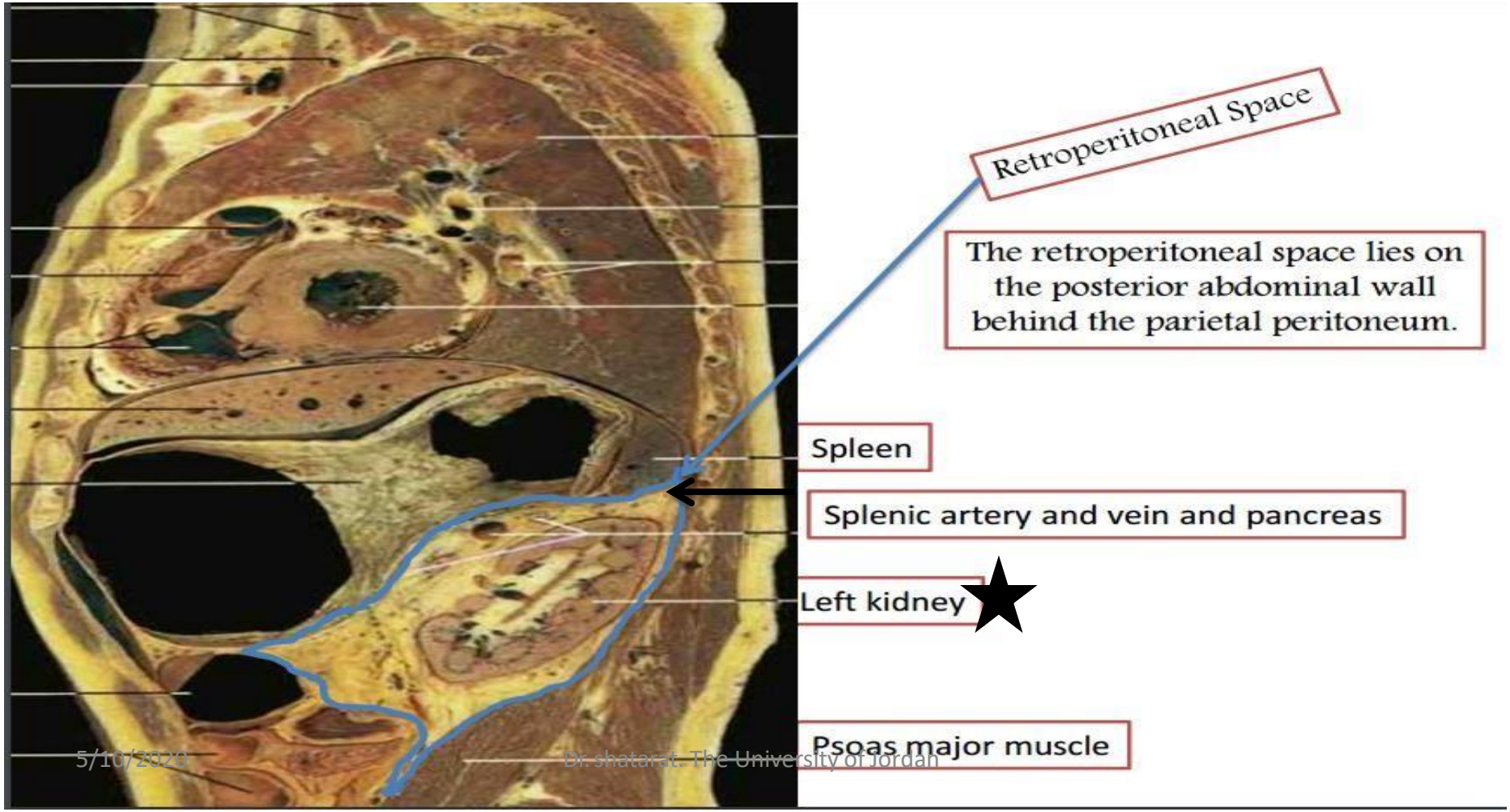
Edited by: Malak Shalfawi, Noor Adnan

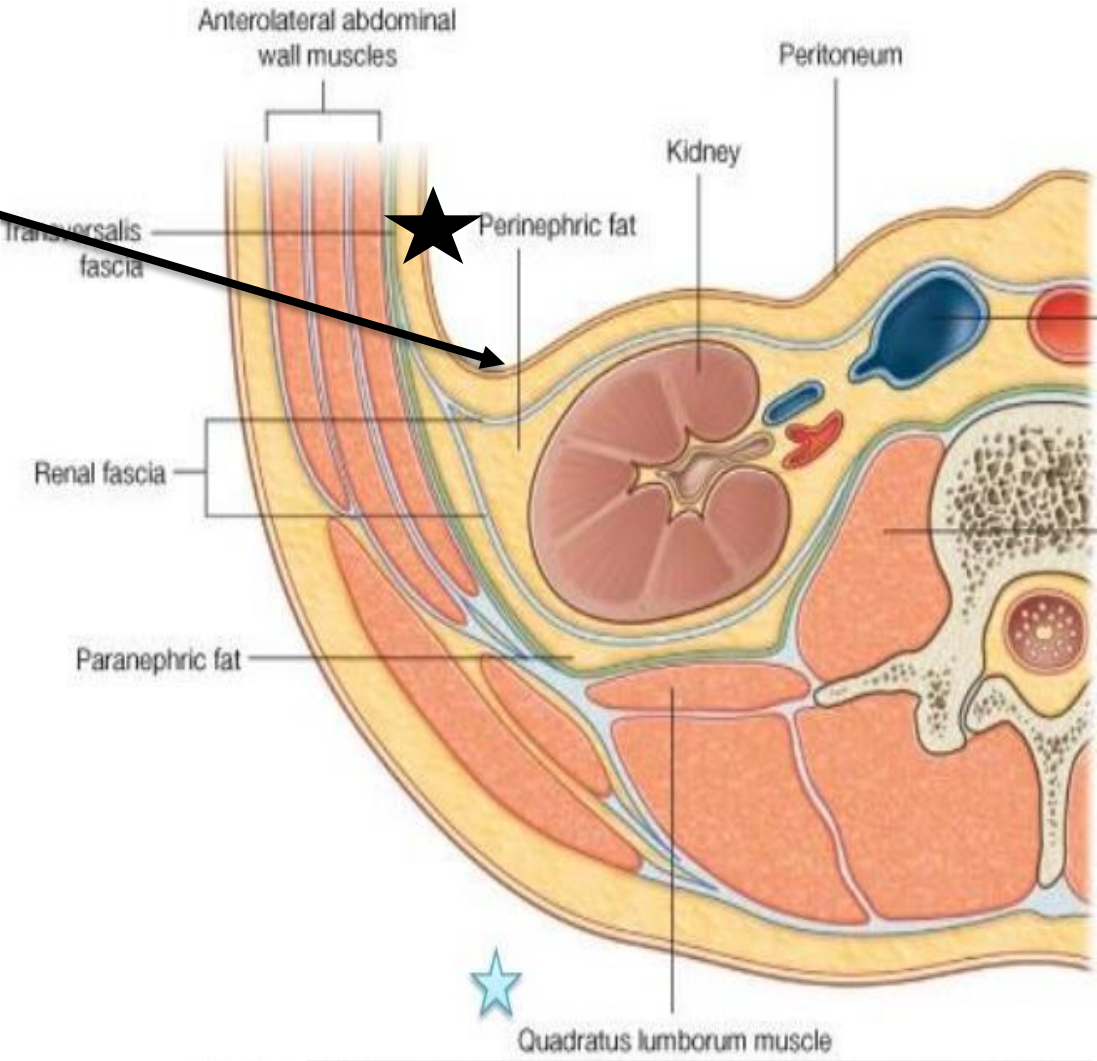
GROSS ANATOMY OF THE SUPRARENAL GLANDS

In the sagittal section below, you can see the retroperitoneal space (encircled by a blue line), which contains structures that lie deep on the posterior abdominal wall and are called retroperitoneal structures, they are the kidneys and suprarenal (adrenal) glands.

➔ **The adrenal glands are two small triangular structures located <u>retroperitoneally</u> at the upper poles of the kidneys.** [notice the black arrow]



You can again notice the kidneys (lying on the posterior abdominal wall and covered by fat), The peritoneum and retroperitoneal space.



➔ **The adrenal glands are covered with a thick connective tissue capsule from which the trabeculae extend into the parenchyma carrying blood vessels and nerves.**

**Extra note: all soft structures in the abdomen, such as the spleen, kidneys and suprarenal glands, have hilum into which all blood vessels and nerve supply getting in or out of them.
But each one of these soft structures has its specific modifications on its hilum. For example, the ureter getting out from the kidneys.

In this section, you can see the vertebral column and the muscles of the posterior abdominal wall (quadratus lumborum and Psoas major)

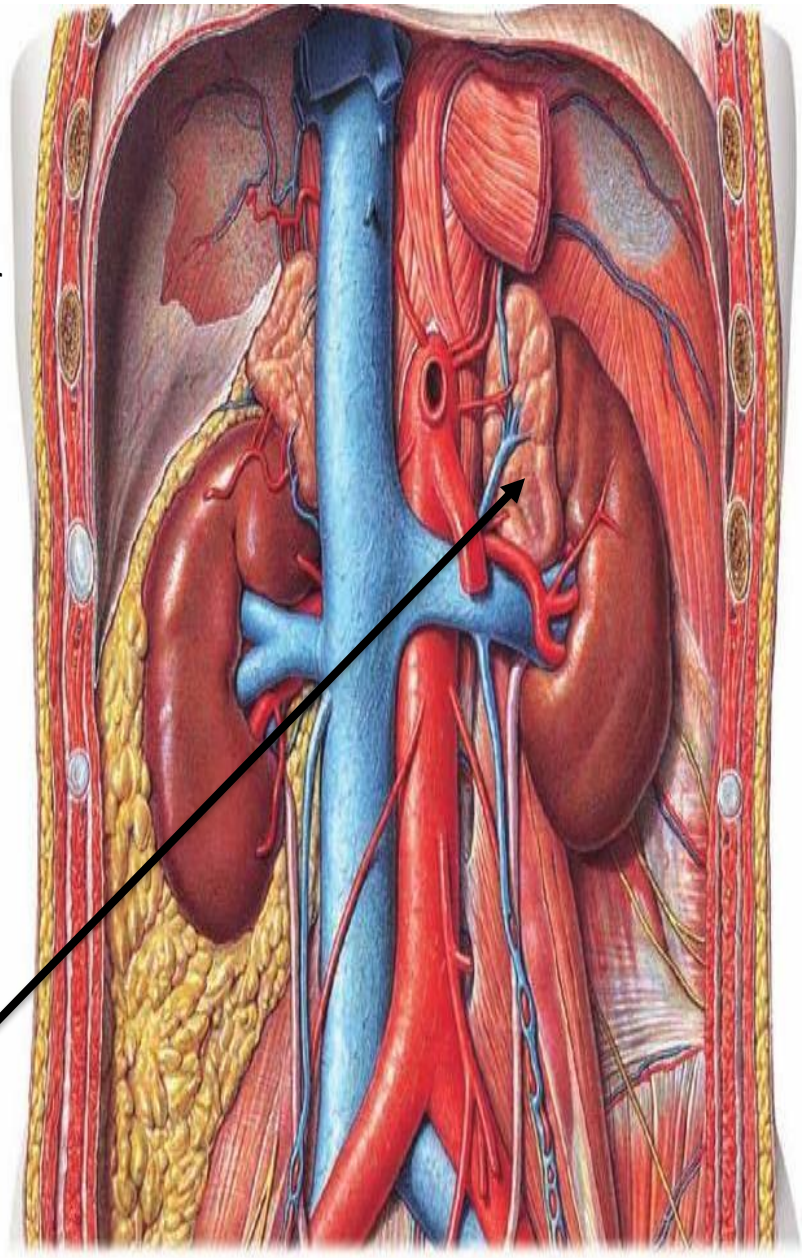
➔ Adrenal glands are found ***on the posterior parietal wall,*** on each side of the vertebral column, at the level of the **11th thoracic rib** and **lateral to the first lumber vertebra**.

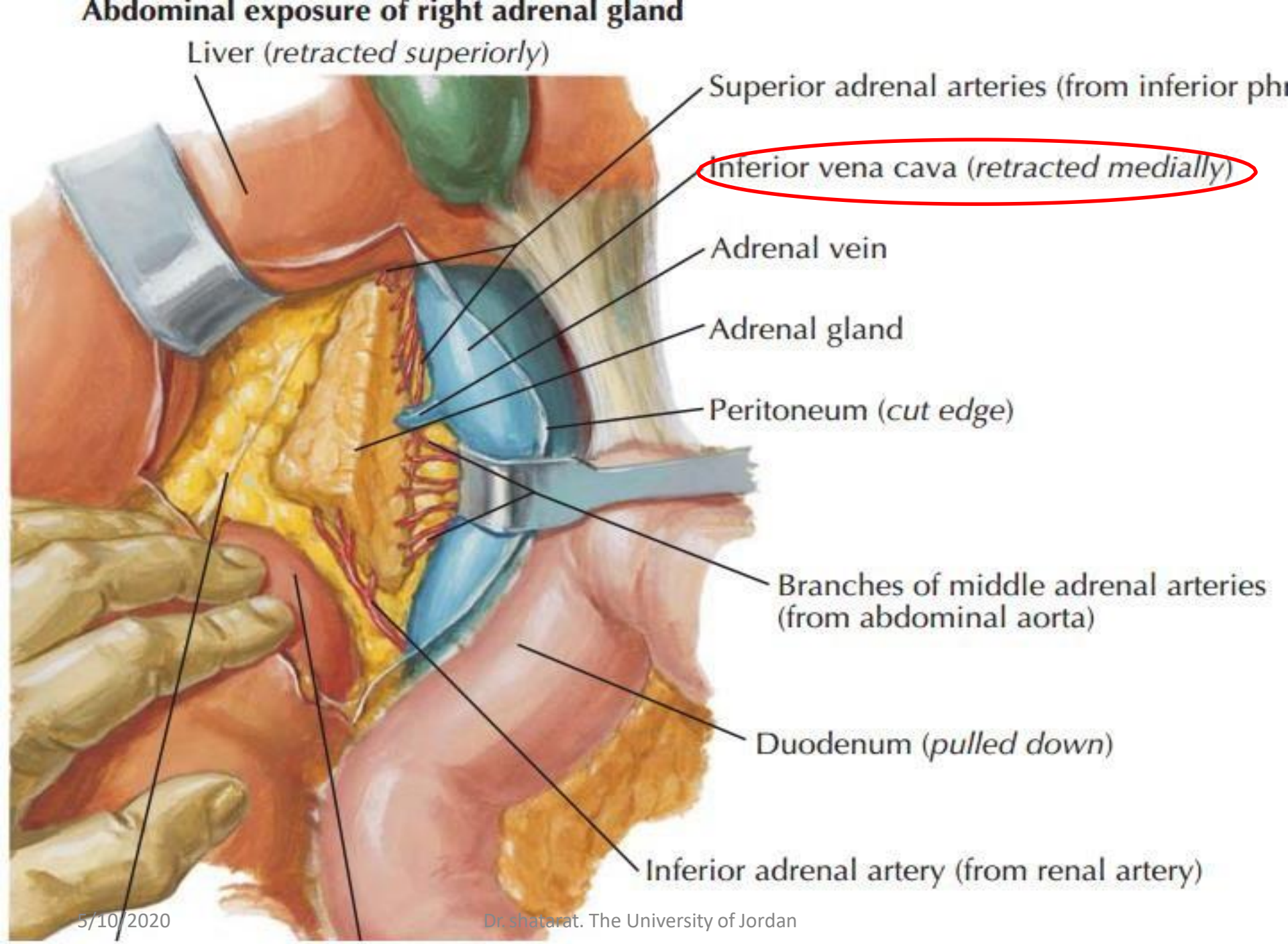
They are in the upper part of the abdomen, almost near the diaphragm, NOT in the middle and NOT inferior!!!!

