

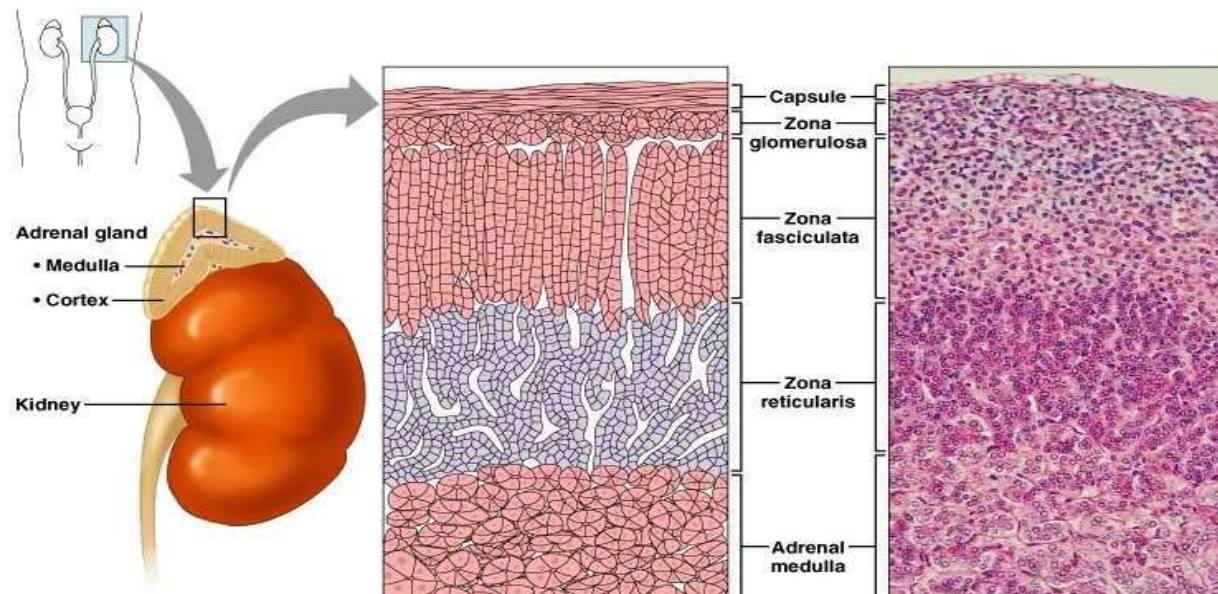
Adrenal (suprarenal) glands

Lecture-05

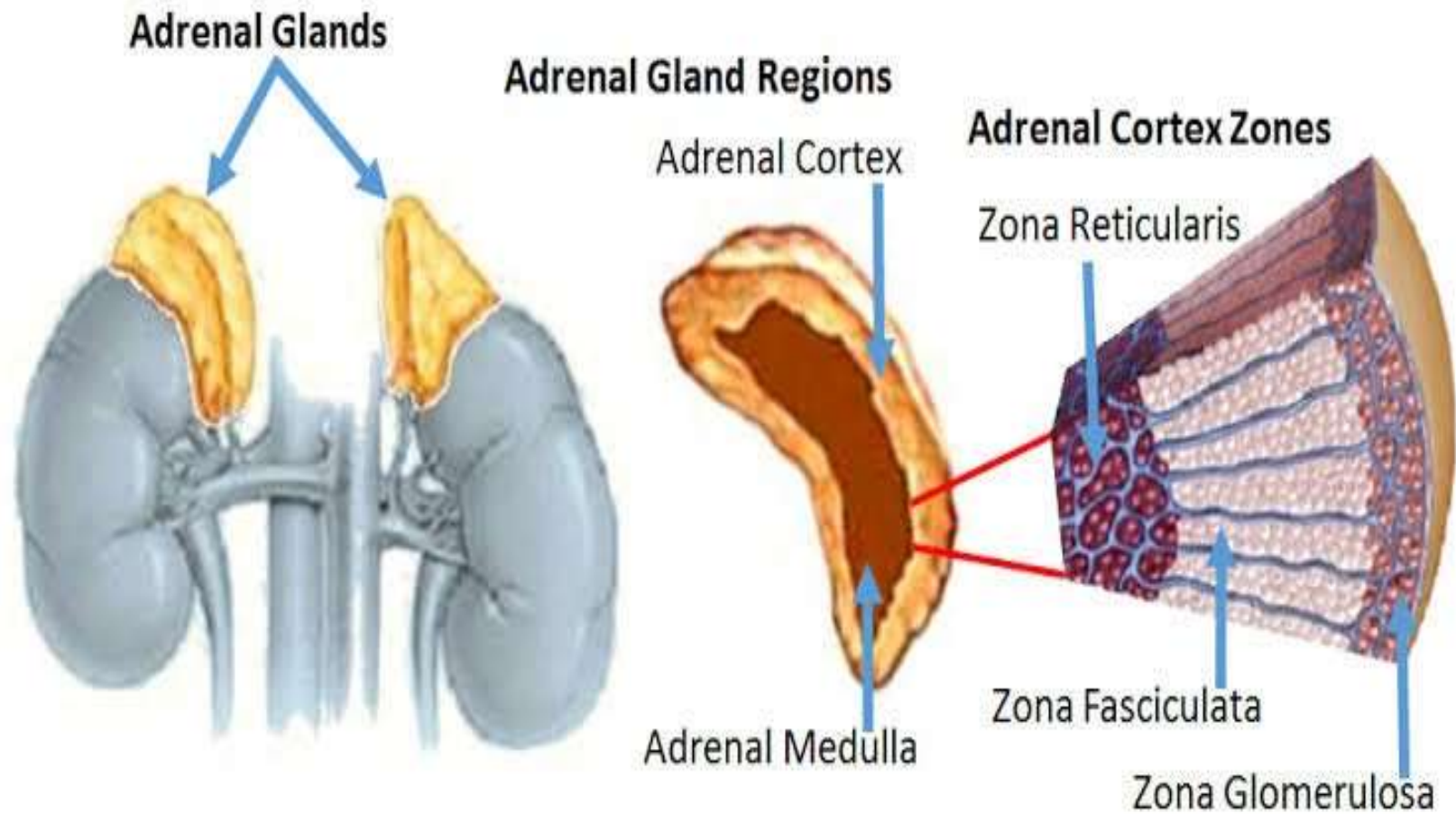
Adrenal (suprarenal) glands

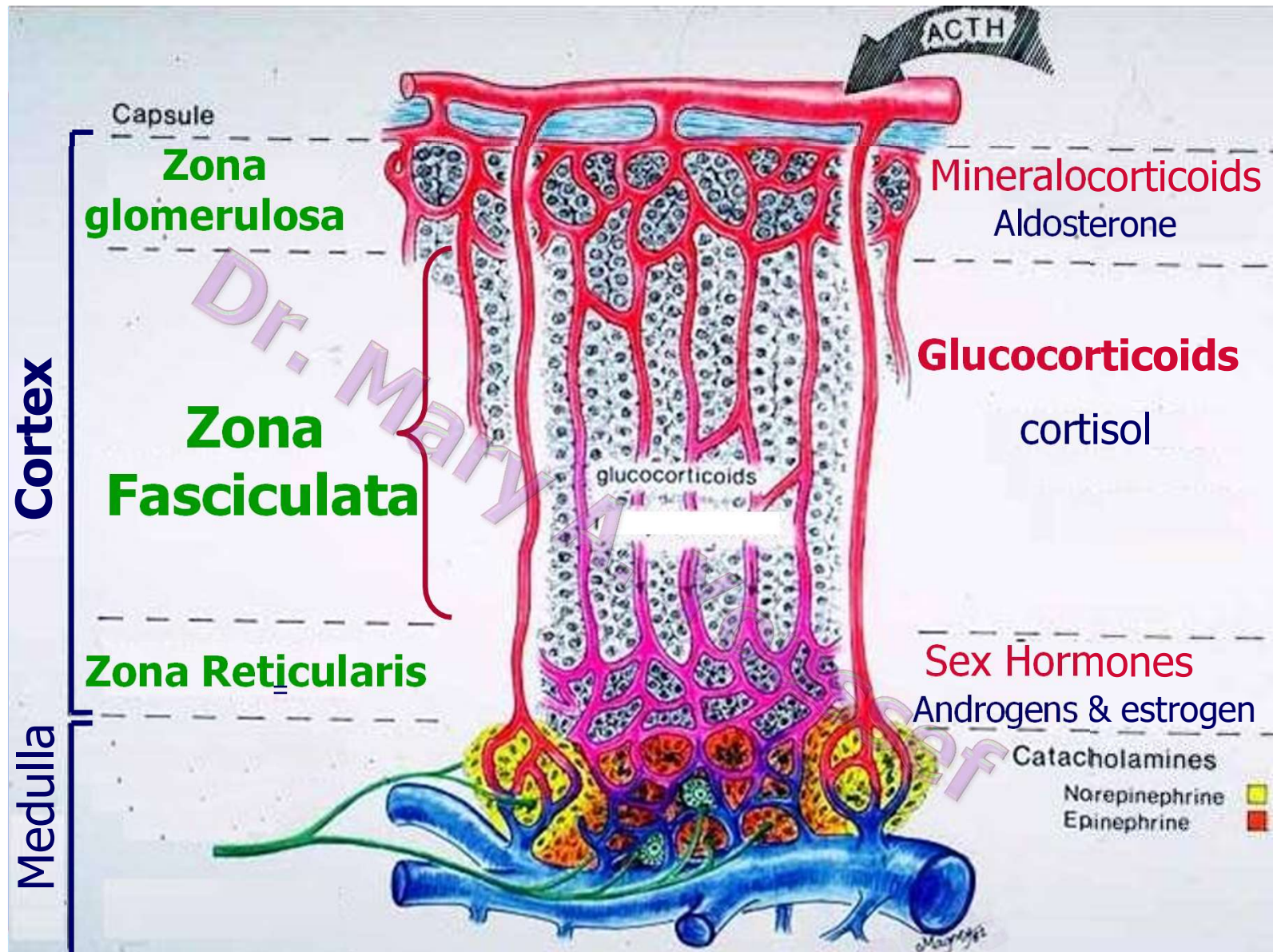
(“suprarenal” means on top of the kidney)

- Each is really two endocrine glands
 - Adrenal cortex (outer)
 - Adrenal medulla (inner)
- Unrelated chemicals but all help with extreme situations



Adrenal Glands





Adrenal Gland

- Adrenal cortex
 - Secretes lipid-based steroid hormones, called “corticosteroids” – “cortico” as in “cortex”
 - MINERALOCORTICIDS
 - Aldosterone is the main one
 - GLUCOCORTICIDS
 - Cortisol (hydrocortisone) is the main one
- Adrenal medulla
 - Secretes epinephrine and norepinephrine

Adrenal Cortex

This is the outer or peripheral zone of the adrenal gland, which makes up the bulk of the gland.

The adrenal cortex is divided into three zones. Each zone has a different cellular arrangements and secretes different groups of steroid hormones.

Layers of Adrenal Cortex

1. Zona-glomerulosa
2. Zona-fasciculata
3. Zona-reticulata

Zona-glomerulosa:

- This is the outermost layer of the adrenal cortex which secretes mineralocorticoid hormones.
- Immediately beneath the capsule.
- Columnar or pyramidal cells
- Arranged in closely packed, rounded, arched cords or small clumps.
- Occupy 15% of the adrenal cortex.

Zona-fasciculata

:

- This is the middle zone of the adrenal cortex which secretes glucocorticoids hormone.
- Occupy 65% of the adrenal cortex.
- Polyhedral, often binucleated cells with lipid droplets in their cytoplasm.
- Cells are also called spongyocytes due to vacuolization.

