

Suprarenal Gland and Chromaffin System

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Introduction

- The **suprarenal glands** (adrenal glands) are **paired endocrine organs** lying on the **superior poles of the kidneys**.
 - They are **retroperitoneal** and surrounded by **perinephric fat** within the **renal fascia**, separated from the kidneys by a thin fibrous septum.
 - Each gland weighs about **4–5 g** and is **golden-yellow** in color due to lipid content.
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Right Suprarenal Gland

- **Shape:** Triangular or pyramidal.
 - **Position:** Lies on the **upper pole of right kidney**, behind the inferior vena cava.
 - **Relations:**
 - *Anterior:* Right lobe of liver, inferior vena cava.
 - *Posterior:* Diaphragm.
 - *Medial:* Inferior vena cava.
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- **Hilum:** On anterior surface where veins emerge.
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Left Suprarenal Gland

- **Shape:** Crescentic or semilunar.
 - **Position:** Lies on the **upper medial border of the left kidney**.
 - **Relations:**
 - *Anterior:* Stomach (through omental bursa), pancreas, spleen.
 - *Posterior:* Diaphragm.
 - *Medial:* Aorta.
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Capsules

- **True capsule:** Condensation of connective tissue of gland.
 - **False capsule:** Formed by renal fascia enclosing perinephric fat.
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Structure

Each gland has two parts:

1. **Cortex (outer yellow layer)**
 - Derived from **mesoderm**.
 - Secretes **steroid hormones**.

- Divided into three zones:
 - **Zona glomerulosa:** Mineralocorticoids (aldosterone).
 - **Zona fasciculata:** Glucocorticoids (cortisol).
 - **Zona reticularis:** Sex steroids (androgens).

2. Medulla (inner dark brown core)

- Derived from **neural crest cells**.
- Contains **chromaffin cells** (modified post-ganglionic sympathetic neurons).
- Secretes **catecholamines — adrenaline and noradrenaline**.
- Under **sympathetic control**, not pituitary.

Functions

PART	HORMONES	MAIN FUNCTION
Cortex	Aldosterone	Sodium and water retention, ? BP
Cortex	Cortisol	Glucose metabolism, stress response, anti-inflammatory
Cortex	Androgens	Secondary sexual characters
Medulla	Adrenaline/Noradrenaline	“Fight-or-flight” response — ? heart rate, BP, blood glucose

Arterial Supply

Each gland receives **three main arteries**:

1. **Superior suprarenal arteries** ? from *inferior phrenic artery*
2. **Middle suprarenal artery** ? from *abdominal aorta*
3. **Inferior suprarenal artery** ? from *renal artery*

These form a **subcapsular arterial plexus**, which supplies both cortex and medulla.

Venous Drainage

- **Single suprarenal vein** from each gland:
 - **Right suprarenal vein** ? directly into *inferior vena cava*
 - **Left suprarenal vein** ? drains into *left renal vein*
 - Venous blood from cortex flows through medulla before exiting, bathing medullary cells with cortical hormones (important for adrenaline synthesis).
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Lymphatic Drainage

- To **lateral aortic (para-aortic)** and **renal lymph nodes**.
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Nerve Supply

- **Preganglionic sympathetic fibers (T10–L1)** via splanchnic nerves.
 - The **medullary chromaffin cells** act as modified sympathetic ganglion cells.
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- Cortex has **no direct nerve supply**, controlled hormonally by **pituitary ACTH**.
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Embryological Derivation

- **Cortex:** Mesodermal coelomic epithelium.
 - **Medulla:** Neural crest (ectodermal).
 - Thus, the gland is a **composite organ of dual origin**.
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Chromaffin System

- Includes **suprarenal medulla, paraganglia, and sympathetic ganglia** that contain chromaffin cells.
 - **Chromaffin reaction:** Cells stain brown with chromic salts (due to oxidation of catecholamines).
 - **Extra-adrenal chromaffin bodies:** Organ of Zuckerkandl (near aortic bifurcation), carotid body, sympathetic chain.
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Clinical Anatomy

- **Addison's disease:** Hypofunction of cortex ? low BP, pigmentation, weakness.
- **Cushing's syndrome:** Excess cortisol ? moon face, obesity, hypertension.
- **Conn's syndrome:** Aldosterone excess ? hypertension, hypokalemia.
- **Pheochromocytoma:** Tumor of medulla ? episodic hypertension, sweating, palpitations.