➔ They have flattened triangular shape and **are embedded in the perirenal fat** at the superior poles of the kidneys.

So, to reach the right adrenal gland, for example, you have to open up the anterior abdominal wall, remove the intestines and their mesenteries, reflect the liver up and the inferior vena cava. After removing all these organs, you still can't see the kidneys or the suprarenal glands, because they are covered by fat that fixes them in their position. [see the picture in the next slide]

➔ lie immediately **superior and slightly anterior** to the upper pole of the kidneys. (the kidneys are posterior to the suprarenal glands)




Abdominal exposure of right adrenal gland
Liver (retracted superiorly)
Superior adrenal arteries (from inferior phr
Inferior vena cava (retracted medially)
Adrenal vein
Adrenal gland
Peritoneum (cut edge)
Branches of middle adrenal arteries (from abdominal aorta)
Duodenum (pulled down)
Inferior adrenal artery (from renal artery)

➔ The suprarenal glands each weigh approximately 5 g.

➔ The secretory parenchymal tissue is organized into two distinct regions

1- **The cortex** is the steroid-secreting portion. It lies beneath the capsule and constitutes nearly 90% of the gland by weight

2- The medulla is the catecholamine-secreting portion. It lies deep to the cortex, forms the center of the gland and **contributes about one-tenth of the total weight**.

➢ **To summarize:** the suprarenal glands lie deep in the abdomen, they are retroperitoneal, superior and slightly anterior to the upper pole of the kidneys, covered with perirenal fat.

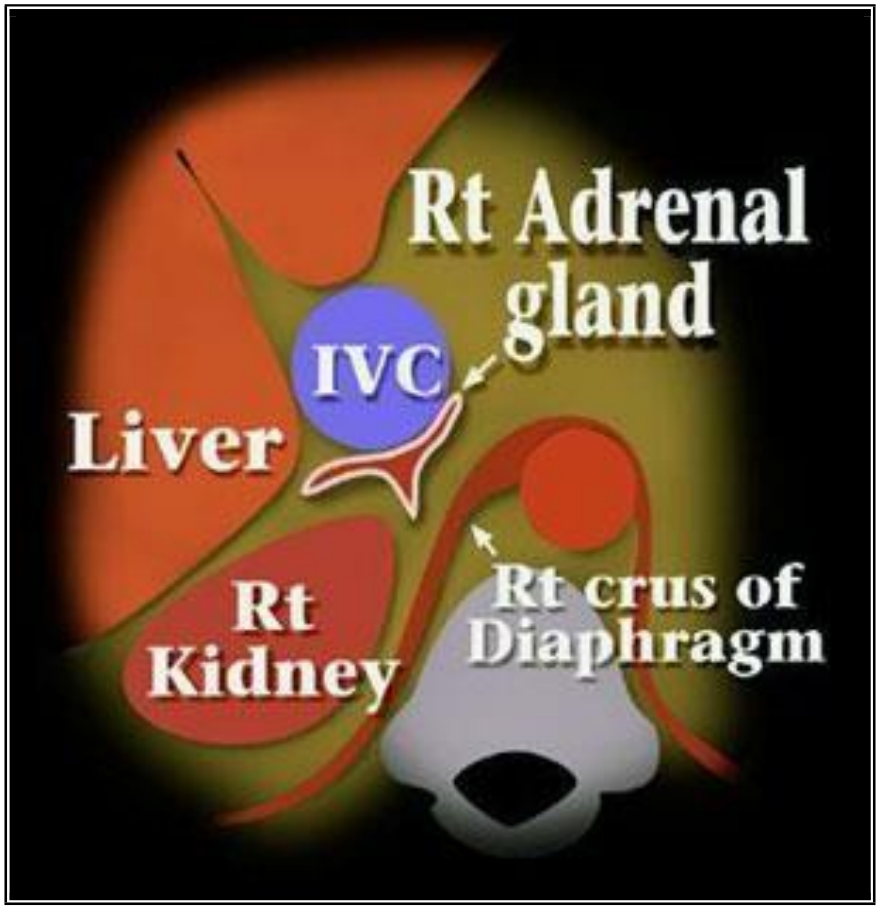
Relations of the **right** suprarenal glnad

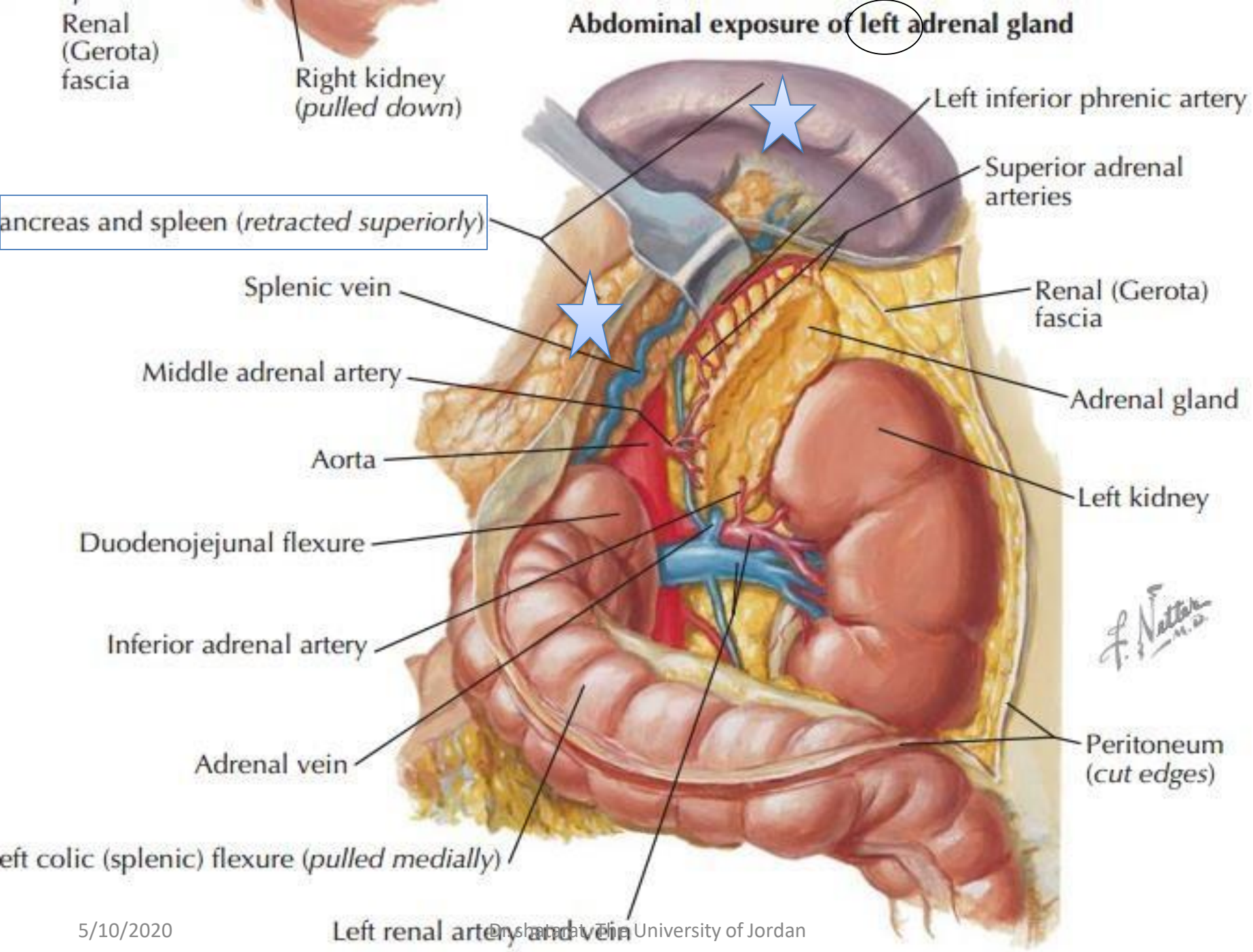
Anteriorly:

- Inferior vena cava (medially)
- Right hepatic lobe (laterally)

Posteriorly:

- Diaphragm (**right** crus)
- Superior pole of the right **kidney**




Renal (Gerota) fascia
Right kidney (pulled down)
Abdominal exposure of left adrenal gland
Left inferior phrenic artery
Superior adrenal arteries
ancreas and spleen (retracted superiorly)
Splenic vein
Renal (Gerota) fascia
Middle adrenal artery
Adrenal gland
Aorta
Left kidney
Duodenojejunal flexure
Inferior adrenal artery
Adrenal vein
Peritoneum (cut edges)
eft colic (splenic) flexure (pulled medially)
Left renal artery and vein

Relations of the **left** suprarenal gland

Anteriorly:

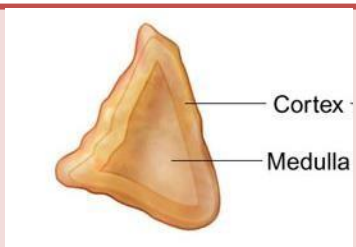
- Stomach [above]
- Lesser sac of peritoneum [above]
- The inferior area is in touch with the pancreas and splenic vein. [below]

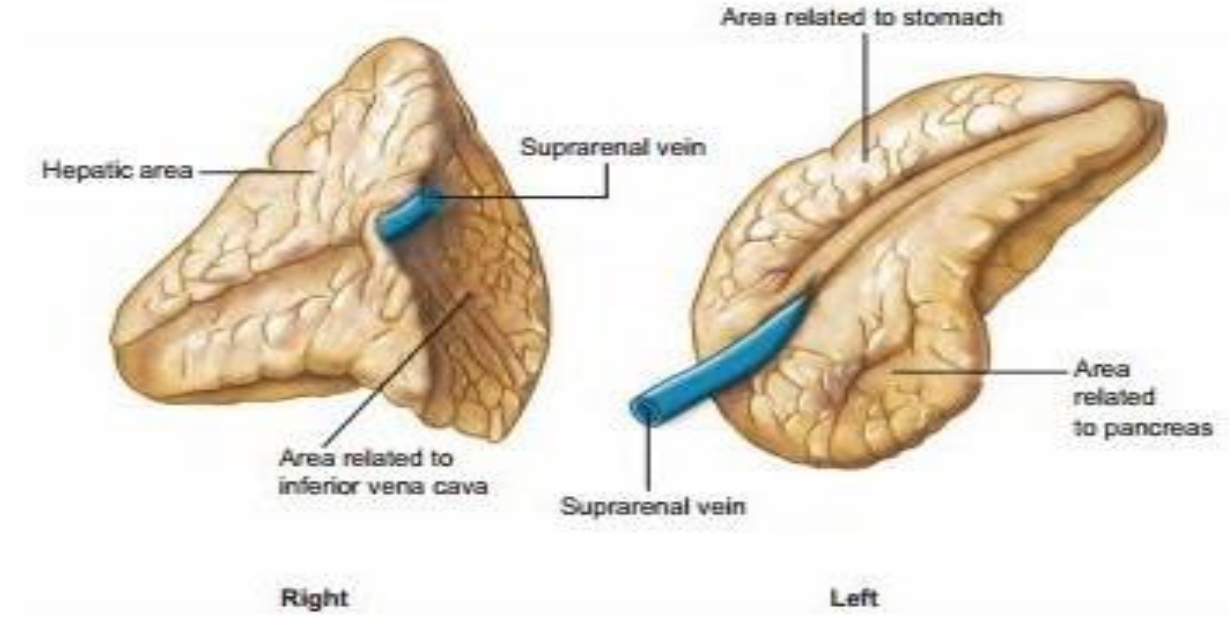
Posteriorly:

- Diaphragm (**left** crus)
- Superior pole of the left **kidney**

>> Remember that the IVC is on the right side, so it isn't related to the left suprarenal gland!!

Comparison between Rt. & Lt. Suprarenals

Right Suprarenal	Left Suprarenal
	
Triangular (pyramidal)	Crescentic (semilunar)
Does NOT reach the hilum of the right kidney	Reaches the hilum of the left kidney [easier to see it anterior to the kidney]
The hilum is directed upwards	The hilum is directed downwards
Its vein is short and drains to the IVC	Its vein is long and drains to the left renal vein.



B

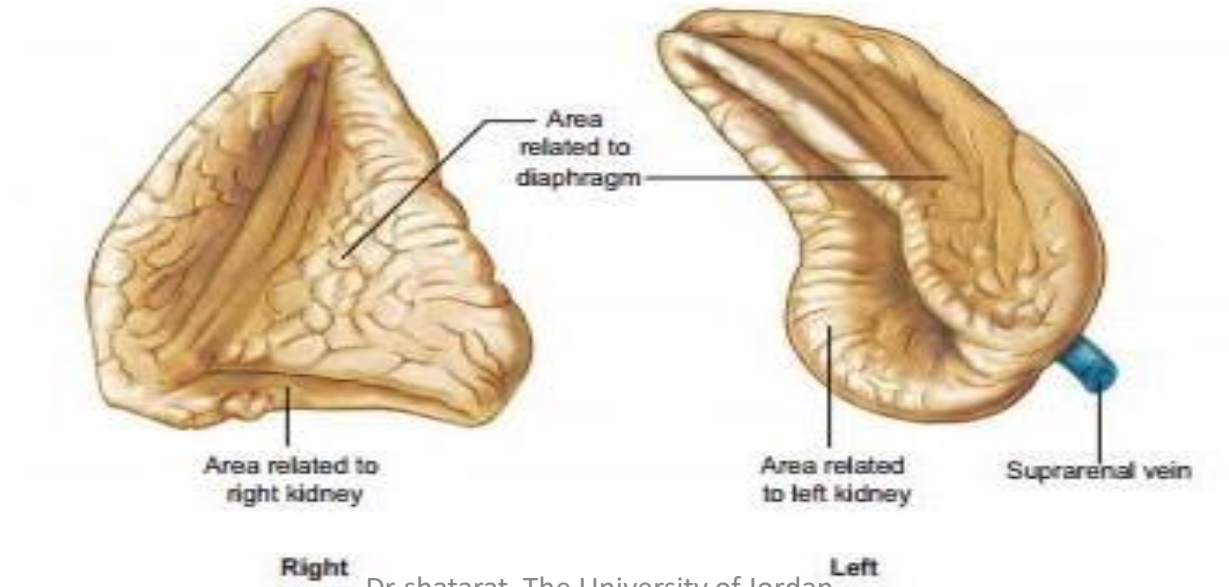


Fig. 72.1 Suprarenal glands: anterior (A) and posterior (B) aspects.

