

ENDOCRINE SYSTEM

Anatomy & Histology
Lec. 6

الجينات



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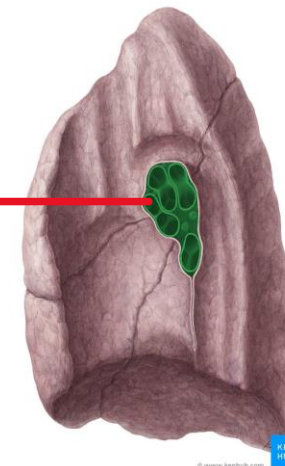
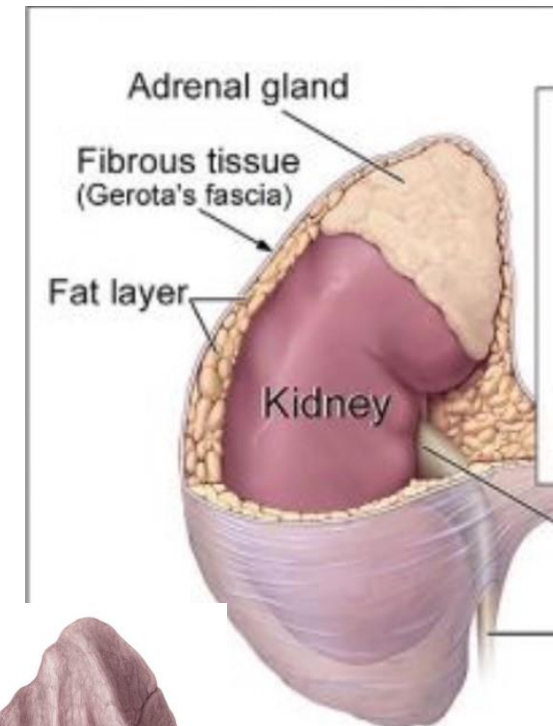
ما ينطق به الدكتور من شرح سيكون باللون الاحمر
وما يكون مهم في شرح الدكتور يكون باللون البنفسجي
ما يكون مهم في السلايدات يكون بخطين أو بخط
معلومات خارجية بالأزرق

Adrenal Gland

Adrenal Gland

- Yellowish retroperitoneal organs that lie on the upper poles of the kidneys
- Surrounded by renal fascia
- Separated from the kidneys by the perirenal fat.
- Has a yellow cortex and a dark brown medulla.
- **lacks a hilum**; suprarenal arteries arising from larger abdominal arteries penetrate the capsule independently

This is hilum (port of an organ), it could be found in liver, spleen and kidney...etc.



Intra-abdominal structure.

Set on the superior wall of each kidney.

Enclose within the renal fascia.

Devoid of the renal fat (no renal fat on them).

Within the renal fascia, each structure has its own compartment: the kidney and its surrounding fat are located in one compartment, while the adrenal gland occupies another compartment without any surrounding adrenal fat.

The right one has pyramid shape, while the left one has crescentic shape.

When the adrenal gland is dissected, it reveals two distinct regions: the lighter outer cortex and the darker inner medulla. This means that there are two different tissues, much like the pituitary gland. (originate from different tissues mesoderm and neural crest then merged together)

The cortex secretes:

- Hormones that include **mineral corticoids**; control of fluid and electrolyte balance.
- **Glucocorticoids**; control of the metabolism of carbohydrates), fats, proteins.
- **Sex hormones** (small amounts); probably play a role in the prepubertal development of the sex organs.

The medulla secretes:

- **Catecholamines** epinephrine and norepinephrine.

Cortex: it is not just one lighter region, it is one region that is divided into 3 different zones (outer, middle, inner) and each zone secrete specific type of hormone.

Sex hormones are released from the adrenal cortex in the form of weak androgens.

The adrenal cortex, specifically the innermost layer known as the zona reticularis, produces and releases weak androgens. These weak androgens include hormones like dehydroepiandrosterone (DHEA) and androstenedione. They are termed "weak" because they have a relatively low androgenic activity compared to stronger androgens like testosterone.

Weak Androgens: These are precursor hormones that have mild androgenic effects on their own. However, they can be converted into more potent androgens (like testosterone) or estrogens (like estradiol) in peripheral tissues.

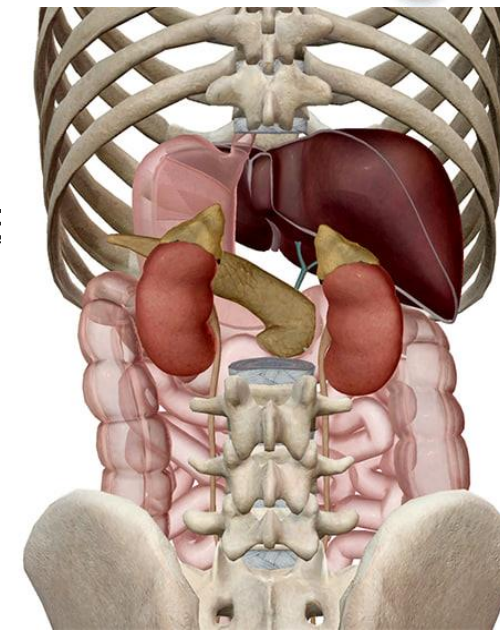
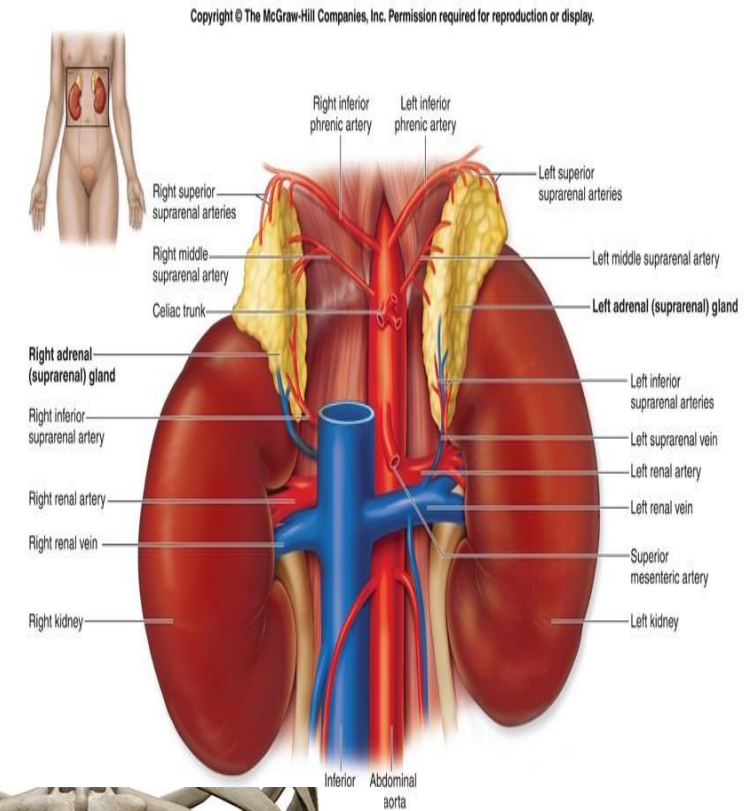
The medulla: these cells were originally meant to be neurons, but modifications occurred to them. However, they retained the ability to synthesize and release epinephrine and norepinephrine.

