Endocrine system
1. Recognize and understand the main parts of the pituitary gland and their locations, relations and connections.

2. Comprehend the blood supply of the pituitary gland and its portal circulation.

3. Understand the embryological origins of the pituitary gland.

4. Grasp the clinical correlations of the pituitary gland on anatomical basis and its surgical approach.

5. Recognize and understand imaging of the pituitary gland.

6. Grasp the histological structure of the pituitary gland and its cells under light and electron microscopes.
THE PITUITARY GLAND
also known as the HYPOPHYSIS
Master organ
It is a pea-sized
Weighs 0.5 g in males and 1.5 g in multiparous women

It is centrally located at the base of the brain, where it lies in a **saddle-shaped depression** of the sphenoid bone called **THE SELLA TURCICA**

A short stalk, the **infundibulum** connects the pituitary gland to the hypothalamus.
Gross Anatomy
A circular fold of dura mater, the **diaphragma sellae** forms the roof of this fossa.

The diaphragma sellae is pierced by a small central aperture through which the pituitary stalk passes, and it separates the anterior part of the upper surface of the gland from the optic chiasma.
➢ The hypophysis is bound on each side by the cavernous sinuses and the structures that they contain.
The cavernous sinuses and the structures that they contain.
it is separated from the floor of the fossa by a large, partially vacuolated **venous sinus**

The sphenoid air sinus

endoscopic transnasal applications in many pituitary surgical centers!!!!!
Radiology
THE SELLA TURCICA
(hypophyseal fossa)
Transnasal 1990s–present

Surgical approach
The pituitary gland is composed of two functional tissues:

- Neural (secretory) tissue
  - Posterior lobe
  - (Neurohypophysis)

- Glandular epithelial tissue
  - The Anterior lobe
  - (Adenohypophysis)
Each endocrine gland has two different embryological origins.
The posterior lobe of the pituitary is derived from a downgrowth (the future infundibulum) neuroectoderm of the floor of the third ventricle (the diencephalon) of the developing brain.

The anterior lobe of the pituitary gland is derived from an evagination of the ectoderm of the oropharynx toward the brain, Rathke’s pouch.

The two portions are of different embryologic origin.
1. Beginning formation of Rathke pouch and infundibular process

2. Neck of Rathke pouch constricted by growth of mesoderm

3. Rathke pouch “pinched off”

4. “Pinched off” segment conforms to neural process, forming pars distalis, pars intermedia, and pars tuberalis
The anterior lobe of the pituitary gland consists of three derivatives of Rathke’s pouch:

1- Pars distalis which comprises the bulk of the anterior lobe of the pituitary gland and arises from the thickened anterior wall of the pouch.
The **median eminence** is part of the **hypothalamus** from which regulatory hormones are released. It is not part of the pituitary gland.

**3-Pars tuberalis**
which develops from the thickened lateral walls of the pouch and forms a sheath around the **infundibulum**

**2-Pars intermedia**
a thin remnant of the posterior wall of the pouch
The embryonic infundibulum gives rise to the posterior lobe of the pituitary gland.

**Infundibulum**, which is continuous with the median eminence and contains the neurosecretory axons forming the hypothalamohypophyseal tracts.
The posterior lobe consists of the following:

- **Pars nervosa**, which contains neurosecretory axons and their endings
Hypophysial arteries are branches of the intercavernous segment of the internal carotid artery. The superior branch leads into the median eminence to start the hypophysial portal system to the anterior lobe. The inferior branch supplies the posterior lobe of the pituitary gland.
They supply the pars tuberalis, median eminence, and infundibulum. These vessels arise from the internal carotid arteries and posterior communicating artery of the circle of Willis.

A-Superior hypophyseal arteries

They supply:

The pars tuberalis
Median eminence
Infundibulum
Inferior hypophyseal artery divides into medial and lateral arteries and forms an arterial ring around the infundibulum.
The inferior hypophysial vessels arise solely from the *internal carotid arteries*

**primarily supply the pars nervosa**

Supply the neurohypophysis

An important functional observation is that most of the anterior lobe of the pituitary gland has **no direct arterial supply**!!!!!
The hypothalamohypophyseal portal system provides the crucial link between the hypothalamus and the pituitary gland.

Superior hypophyseal arteries give rise to fenestrated capillaries (the primary capillary plexus). They run along the pars tuberalis and drain into hypophyseal portal veins. These veins give rise to a second fenestrated sinusoidal capillary network (the secondary capillary plexus).