Zona-reticularis

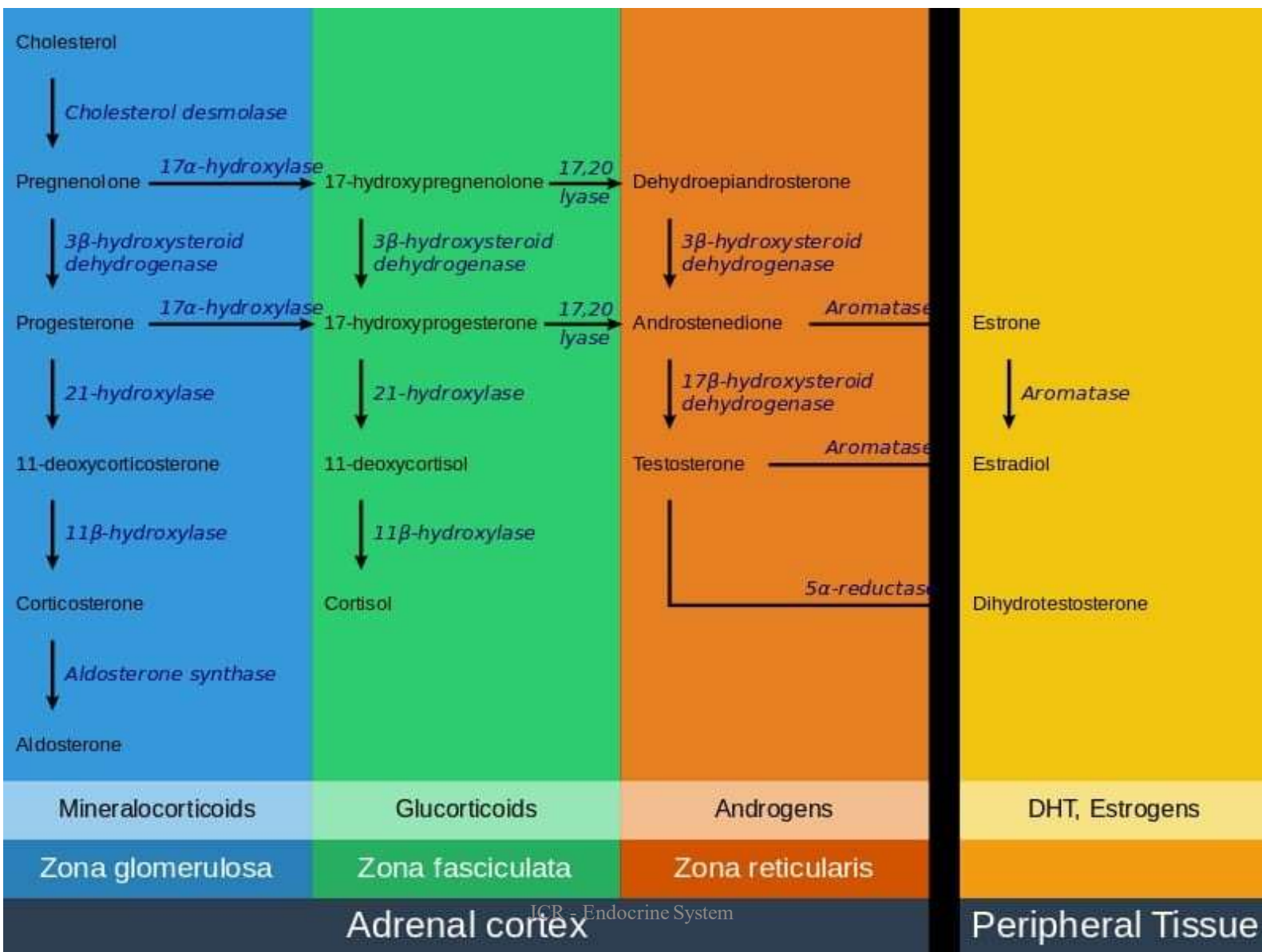
- This is the innermost layer of the adrenal cortex which secretes androgen but in small quantities.
- Occupy 7% of the adrenal cortex.
- Smaller cells disposed in irregular cords forming anastomosing network.
- Presence of lipofuscin pigment granules –large and numerous.

Hormones of the Adrenal cortex

The adrenocortical hormones and their functions in the body are classified into three groups:

1. Mineralocorticoids
2. Glucocorticoids
3. Adrenal androgens.

Biosynthesis of adrenal hormones:



Mineralocorticoids

Mineralocorticoids:

- secreted from the adrenal cortex-zona glomerulosa.
- Main secreted hormone is aldosterone.
- It also secretes deoxy-corticosterone, 9-alpha flourocortisol, cortisol, cortisone.

Functions:

- Maintain balance of electrolytes content of the body fluid.
- Increased tubular reabsorption of Na^+ ions in the exchange for K^+ and H^+ ions.

Mineralocorticoids

- Act mainly on the distal kidney tubules, salivary glands and sweat glands.
- Increase blood volume and cardiac output.
- Increase blood pressure.

Regulations of aldosterone secretion :

- Increased of K^+ ions.
- Decreased of Na^+ ions.
- Undefined pituitary factors.
- ACTH
- Hypotension
- Increased renin angiotensin

Aldosterone, the main *mineralocorticoid*

- Secreted by adrenal cortex in response to a decline in either blood volume or blood pressure (e.g. severe hemorrhage)
 - Is terminal hormone in renin-angiotensin mechanism
- Stimulates distal and collecting tubules in kidney to reabsorb more sodium
 - Water passively follows
 - Blood volume thus increases

Glucocorticoids

Secreted from adrenal cortex-zona fasciculata.

Main secreted hormones are:

- Cortisol
- Prednisone & methyl prednisone
- Corticosterone
- Cortisone

Functions

Effects in the metabolism of carbohydrates, proteins and lipids.

- Stimulation of gluconeogenesis.
- Mobilization of amino acids from extra hepatic tissues.
- Inhibition of glucose uptake in muscles and adipose tissues.
- Stimulation of fat breakdown. .

Functions

- Suppress immune response.
 - Destroying circulating lymphocytes.
 - Inhibiting mitotic activity.
 - Controlling secretion of cytokines.
- Promotes maturation of lungs and production of surfactants in fetal development

Cortisol, the most important *glucocorticoid*

(Glucocorticoid receptors are found in the cells of most vertebrate tissues)

- It is essential for life
- Helps the body deal with stressful situations within minutes
 - Physical: trauma, surgery, exercise
 - Psychological: anxiety, depression, crowding
 - Physiological: fasting, hypoglycemia, fever, infection
- Regulates or supports a variety of important cardiovascular, metabolic, immunologic, and homeostatic functions including water balance

People with adrenal insufficiency: these stresses can cause hypotension, shock and death: must give glucocorticoids, eg for surgery or if have infection, etc.

