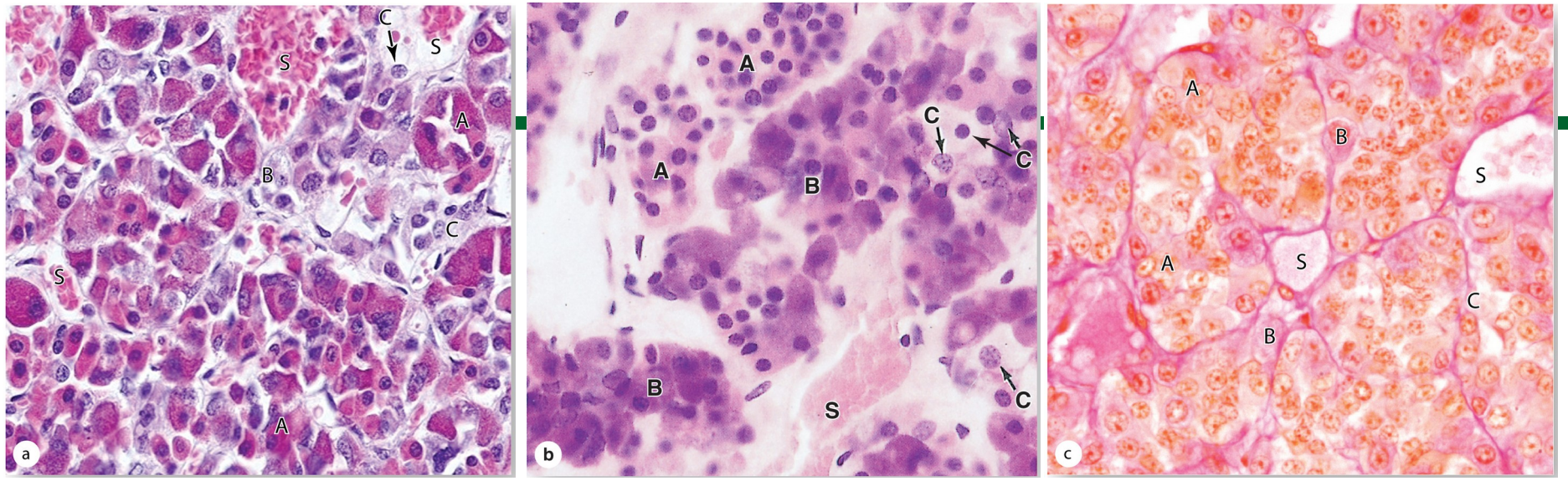
Adenohypophysis

Pars distalis: 75% of the adenohypophysis. Chromophils: basophils and acidophils, based on affinities for basic and acidic. Store hormones in granules. Chromophobes: lightly staining cells

Pars intermedia: thin zone of basophilic cells between the pars distalis and the pars nervosa of the neurohypophysis

Pars tuberalis: smaller funnel-shaped region surrounding the infundibulum of the neurohypophysis Most of the cells of the pars tuberalis are **gonadotrophs**.

Pars Distalis



acidophil cells (**A**)
basophils (**B**)
chromophobes (**C**)
capillaries and sinusoids (**S**)

TABLE 21.2 Staining Characteristics of Cells Found in the Anterior Lobe of the Pituitary Gland

Cell Type	Percentage of Total Cells	General Staining	Specific Staining	Product
Somatotrope (GH cell)	50	Acidophil	Orange G (PAS −)	Growth hormone (GH)
Lactotrope (PRL cell)	15–20	Acidophil	Orange G (PAS −) Herlant's erythrosine Brooke's carmosine	Prolactin (PRL)
Corticotrope (ACTH cell)	15–20	Basophil	Lead hematoxylin (PAS +)	Proopiomelanocortin (POMC), which is cleaved in human into adrenocorticotropic hormone (ACTH) and β-lipotrophic hormone (β-LPH)
Gonadotrope (FSH and LH cells)	10	Basophil	Aldehyde-fuchsin Aldehyde-thionine (PAS +)	Follicle-stimulating hormone (FSH) and luteinizing hormone (LH)
Thyrotrope (TSH cell)	~5	Basophil	Aldehyde-fuchsin Aldehyde-thionine (PAS +)	Thyroid-stimulating hormone (TSH)

MEDICAL APPLICATION: Benign pituitary adenomas often produce excessive numbers of functional acidophils or basophils. Adenomas involving somatotropic cells can cause gigantism if occurring in children before closure of the long bones' epiphyseal plates or acromegaly in adults, with musculoskeletal, neurologic, and other medical consequences.

https://vimeo.com/62985496 (0-4:30)

Neurohyphophysis: Pars nervosa and the infundibular stalk

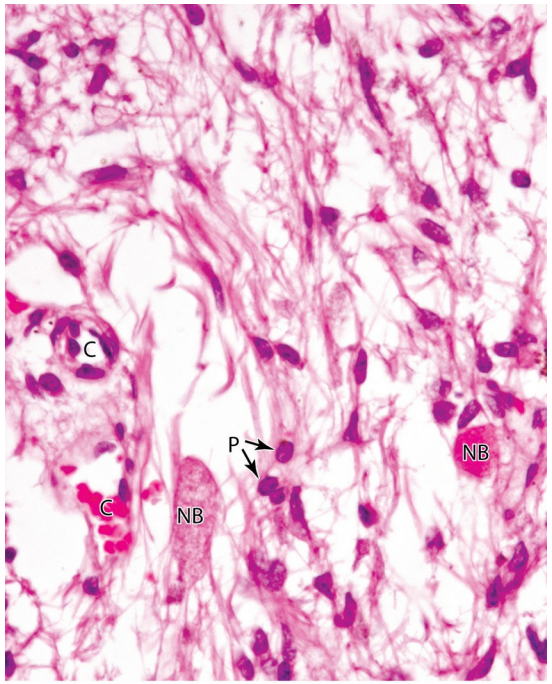


TABLE **20–3** Hormones of the posterior pituitary.

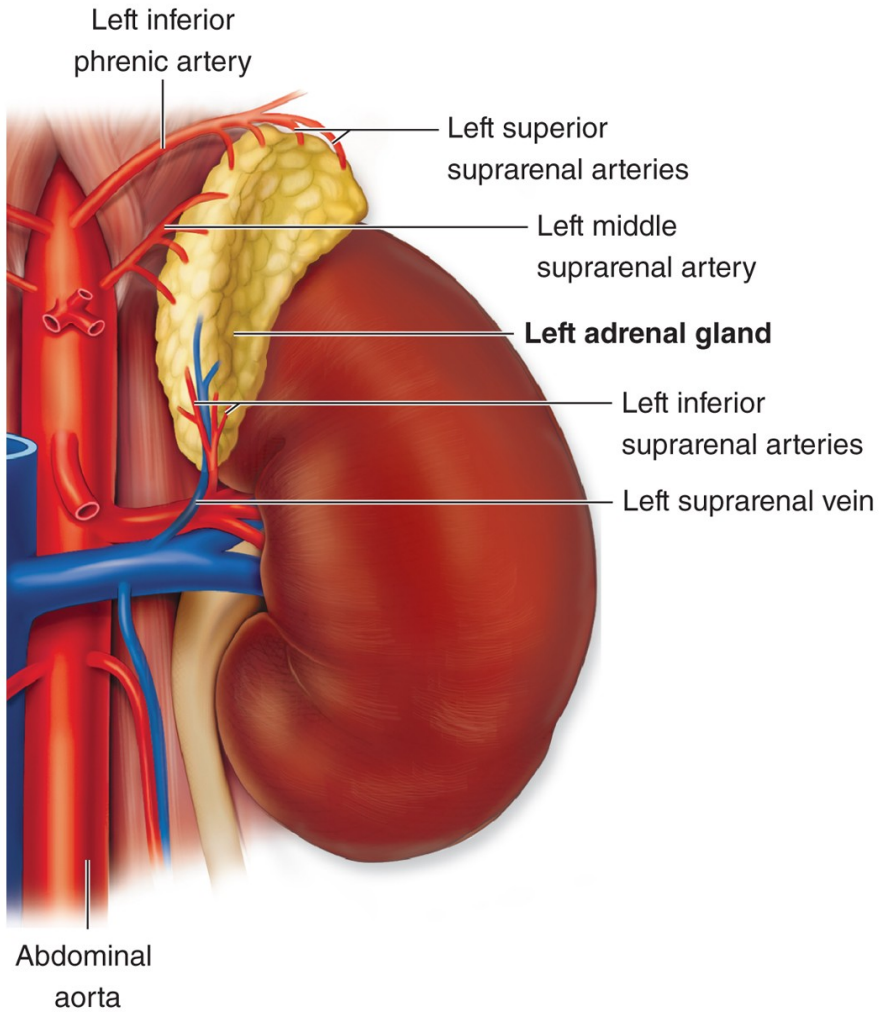
Hormone	Function
Vasopressin/antidiuretic hormone (ADH)	Increases water permeability of renal collecting ducts
Oxytocin	Stimulates contraction of mammary gland myoepithelial cells and uterine smooth muscle

The neurohypophysis does NOT synthesize its two hormones
Neurosecretory (**Herring**) **bodies** (**NB**): swellings at the end unmyelinated axons of hypothalamic neurons of which release oxytocin or vasopressin **(ADH)**. Released hormones are picked up by capillaries (**C**) for distribution
Pituicytes (**P**): Glial cells that resemble astrocytes

MEDICAL APPLICATION: Posterior pituitary function can be adversely affected by heritable mutations in the gene for vasopressin (ADH)-neurophysin, by compression from a tumor in adjacent tissues, and by head trauma. By lowering levels of vasopressin, such conditions can produce diabetes insipidus, a disorder characterized by inability to concentrate urine, which leads to frequent urination (polyuria) and increased thirst (polydipsia).

http://highered.mheducation.com/sites/0072495855/student_view0/chapter20/animation__hormonal_communication.html

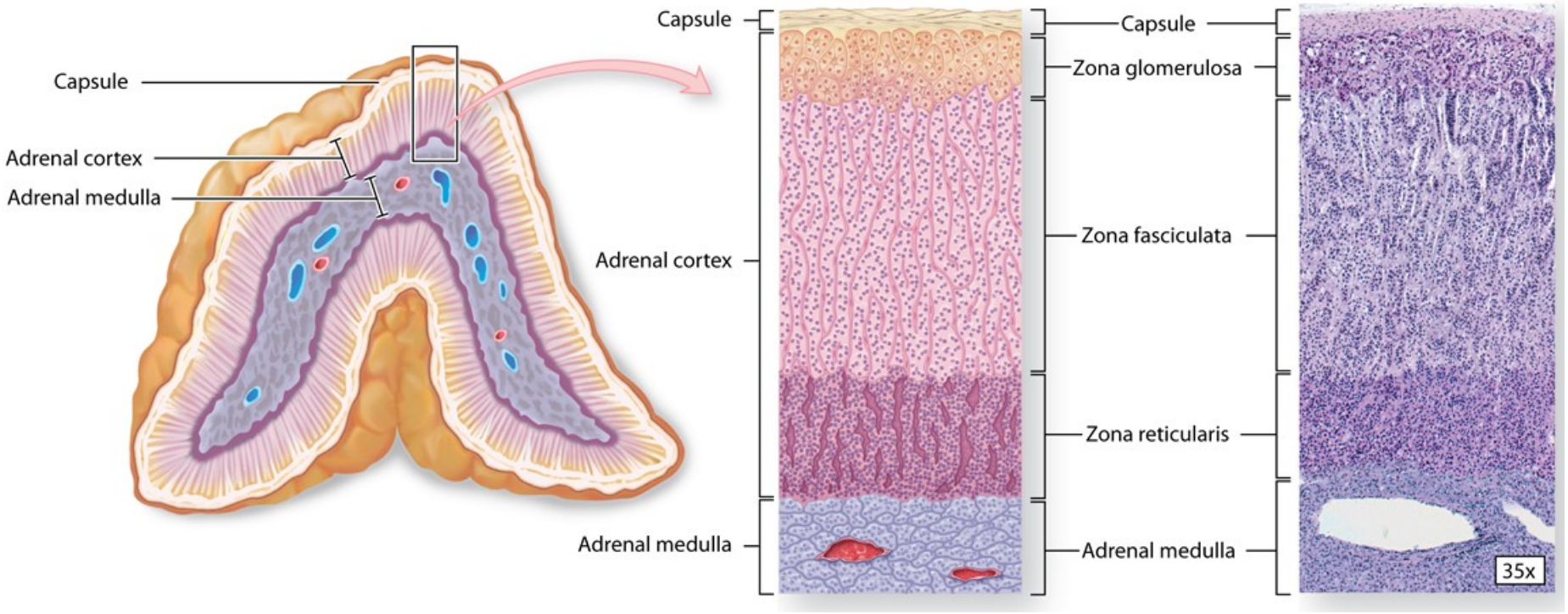
Location and blood supply of the adrenal glands



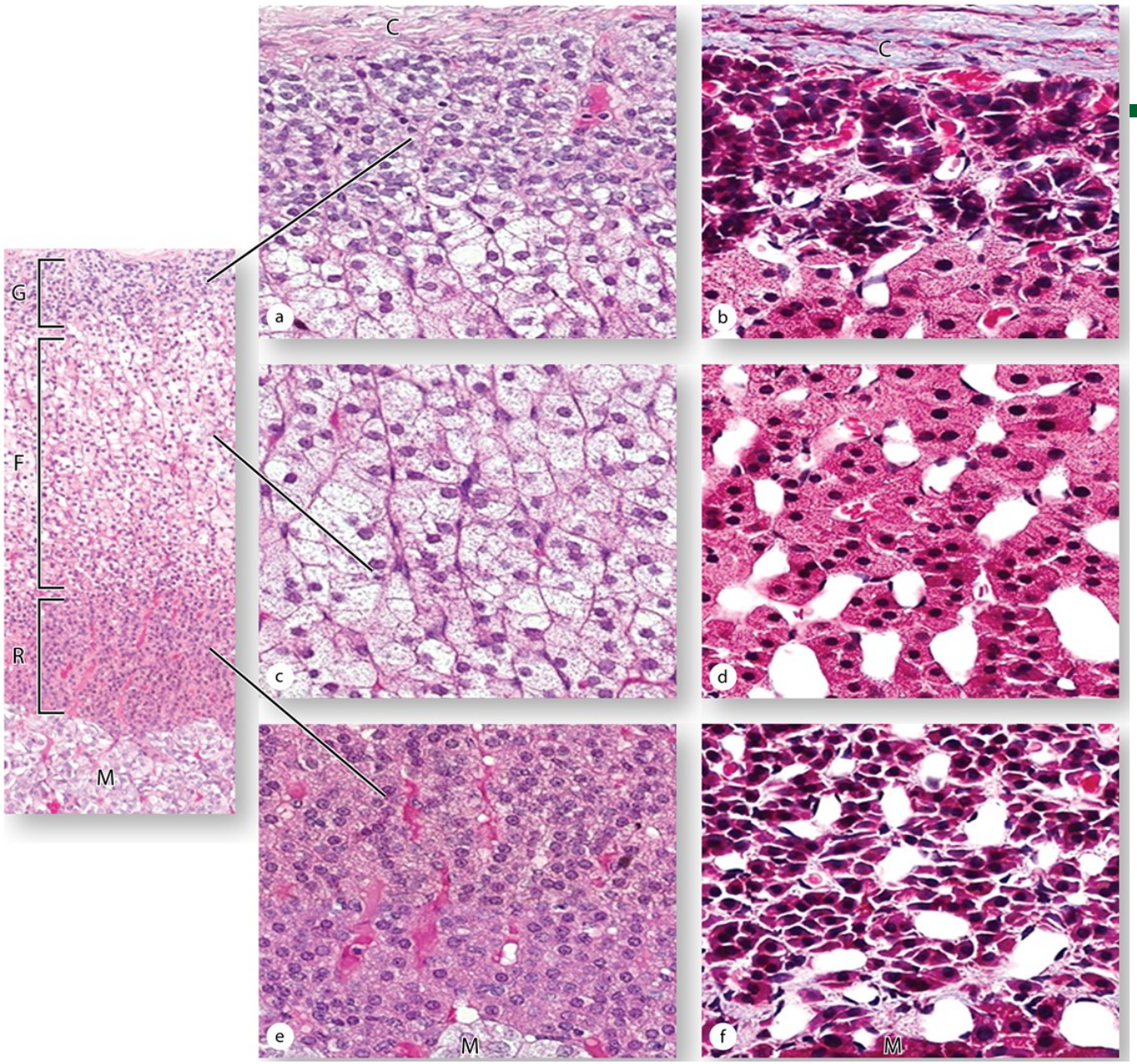
The paired adrenal glands are located at the superior pole of each kidney and each consists of an outer cortex that produces a variety of steroid hormones and an inner medulla that produces epinephrine and norepinephrine.

This anterior view of the left adrenal gland and kidney shows the blood vessels supplying these glands.

Inside the capsule of each adrenal gland is an adrenal cortex



MEDICAL APPLICATION: Addison disease or adrenal cortical insufficiency is a disorder, usually autoimmune in origin, which causes degeneration in any layer of adrenal cortex, with concomitant loss of glucocorticoids, mineralocorticoids, or androgen production.



Adrenal cortex

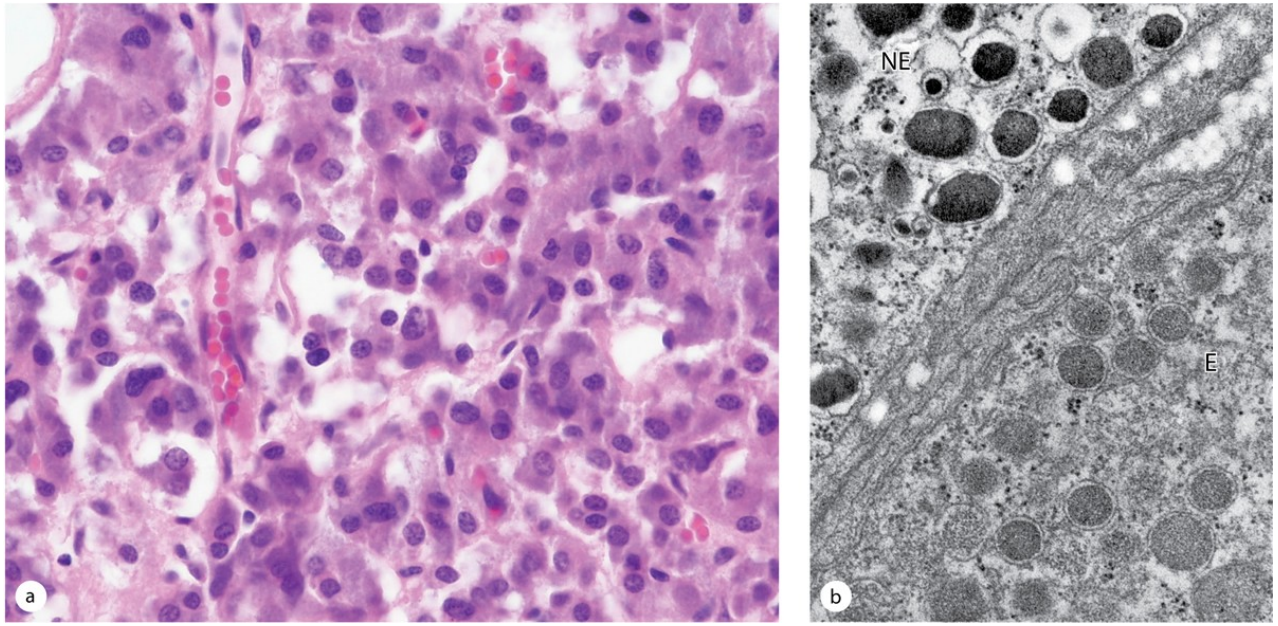
capsule (**C**), zonae glomerulosa (**G**), fasciculata (**F**), and reticularis (**R**), surrounding the medulla (**M**). Shown here are sections from two adrenal glands, stained with H&E (left) and Mallory trichrome, in which the sparse collagen appears blue (right).

(a, b) zona glomerulosa: rounded clusters of columnar cells principally secreting the mineral corticoid **aldosterone**.
(c, d) zona fasciculate: long cords of large, spongy-looking cells mainly secreting glucocorticoids such as **cortisol**.
(e, f) zona reticularis: better stained, arranged in a close network and secrete mainly **sex steroids**.

Cells of all the layers are closely associated with sinusoidal capillaries.

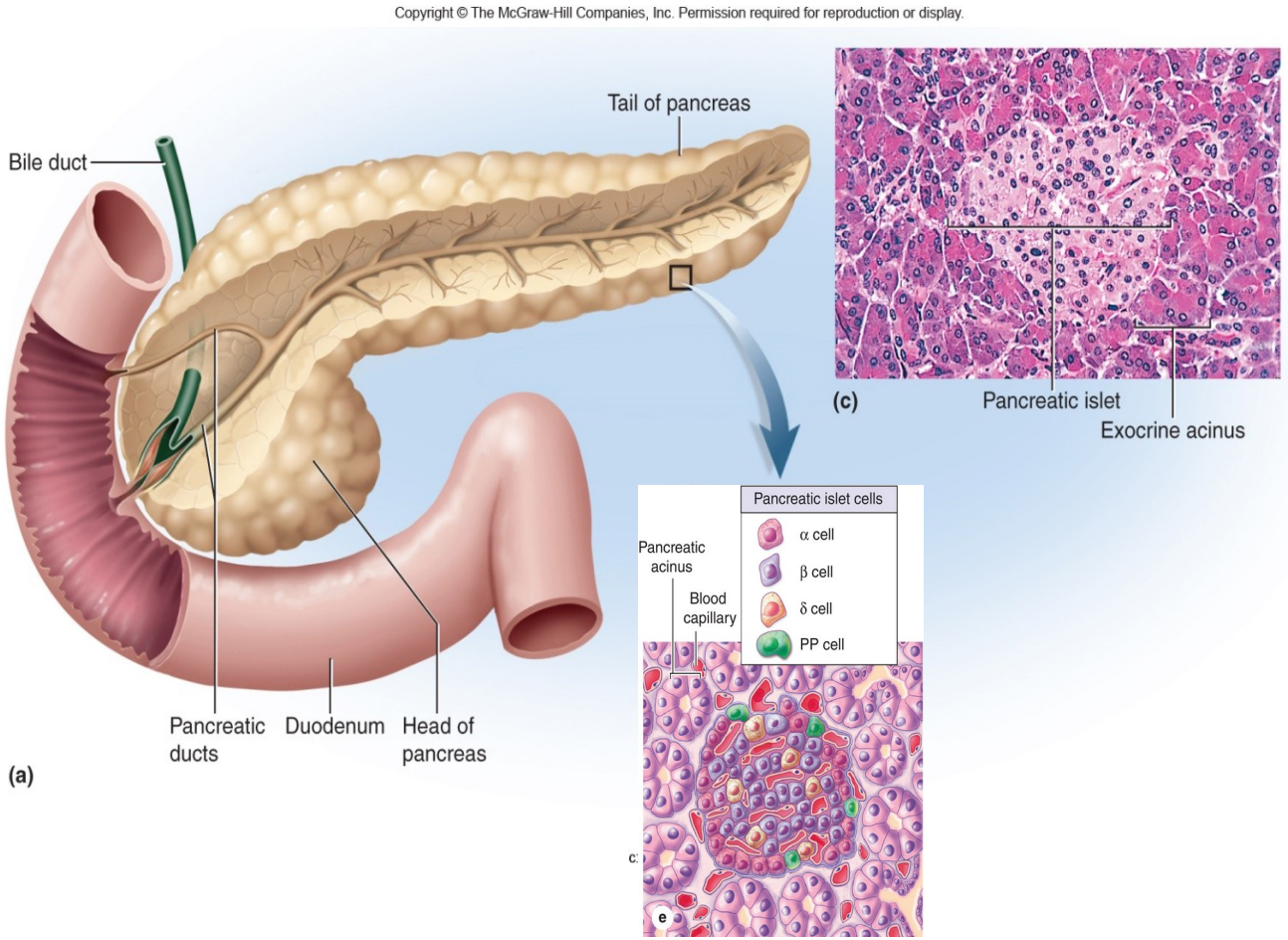
The hormone-secreting cells of the adrenal medulla are chromaffin cells, which resemble sympathetic neurons.

Chromaffin Cells: large pale-staining cells, arranged in cords interspersed with wide capillaries.
Granules of norepinephrine-secreting cells (**NE**) are more electron-dense than those of cells secreting epinephrine (**E**). Most of the hormone produced is epinephrine, which is only made in the adrenal medulla



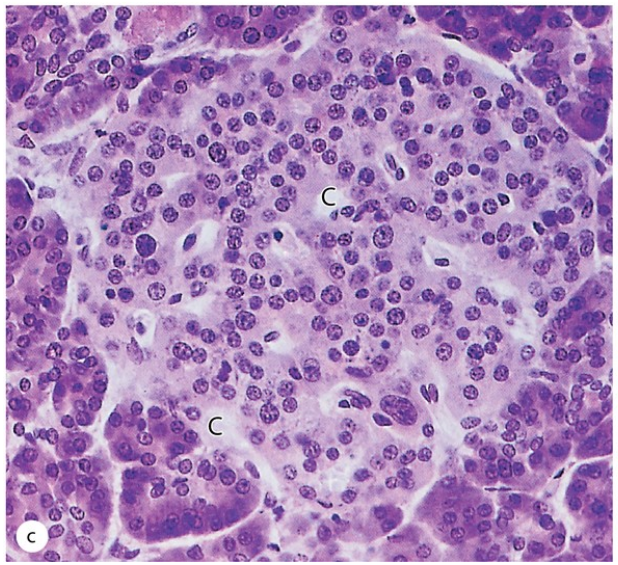
❯❯ **MEDICAL APPLICATION** In the adrenal medulla, **benign pheochromocytomas** periodically secrete high levels of atecholamines that cause swings in blood pressure between hypertension and hypotension.

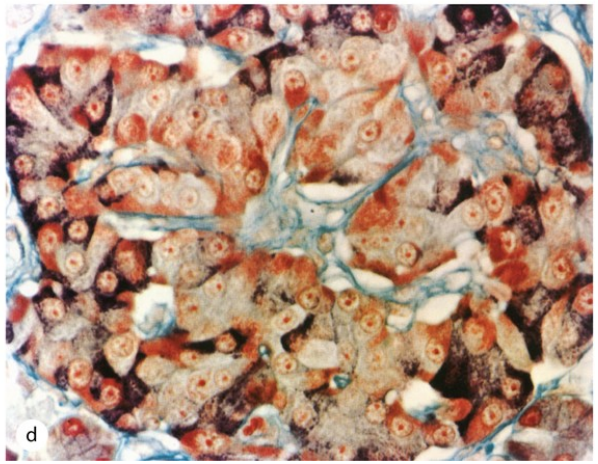
The Pancreatic Islets: endocrine cell clusters



α: glucagon breaks down **glycogen** and **fat** to increases blood glucose
β: insulin causes cell uptake of glucose, decrease of blood glucose
δ: Somatostatin inhibits release of GH and TSH in anterior pituitary and HCl secretion by gastric parietal cells
PP: Pancreatic polypeptide
Polypeptide (rare) stimulates activity of gastric chief cells; inhibits bile secretion, pancreatic enzyme and bicarbonate secretion, and intestinal motility

Pancreatic islets are clumped masses of pale-staining endocrine cells embedded in the exocrine acinar tissue of the pancreas.





C: Fenestrated capillaries. This local vascular system allows specific islet hormones to help control secretion of other islet cells and the neighboring acini.

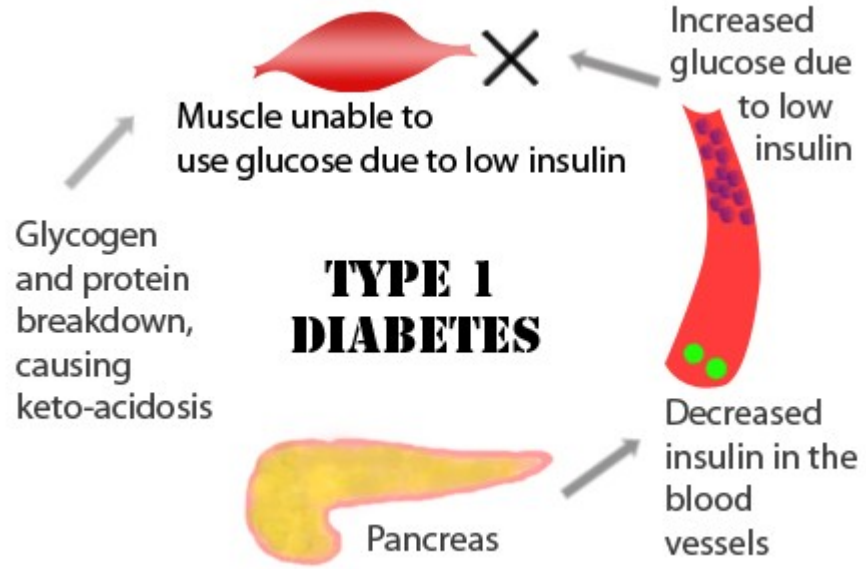
(d) An islet prepared with a modified aldehyde fuchsin stain shows that granules in the **peripheral α cells** are a deep brownish purple and the **central β cells** granules are brownish orange

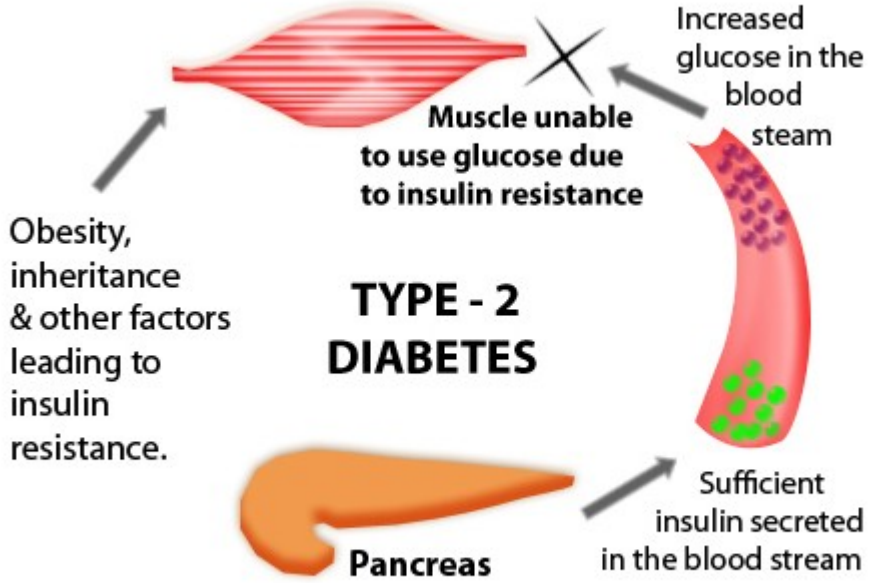
Immunohistochemistry with antibodies against the various islet polypeptide hormones allows definitive identification of each islet cell type.

MEDICAL APPLICATION: Diabetes mellitus is characterized by loss of the insulin effect and a subsequent failure of cells to take up glucose, leading to elevated blood sugar or hyperglycemia.

Type 1 diabetes or insulin-dependent diabetes mellitus (IDDM) is caused by loss of the β cells from autoimmune destruction and is treated by regular injections of insulin.