BLOOD SUPPLY

Blood supply of the adrenals

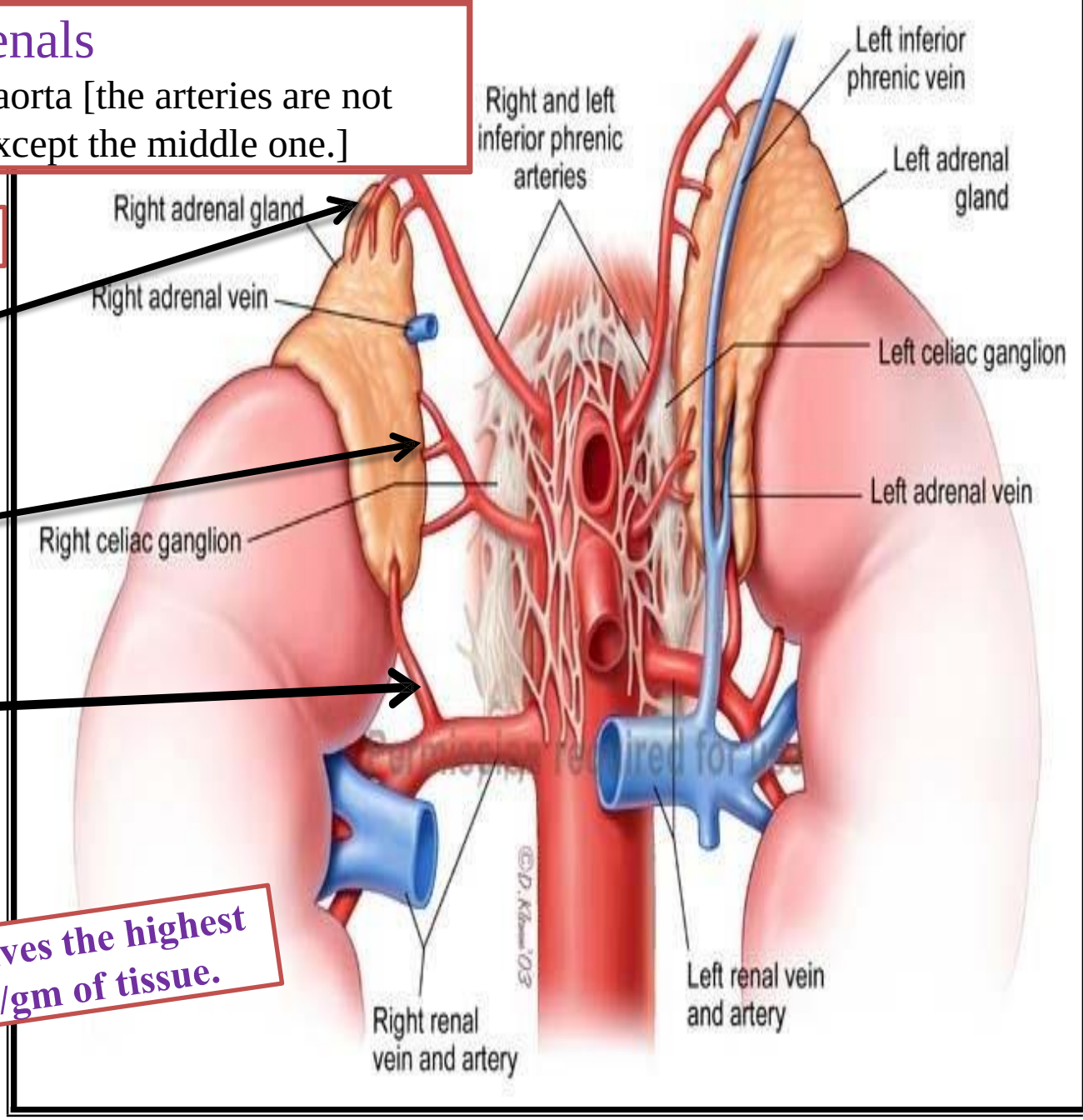
they are close to the abdominal aorta [the arteries are not direct branches from the aorta except the middle one.]

Each gland receives 3 arteries

Superior suprarenal a. from the inferior phrenic artery

Middle suprarenal a. from the abdominal aorta.

Inferior suprarenal a. from the renal artery.



The suprarenal gland receives the highest blood supply in the body/gm of tissue.

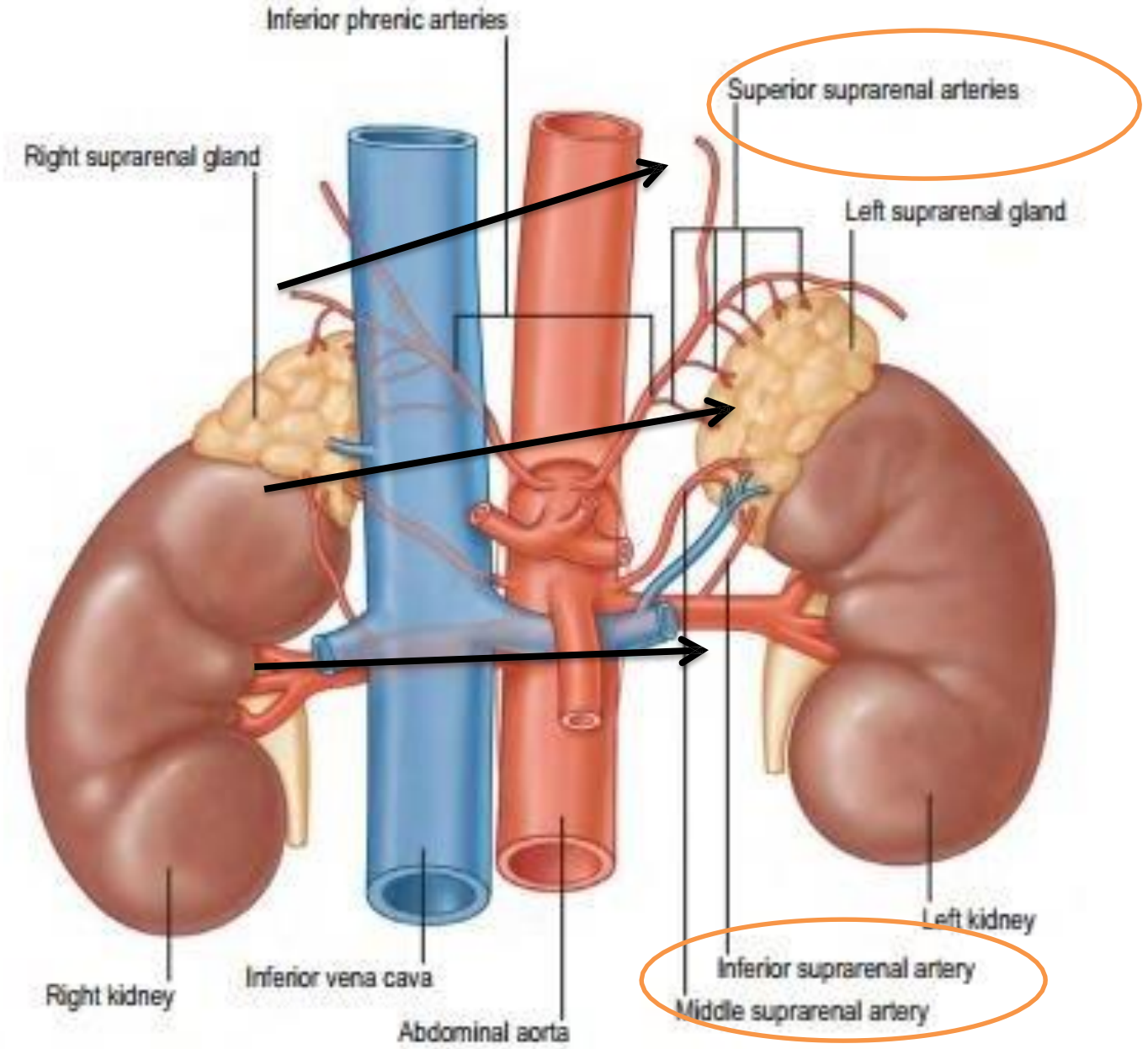
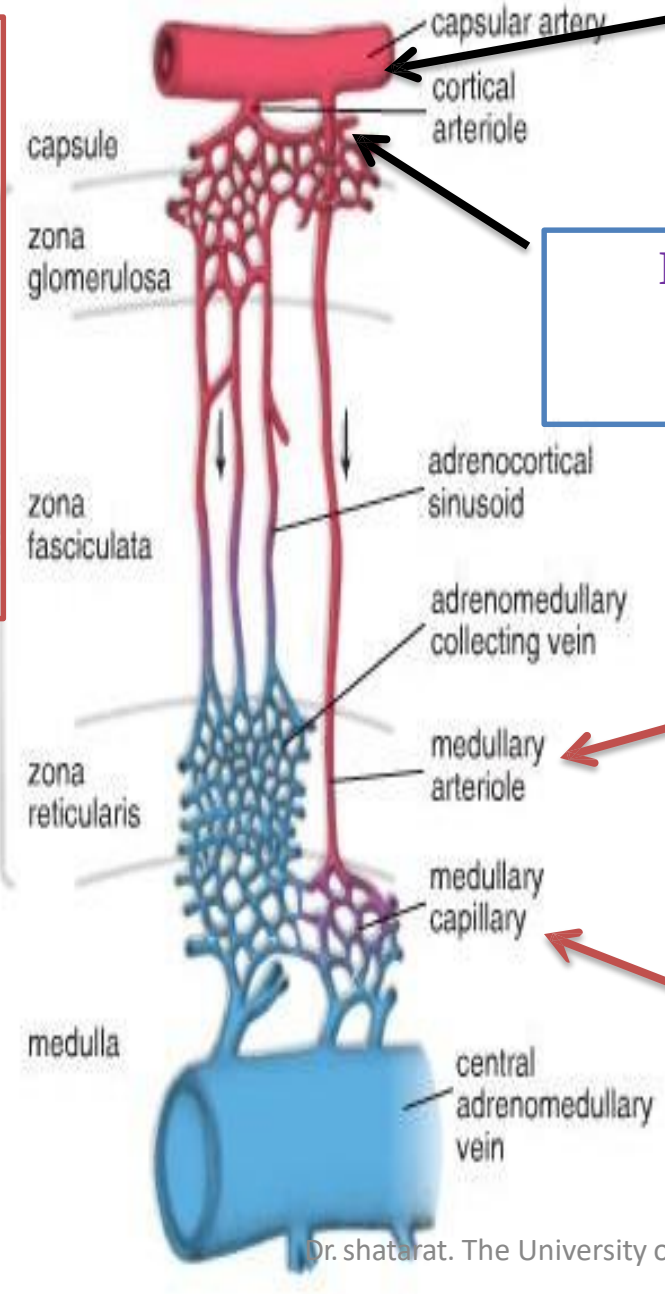


Fig. 72.3 Arterial supply and venous drainage of the suprarenal glands. (From Drake, Vogl and Mitchell, 2005).

The capsule is penetrated by ~ 60 arterioles.

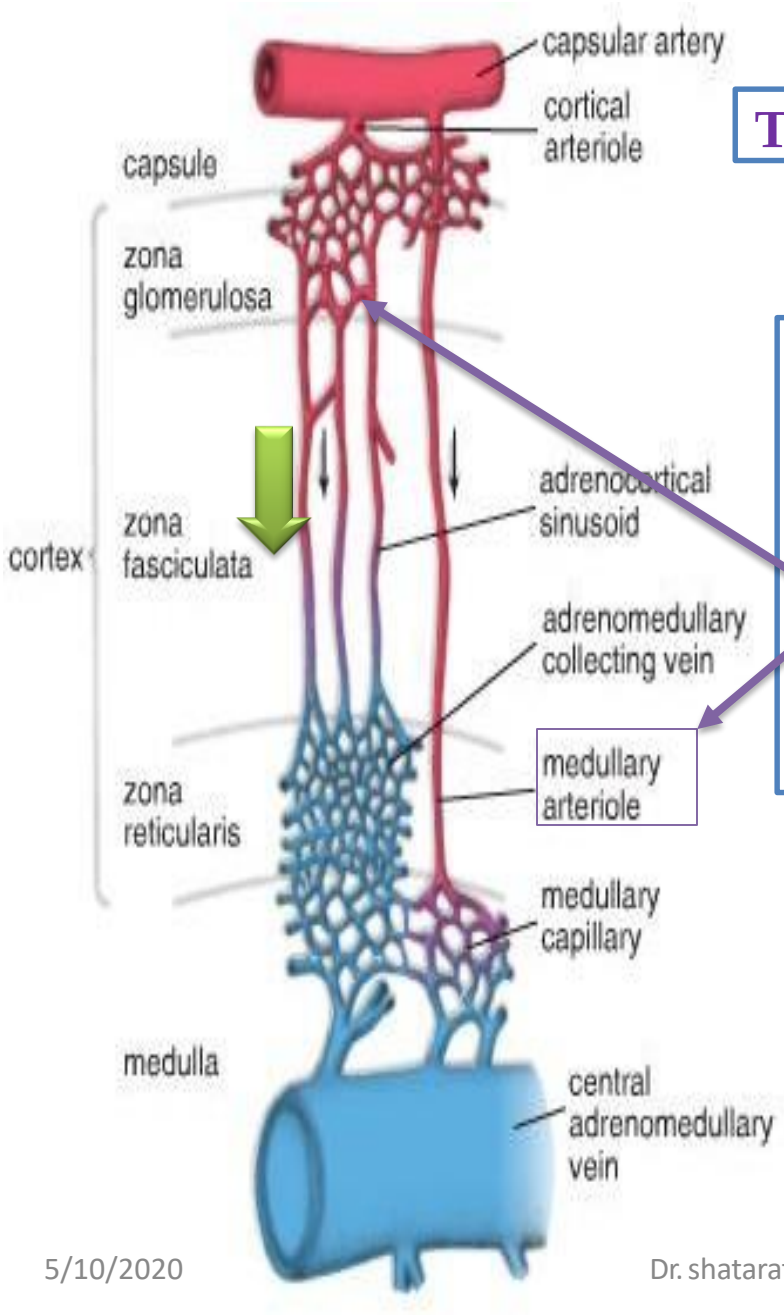
A) short <u>capsular capillaries</u> that supply the capsule.

The superior, middle, and inferior suprarenal arteries In the capsule they branch forming a system that consists of



B) intermediate fenestrated cortical sinusoidal capillaries that supply the cortex

C) long medullary arterioles that traverse the cortex traveling within the trabeculae, and bring arterial blood to the **medullary capillary sinusoids**.



The medulla thus has a dual blood supply

Arterial blood from
the medullary arterioles
and
"venous" blood from
the cortical sinusoidal capillaries
that have already supplied the cortex.

Arterial and venous capillaries within the adrenal gland **help to integrate the function of the cortex and medulla**.
For example, ***cortisol-enriched blood flows from the cortex to the medulla,*** where cortisol enhances the activity of *phenylethanolamine-Nmethyltransferase* that **converts norepinephrine to epinephrine**.

