8. HORMONES
The **endocrine system** includes special glands whose cells function is to secrete chemical regulators, commonly referred to as **hormones**, into the internal media of the organism (blood, lymph).

Hormones are produced in the gland cells, secreted into the blood or lymph and exercise control over metabolism and development of the organism.

**General biological characters:**

- Remote action
- Strict specificity of biological action (no hormone can be entirely replaced by another one)
- High biological activity (small amounts are sufficient for the vital activity of the organism)

Hormone-secreting glands are:

- Central glands
- Peripheral glands
# CENTRAL GLANDS

<table>
<thead>
<tr>
<th>Hypotalamus</th>
<th>Neuropeptides</th>
<th>Control of the secretion of the tropic hypophyseal hormones</th>
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<tr>
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<td>Releasing hormones (liberins)</td>
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<td>Inhibitory hormones (statins)</td>
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<td></td>
<td>Vasopressin, Oxytocin</td>
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<td></td>
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<td>Control of the metabolism and function of the peripheral tissues and organs</td>
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</table>

<table>
<thead>
<tr>
<th>Pituitary gland</th>
<th>Thyrotropin</th>
<th>Control of the formation and secretion of hormones in the peripheral endocrine glands,</th>
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<td>Corticotropin</td>
<td>Partial involvement in direct metabolism in peripheral tissues and organs</td>
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<td>Gonadotropin</td>
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<td>Follitropin</td>
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<td></td>
<td>Lutropin</td>
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<td></td>
<td>Prolactin (lactotropin)</td>
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<td></td>
<td>Somatotropin</td>
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<td></td>
<td>Melanotropin</td>
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<td></td>
<td>α and β lipotropins</td>
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<td></td>
<td>Vasopresin, oxytocin supplied from hypotalamus</td>
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<tr>
<th>Epiphysis</th>
<th>Melatonin</th>
<th>Control of production of hypophyseal gonadotropin</th>
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<tbody>
<tr>
<td></td>
<td>Adrenoglomerulotropin</td>
<td>Control of aldosterone secretion in adrenal cortex</td>
</tr>
</tbody>
</table>

# Peripheral Glands

<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormones</th>
<th>Action of the peripheral gland hormones on metabolism and functions of the peripheral tissues and organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid</td>
<td>Iodotyronines (thyroxine, triiodothyronine)</td>
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<tr>
<td></td>
<td>Calcitonine</td>
<td></td>
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<tr>
<td>Parathyroid</td>
<td>Parathyrine</td>
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<tr>
<td></td>
<td>Calcitonine</td>
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<tr>
<td>Pancreas</td>
<td>Insulin</td>
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<tr>
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<td>Glucagon</td>
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<tr>
<td>Adrenal glands</td>
<td>Corticosteroids: corticosterone, cortisol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aldosterone</td>
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</tr>
<tr>
<td></td>
<td>Estrogens, androgens</td>
<td></td>
</tr>
<tr>
<td>Cortex</td>
<td>Adrenalin (epinephrine), noradrenalin (norepinephrin)</td>
<td></td>
</tr>
<tr>
<td>Medulla</td>
<td></td>
<td></td>
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<tr>
<td>Sex glands</td>
<td>Androgens: testosterone, 5α-dihidrotestosterone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estrogens: estradiol, estrone, estriol</td>
<td></td>
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<tr>
<td>Testes</td>
<td>Gestagens: progesterone</td>
<td></td>
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<tr>
<td>Ovaries</td>
<td>Relaxin</td>
<td></td>
</tr>
<tr>
<td>Placenta</td>
<td>Estrogens, gestagens, testosterone, chorionic gonadotropin, placental lactogen, thyrotropin, relaxin</td>
<td></td>
</tr>
<tr>
<td>Thymus</td>
<td>Thymosin</td>
<td></td>
</tr>
</tbody>
</table>
Hormone-like compounds

Endocrine functions are also exercised by other secreting biologically active compounds whose properties resemble those of hormones: hormone-like compounds or hormonoids or local hormones or parahormones.

Their action is at the site they are produced.