Type 2 diabetes or non–insulin-dependent diabetes mellitus (NIDDM), β cells are present but fail to produce adequate levels of insulin in response to hyperglycemia and the peripheral target cells "resist" or no longer respond to the hormone. Type 2 diabetes commonly occurs with obesity, and poorly understood, multifactorial genetic components are also important in this disease's onset.





http://highered.mheducation.com/sites/0072507470/student_view0/chapter18/animation__blood_sugar_regulation_in_diabetics.html

The Thyroid Gland

Largest endocrine gland: Composed of two lobes and an isthmus below the larynx

- Dark reddish brown color due to rich blood supply

Thyroid follicles: sacs that compose most of thyroid

- Contain protein-rich colloid
- Follicular cells: simple cuboidal epithelium that lines follicles

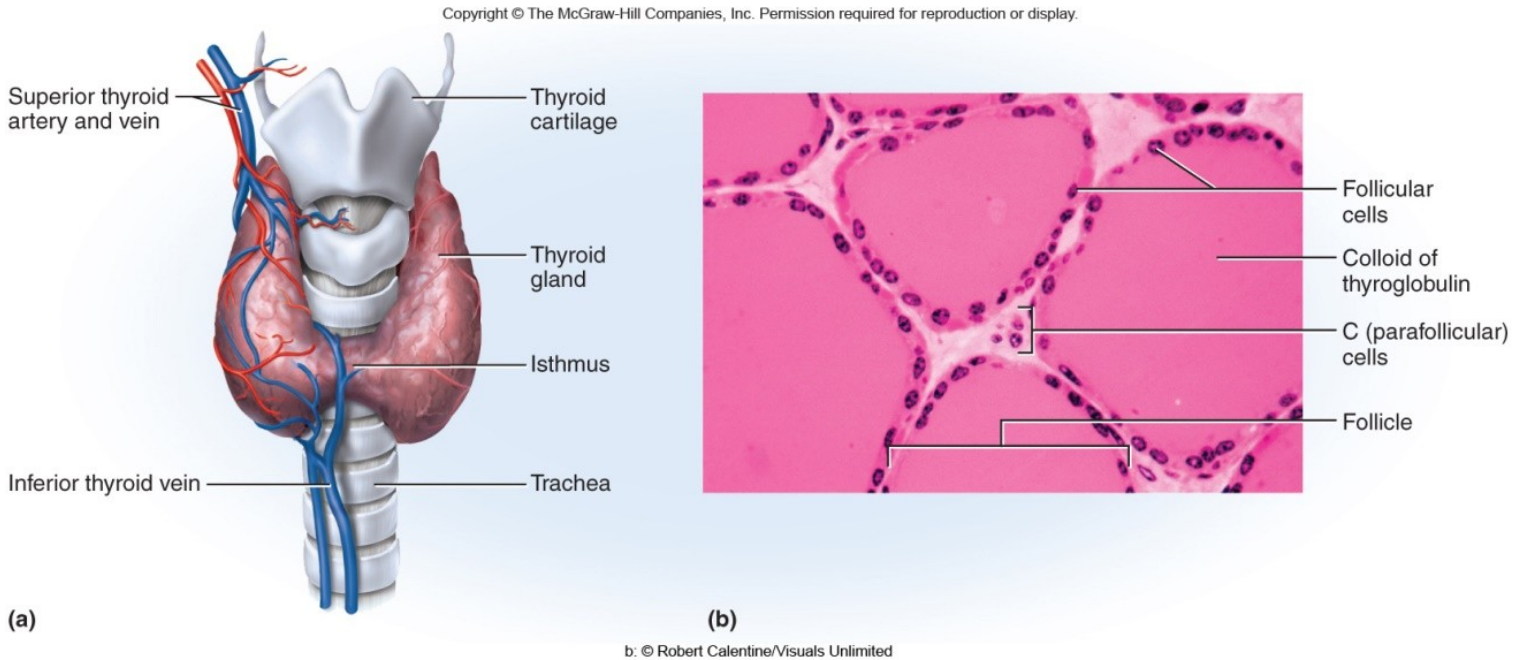
The Thyroid Gland

Thyrocytes (Follicular cells) secretes thyroxine (T_4 because of four iodine atoms) and triiodothyronine (T_3)—T_4 which is converted to T_3

- Increases metabolic rate, O_2 consumption, heat production (calorigenic effect), appetite, growth hormone secretion, alertness, quicker reflexes

Parafollicular (C or clear) cells secrete calcitonin with rising blood calcium

- Stimulates osteoblast activity and bone formation

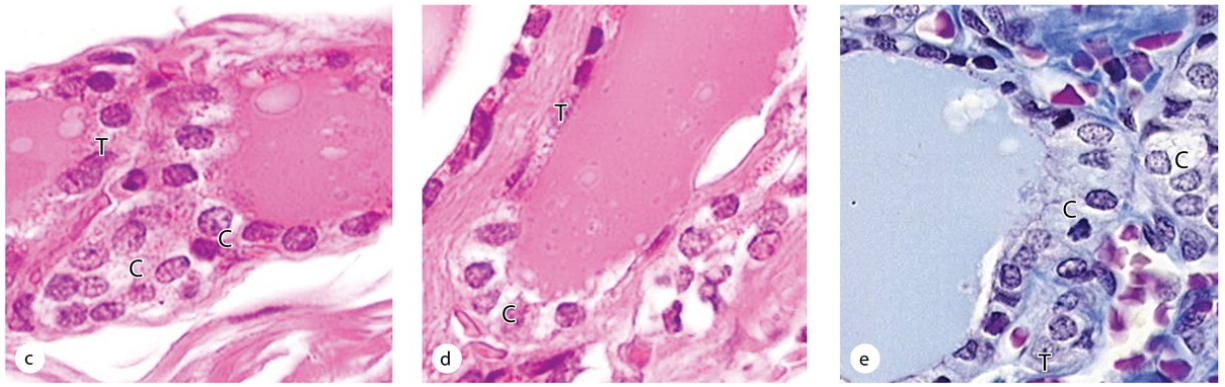


MEDICAL APPLICATION:
Chronic dietary iodine deficiencies inhibit thyroid hormone production, causing thyrotropic cells of the anterior pituitary gland to produce excess TSH. This leads to excessive
growth of thyroid follicles and enlargement of the thyroid gland, a condition known as goiter.

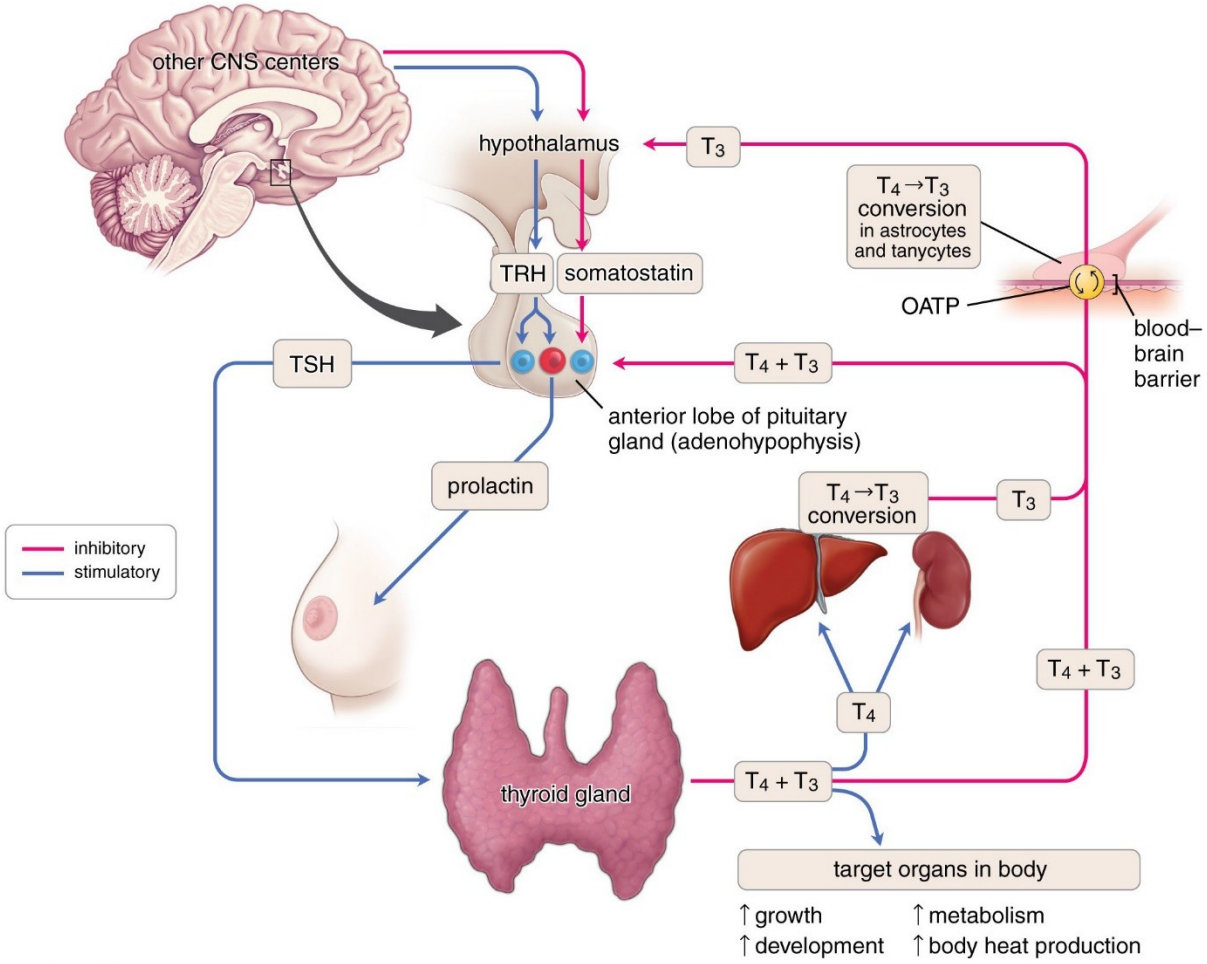
MEDICAL APPLICATIONS

Graves disease is an autoimmune disorder in which antibodies produce chronic stimulation of the follicular cells and release of thyroid hormones (hyperthyroidism), which causes a hypermetabolic state marked by weight loss, nervousness, sweating, heat intolerance, and other features.

Hypothyroidism, with reduced thyroid hormone levels, can be caused by local inflammation (thyroiditis) or inadequate secretion of TSH by the anterior pituitary gland and is often manifested by tiredness, weight gain, intolerance of cold, and decreased ability to concentrate.



Production, transport, and regulation of thyroid hormones is regulated through a negative feedback system



Follicular cells: produce 20X more T4 than T3. T4 → T3 (more active) in peripheral organs (e.g., liver, kidney)
99% of T4 and T3: bound to thyroglobulin for solubility

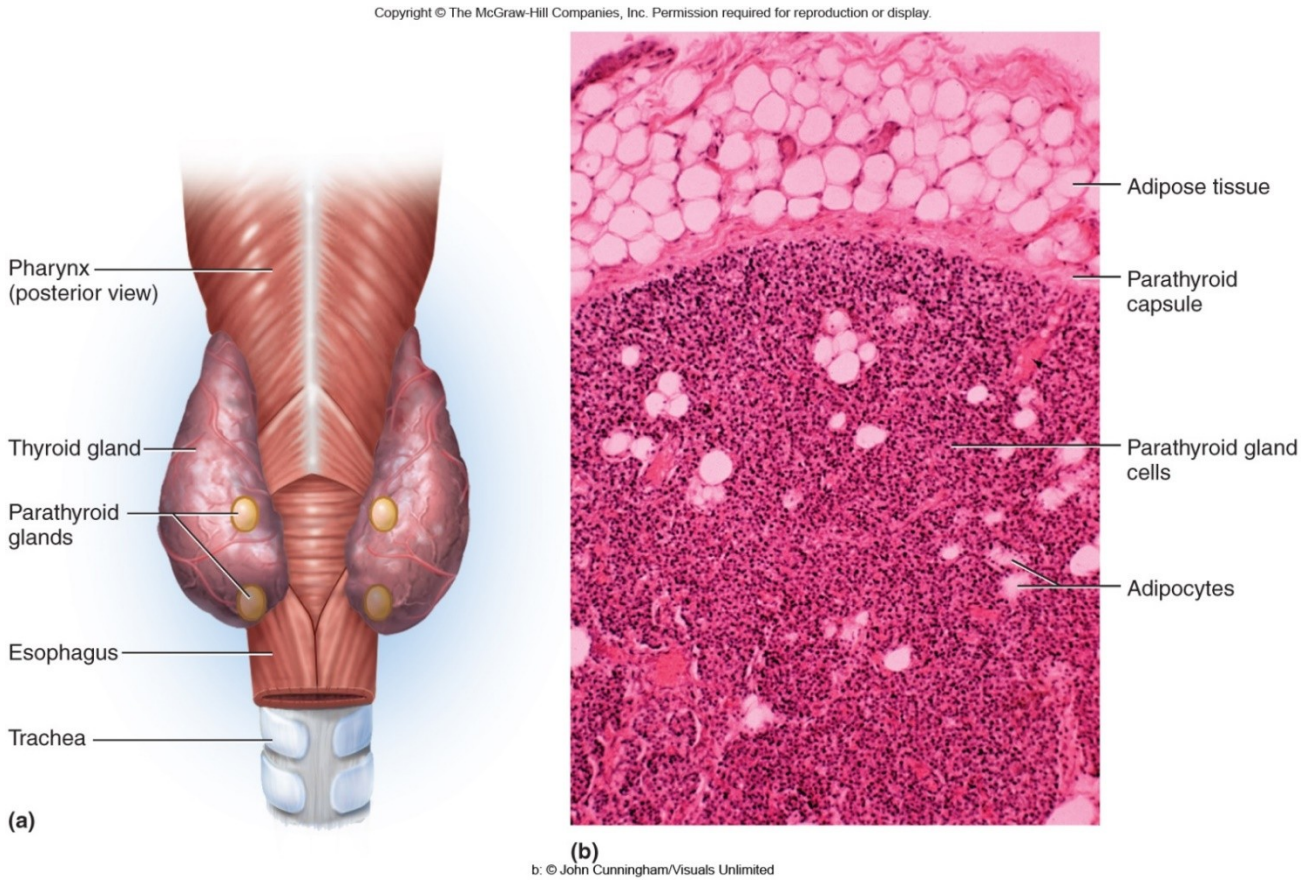
Remaining free (unbound) T4 and T3: Crosses BBB for negative feedback on the system and inhibit further release In the hypothalamus, T3 inhibits TRH and stimulates somatostatin.

http://highered.mheducation.com/sites/9834092339/student_view0/chapter46/mechanism_of_thyroxine_action.html

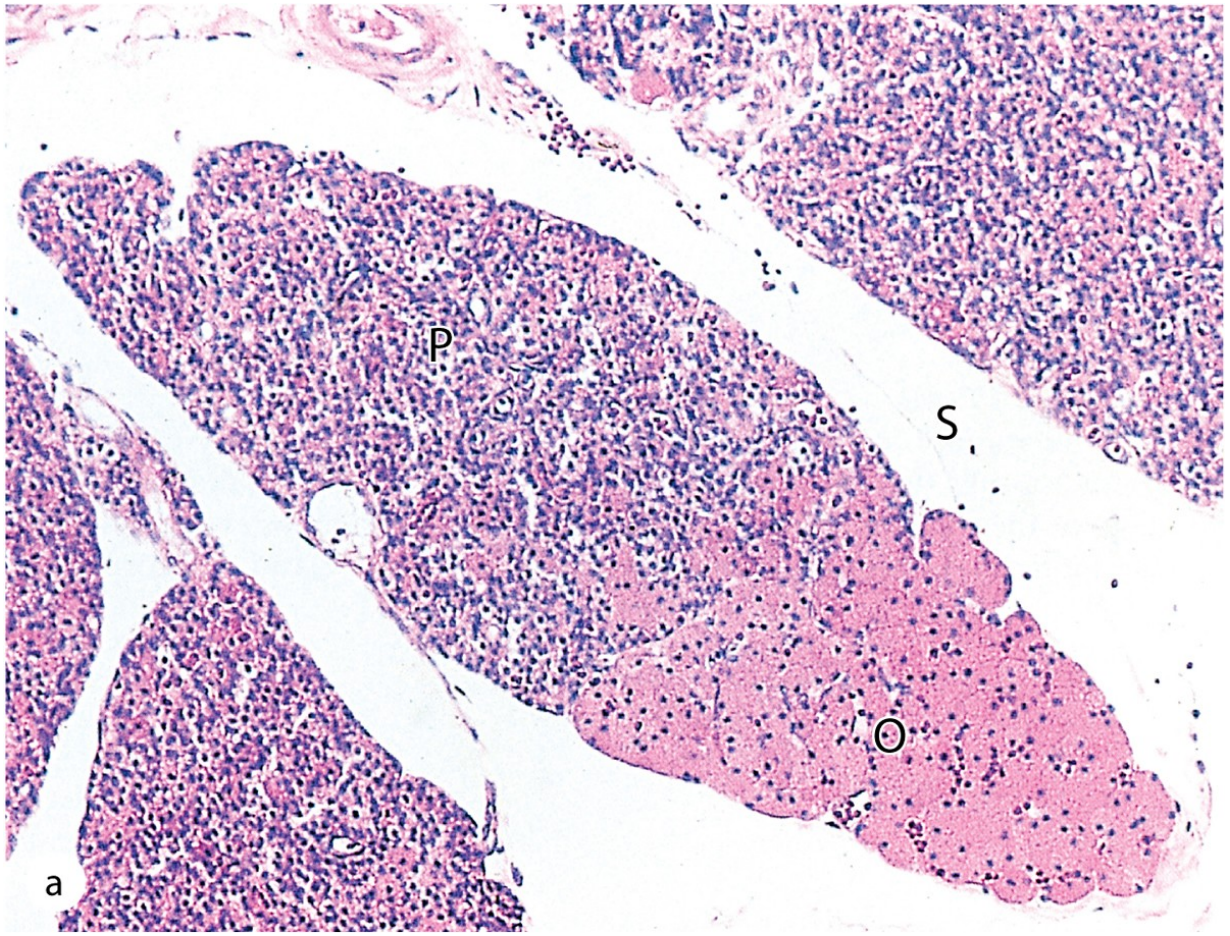
The Parathyroid Glands

Four glands partially embedded in posterior surface of thyroid gland
- Can be found from as high as hyoid bone to as low as aortic arch

Secrete parathyroid hormone (PTH):
- Increases blood Ca^{2+} levels: decreased urinary excretion, promotes synthesis of calcitriol → increased digestive absorption of Ca^{2+}
- Increased bone resorption via increase osteoclast activity



Parathyroid histology



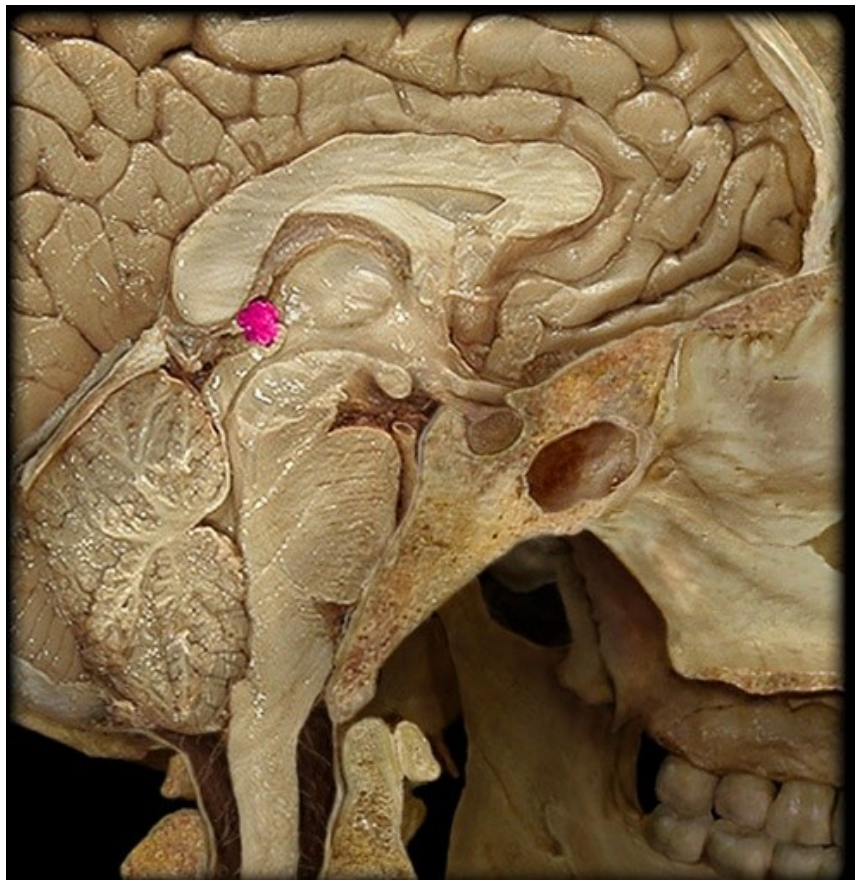
A small lobe of parathyroid gland, surrounded by connective tissue septa (**S**), shows mainly densely packed cords of small principal cells (**P**). Older parathyroid glands show increasing numbers of much larger and acidophilic nonfunctional oxyphil cells (**O**) that may occur singly or in clumps of varying sizes

MEDICAL APPLICATION In **hypoparathyroidism**, diminished secretion of PTH can cause bones to become more mineralized and denser and striated muscle to exhibit abnormal contractions due to inadequate calcium ion concentrations.

Excessive PTH produced in **hyperparathyroidism** stimulates osteoclast number and activity, leading to increased levels of blood calcium that can be deposited pathologically in cartilage, arteries, or the kidneys.

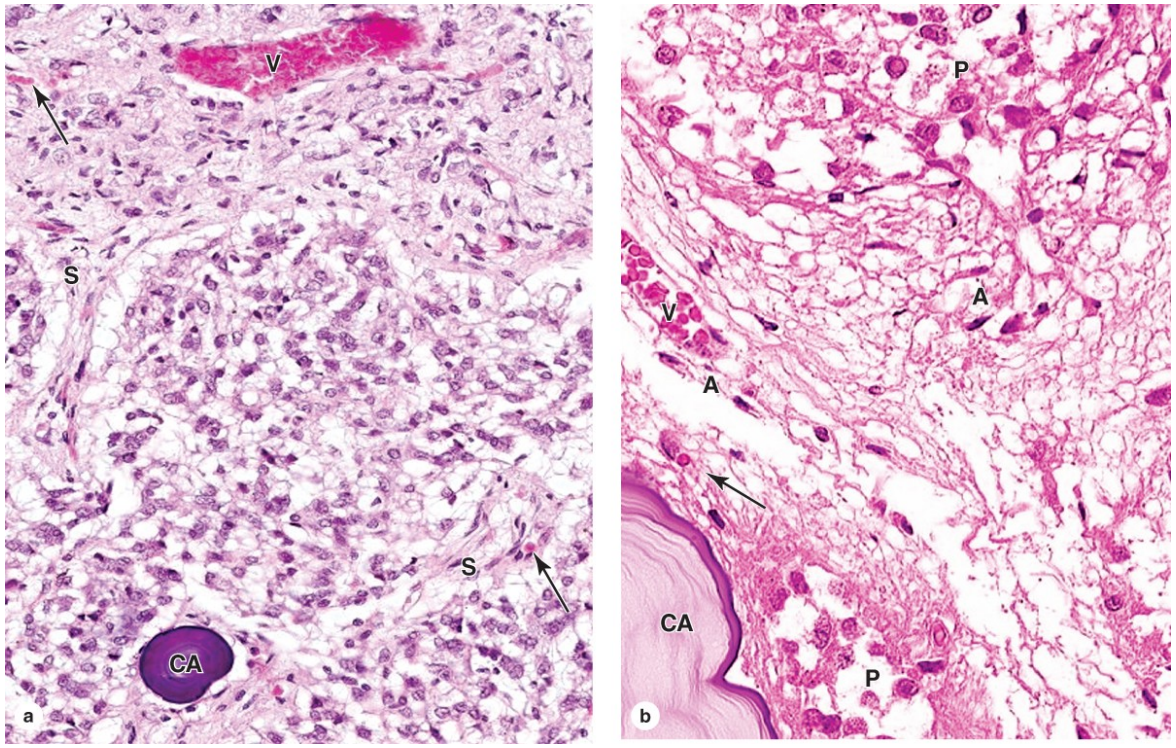
The Pineal Gland

After age 7, it undergoes **involution** (shrinkage), 75% by end of puberty
- Tiny mass of shrunken tissue in adults
- May regulate timing of puberty in humans



May synchronize physiological function with 24-hour **circadian rhythms** of daylight and darkness
- Synthesizes **melatonin** from serotonin during the night
- Fluctuates seasonally with changes in day length → **Seasonal affective disorder (SAD)** occurs in winter or northern climates
- Symptoms: depression, sleepiness, irritability, and carbohydrate craving
- Two to 3 hours of exposure to bright light each day reduces the melatonin levels and the symptoms (phototherapy)

Pineal Histology



Pinealocytes (**P**) surrounded by septa (**S**) containing venules (**V**) and capillaries (arrows
Corpus arenaceum (**CA**): extracellular mineral deposit called a of unknown physiologic significance but an excellent marker for the pineal

astrocytes (**A**): darker, more elongated nuclei
small blood vessels (**V**)
Capillaries (arrow) are not nearly as numerous as in other endocrine glands.

Along the septa run unmyelinated tracts of sympathetic fibers, associated indirectly with photoreceptive neurons in the retinas and running to the pinealocytes to stimulate melatonin release in periods of darkness.

MEDICAL APPLICATION

Densely calcified corpora arenacea can be used as landmarks for the midline location of the pineal gland in a various radiological examinations of the brain. Tumors originating from pinealocytes are very rare, but they can be either benign or highly malignant.

TABLE 20–5 Cells, important hormones, and functions of other major endocrine organs.

Gland	Endocrine Cells	Major Hormones	Major Functions
Adrenal glands: Cortex	Cells of zona glomerulosa	Mineralocorticoids	Stimulate renal reabsorption of water and Na^+ and secretion of K^+ to maintain salt and water balance
	Cells of zona fasciculata	Glucocorticoids	Influence carbohydrate metabolism; suppress immune cell activities
	Cells of zona reticularis	Weak androgens	Precursors for testosterone or estrogen
Adrenal glands: Medulla	Chromaffin cells	Epinephrine	Increases heart rate and constricts vessels
		Norepinephrine	Dilates vessels and increases glucose release
Pancreatic islets	α Cells	Glucagon	Raises blood glucose levels
	β Cells	Insulin	Lowers blood glucose levels
	δ Cells	Somatostatin	Inhibits secretion of insulin, glucagon, and somatotropin
	PP cells	Pancreatic polypeptide	Inhibits secretion of pancreatic enzymes and HCO_3^-
Thyroid glands	Follicular cells	Thyroid hormones (T_3 and T_4)	Increase metabolic rate
	Parafollicular or C cells	Calcitonin	Lowers blood Ca^{2+} levels by inhibiting osteoclast activity
Parathyroid glands	Chief cells	Parathyroid hormone (PTH)	Raises blood Ca^{2+} levels by stimulating osteoclast activity
Pineal gland	Pinealocytes	Melatonin	Regulates circadian rhythms

SEM Seminiferous Tubules

Male Reproductive

CHAPTER 21

Sex Determination: More Complicated Than You Thought:
http://ed.ted.com/on/C1lWtSAb

Overview of the Reproductive System

Male reproductive system: produce sperm, introduces gametes into female

Female reproductive system: produces eggs, receives sperm, provides for the union of the gametes, harbors the fetus, and nourishes the offspring

Primary sex organs (**gonads**): Produce gametes (**testes** or **ovaries**)

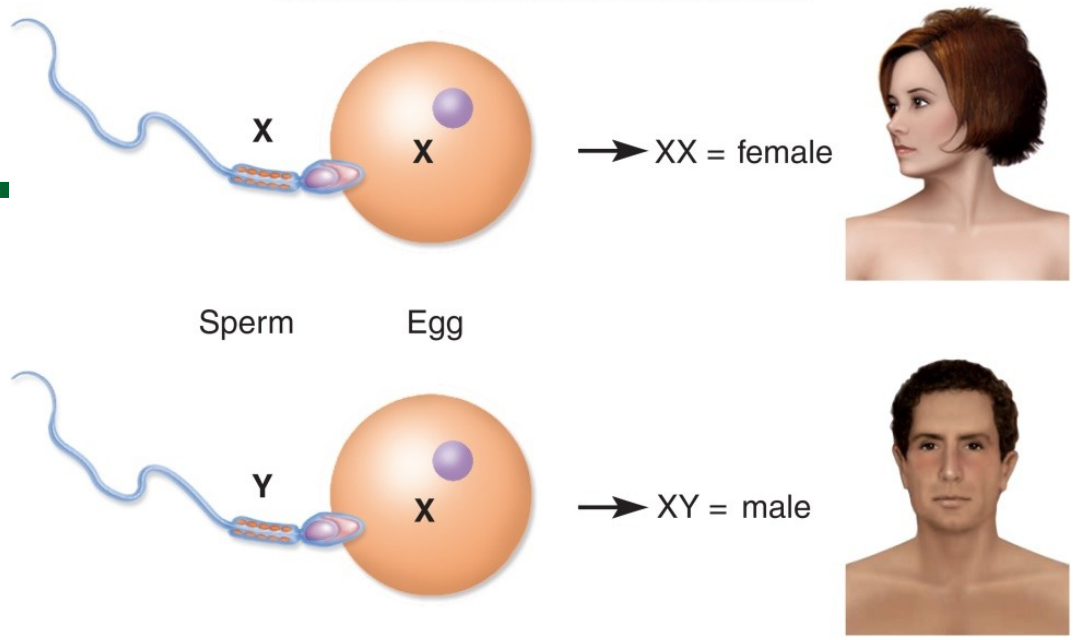
Secondary sex organs: necessary for reproduction, but don't produce gametes

- Male: system of ducts, glands; penis delivers sperm cells
- Female: uterine tubes, uterus, and vagina receive sperm and harbor developing fetus

TABLE 27.1 The External and Internal Genitalia

External Genitalia	Internal Genitalia
Male	
Penis	Testes (s., *testis*)
Scrotum	Epididymides (s., *epididymis*) Ductus deferentes (s., *ductus deferens*) Seminal vesicles Prostate Bulbourethral glands
Female	
Mons pubis	Ovaries
Labia majora (s., *labium majus*)	Uterine tubes
Labia minora (s., *labium minus*)	Uterus
Clitoris	Vagina
Vaginal orifice	
Vestibular bulbs	
Vestibular glands	
Paraurethral glands	

Sexual reproduction



Male parent: Y chromosome, gamete (sperm, spermatozoon) has motility

Female parent: lacks Y chromosome, gamete (egg, ovum) contains nutrients for developing embryo

Mammals: female parent provides sheltered internal environment and prenatal nutrition of the embryo

Androgen-Insensitivity Syndrome: XY chromosomes, testes produce normal male levels of testosterone but target cells lack receptors. External genitalia develop female anatomy as if no testosterone were present, presence of testes in the abdomen, no uterus or menstruation

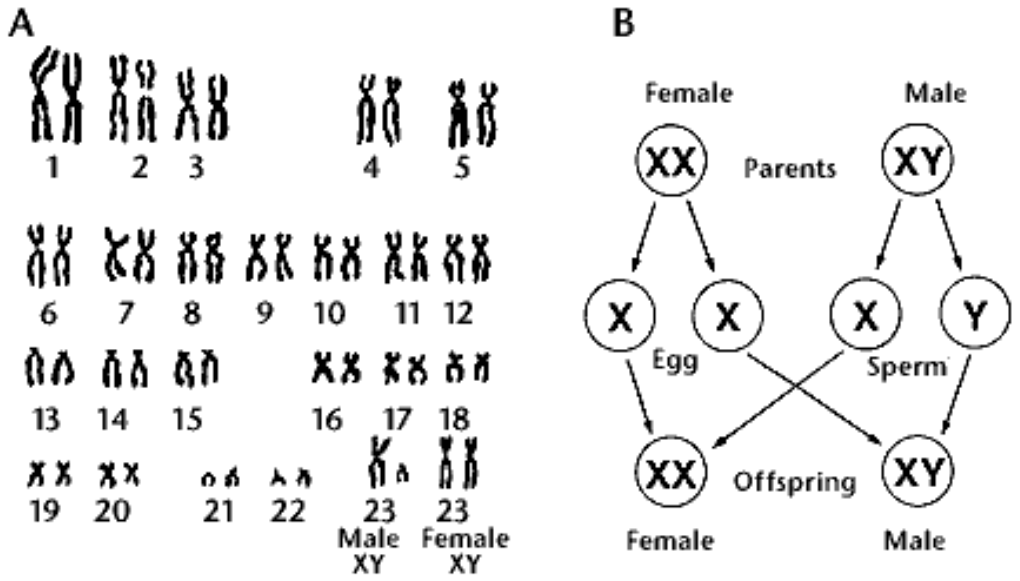
http://www.dailymail.co.uk/video/news/video-1155630/Doctors-explain-androgen-insensitivity-syndrome.html

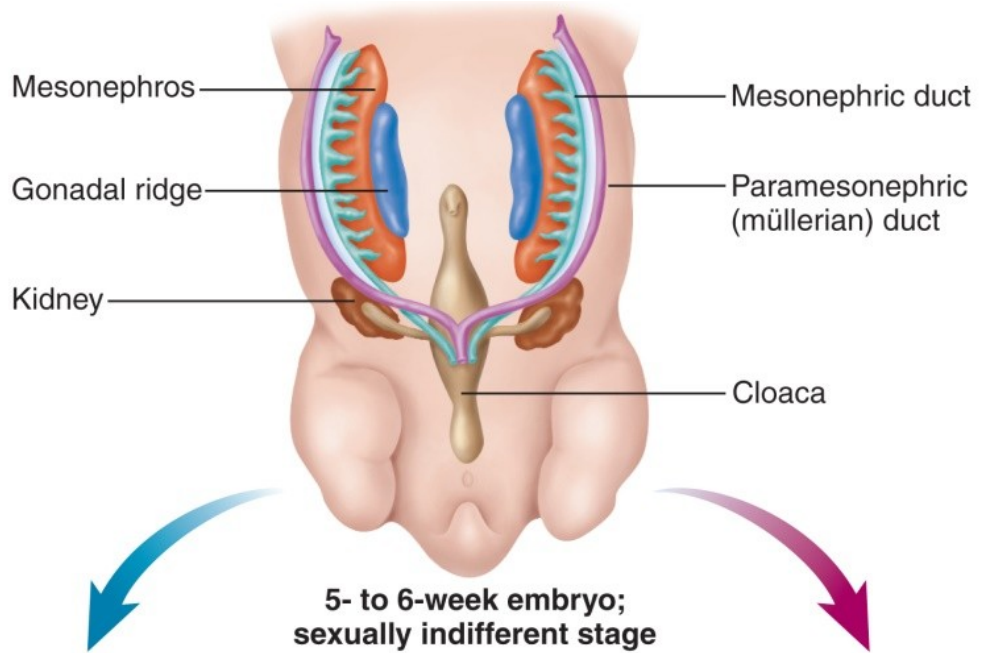
Chromosomes and Sex Determination

Human cells: 22 pairs of autosomes, 1 pair of sex chromosomes (XY males: XX females)

<u>Initially, a fetus is sexually undifferentiated</u>
SRY gene (sex-determining region of Y chromosome): codes for a protein, testes-determining factor (TDF), that initiates development of testes

