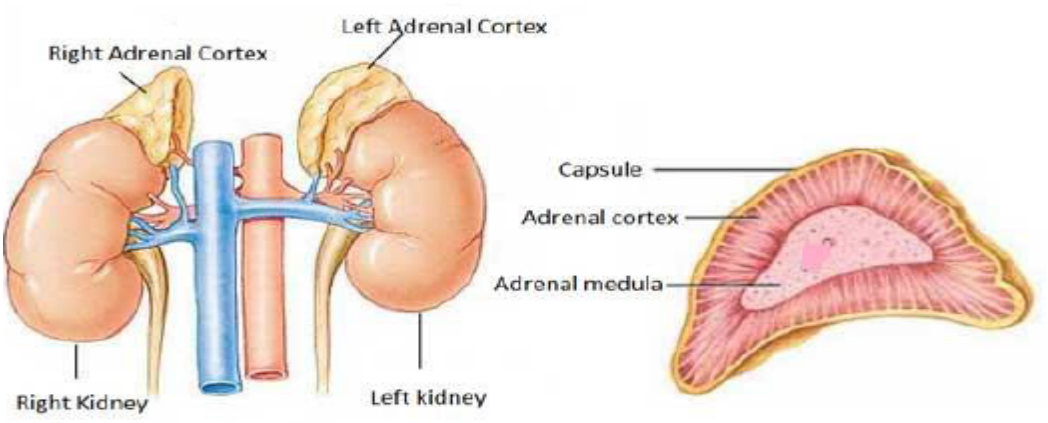
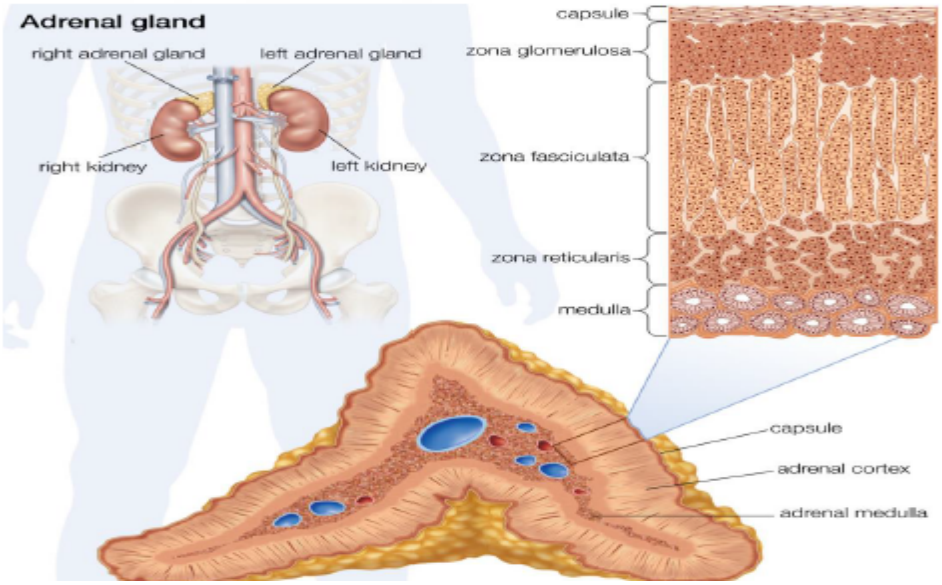
ADRENAL GLAND

The adrenal glands are small glands located on top of each kidney. They produce hormones that you can't live without, including sex hormones and cortisol. Cortisol helps you respond to stress and has many other important functions.
The **adrenal glands** (also known as **suprarenal glands**) are endocrine glands that produce a variety of hormones including adrenaline and the steroids aldosterone and cortisol.

STRUCTURE OF ADRENAL GLAND

There are two adrenal glands that occur atop each kidney which is why these are also called suprarenal glands. The glands are pyramid-shaped, but the exact shape might differ in different people with age and their physiological condition. The glands are enclosed in a fibrous capsule and a cushion of fat that serves to protect the gland from internal shocks.