The mode of their release is not through axons (they do not target neurons, muscles, or glands); instead, they are released directly into the bloodstream.

Location and Description

Both adrenal glands are located laterally to the aorta, with the left adrenal gland being more closely related to it laterally

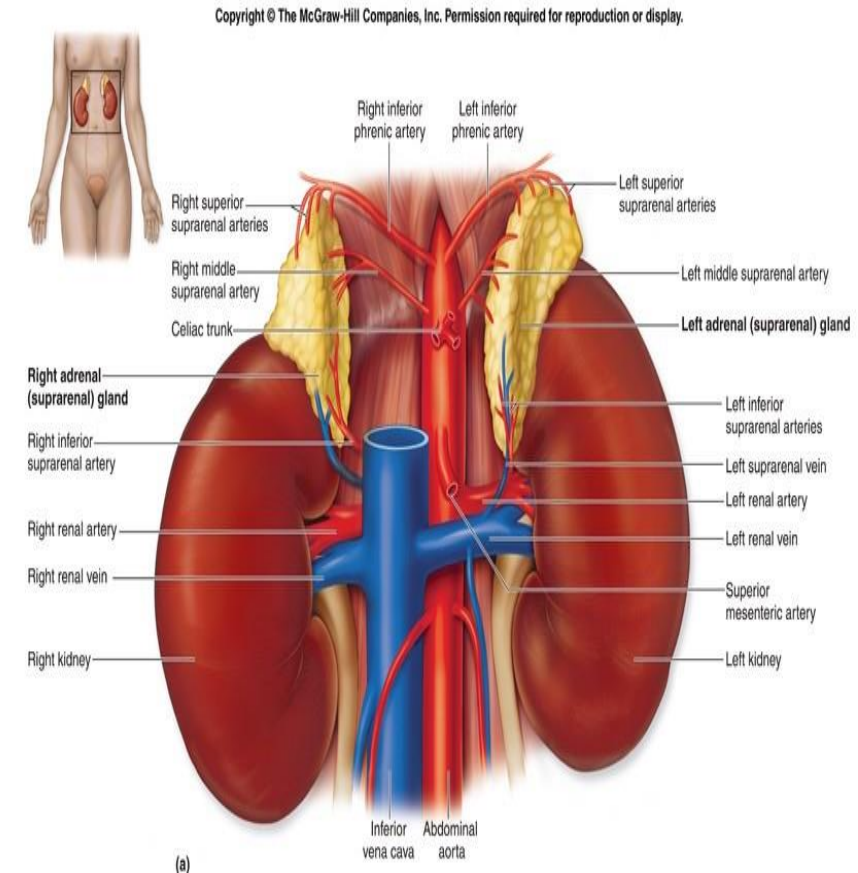
- The **right** is pyramid shaped:
 - Caps the upper pole of the right kidney.
 - It lies behind the right lobe of the liver and extends medially behind the inferior vena cava.
 - The right adrenal gland is partially lateral to the inferior vena cava (IVC), with a small portion of it also located inferior to the IVC. The IVC is more deviated to the right side.
 - **It rests posteriorly on the diaphragm.**
- The **left** is crescentic in shape:
 - Extends along the medial border of the left kidney from the upper pole to the hilus.
 - It lies behind the pancreas, the lesser sac, and the stomach
 - **Spleen lateral to it.**
 - **Rests posteriorly on the diaphragm.**



Blood supply

Left and Right, there are small variations, but we won't talk about them.

- Both the right and left adrenal glands receive their blood supply from vessels that penetrate from surrounding regions due to the absence of a hilum
- A superior suprarenal artery branch of inferior phrenic artery.
- A middle suprarenal artery branch of aorta.
- An inferior suprarenal artery branch of renal artery.
- A single **vein** emerges from the hilum of each gland (from the base of the gland, no actual hilum) and drains into the IVC on the right and into the renal vein on the left.