Gonads begin to develop at 5 or 6 weeks as gonadal ridges

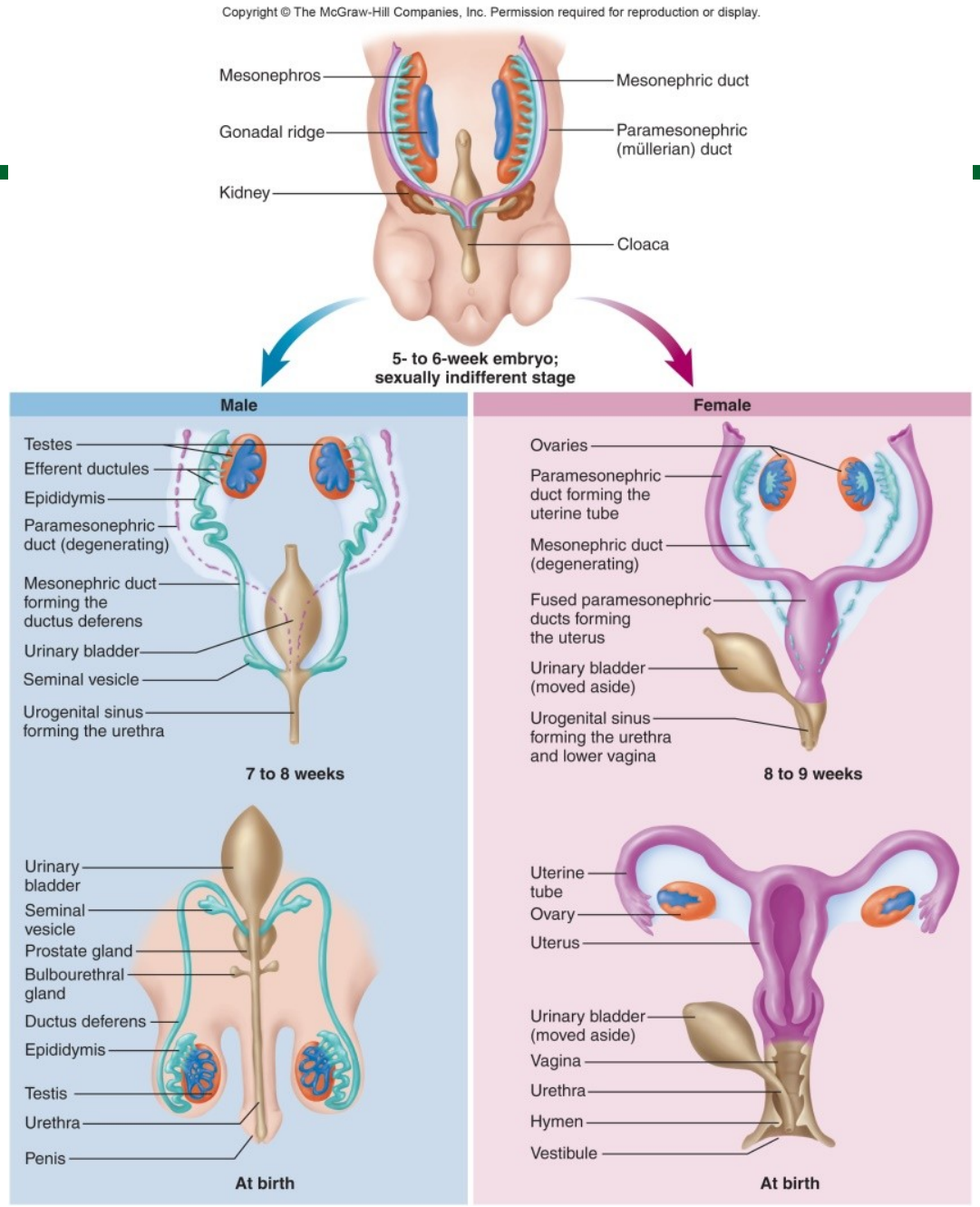




Sexual Differentiation

Male: gonads secrete testosterone at 8 to 9 weeks, **stimulate mesonephric (wolffian) ducts** → male reproductive system;
Testes secrete **müllerian-inhibiting factor** causing **paramesonephric ducts degeneration**
Female: Paramesonephric (müllerian) ducts → female reproductive tract; mesonephric ducts degenerate

If estrogen was the hormone that directed the female development, all fetuses would be feminized (estrogen levels are always high in pregnancy)



Similarity of external genitalia

Male:

Genital tubercle → head (glans) of penis

Urogenital folds encloses urethra → penis

Labioscrotal folds → scrotum

Female:

Genital tubercle → glans of clitoris

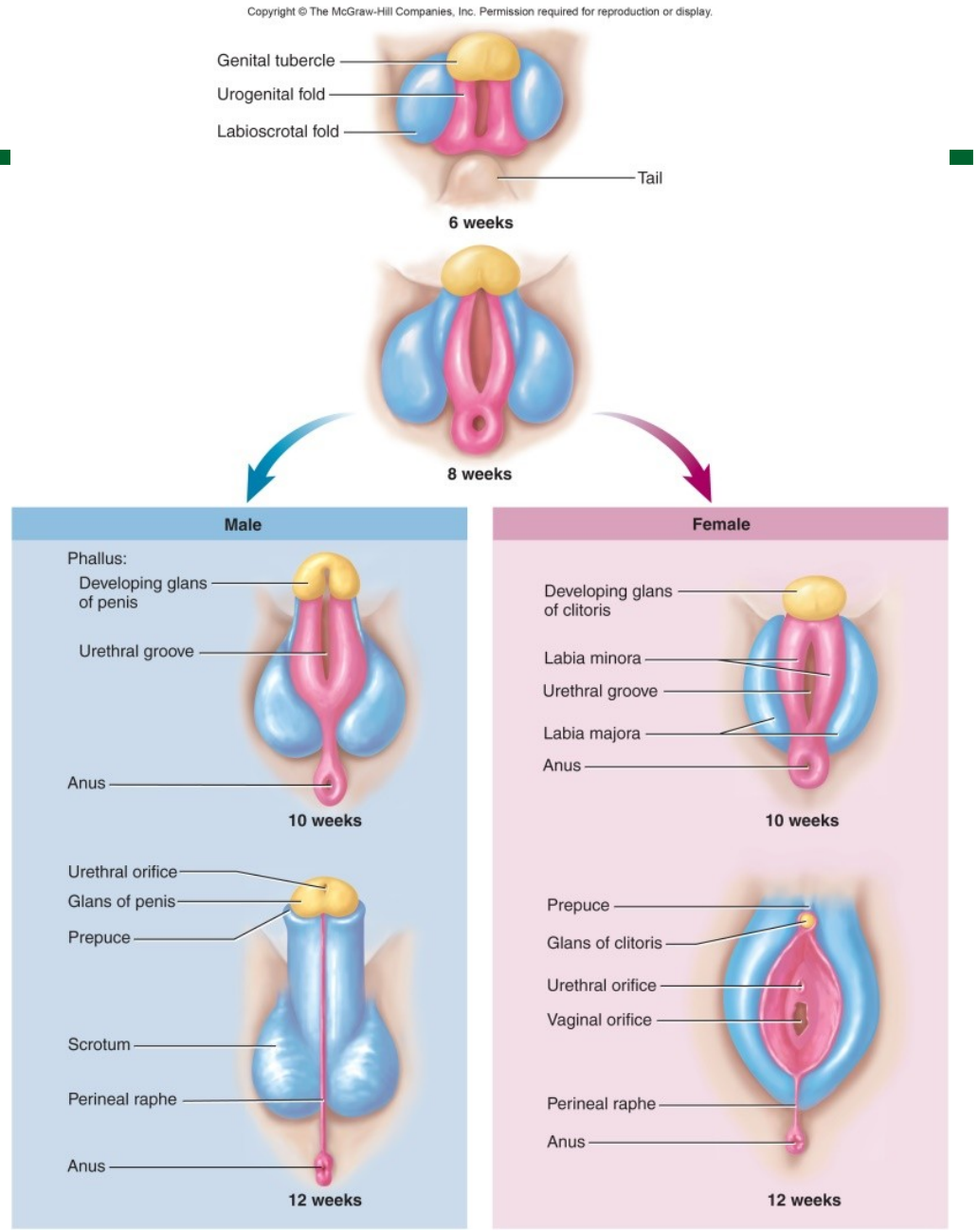
Urogenital folds → labia minora

Labioscrotal folds → labia majora

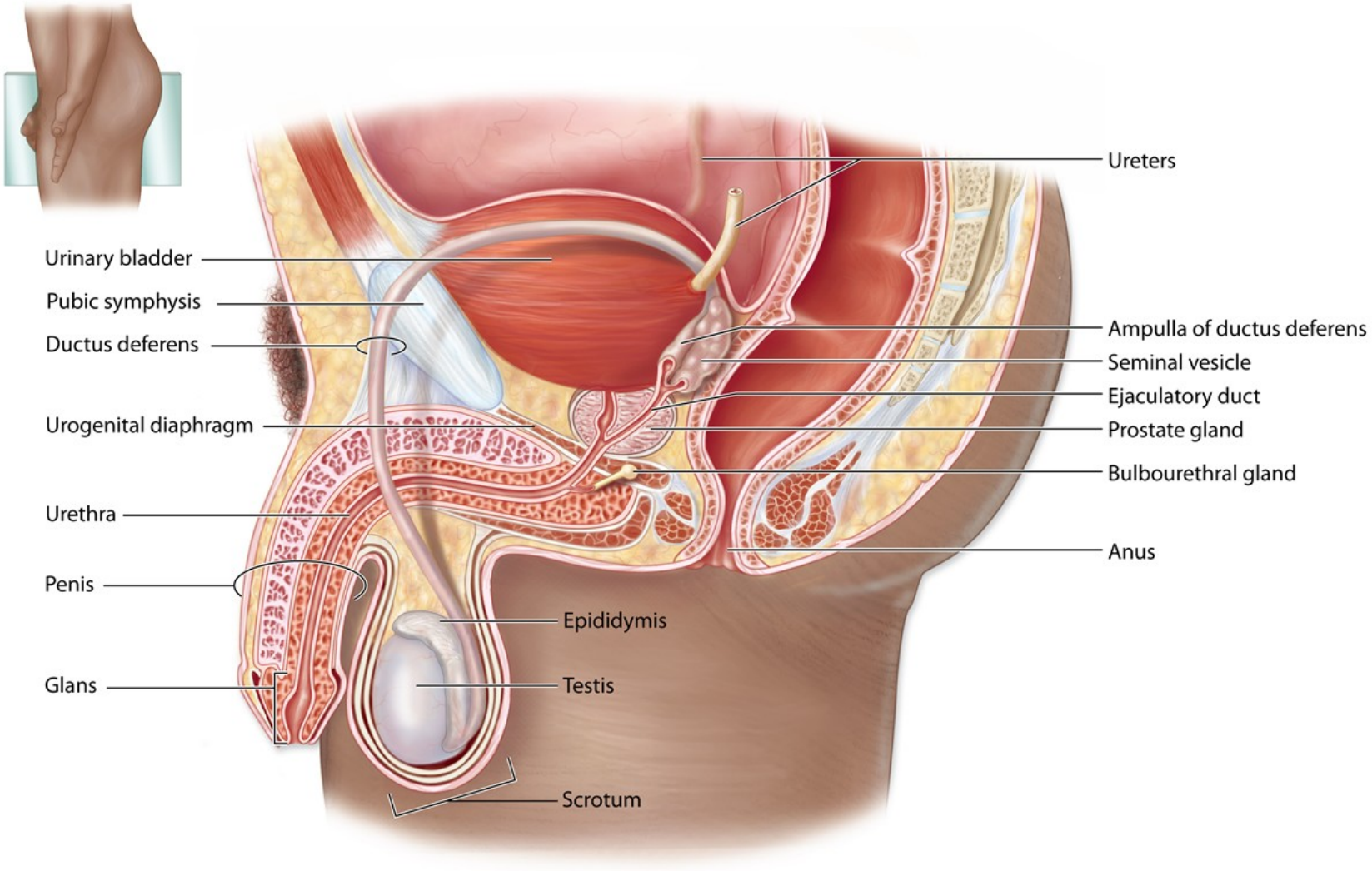
Genitalia formed by week 12

Male and female organs from same embryonic structure are homologous

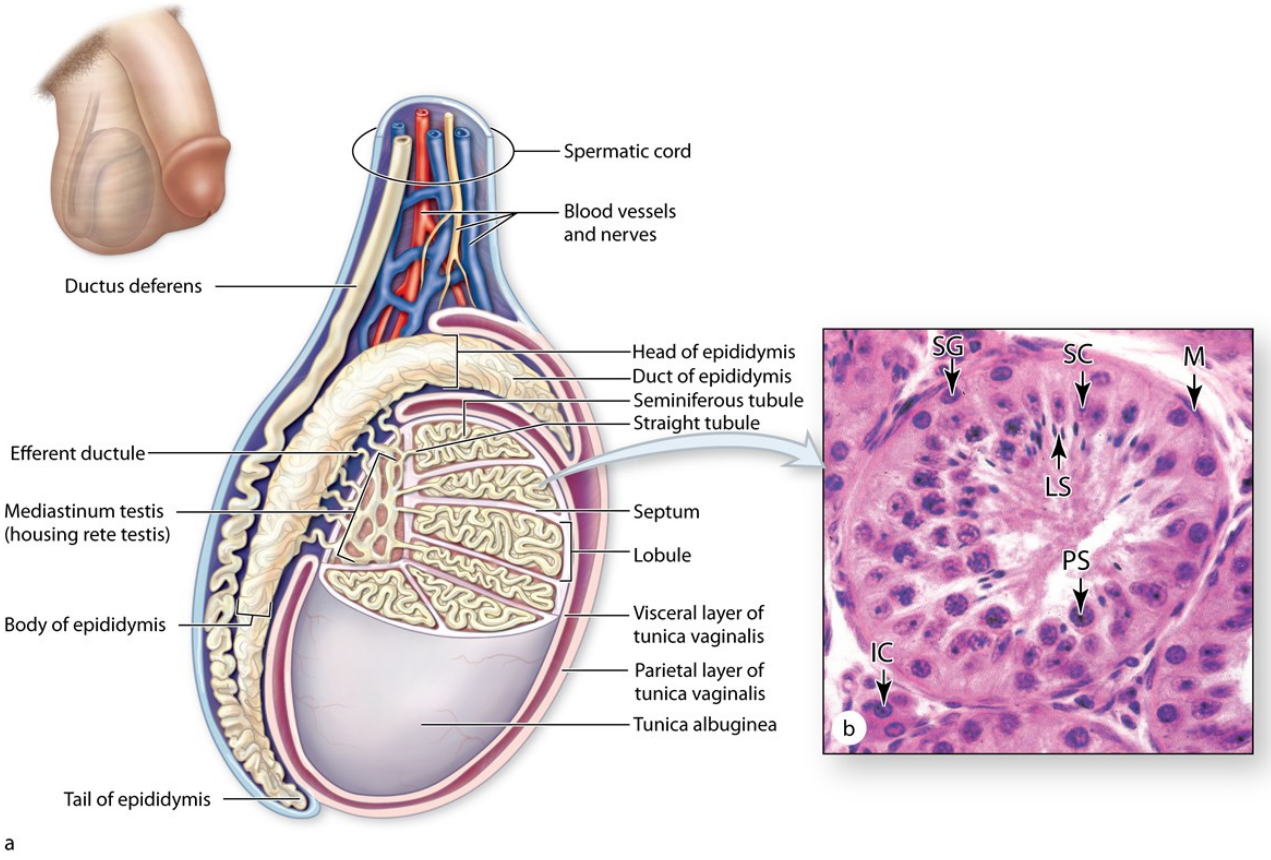
Penis~clitoris, scrotum~labia majora



The male reproductive system



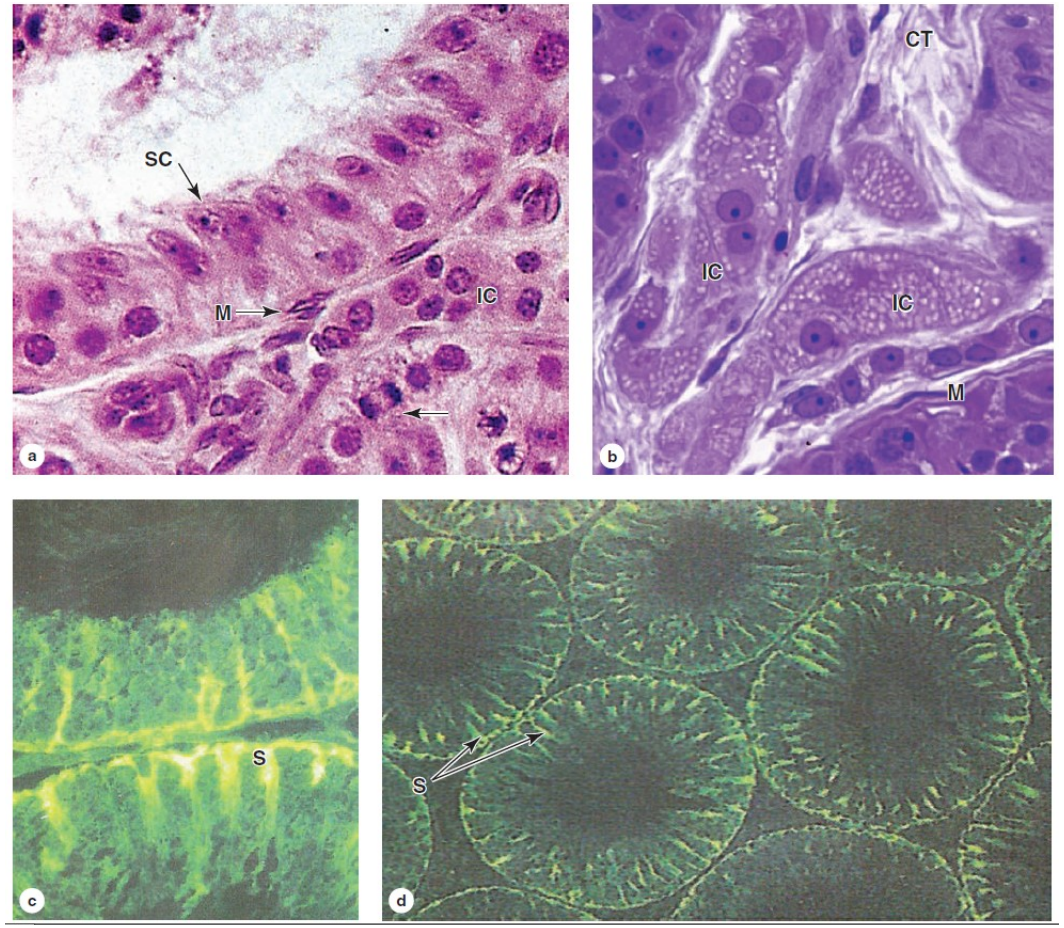
The Testes: (testicles: endocrine /exocrine glands that produce sex hormones and sperm



Spermatogonia (SG) **Sertoli Cells (SC)**
primary spermatocytes (PS) **late spermatids (LS)**
interstitial cells (IC)

Tunica Vaginalis: anterior cover
Tunica Albuginea: white fibrous capsule
Connective tissue septa: divides testes 250 to 300 lobules
Seminiferous tubules: 1 to 3 per lobule, lined with a thick germinal epithelium for sperm generation
Interstitial (Leydig) cells: between tubules produce testosterone
Sustentacular (Sertoli) Cells: between germ cells, protect the germ cells, and promote their development
Germ cells depend on them for nutrients, waste removal, growth factors, and other needs

Seminiferous tubule and interstitial cells



(a-b) Seminiferous tubules are surrounded by connective tissue (**CT**) containing many large interstitial cells (**IC**) that secrete androgens. Sertoli cells (**SC**),
Dividing spermatogenic stem cells with round nuclei (**arrow**).

(c-d) Immunohistochemistry (antibody against sulfated glycoprotein-1 of Sertoli cells (**S**) in the seminiferous tubules.

MEDICAL APPLICATION Both interstitial cell tumors and Sertoli cell tumors are rare. Most (95%) testicular cancer involves germ cell tumors, which only appear after puberty and are much more likely to develop in men with untreated cryptorchidism.

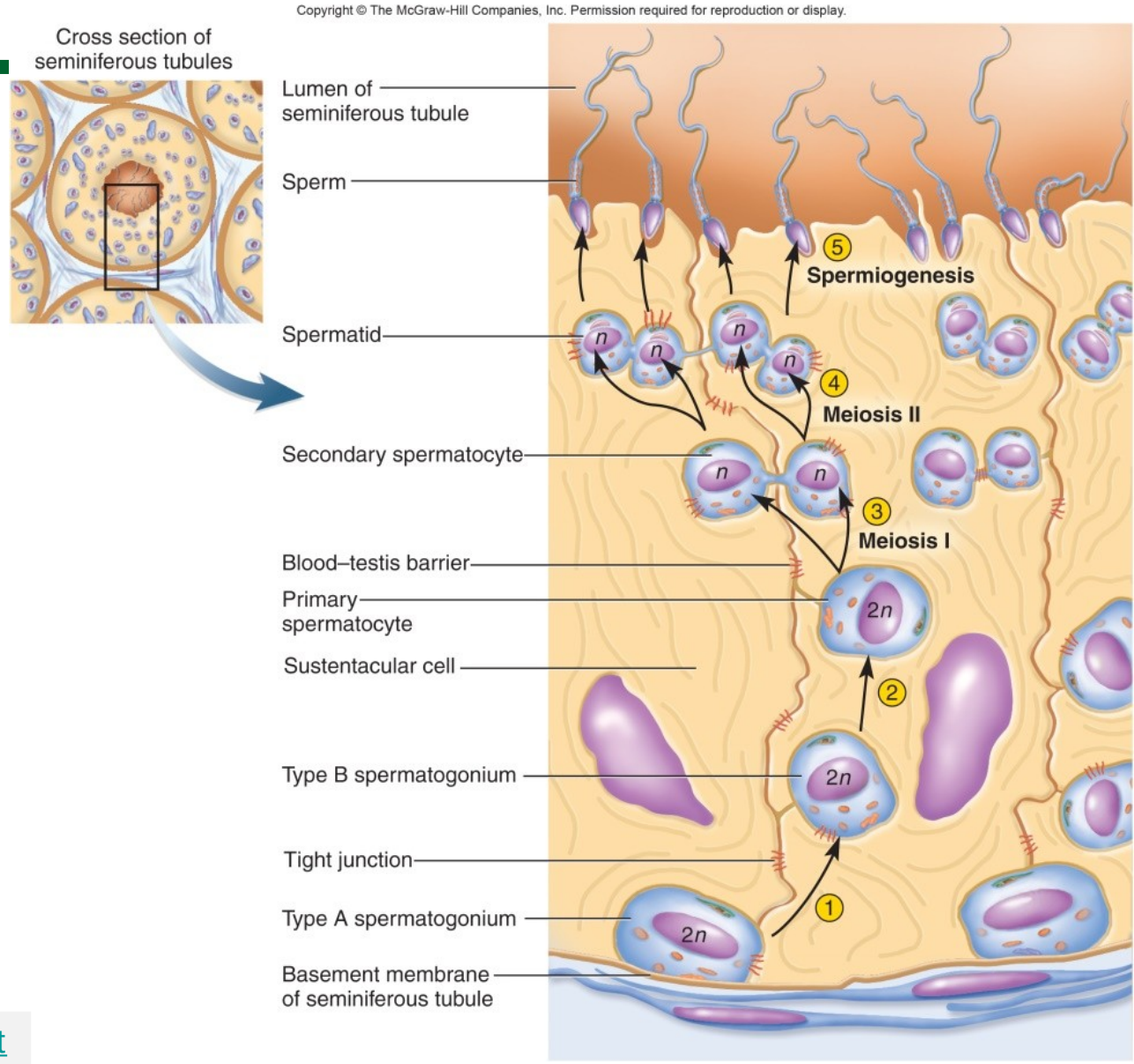
Spermatogenesis

Spermatogonia: divide by mitosis in seminiferous tubules

One daughter cell of each division remains in tubule wall as stem cell: **Type A spermatogonium**

Other daughter cell migrates slightly away from wall and is on its way to producing sperm: **Type B spermatogonium**

Primary spermactye (protected by the blood–testis barrier) → secondary spermacyte → spermatid → sperm



http://highered.mheducation.com/sites/0072495855/student_view0/chapter28/animation__spermatogenesis__quiz_1_.html

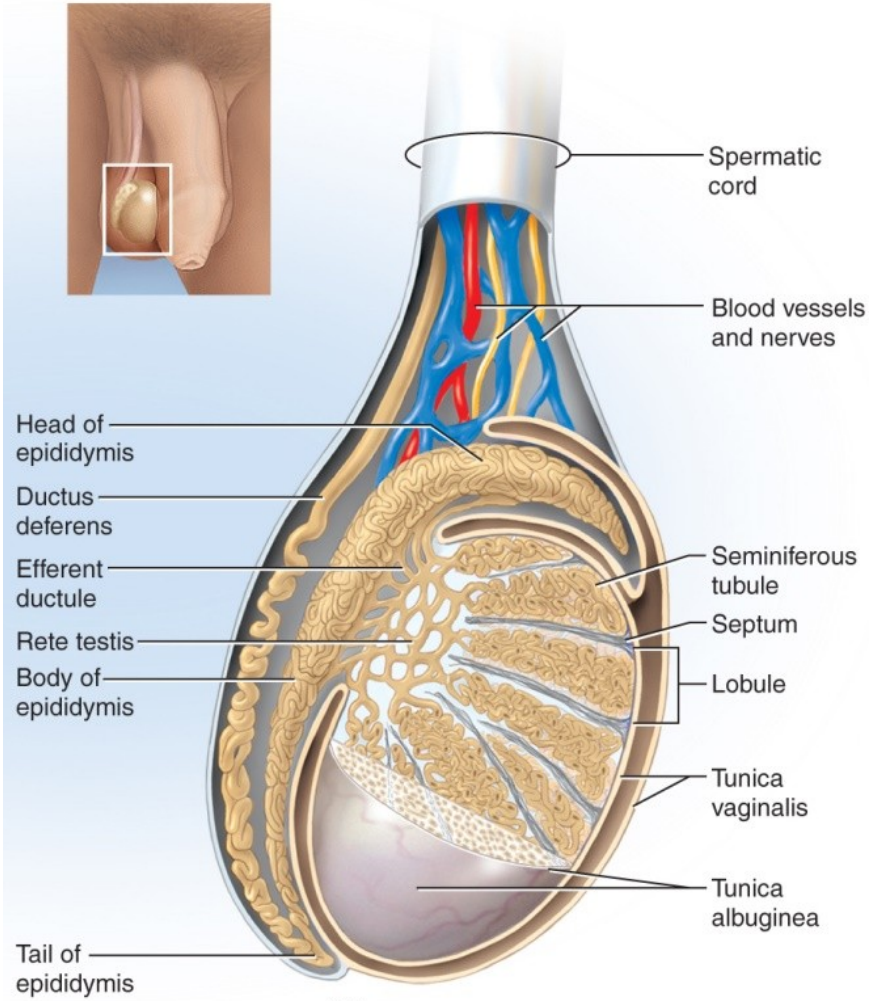
Rete Testes

Rete testis: collects sperm from seminiferous tubules, move with flow of fluid secreted by the sustentacular cells. Sperm do not swim while in the male reproductive tract.

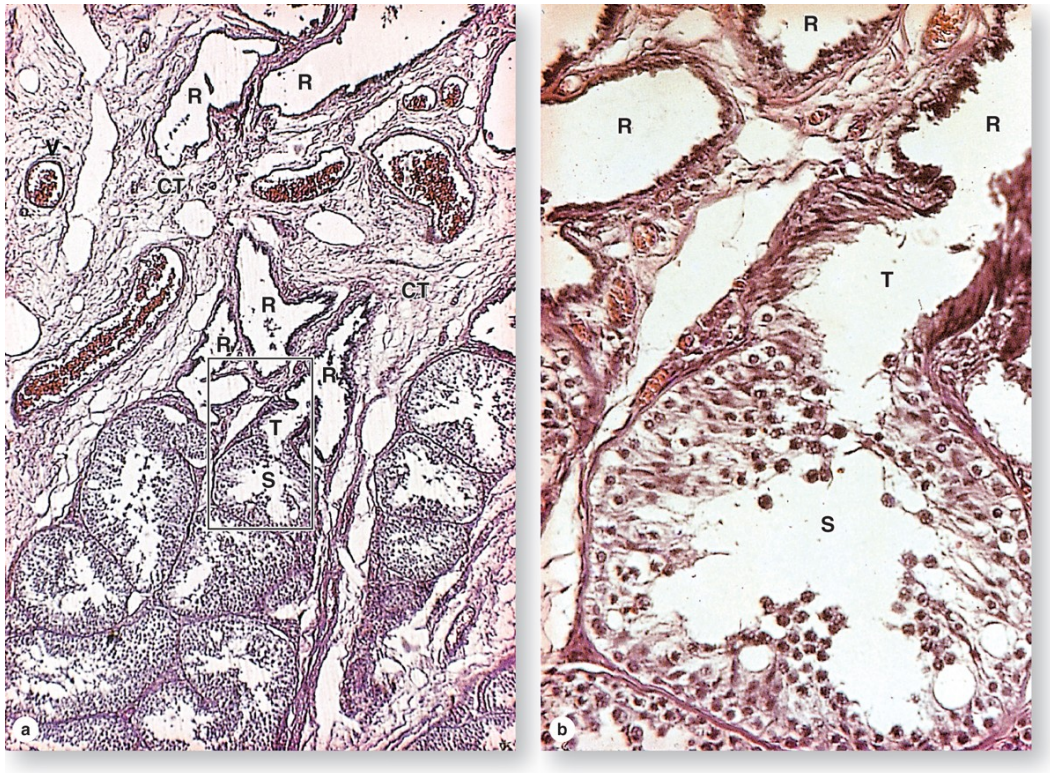
Testicular artery: Low BP, poor O2 supply to the testes.

Blood flow: Testicular artery → pampiniform → testicular veins → inferior vena cava (R) or left renal vein (L)

Blood–testis barrier (BTB): tight junctions between sustentacular cells, keeps Abs out, as germ cells are immunologically different from body cells and would be attacked by the immune system



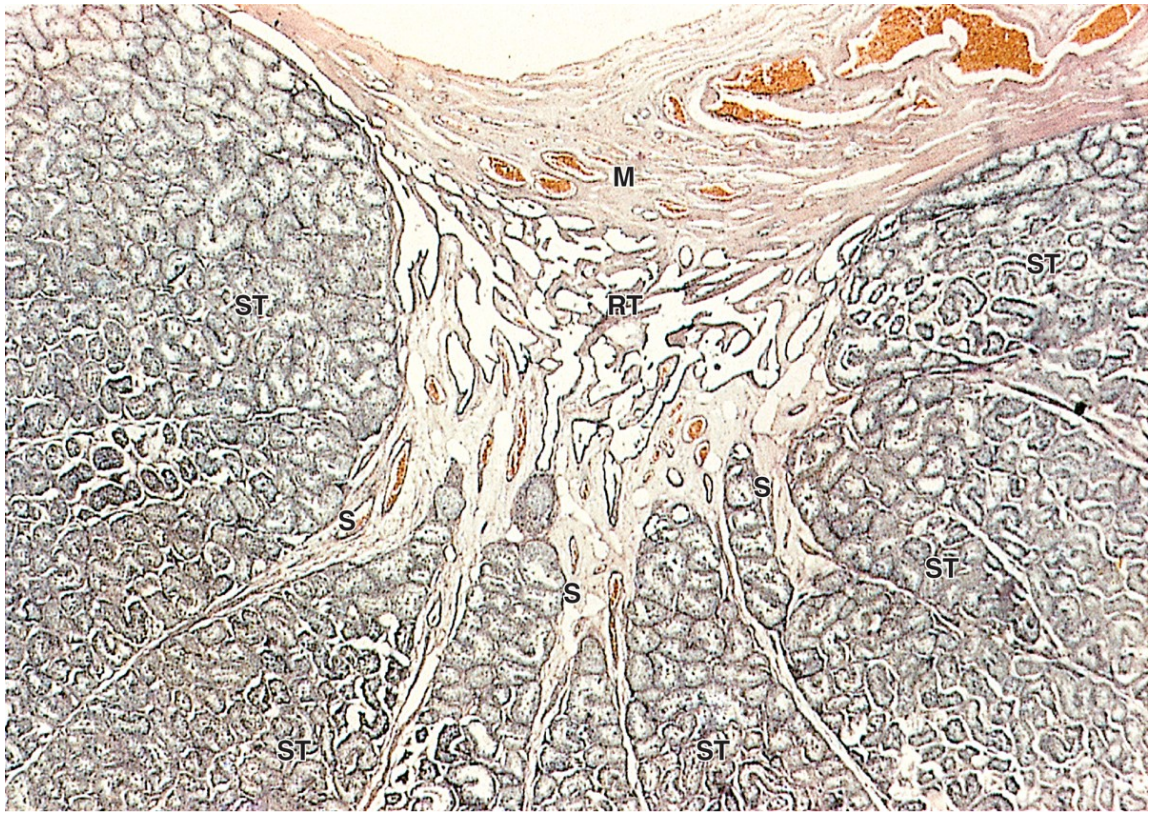
Seminiferous tubules, straight tubules and rete testis



(a) The seminiferous tubules (**S**) drain into short, much narrower straight tubules (**T**), which connect to the rete testis (**R**), a network of channels embedded along with blood vessels (**V**) in the connective tissue (**CT**) of the mediastinum testis.

(b) At higher magnification the enclosed portion of part **a** shows the transition from wide seminiferous tubule (**S**) to the straight tubule (**T**). Initially the straight tubule wall has only tall Sertoli cells devoid of germ cells. The wall becomes a **simple cuboidal epithelium** near its connection to the rete testis (**R**), which is also lined with simple cuboidal epithelium

Lobules converging at rete testis



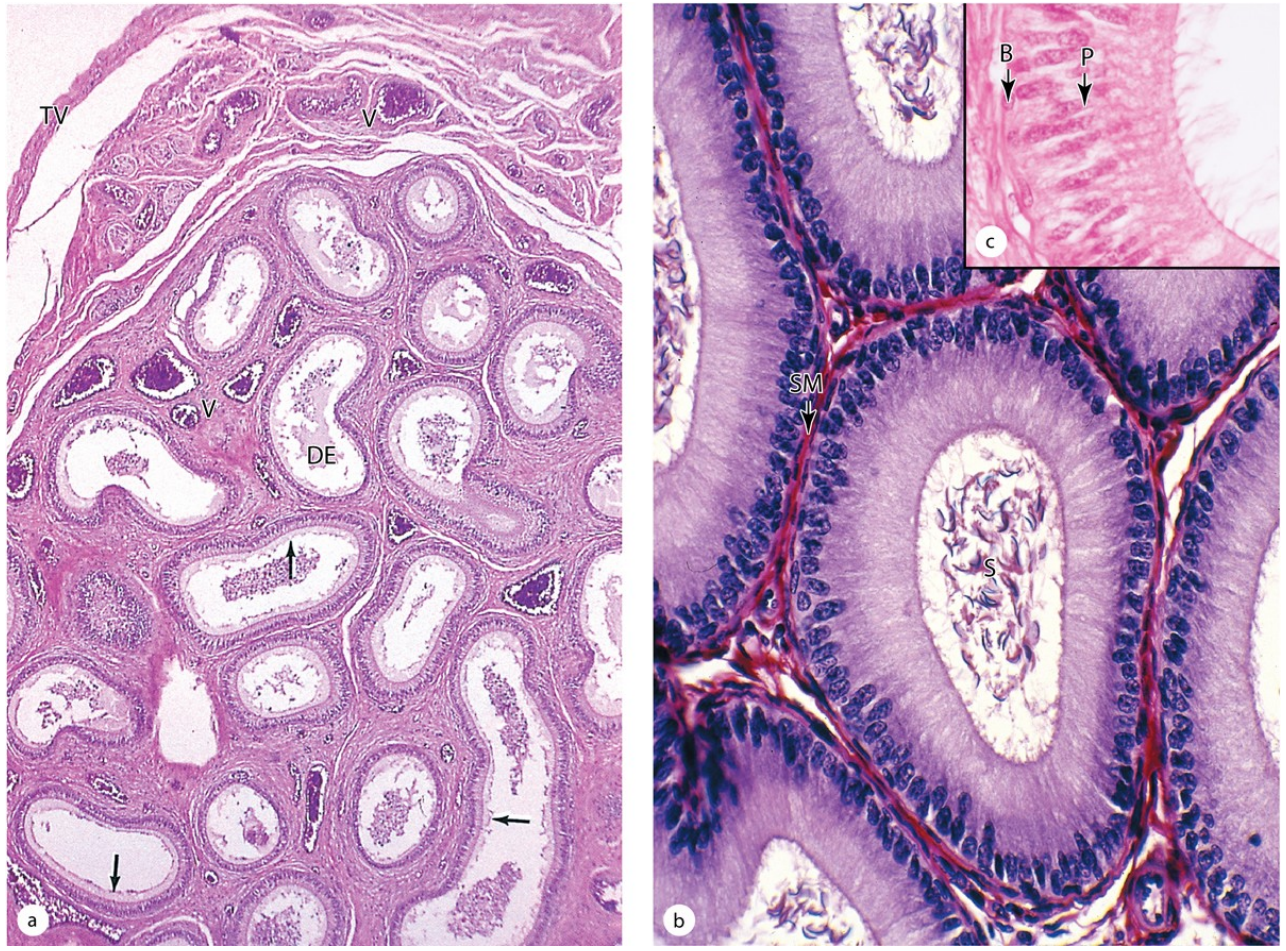
Mediastinum testis (**M**) form thin septa (**S**) to subdivide testis.
Seminiferous tubules (**ST**) form rete testis (**RT):** move sperm into the epididymis.

