

# The adrenocortical hormones

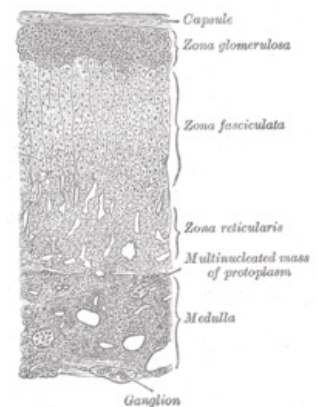
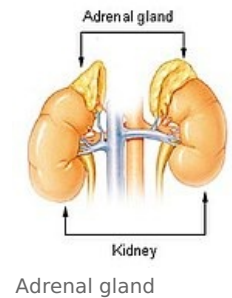
## Adrenal gland

The adrenal glands or suprarenal glands are small paired organs situated superiorly to the kidneys resembling caps surrounded by dense adipose tissue. They have many activities due to their dual embryonic origin during development. The adrenal gland divides into the adrenal outer cortex and the adrenal inner medulla with the latter being of neuronal embryonic origin.

### Adrenal cortex

The adrenal cortex composes the outer layer of the adrenal gland and consists of three sublayers called zonae each of which produces structurally similar and functionally different compounds and hormones. The cortical zonae are the zona glomerulosa, fasciculata and reticularis producing and secreting minerocorticoids, glucocorticoids and sex steroids respectively.

- **Zona Glomerulosa:** is the outermost layer of the cortex specialized in the production and secretion of minerocorticoids and predominantly aldosterone a hormone involved in extracellular fluid volume and osmolality control. Aldosterone is generally responsible for the renal absorption of  $\text{Na}^+$  and excretion of  $\text{K}^+$  from the distal part of the distal convoluted tubule and collecting duct and intestinal absorption of  $\text{Na}^+$  in lesser extend.
- **Zona Fasciculata:** is the intermediate layer of the cortex specialized in the production and secretion of glucocorticoids and predominantly cortisol and corticosterone hormones involved in metabolism control along with inflammatory regulation being of vital importance for life maintenance.
- **Zona Reticularis:** is the innermost layer of the cortex specialized in the production and secretion of sex steroid hormones and predominantly androgens and androgen precursors. The zona reticularis secretes androstenedione, dehydroepiandrosterone and dehydroepiandrosterone which are not effective androgens as testosterone. However, when secreted they are transported to the gonads either testes or ovaries where they are converted to the more potent testosterone and to the most potent sex steroid hormone called dihydrotestosterone. The androgens stimulate and control the development and maintenance of male characteristics (and of female characteristics to lesser extend). This includes the activity of the accessory male sex organs and development of male secondary sex characteristics.



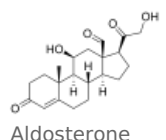
Adrenal cortex and medulla

### Adrenal medulla

The adrenal medulla is the innermost part of the adrenal gland situated underneath the adrenal cortex and resembles literally a large ganglion since it is composed of medullary chromaffin cells which are considered to have neuroendocrine properties since they derive from neuronal embryonic origin during the adrenal gland development. The adrenal medulla is an area specialized in production and secretion of norepinephrine and epinephrine collectively known as catecholamines. Catecholamines perform more or less the same function as the neurotransmitters of the adrenergic fibers of the sympathetic nervous system, acting through the same type of adrenergic receptors.

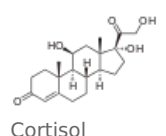
## The adrenocortical hormones

The adrenocortical hormones are the compounds secreted by the adrenal gland except catecholamines. Therefore the adrenocortical hormones refer to glucocorticoids-cortisol, minerocorticoids-aldosterone and sex steroids-androgens. Precursor of all adrenocortical hormones is cholesterol.