Lymph drainage

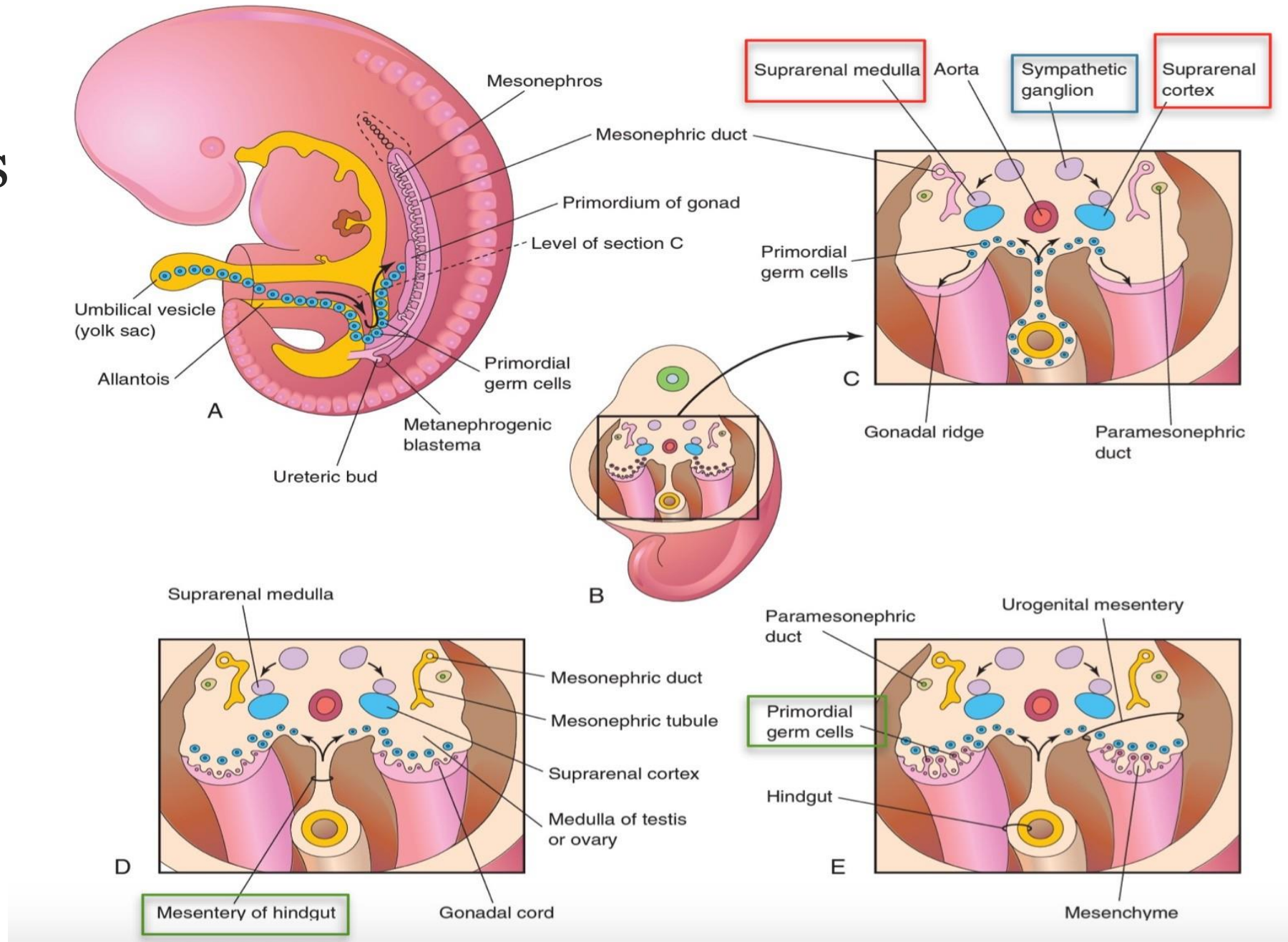
- The lymph drains into the lateral aortic nodes on the lateral boundaries of aorta.

Nerve supply

- Preganglionic sympathetic fibers derived from the splanchnic nerves supply the glands.
- Most of the nerves end in the medulla of the gland.

Picture 1

Organogenesis



Picture 1, (C)

First wave of the cells:

During embryonic development, in the area between the mesentery of the hindgut and the gonadal ridge, mesodermal cells arise and begin to invade the surrounding mesenchyme. These cells proliferate and contribute to the formation of the gonadal cortex, the arising cortex is called fetal cortex (around week 5).

Picture 2

After the formation of the fetal cortex, neural crest cells migrate inward to join these cells.

Subsequently, a second wave of cells from the same mesodermal origin forms another cortex, resulting in two cortical layers: the initial fetal or primary or primitive cortex and the definitive cortex. Concurrently, the neural crest cells advance inward, eventually forming and encapsulating the medulla completely.

Picture 2, (D) :

This (blue circle) is proliferating and differentiating, the outer (yellow) also is proliferating and differentiating, until we reach medulla (H).

According to (H) fetal cortex is the part of the adrenal cortex that immediately surrounds the medulla and is situated between the medulla and the outer zones formed by the secondary wave of cortical cells, known as the definitive cortex.

Organogenesis

there is no explanation for this yellow color so ignore it, doctor said.

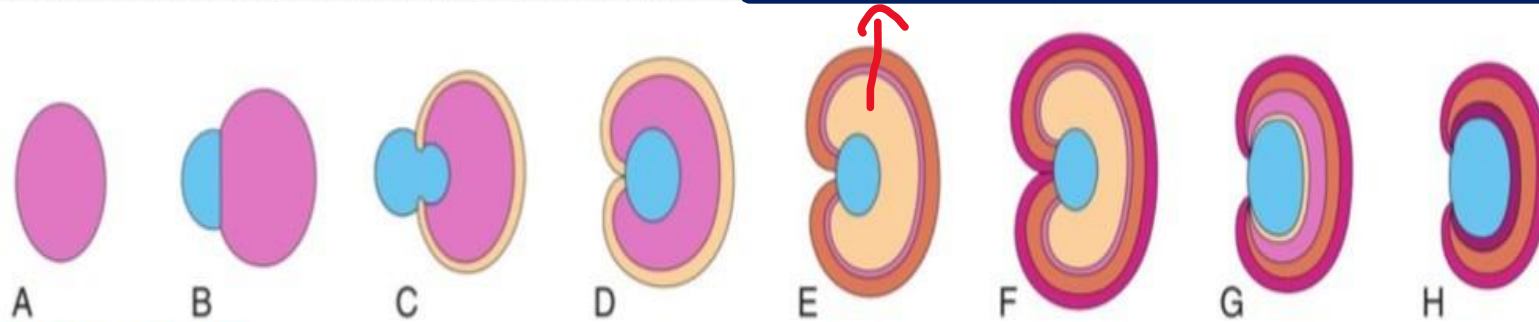


FIGURE 12-27 Schematic drawings illustrating development of the suprarenal glands. **A**, At 6 weeks, showing the mesodermal primordium of the fetal cortex. **B**, At 7 weeks, showing the addition of neural crest cells. **C**, At 8 weeks, showing the fetal cortex and early permanent cortex beginning to encapsulate the medulla. **D** and **E**, Later stages of encapsulation of the medulla by the cortex. **F**, Gland of a neonate showing the fetal cortex and two zones of the permanent cortex. **G**, At 1 year, the fetal cortex has almost disappeared. **H**, At 4 years, showing the adult pattern of cortical zones. Note that the fetal cortex has disappeared and that the gland is much smaller than it was at birth (*F*).

There are three primary germinal layers in embryonic development, the neural crest is often referred to as the fourth germinal layer due to its significant contributions to various structures.