MEDICAL APPLICATION Acute or chronic inflammation of the testis ducts (**orchitis)** can be caused by urinary tract infection or *Chlamydia* or *Neisseria gonorrhoeae*.

Persistent inflammation (**epididymitis)** causes massive invasion by leukocytes into the infected duct, stimulating fibrosis that obstructs the epididymis and is a common cause of male infertility.

Killer Sex Disease Now DRUG RESISTANT! https://www.youtube.com/watch?v=0b2ngu5Vr4Y

Epididymis: sperm undergo maturation and short-term storage



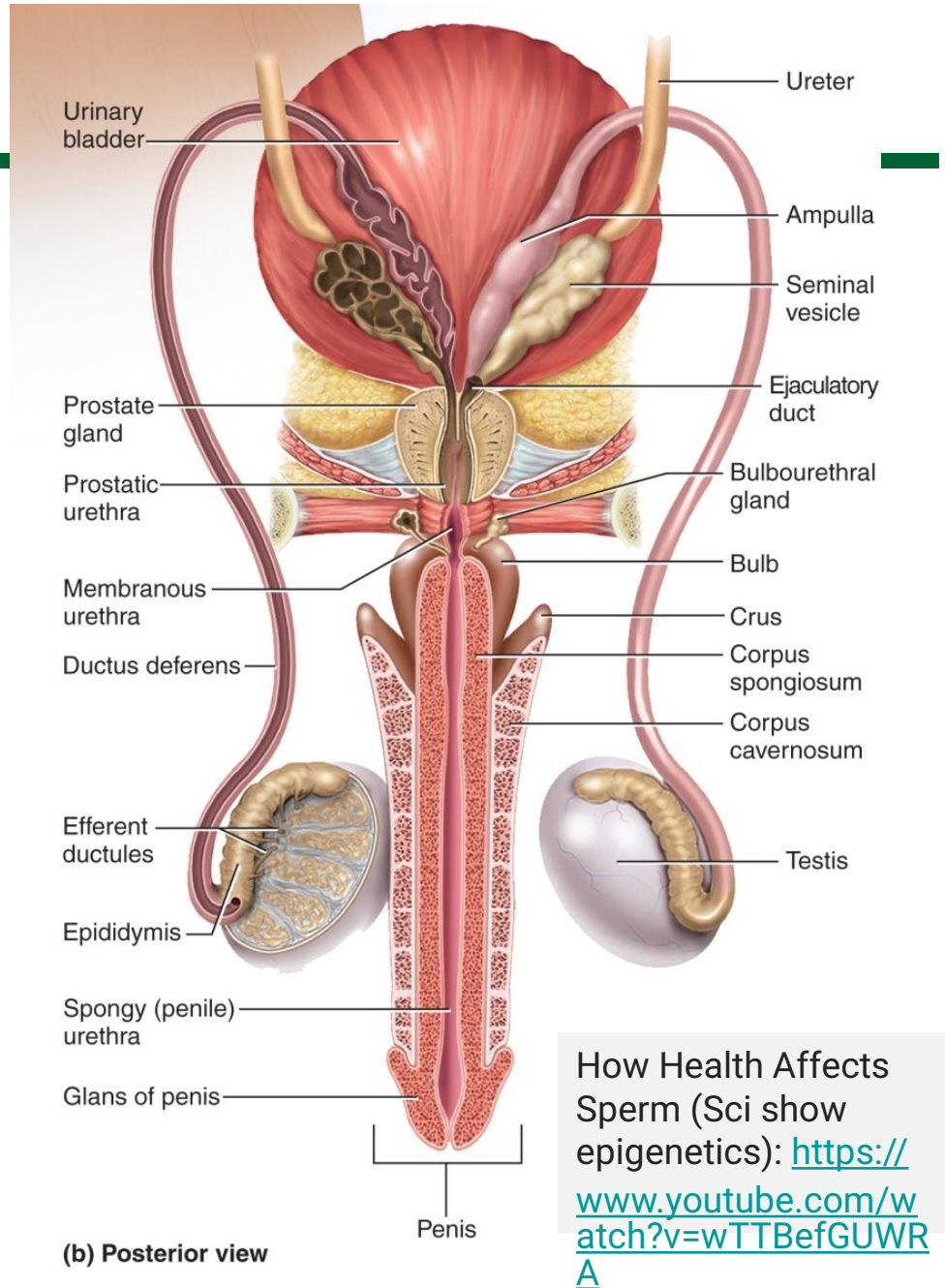
Epididymis (**DE**) is enclosed by connective tissue with many blood vessels (**V**) and covered by a capsule and the tunica vaginalis (**TV**). Lined by a pseudostratified columnar epithelium with long stereocilia (**arrows**).

The columnar epithelium of the epididymal duct is surrounded by a thin circular layer of smooth muscle (**SM**) cells and its lumen contains sperm (**S**).

The spermatic ducts: testis to urethra

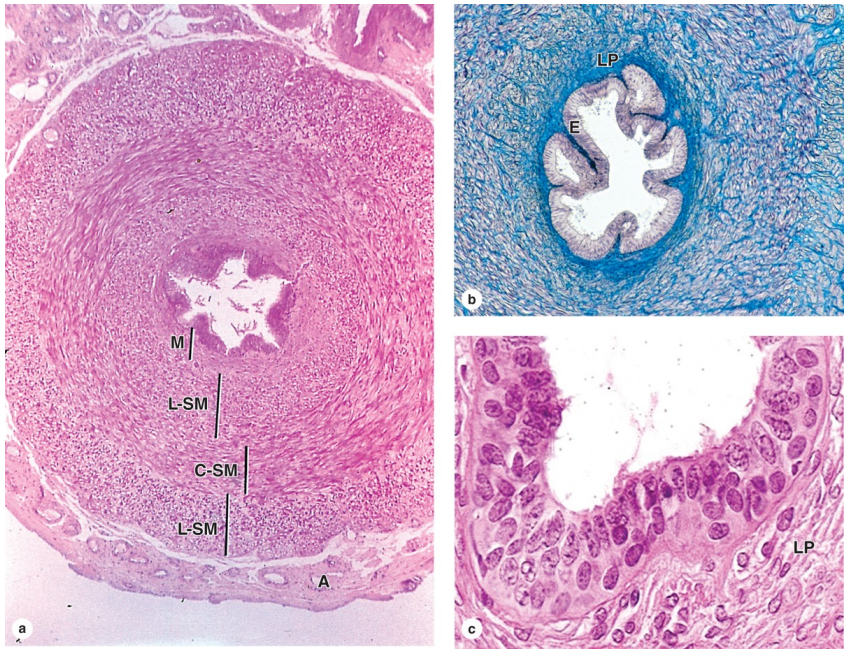
Efferent ductules: ~12 small ciliated ducts collecting sperm from rete testes and transporting it to epididymis
Duct of the epididymis: Site of sperm maturation and storage (fertile for 40 to 60 days)
Ductus (vas) deferens: from scrotum to bladder
Seminal vesicle: form semen secretion
Semen passes through prostate via **Ejaculatory duct** to empty into urethra

MEDICAL APPLICATION Male infertility is frequently idiopathic (unknown causes). Poor semen quality results from reduces sperm cell density, abnormal sperm morphology, and flagellar defects that impair sperm motility.



How Health Affects Sperm (Sci show epigenetics): https://www.youtube.com/watch?v=wTTBefGUWRA

Ductus deferens



Mucosa (**M**), a thick muscularis with inner and outer layers of longitudinal smooth muscle (**L-SM**) and an intervening layer of circular smooth muscle (**C-SM**), and an external adventitia (**A**). The muscularis is specialized for powerful peristaltic movement of sperm at ejaculation.

(b) The lamina propria (**LP**) is rich in elastic fibers and the thick epithelial lining (**E**) shows longitudinal folds. Mallory trichrome.

(c) Higher magnification of the mucosa shows that the epithelium is pseudostratified with basal cells and many columnar cells, some with stereocilia.

MEDICAL APPLICATION: In **vasectomy,** a small incision is made through the scrotal skin near the two ducts and the two ends (or only the end leading to the abdomen) are cauterized and tied. After vasectomy sperm are still produced, but they degenerate and are removed by macrophages in the epididymis (and in the scrotal sac if the short portion of the vas is left open-ended.)

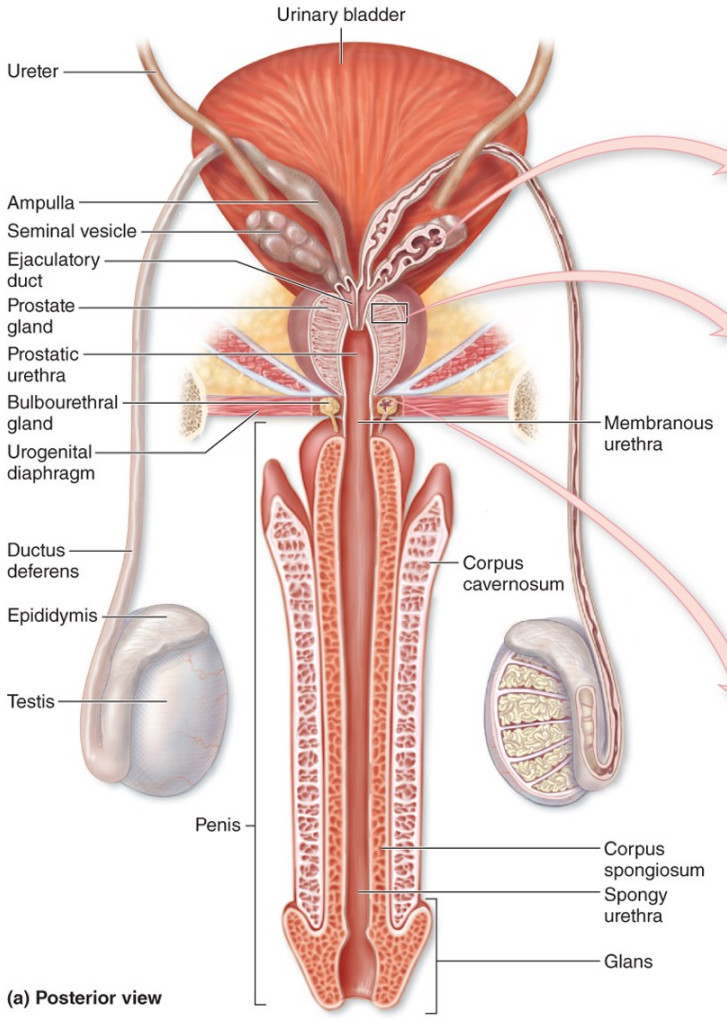
The Accessory Glands

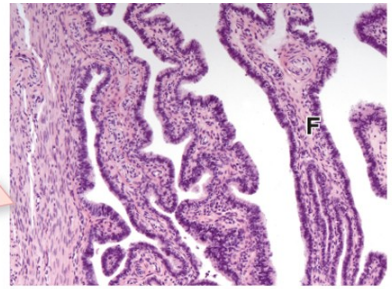
Seminal vesicles: Forms 60% of semen. Fructose (energy), prostaglandins (stimulates female activity), fibrinogen (semen coagulation)

Prostate gland: Thin milky secretion forms 30% of semen. Prostoglandins, enzymes

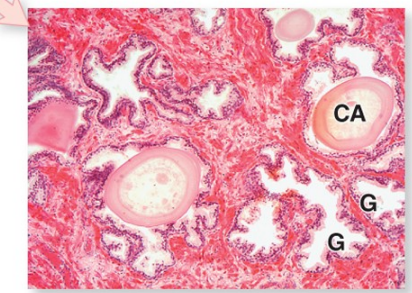
Bulbourethral (Cowper) glands: lubricates the head of the penis in preparation for intercourse, neutralizes acidity of residual urine in the urethra

MEDICAL APPLICATION Prostate cancer (adenocarcinoma), the most common cancer in nonsmoking men, occurrs mainly in glands of the peripheral zone.

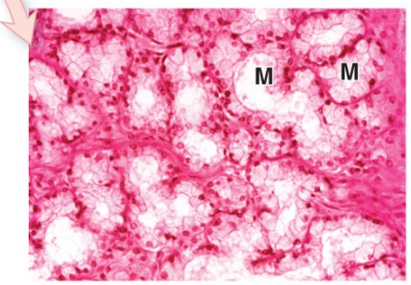




(b) Seminal vesicle



(c) Prostate gland

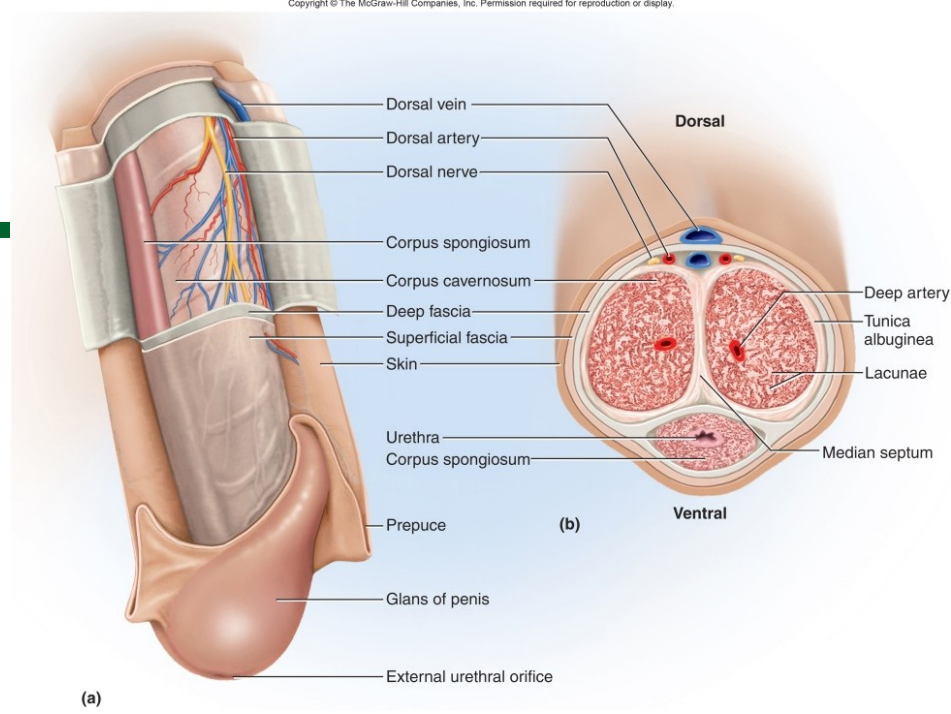


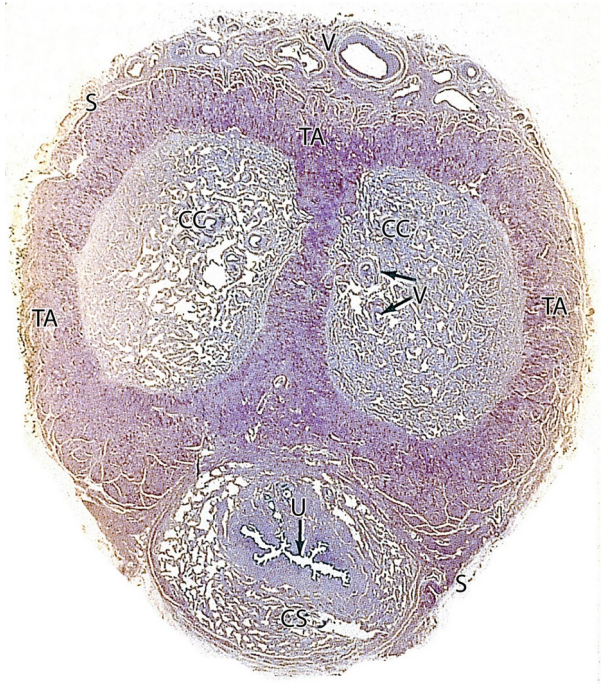
(d) Bulbourethral gland

The penis

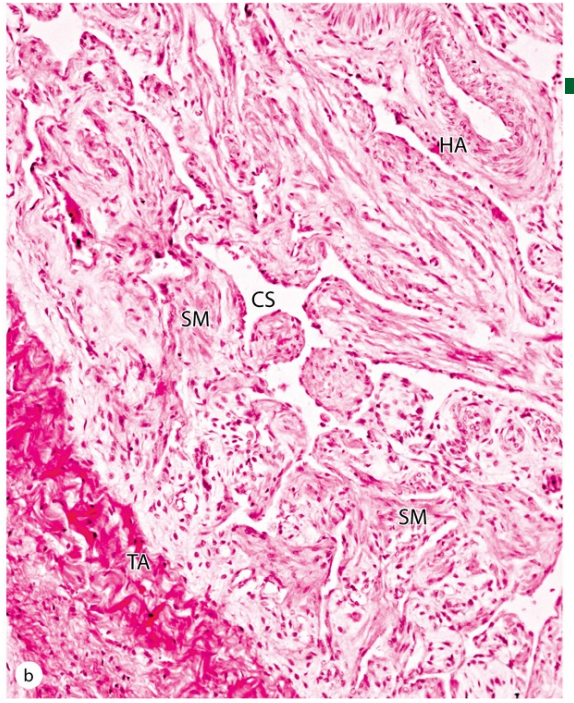
Foreskin: Extends over glans as **prepuce**, removed by circumcision
Three cylindrical bodies of erectile tissue: fill with blood during sexual arousal → enlargement → erection
Corpus spongiosum: encloses spongy (penile) urethra
Corpora cavernosa: Diverge like arms (crus) of a Y, attaches penis to pubic arch,
Lacunae: blood sinuses
Trabeculae: partitions between lacunae

corpus spongiosum (**CS**) urethra (**U**) corpora cavernosa (**CC**) tunica albuginea (**TA**) blood vessels (**V**) skin (**S**), which distally forms the large foreskin fold and becomes thin over the glans





Penile urethra and erectile tissue

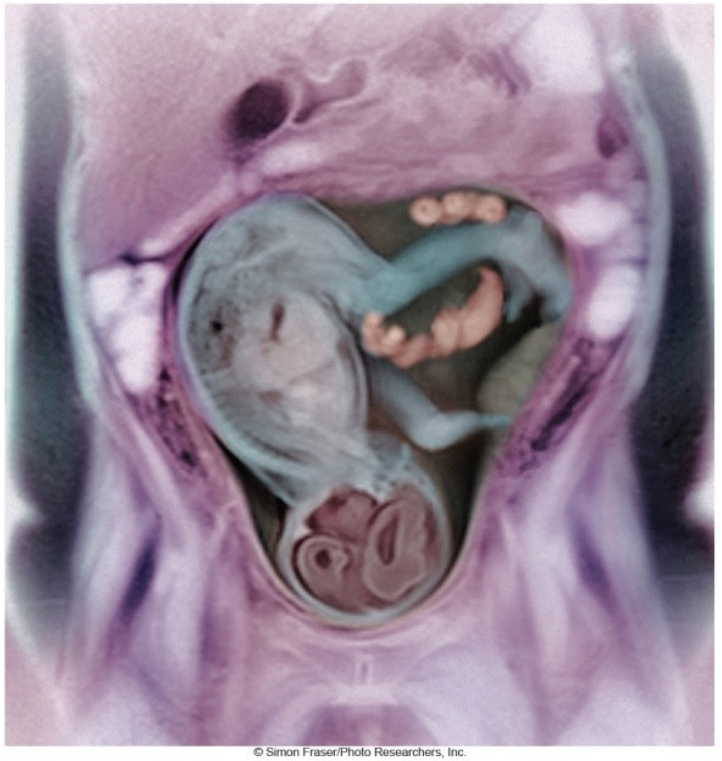


(a) The corpus spongiosum (**CS**) surrounds the longitudinally folded wall of the penile urethra (**PU**). Small urethral glands (**UG**) with short ducts to the urethra release mucus during erection, supplementing the similar secretion from the bulbourethral glands. The two dorsal corpora cavernosa (**CC**) are ensheathed by dense, fibrous tunica albuginea (**TA**) and in one here a small helicine artery (**HA**)
(b) A higher magnification of erectile tissue is shown with a small portion of tunica albuginea (**TA**) and fibrous, elastic connective tissue containing smooth muscle (**SM**) and many small, cavernous spaces (**CS**) lined by vascular endothelium. Very little blood normally passes through this vasculature due to constriction of the helicine arteries (**HA**) serving them.

MEDICAL APPLICATION: Acetylcholine from parasympathetic nerves causes the vascular endothelial cells of the helicine arteries and cavernous tissue to release nitric oxide (NO). NO causes surrounding smooth muscle cells to relax and promotes blood flow for the erection.

Erectile dysfunction , or impotence , can result from diabetes, anxiety, vascular disease, or nerve damage during prostatectomy. Drugs may alleviate the problem by inhibiting smooth muscle cells of helicine arteries and erectile tissue.

Duct	Location	Epithelium	Support Tissues	Function(s)
Seminiferous tubules	Testicular lobules	Spermatogenic, with Sertoli cells and germ cells	Myoid cells and loose connective tissue	Produce sperm
Straight tubules (tubuli recti)	Periphery of the mediastinum testis	Sertoli cells in proximal portions, simple cuboidal in distal portions	Connective tissue	Convey sperm into the rete testis
Rete testis	In mediastinum testis	Simple cuboidal	Dense irregular connective tissue	Channels with sperm from all seminiferous tubules
Efferent ductules	From rete testis to head of epididymis	Alternating patches of simple cuboidal nonciliated and simple columnar ciliated	Thin circular layer of smooth muscle and vascular loose connective tissue	Absorb most fluid from seminiferous tubules; convey sperm into the epididymis
Epididymal duct	Head, body, and tail of the epididymis	Pseudostratified columnar, with small basal cells and tall principal cells bearing long stereocilia	Circular smooth muscle initially, with inner and outer longitudinal layers in the tail	Site for sperm maturation and short-term storage; expels sperm at ejaculation
Ductus (vas) deferens	Extends from epididymis to ejaculatory ducts in prostate gland	Pseudostratified columnar, with fewer stereocilia	Fibroelastic lamina propria and three very thick layers of smooth muscle	Carries sperm by rapid peristalsis from the epididymis to the ejaculatory ducts
Ejaculatory ducts	In prostate, formed by union of ductus deferens and ducts of the seminal vesicles	Pseudostratified and simple columnar	Fibroelastic tissue and smooth muscle of the prostate stroma	Mix sperm and seminal fluid; deliver semen to urethra, where prostatic secretion is added



Female Reproductive System

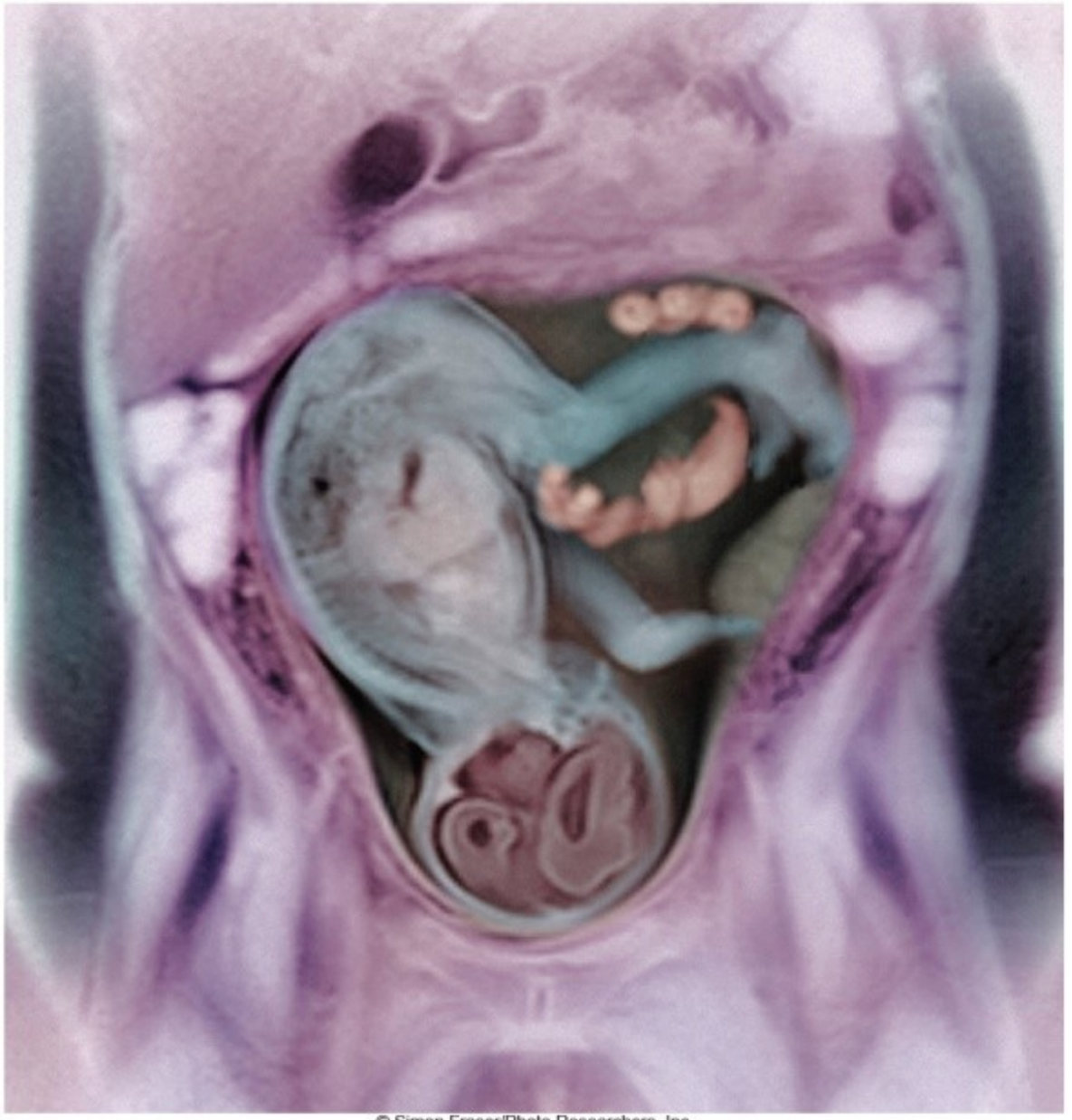
BI 455 CHAPTER 23

Introduction

The female reproductive system is more complex than the male system because it serves more purposes

- Produces and delivers gametes
- Provides nutrition and safe harbor for fetal development
- Gives birth
- Nourishes infant

Female system is more cyclic, and the hormones are secreted in a more complex sequence than the relatively steady secretion in the male



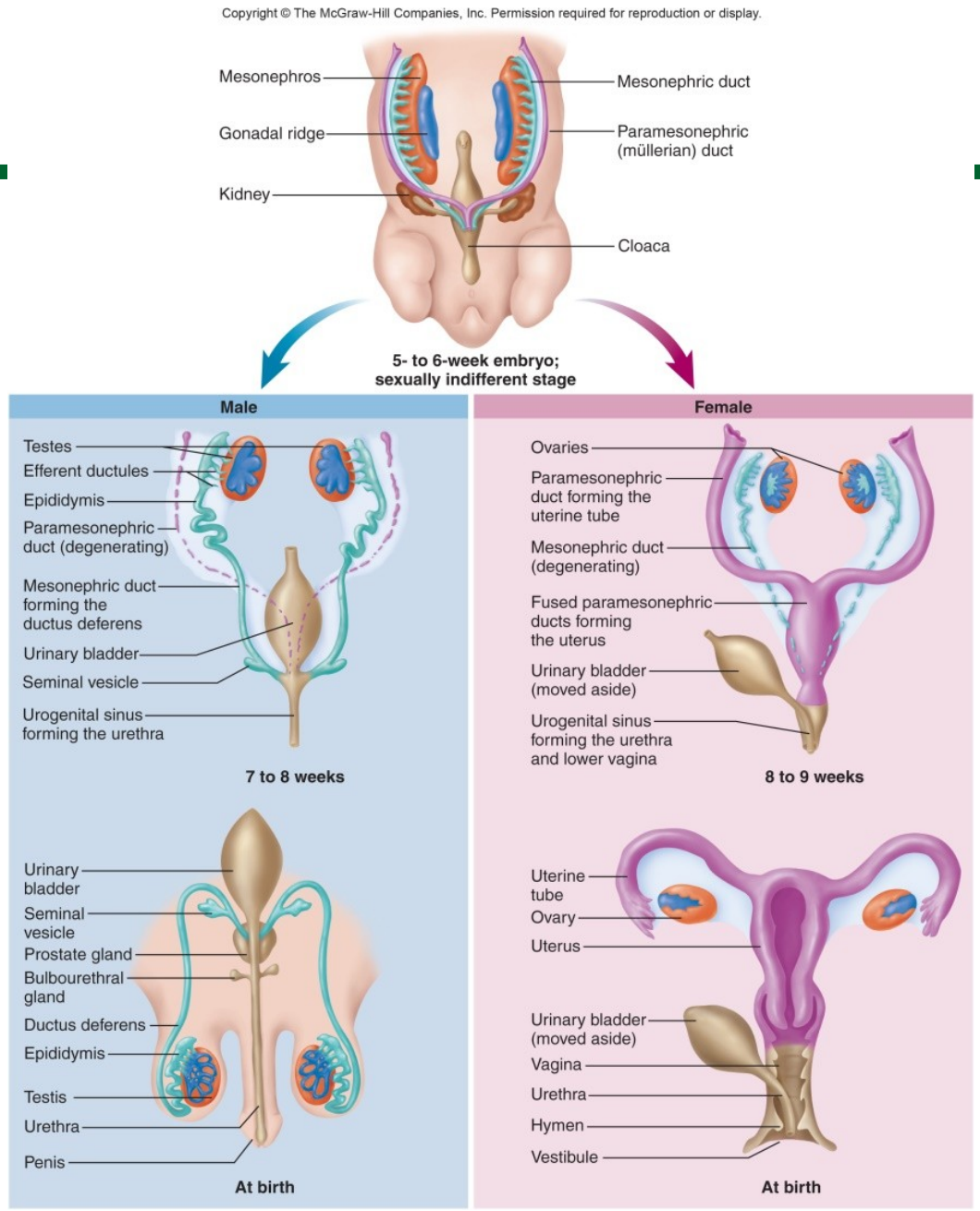
Sexual Differentiation: indistinguishable for 8 to 10 weeks

Female reproductive tract develops from the paramesonephric ducts in absence of testosterone and müllerian-inhibiting factor (MIF)

Without testosterone:

- Mesonephric ducts to degenerate
- Genital tubercle becomes the glans clitoris
- Urogenital folds become the labia minora
- Labioscrotal folds develop into the labia majora

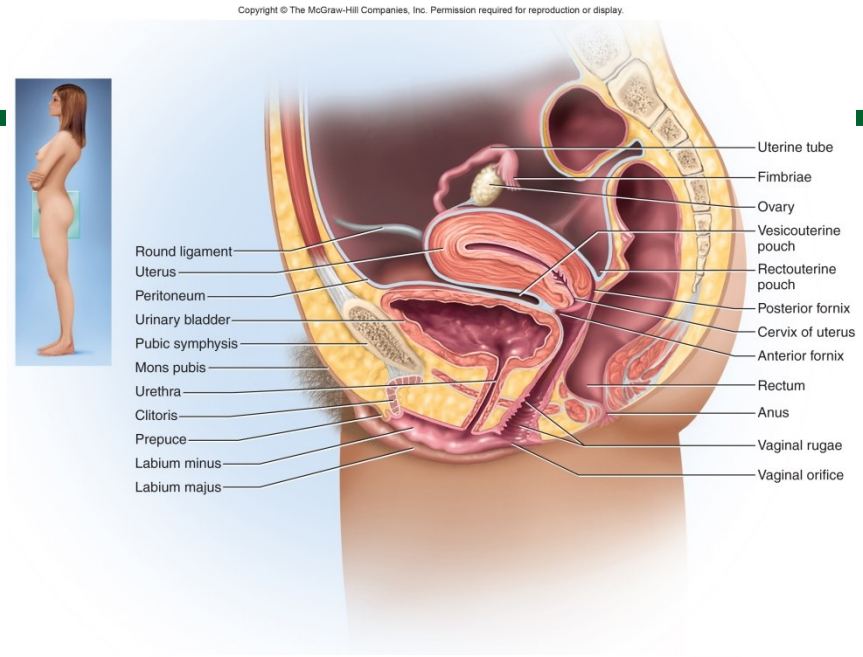
Without MIF: Paramesonephric ducts develop into the uterine tubes, uterus, and vagina