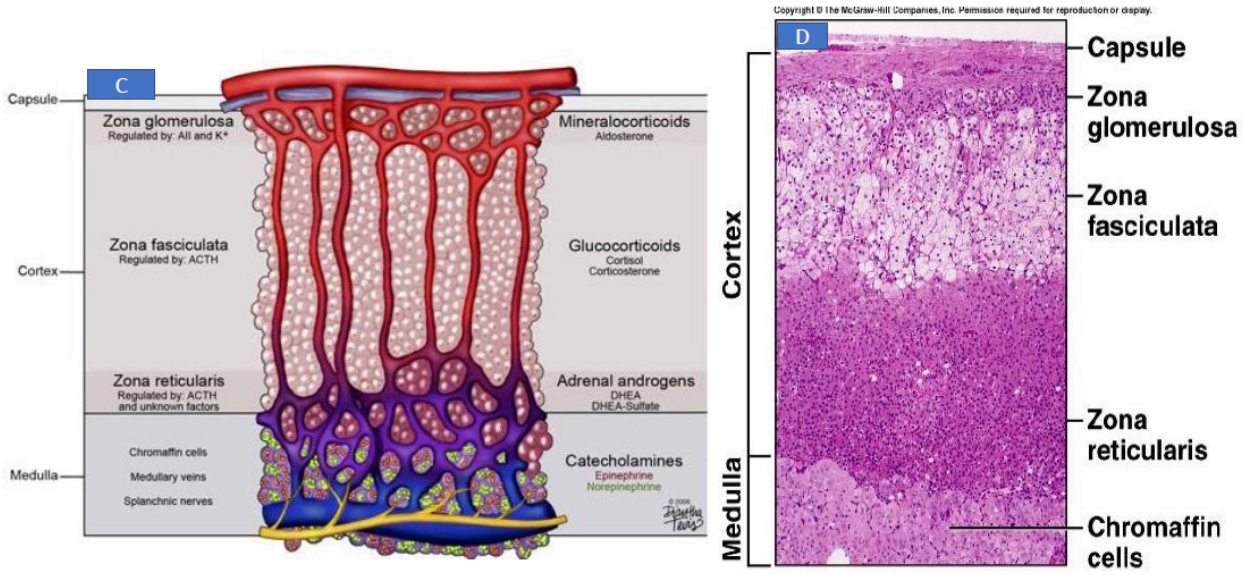


Fig. Diagrammatic representation of adrenal cortex regions (C) and histological view of adrenal cortex region (D)

Adrenal Cortex

- The adrenal cortex is the more important part of the adrenal gland that is composed of glandular epithelium.
- It consists of three distinct zones; zona glomerulosa, zona fasciculate and zona reticularis.
- The zona glomerulosa is the outermost zone that is composed of a thin layer of columnar cells arranged in an arched pattern. Zona glomerulosa of the adrenal cortex produces the hormone aldosterone.
- Zona fasciculata is the middle and thickest zone of the cortex. It is composed of columns of secretory cells surrounded by multiple capillaries. This zone produces glucocorticoids.
- The zona reticularis is the innermost layer composed of polyhedral cells arranged in linear or round nests or clumps. The region mostly produces glucocorticoids, but some species might produce the sex steroids called androgens.

Adrenal Medulla

- The adrenal medulla is present completely surrounded by the adrenal cortex and accounts for a small portion of the adrenal gland.
- The adrenal medulla, unlike the adrenal cortex, is composed of neural tissues in the embryo and is considered a part of the sympathetic nervous system.
- The adrenal medulla consists of the medullar chromaffin cells that are present within blood-filled capillaries and sinusoids.
- The medullary chromaffin cells of the adrenal medulla are modified postganglionic sympathetic neurons that synthesize catecholamines like epinephrine or adrenaline and norepinephrine.

Hormones of Adrenal Gland

The hormones produced by the adrenal gland can be classified into different groups depending on whether they are synthesized by the adrenal medulla or adrenal cortex.

Hormones of the adrenal cortex

The adrenal cortex releases three groups of steroid hormones, each of which are secreted by different regions within the adrenal cortex.

Mineralocorticoids

- Mineralocorticoids are a group of steroid hormones secreted by the cells of the zona glomerulosa of the adrenal cortex.
- Mineralocorticoids function to regulate the concentrations of mineral salts (like Na+ and K+) in the extracellular fluids.
- The balance in the level of these cations is essential as the change in concentration can bring changes in blood volume and blood pressure.
- The regulation of Na+ and K+ in the body is performed mostly by the mineralocorticoid, aldosterone.
- Aldosterone is the most important mineralocorticoid, accounting for about 95% of all the mineralocorticoids produced.
- Aldosterone stimulates the distal tubules of the nephrons in the kidney to reabsorb Na+ and water and increase the elimination of K^+ into the urine.
- The regulatory effects of aldosterone last for about 20 minutes which allows the control of the plasma electrolyte balance.