See the green arrow in the previous slide

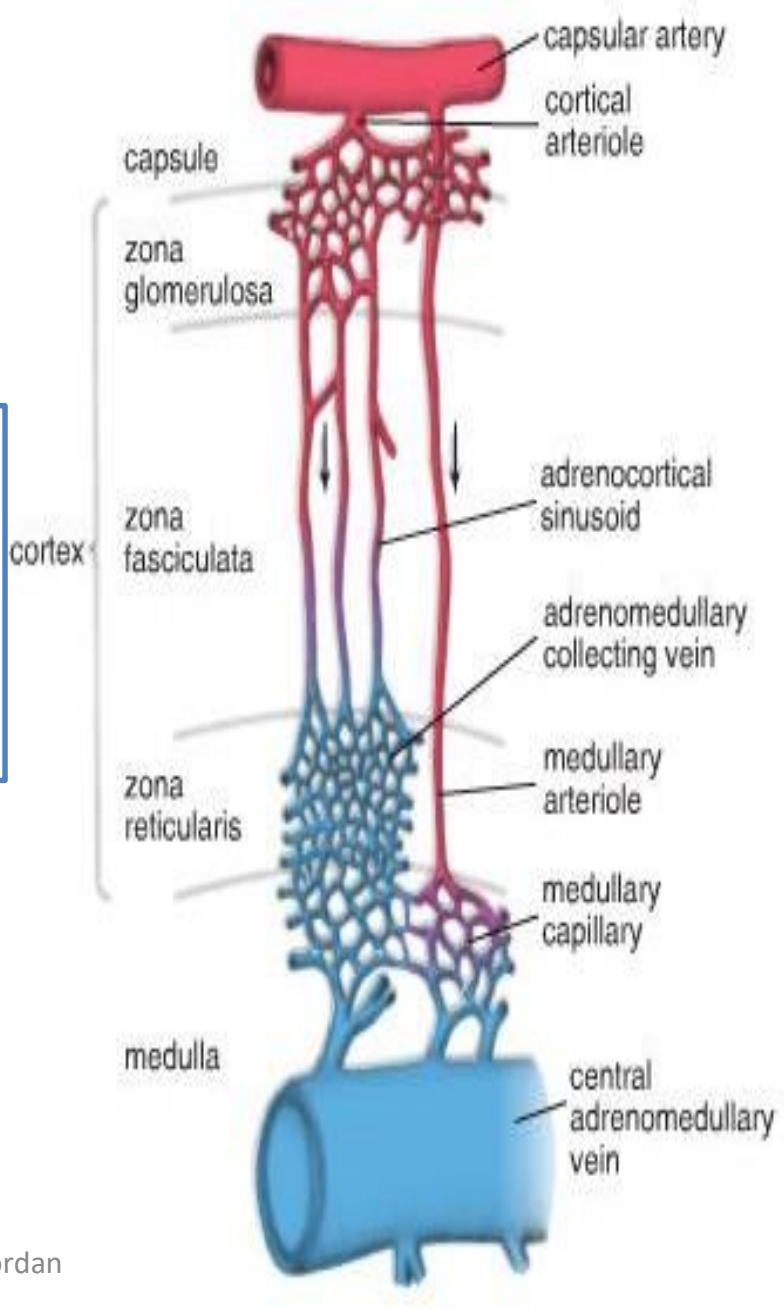
An example of extra-adrenal chromaffin tissues

Extra-adrenal chromaffin tissues lack these high levels of cortisol and produce **norepinephrine** almost exclusively

The largest cluster of chromaffin cells outside the adrenal medulla is near the level of the inferior mesenteric artery and is referred to as the organ of **Zuckerkandl**, which is quite prominent in fetuses and is a major source of catecholamines in the first year of life

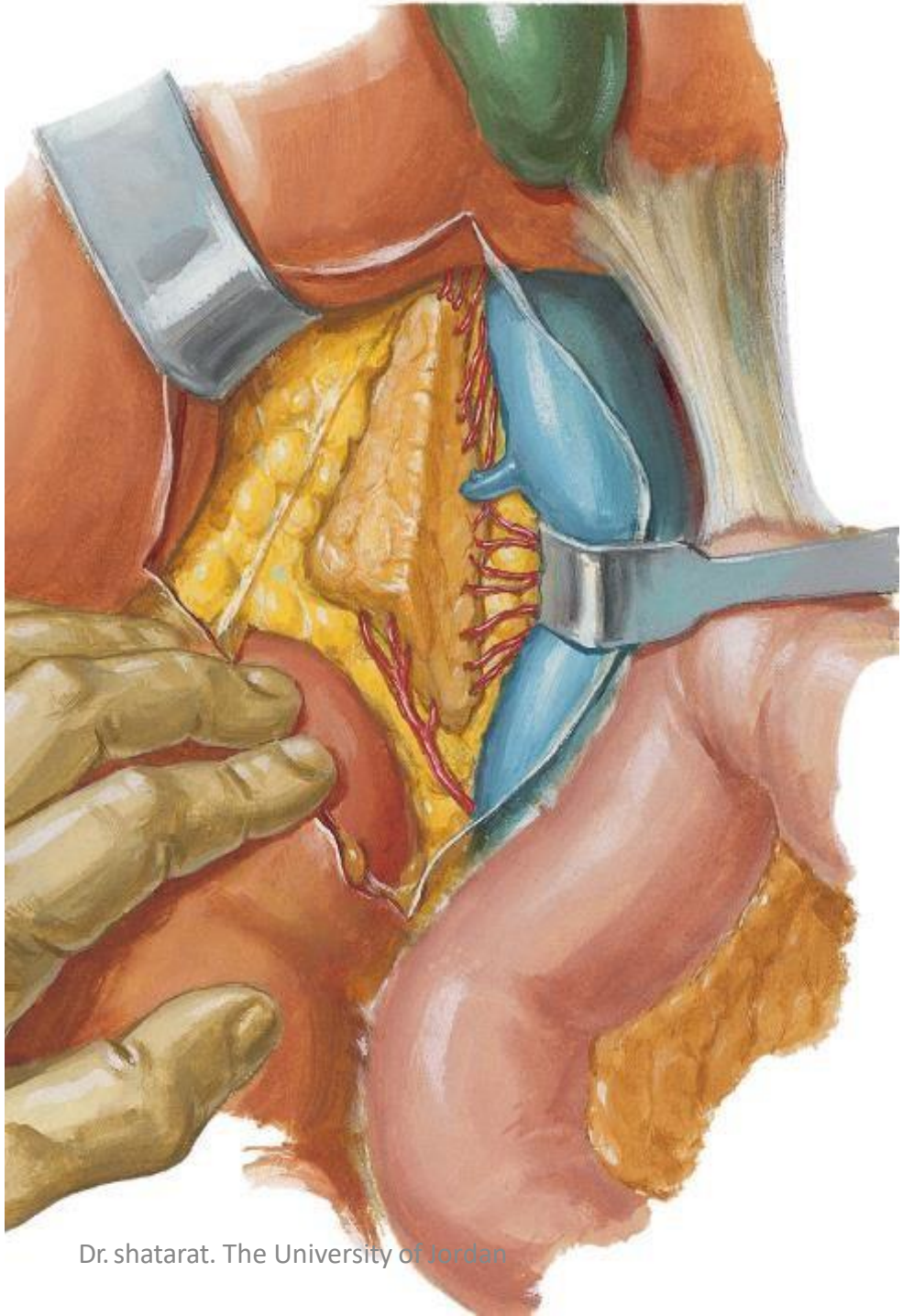
Venous drainage of the adrenal glands is achieved via the suprarenal veins:
[we don't have three suprarenal veins/ we have only one central vein for each gland, the large central adrenomedullary vein]

The venules that arise from the cortical and medullary sinusoids drain into the small adrenomedullary collecting veins that join to form
The Large Central Adrenomedullary Vein
which then drains directly into :

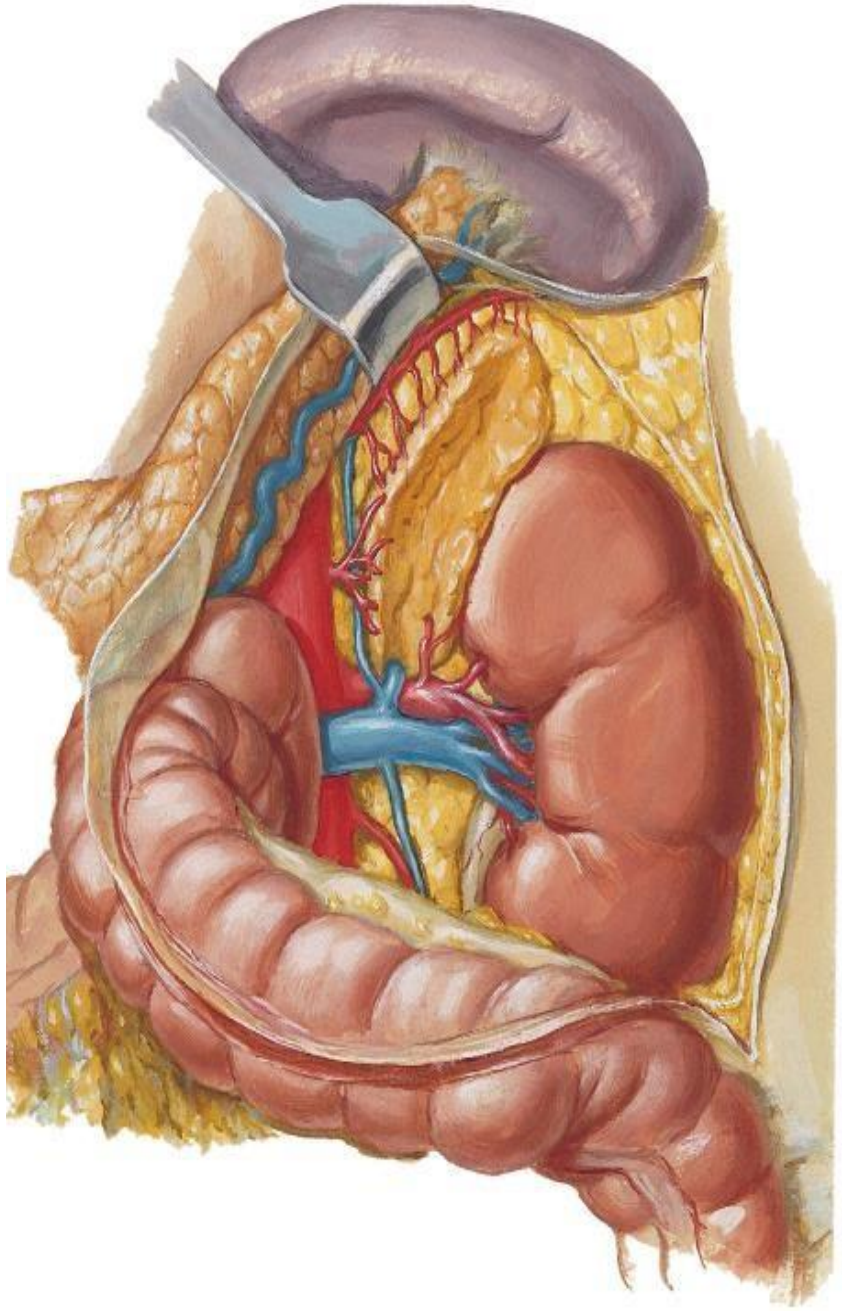


the right suprarenal vein (short) drains into the inferior vena cava

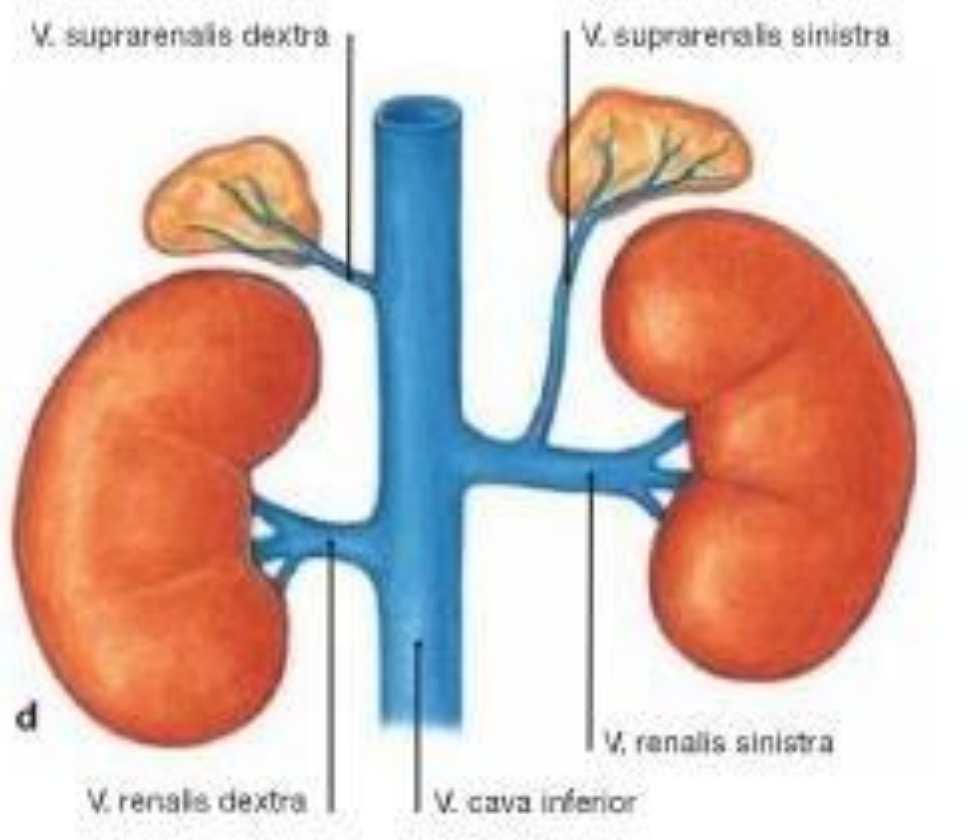
Because the IVC is on the right side



the left suprarenal vein (longer) drains into the renal vein or the left inferior phrenic vein



Only one suprarenal vein exists for each adrenal gland and this vein has in its wall smooth muscles that squeeze it to give all its content to the nearby IVC or renal vein and finally into IVC



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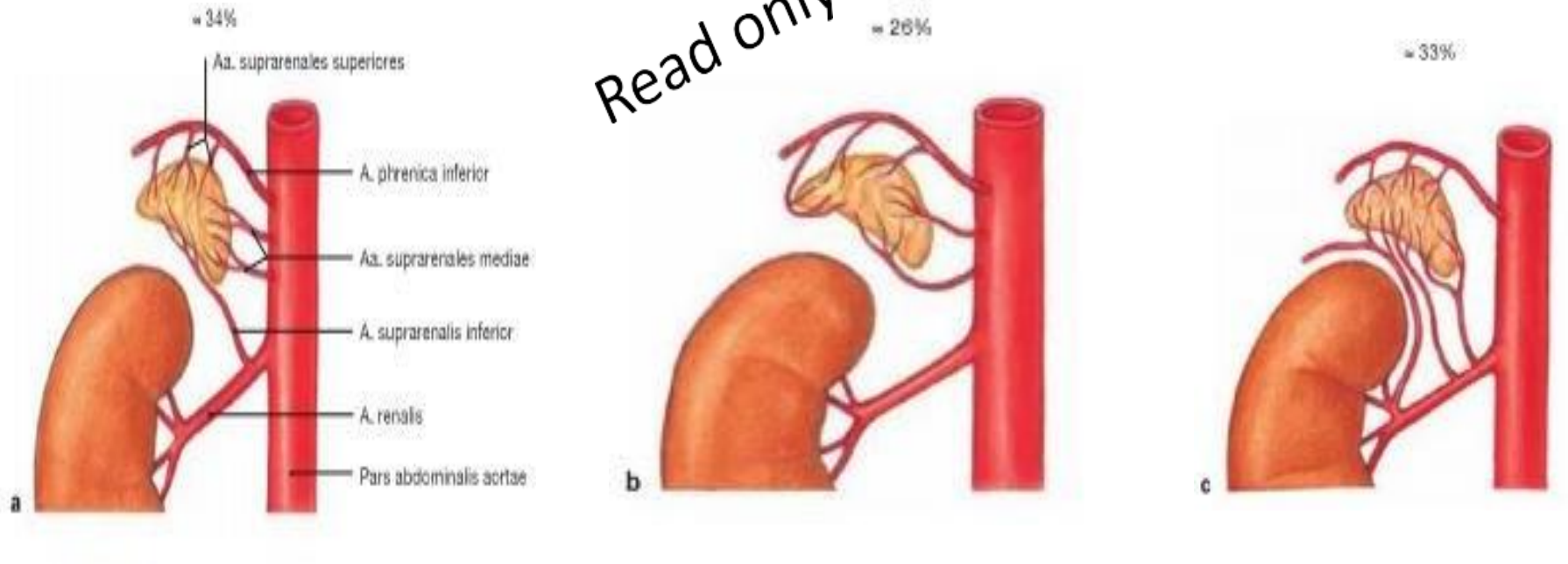