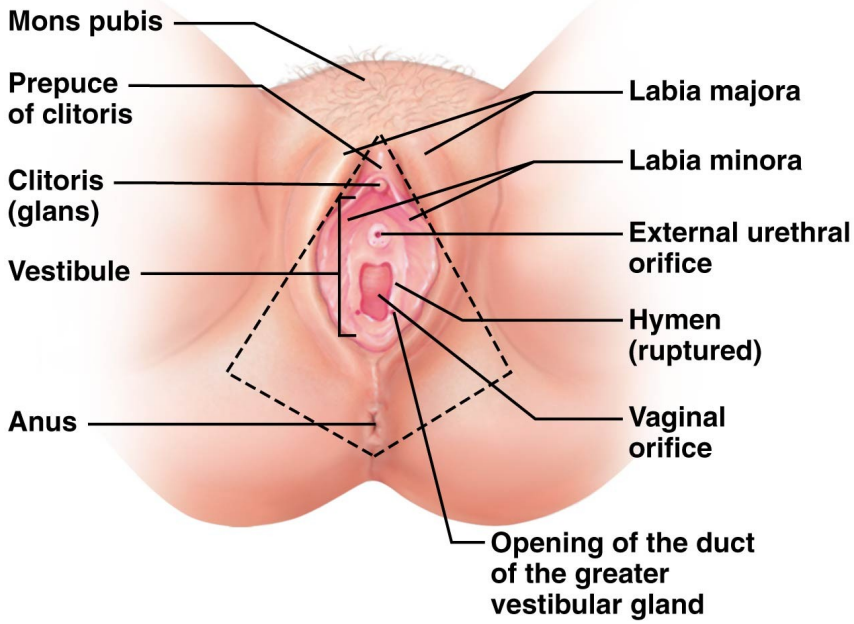


The Genitalia

- Internal genitalia: Ovaries, uterine tubes, uterus, and vagina
- External genitalia: Clitoris, labia minora, and labia majora

- **Primary sex organs**: Ovaries
- **Secondary sex organs**: Other internal and external genitalia

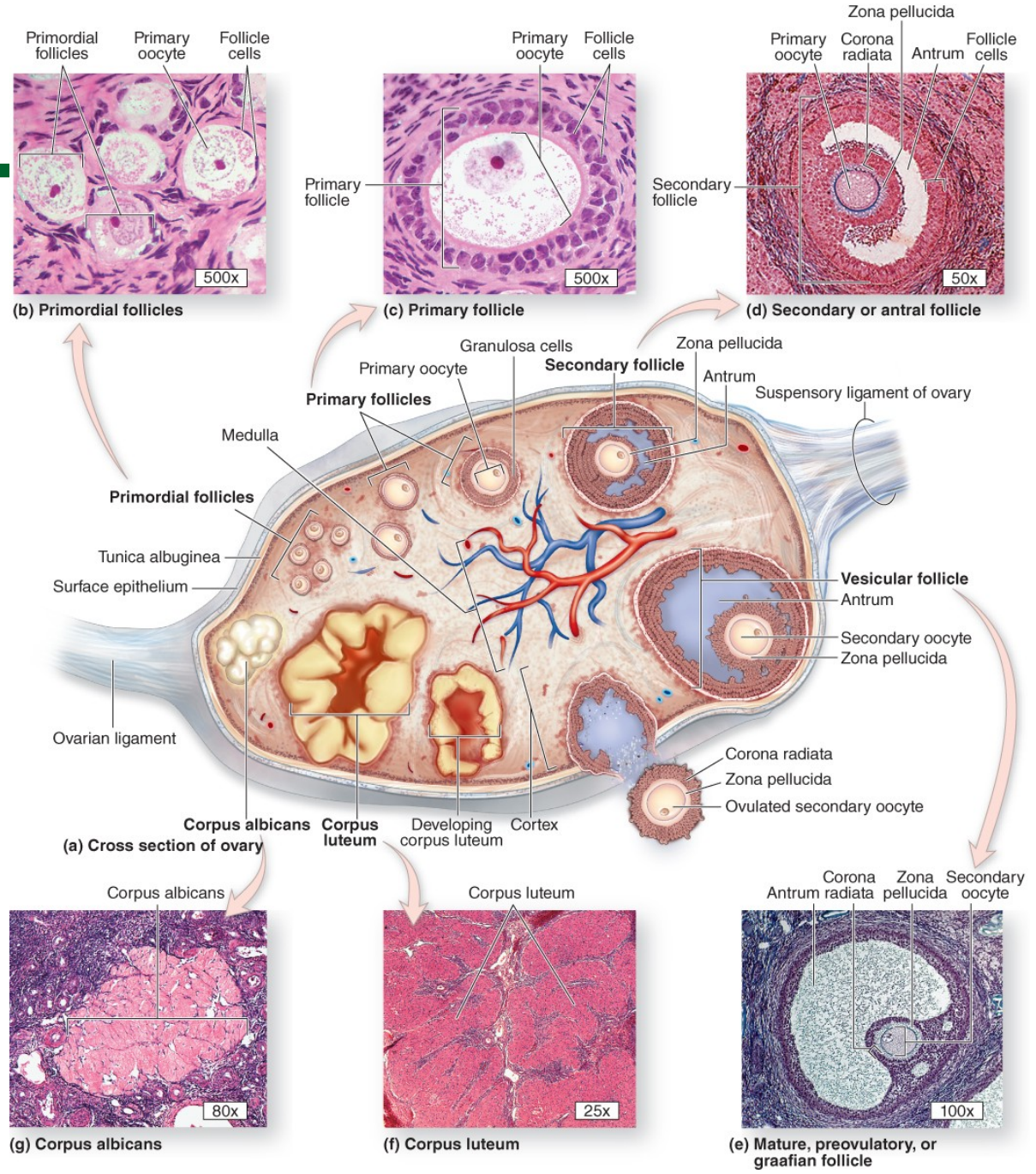




The ovary produces both oocytes and sex hormones.

Tunica albuginea: capsule, like on testes
Outer cortex: germ cells develop
Inner medulla: major arteries and veins.
Ovulation: bursting of the follicle and releasing the egg

primordial follicles **(b)** → primary follicle **(c)** → secondary follicle **(d)** → large vesicular follicle **(e)**. After ovulation, remains form corpus luteum **(f)** → degenerates into the corpus albicans **(g)**



Embryonic development of ovary

Females are born with lifetime supply of **primary oocytes,** surrounded by simple squamous **primordial follicles**: arresting in early meiosis I

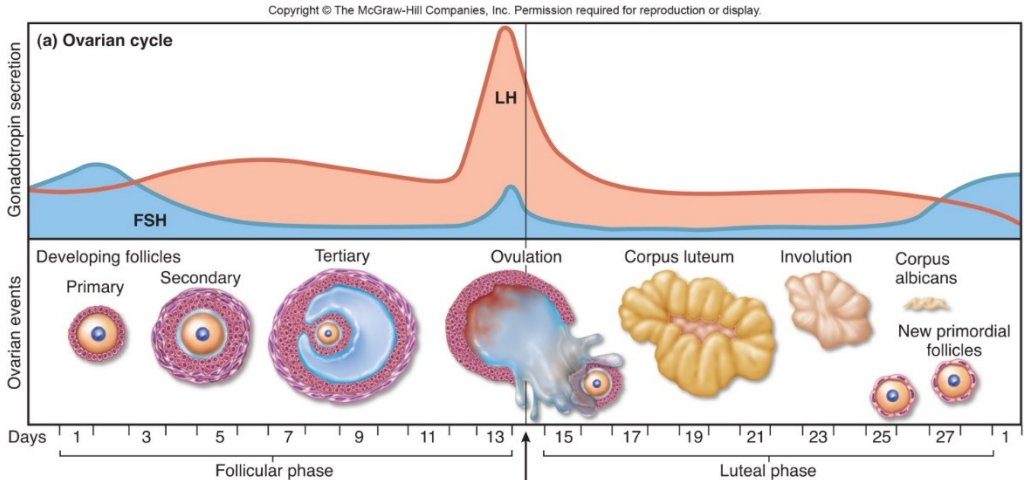
Egg, or ovum: any stage from the primary oocyte to the time of fertilization

FSH: stimulates monthly cohorts of oocytes to complete meiosis I

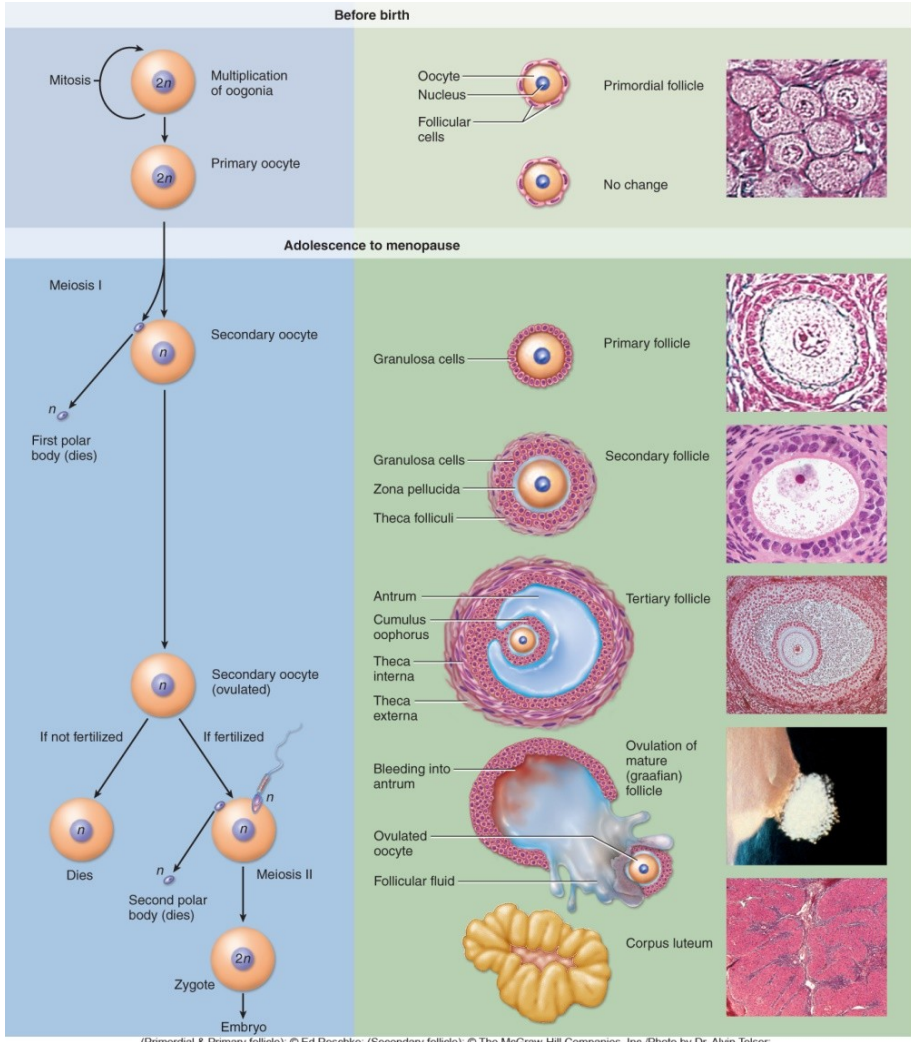
First polar body: Disintegrates after meiosis I

Secondary oocyte: proceeds to metaphase II. Simple cuboidal **primary follicles,** stratified cuboidal granulosa cells in **secondary follicles,** hormone secreting **Tertiary follicles**

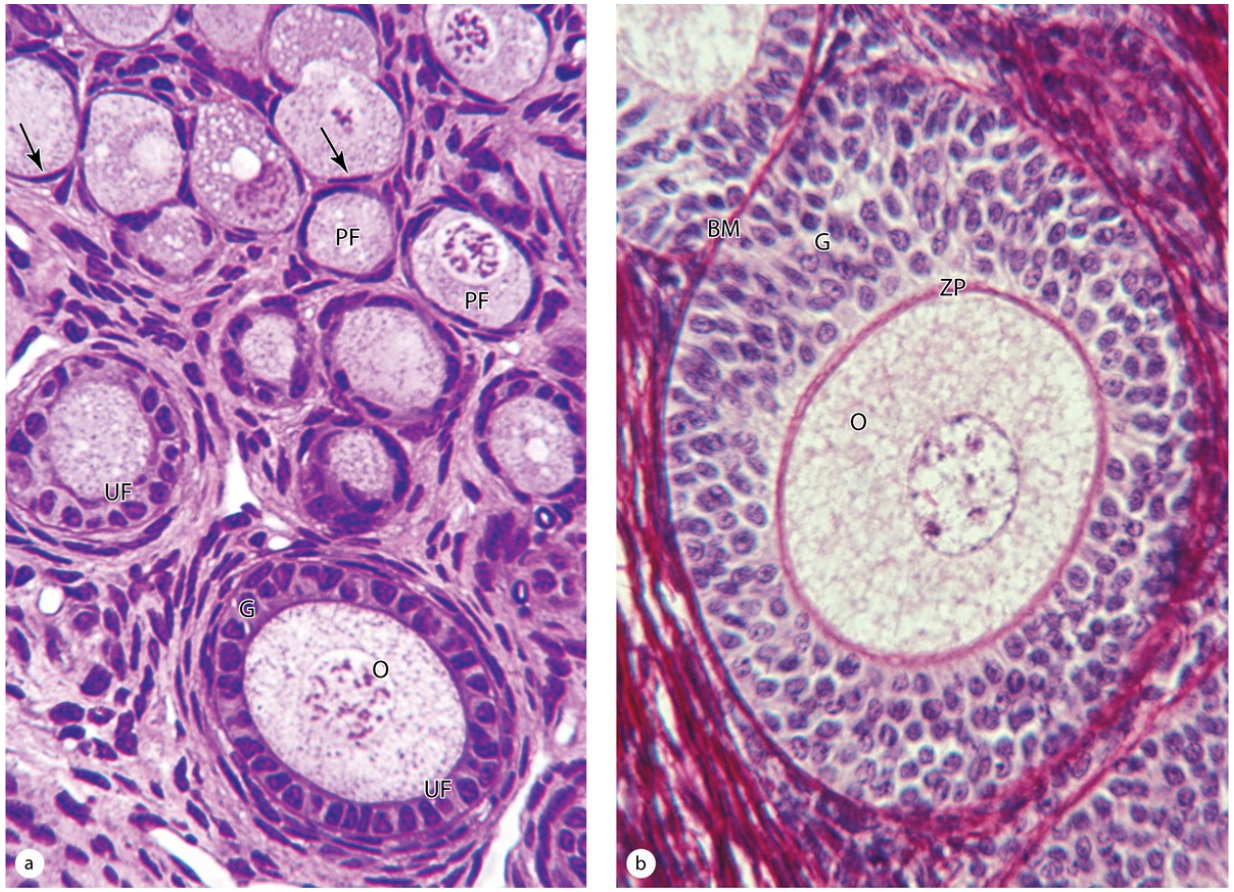
Fertilization triggers completion of Meiosis II



http://highered.mheducation.com/sites/0072495855/student_view0/chapter28/animation__maturation_of_the_follicle_and_oocyte.html



(a) Primordial and (b) Primary follicles



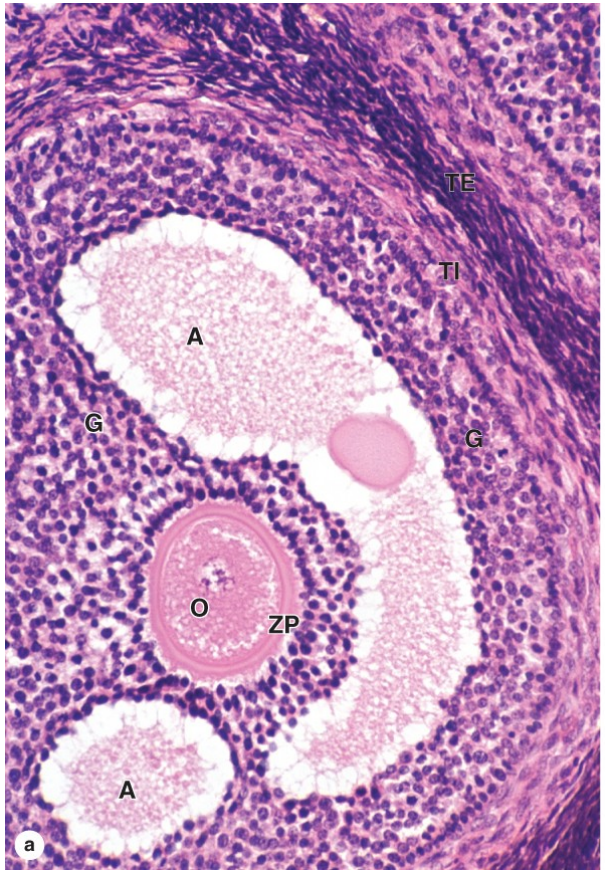
(a) primordial follicles (**PF**) and their flattened follicle cells (**arrows**)
granulosa cells (**G**) form a single cuboidal layer around the large primary oocyte (**O**)

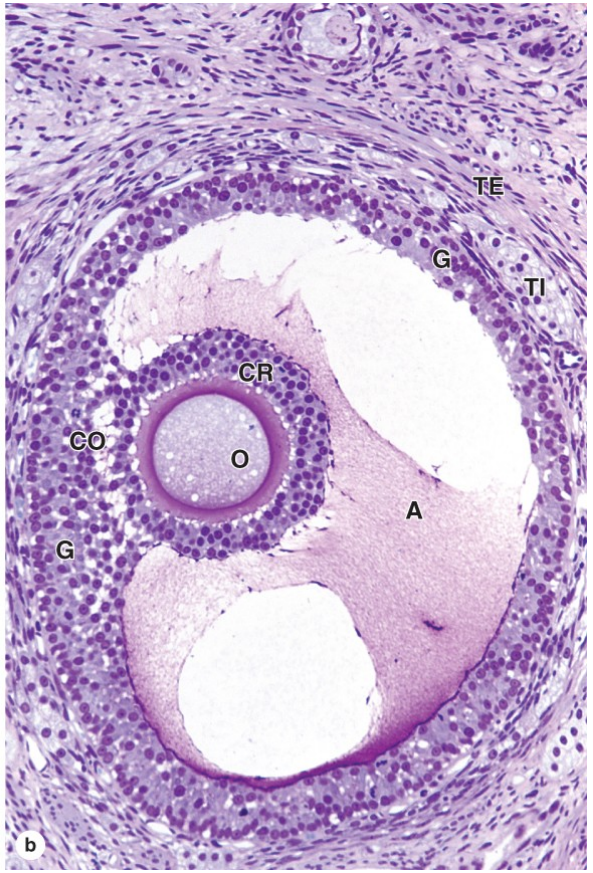
(b) larger multilayered primary follicle. Granulosa cells (**G**) have now proliferated to form several layers. zona pellucida (**ZP**): glycoprotein layer produced by the oocyte that is required for sperm binding and fertilization. The primary oocyte is now a very large cell. basement membrane (**BM**)

MEDICAL APPLICATION Polycystic ovary syndrome (PCOS) is characterized by enlarged ovaries with numerous cysts and an anovulatory state (with no follicles completing maturation successfully).
Increased androgen production by the ovaries or adrenals is likely involved.
PCOS is a common cause of **infertility** in women.

(a) An antral follicle shows the large, fluid-filled antral cavities or vesicles (**A**)
The oocyte (**O**) is surrounded by the zona pellucida (**ZP**) and granulosa cells (**G),** Steroid-secreting theca interna (**TI**) and a covering theca externa (**TE**).

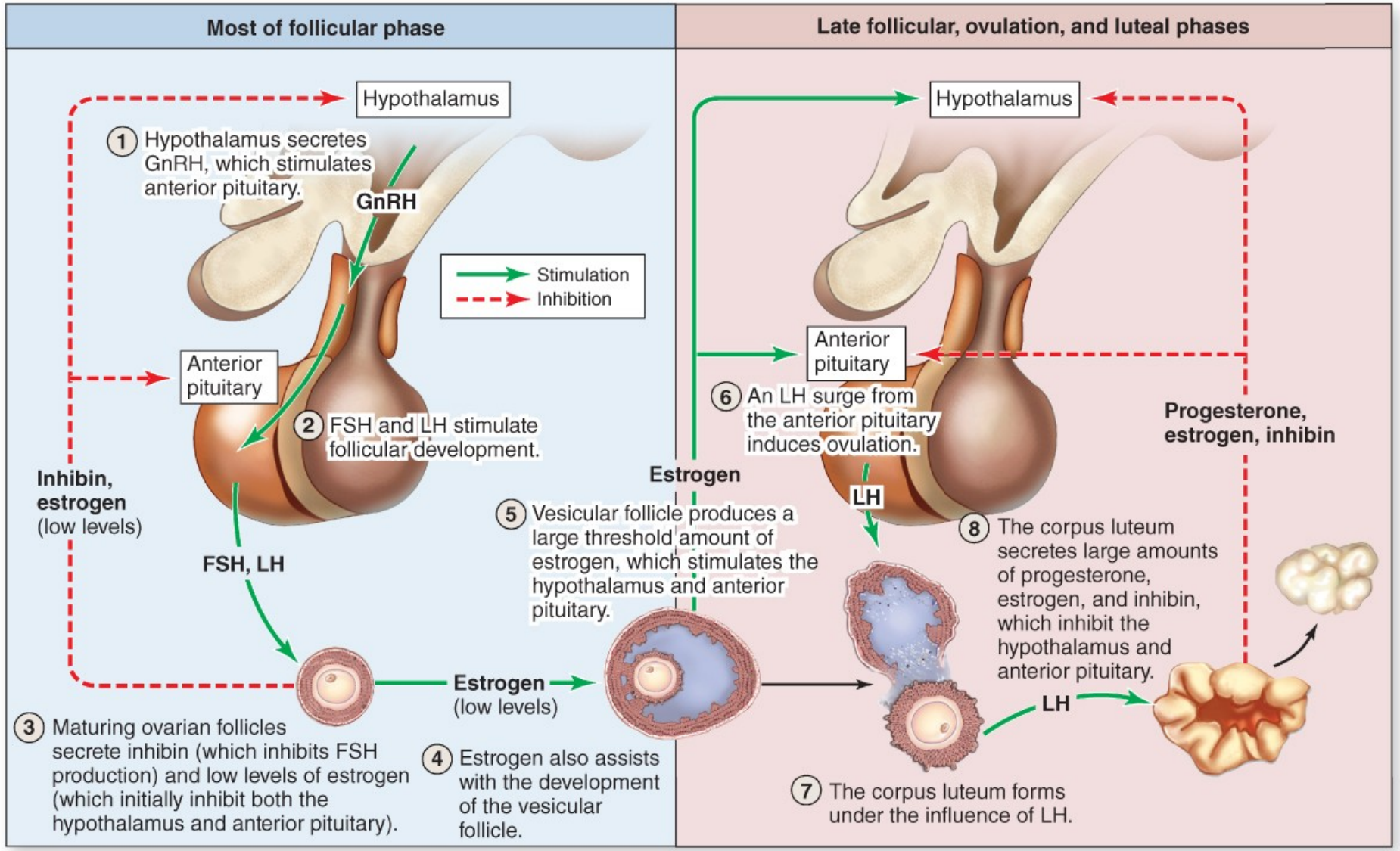
(b) A slightly more developed preovulatory follicle shows a very large single antrum (**A**). The oocyte (**O**) is surrounded by granulosa cells that now make up the corona radiata (**CR**). The corona radiata and oocyte are attached to the side of the follicle within a larger mass of granulosa cells called the **cumulus oophorus** (**CO**)





MEDICAL APPLICATION Late primary or antral follicles can produce **follicular cysts**, which are thin-walled, fluid-filled structures with both granulosa and thecal endocrine cells. Follicular cysts are common and usually benign, but can produce high estrogen levels and lead to menstrual irregularities. If cyst formation disrupts blood vessels blood enters the fluid, often rapidly, and produces a **hemorrhagic cyst**.

The ovarian cycle is initiated by hypothalamic GnRH, causing the AP to secrete FSH and LH

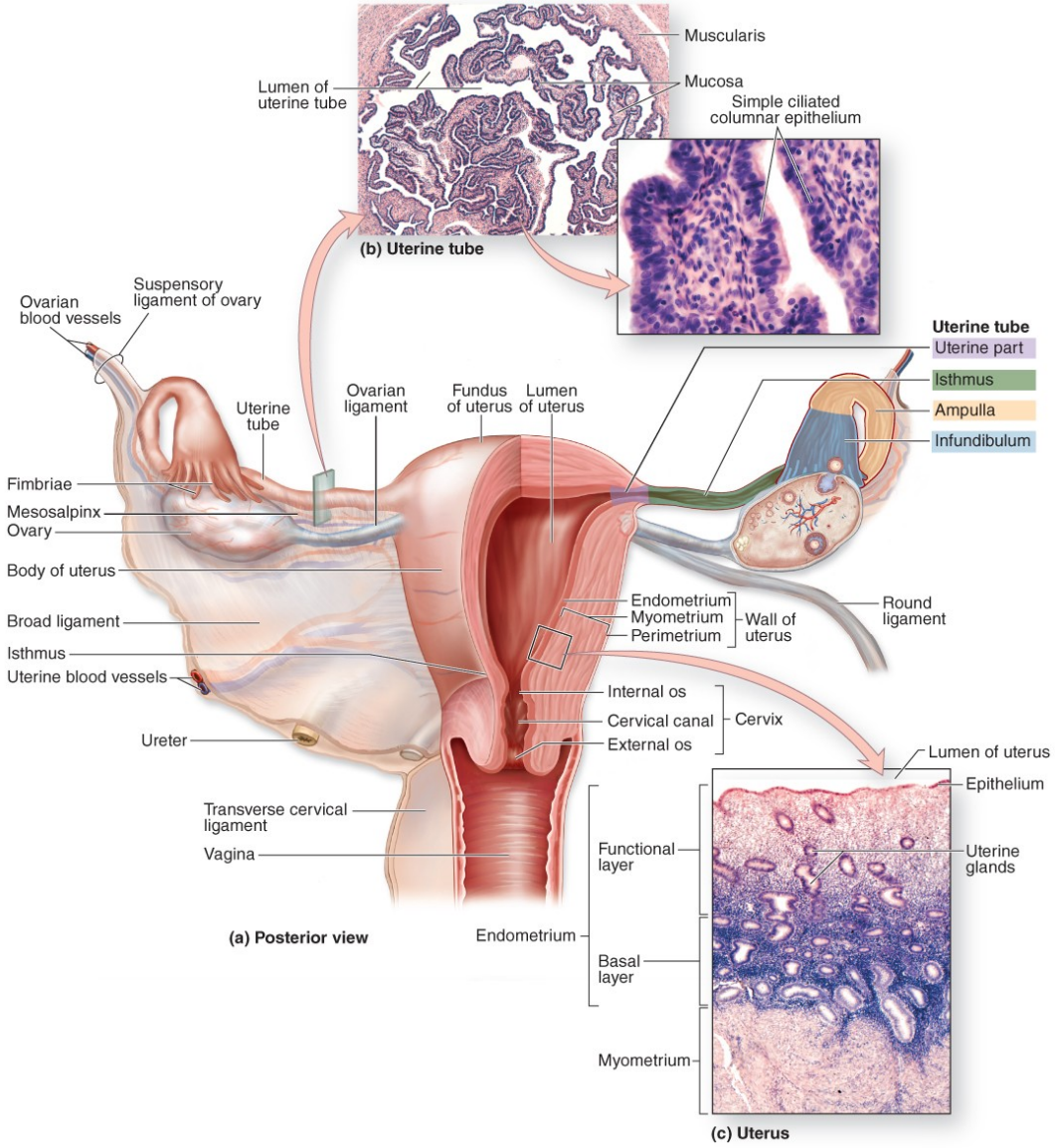


Uterine tubes and uterus

The uterine tubes catch the ovulated secondary oocyte, nourish both the oocyte and sperm, provide the microenvironment for fertilization, and transport the embryo undergoing cleavage to the uterus.

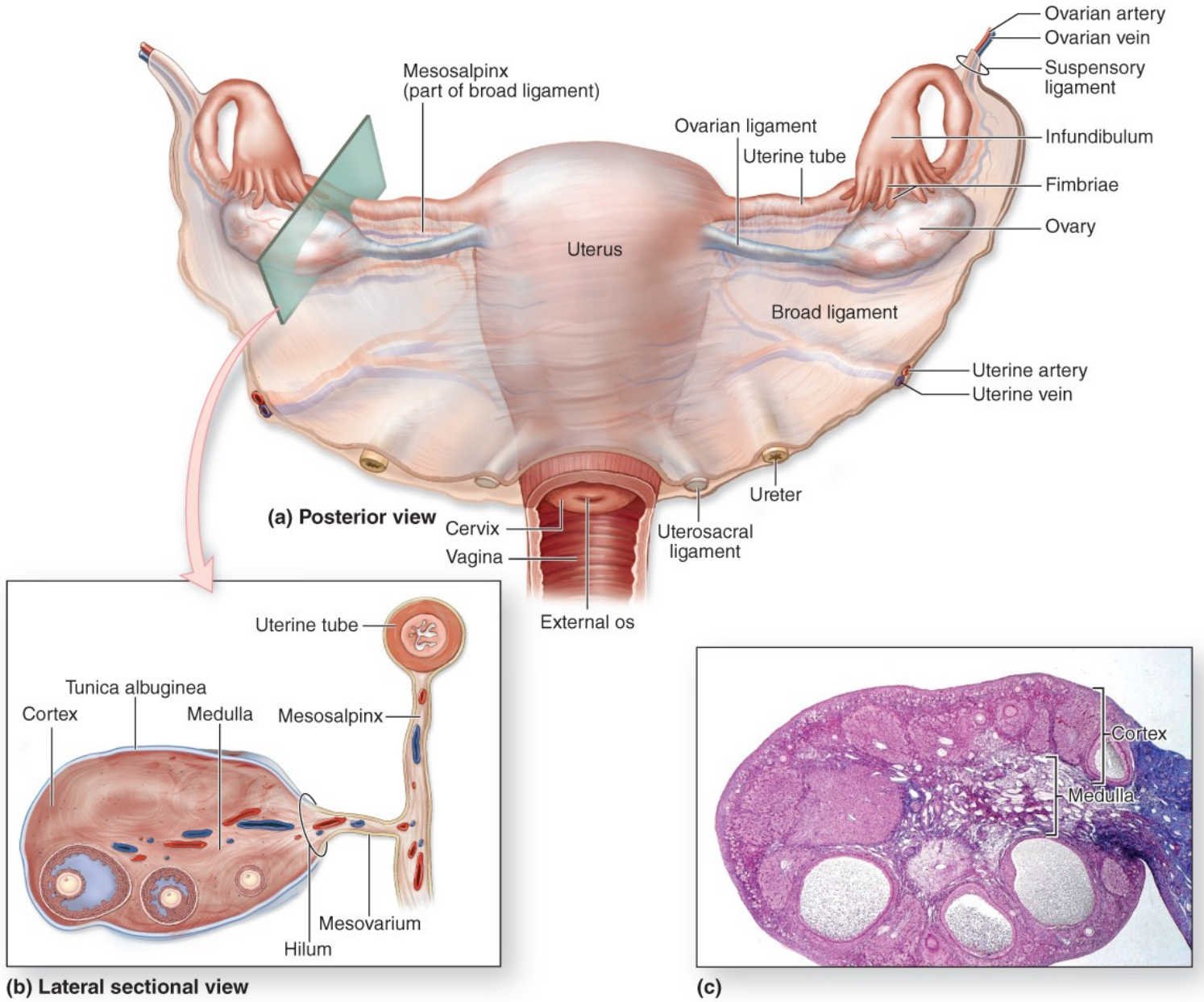
MEDICAL APPLICATION: Mucosal damage or adhesions can lead to i**nfertility** or an **ectopic (tubal) pregnancy** if there is blockage of oocyte or embryo transport to the uterus.
The tube cannot contain the growing embryo and will rupture, causing potentially fatal hemorrhage.

Tubal ligation is a common surgical type of contraception.