- **Adrenal hemorrhage (Waterhouse-Friderichsen):** Seen in meningococcal septicemia ? shock.
- **Congenital adrenal hyperplasia:** Genetic enzyme defect ? androgen excess, ambiguous genitalia.

? Venous Drainage

- Each gland has a **single large central vein**, which drains blood from both cortex and medulla.
- **Right suprarenal vein** ? short, opens **directly into inferior vena cava**.
- **Left suprarenal vein** ? long, joins **left renal vein**.
- The **medullary veins** receive blood from the cortical sinusoids, so medullary cells are exposed to high steroid concentrations — aiding conversion of noradrenaline to adrenaline.

? Lymphatic Drainage

- Lymphatics from both glands drain into **lateral aortic (para-aortic)** and **renal lymph nodes**.
 - No lymphatics from medulla directly reach cisterna chyli.
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? Nerve Supply

- Supplied by **preganglionic sympathetic fibers** from **T10–L1 spinal segments**.
 - **Cortex:** Has no direct nerve supply; regulated hormonally by **pituitary ACTH**.
 - **Medulla:** Supplied by **greater and lesser splanchnic nerves**; chromaffin cells act as **modified sympathetic neurons**, secreting adrenaline and noradrenaline directly into blood.
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? Clinical Anatomy

1. Addison's Disease:

- Hypofunction of cortex ? cortisol & aldosterone.
- Symptoms: Weakness, hypotension, pigmentation, salt loss.

2. Cushing's Syndrome:

- Hypersecretion of cortisol (often due to pituitary adenoma).
- Features: Moon face, truncal obesity, hypertension, striae.

3. Conn's Syndrome:

- Hypersecretion of aldosterone.
- Features: Hypertension, hypokalemia, muscle weakness.

4. Pheochromocytoma:

- Tumor of medulla (chromaffin cells).
- Causes episodic hypertension, palpitations, sweating, headache.

5. **Waterhouse–Friderichsen Syndrome:**

- Bilateral adrenal hemorrhage in meningococcal septicemia.
- Leads to acute adrenal insufficiency and shock.

6. **Congenital Adrenal Hyperplasia:**

- Genetic enzyme deficiency (21-hydroxylase).
- Excess androgens ? ambiguous genitalia in females.

7. **Adrenal Crisis:**

- Acute insufficiency due to sudden withdrawal of steroids or infection.

? Histology

• **Cortex:**

- **Zona glomerulosa:** Arched clusters of small columnar cells secreting aldosterone.
- **Zona fasciculata:** Long cords of lipid-laden cells (spongiocytes) secreting cortisol.
- **Zona reticularis:** Network of darkly stained cells secreting sex steroids.

• **Medulla:**

- Chromaffin cells arranged in cords around veins.
 - Contain secretory granules rich in catecholamines.
 - Stain brown with chromic salts (chromaffin reaction).
 - Surrounded by sympathetic ganglion cells and venous sinusoids.
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? Development

- **Cortex:** From **mesoderm of posterior abdominal wall**.
 - *Fetal cortex* forms early, later replaced by *definitive cortex*.
 - **Medulla:** From **neural crest cells**, migrating inward to form chromaffin tissue.
 - By birth:
 - Gland relatively large due to prominent fetal cortex.
 - After birth, gland shrinks as fetal cortex regresses.
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?? Molecular Regulation