Cortisol, continued

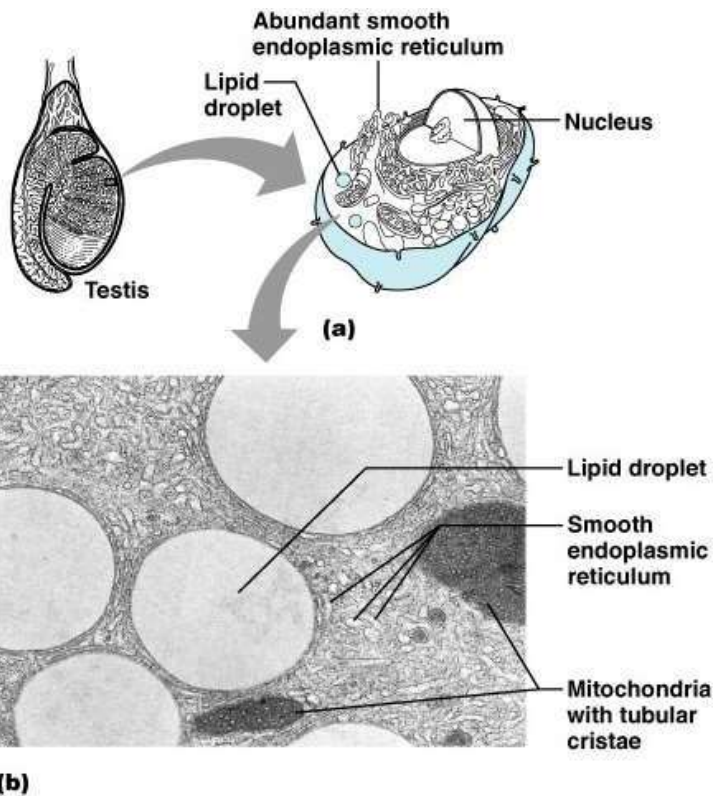
- Keeps blood glucose levels high enough to support brain's activity
 - Forces other body cells to switch to fats and amino acids as energy sources
- Catabolic: break down protein
- Redirects circulating lymphocytes to lymphoid and peripheral tissues where pathogens usually are
- In large quantities, depresses immune and inflammatory response
 - Used therapeutically
 - Responsible for some of its side effects

Hormonal stimulation of glucocorticoids

HPA axis (hypothalamic/pituitary/adrenal axis)

- With stress, hypothalamus sends CRH to anterior pituitary (adenohypophysis)
- Pituitary secretes ACTH
- ACTH goes to adrenal cortex where stimulates glucocorticoid secretion
 - Sympathetic nervous system can also stimulate it
- Adrenal cortex also secretes DHEA (dehydroepiandrosterone)
 - Converted in peripheral tissues to testosterone and estrogen (also steroid hormones)
 - Unclear function in relation to stress

In general:



- Steroid-secreting cells have abundant smooth ER
 - As opposed to rough ER in protein-secreting cells
- Steroids directly diffuse across plasma membrane
 - Not exocytosis
- Abundant lipid droplets
 - Raw material from which steroids made

Androgen

- Secreted from the adrenal cortex-zona reticularis.
- Exhibit actions similar to testosterone.

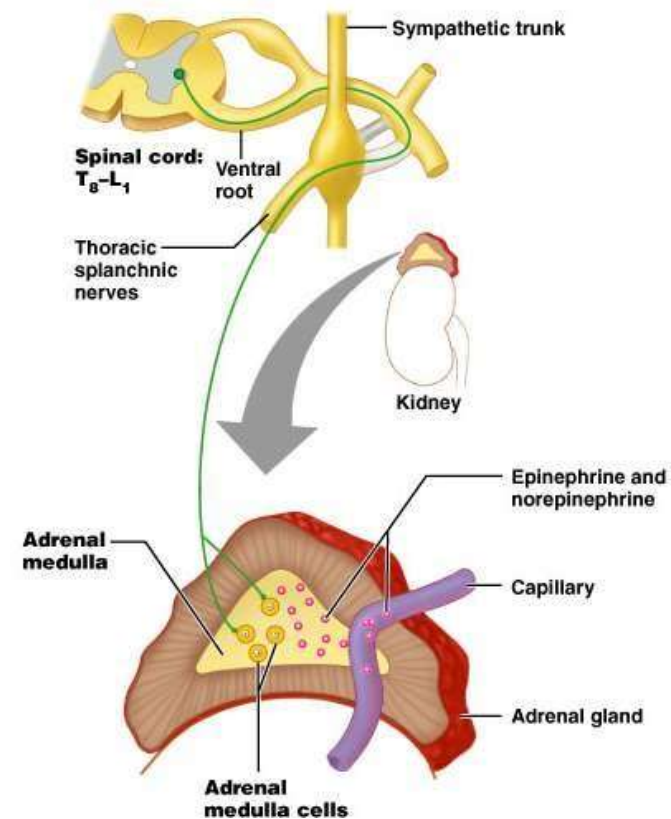
Functions :

- Responsible for the development and maintenance of reproductive functions.
- Stimulation of secondary sex characteristic.
- Stimulates the production of skeletal muscles and bones and RBC.

- **Regulations of androgen:**
 1. Controlled by luteinizing hormone (LH) and follicle stimulating hormone (FSH).
 2. Prolactin shows an inhibitory effect on androgen secretion.
- **Adrenal glands disorders :**
 1. Tumors including pheochromocytomas. Infections
 2. Genetic mutations.
 3. Cushing's syndrome.
 4. Addison's disease.
 5. A problem in another gland, such as pituitary.
 6. Hyperaldosteronism.