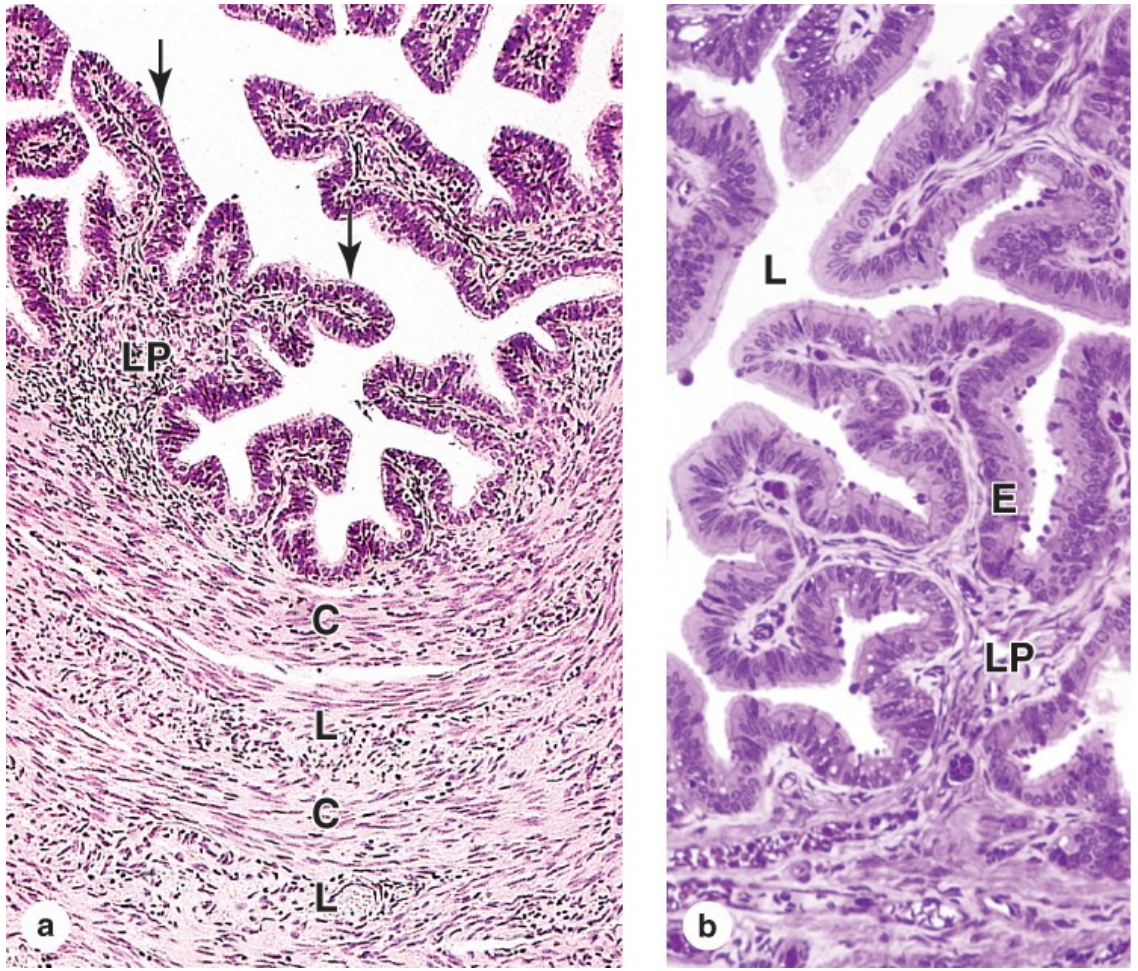


The Uterine Tubes (Oviduct/Fallopian Tube): Muscular tube lined with ciliated cells

Highly folded into longitudinal ridges
Infundibulum: flared, trumpet-shaped distal (ovarian) end
Fimbriae: feathery projections on infundibulum
Mesosalpinx: the superior portion of the broad ligament that enfolds uterine
Ovarian ligament: ovaries → uterus
Suspensory ligament: ovaries → pelvic wall. Contains ovarian artery, vein, and nerves
Mesovarium: ovaries → broad ligament



Mucosa of the uterine tube wall

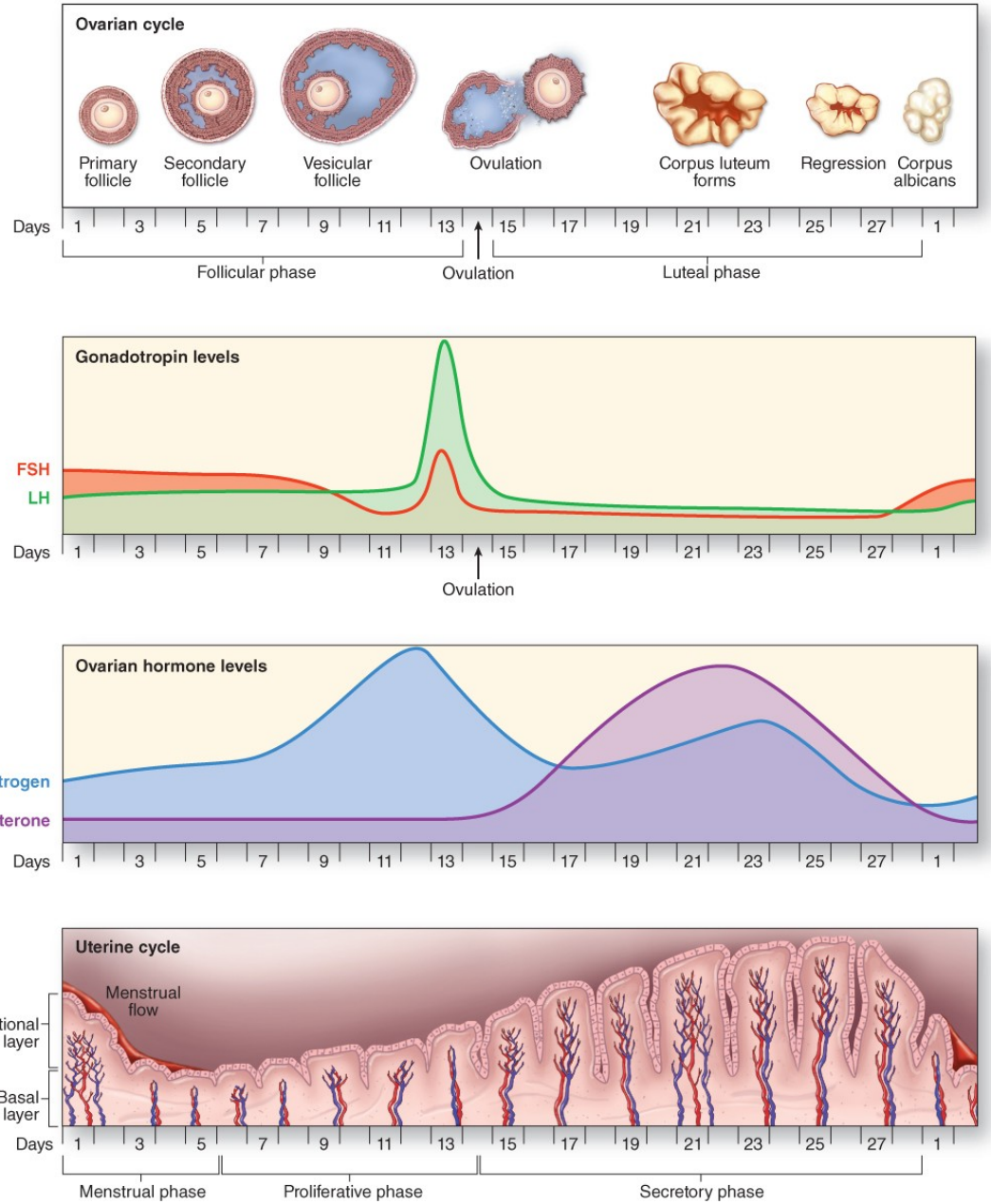


(a) A cross section of the uterine tube at the ampulla shows the interwoven circular (**C**) and longitudinal (**L**) layers of smooth muscle in the muscularis and in the complex of folded mucosa, the lamina propria (**LP**) underlying a simple columnar epithelium (arrows).

(b) The oviduct mucosa, with folds projecting into the lumen (**L**), has simple columnar epithelium (**E**) on the lamina propria (**LP**).

MEDICAL APPLICATION: Endometriosis results when endometrial tissue grows on the ovaries, oviducts, or elsewhere. Under the influence of estrogen and progesterone, the ectopic tissue grows and degenerates monthly but cannot be removed effectively from the body. In addition to pain endometriosis can produce inflammation, ovarian cysts, adhesions, and scar tissue that can cause infertility

Correlation of ovarian and menstrual cycles with levels of their controlling hormones.



The cyclic development of **ovarian follicles** and the **corpus luteum**, controlled by the pituitary **gonadotropins** FSH and LH, lead to cyclic shifts in the levels of the major ovarian hormones: steroidal **estrogens and progesterone**.

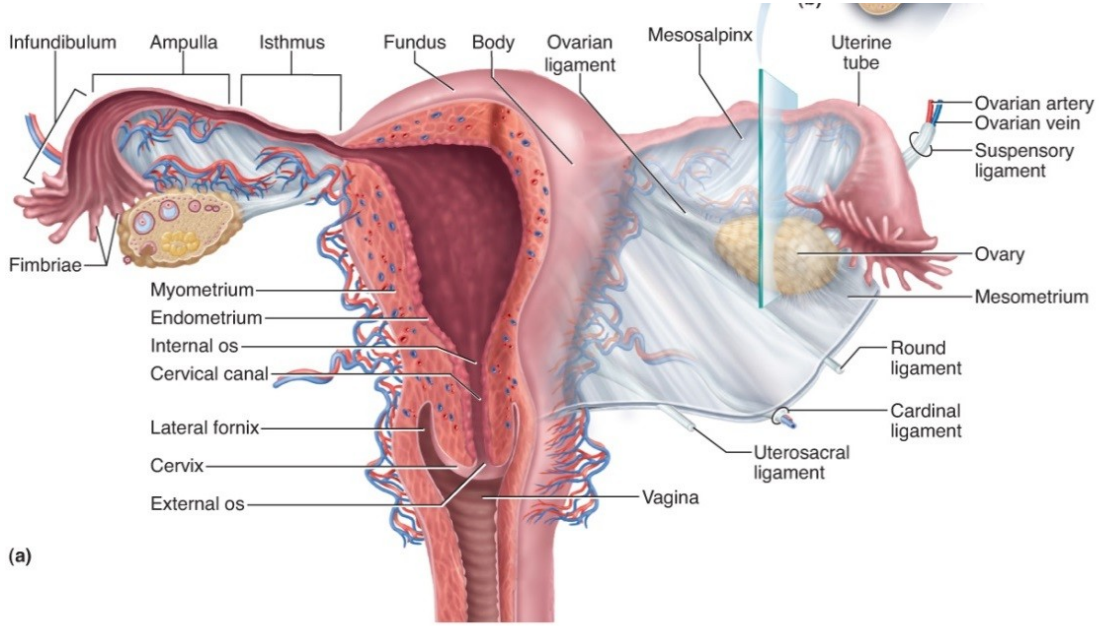
Estrogen stimulates the proliferative phase of the uterine cycle and its level peaks near the day of ovulation,
After ovulation the corpus luteum forms and produces both progesterone and estrogens, which together promote growth and development of the endometrial **functional layer.**

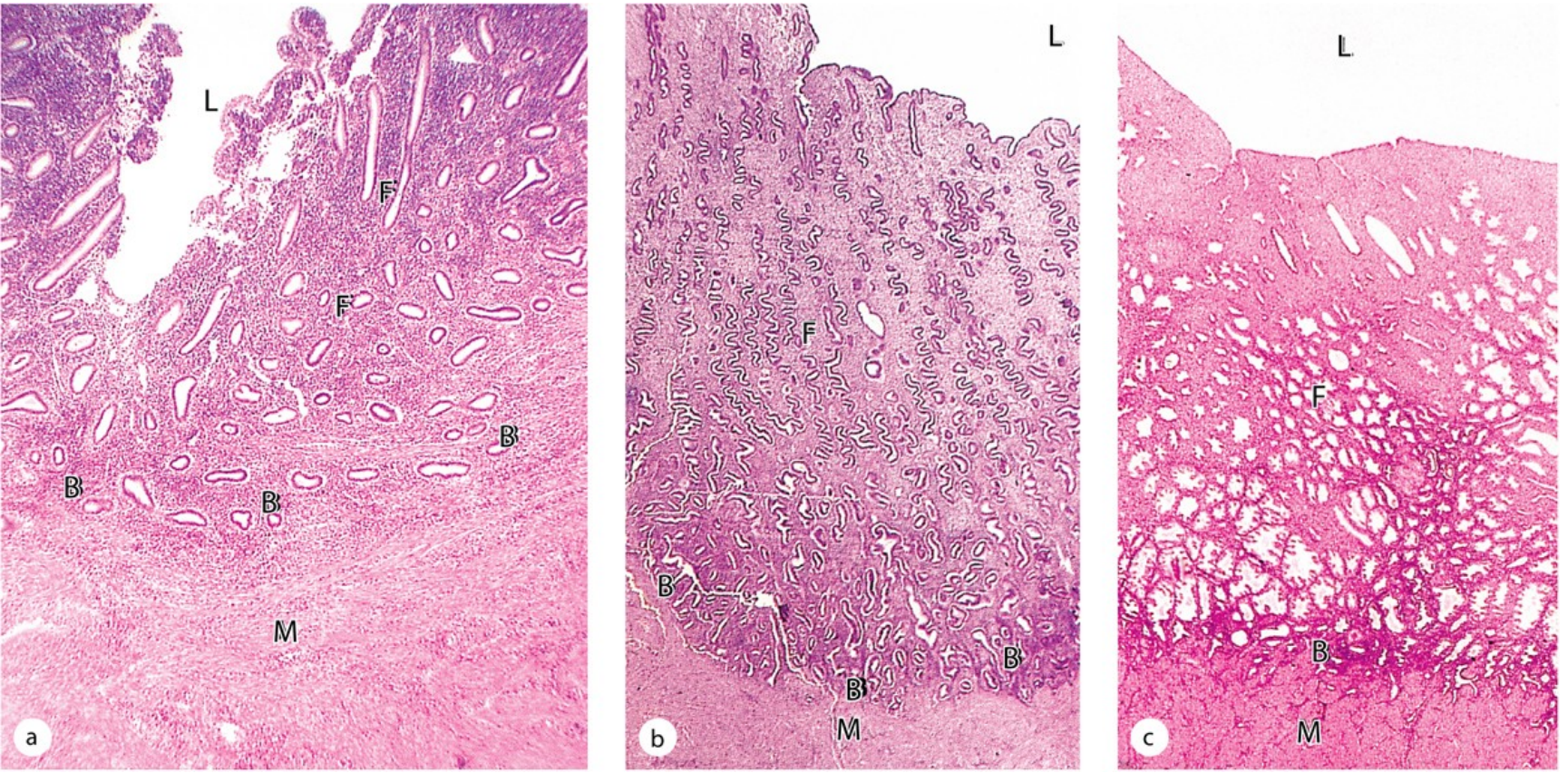
Without fertilization, regression of the corpus luteum leads to declining levels of the steroid hormones endometrial issue sloughs off as the menstrual flow,

http://ed.ted.com/lessons/how-menstruation-works-emma-bryce

Fundus: broad superior curvature
Body (corpus): middle portion
Cervix: cylindrical inferior end
Lumen is roughly triangular
Upper two corners are openings to **uterine tube**
Cervical canal connects lumen to vagina
Internal os: superior opening of canal into body of uterus
External os: inferior opening of canal into vagina
Cervical glands: secrete mucus that prevents spread of microorganisms from vagina to uterus

The Uterus: thick muscular chamber that opens into roof of the vagina and usually tilts forward over the urinary bladder





Proliferative, secretory, and premenstrual phases in the uterus.

Endometrium:
Functional layer (**F**)
closest to the lumen (**L**)
Basal layer (**B**)

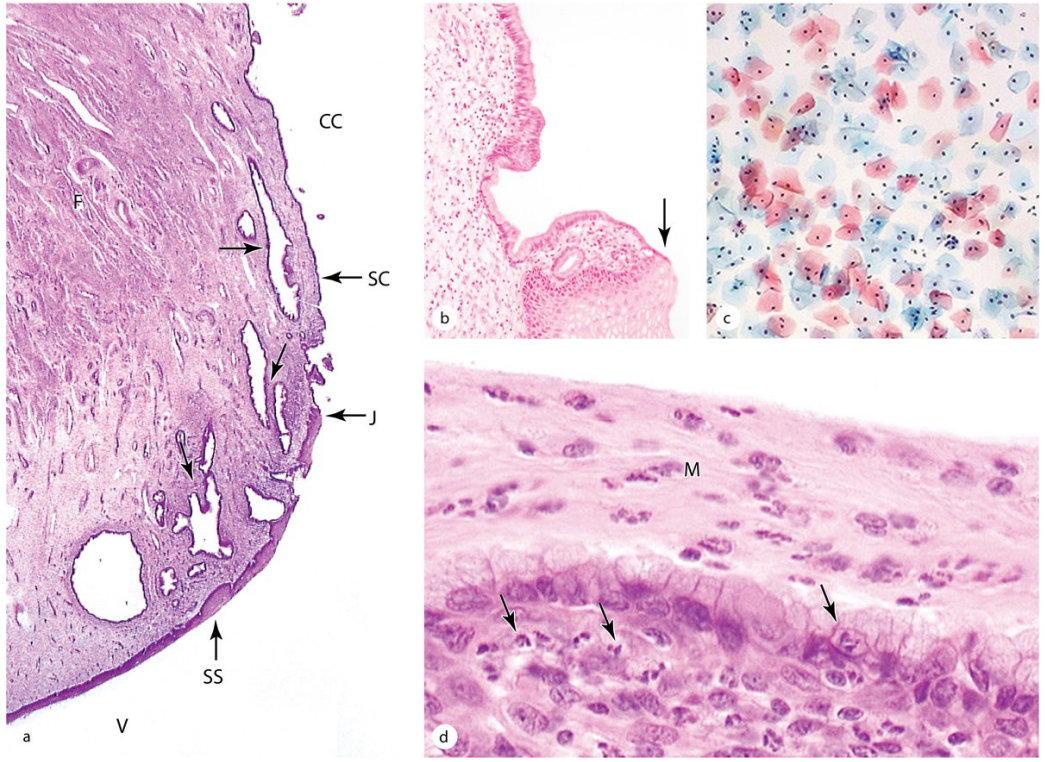
Myometrium (**M**).

(a) proliferative phase: the functional layer is still relatively thin, the stroma is more cellular, and the glands (**G**) are relatively straight, narrow, and empty.
(b) secretory phase: functional layer is four times thicker than the basal layer. The tubular glands have wider lumens containing secretory product and coil tightly up through the stroma
(c) premenstrual phase: constriction of arteries produces hypoxia. Glands (**G**) dissolve, breakdown of the stromal matrix.

TABLE 22–1 Summary of events of the menstrual cycle.

	Stage of Cycle			
	Proliferative	Secretory or Luteal		Menstrual
Main actions of pituitary hormones	Follicle-stimulating hormone stimulates rapid growth of ovarian follicles	Peak of luteinizing hormone at the beginning of secretory stage, secreted after estrogen stimulation, induces ovulation and development of the corpus luteum		
Main events in the ovary	Growth of ovarian follicles; dominant follicle reaches preovulatory stage	Ovulation	Development of the corpus luteum	Degeneration of the corpus luteum
Dominant ovarian hormone	Estrogens, produced by the growing follicles, act on vagina, tubes, and uterus	Progesterone, produced by the corpus luteum, acts mainly on the uterus		Progesterone production ceases
Main events in the endometrium	Growth of the mucosa after menstruation	Further growth of the mucosa, coiling of glands, secretion		Shedding of part of the mucosa about 14 days after ovulation

Cervix



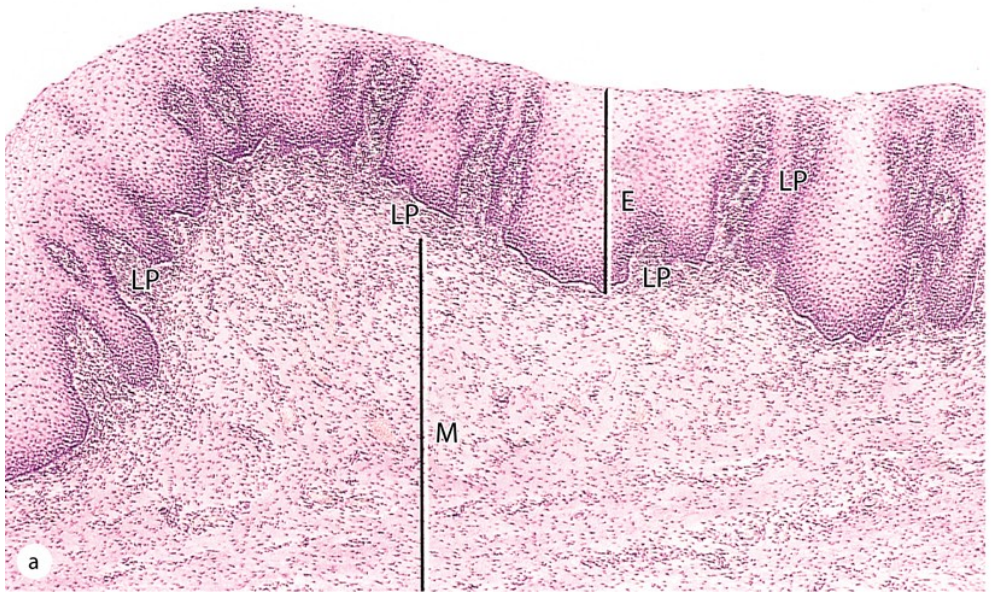
The mucosa of the cervical canal (**CC**) is continuous with the endometrium and like that tissue is lined by simple columnar epithelium (**SC**) and cervical mucous glands (**arrows**).

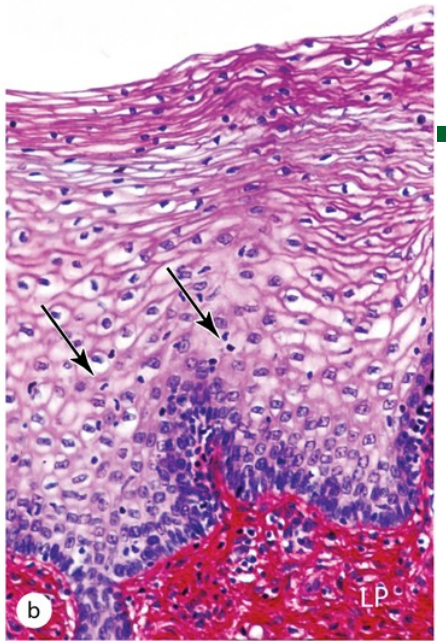
At the external os, columnar epithelium → stratified squamous epithelium (**SS**) covering the exocervix and vagina.

(c) Exfoliative cytology of epithelial cells from the exocervical mucosa in a routine cervical smear. The squamous cells, stain differently according to their content of keratins. Cells with atypical nuclei or other abnormalities can be detected by this method that is used routinely to check for cervical carcinoma.

(d) The endocervical mucosa is exposed to a relatively high population of microorganisms and normally has a large number of neutrophils and other leukocytes (**arrows**)

MEDICAL APPLICATION: The incidence of cervical cancer worldwide has been greatly reduced by widespread, routine screening by exfoliative cytology to examine for dysplasia of the cervical epithelium. The test called the Pap smear after its developer George Papanicolaou, who introduced this diagnostic technique in the 1920s, uses cells that have been lightly scraped from cervix. Abnormal cells suggestive of precancerous changes in the epithelium are then detected microscopically. The epithelial dysplasia that precedes squamous cell neoplasia, the most common type of cervical cancer, occurs in metaplastic cells of the transformation zone at a mean age of 54 years. The human papillomas virus (HPV) is strongly implicated in the pathogenesis





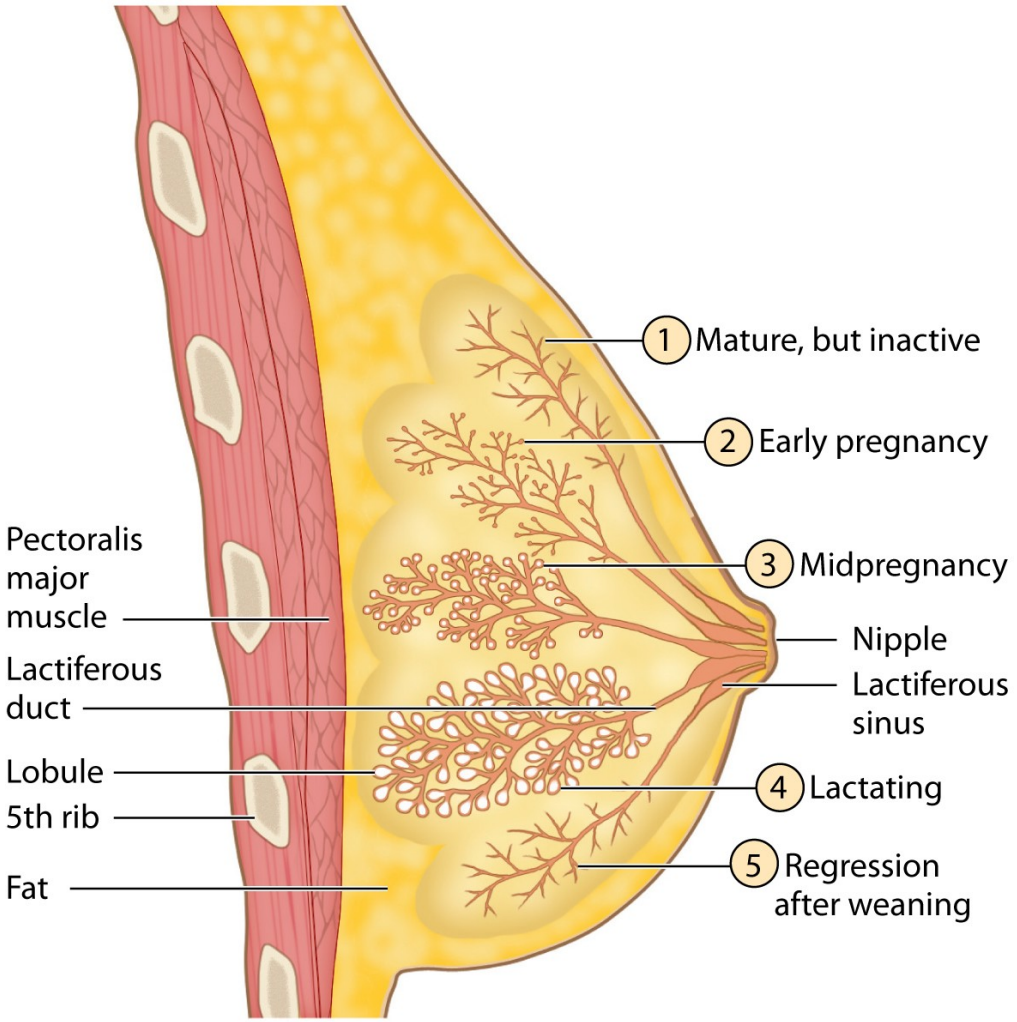
Vagina

The vagina has mucosal, muscular, and adventitial layers.
Lamina propria (**L**) is highly cellular and extends narrow papillae into the thick, nonkeratinized stratified squamous epithelium (**E**). The muscular layer (**M**) has bundles of smooth muscle arranged in a circular manner near the mucosa and longitudinally near the

❯❯ MEDICAL APPLICATION

Atrophic vaginitis involves thinning or atrophy of the vaginal epithelium caused by diminished estrogen levels and occurs most often in postmenopausal woman. This change allows the more frequent inflammation and infections characteristic of this condition. Primary squamous cell carcinoma of the vagina occurs rarely, with most vaginal malignancies having spread secondarily from the cervix or vulva.

Mammary gland

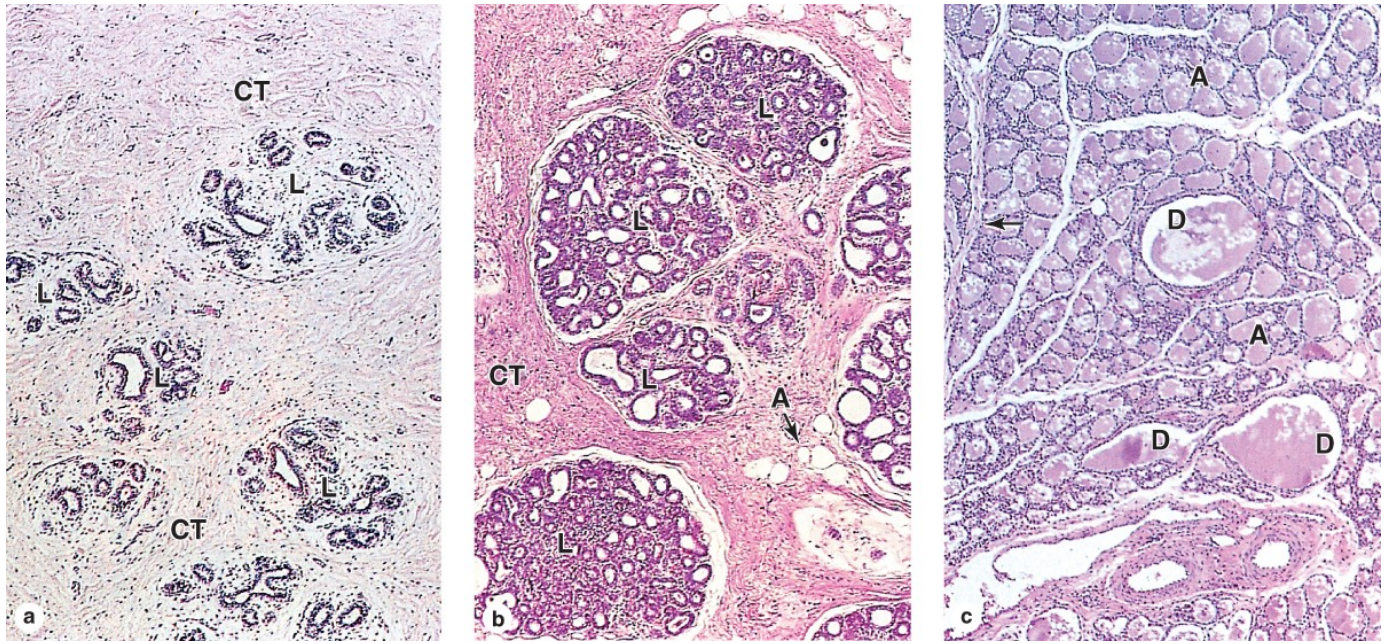


(**1**) Before pregnancy, the gland is inactive, with small ducts and only a few small secretory alveoli.
(**2**) Alveoli develop and begin to grow early in a pregnancy.
(**3**) By midpregnancy, the alveoli and ducts have become large and have dilated lumens.
(**4**) At parturition and during the time of lactation, the alveoli are greatly dilated and maximally active in production of milk components.
(**5**) After weaning, the alveoli and ducts regress with apoptotic cell death.

MEDICAL APPLICATION When a woman is breast-feeding, the nursing action of the child stimulates tactile receptors in the nipple, resulting in liberation of the posterior pituitary hormone **oxytocin.** This hormone causes contraction of the smooth muscle of the lactiferous sinuses and ducts, as well as the myoepithelial cells of alveoli, resulting in the milk-ejection reflex.

Negative emotional stimuli, such as frustration, anxiety, or anger, can inhibit the liberation of oxytocin and thus prevent the reflex.

Alveolar development in the breast during pregnancy



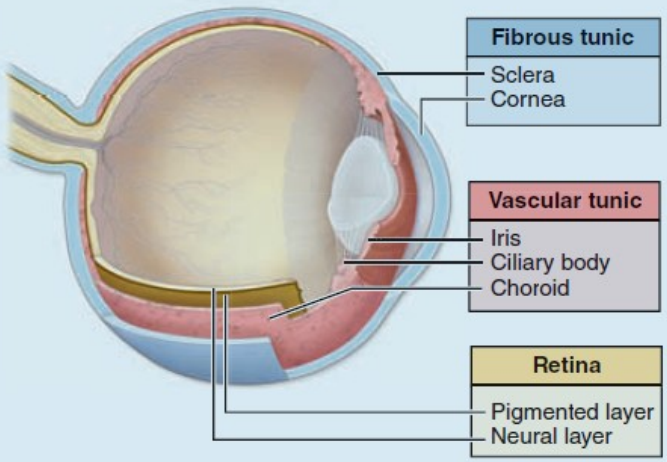
(a) Nonpregnant glands inactive, with small ducts and few lobules (**L**) having secretory alveoli which are not well-developed.
(b) During pregnancy: duct system grows, secretory units much larger and more extensively branched.
(c) During lactation, the lobules are greatly enlarged and the lumens of both the numerous glandular alveoli (**A**) and the excretory ducts (**D**) are filled with milk.

MEDICAL APPLICATION Breast cancer is almost always derived from epithelial cells in the terminal lobules of the glands. **Invasive ductal carcinoma**: intralobular ducts invade the surrounding stroma, forming a fixed, palpable mass. If the treatment is mastectomy, axillary lymph nodes are usually also removed surgically and examined histologically for the presence of metastatic mammary carcinoma cells. Early detection (eg, through self-examination, mammography, ultrasound, and other techniques) and consequent early treatment have significantly reduced the mortality rate.
Bacterial infection of a mammary gland, or **acute mastitis**, may occur in the lactating or involuting breast, usually
after obstruction by milk left within small components of the duct system.

Eye & Ear

BI 455 CHAPTER 23

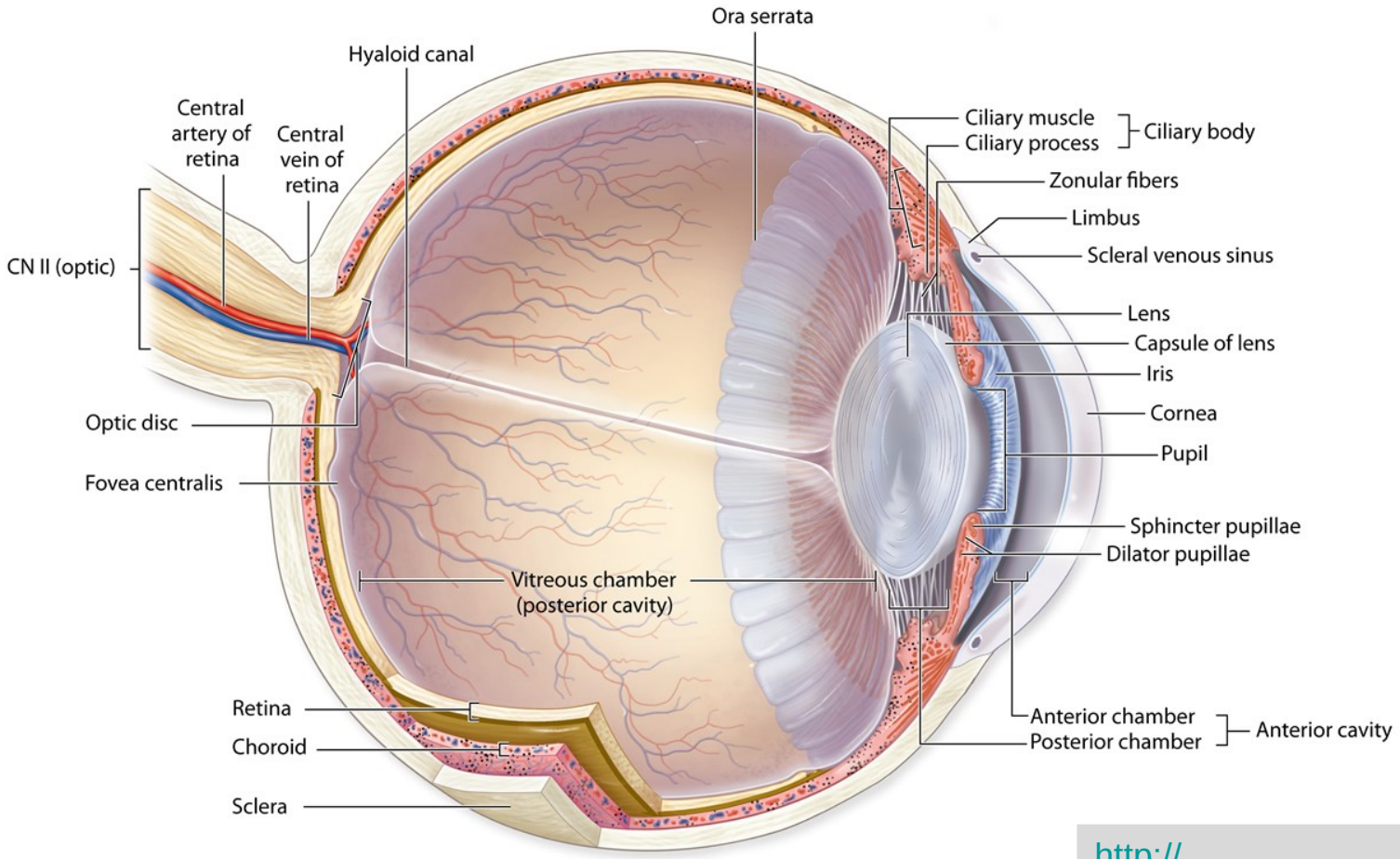
http://ed.ted.com/lessons/the-evolution-of-the-human-eye-joshua-harvey



Structures	Components	Function
Fibrous Tunic (External Layer)		
Sclera	Dense irregular connective tissue	Supports eye shape Protects delicate internal structures Extrinsic eye muscle attachment site
Cornea	Two layers of epithelium with organized connective tissue in between	Protects anterior surface of the eye Refracts (bends) incoming light
Vascular Tunic (Middle Layer)		
Choroid	Areolar connective tissue; highly vascularized	Supplies nourishment to retina Pigment absorbs extraneous light
Ciliary body	Ciliary smooth muscle and ciliary processes; covered with a secretory epithelium	Holds suspensory ligaments that attach to the lens and change lens shape for far and near vision Epithelium secretes aqueous humor
Iris	Two layers of smooth muscle (sphincter pupillae and dilator pupillae) and connective tissue, with a central pupil	Controls pupil diameter and thus the amount of light entering the eye
Retina (Internal Layer)		
Pigmented layer	Pigmented epithelial cells	Absorbs extraneous light Provides vitamin A for photoreceptor cells
Neural layer	Photoreceptors, bipolar neurons, ganglion cells, and supporting Müller cells	Detects incoming light rays; light rays are converted to nerve signals and transmitted to the brain

Internal anatomy of the eye

Three major layers or tunics of the wall
Refractive elements: cornea, lens, and vitreous



http://ed.ted.com/lessons/eye-vs-camera-michael-mauser

The lens: transparent, elastic tissue that focuses light on the retina.