Normal variations in the adrenal gland
A) arterial supply via three arteries
b) arterial supply without tributary from the A. ranalis c) arterial supply without a direct branch of the Aorta

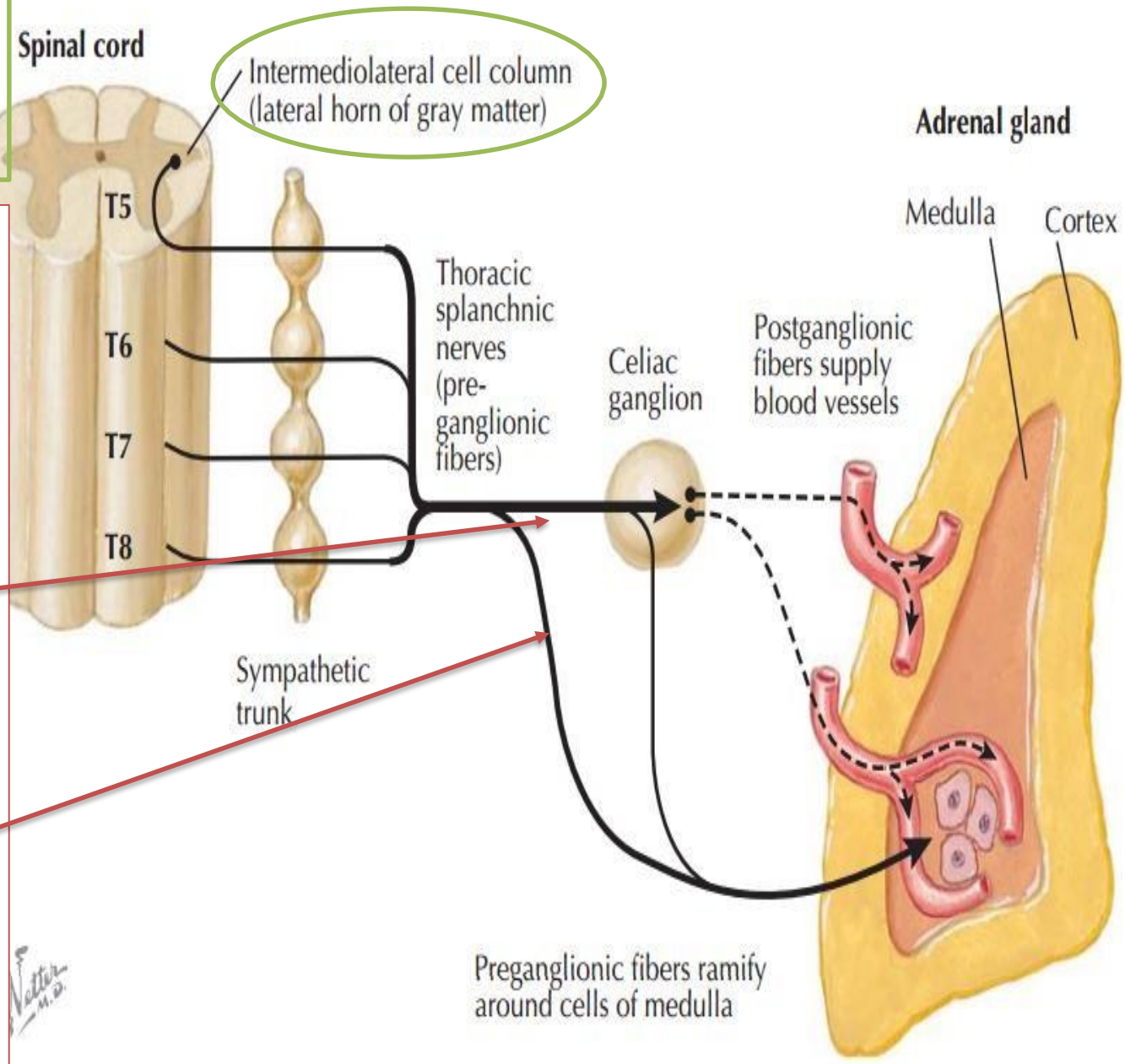
NERVE SUPPLY

Relative to their size, the adrenal glands have a richer innervation than other viscera

as you can see in the picture emerging from T5 T6 T7 T8 <u>preganglionic Sympathetic nerves</u> that go directly and immediately:

A. *some of them will arrest in Celiac ganglion (around the celiac artery of aorta)*

B. *Others will carry on as preganglionic reaching the suprarenal glands immediately [to the medulla or to the Arteries of the medulla].*



Our brain is the main organizer of our responses.

→ So, in case of any stimulus, like external sings of fear and threatening [fight or fight], **our brain through 3 parts (hypothalamus, pons, medulla) would send massages to the spinal cord/ sympathetic lateral horns of T1-L2**.

→ we call these lateral horns **thoracolumbar outflow** and they are *the only place where we have Sympathetic in CNS.*

What does this mean??

This gland is under very fast response to any order from the brain

Simply your brain needs to be stimulated/ Fight or Flight → signals go to lateral horns [we call them splanchnic nerves] without interrupting → they supply the gland

Catecholamines are released from the adrenal medullary and sympathoneuronal systems—both are key components of the fight-or-flight reaction

This reaction is triggered by ***neural signals from several sites in the brain*** (e.g., the *hypothalamus, pons, and medulla*), leading to synapses on ***cell bodies in the intermediolateral cell columns*** of ***the thoracolumbar spinal cord***

The preganglionic sympathetic nerves leave the spinal cord and synapse in ***paravertebral and preaortic ganglia*** of the ***sympathetic chain***.
Preganglionic axons from the lower thoracic and lumbar ganglia innervate the adrenal medulla ***via the splanchnic nerve***

ACETYLCHOLINE is the neurotransmitter in **the ganglia**, and the postganglionic fiber releases **NOREPINEPHRINE.**
The **chromaffin** cell of the adrenal medulla is a "**postganglionic fiber** equivalent," and its chemical transmitters are epinephrine and norepinephrine.

Embryology

As all glands in our body the suprarenal gland has 2 origins :

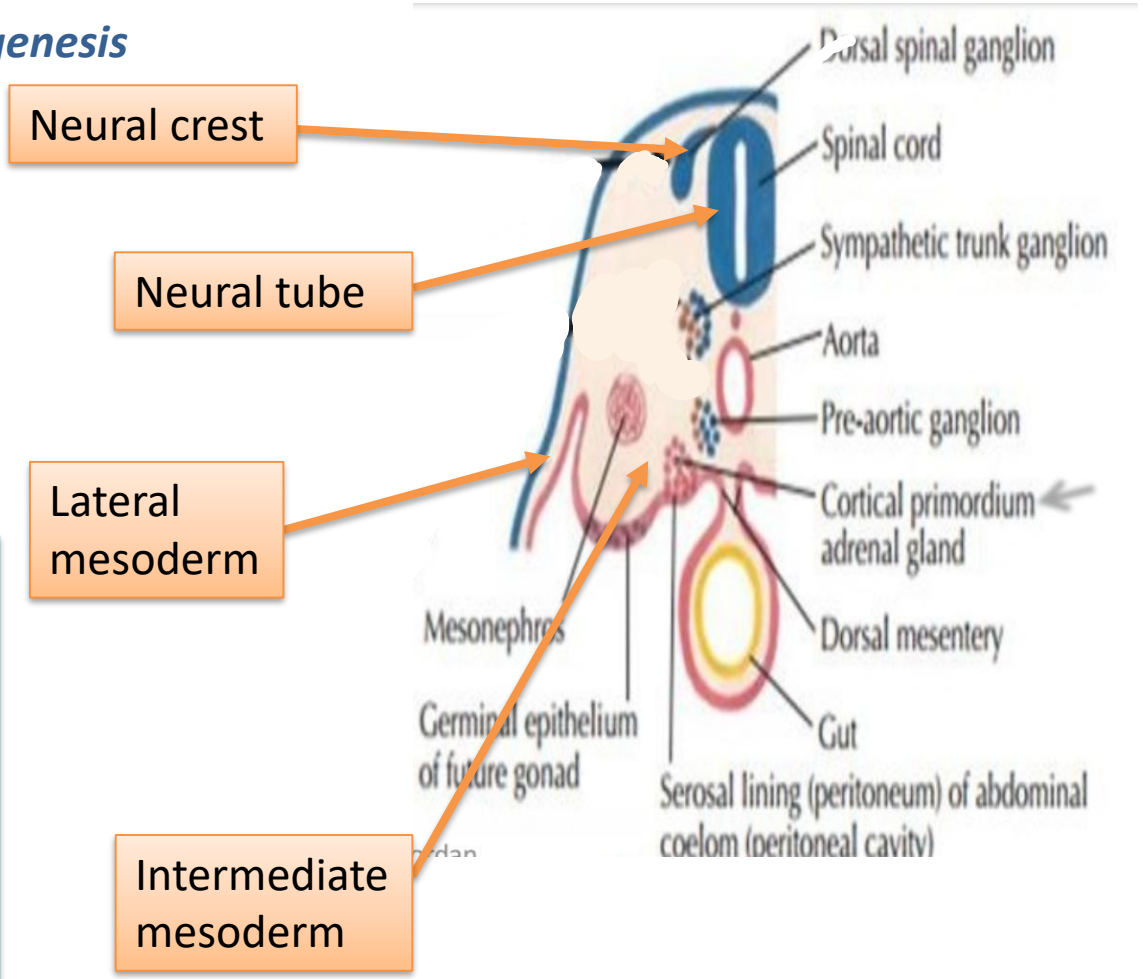
A. The first origin comes from neural crest

B. The second origin comes from intermediate mesoderm

This is an embryo During embryogenesis

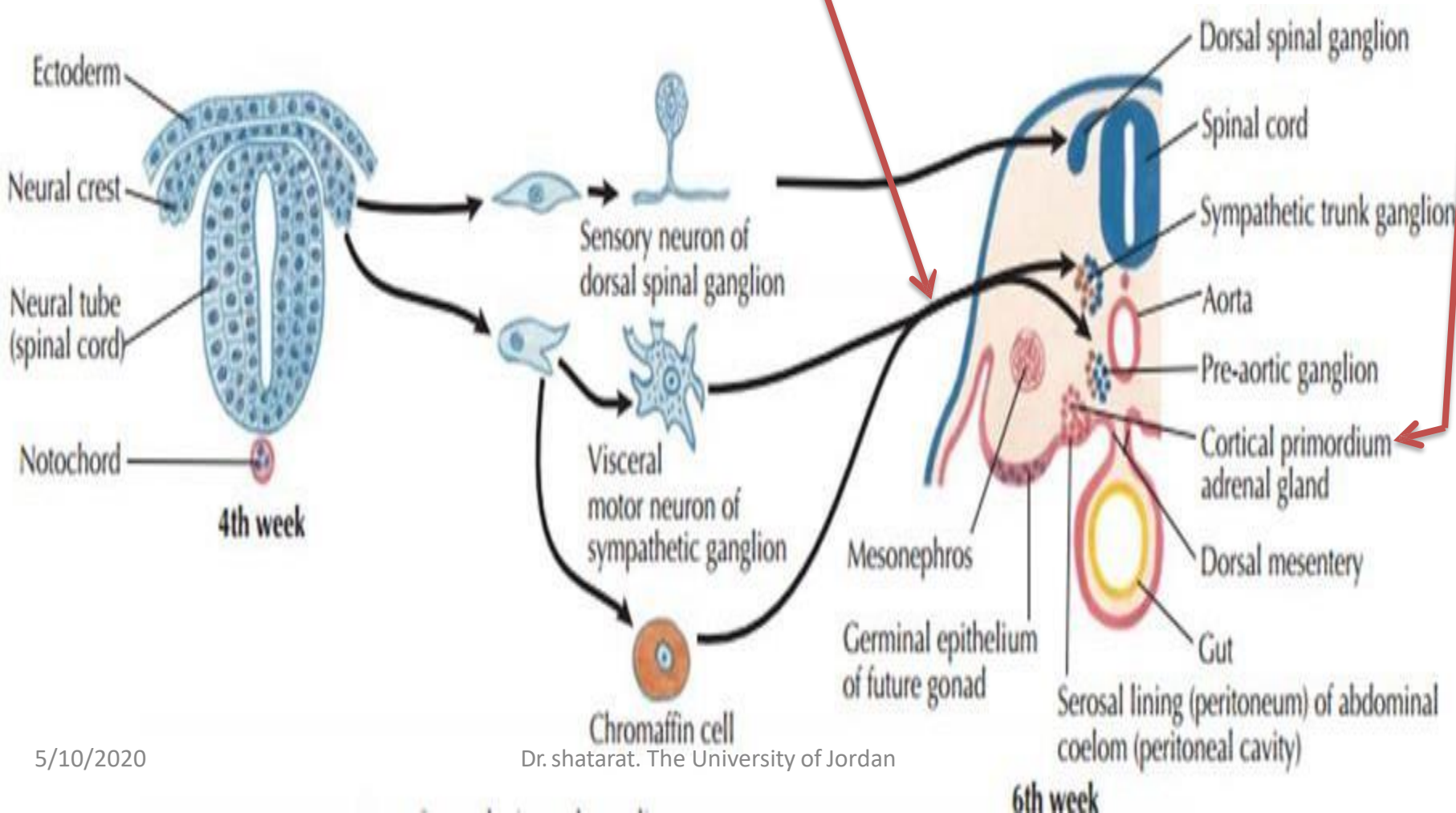
Neural crest comes from the neural tube migrating to the nearby mesoderm at the same time of the closure of the tube

Some of these migrating neural cells will migrate **dorsally** forming Melanocytes, some of them will migrate **Cranially** important in the formation of the face and some of them will migrate **ventrally** and we will talk about them in this lecture