- **Steroidogenic Factor-1 (SF-1):** Controls adrenal cortex development and steroidogenesis.
 - **DAX-1 and WT-1 genes:** Regulate cortical differentiation.
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- **BMP and ACTH:** Promote cortex proliferation.
 - **Phox2B and Mash1:** Control chromaffin cell differentiation in medulla.
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???? Dissection Points

- The gland lies in **perinephric fat** at upper pole of kidney.
 - Carefully dissect the renal fascia to expose it.
 - Note that the **right gland** is smaller and pyramidal, **left gland** larger and semilunar.
 - Trace its veins to IVC (right) and left renal vein (left).
 - Identify three arteries entering at multiple points on the surface.
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? Chromaffin System

- Comprises **chromaffin cells** found in adrenal medulla and in extra-adrenal sites (paraganglia).
- These cells secrete **catecholamines (adrenaline, noradrenaline)** under sympathetic stimulation.
- **Chromaffin reaction:** Cells stain brown due to oxidation of catecholamines with chromic salts.
- **Extra-adrenal chromaffin bodies include:**

- *Organ of Zuckerkandl* (near aortic bifurcation)
- *Carotid body*
- *Aortic and sympathetic paraganglia*
- These structures help regulate **vascular tone** in fetal life and early infancy.

? Facts to Remember

- Each suprarenal gland is a **retroperitoneal endocrine organ** lying on the upper pole of the kidney.
- **Right gland** ? smaller, pyramidal; **Left gland** ? larger, crescentic.
- Both glands are enclosed within the **renal fascia**, separated from the kidney by a fibrous septum.
- **Cortex** (mesodermal) and **medulla** (neural crest) have **dual embryological origin**.
- The **cortex** secretes **steroid hormones**:
 - Zona glomerulosa ? aldosterone
 - Zona fasciculata ? cortisol
 - Zona reticularis ? androgens
- The **medulla** secretes **catecholamines** (adrenaline and noradrenaline).

- The **cortex** is controlled by **pituitary ACTH**; the **medulla** by **sympathetic preganglionic fibers**.
 - Each gland receives **three arteries** — superior (from inferior phrenic), middle (from aorta), inferior (from renal artery).
 - Each gland has **a single vein** —
 - Right ? inferior vena cava
 - Left ? left renal vein
 - Venous blood from cortex flows through the medulla ? provides steroids necessary for **adrenaline synthesis**.
 - Lymph drains to **lateral aortic and renal lymph nodes**.
 - **Chromaffin cells** are modified sympathetic neurons showing brown color with chromic salts.
 - **Organ of Zuckerkandl** (near aortic bifurcation) is the largest extra-adrenal chromaffin body.
 - The glands are **essential for life** — total removal leads to death unless hormone replacement is given.
 - Tumors of medulla ? **pheochromocytoma**, producing paroxysmal hypertension.
 - Overactivity of cortex ? **Cushing's or Conn's syndrome**; underactivity ? **Addison's disease**.
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1. Addison's Disease (Adrenal Insufficiency)

- Destruction or atrophy of adrenal cortex.
- Features: Hypotension, fatigue, skin pigmentation, salt loss, and weight loss.

2. Cushing's Syndrome

- Overproduction of cortisol due to adrenal or pituitary tumor.
- Features: Moon face, truncal obesity, hypertension, osteoporosis, diabetes.

3. Conn's Syndrome (Primary Hyperaldosteronism)

- Excess aldosterone secretion.
- Features: Hypertension, hypokalemia, muscle weakness, metabolic alkalosis.

4. Pheochromocytoma

- Tumor of adrenal medulla.
- Secretes excess catecholamines ? paroxysmal hypertension, sweating, tachycardia, headache.

5. Waterhouse–Friderichsen Syndrome

- Acute adrenal hemorrhage secondary to meningococcal septicemia.
- Leads to circulatory collapse and death if untreated.

6. **Congenital Adrenal Hyperplasia (CAH)**

- Enzyme deficiency (most commonly 21-hydroxylase).
- Leads to androgen excess ? virilization of females, salt loss.