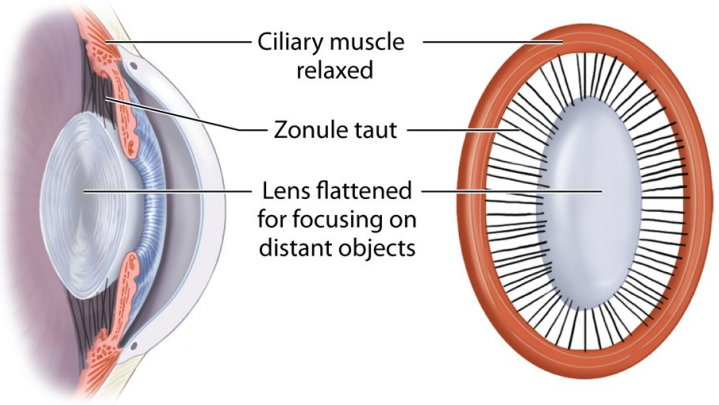
Lens capsule (**LC**): thick, external lamina

Columnar lens epithelium (**LE**): Epithelial cells proliferate and give rise to lens fibers.

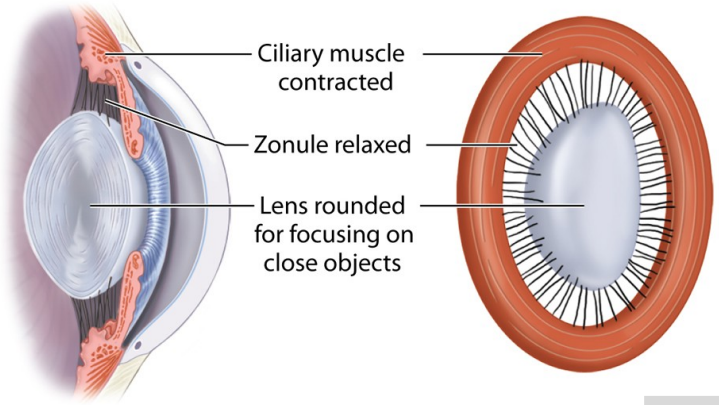
Differentiating lens fibers (**DLF**): have nuclei, making crystallin proteins

Mature lens fibers (**MLF**): No nuclei, densely packed, transparent

Accommodation: changes in shape of lens keep images focused on the retina



(a)



(b)

(a)<u>Distant vision:</u> Ciliary muscle relaxes, lens flattens

(b)<u>Near vison:</u> Ciliary muscle contracts, lens rounds

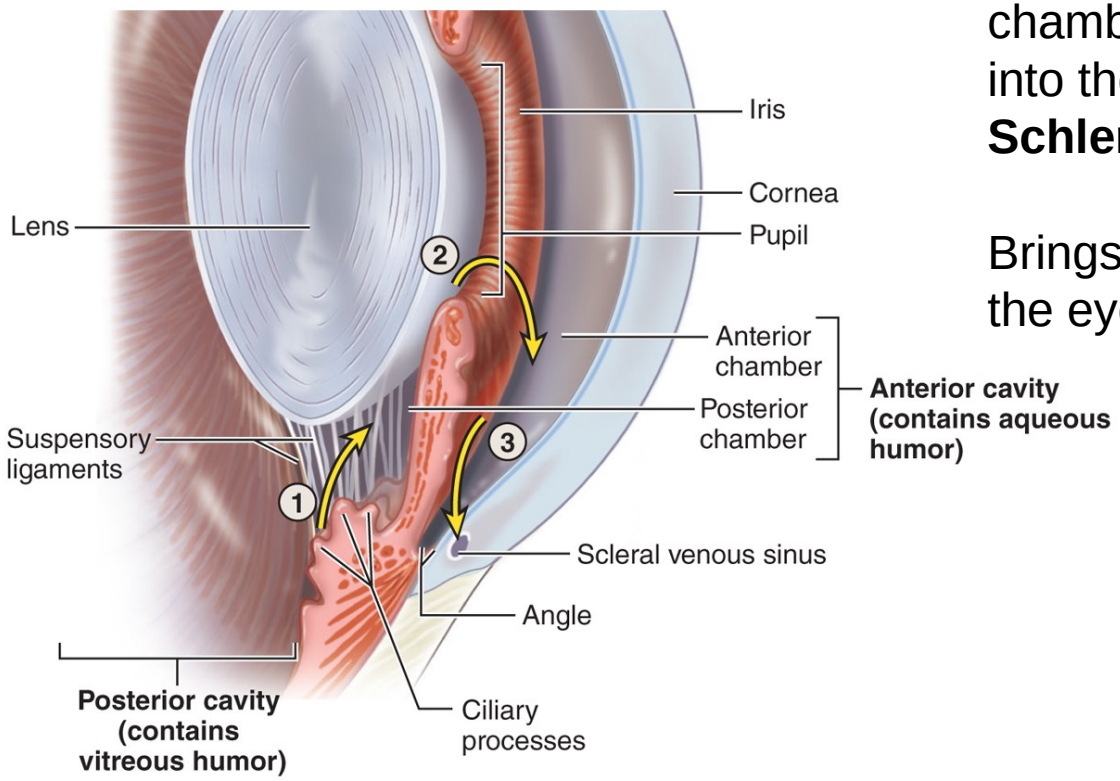
MEDICAL APPLICATION

Presbyopia (far sightedness): Denaturation of crystallins commonly begins to occur in lens fibers, making them less transparent.

Cataract: areas of lens become opaque. the condition is termed a Causes: excessive UV exposure, trauma, diabetes mellitus, and hypertension.

Lens accommodation: https://

Production and removal of aqueous humor



1. Aqueous humor is secreted by the ciliary processes into the posterior chamber.
2. Aqueous humor moves from the posterior chamber, through the pupil, to the anterior chamber.
3. Excess aqueous humor is resorbed via the scleral venous sinus.

Eye Anatomy- Vitreous and Aqueous Humor: https://www.youtube.com/watch?v=7E40NZsQO4E

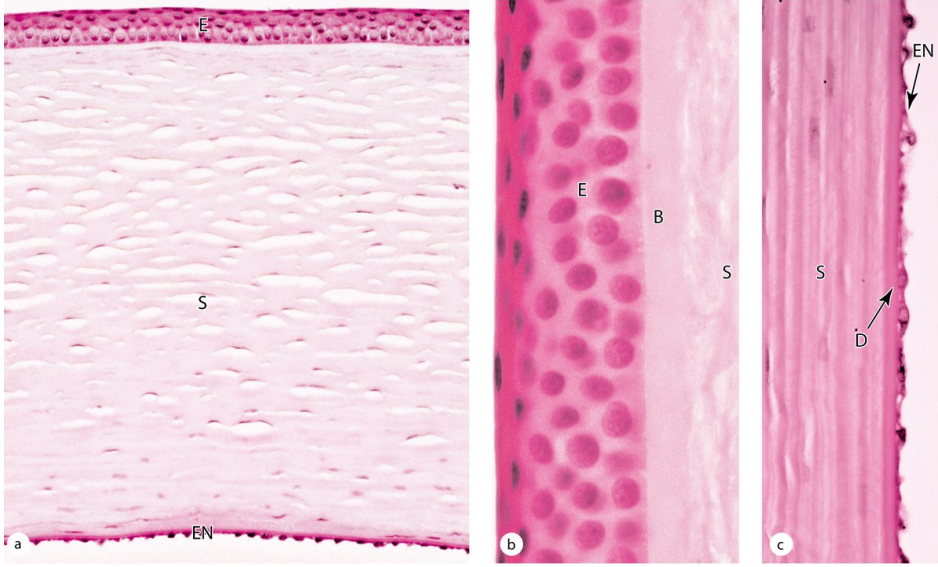
Aqueous humor secreted from **ciliary processes** into posterior chamber of the anterior cavity, flows into the anterior chamber through the **pupil**, and drains into the **scleral venous sinus (canal of Schlemm)**.

Brings nutrients to the **anterior cavity** of the eye.

MEDICAL APPLICATION:.
Glaucoma: If aqueous humor drainage is impeded, intraocular pressure pushes vitreous body against the retina

Cornea

External stratified squamous epithelium (**E**): nonkeratinized, sensory-free nerve endings that trigger the blinking reflex.
Stroma (**S**): Collagen fibers with flattened **keratocytes**. Avascular, nutrients diffuse aqueous humor behind the cornea



Medical Application: The shape of the cornea can be changed via laser - assisted in situ keratomileusis **(LASiK)** surgery. The corneal epithelium is displaced as a flap and the stroma reshaped by an excimer laser which vaporizes collagen and keratocytes in a highly controlled manner with no damage to adjacent cells or ECM. LASiK surgery is used to correct myopia (near-sightedness), hyperopia (far-sightedness), or astigmatism (irregular curvature of the cornea).

Corneal grafts (transplants) between unrelated individuals can usually be accomplished successfully without immune rejection due in part to this tissue's lack of both a vascular supply and lymphatic drainage.

https://www.youtube.com/watch?v=TL4m7cPYyUY

Corneoscleral junction (limbus) and ciliary body

Corneoscleral junction (**CSJ**): corneal stroma merges with the opaque, vascular sclera (**S**).

Conjunctiva (**C**) cover the anterior sclera and lining the eyelids.

Scleral venous sinus (**SVS**), or canal of Schlemm: receives aqueous humor from an adjacent trabecular meshwork at the surface of the anterior chamber (**AC**).

Iris (**I**): anterior extension of ciliary body and Ciliary body:

- Ciliary muscle (**CM**): smooth muscle
- Ciliary processes (**CP**): epithelium, produces aqueous humor that flows through pupil into the anterior chamber
- Ciliary zonule (**CZ**): fibrillin-rich fibers that attach to the capsule of the lens (**L**)

Posterior chamber (**PC**)

Vitreous chamber (**VC**)

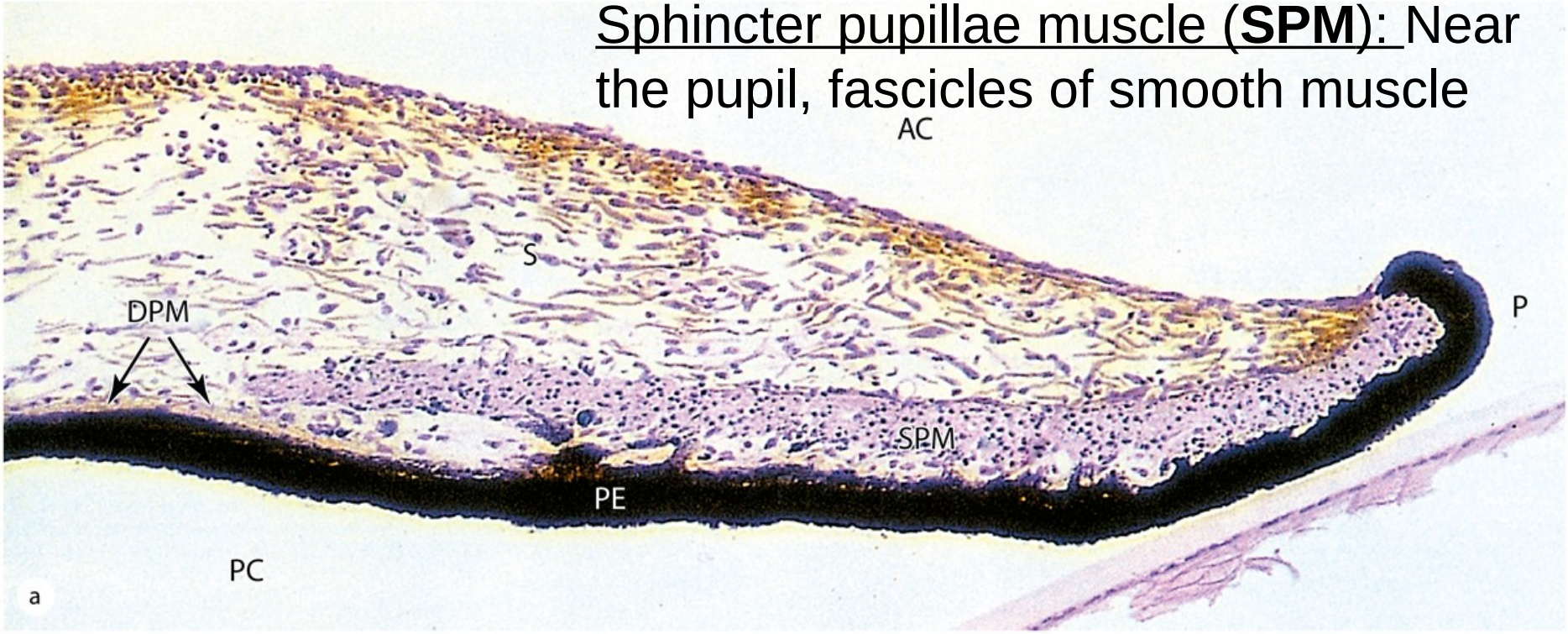
The iris regulates the amount of light to which the retina is exposed

Pupil (**P**): Space between iris

Anterior chamber (**AC**): On anterior surface of iris,

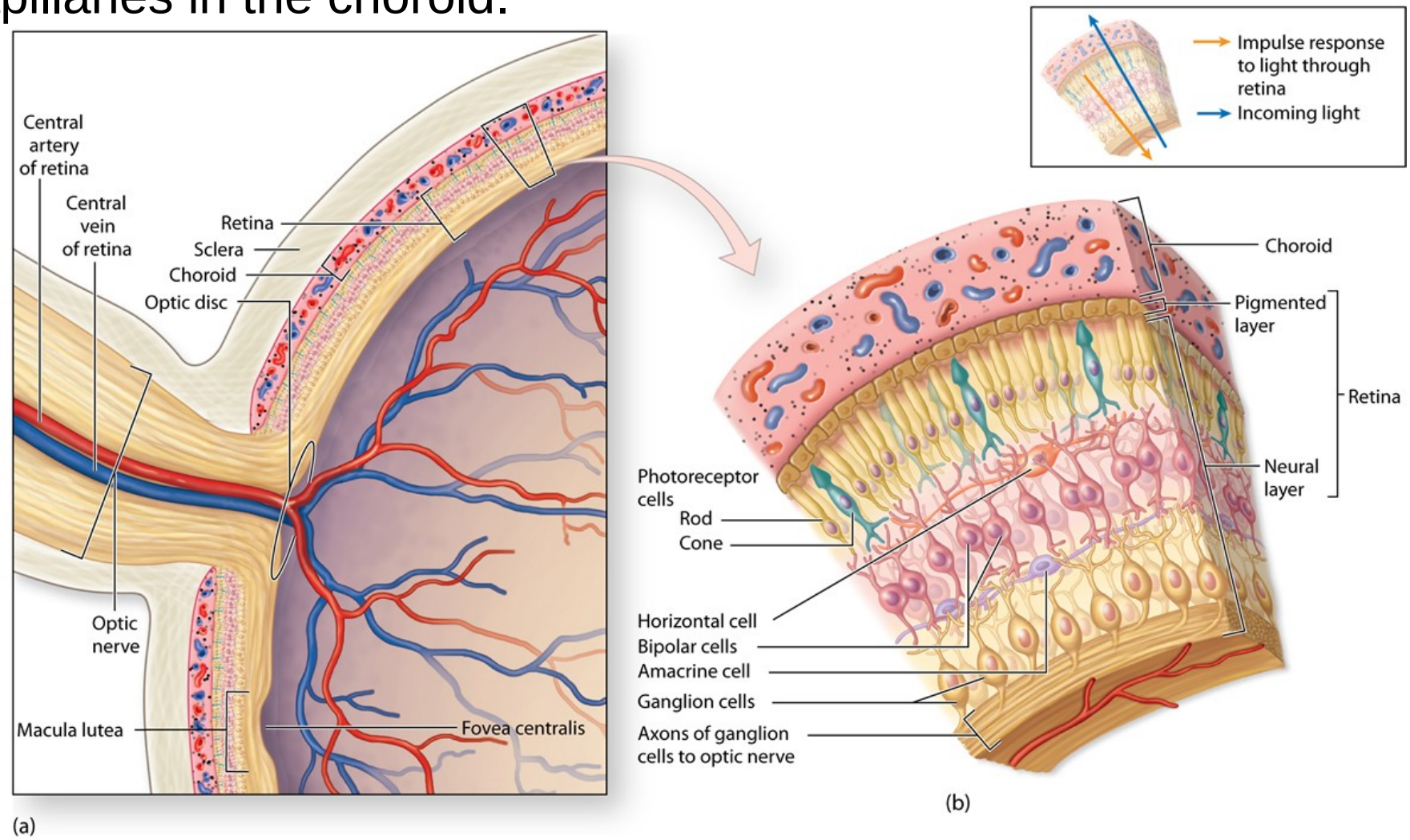
External pigmented epithelium (**PE**): Rich in melanin granules to protect the eye's interior from an excess of light. Dilator pupillae muscle (**DPM**): Extends along most of the iris.

Sphincter pupillae muscle (**SPM**): Near the pupil, fascicles of smooth muscle



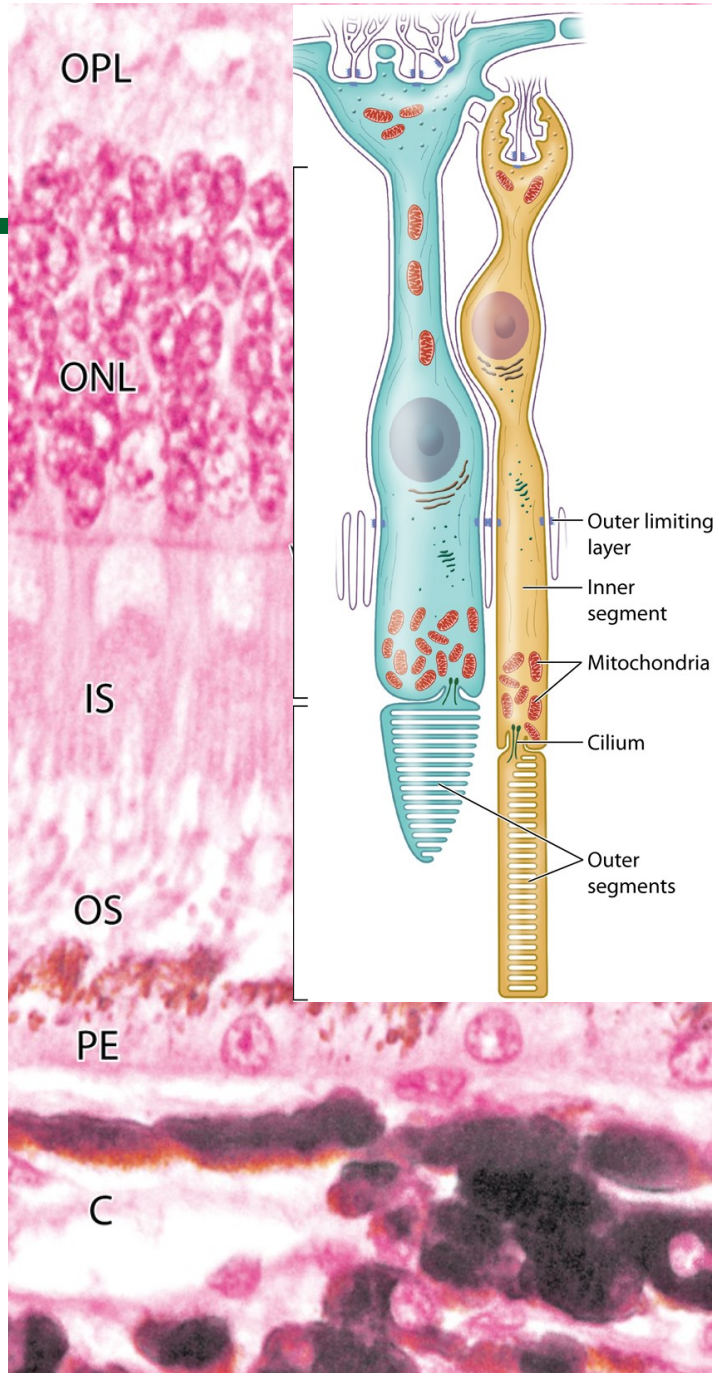
The retina is the thick layer of the eye inside the choroid.

Nutrients and O_2 for the outer retinal layers diffuse from capillaries in the choroid.

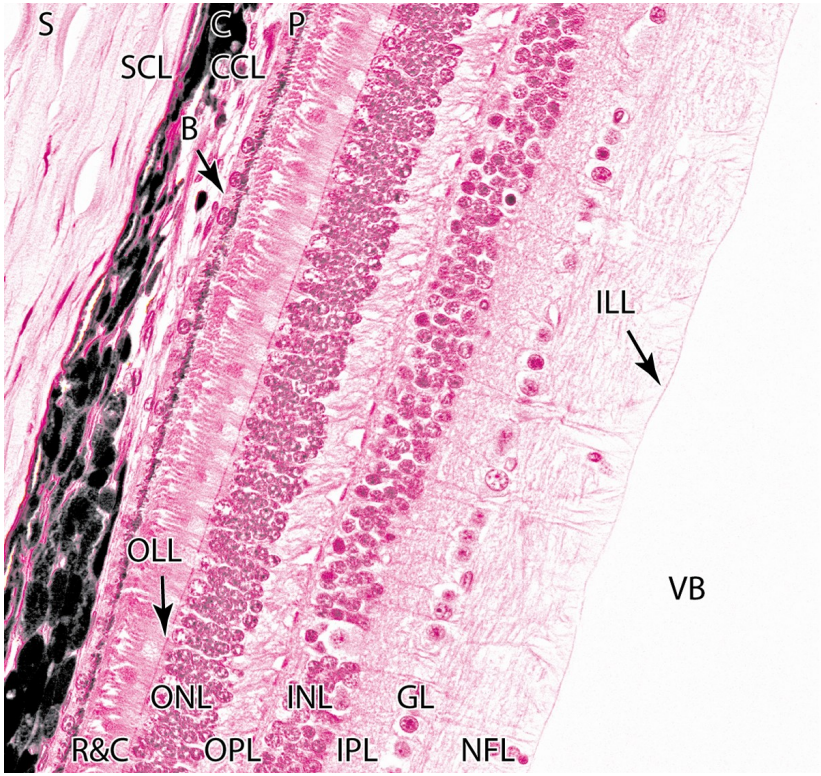


Retina: pigmented epithelium and photosensitive neural layer

Outer plexiform layer (**OPL**):
Axons of rods and cones
Outer nuclear layer (ONL):
Nuclei of rods and cones
Inner segments (**IS**):
mitochondria-rich
Outer segments (**OS**):
Photosensitive stacks of folded membranes with visual pigments
Pigmented epithelium (PE):
simple cuboidal cells inside choroid (C).



Lateral wall of the eye: sclera, choroid, and retina

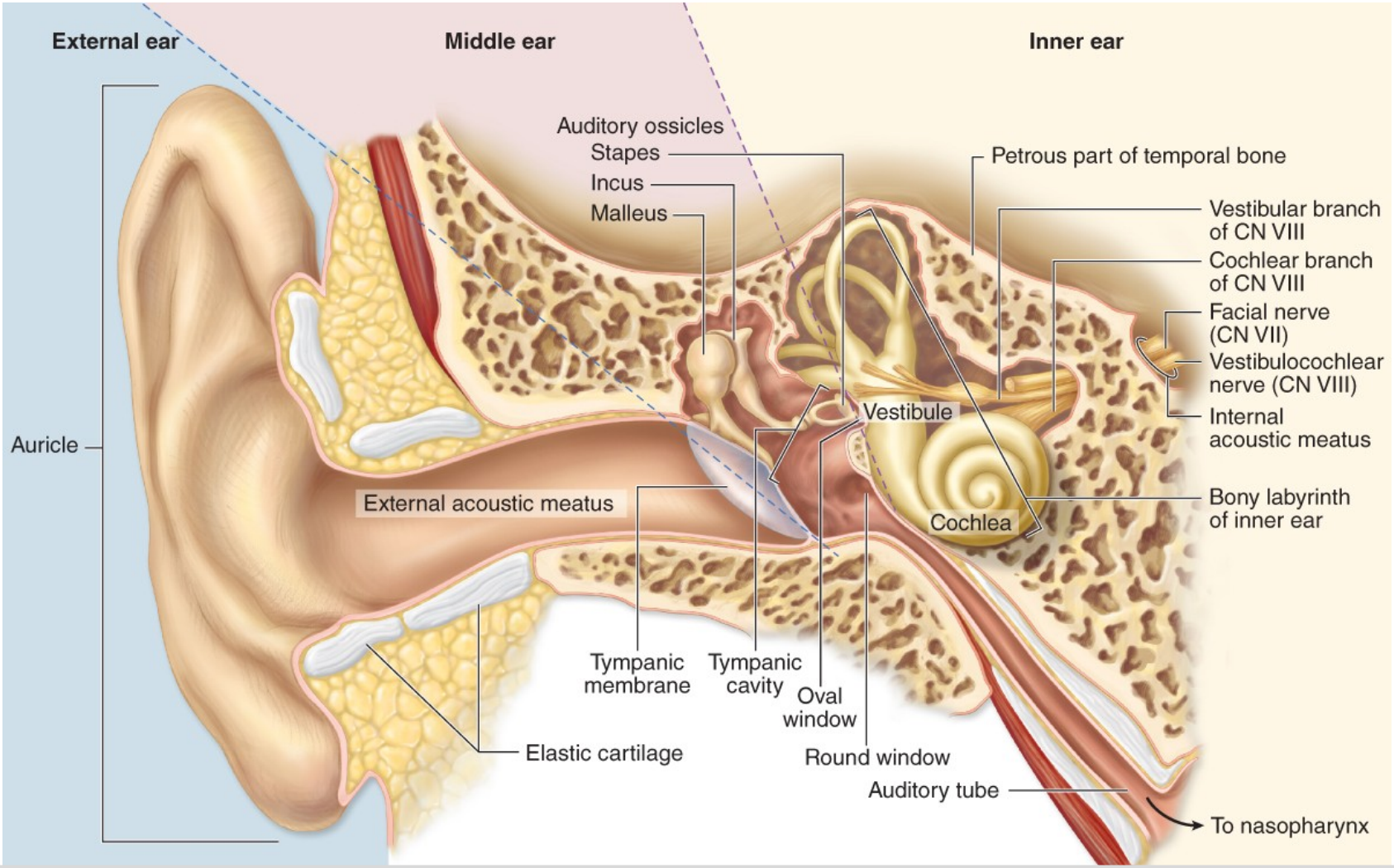


MEDICAL APPLICATION:

Retinal detachment: The pigmented epithelium and the photoreceptor layer of the retina, can be separated by head trauma. Loss of metabolic support causes this area of retina to dies. Prompt repositioning of the retina and reattaching it with laser surgery is an effective treatment.

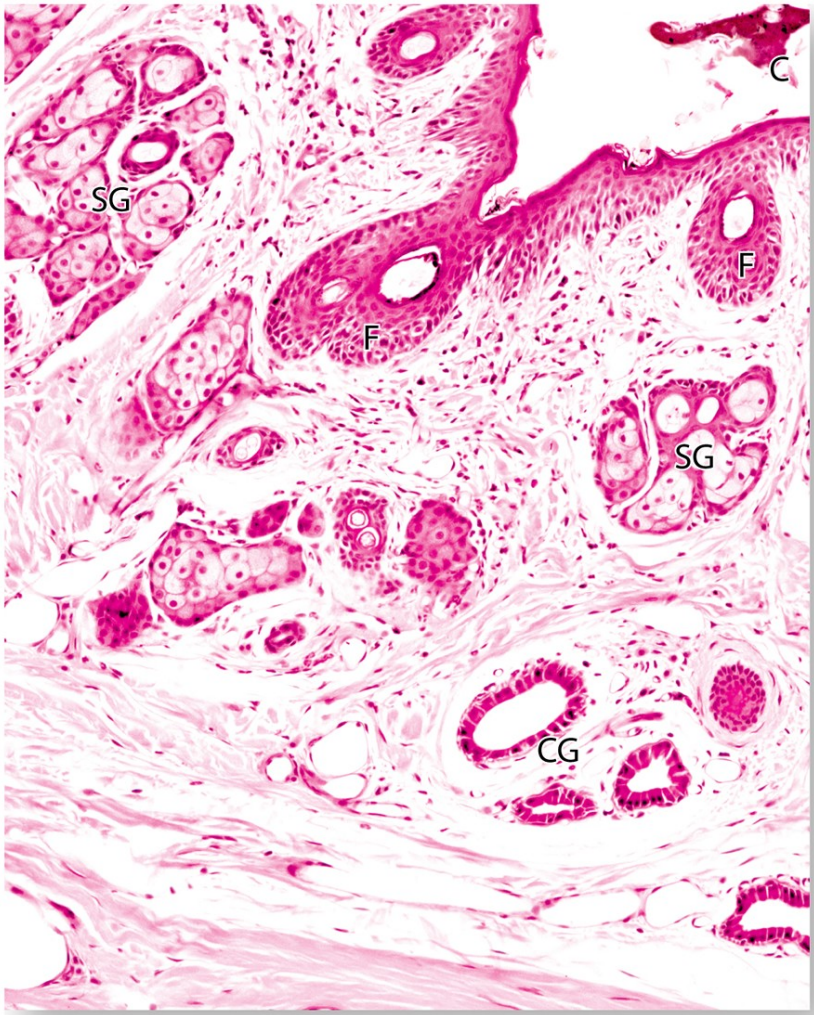
http://ed.ted.com/lessons/could-a-blind-eye-regenerate-david-davila

Major divisions of the ear: external, middle, and internal



Ear Anatomy | Inside the ear | 3D Human Ear animation video | Biology | Elearnin: https://www.youtube.com/watch?v=p3Oy4lodZU4

The external acoustic meatus leads from the opening in the auricle to the tympanic membrane (or eardrum).



Outer third of the acoustic meatus is lined with skin.