This system of vessels carries the neuroendocrine secretions of hypothalamic nerves from their sites of release in the median eminence and infundibulum directly to the cells of the pars distalis.
Most of the blood from the pituitary gland drains into the cavernous sinus and then into the systemic circulation.

Some evidence suggests, however, that blood can flow via short portal veins from the pars distalis to the pars nervosa and that blood from the pars nervosa may flow toward the hypothalamus. These short pathways provide a route by which the hormones of the anterior lobe of the pituitary gland could provide feedback directly to the brain without making the full circuit of the systemic circulation.
Neurohypophysis is neural tissue and is formed by the distal axons of the supraoptic nucleus (SON) and the paraventricular nucleus (PVN) of the hypothalamus.
The axon terminals store neurosecretory granules that contain vasopressin.

The blood supply for the posterior pituitary is from the inferior hypophysial arteries.

The venous drainage is into the cavernous sinus and internal jugular vein.
The stored vasopressin in neurosecretory granules in the posterior pituitary produces a bright signal on (MRI) **the “posterior pituitary bright spot.”**

The posterior pituitary bright spot is present in most healthy individuals and is absent in individuals with central diabetes insipidus.

*Posterior pituitary bright spot. Sagittal T1-MRI image showing hyperintensity (arrow) in the posterior aspect of the sella turcica.*
Clinical applications
Sheehan Syndrome

Postpartum hemorrhage

Rapid drop in blood pressure

Normal pituitary gland

Hyperplastic pituitary of pregnancy

Thrombosis, necrosis, and scar formation

Scar

Rim of relatively normal tissue

Failure of lactation (often first sign postpartum)

Adrenal cortical insufficiency (acute initial shock, loss of pubic and body hair, asthenia, hypoglycemia)

Gonadal insufficiency (amenorrhea)

Hypothyroidism

Prolactin deficient

ACTH deficient

FSH and LH deficient

TSH deficient
The pituitary gland enlarges during pregnancy (primarily because of lactotroph hyperplasia) and the portal venous blood supply is uniquely vulnerable to changes in arterial blood pressure. Severe postpartum uterine hemorrhage, spasm of the infundibular arteries, which are drained by the hypophysial portal vessels, could result in pituitary infarction.

If the lack of blood flow continued for several hours, most of the tissues of the anterior pituitary gland infarcted; when blood finally started to flow, stasis and thrombosis occurred in the stalk and the adenohypophysis.
The optic chiasm lies above the diaphragma sellae.

The most common sign that a pituitary tumor has extended beyond the confines of the sella turcica is a visual defect caused by the growth pressing on the optic chiasm.

The most frequent disturbance is a **Bitemporal hemianopsia** which is produced by the tumor pressing on the crossing central fibers of the chiasm and sparing the uncrossed lateral fibers.
Bitemporal hemianopsia

A city as seen with bitemporal hemianopsia.
Craniopharyngioma is the most common tumor found in the region of the pituitary gland in children and adolescents and constitutes about 3% of all intracranial tumors and up to 10% of all childhood brain tumors.

Craniopharyngiomas histologically benign epithelioid tumors arising from embryonic squamous remnants of Rathke pouch—may be large (e.g., > 6 cm in diameter) and invade the third ventricle and associated brain structures.
Suprasellar

Hypothalamic manifestations (obesity, somnolence) with or without hypopituitarism and/or diabetes insipidus

Intrasellar anterior lobe

Anterior lobe hypofunction of variable degree

Intrasellar posterior lobe

Diabetes insipidus
Reabsorption of water in cortical and medullary collecting ducts lost in absence of ADH

Central Diabetes Insipidus
The typical presentation is acute onset of severe headache (frequently described as “the worst headache of my life”) vision loss.

(The hemorrhagic expansion takes the path of least resistance and extends superiorly and compresses the optic chiasm); ocular nerve palsies (e.g., ptosis, diplopia) caused by impingement of the third, fourth, and sixth cranial nerves in the cavernous sinuses.
1. Recognize and understand the coverings of the thyroid gland and their clinical importance.

2. Recognize and understand the main parts of the thyroid gland and their locations, relations and connections.

3. Comprehend the blood supply of the thyroid gland, their relations with recurrent and external laryngeal nerves.

4. Understand the embryological origins of the pituitary gland and its associated malformations.

5. Grasp the clinical correlations of the midline structures of neck related to the thyroid gland and differentiate between them and the those on the lateral side of the neck.