Two origins

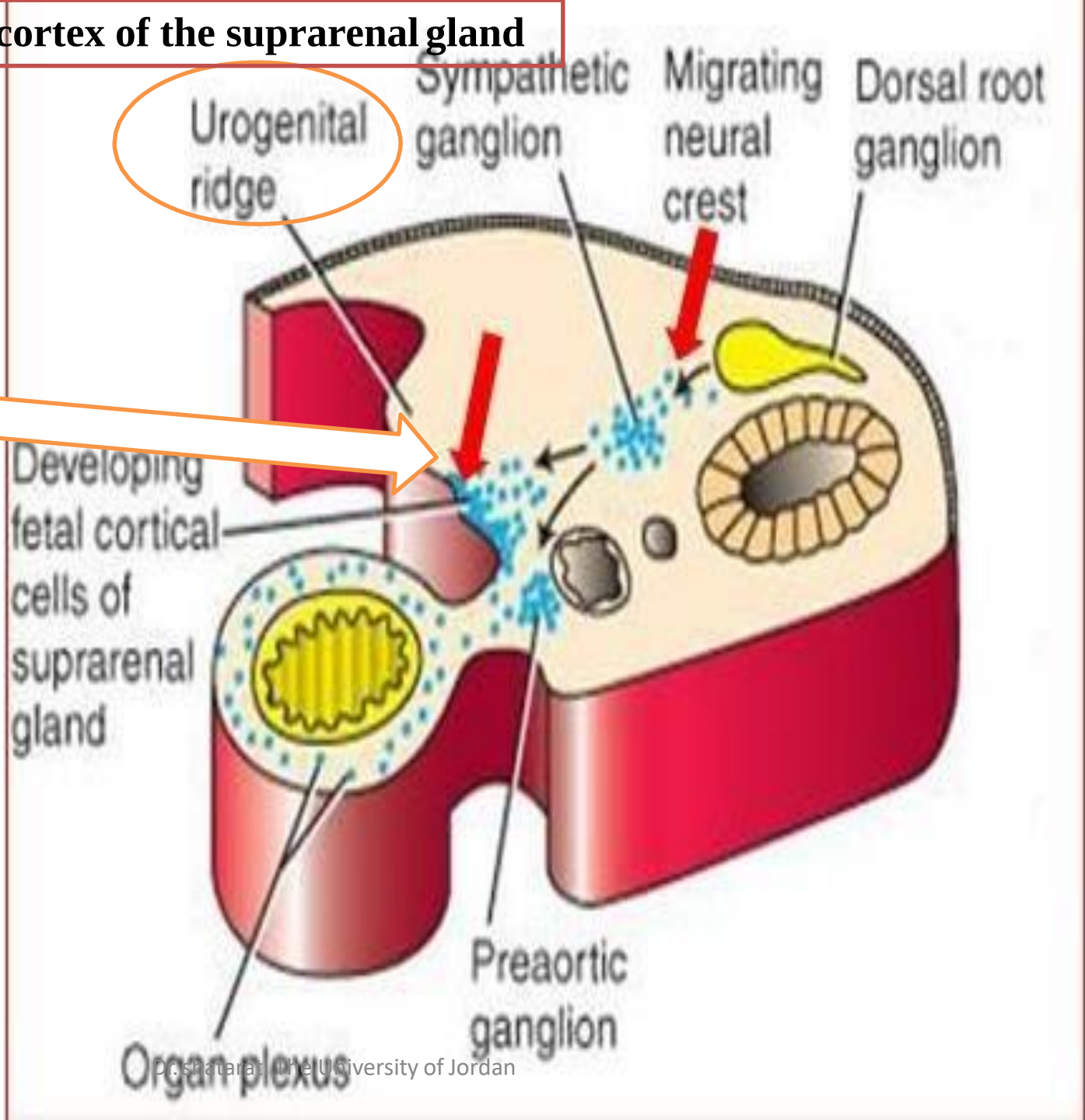
Embryologically, the **cortical** cells originate from **mesodermal mesenchyme**, whereas
the medulla originates from ectodermal origin (**neural crest cells)** that migrate into the developing gland



1-Development of the cortex of the suprarenal gland

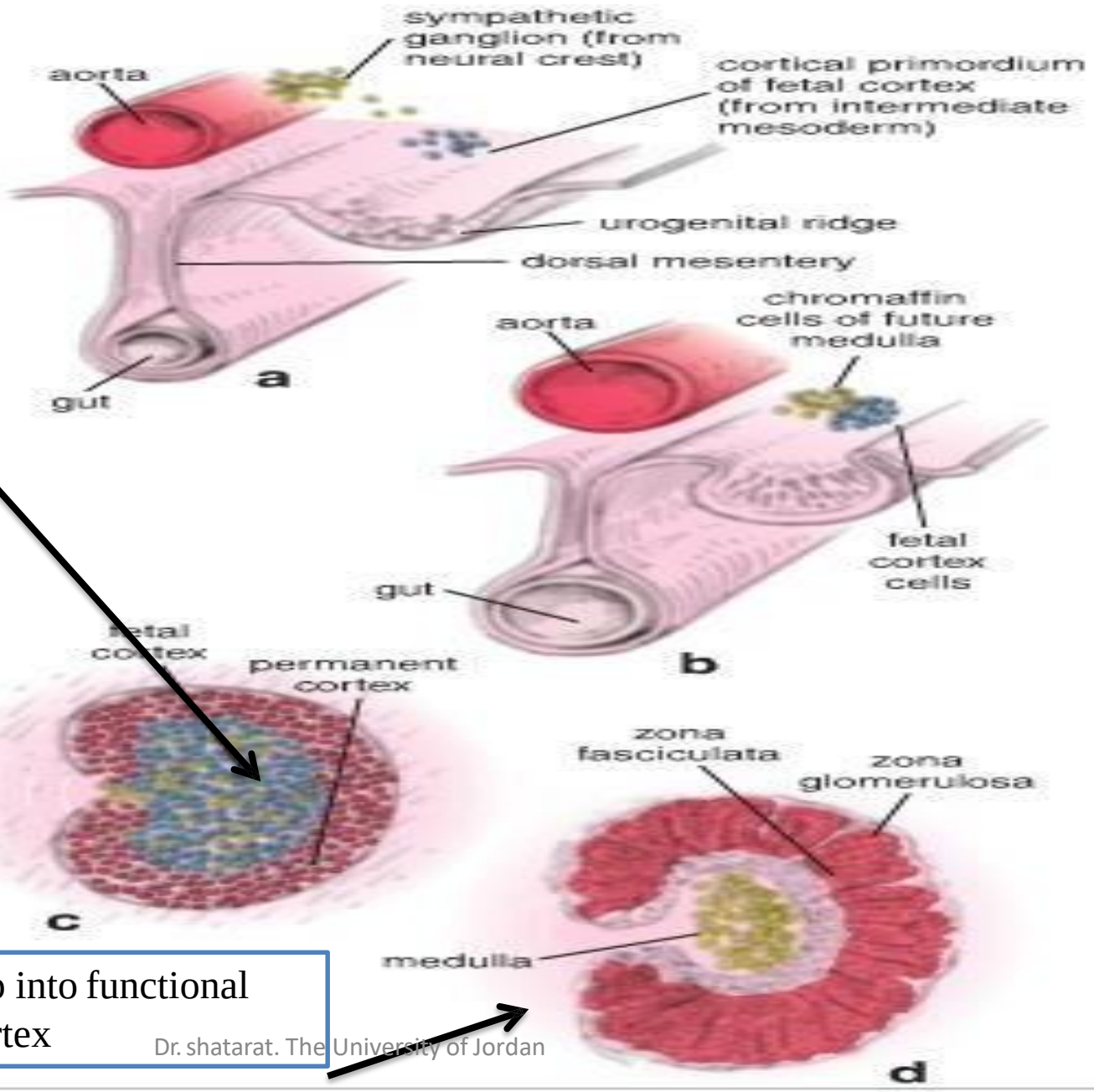
It develops during the week 4 – 6 from mesoderm adjacent to urogenital ridge

intermediate mesoderm gives off parts of the urogenital system which has clinical application : If something develops near to other structures they may have some clinical manifestations together



At the beginning of 8th week of development **mesothelial cells** proliferate and differentiate into large **acidophilic cells** which surround the **medullary primordium** and form the fetal or primitive suprarenal cortex

[They migrate and surround the already Migrating medulla]



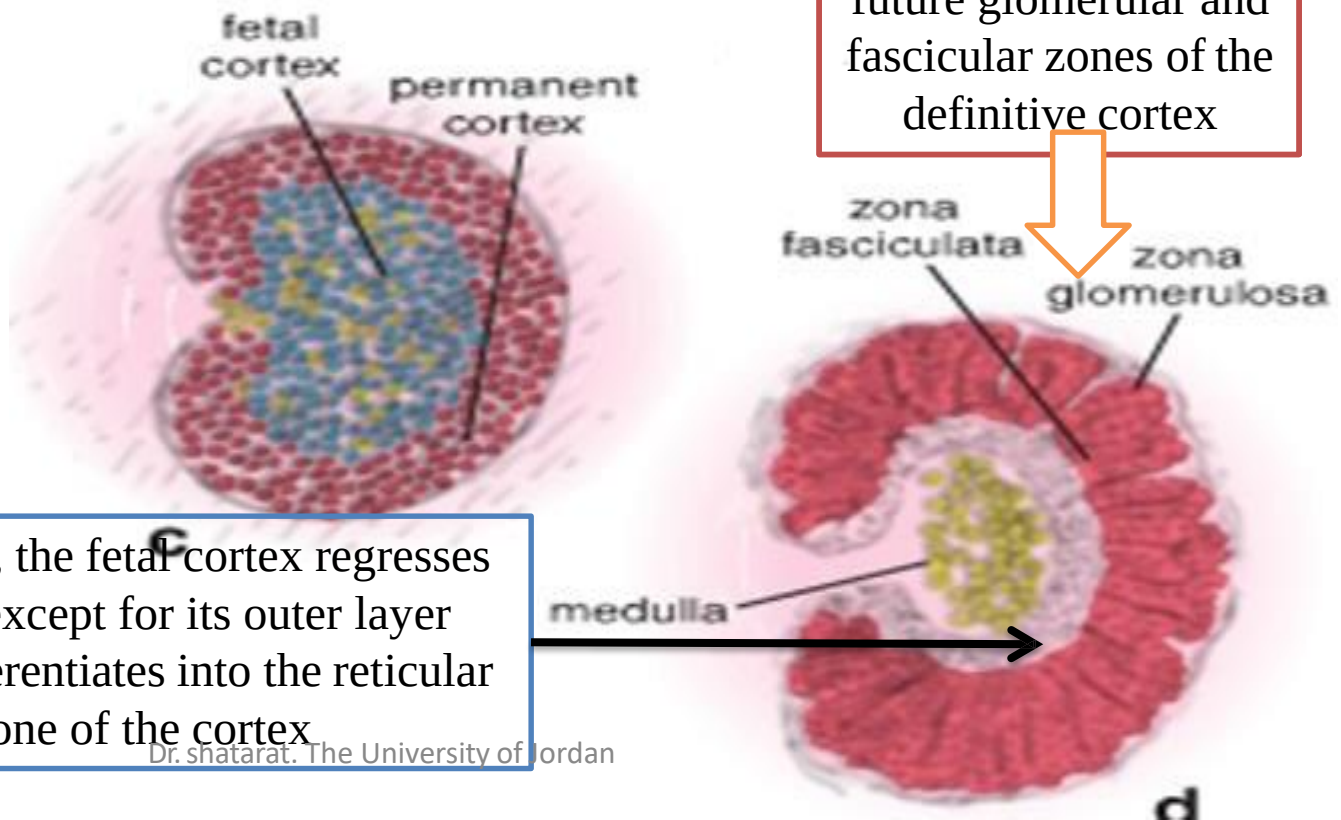
Definite cortex develop into functional adrenal cortex

At the end of the 3ed month of development
a second wave of smaller
basophlic mesothelial cells surround the original acidophilic cell mass.

These smaller cells form the definitive cortex of the gland

The small basophilic cells will form the future glomerular and fascicular zones of the definitive cortex

If we divide The cortex into 3 parts the upper 2 parts are the derivatives of the permanent cortex

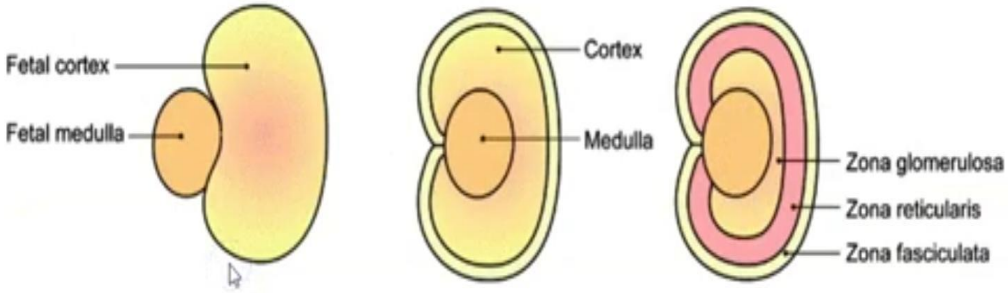


Fetal cortex produce steroid during gestation

After birth, the fetal cortex regresses rapidly, except for its outer layer which differentiates into the reticular zone of the cortex

Histologically the adrenal glands has 3 zones that come from different areas :

1. Both zona Glumerulosa and zona Fasciulata come from permanent cortex
2. Zona Reticularis comes from fetal cortex



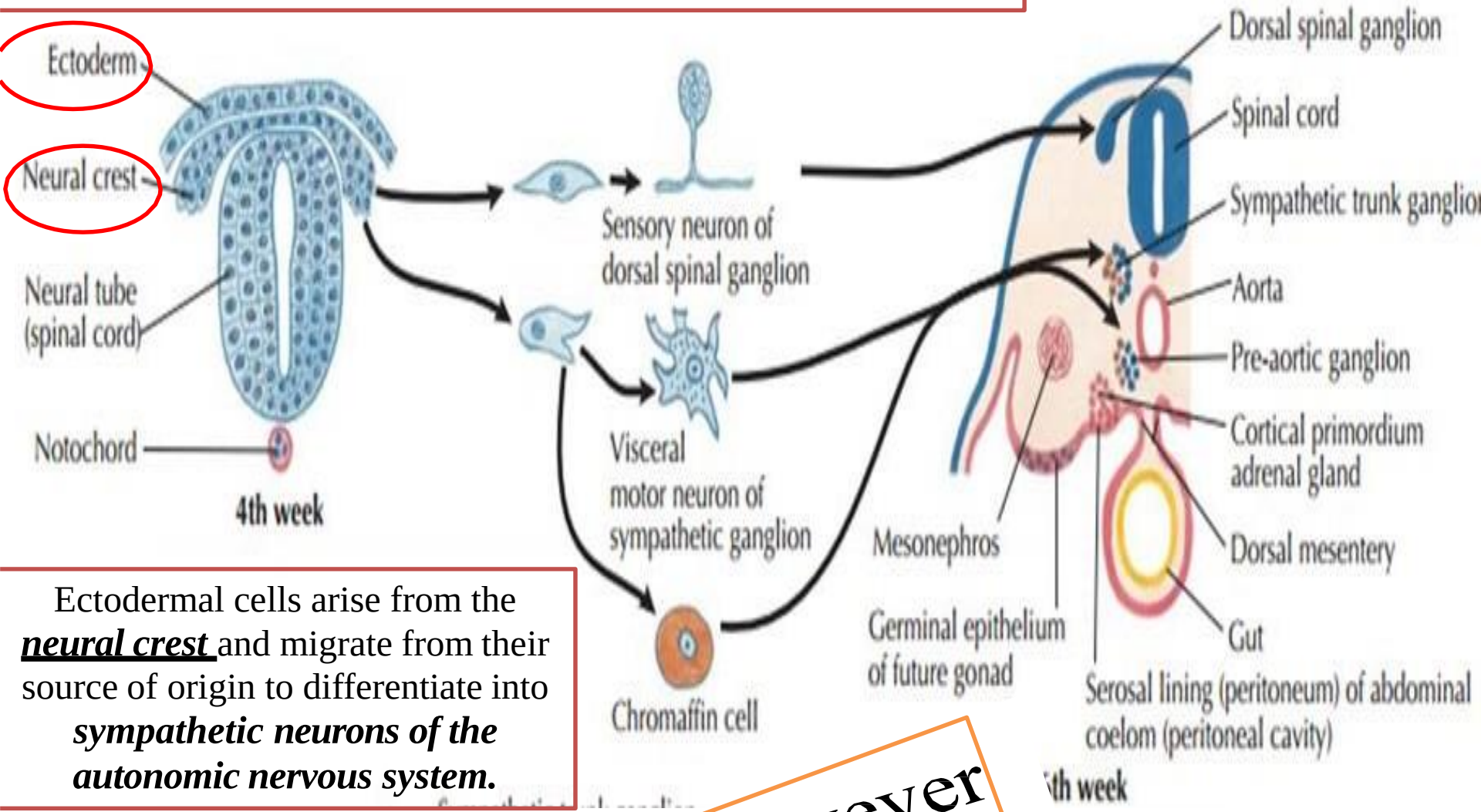
Summary

Cortex comes from intermediate mesoderm near the urogenital ridge and it is formed into 2 waves. the first wave migrates to the future site of suprarenal gland at the same time when the medullary cells migrate to meet them. these cells are Large and acidophilic, forming fetal cortex which has a function during development {secretes steroids}.