Adrenal medulla

- Part of autonomic nervous system
- Spherical chromaffin cells are modified postganglionic sympathetic neurons
 - Secrete epinephrine and norepinephrine
 - Amine hormones
 - Fight, flight, fright
- Vesicles store the hormones



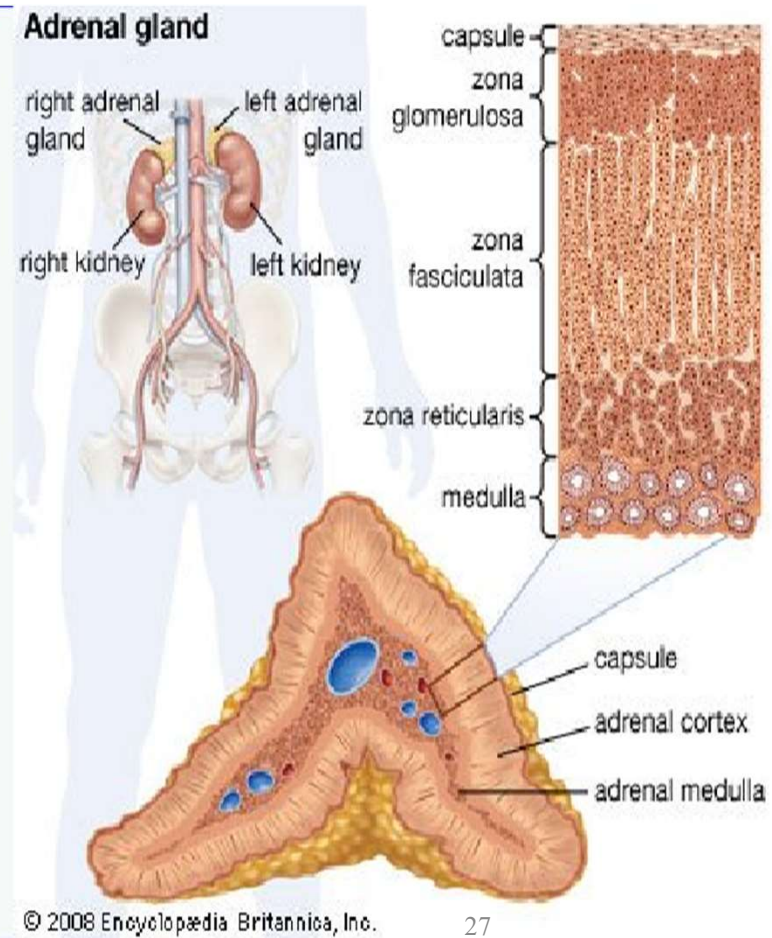
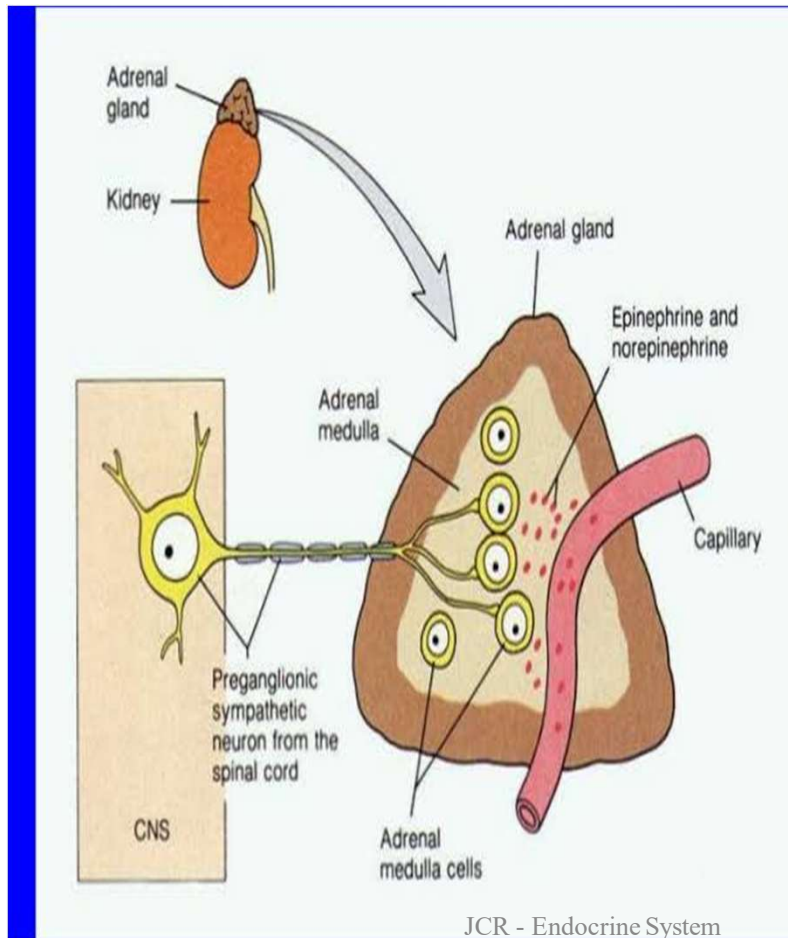
Introduction

- The *adrenal medulla* is part of the adrenal gland it is located at the center of the gland. It is surrounded by *adrenal cortex*. It is the innermost part of the adrenal gland and it has such type of cells that secrete *epinephrine* also known as *adrenaline* and *norepinephrine* which is known as *noradrenaline*. It also secretes dopamine at a small amount in response to stimulation by sympathetic preganglionic neurons.
- In general adrenal medulla is a less common site of chemically induced degenerative lesions.

Structure of adrenal medulla

- The adrenal medulla consists of irregularly shaped cells grouped around blood vessels. These cells are intimately connected with the sympathetic division of the *autonomic nervous system*(ANS).
- The cells of the adrenal medulla are derived from the neural crest in contrast to the mesodermal origin of the adrenal cortex. The secretory cells of the adrenal medulla are called *chromaffin* cells because of the formation of colored polymers of *catecholamines* after exposure to oxidizing agents such as chromate.
- In fact these adrenal medullary cells are modified *postganglionic* neurons and *preganglionic* autonomic nerve fibers lead to them directly from the central nervous system.