6. Recognize and understand imaging of the thyroid gland.

7. Grasp the histological structure of the thyroid gland and its cells under light.
Gross anatomy
➢ It is placed **anteriorly** in the **lower neck** at the level with the **5th cervical** to the **1st thoracic vertebrae**

Transverse sections through the neck at the level of the second **sixth cervical** vertebrae
It consists of

**Right and left lobes**

connected by

**a narrow isthmus**
its apex being directed upward as far as the oblique line on the lamina of the thyroid cartilage

its base lies below at the level of the fourth or fifth tracheal ring.

It should be noted that the normal thyroid gland is nearly always asymmetric. The right lobe may be even twice as large as the left lobe.

The right upper pole extends higher up in the neck, and the lower pole extends lower.

Note

The posteromedial aspects of the lobes are attached to the side of the cricoid cartilage by a lateral thyroid ligament.
4- THE ISTHMUS

The isthmus extends across the midline in front of the 2\textsuperscript{nd}, 3\textsuperscript{rd}, and 4\textsuperscript{th} tracheal rings.

5- Pyramidal lobe

persists in at least 15\% of the population

is often present, and it projects upward from the isthmus.

Note

A fibrous or fibromuscular band, the levator of the thyroid gland, musculus levator glandulae thyroideae, sometimes descends from the body of the hyoid to the isthmus or pyramidal lobe.
6- Coverings and fascia of the thyroid gland

The thyroid gland is surrounded by

A-False capsule
B-True capsule

False capsule
True capsule
A-True capsule, a thin fibrous capsule, which is formed by condensation of the stroma of the gland.

➢ It is attached by means of dense connective tissue to the cricoid cartilage (part of the larynx) and superior tracheal rings (part of the trachea).

Clinical note

The True capsule of thyroid capsule is much denser in front than behind and the enlarging gland therefore tends to push backwards, burying itself round the sides and even the back of the trachea and oesophagus.

cause dangerous **Dyspnea**

**Dysphagia**
**B- False capsule**

it is a loose sheath formed by the visceral portion of the **pretracheal** layer of deep cervical fascia external to the true capsule

➢ The false capsule thickens between the cricoid cartilage and thyroid gland to form the

**ligament of Berry**

(The suspensory ligament of the thyroid) gland

(attaches the thyroid gland to trachea)
The false capsule of the thyroid gland also attaches the gland to the larynx and even to the hyoid bone. This explains why the thyroid gland follows the movements of the larynx in swallowing.

It is clear that the false capsule is attached to both the larynx and trachea.

This explains why the thyroid gland follows the movements of the larynx in swallowing.

Clinical note: This information is important because any pathologic neck swelling that is part of the thyroid gland will move upward when the patient is asked to swallow.

6/24/2018 Dr.Shatarat
The pretracheal layer of deep cervical fascia is attached to hyoid bone. And

The attachment of the sternothyroid muscles to the thyroid cartilage effectively binds down the thyroid gland to the larynx.

This limits upward expansion of the gland.

However, downward expansion has no limitation.

A large goitre will extend downwards into the superior mediastinum ('Plunging Goitre')

Or

Retrosternal Goiter
7- Relations of the Lobes

A- The superior belly of the omohyoid
B- The sternohyoid
C- The sternothyroid
D- The anterior border of the sternocleidomastoid

Anterolaterally
The anastomosis between the **superior and inferior thyroid arteries**.

Posteriorly

The rounded posterior border of each lobe is related posteriorly to the **superior and inferior parathyroid glands** and...
Posterolaterally:
The carotid sheath with the common carotid artery, the internal jugular vein, and the vagus nerve.

Medially:
The larynx, the trachea, the pharynx, and the esophagus. Associated with these structures are the cricothyroid muscle and its nerve supply, the external laryngeal nerve. In the groove between the esophagus and the trachea is the recurrent laryngeal nerve.
8-Blood Supply
A-The superior thyroid artery
B-The inferior thyroid artery
C- Sometimes the thyroidea ima.

**A-The superior thyroid artery**, a branch of the external carotid artery, descends to the upper pole of each lobe, accompanied by **The External Laryngeal Nerve**
The superior thyroid artery on each side is related to the external laryngeal nerve, which supplies the cricothyroid muscle.

Damage to the external laryngeal nerve results in an inability to tense the vocal folds and in hoarseness.