### Regulation of the adrenocortical hormones secretion

1. The secretion of adrenocortical hormones and specifically that of glucocorticoids and sex steroids is controlled by the hypothalamus whereas regulation of aldosterone release is under the control of the extracellular fluid volume regulation and  $\text{Na}^+$  balance.
2. The paraventricular nuclei of the hypothalamus produce and secrete CRH (corticotropin releasing hormone)
3. CRH enters the primary hypophyseal capillary bed at the median eminence and enters the secondary hypophyseal capillary bed
4. CRH reaches the anterior pituitary lobe and acts on specialized cells called corticotrophs.
5. Stimulation of the corticotrophs induces production and secretion of ACTH (adrenocorticotrophic hormone)
6. ACTH enters the secondary hypophyseal capillary bed and reaches the blood circulation
7. ACTH acts in an endocrine fashion reaching the adrenal cortex affecting the secretory status of the



## Glucocorticoids

### Characteristics:

Glucocorticoids are the hormones secreted by the zona fasciculata of the adrenal cortex. The most abundant glucocorticoid is cortisol. Cortisol is an essential hormone for the human body, for example, bilateral removal of the adrenal glands eventually causes death, thus the patient must be administered cortisol for the rest of the life in order to sustain life. Cortisol is not stored in the adrenocortical cell to any significant extent, so a need for high amount of hormone requires rapid activation of the entire synthetic mechanism from cholesterol. Cortisol is transported in blood bound to a carrier protein called transcortin. Cortisol secretion exhibits distinct diurnal variation with a peak in the morning and minimum during sleep.

### Function:

#### 1. Metabolic activity

Cortisol promotes mobilization of protein in order to provide amino acids for gluconeogenesis critical for the survival of a fasting body. This is achieved primarily through acceleration of protein degradation and inhibiting of protein synthesis. During hypoglycemia the initial response to increase the glycemia is promoted by glucagon, thyroxine and epinephrine and later by cortisol.

Cortisol has a weak lipolytic effect promoting mobilization of fatty acids and glycerol during fasting conditions in order to enhance the formation of energy through  $\beta$  oxidation and gluconeogenesis from fats.

#### 2. Antiinflammatory activity

inhibition of the recruitment of circulating leukocytes to the site of trauma or infection  
inhibition of differentiation and proliferation of local inflammatory basophils and mast cells  
decrease of the number of T cells with subsequent inhibition of the cell-mediated immunity  
decrease of phagocytic and bacteriocidal activity of neutrophils and probably macrophages  
reduction of local release of proteolytic enzymes

## Minerocorticoids

Aldosterone circulates in plasma bound to an aldosterone-binding protein, to transcortin and to albumin. Aldosterone receptor in the cytoplasm of target cells influence the transcription and protein synthesis in order to provide  $\text{Na}^+$  and  $\text{K}^+$  pumps for  $\text{NaCl}$  reabsorption and potassium excretion.

1. In the renal nephrons, aldosterone stimulates the active reabsorption of  $\text{Na}^+$  from the tubular fluid by the distal part of the distal tubules and collecting ducts and excretion of potassium. This is achieved through stimulation of the  $\text{Na}^+/\text{K}^+$  ATPase pump and increase of density of  $\text{Na}^+$  channels at the luminal membrane
2. Stimulation of  $\text{Na}^+$  reabsorption from the intestine
3. Decrease in the ratio of  $\text{Na}^+$  over  $\text{K}^+$  in sweat and saliva
4. Indirect increase of blood volume and blood pressure

## Sex steroids

Dehydroepiandrosterone and androstenedione are the major androgenic product of the adrenal glands possessing only weak androgenic effect, but they are converted into testosterone in peripheral tissues and especially in gonads. In women the adrenals supply half of the androgenic hormone requirements. The further conversion to estradiol and estrone is of little significance in women until the ovaries cease to function after menopause. Then estrogens secreted directly from adrenal glands or arising in the periphery from adrenal precursors become the only source for this biological activity. In man, adrenal androgen precursors have little biological importance because the testes produce a large quantity of testosterone.

## Links

## Bibliography

MURRAY, Robert K. – BENDER, David A.. *Harper's Illustrated Biochemistry*. 29<sup>th</sup> edition. McGraw-Hill Companies, Inc., 2012. ISBN 978-0-07-176576-3.