Organogenesis--cortex

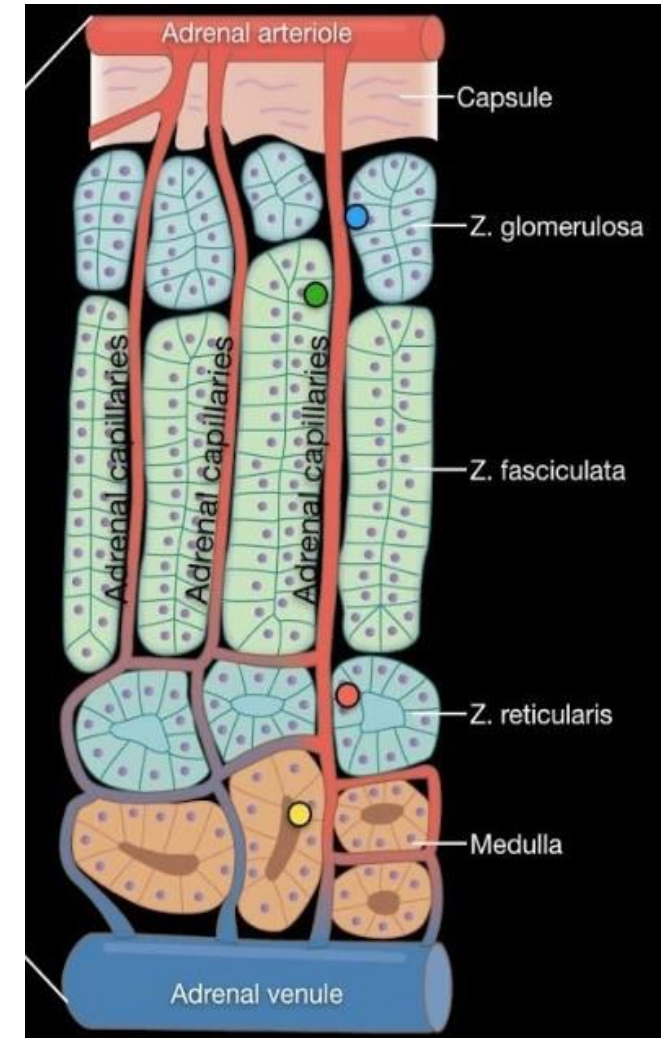
- Develops from two components: a mesodermal portion---cortex, and an ectodermal portion---- medulla.
- During the 5th week, mesothelial cells between the root of the mesentery and the developing gonad begin to proliferate and penetrate the underlying mesenchyme.
- Here, they differentiate into large acidophilic organs, which form the **fetal cortex, or primitive cortex**.
- Shortly afterward a second wave of cells (smaller) from the mesothelium penetrates the mesenchyme and surrounds the original acidophilic cell mass--- **definitive cortex** of the gland.
- After birth the fetal cortex regresses rapidly (largely completed in the first few weeks of life) except for its outermost layer, which differentiates into the reticular zone.
- The adult structure of the cortex is not achieved until puberty.
- After birth, the fetal cortex rapidly regresses. This means that at birth, the adrenal gland is relatively large, primarily due to the presence of the fetal cortex. This size is significantly larger than what is typical in adulthood. Over time, the fetal cortex gradually regresses until the adrenal gland reaches its normal size by puberty.
- This is important surgically because I know that the adrenal gland is quite delicate and fragile at birth, as it is larger than normal, and fetal cortex cells are still not optimally organized, making them friable or easy to damage.

Organogenesis--Medulla

- While the fetal cortex is being formed, cells originating in the sympathetic system (sympathochromaffin cells—neural crest) invade its medial aspect, where they are arranged in cords and clusters.
- The adrenal medulla originates from neural crest cells. Neural crest cells typically form ganglia and neurons (sympathetic neurons with dendrites and axons), but in the adrenal medulla, they are modified to become chromaffin cells (CCs).
- chromaffin cells: modified postganglionic sympathetic neurons.
- Modified: lack of axons and dendrites and are innervated by preganglionic sympathetic neurons.
- These cells give rise to the medulla of the suprarenal gland.
- They stain yellow-brown with chrome salts and hence are called chromaffin
- The medulla comes to occupy a central position and is arranged in cords and clusters.
- Preganglionic sympathetic nerve fibers grow into the medulla and influence the activity of the medullary cells.
- When these cells are excited by preganglionic sympathetic neurons, they respond by releasing epinephrine and norepinephrine into the blood, functioning in an endocrine mode rather than communicating directly with other neurons.
- They are hormones not neurotransmitters in adrenal gland because the way they were released.

Histology

- Cells of cortex and medulla are grouped in cords **along wide capillaries.**
- Suprarenal arteries -----subcapsular arterial plexus.
- From this plexus arterioles for the adrenal cortex and Medulla emerge separately---- networks of fenestrated capillaries and sinusoids.
- Cortical capillaries irrigate endocrine cells then drain into the medulla.
- The medulla---- **dual blood supply:**
- Venous drainage from the glands occurs via the suprarenal veins



We have 3 zones in the cortex:

- 1. Zona Glomerulosa**
 - 2. Zona Fasciculata**
 - 3. Zona reticularis**
- The suprarenal arteries form an arterial plexus which will supply cortex and medulla separately, but eventually the capillaries drainage of the cortex will irrigate the medulla, which means that it has a dual blood supply.**

Adrenal Cortex

- **Steroid-secreting cells:** acidophilic cytoplasm rich in lipid droplets (WHITE appearance), with **central nuclei**.
-

Steroid-secreting cells contain vacuoles filled with whitish appearance that is variable within the zones:

1-The middle zone is the most whitish zone

2-The outer zone is slightly less whitish and more pinkish

3-The inner zone contains the least amount of fat vacuoles --->least whitish ---> most pinkish (eosinophilic)

- SER is the most abundant and needed organelle in the adrenal cortex
- The nucleus is centrally located because we have many fat vacuoles and other many structures in the cytoplasm
- Profuse **SER** of interconnected tubules, which contain the enzymes for cholesterol synthesis and conversion of the steroid prohormone pregnenolone into specific active steroid hormones.
- The **mitochondria** are often spherical, with tubular rather than shelflike cristae
- The function of steroid-producing cells involves close collaboration between SER and mitochondria.

Adrenal cortex

- Steroid hormones are **not stored** in granules ---- small lipid-soluble molecules, steroids diffuse freely from cells
- The adrenal cortex has three concentric zones.