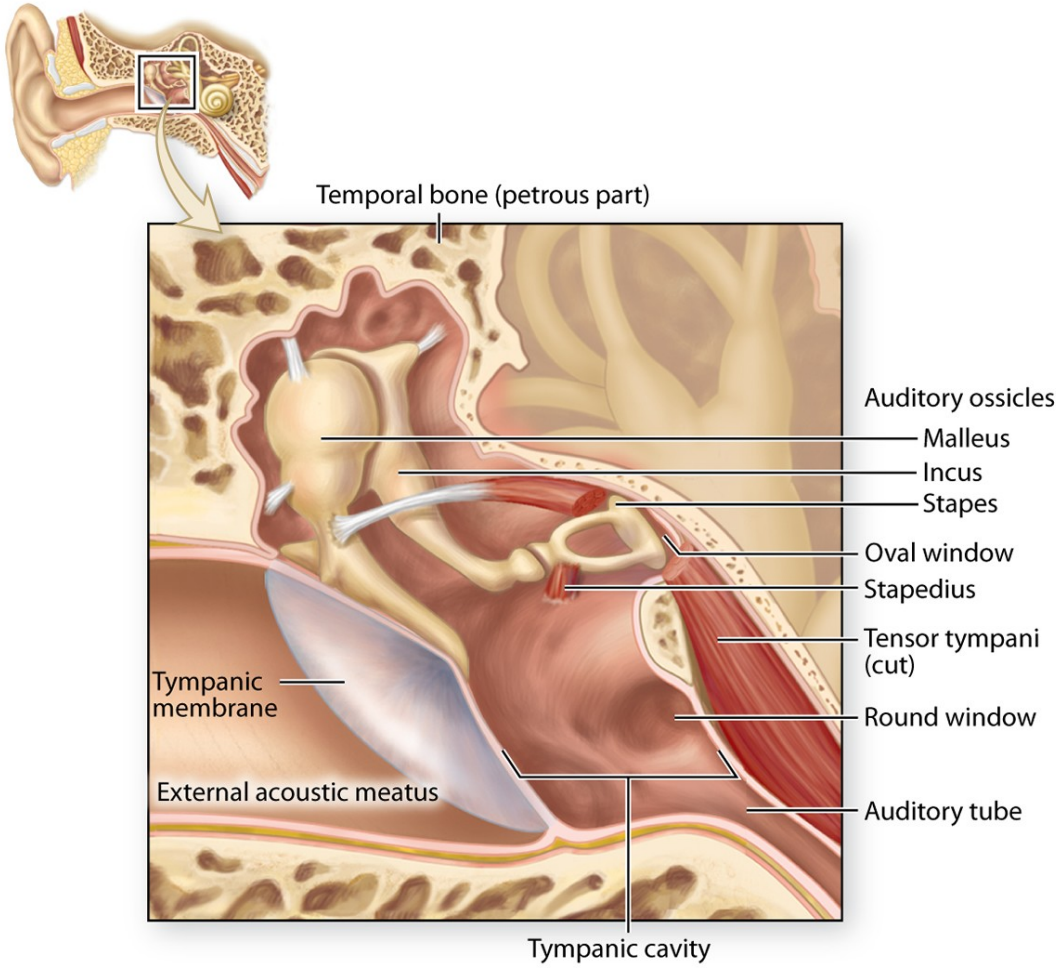
Small hair follicles (**F**)

Sebaceous glands (**SG**)
Ceruminous glands (**CG**): and modified apocrine sweat glands

Secretions from these two glands form a yellowish, waxy product called **cerumen** (**C**)

Middle Ear

Three **auditory ossicles** are enclosed by the **temporal bone** and the **tympanic membrane**



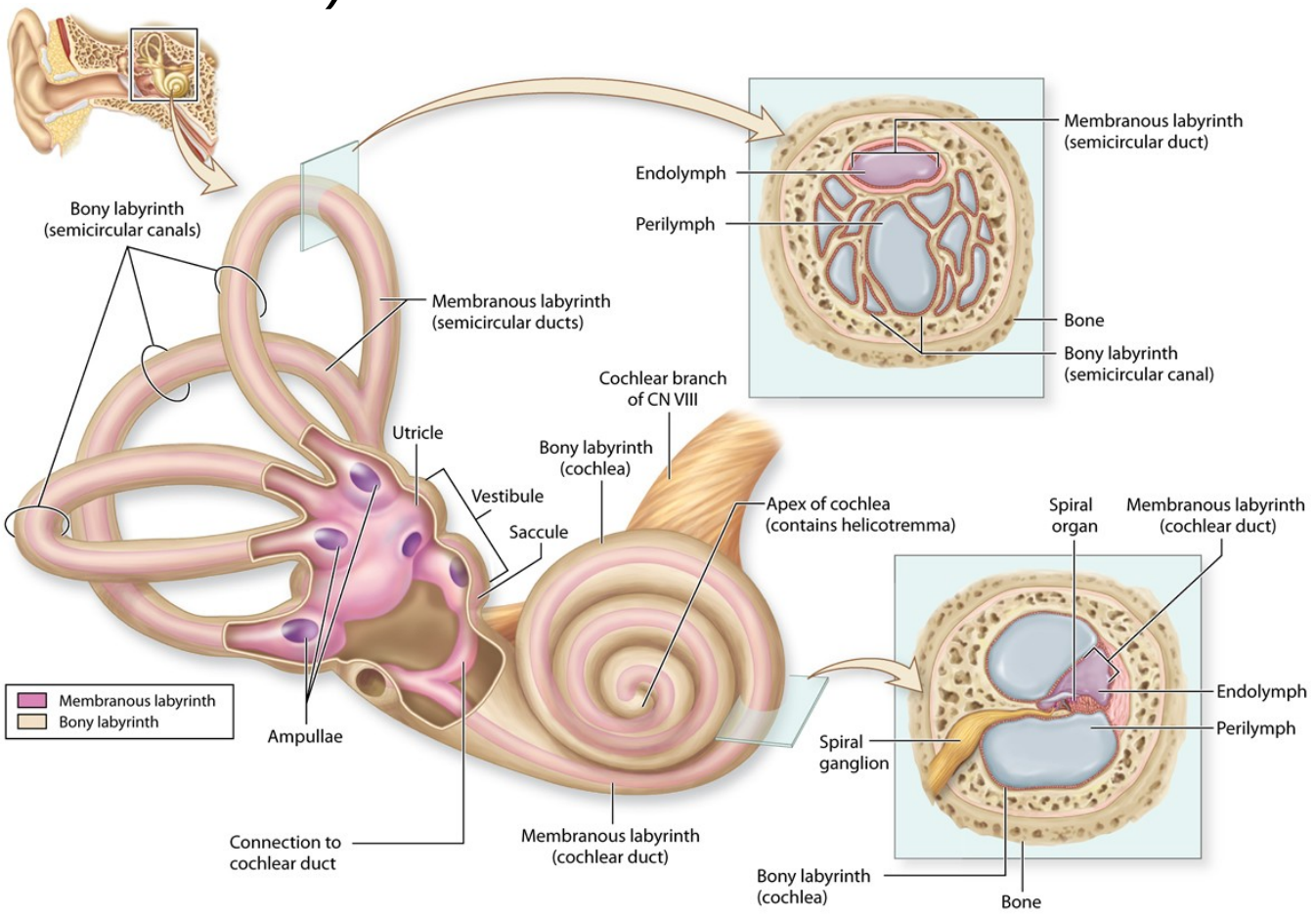
MEDICAL APPLICATION

Inflammation **(otitis media)** of middle ear vua viral or bacterial infections from the upper respiratory tract via the auditory tubes.

Otitis media is common in children, as short auditory tubes facilitate infection of the tympanic cavity.

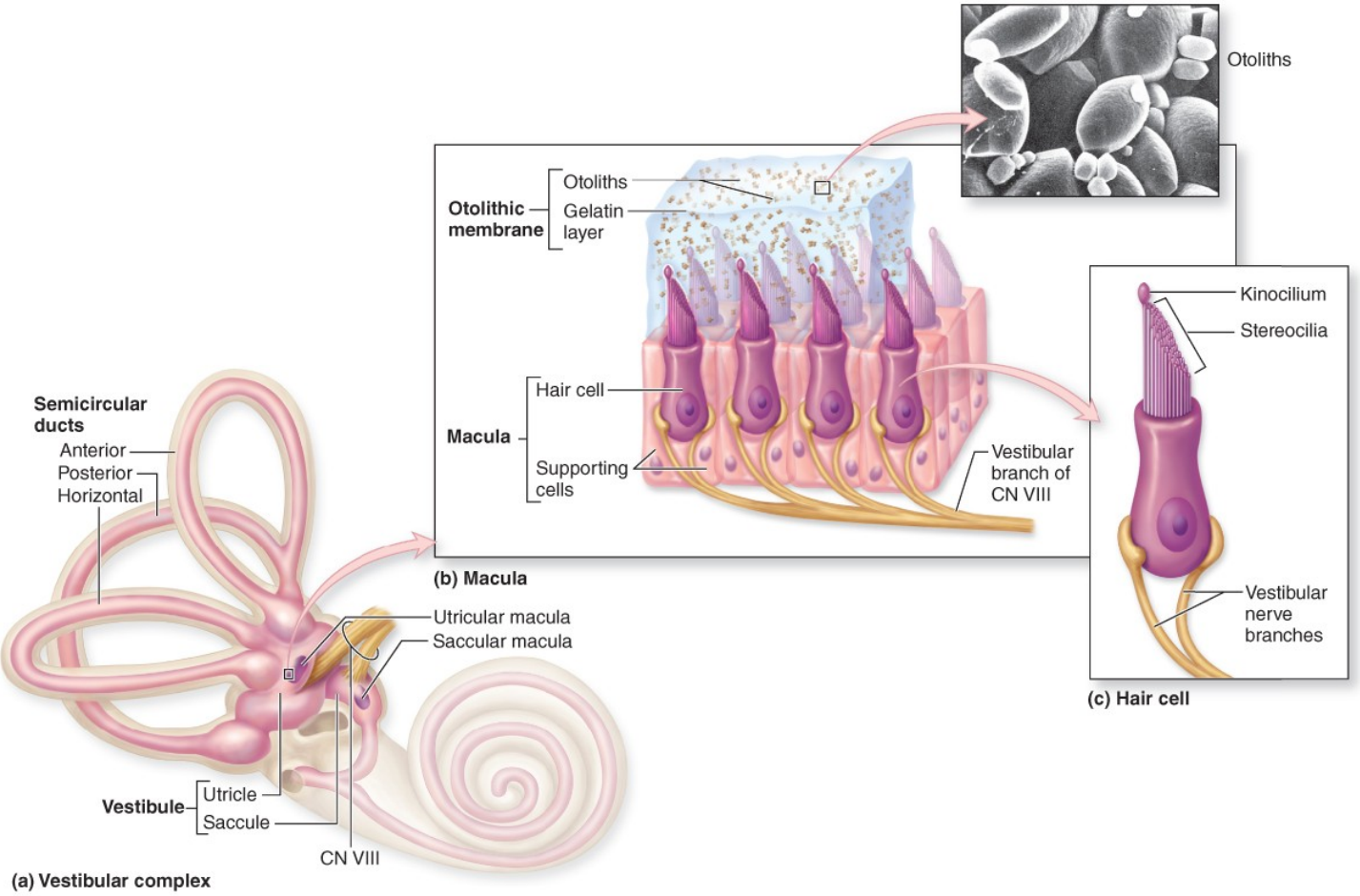
The internal ear consists of a cavity in the temporal bone, the bony labyrinth, which houses a fluid-filled membranous labyrinth.

The membranous labyrinth includes the vestibular organs for the sense of equilibrium and balance (the **saccule, utricle**, and **semicircular ducts**) and the **cochlea** for the sense of hearing.

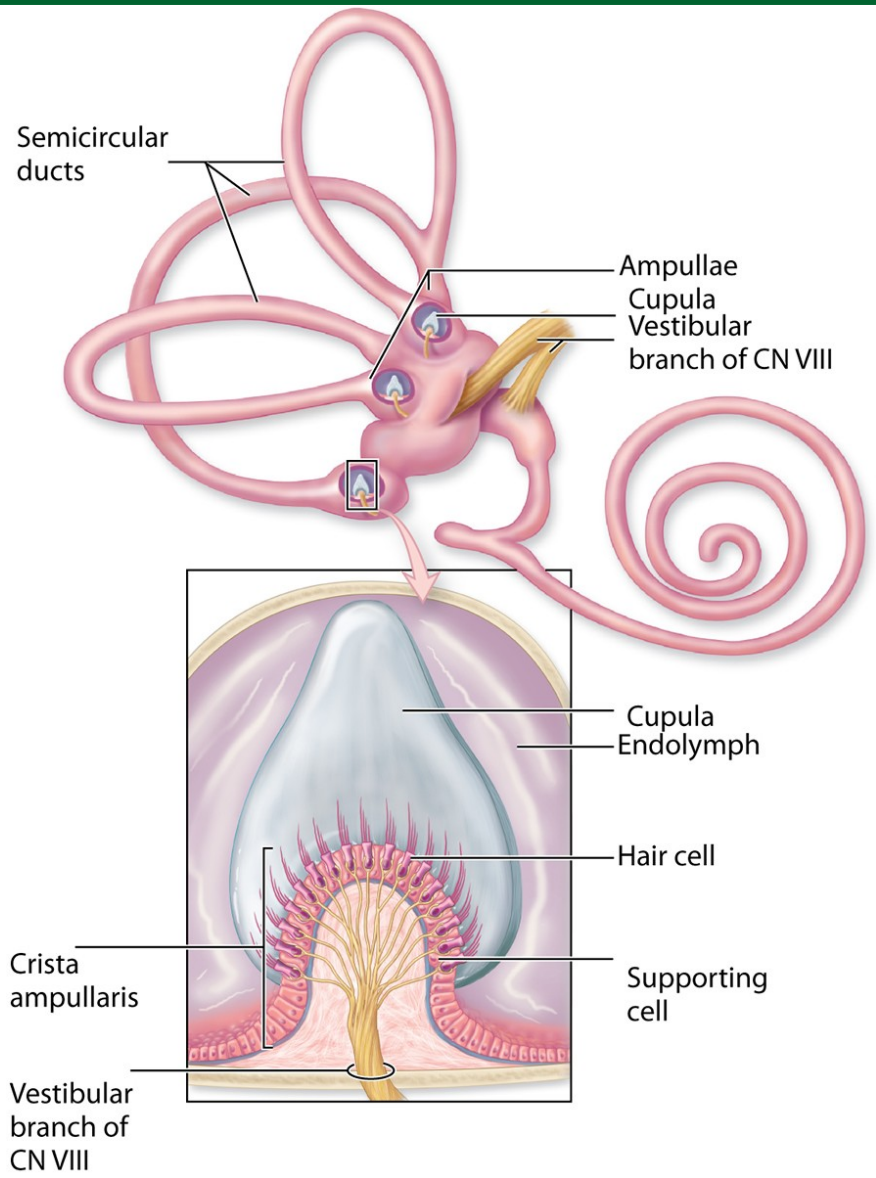


Vestibular maculae are specialized for detecting gravity and endolymph movements.

Hair cells: covered by a gelatinous otolithic layer, basal ends of the cells have synaptic connections with the nerve fibers.
Kinocilia and **stereocilia**: moved by gravity or movement of the head.



Ampullae and cristae of the semicircular ducts



Ampulla: end of semicircular ducts
Crista ampullaris: Contain hair cells with hair bundles projecting into layer of proteoglycan called the cupula.

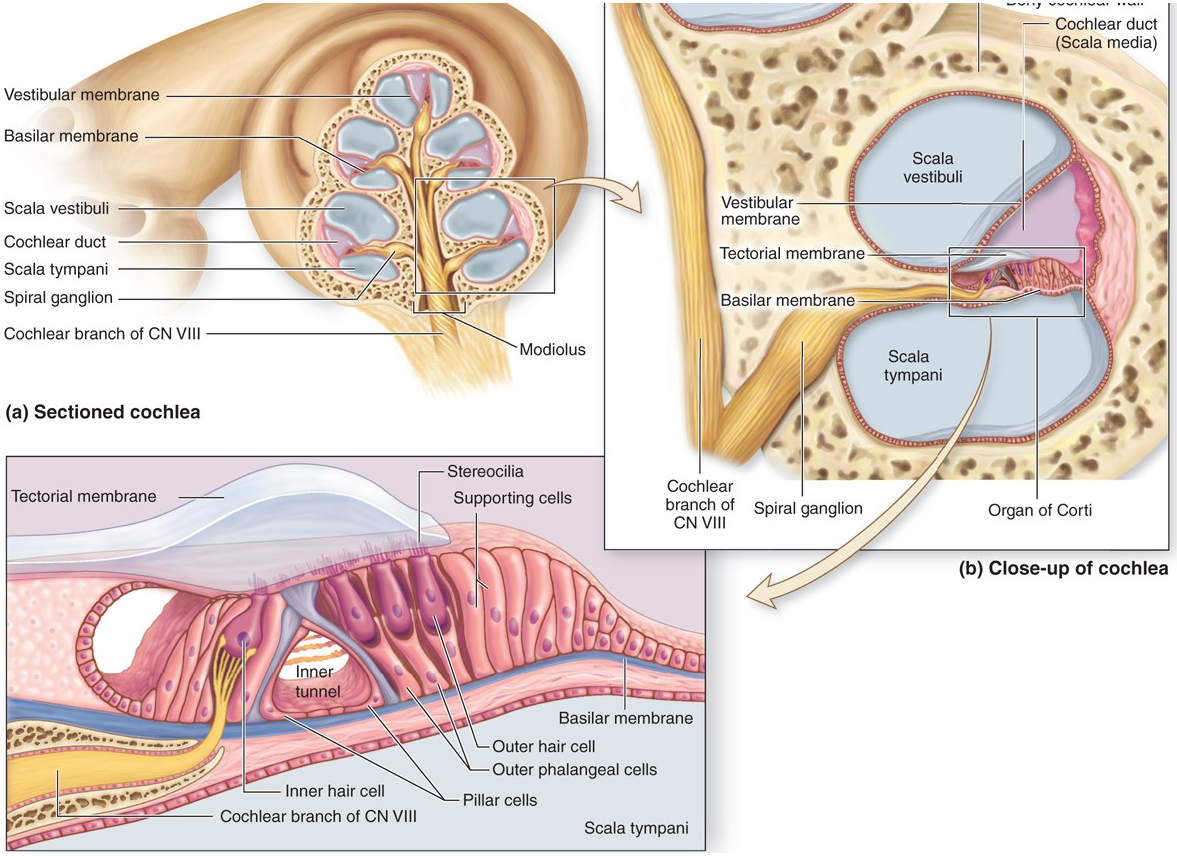
Cupula is moved by endolymph movement within the semicircular duct.

MEDICAL APPLICATION: Vertigo caused by internal ear inflammation or neurologic conditions.

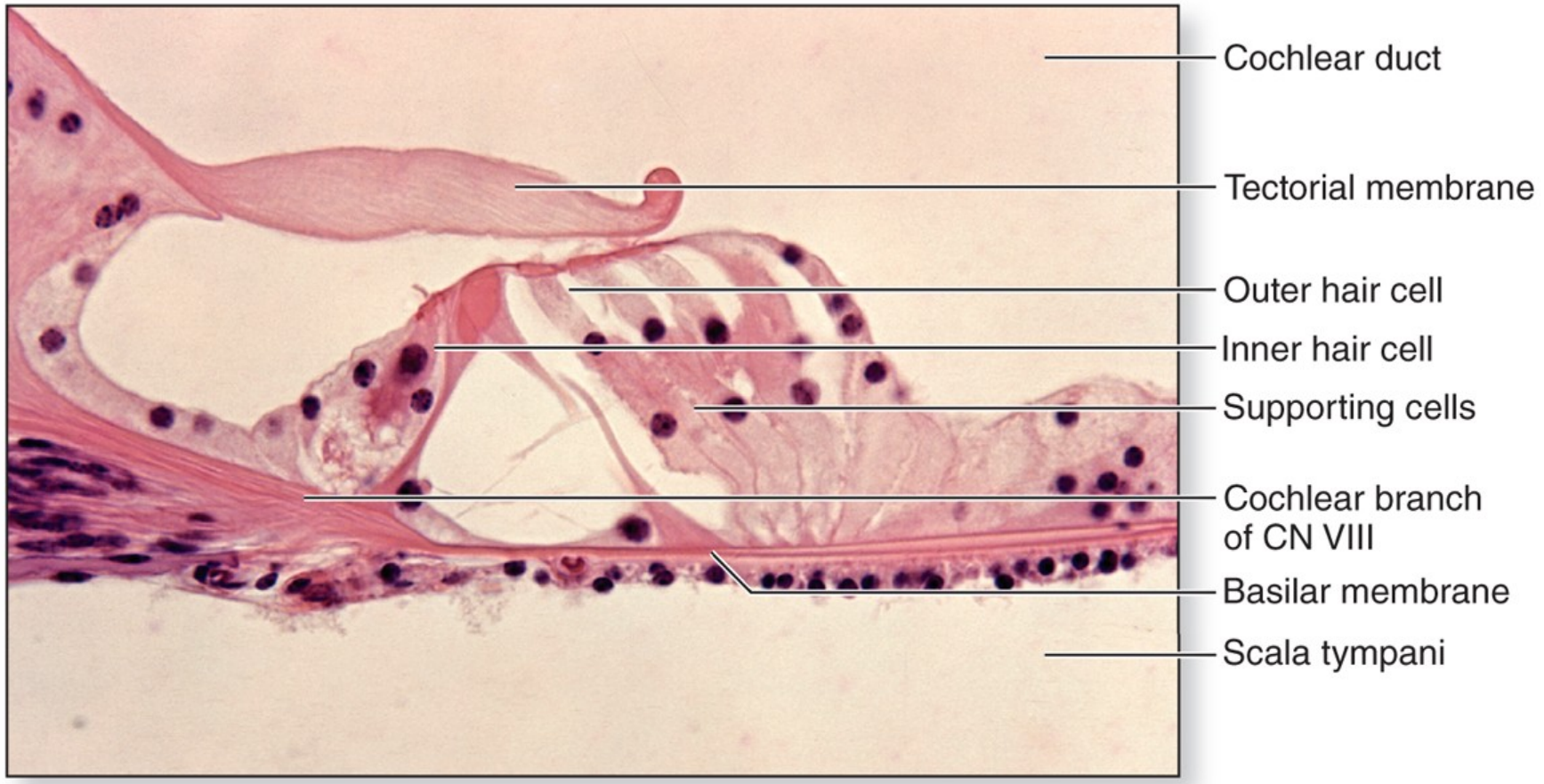
Brief periods of vertigo produced by sudden changes in position of head, such as standing up quickly or sitting up after lying in bed, may result when otoliths detach from the otolithic membrane.

Cochlea and spiral organ (of Corti)

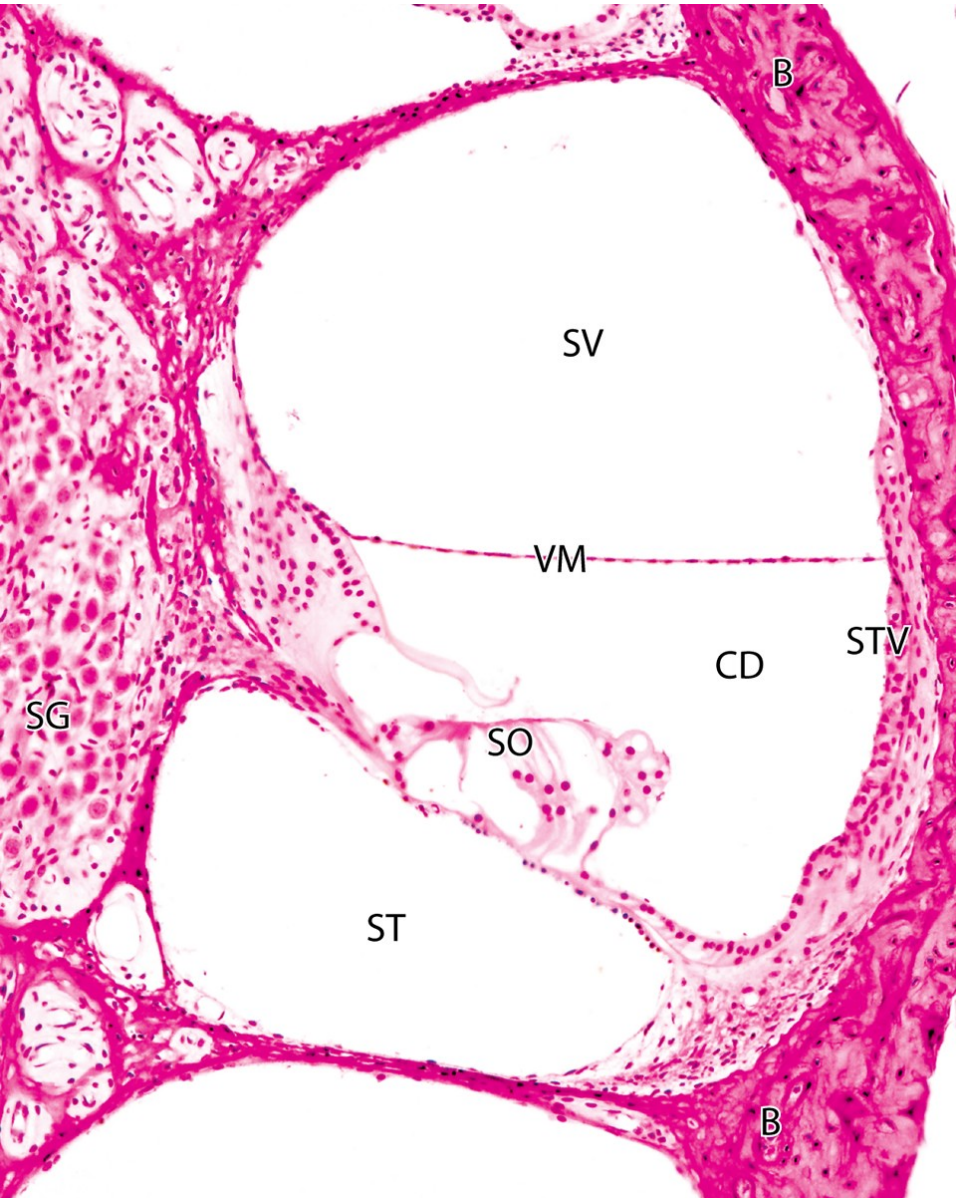
Cochlea: snail-like spiral bony and membranous labyrinths.
Cochlear duct (scala media): Endolymph filled
Organ of Corti: on the basilar membrane,
Perilymph-filled spaces: scala vestibuli and scala tympani.



http://highered.mheducation.com/sites/0072495855/student_view0/chapter19/animation__effect_of_sound_waves_on_cochlear_structures__quiz_1_.html



(d) Organ of Corti

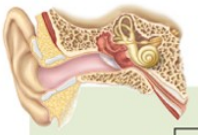


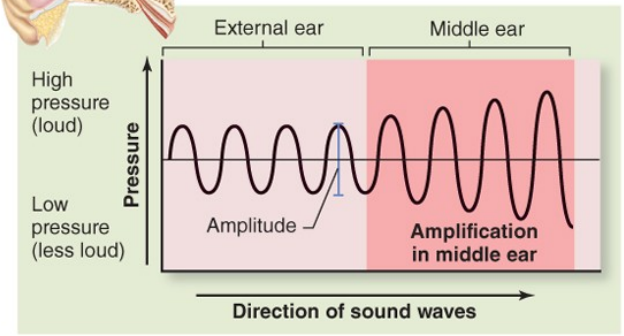
Cochlear duct and spiral ganglion:

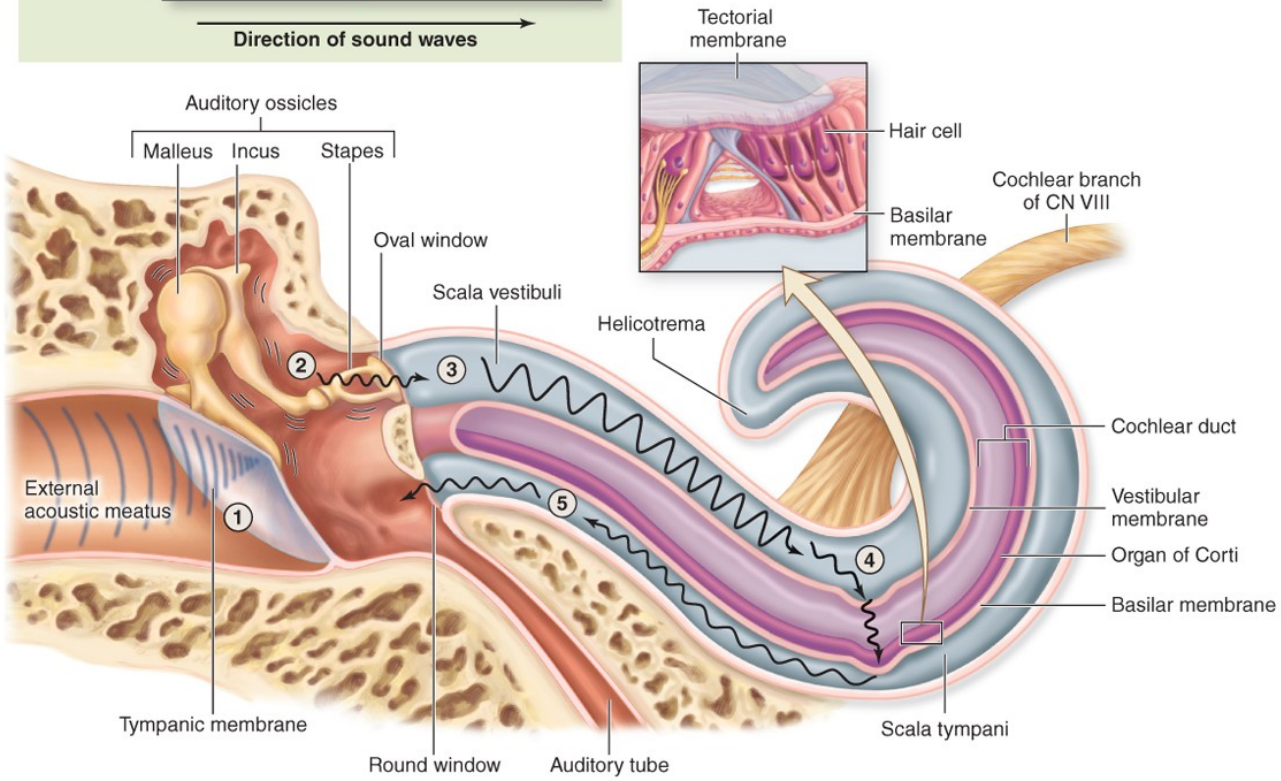
Cochlear duct (**CD**): filled with endolymph produced in the epithelial cells of stria vascularis (**STV**),
Bone (B)
Scala vestibuli (**SV**) and scala tympani (**ST**): filled with perilymph

Vestibular membrane (**VM**): separates perilymph in the scala vestibuli from endolymph in the cochlear duct.
Spiral ganglion (**SG**): Contains cell bodies of bipolar neurons which send axons to the cochlear nuclei of the brain.

Path of sound waves through the ear







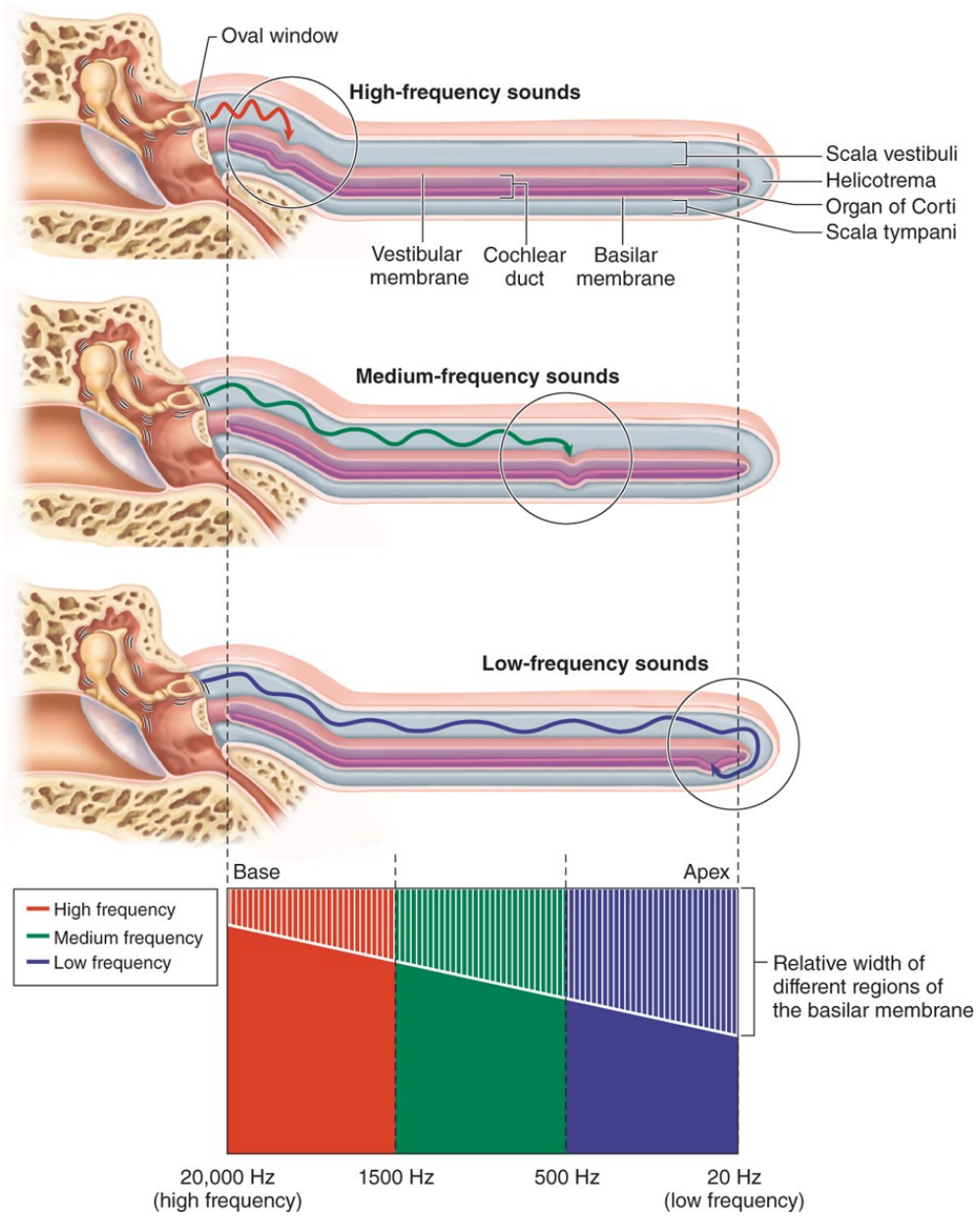
1. Sound waves enter ear and cause the tympanic membrane to vibrate.
2. Tympanic membrane vibration moves auditory ossicles; sound waves are amplified.
3. The stapes at the oval window generates pressure waves in the perilymph within the scala vestibuli.
4. Pressure waves cause the vestibular membrane to move, resulting in pressure wave formation in the endolymph within the cochlear duct and displacement of a specific region of the basilar membrane. Hair cells in the organ of Corti are distorted, initiating a nerve signal in the cochlear branch of CN VIII.
5. Remaining pressure waves are transferred to the scala tympani and exit the inner ear via the round window.

MEDICAL APPLICATION

Conductive hearing loss: conduction of vibrations by the chain of ossicles from the tympanic membrane to the oval window reduced

Sensorineural deafness: defects in any structure or cell from the cochlea to the auditory centers of the brain

Interpretation of sound waves in the cochlea



High-frequency sound waves (red arrow) generate pressure waves that displace the basilar membrane near the base of the cochlea, close to the oval window.
Medium-frequency sound waves (green arrow) and low-frequency sound waves (blue arrow) displace the membrane closer to the apex

MEDICAL APPLICATION

Cochlear implant: A microphone transmits signals to a receiver that stimulates nerve branches appropriate for those frequencies.

https://www.youtube.com/watch?v=zeg4qTnYOpw