7. **Adrenal Crisis**

- Acute failure of adrenals due to stress, infection, or sudden steroid withdrawal.
- Manifests as hypotension, hypoglycemia, and shock.

8. **Adrenal Incidentaloma**

- Benign adrenal mass discovered incidentally on imaging; may secrete hormones.

9. **Ectopic Adrenal Tissue**

- Small accessory adrenal rests found along the gonadal descent path.

10. **Adrenal Cysts or Hemorrhage in Newborn**

- Due to birth trauma or hypoxia; may mimic abdominal tumor.

11. **Adrenal Metastasis**

- Common secondary site for carcinoma (especially lung and breast).

12. **Addisonian Crisis**

- Acute adrenal insufficiency precipitated by stress in a chronically deficient patient.

13. **Chromaffinoma (Extra-Adrenal Pheochromocytoma)**

- Arises from paraganglia (e.g., organ of Zuckerkandl).

14. **ACTH-Dependent Cushing's Disease**

- Pituitary overproduction of ACTH causing bilateral cortical hyperplasia.

15. **Adrenogenital Syndrome**

- Congenital enzyme defect ? excessive androgen secretion ? precocious puberty in boys, masculinization in girls.

16. **Adrenal Calcification**

- Seen in tuberculosis and old hemorrhage.

17. **Hyperpigmentation in Addison's Disease**

- Due to increased ACTH stimulating melanocytes.

18. **Adrenalectomy Considerations**

- Bilateral removal requires lifelong hormone replacement; right gland more difficult to remove due to short vein.

19. **Functional Zuckerkandl Tumor**

- Extra-adrenal paraganglioma secreting catecholamines.

20. Steroid Therapy Suppression

- Long-term exogenous steroids suppress ACTH and cause cortical atrophy ? risk of adrenal crisis if suddenly stopped.

? Frequently Asked Questions – Suprarenal Gland and Chromaffin System

1. Where are the suprarenal glands located?

They lie **on the upper poles of the kidneys**, behind the peritoneum, enclosed within the **renal fascia**, one on each side of the vertebral column.

2. What are the shapes of the two glands?

- **Right gland:** Pyramidal or triangular.
 - **Left gland:** Crescentic or semilunar.
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3. What are the relations of the right suprarenal gland?

- **Anterior:** Liver and inferior vena cava.
 - **Posterior:** Diaphragm.
 - **Medial:** Inferior vena cava.
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4. What are the relations of the left suprarenal gland?

- **Anterior:** Stomach, pancreas, spleen (through omental bursa).
 - **Posterior:** Diaphragm.
 - **Medial:** Aorta.
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5. What are the coverings of the suprarenal gland?

- **True capsule:** Condensed connective tissue.
 - **False capsule:** Formed by renal fascia and perinephric fat.
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6. What is the embryological origin of the suprarenal gland?

- **Cortex:** From **mesoderm** (coelomic epithelium).
 - **Medulla:** From **neural crest cells**.
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7. What is the dual function of the gland?

It is both an **endocrine organ** and a **modified sympathetic ganglion**.

- Cortex ? secretes steroid hormones.
 - Medulla ? secretes catecholamines.
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8. Name the three zones of the adrenal cortex.

1. **Zona glomerulosa** – secretes *aldosterone*.

2. **Zona fasciculata** – secretes *cortisol*.
 3. **Zona reticularis** – secretes *androgens*.
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9. What are the functions of the adrenal medulla?

Secretes **adrenaline and noradrenaline**, which increase heart rate, BP, and blood glucose during stress (“fight or flight” response).

10. What are chromaffin cells?

Modified postganglionic sympathetic neurons present in the **medulla** and **paraganglia**, which secrete catecholamines and stain brown with chromic salts.

11. What is the chromaffin reaction?

Brown staining of chromaffin cells due to oxidation of catecholamines when treated with chromic salts.