1. Zona glomerulosa

2. Zona fasciculata

3. Zona reticularis; **which has direct contact with the medulla, (bigger at birth).**

1. Zona glomerulosa

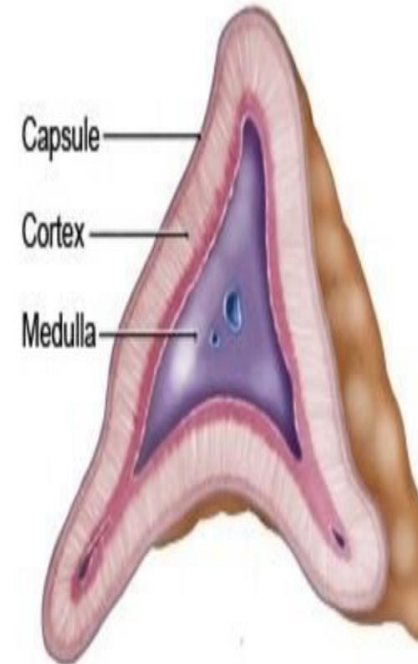
2. Zona fasciculata

3. Zona reticularis

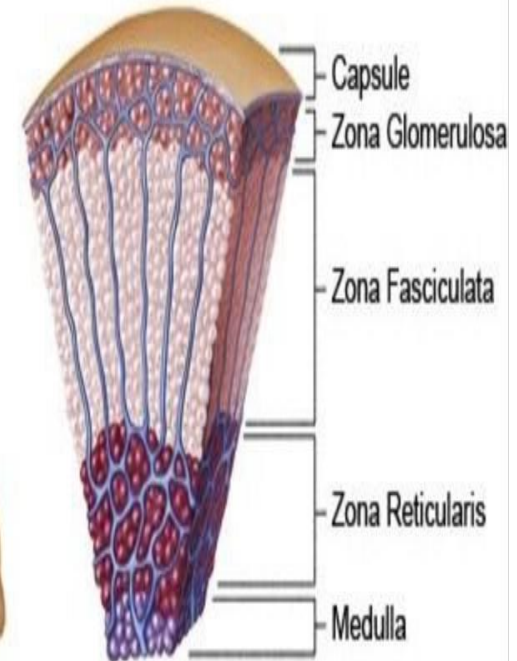
Originated from definitive cortex

Originated from fetal cortex

Transverse Section



Microscopic Section

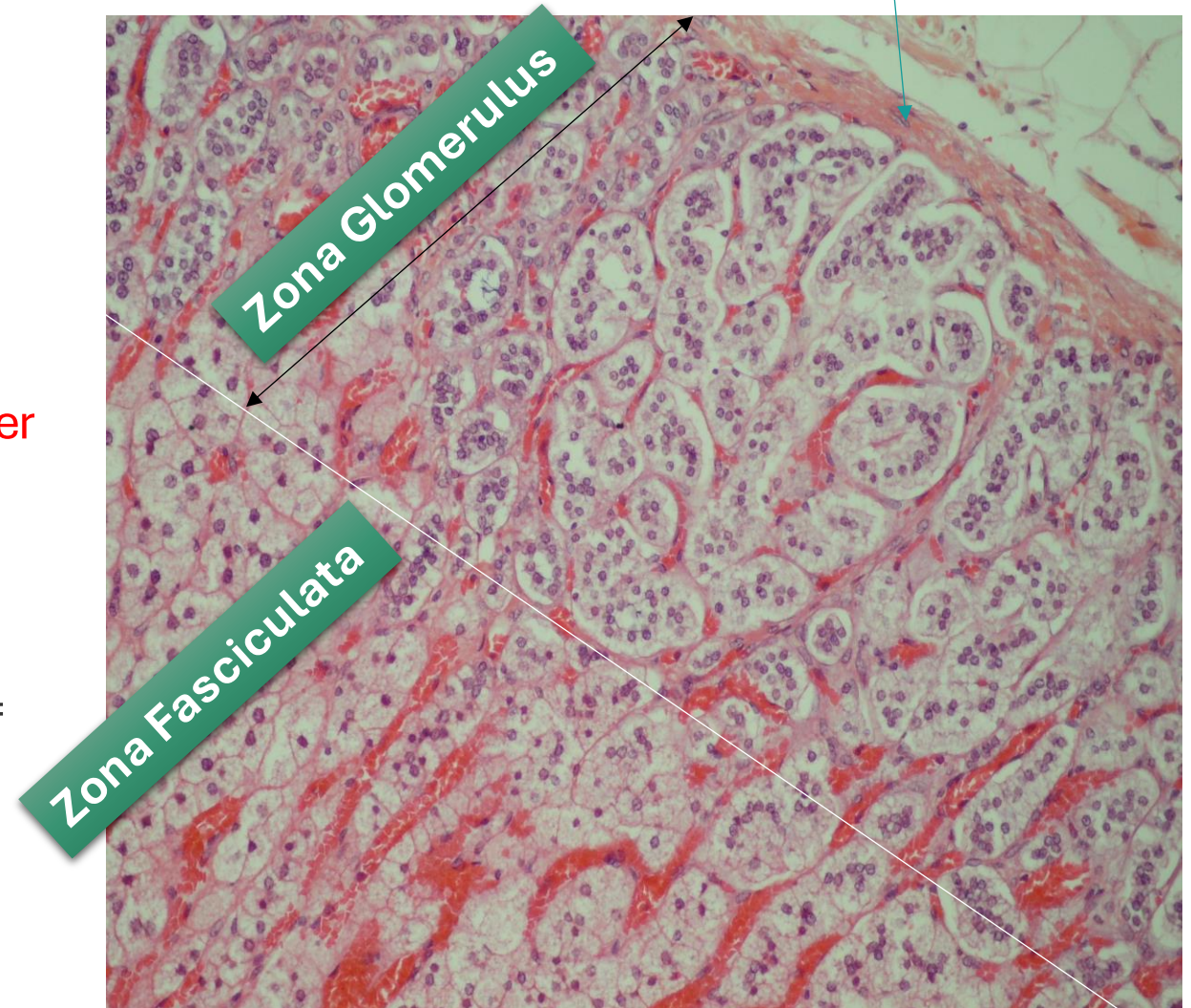


Cortex- zona glomerulosa

- Immediately inside the capsule and comprising about 15% of the cortex
- Consists of closely packed, rounded or arched cords of columnar or pyramidal cells. (relatively long)
- Many capillaries **but slightly less than the two inner zones**