And second wave that is mesodermal in origin [the basophilic cells] would come and follow, then they surround the fetal cortex and differentiate into permanent cortex which would give us the upper 2 layers of the cortex.

Then the fetal cortex would differentiate into the reticular layer.

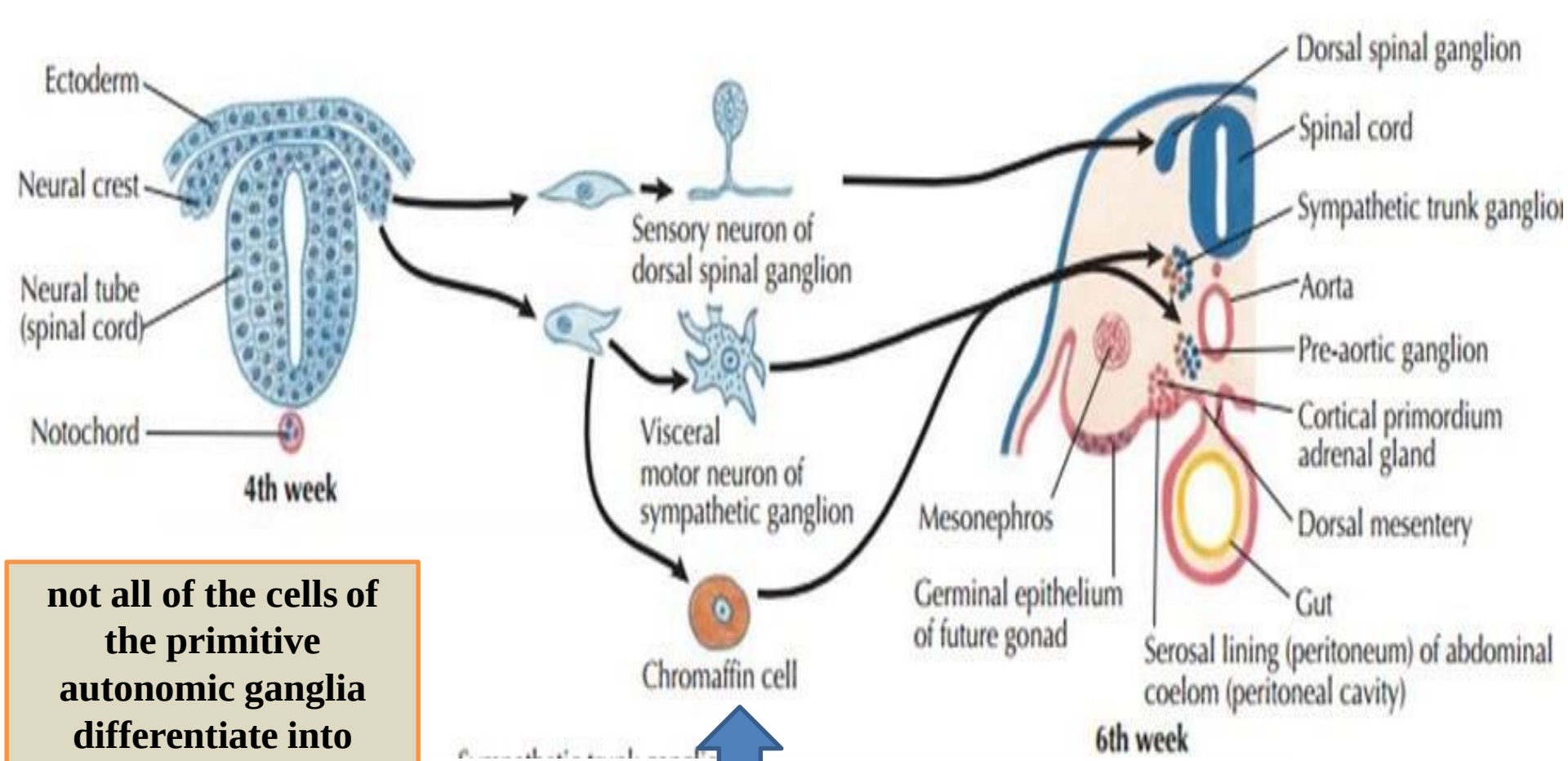
2-Development of the MEDULLA of the suprarenal gland



Ectodermal cells arise from the ***neural crest*** and migrate from their source of origin to differentiate into ***sympathetic neurons of the autonomic nervous system.***

However

Note: All ganglia in our body are formed By neural crest but not all of them differentiate into neurons

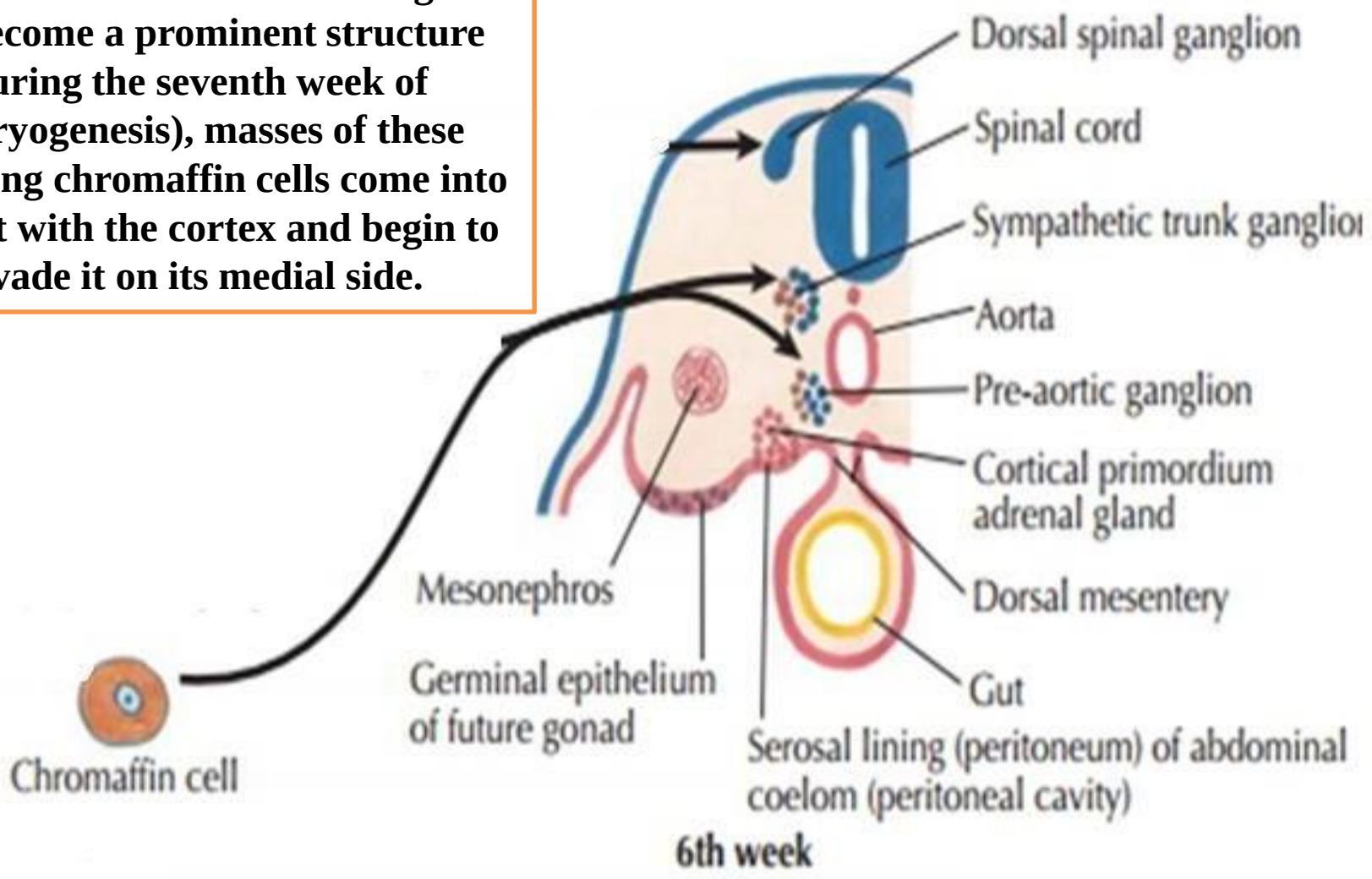


not all of the cells of the primitive autonomic ganglia differentiate into neurons.

Some become **endocrine cells**, designated as **chromaffin cells because they stain brown with chromium salts**

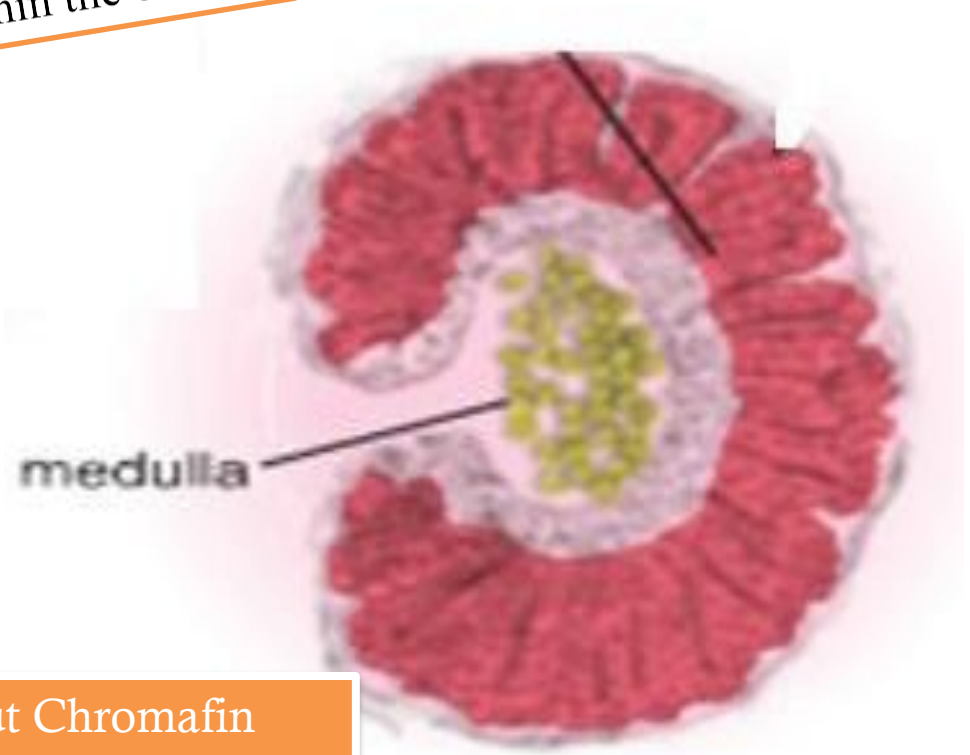
Certain chromaffin cells migrate from the primitive autonomic ganglia adjacent to the developing cortex to give rise eventually to the medulla of the adrenal glands.

When the cortex of the adrenal gland has become a prominent structure (during the seventh week of embryogenesis), masses of these migrating chromaffin cells come into contact with the cortex and begin to invade it on its medial side.



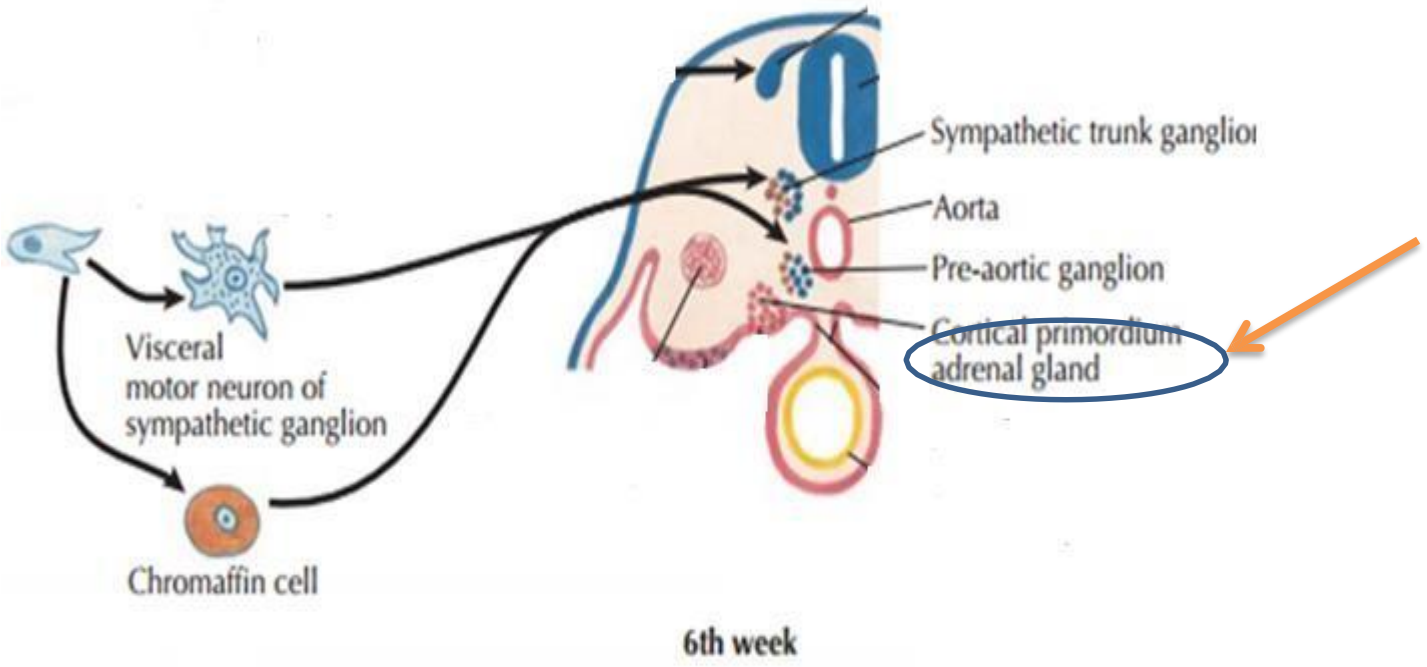
By the middle of fetal life, some of the chromaffin cells have migrated to the central position within the cortex

Chromafin cells migrate and meet cortex which is mesodermal in origin forming the medulla and cortex of adrenal gland



The medulla is nothing but Chromafin cells that are neural crest in origin.