Structure of adrenal medulla



Functions of adrenal medulla

- **Biosynthesis of hormones:**

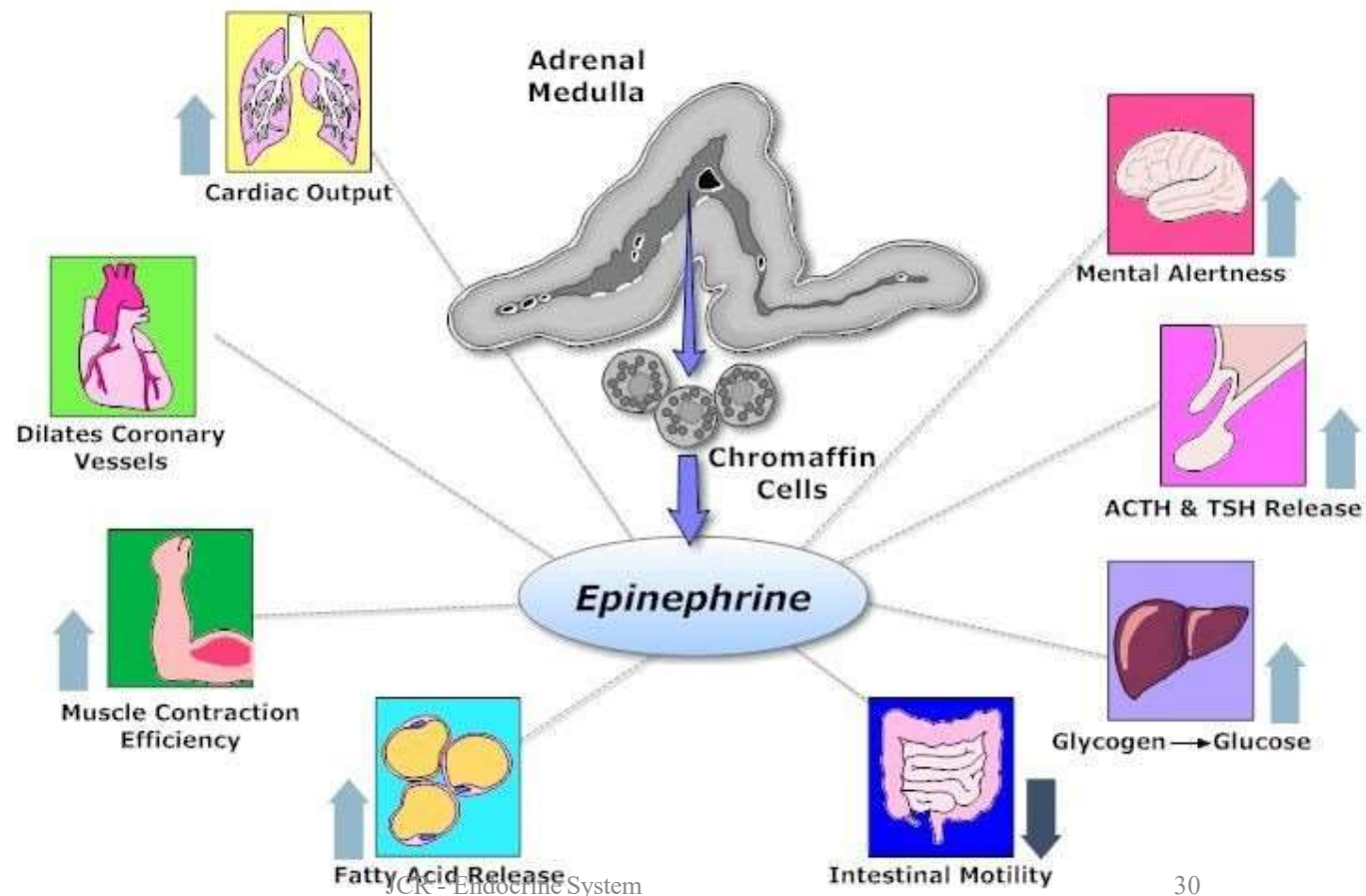
The adrenal medulla is the principal site of the conversion of the amino acid tyrosine into the catecholamines **epinephrine, norepinephrine and dopamine.**

- **Stimulation of the sympathetic nerves** to the adrenal medullae causes **large quantities of epinephrine and norepinephrine** to be released into the **circulating blood**, and these two hormones in turn are carried in the blood to all tissues of the body. On average, about **80 percent** of the secretion is **epinephrine** and **20 percent** is **norepinephrine.**

Functions of adrenal medulla

- The circulating epinephrine and norepinephrine have almost the **same effects on the different organs** as the effects **caused by direct sympathetic stimulation**, except that the effects last 5 to 10 times as long because both of these hormones are removed from the blood slowly over a period of 2 to 4 minutes.
- The circulating norepinephrine causes **constriction** of most of the **blood vessels** of the body; it also causes **increased activity of the heart, inhibition of the gastrointestinal tract, dilation of the pupils of the eyes**, and so forth.

Effects of Epinephrine



JCK - Endocrine System

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Regulatory activity of adrenal medulla