It has less vacuoles than fasciculata

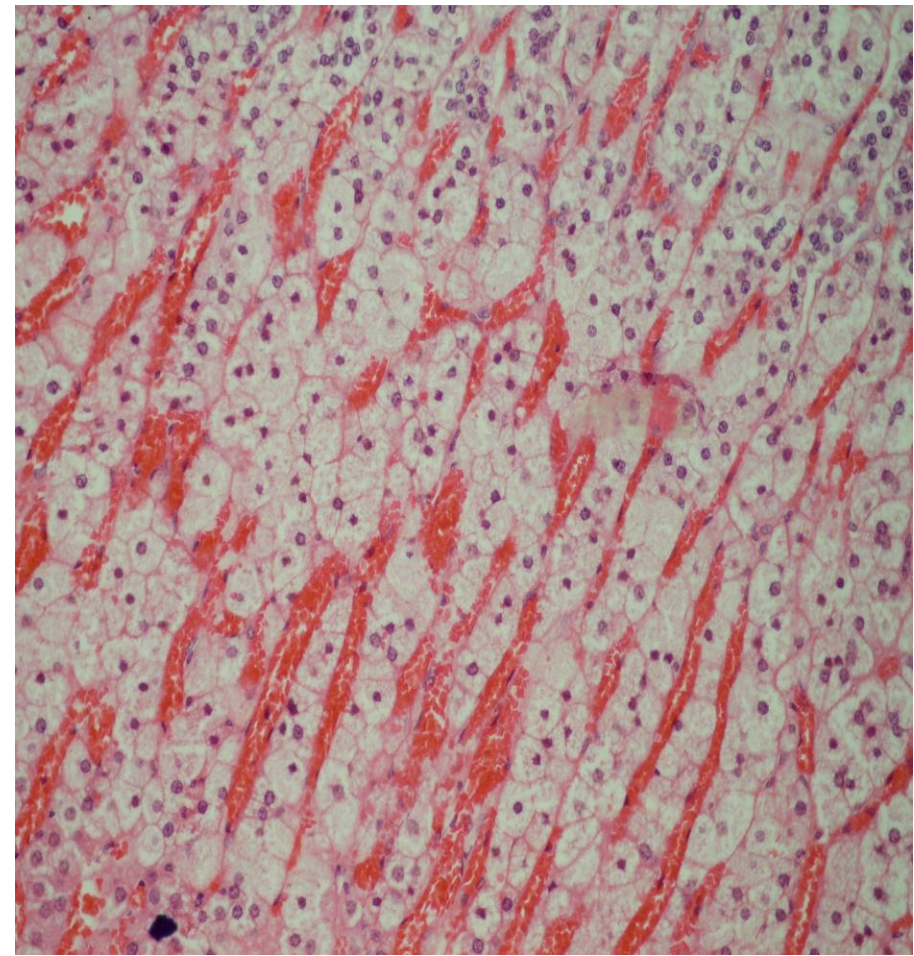
- The steroids are called mineralocorticoids
- The principal product is aldosterone (uptake of Na⁺, K⁺, and water by cells of renal tubules).
- Aldosterone secretion is stimulated primarily by angiotensin II (increase in plasma K⁺ concentration, weakly by ACTH.



We can distinguish Zona glomerulosa from its rounded shape

Cortex- zona fasciculata

- 65%-80% of the cortex (**huge cells --> produce large number of hormones**)
 - Long cords of large polyhedral cells, one or two cells thick,
 - **Fenestrated sinusoidal capillaries**
 - Cells are filled with **lipid droplets**.
 - Secrete **glucocorticoids**, especially **cortisol** (carbs metabolism---gluconeogenesis in many cells (liver))
-
- Suppresses many **immune functions**.
 - Induce fat mobilization and muscle proteolysis.
 - Secretion is controlled by **ACTH (negative feedback)**
 - Small amounts of weak androgens are also produced here.