Thus, **The Superior Thyroid Artery during surgery on the thyroid**, is **ligated near the gland** to avoid injury to the external laryngeal nerve.
a branch of the **thyrocervical trunk**, ascends behind the gland to the level of the cricoid cartilage.

- It then turns medially and downward to reach the posterior border of the gland.

*The recurrent laryngeal nerve* crosses either in front of or behind the artery, or it may pass between its branches.
The terminal branches of the **inferior** thyroid artery on each side are related to the **RECURRENT LARYNGEAL NERVE.**
Thus, **THE INFERIOR THYROID ARTERY during surgery on the thyroid**, is **ligated away from the gland** to avoid injury to the recurrent laryngeal nerve.

---

6/24/2018

Dr.Shatarat
C-The thyroidea ima, In approximately 10% of people, a thyroid ima artery arises from the brachiocephalic trunk, or the arch of the aorta, from the right common carotid subclavian, or internal thoracic arteries.

ascends on the anterior surface of the trachea, which it supplies, and continues to the isthmus of the thyroid gland.

Clinical note

The possible presence of this artery must be considered when performing procedures in the midline of the neck inferior to the isthmus because it is a potential source of bleeding.
Lesions of the Laryngeal Nerves

The muscles of the larynx are innervated by the recurrent laryngeal nerves, with the exception of the cricothyroid muscle, which is supplied by the external laryngeal nerve. Both these nerves are vulnerable during operations on the thyroid gland because of the close relationship between them and the arteries of the gland.

To be discussed next year
9-The veins from the thyroid gland

**A-Superior thyroid vein**
which drains into the internal jugular vein;

**B-The middle thyroid vein**
which drains into the internal jugular vein;

**C-The inferior thyroid vein**
The inferior thyroid veins of the two sides anastomose with one another as they descend in front of the trachea. They drain into the left brachiocephalic vein in the thorax.

6/24/2018
Dr.Shatarat
10-The lymphatic vessels of the thyroid gland communicate with a capsular network of lymphatic vessels.

From this network, the vessels pass initially to **prelaryngeal, pretracheal**, and **paratracheal** lymph nodes, which drain in turn to the superior and inferior deep cervical nodes. Inferior to the thyroid gland, the lymphatic vessels pass directly to the inferior deep cervical lymph nodes.
The uppermost, just above the thyroid isthmus, in front of the cricoid cartilage, and medial to a pyramidal lobe, if present, is a constant node group of one to five nodes, which has been termed

**The Delphian node**

enlargement of which is indicative of metastasis from thyroid or laryngeal carcinoma.
Embryology
In a cross section of the embryo in the area of the head and neck, the following can be noticed:

**THE PHARYNGEAL ARCHES**

The pharyngeal pouches appear with development of the arches and clefts, a number of outpocketings,

**The pharyngeal pouches appear**

The pharyngeal pouches appear with development of the arches and clefts, a number of outpocketings,
Thyroid Gland

1-begins to develop during the third week as an endodermal thickening in the floor of the pharynx between the **tuberculum impar** and the **copula** at a point later indicated by the **foramen cecum**.
2- It descends in front of the pharyngeal gut as a bilobed diverticulum.

3- During this migration, the thyroid remains connected to the tongue by a narrow canal, the **thyroglossal duct**.
4-As development continues, the duct elongates, and its distal end becomes bilobed. Soon, the duct becomes a solid cord of cells, and as a result of epithelial proliferation, the bilobed terminal swellings expand to form the thyroid gland.

5-The thyroid gland now migrates inferiorly in the neck and passes either anterior to, posterior to, or through the developing body of the hyoid bone.

6-By the seventh week, it reaches its final position in relation to the larynx and trachea. Meanwhile, the solid cord connecting the thyroid gland to the tongue fragments and disappears.
7-The site of origin of the thyroglossal duct on the tongue remains as a pit called **the foramen cecum**.

8-The thyroid gland may now be divided into a small median isthmus and two large lateral lobes.
Second origin of the thyroid gland

9-The ultimobranchial bodies (from the fifth pharyngeal pouch) and neural crest cells are believed to be incorporated into the thyroid gland, where they form the parafollicular cells, which produce calcitonin.
Congenital Anomalies of the Thyroid Gland

1- Agenesis of the Thyroid
Failure of development of the thyroid gland may occur and is the commonest cause of cretinism.