Some chromaffin cells also migrate to form paraganglia, collections of chromaffin cells on both sides of the aorta.



The largest cluster of chromaffin cells outside the adrenal medulla is near the level of the inferior mesenteric artery and is referred to as the organ of **Zuckerkandl**, which is quite prominent in fetuses and is a major source of catecholamines in the first year of life

Congenital anomalies of the suprarenal gland

Read only

Prior to month 5 of **intrauterine development**

The cortex appears to develop autonomously

After the 5th month, the development of the adrenal gland depends on hypophyseal corticotropic hormone (ACTH)

Therefore, In case of anencephaly

Anencephaly: is a serious birth defect in which a baby is born without parts of the brain and skull. It is a type of neural tube defect (NTD). As the neural tube forms and closes, it helps form the baby's brain and skull (upper part of the neural tube), spinal cord, and back bones (lower part of the neural tube)

Read only

has little effect **before month 5** of fetal life since development of the adrenal up to this point appears to be autonomous

After month 5, development of the fetal cortex cannot occur without **ACTH,** thus, in the anencephalic, there is an involution of the adrenal cortex leading to **agenesis** or **hypoplasia**

note

agenesis : refers to the failure of an organ to develop during embryonic growth

IN HYDROCEPHALUS

Read only

s a condition in which there is an accumulation of cerebrospinal fluid (CSF) within the brain.

The hypothalamus is undamaged.

The adrenals develop normally

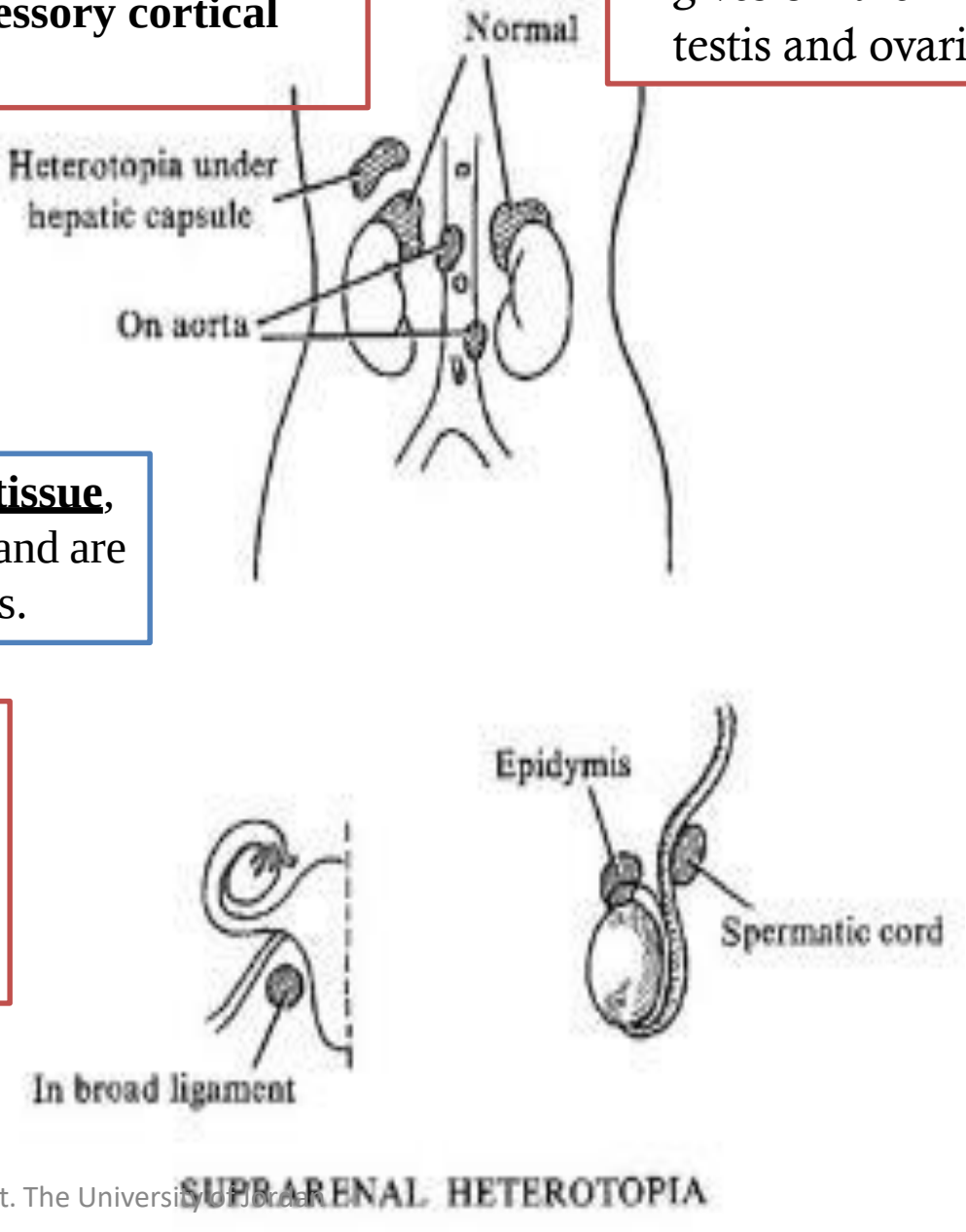
The origin of the cortex of the suprarenal gland is (near to urogenital ridge) which explains the presence of accessory para-testicular and para-ovarian accessory cortical masses

Urogenital crest gives off the testis and ovaries

True accessory adrenal glands, consisting of **both cortex and medulla**, are **rarely** found in adults. When they are present, they may be within **the celiac plexus** or embedded in the **cortex of the kidney**..

Adrenal rests, **composed of only cortical tissue**, **termed cortical bodies,** occur **frequently** and are usually located near the adrenal glands.

In adults, accessory separate cortical or medullary tissue may be present in the spleen, in the retroperitoneal area below the kidneys, along the aorta, or in the pelvis.



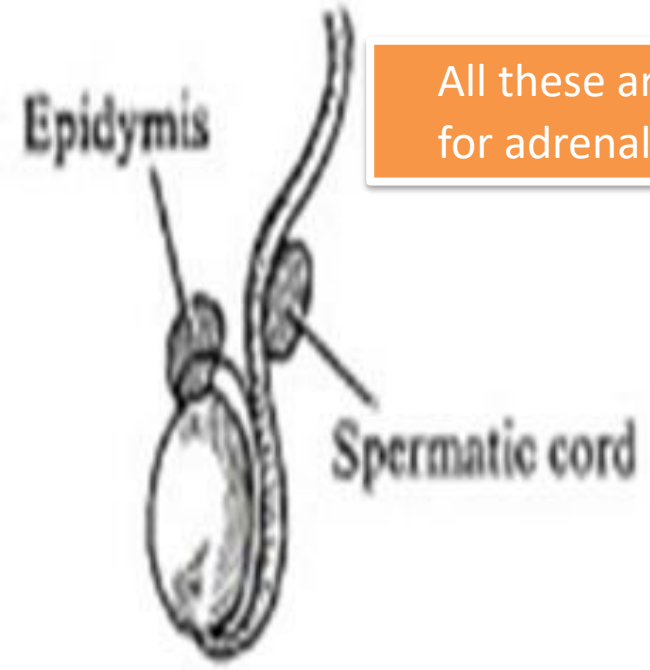
Because the adrenal glands are situated close to the gonads during their early development

accessory tissue may also be present in the

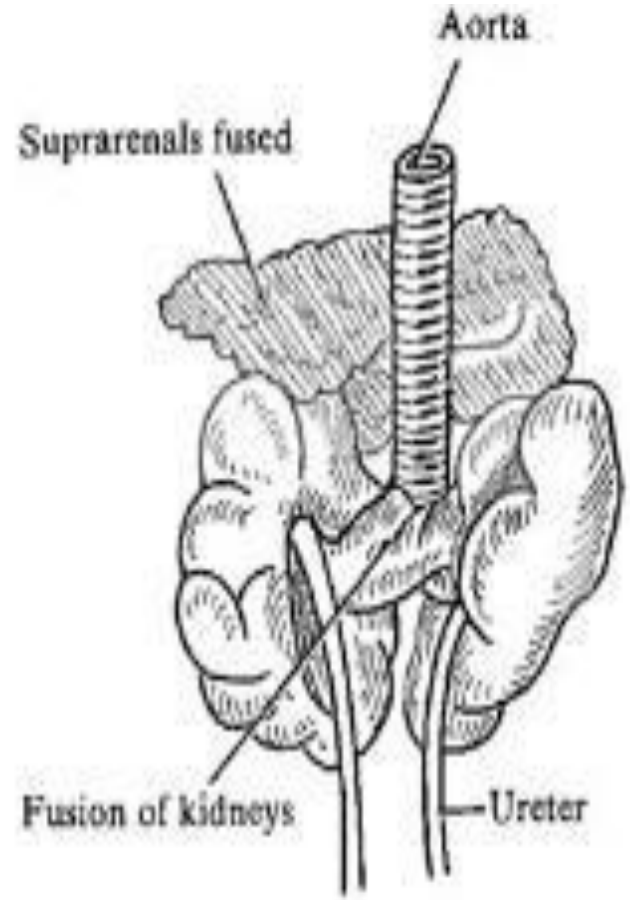
spermatic cord, attached to the testis in the scrotum

attached to the ovary, or in the broad ligament of the uterus. Although one adrenal gland may be absent occasionally, complete absence of the adrenal glands is extremely rare

All these are areas where you need to look for adrenal tissue



Fusion of the suprarenal glands seen when the kidneys are also fused across the midline



FUSION OF SUPRARENAL GLANDS BEHIND AORTA

The idea is that sometimes cells especially neural crest may settle down in the targeted area but other times they will not. [like what happens in testis and thyroid gland]

Congenital adrenal hypoplasia
usually manifests itself shortly after birth with many of the symptoms of **Addison's disease**

Agenesis of the adrenal: unilateral agenesis of the gland is almost always associated with agenesis of the kidney on the same side

The combination of 2 parts of a gland (neural crest coming to meet mesodermal cells), sometimes they don't meet, so they stay as different structures totally away from each other

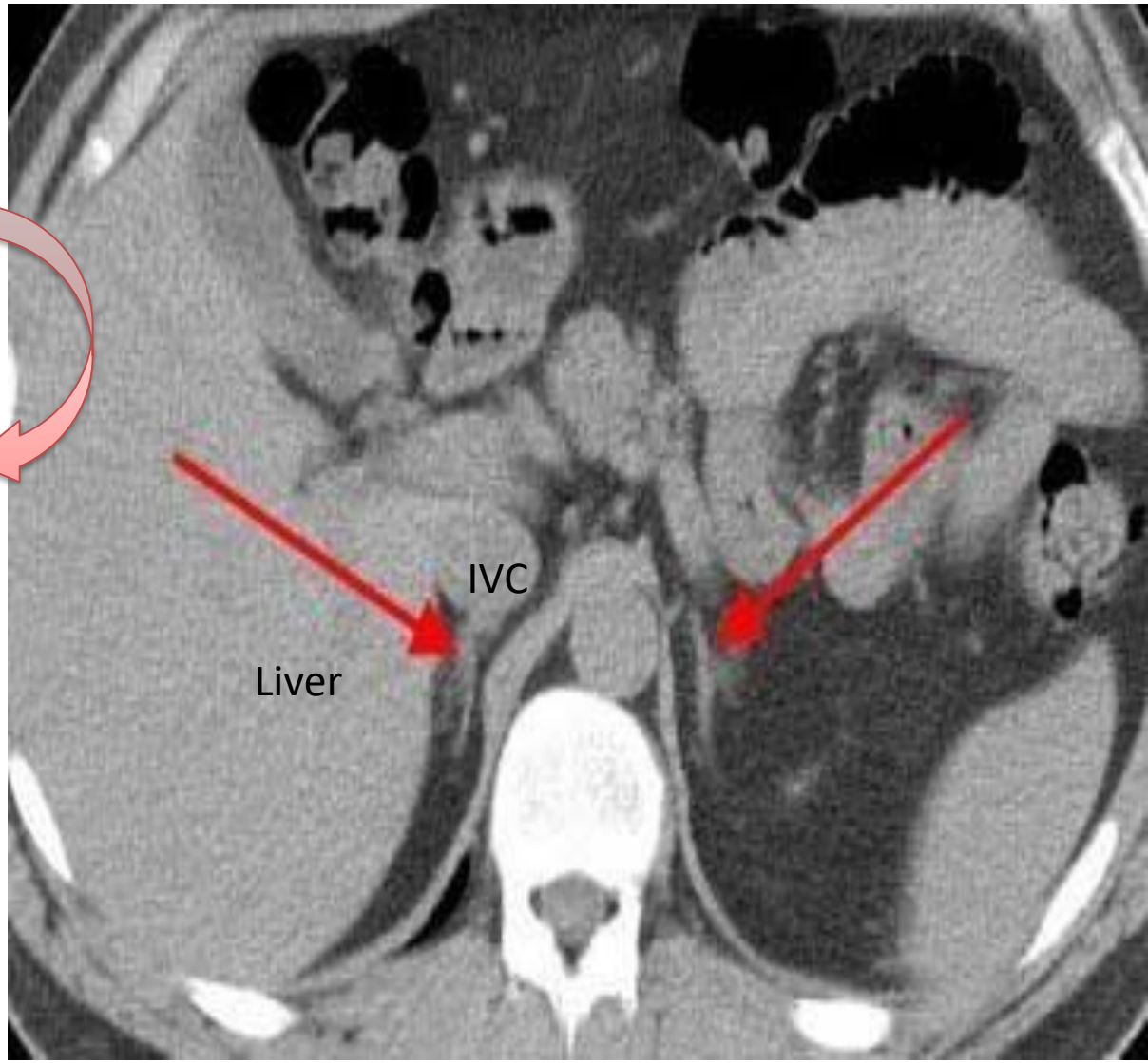
IMAGING OF THE SUPRARENAL GLAND

The adrenal gland is ***the fourth most common site of metastasis***, and adrenal metastases may be found in as many as 25% of patients with known primary lesions

Because of its high blood supply

Adrenal cortical adenoma can be diagnosed with a high degree of accuracy: the specificity of imaging studies ranges from **95-99%, and the sensitivity is greater than 90%**

http://emedicine.medscape.com/article/376240-overview



Unenhanced CT scan through the level of the adrenal glands shows normal appearing bilateral adrenal glands in the suprarenal fossa. The glands take on the appearance of an upside down **"V" or "Y"** often (arrows).

Kidney can't be seen here since it is taken at a level that's high up