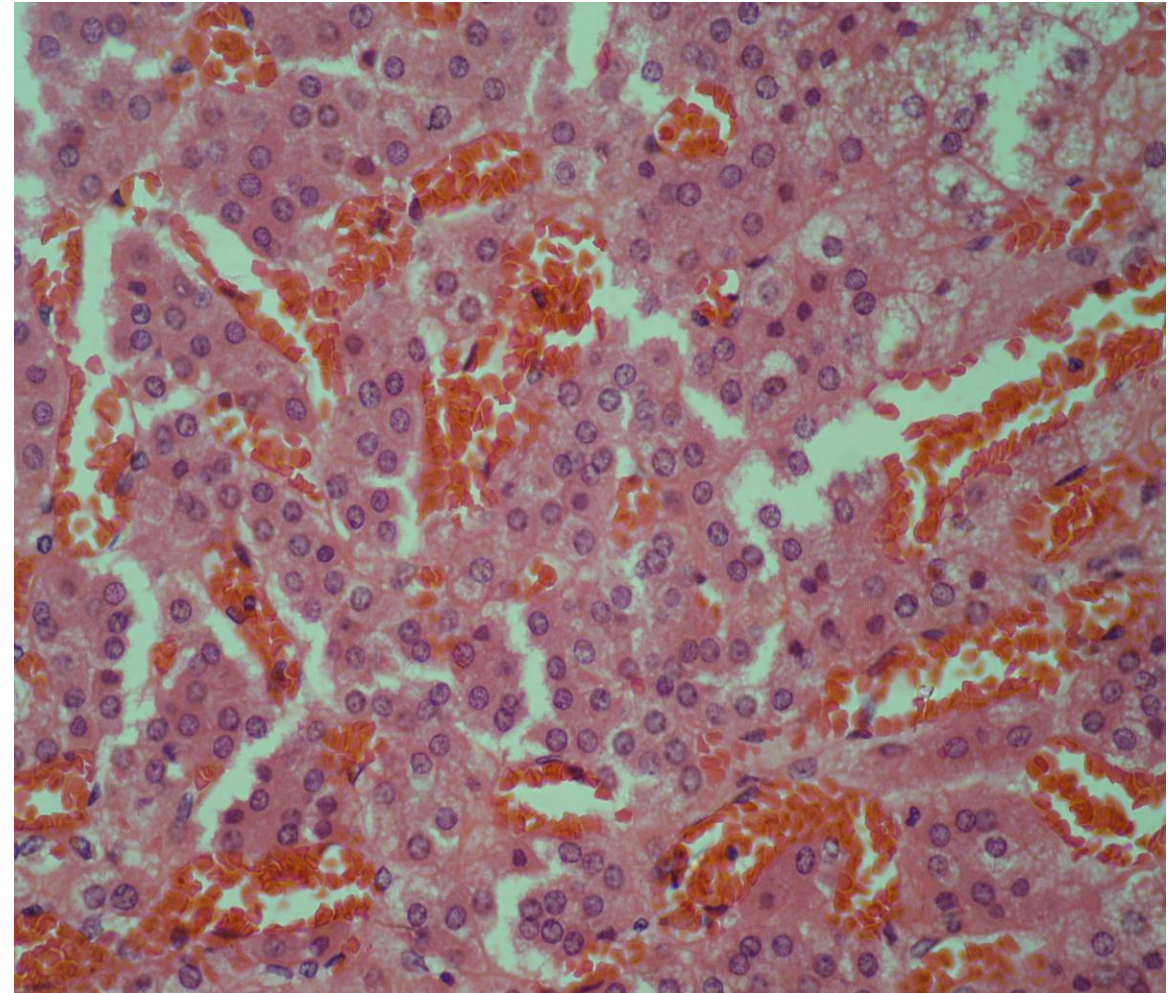


We can distinguish it from its whitish and Straight cords cell appearance .

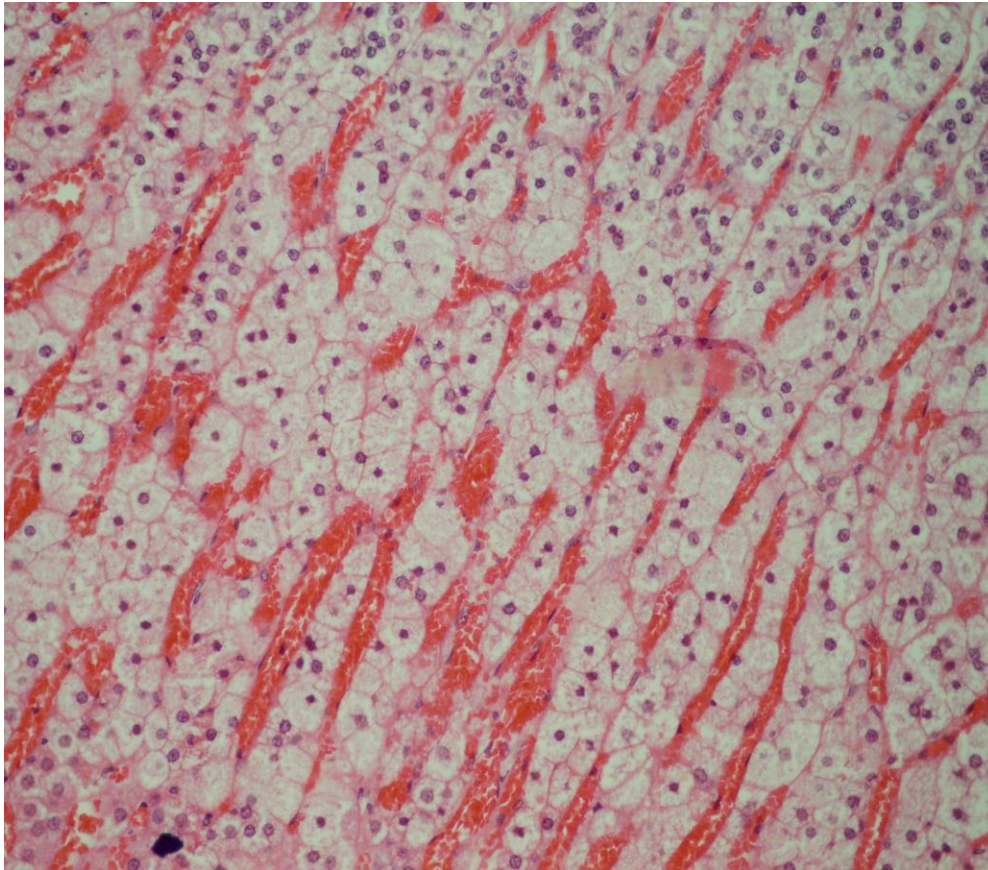
Sinusoids : complex network of capillaries , wider compared to glomerulosa and more in number

Cortex- zona reticularis

- 10% of the cortex
 - Consists of smaller cells in a network of irregular cords interspersed with **Wide capillaries**
 - The cells are more heavily stained than those of the other zones (fewer lipid droplet and more lipofuscin pigment)
 - Primarily secrete weak androgens (also produce cortisol).
 - **Dehydroepiandrosterone (DHEA)** that is converted to testosterone in both men and women.
 - Secretion is stimulated by ACTH with regulatory feedback.
- Innermost zone, derived from mesoderm, fetal cortex, irregular network of cells, sinusoid is slightly wider.