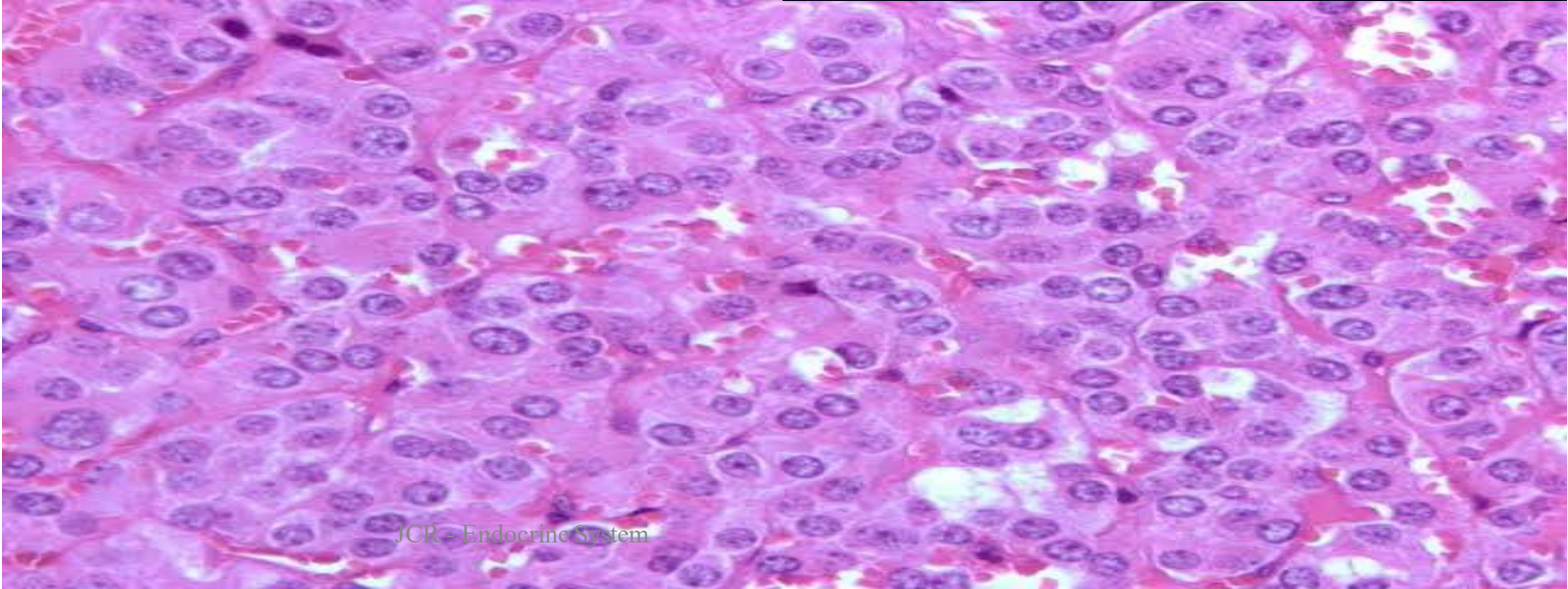
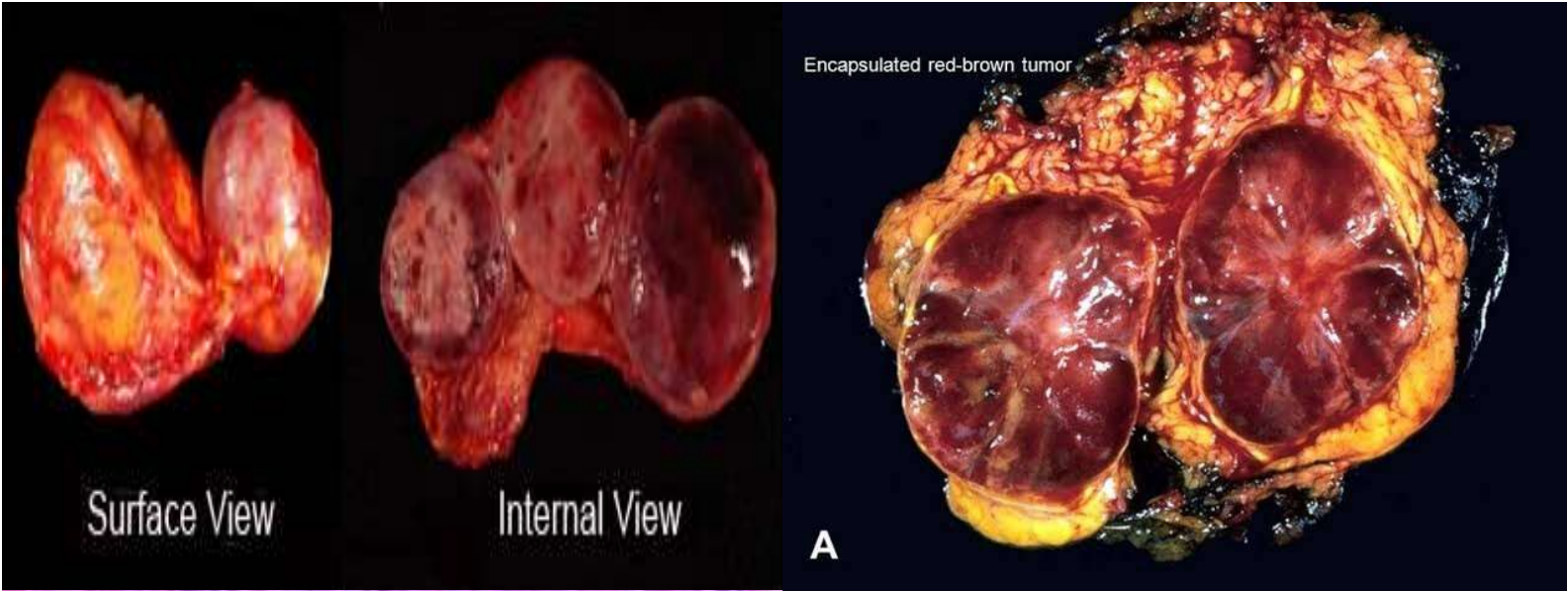
- Adrenal medulla is the **part** of the **sympathetic system** and is important for the **regulation** of **blood pressure** . **Catecholamines** released from the adrenal medulla also have metabolic effects . The following are the most important **effects** of catecholamines:
 - They increase **blood pressure** , skeletal muscle blood flow, **skeletal contractility**, heart rate, blood glucose, lipolysis.
 - They decrease **visceral blood flow** ,gastrointestinal contractility ,urinary output.

Disorder of the adrenal medulla

- **Pathology** within the adrenal medulla and the autonomic nervous system is primarily because of **neoplasms**. The most common **tumour**, called **pheochromocytoma** when located in the adrenal medulla, originates from **chromaffin** cells and excretes **catecholamines**.
- Those tumours found in extra-adrenal chromaffin cells are sometimes referred to as secreting **paragangliomas**. Neoplasms may also be of neuronal lineage, such as **neuroblastomas** and **ganglioneuromas**.