12. What is the blood supply of suprarenal gland?

Each gland receives **three arteries**:

- Superior suprarenal – from inferior phrenic artery.
 - Middle suprarenal – from abdominal aorta.
 - Inferior suprarenal – from renal artery.
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13. What is the venous drainage of the glands?

- **Right suprarenal vein ? inferior vena cava.**

- **Left suprarenal vein ? left renal vein.**
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14. What is the lymphatic drainage?

To **lateral aortic (para-aortic)** and **renal lymph nodes**.

15. What is the nerve supply of the glands?

- **Cortex:** Controlled hormonally by ACTH.
 - **Medulla:** Supplied by preganglionic sympathetic fibers (T10–L1) through splanchnic nerves.
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16. What are the hormones secreted by the adrenal cortex?

- **Aldosterone:** Regulates sodium and water balance.
 - **Cortisol:** Increases blood glucose, reduces inflammation.
 - **Androgens:** Contribute to secondary sexual characters.
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17. What are the hormones secreted by the adrenal medulla?

Adrenaline and noradrenaline, collectively called catecholamines.

18. How does the adrenal medulla differ from a sympathetic ganglion?

- Medulla secretes hormones directly into blood.
 - Sympathetic ganglia transmit impulses via axons.
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19. What are the clinical conditions due to adrenal cortical hyperfunction?

- **Cushing's syndrome** – cortisol excess.
 - **Conn's syndrome** – aldosterone excess.
 - **Adrenogenital syndrome** – androgen excess.
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20. What are the clinical conditions due to adrenal cortical hypofunction?

- **Addison's disease** – failure of cortex leading to pigmentation, hypotension, and salt loss.
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21. What are the clinical conditions due to adrenal medullary tumor?

- **Pheochromocytoma** – excess catecholamine secretion ? episodic hypertension, tachycardia, sweating, headache.
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22. Why is the right adrenal vein important surgically?

It is very short and opens directly into IVC ? prone to tearing during surgery.

23. Why is the left gland larger than the right?

Because of its **semilunar shape** and broad contact with stomach and pancreas.

24. What is the effect of adrenalectomy (removal)?

Bilateral removal causes **death** unless replaced by steroid therapy.

25. Why does adrenal medulla depend on cortex for adrenaline synthesis?

Cortisol from the cortex induces the **enzyme phenylethanolamine-N-methyltransferase (PNMT)** needed to convert noradrenaline to adrenaline.

26. What is the function of aldosterone?

Regulates sodium retention, potassium excretion, and helps maintain blood pressure.

27. What is the function of cortisol?

Promotes gluconeogenesis, suppresses inflammation, maintains BP and stress response.

28. What is the Organ of Zuckerkandl?

A large **extra-adrenal chromaffin body** near the aortic bifurcation; active in fetal life.

29. What is congenital adrenal hyperplasia?

Genetic enzyme deficiency (commonly 21-hydroxylase) causing androgen excess and ambiguous genitalia in females.

30. What is Waterhouse–Friderichsen syndrome?

Acute adrenal hemorrhage in meningococcal septicemia causing shock and adrenal failure.

31. Which adrenal vein drains into the renal vein?

Left suprarenal vein.

32. Which part of the adrenal gland is controlled by ACTH?

The **cortex** (especially zona fasciculata and zona reticularis).

33. What is the most common site of extra-adrenal pheochromocytoma?

Organ of Zuckerkandl near the aortic bifurcation.

34. Why is the cortex yellow and the medulla dark brown?

- **Cortex:** Rich in lipid (cholesterol, phospholipids).
 - **Medulla:** Rich in chromaffin granules containing catecholamines.
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35. What is the blood supply pattern inside the gland?

Arteries form a **subcapsular plexus** ? capillaries for cortex and medulla ? central vein.

36. What is the function of the chromaffin reaction?

Used to identify catecholamine-producing cells (diagnostic feature).