They are produced by cells dispersed in different tissues:
- Cells of the gastrointestinal tract (gastrine, secretine)
- Intestinal chromaffin cells (serotonin – regulator of the intestinal function)
- Most cells of the connective tissue (heparin, histamine)
- Cells of kidneys, seminal vesicles (prostaglandins)
CHEMICAL STRUCTURE

- **Protein-peptide** hormones produced by
  - Hypothalamus: regulatory hormones
  - Pituitary gland: tropic hormones
  - Thyroid: calcitonin
  - Parathyroid: parathyrine, calcitonin
  - Pancreas: insulin, glucagon

- **Aminoacid derivatives:**
  - Adrenalin derived from phenylalanine and tyrosine
  - Iodothyronines derived from tyrosine
  - Melatonin derived from tryptophan

- **Steroids:**
  - Sex hormones: androgens, estrogens, gestagens
  - Glucocorticoids
  - Mineralocorticoid: aldosterone
NEUROENDOCRINE RELATIONSHIP

- **Neural input**
  - Hypothalamus
  - Anterior pituitary gland
    - TSH
    - ACTH
    - FSH
    - LH
    - PRL
    - GN
    - MSH
  - Posterior pituitary gland
    - Oxytocin
    - Vasopressin

**Regulatory hormones (R, I)**
- Primary target
  - Thyroid
    - Thyroxine
  - Adrenal cortex
    - Corticosteroids
  - Testes / ovaries
    - Estrogens
    - Testosterone
    - Gestagens
  - Mammary glands
  - Sex accessory tissues
  - Bones
  - Skin
  - Muscles, liver, other tissues
MUTUALLY EXCLUSIVE RELATIONSHIP OF ENDOCRINE SYSTEM

Nervous impulse

Hypothalamus

Releasing hormones (liberins)

Pituitary gland

Pituitary gland hormones (tropic hormones)

Peripheral glands

Specific hormones

Peripheral organs/cells

Metabolites:
- Glucose
- Aminoacids
- Fatty acids, cholesterol
- Nucleotides, nucleosides
- Ca^{2+}, Na^{+}, K^{+}, Cl^{-}

Short feed-back

Long feed-back
HORMONAL CONTROL

Extracellular regulators, including hormones, act as first messengers.

Types of action:
- Membrane, local action
- Membrane intracellular, indirect action
- Cytosolic, direct action

1. MEMBRANE TYPE OF ACTION

The hormone, at the site of its binding with the cell membrane, acts as an allosteric effector for membrane transport system and renders the membrane permeable to glucose, aminoacids, certain ions.

The glucose and amino acids influence the biochemical cellular processes, while a change in ion partition on both sides of the membrane affects the electric potential and function of the cell.

E.g. insulin
The first messengers are not able to enter in the cell and cannot influence the intracellular processes directly. They act through a second messenger, intracellular, which triggers a chain of successive biochemical reactions leading to a modification of cellular functions.

First messenger (hormone) reaches the receptor on the outer side of the cell membrane.

The hormone-receptor complex acts on a protein (membrane transducer)

The transducer transmits the signal to an enzyme (chemical amplifier) acting as a catalyst for the production of a second messenger inside the cell.

The second messenger binds to a special protein (internal effector) which exerts an influence in the activity of a definite enzyme or on the properties of non-enzyme proteins (changes of the chemical rates, permeability, contractility, activation of genes)

E.g. cAMP, cGMP, diacylglycerides, inositol-triphosphate, Ca^{2+}, peptides
3. CYTOSOLIC MECHANISM OF ACTION

- Is typical for the compounds that can penetrate through the lipid layer of cell membrane, for example steroid hormones, vitamin D

- The hormone forms a complex with a cytosolic or nuclear receptor

- By selectively affecting the gene activity of nuclear chromosomes and exerting influence on the metabolism and function of cell, the hormone-receptor complex controls the enzyme concentration in the cell

- E.g. iodothyronine have a combined type of action, both intracellular-membrane and cytosolic
**PROHORMONES**

- Polypeptide hormones are synthesized as inactive prohormones (hormonogens).
- They become active after the extracellular activation by the peptidases.

<table>
<thead>
<tr>
<th>Prohormone</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proinsulin</td>
<td>pancreas</td>
</tr>
<tr>
<td>Proparathyroid hormone</td>
<td>parathyroid</td>
</tr>
<tr>
<td>Angiotensinogen</td>
<td>liver</td>
</tr>
<tr>
<td>Progastrin</td>
<td>stomach</td>
</tr>
</tbody>
</table>
The hypothalamus, a specialized portion of the brain, coordinates the endocrine system, receiving and integrating messages from the central nervous system.

It produces regulatory hormones that act on the anterior lobe of pituitary gland (adenohypophysis) controlling its function:

- stimulating its production (releasing factors, liberins) or
- inhibiting the production (inhibiting factors)

Hypothalamus also produces neurohormones: oxytocin, vasopressin that are stored in the posterior lobe of pituitary gland (neurohypophysis)
HORMONES OF HYPOTHALAMUS-HYPOPHYSEAL SYSTEM

HORMONES OF PITUITARY GLAND

In the anterior lobe of pituitary gland (adenohypophysis) **tropic hormones** (tropins) are produced.