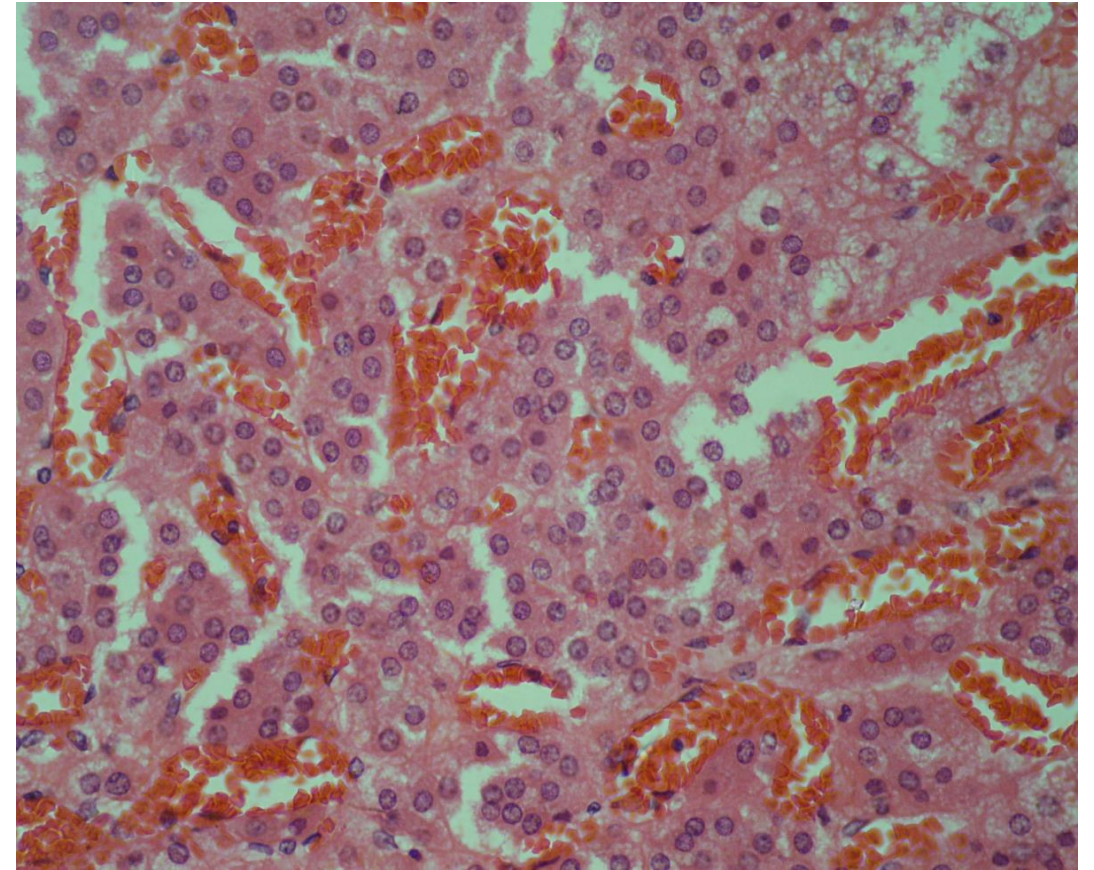


Cortex- zona Fasciculata & Reticularis



Histology:

- arranged in long cords
- Largest zone
- Lipid filled cytoplasm (white color)



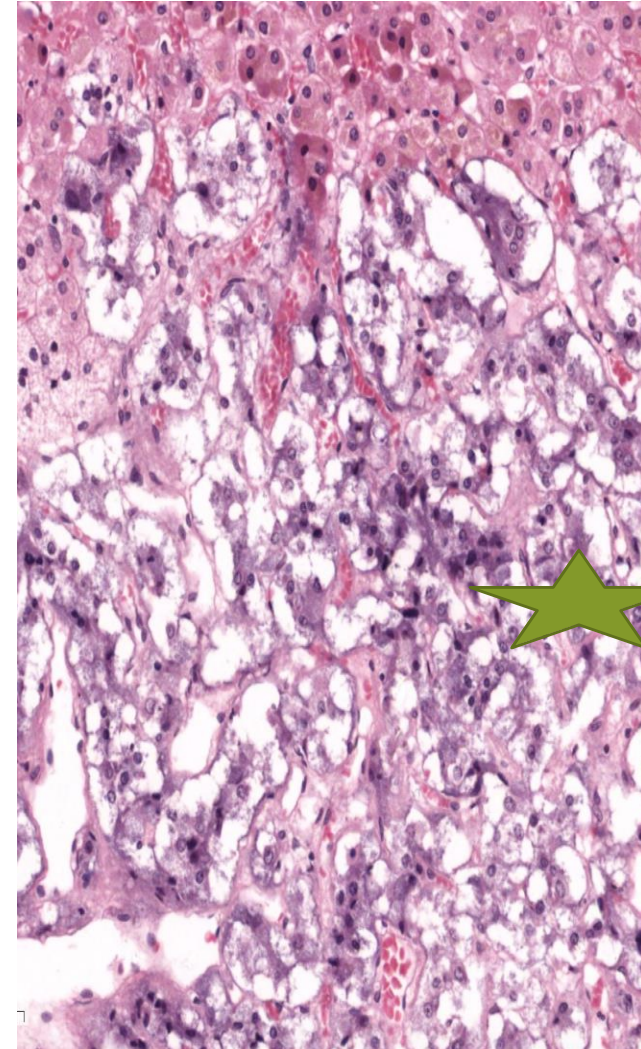
Histology:

- Wide capillaries
- highly stained
- few lipid droplets + more lipofuscin pigment

The adrenal medulla

- Composed of large, pale-staining polyhedral cells--- cords or clumps and supported by a reticular fiber network
- A profuse supply of **sinusoidal capillaries** intervenes between adjacent cords
- A few parasympathetic ganglion..
- Medullary parenchymal cells, known as CCs **chromaffin cells** (modified sympathetic postganglionic neurons; lacking axons and dendrites, they don't behave like neurons but they receive sympathetic innervation).
- The origin of medulla is chromaffin cells – neural crest

Some believe that the neural crest is the 4th layer because of its importance. (in addition to ectoderm, endoderm and mesoderm)



The adrenal medulla (AM)

- CCs contain many **electron-dense granules** (catecholamines, either epinephrine or norepinephrine)
- The **conversion** of norepinephrine to epinephrine (adrenalin) occurs **only in chromaffin cells** of the AM.
- **80%** of the catecholamine secreted from the adrenal is epinephrine. **but during normal resting states small and equal amounts are secreted of both**
- Medullary CCs are innervated by **preganglionic** sympathetic neurons.
- **Epinephrine** increases heart rate, dilates bronchioles, and dilates arteries of cardiac and skeletal muscle.
- **Norepinephrine** constricts vessels of the digestive system and skin, increasing blood flow to the heart, muscles, and brain.
- **Both** hormones stimulate glycogen breakdown, elevating blood glucose levels.
- During **normal** activity the adrenal medulla continuously secretes **small** quantities of

Surgical Significance/ Trauma

Surgical Significance of Renal Fascia

- The suprarenal glands, together with the kidneys, are enclosed within the renal fascia.
- The suprarenal glands lie in a separate compartment, which allows the two organs to be separated easily at operation. **So we don't have to open the whole fascia**

Susceptibility to Trauma at Birth

- The suprarenal glands are relatively large at birth because of the presence of the fetal cortex.
The Fragility of adrenal glands at birth due to the large size of the fetal cortex
- Later, when this part of the cortex involutes, the gland becomes reduced in size.
- During the process of involution, the cortex is friable and susceptible to damage and severe hemorrhage.