2- Incomplete Descent of the Thyroid
The descent of the thyroid may be arrested at any point between the base of the tongue and the trachea. Lingual thyroid is the most common form of incomplete descent. The mass of tissue...
Aberrant thyroid tissue may be found anywhere along the path of descent of the thyroid gland. It is commonly found in the base of the tongue, just behind the foramen cecum, and is subject to the same diseases as the thyroid gland itself.

caution!!! A mass in the posterior midline might be the only thyroid in the patient’s body.
Thyroglossal Duct and Thyroid Abnormalities
3-Persistent Thyroglossal Duct
Conditions related to a persistence of the thyroglossal duct usually appear in childhood, in adolescence, or in young adulthood.
Thyroglossal Duct and Thyroid Abnormalities
A thyroglossal cyst may lie at any point along the migratory pathway of the thyroid gland but is always near or in the midline of the neck. By its name, it is a cystic remnant of the thyroglossal duct. Although approximately 50% of these cysts are close to or just inferior to the body of the hyoid bone, they may also be found at the base of the tongue or close to the thyroid cartilage. Sometimes a thyroglossal cyst is connected to the outside by a fistulous canal, a thyroglossal fistula. Such a fistula usually arises secondarily after rupture of a cyst but may be present at birth.
Thyroglossal cyst. These cysts, which are remnants of the thyroglossal duct, may be anywhere along the migration pathway of the thyroid gland. They are commonly found behind the arch of the hyoid bone. An important diagnostic characteristic is their midline location.
Branchial fistulas occur when the second pharyngeal arch fails to grow caudally over the third and fourth arches, leaving remnants of the second, third, and fourth clefts in contact with the surface by a narrow canal. Such a fistula, found on the lateral aspect of the neck directly anterior to the sternocleidomastoid muscle, usually provides drainage for a lateral cervical cyst. These cysts, remnants of the cervical sinus, are most often just below the angle of the jaw. Frequently a lateral cervical cyst is not visible at birth but becomes evident as it enlarges during childhood.
4-Thyroglossal Sinus (Fistula)
Occasionally, a thyroglossal cyst ruptures spontaneously, producing a sinus). Usually, this is a result of an infection of a cyst. All remnants of the thyroglossal duct should be removed surgically.
5-Accessory Thyroid Tissue

- Hyoid
- Connective tissue band
- Accessory thyroid tissue
- Pyramidal lobe (remnant of thyroglossal duct)
- Incomplete isthmus

Anterior view
1-As the lateral lingual swellings increase in size, they overgrow the tuberculum impar and merge, forming the anterior two-thirds, or body, of the tongue. Since the mucosa covering the body of the tongue originates from the first pharyngeal arch, sensory innervation to this area is by the mandibular branch of the trigeminal nerve.

The body of the tongue is separated from the posterior third by a V-shaped groove, the terminal sulcus.

2-The posterior part, or root, of the tongue originates from the second, third, and part of the fourth pharyngeal arch. The fact that sensory innervation to this part of the tongue is supplied by the glossopharyngeal nerve indicates that tissue of the third arch overgrows that of the second.

Some of the tongue muscles probably differentiate in situ, but most are derived from myoblasts originating in occipital somites. Thus, tongue musculature is innervated by the hypoglossal nerve.
Tuberculum impar

Copula (hypobranchial eminence)

Epiglottal swelling

Foramen cecum

Terminal sulcus

Lateral lingual swelling

Palatine tonsil

Root of tongue

In the floor of the pharynx

6/24/2018

Dr. Shatarat
Radiology
Fig. 28.20 Thyroid sonogram.

Right common carotid artery

Isthmus of thyroid

Trachea

Left lobe of thyroid

Right lobe of thyroid

Left common carotid artery
Fig. 28.21  $T_2$-weighted MRI at the level of the thyroid isthmus: compare with Fig. 28.20.
Fig. 188 (a) Transverse section of the neck through C6—showing the fascial planes and also the contents of the pretracheal fascia (or 'visceral compartment of the neck'). (b) CT scan through the C6 level; compare this with the diagram.
Metastatic disease to the thyroid is common; it likely relates to its rich blood supply of approximately 560 mL/100 g tissue/min (a flow rate per gram of tissue that is second only to the adrenal glands)
GROSS ANATOMY OF THE SUPRArenal GLANDS
1. Recognize and understand the suprarenal glands and their locations, relations and connections.
2. Comprehend the blood supply of suprarenal glands.
3. Understand the embryological origins of the suprarenal glands.
4. Grasp the clinical correlations of the suprarenal glands development.
5. Recognize and understand imaging of suprarenal glands.
6. Grasp the histological structure of the suprarenal glands and its cells under light and electron microscopes.
Suprarenal ADRENAL GLANDS secrete both steroid hormones and catecholamines.
The adrenal glands are two small triangular structures located retroperitoneally at the upper poles of the kidneys.
The adrenal glands are covered with a thick connective tissue capsule from which trabeculae extend into the parenchyma carrying blood vessels and nerves.
They have a flattened triangular shape and are embedded in the perirenal fat at the superior poles of the kidneys. They 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 lumbar vertebra.