Pheochromocytoma

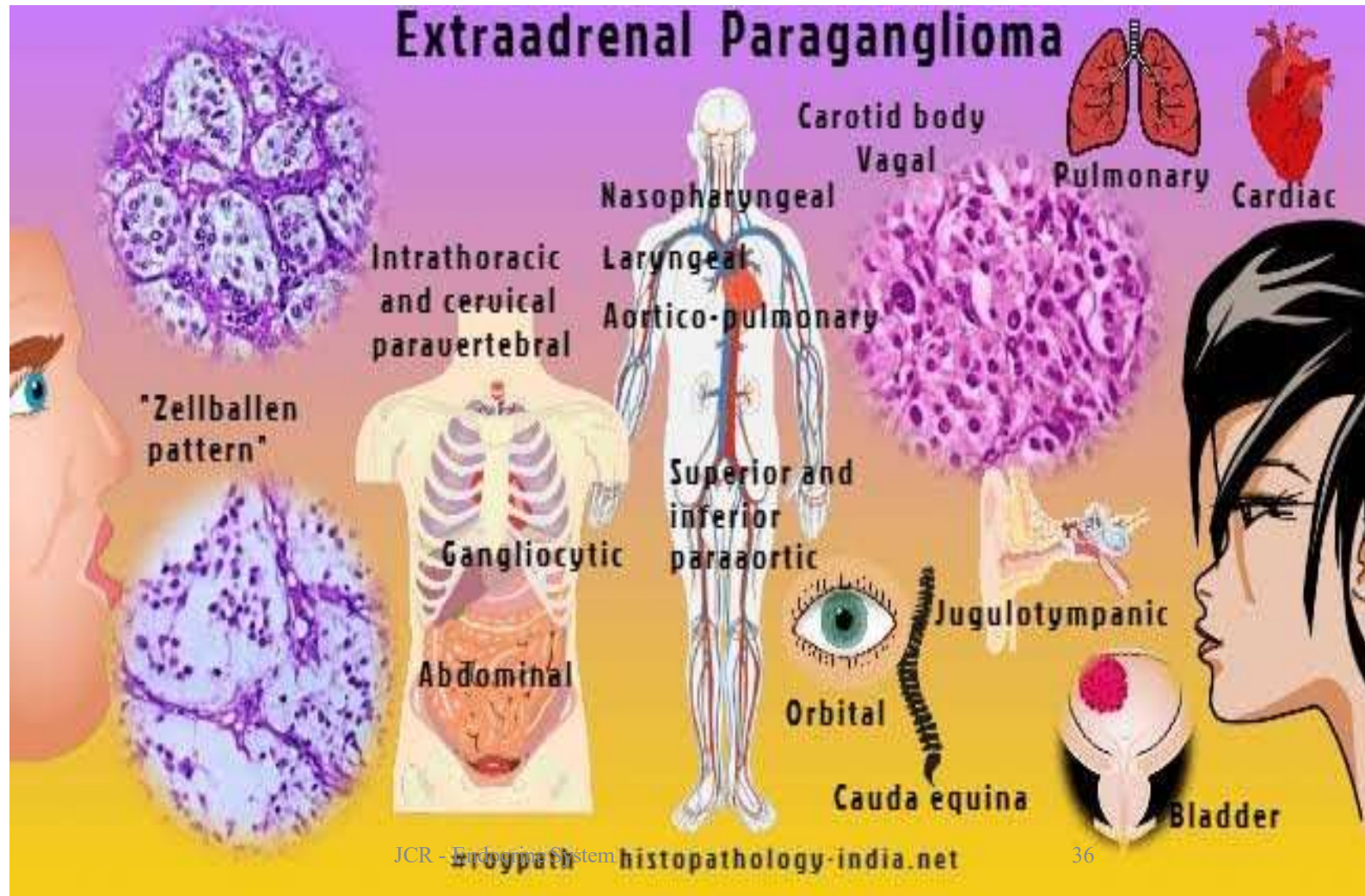
- Pheochromocytoma is a **chromaffin** cell **neoplasm** that typically causes symptoms and signs from **episodic catecholamine** release, including paroxysmal **hypertension**.
- In population-based cancer studies, its frequency is approximately **two** cases **per million** of the population. The diagnosis of pheochromocytoma is typically made in the **fourth or fifth** decade of life without gender differences.



Paragangliomas

- Extra-adrenal pheochromocytomas can be referred to as paragangliomas. They arise from **paraganglionic chromaffin** cells in association with **sympathetic nerves**, and are found in the organ of Zuckerkandl, urinary bladder, chest, neck and at the base of the skull.
- They are more **common** in **children** than in adults, and are more frequently **malignant**. As discussed earlier, mutations in the *SDH* family may predispose to head and neck paragangliomas and pheochromocytoma.

Paragangliomas



Neuroblastomas

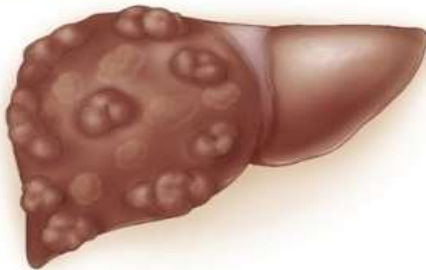
- Neuroblastomas and ganglioneuromas are **tumours** of the primitive **neuroblast cells** from the sympathetic nervous system in ganglia and the adrenal medulla. They may represent a continuum of neuronal maturation and are the most common malignancy found in children, representing 7–10% of all childhood cancers.
- Because of their more mature **ganglion** cells which are histologically **benign**, **ganglioneuromas** are often metabolically **inactive** and asymptomatic. They are found incidentally or with compressive symptoms mostly in the **posterior mediastinum** or retroperitoneum.

Neuroblastoma

Paraspinal tumor



Liver infiltration

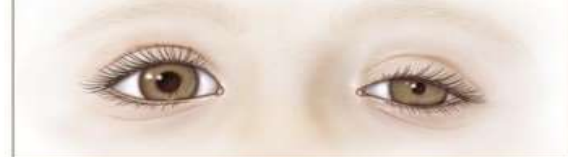


Bone marrow metastasis

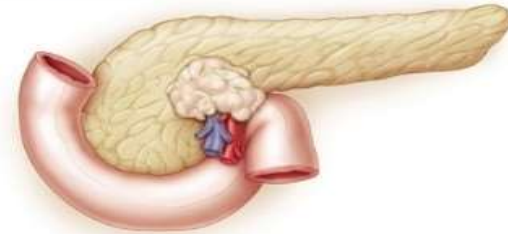


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Horner's syndrome



Celiac-axis tumor



Adrenal tumor