Glucocorticoids

- Glucocorticoids are essential to life as these influence the energy metabolism in the body.
- The primary function of glucocorticoids is to maintain blood glucose and blood pressure by influencing the activity of vasoconstrictors.
- Glucocorticoids include three steroid hormones; cortisol, cortisone, and corticosterone, out of which only the cortisol is secreted in significant amounts in humans.
- The cortisol works by modifying the gene activity on the target cells, and the levels of cortisol produced in the body occur in a definite pattern.
- The secretion of glucocorticoids is regulated by a negative feedback mechanism with the help of ACTH produced by the pituitary gland. ACTH released by the anterior pituitary is stimulated by the hypothalamic corticotrophin-releasing hormone.
- The prime metabolic effect of cortisol is to induce gluconeogenesis in order to limit the use of glucose and mobilize other biomolecules like fatty acids and proteins for energy.

Gonadocorticoids/Androgens/Sex Hormones

- The gonadocorticoids or androgens produced by the adrenal cortex are weak sex hormones and are converted into potent sex hormones.
- Gonadocorticoids include hormones like androstenedione and dehydroepiandrosterone, which are secreted in amounts that are insignificant as compared to those secreted by gonads after puberty.

- Even though the exact function of these androgens is not yet known, they have been associated with axillary and pubic hair development in both males and females.
- The sex hormones in females are responsible for sex drive and account for most of the estrogen produced in the body after menopause.

Hormones produced by the adrenal medulla

Epinephrine and Norepinephrine

- The adrenal medulla produces two hormones in response to stress; epinephrine and norepinephrine.
- The amount of these two hormones produced by the adrenal medulla is in the ratio of 4:1 in terms of epinephrine to norepinephrine.
- Epinephrine is more potent in stimulating metabolic activities in the body in the form of bronchial dilation and increased blood flow to the skeletal muscles.
- Norepinephrine, in turn, influences peripheral vasoconstriction and blood pressure.
- The hormones of the adrenal medulla usually produce a brief response to stressors that are short-lived.

The functions of the adrenal gland

The functions of the adrenal gland depend on the hormone produced by the gland. The following are some of the functions of the adrenal gland;

1. Mineralocorticoids are involved in the regulation of sodium and potassium ions present in the blood and other extracellular fluids.
2. Cortisol produced by the adrenal cortex functions to regulate metabolism, the immune system, and the cardiovascular system.
3. The hormones of the adrenal gland work to enable the body to adapt to increased stress conditions.
4. The androgens produced by the adrenal gland are converted to sex hormones that are essential for the development of the reproductive system.
5. The hormones of the adrenal medulla like catecholamines, epinephrine, and norepinephrine are involved in performing the fight or flight response.

Diseases and Disorders of Adrenal Gland

The following are the diseases and disorders associated with the adrenal gland;

Cushing's syndrome

- Cushing's syndrome is a condition caused due to the hypersecretion of cortical, which is the primary glucocorticoid hormone of the adrenal cortex.
- The hypersecretion can occur due to the formation of adrenal tumors or the hypersecretion of the ACTH by the pituitary.
- The condition is characterized by adiposity of the face, neck, and abdomen followed by extensive tissue protein breakdown.
- Osteoporosis and increased gluconeogenesis can occur, resulting in hyperglycemia and glycosuria.

Adrenal Hypoplasia

- Adrenal hypoplasia is a condition resulting from the underdevelopment of the adrenal cortex due to various clinical conditions.

- Hypoplasia of the adrenal cortex can either be primary or secondary. Primary hypoplasia results in hyposecretion of adrenal hormones and underdevelopment of the adrenal gland.
- Secondary hypoplasia is less common and less severe that only affects the secretions of the gland.

Addison's Disease

- Addison's disease is a disorder caused due to the destruction of the adrenal gland due to the hyposecretion of glucocorticoids and mineralocorticoids.
- The disease can occur due to the formation of autoantibodies by the immune system against the cortical cells.
- Some common symptoms of this condition are muscle weakness, tiredness, hypoglycemia, and increased skin pigmentation.

Adrenocortical adenomas

- Cortisol-producing adenomas result due to high levels of cAMP or protein kinase A in the body.
- These adenomas are usually benign, but in some cases, these can produce different hormones of the gland, resulting in hypersecretion.
- The formation of adrenal adenomas is stimulated by the binding of ACTH to receptors which induce the release of protein kinase A. Protein kinase A is a pathway for the formation of cortical cells.