- lie immediately superior and slightly anterior to the upper pole of the kidneys
- The suprarenal glands each weigh approximately 5 g (the medulla contributes about one-tenth of the total weight).
The secretory parenchymal tissue is organized into two distinct regions.

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

The medulla is the catecholamine-secreting portion. It lies deep to the cortex and forms the center of the gland.
Abdominal exposure of right adrenal gland

Liver (retracted superiorly)

Superior adrenal arteries (from inferior phrenic artery)

**Interior 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)
Relations of the right suprarenal gland

**Anteriorly:**
- Inferior vena cava (medially)
- Right hepatic lobe (laterally)

**Posteriorly:**
- Diaphragm (right crus)
- Superior pole of the right kidney
Relations of the left suprarenal gland

Anteriorly:
- Stomach
- Lesser sac of peritoneum
- The inferior area is in touch with the pancreas and splenic vein.

Posteriorly:
- Diaphragm (left crus)
- Superior pole of the left kidney
### Comparison between Rt. & Lt. Suprarenals

<table>
<thead>
<tr>
<th>Right Suprarenal</th>
<th>Left Suprarenal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangular (pyramidal)</td>
<td>Crescentic (semilunar)</td>
</tr>
<tr>
<td>Does NOT reach the hilum of the right kidney</td>
<td>Reaches the hilum of the left kidney</td>
</tr>
<tr>
<td>The hilum is directed upwards</td>
<td>The hilum is directed downwards</td>
</tr>
<tr>
<td>Its vein is short and drains to the IVC</td>
<td>Its vein is long and drains to the left renal vein.</td>
</tr>
</tbody>
</table>

6/24/2018
Dr. Shatarat. The University of Jordan
Fig. 72.1 Suprarenal glands: anterior (A) and posterior (B) aspects.
BLOOD SUPPLY
Blood supply of the adrenals

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.
The capsule is penetrated by ~60 arterioles.

**A)** short capsular capillaries that supply the capsule.

**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
- "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.

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:

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

Why?
The left suprarenal vein (longer) drains into the left renal vein or the left inferior phrenic vein. Why?
only one suprarenal vein exists for each adrenal gland
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.
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
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.
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.
At the end of the 3rd month of development, a second wave of smaller **basophilic 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.

**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.
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
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.
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
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).

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

**Note**

**Agenesis**: refers to the failure of an organ to develop during embryonic growth.

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 *agnesesis* or *hypoplasia*.
IN HYDROCEPHALUS

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.

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

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%**.


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).
PARATHYROID GLAND

Gross anatomy
Superior glands usually dorsal to the external laryngeal nerve at level of cricoid cartilage

Inferior glands located ventral to the recurrent laryngeal nerve.
Most of the blood supply comes from branches of inferior thyroid artery, although branches from superior thyroid supply ~ 20% of the superior gland.

Glands drain ipsilaterally by superior, middle, and inferior thyroid veins.
In the fifth week, epithelium of the dorsal wing of the third pouch differentiates into INFERIOR PARATHYROID GLAND while the ventral wing forms THE THYMUS. Both gland primordia lose their connection with the pharyngeal wall, and the thymus then migrates in a caudal and a medial direction, pulling the inferior parathyroid with it.
Epithelium of the dorsal wing of the fourth pharyngeal pouch forms
THE SUPERIOR PARATHYROID GLAND

When the parathyroid gland loses contact with the wall of the pharynx, it attaches itself to the dorsal surface of the caudally migrating thyroid as the superior parathyroid gland

**thymus**

*Figure 15.11* Migration of the thymus, parathyroid glands, and ultimobranchial body. The thyroid gland originates in the midline at the level of the foramen cecum and descends to the level of the first tracheal rings.
The inferior parathyroid glands occasionally migrate to the level of the aortic arch or, rarely, fail to migrate, remaining in the high neck.