37. What happens in adrenal hypoplasia congenita?

Failure of adrenal cortex development ? adrenal insufficiency in infancy.

38. What is the effect of stress on adrenal gland?

Stress stimulates ACTH ? increased cortisol and catecholamine secretion (fight or flight).

39. What is the origin of the adrenal medulla in terms of nervous system?

Derived from **sympathetic neural crest cells**.

40. Why is the adrenal gland called a 'life-saving gland'?

Because absence of adrenal cortical hormones leads to **death within days** due to electrolyte imbalance and circulatory collapse.

1. The suprarenal glands are located:

- A. In front of kidneys
 - B. **On the upper poles of kidneys ?**
 - C. Behind kidneys
 - D. Below kidneys
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2. The right suprarenal gland is:

- A. Crescentic
 - B. Oval
 - C. **Pyramidal ?**
 - D. Triangular and elongated
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3. The left suprarenal gland is:

- A. Pyramidal
 - B. Conical
 - C. **Crescentic ?**
 - D. Oval
-

4. The suprarenal glands are covered by:

- A. Peritoneum
 - B. **Renal fascia (Gerota's fascia) ?**
 - C. Fascia transversalis
 - D. Parietal peritoneum
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5. The embryological origin of adrenal cortex is:

- A. Endoderm
 - B. Ectoderm
 - C. **Mesoderm ?**
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D. Neural crest

6. The embryological origin of adrenal medulla is:

- A. Mesoderm
 - B. Endoderm
 - C. **Neural crest (ectodermal) ?**
 - D. Mesonephric duct
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7. Which part of adrenal gland secretes steroid hormones?

- A. **Cortex ?**
 - B. Medulla
 - C. Capsule
 - D. Both cortex and medulla
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8. Which part secretes adrenaline and noradrenaline?

- A. Cortex
 - B. **Medulla ?**
 - C. Capsule
 - D. Both
-

9. The hormone aldosterone is secreted by:

- A. Zona fasciculata
 - B. Zona reticularis
 - C. **Zona glomerulosa ?**
 - D. Medulla
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10. The hormone cortisol is secreted by:

- A. Zona glomerulosa
- B. **Zona fasciculata ?**
- C. Zona reticularis

D. Medulla

11. The adrenal cortex is controlled by:

- A. Hypothalamus directly
 - B. **Pituitary ACTH ?**
 - C. Sympathetic nerves
 - D. Parasympathetic nerves
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12. The adrenal medulla is controlled by:

- A. **Preganglionic sympathetic fibers (T10–L1) ?**
 - B. ACTH
 - C. Parasympathetic fibers
 - D. Somatic nerves
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13. The chromaffin reaction is seen in:

- A. Cortical cells
 - B. **Medullary cells ?**
 - C. Zona fasciculata
 - D. Zona reticularis
-

14. Which hormone increases blood pressure and heart rate?

- A. Aldosterone
 - B. Cortisol
 - C. **Adrenaline ?**
 - D. Insulin
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15. Which of the following is NOT secreted by the adrenal cortex?

- A. Aldosterone
 - B. Cortisol
 - C. **Adrenaline ?**
-

D. Androgen

16. The enzyme converting noradrenaline to adrenaline requires:

- A. ACTH
 - B. **Cortisol (PNMT induction) ?**
 - C. Adrenalinase
 - D. Dopamine
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17. Which artery supplies the adrenal gland?

- A. Superior adrenal artery
 - B. Middle adrenal artery
 - C. Inferior adrenal artery
 - D. **All of the above ?**
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18. The venous drainage of right adrenal gland is into:

- A. Renal vein
 - B. **Inferior vena cava ?**
 - C. Hepatic vein
 - D. Azygos vein
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19. The venous drainage of left adrenal gland is into:

- A. Inferior vena cava
 - B. **Left renal vein ?**
 - C. Left gonadal vein
 - D. Portal vein
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20. Lymphatic drainage of adrenal gland is to:

- A. Internal iliac nodes
 - B. Inguinal nodes
 - C. **Lateral aortic (para-aortic) nodes ?**
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D. Mesenteric nodes

21. The main hormone responsible for sodium retention is:

- A. Cortisol
 - B. **Aldosterone ?**
 - C. Adrenaline
 - D. Noradrenaline
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22. Cushing's syndrome is due to:

- A. Aldosterone excess
 - B. **Cortisol excess ?**
 - C. Catecholamine deficiency
 - D. Cortisol deficiency
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23. Addison's disease results from:

- A. Excess cortisol
 - B. Excess aldosterone
 - C. **Deficiency of adrenal cortical hormones ?**
 - D. Pheochromocytoma
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24. Conn's syndrome is due to:

- A. Cortisol excess
 - B. Androgen excess
 - C. **Aldosterone excess ?**
 - D. Noradrenaline deficiency
-

25. Pheochromocytoma is a tumor of:

- A. Cortex
- B. Capsule
- C. **Medulla ?**

D. Zona fasciculata

26. Waterhouse–Friderichsen syndrome is due to:

- A. Medullary tumor
 - B. **Adrenal hemorrhage in meningococcal infection ?**
 - C. Cortical tumor
 - D. Pituitary hyperplasia
-

27. The adrenal glands are essential for life because they secrete:

- A. Adrenaline
 - B. **Cortisol and aldosterone ?**
 - C. Androgens
 - D. ACTH
-

28. Organ of Zuckerkandl is:

- A. Pancreatic structure
 - B. **Extra-adrenal chromaffin body near aortic bifurcation ?**
 - C. Adrenal cortex
 - D. Paraganglion of vagus
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29. The cortical layer richest in lipid is:

- A. Zona glomerulosa
 - B. **Zona fasciculata ?**
 - C. Zona reticularis
 - D. Capsule
-

30. Which of the following has no direct nerve supply?

- A. **Adrenal cortex ?**
 - B. Medulla
 - C. Chromaffin tissue
-

D. Organ of Zuckerkandl

31. Which artery does NOT supply the adrenal gland?

- A. Inferior phrenic
 - B. Aorta
 - C. Renal
 - D. **Gonadal ?**
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32. The right adrenal vein is short because:

- A. It drains into hepatic vein
 - B. **It drains directly into IVC ?**
 - C. It crosses the aorta
 - D. It drains into portal vein
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33. Which of the following is a mesodermal derivative?

- A. Adrenal medulla
 - B. Sympathetic ganglion
 - C. **Adrenal cortex ?**
 - D. Chromaffin cells
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34. The adrenal medulla corresponds functionally to:

- A. Parasympathetic ganglion
 - B. **Sympathetic ganglion ?**
 - C. Somatic motor nucleus
 - D. None
-

35. In Addison's disease, hyperpigmentation occurs due to:

- A. Cortisol deficiency
 - B. **Increased ACTH stimulating melanocytes ?**
 - C. High aldosterone
-

D. Catecholamine excess

36. The enzyme deficiency causing congenital adrenal hyperplasia most often is:

- A. 11- β -hydroxylase
 - B. **21-hydroxylase ?**
 - C. 17-hydroxylase
 - D. 3- β -dehydrogenase
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37. Adrenal hypoplasia congenita results in:

- A. Cortisol excess
 - B. **Adrenal insufficiency in infancy ?**
 - C. Androgen excess
 - D. None
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38. The adrenal cortex is derived from:

- A. Neural crest
 - B. Endoderm
 - C. **Mesodermal coelomic epithelium ?**
 - D. Mesonephric duct
-

39. Which structure secretes both epinephrine and norepinephrine?

- A. Adrenal cortex
 - B. **Adrenal medulla ?**
 - C. Zona fasciculata
 - D. Sympathetic ganglion
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40. Which hormone increases blood glucose during stress?

- A. Aldosterone
 - B. **Cortisol ?**
 - C. ADH
 - D. Insulin
-