From the posterior lobe (neurohypophysis) **neurohormones** (oxytocin, vasopressin) are released.

**Structure:**
- thyrotropin, follitropin, lutropin – glycoproteins
- vasopressin, oxytocin – cyclic octapeptides
<table>
<thead>
<tr>
<th>Hypothalamic hormones</th>
<th>Tropic hormones</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Releasing factors</strong></td>
<td><strong>Inhibiting factors</strong></td>
</tr>
<tr>
<td>Thyreoliberin – thyrotropin regulatory hormone (TRH)</td>
<td>Thyrotropin (TSH)</td>
</tr>
<tr>
<td>Corticoliberin – corticotropin regulatory hormone</td>
<td>Corticotropin (ACTH)</td>
</tr>
<tr>
<td>Folliliberin – follicle stimulating h. regulatory hormone (FSH-RH)</td>
<td>Follitropin (FSH)</td>
</tr>
<tr>
<td>Luliberin – luteinizing regulatory hormone (LH-RH)</td>
<td>Lutropin (LH)</td>
</tr>
<tr>
<td>Prolactoliberin – prolactin regulatory hormone (PRH)</td>
<td>Prolactostatin – prolactin inhibitory hormone (PIH)</td>
</tr>
<tr>
<td>Melanoliberin - melanocyte regulatory hormone (MSH-RH)</td>
<td>Melanostatin - melanocyte inhibitory hormone (MSH-IH)</td>
</tr>
<tr>
<td>Somatoliberin – growth hormone regulatory hormone (GH-RH)</td>
<td>Somatostatin - growth h. inhibitory hormone (GH-RH)</td>
</tr>
<tr>
<td></td>
<td>Prolactin (PRL)</td>
</tr>
<tr>
<td></td>
<td>Melanotropin (MSH)</td>
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<tr>
<td></td>
<td>Somatotropin (STH)</td>
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<tr>
<td></td>
<td>Growth h (GH)</td>
</tr>
</tbody>
</table>
MECHANISM OF ACTION OF HYPOPHYSEAL HORMONES

Tropic hormones exert their function

• on the peripheral glands or
• directly on the peripheral tissues

by binding on the membrane receptors and activating adenylate cyclase.

The resulting cAMP determines the effects in the target cells:

• Control of biosynthesis and hormonal secretion by peripheral glands (thyrotropin, corticotropin, follitropin, lutropin, prolactin, somatotropin)
• Control of sex cell production (follitropin)
• Control of effector tissues (corticotropin, lutropin, follitropin, prolactin, somatotropin, melanotropin, oxytocin, vasopressin)
• Control of the nervous system (corticotropin)
DIRECT EFFECT ON PERIPHERAL TISSUES

- Thyroid stimulating hormone = thyrotropin (TSH)
- Adrenocorticotropin (ACTH):
  - adenylate cyclase activation; cAMP activates the lipase → release of fatty acids and glycerol (direct action on fat tissue by stimulating the glucose absorption and fat mobilizing);
  - action on melanin production
- α and β lipotropins:
  - fat mobilizing action (cAMP mechanism)
- Gonadotropins (follicle stimulating h= FSH, luteinizing h= LH)
  - Fat mobilizing (cAMP)
- Prolactin: protein and lactose synthesis by mammary gland epithelium
Melanotropin:
• Production of melanin in the skin, iris, epithelial pigment in retina
• Fat-mobilizing (cAMP)

Somatotropin/ growth hormone (STH, GH):
• Only hormone with species-specific effect
• Stimulates cartilage cell division, growth of bones in length, internal organs, soft tissue of face and oral cavity
• Stimulates secretion of glucagon more than insulin
• Deficiency – dwarfism proportionate constitution, no mental retardation
• Hypersecretion – giantism or acromegalia
Vasopressin or antidiuretic hormone (ADH):

- Fat mobilizing action
- Selective control of water reabsorption in the distal tubes and collecting ducts of the kidneys and activates adenylate cyclase; cAMP activates protein kinases that phosphorylate the proteins in the membranes to increase the permeability for water; reduces diuresis, ↑ density and Na$^+$ and Cl$^-$ concentration in urine.
- ↑ contraction of muscles in arterioles and capillaries and determine moderate ↑ in blood pressure
- Deficiency: diabetes insipidus (large discharge of urine (4-10L/day), low density, polydipsia

Oxytocin:

- ↑ contraction of uterus muscles, ↑ Ca$^{2+}$ intracellular, cAMP,
- ↑ synthesis of protein in mammary glands during lactation
- ↑ the release of milk – ↑ contractility of myoepithelium of mammary ducts
- Insulin-like effect on fat tissue (↑ G consumption and TG synthesis)
THYROID HORMONES

Iodothyronines:

– Triiodothyronine (T3)
– Tetraiodothyronine = Thyroxine (T4)

Function:
– control the energy metabolism
– exert influence on cell division and differentiation
4-(4-hydroxiphenoxi)phenylalanine
tyronine

3,3'-diiodotyronine, T2
reduced hormonal activity

3,3',5'-triiodotyronine, T3'
reduced hormonal activity

3,5,3'-triiodotyronine, T3
active

3,5,3',5'-tetraiodotyronine, T4
Thyroxine
active
Calcitonin - polipeptide MW 30,000

Function: control of calcium-phosphorus metabolism
Hyperfunction = **Hyperthyroidism**

Thyrotoxicosis = **Graves-Basedow’s disease**
- T3 is predominant
- Accelerated catabolism of carbohydrate, triacylglycerides, proteins.
- Increased basal metabolism
- Elevated body temperature
- Loss of body weight
- Tachycardia
- Hyperexcitability
- Exophthalmia (protrusion of the eyeballs)
Hypofunction = Hypothyrosis

In child: infantile myxedema, cretinism
= Ineffective action of the hormones on cell division and cell differentiation
  – Physical retardation with disproportionate constitution due to improper growth of bone tissue,
  – Extreme mental retardation due to impaired differentiation of the neurons
  – Basal metabolism reduced, body temperature below normal

In adult: myxedema manifested in
  – Reduced basal metabolism, lowered body temperature
  – Less retentive memory
  – Impaired renewal of dermal epithelium (dry skin)
  – Deposition of mucoid materials in subcutaneous fat
PARATHYROID GLANDS

- **Calcitonine** (also secreted by thyroid gland) – protein of 32 aa

- **Parathyrine** (parathormone, PTH) – 84 aa

  Function: control the balance of calcium and organic phosphate
Dysfunction of parathyroids

**Hypofunction = hypoparathyrosis** = determine reduced Ca2+ concentration in the blood and extracellular fluid, that facilitates the Na+ flow into the cell, increasing the excitability of nerve and muscle cells = hyperexcitability of the neuromuscular system (convulsive contraction of muscles)

**Hyperparathyrosis =**
- mobilization of endogenic calcium from bones (risk of fracture);
- calcemia is increased,
- phosphate lower;
- calcium is deposited in the internal organs (calcification of blood vessels, kidney, gastrointestinal tract, liver)
Cells of Langerhans islands

- A-type (α-cells) secrete glucagon
- B-type (β-cells) secrete insulin
- D-type secrete somatostatin
- PP-type (F-cells) secrete pancreatic polypeptide (that is produced in the acinous tissue, too)
Glucagon

- A single-chain polypeptide with MW 3485, composed of 29 aa residues
- Produced by the α-cells as pre-proglucagon and proglucagon (37aa) which is hydrolyzed by proteases to generate the active glucagon
- Secretion is increased by Ca2+ and arginine
  - inhibited by glucose and somatostatin

\[
\text{NH}_2\text{Hs-Sr-Gly-Thre-Ph-Thre-Ser-Asp-Ty}r\text{Ser-Iys-Tyre}d\text{Asp} \\
1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9\ 10\ 11 \\
\text{-Sr-Arg-Arg-Ala-Asp-He-Vl-Ch-Try-Leu-Mt-Asn-Th-CO}H \\
16\ 17\ 18\ 19\ 20\ 21\ 22\ 23\ 24\ 25\ 26\ 27
Glucagon Mechanism of Action

- **Targets:** liver, fat tissue, muscle

- Binds to the membrane receptors, activates the adenylate cyclase, increase the cAMP that stimulates
  - the mobilization of glycogen in the liver and muscles and
  - triglycerides in the fat tissue.

Thus the concentration of glucose↑, glycerol↑, fatty acids ↑ The catabolism of FA produce a large amount of acetyl-CoA and ketone bodies (ketonemia, ketonuria)

- In the liver it inhibits the protein synthesis and facilitates the protein breakdown. The aa ↑ are used in
  - urea production and
  - gluconeogenesis → glucose ↑
Insulin

Secreted by β-cells as **preproinsulin** a single-chain polypeptide
this is hydrolyzed and generates the proinsulin (84 aa);
this is cleaved into **peptide-C** (33 aa) and **insulin** (51 aa) with MW about 6000
The secretion is increased by glucose and Ca$^{2+}$, asparagine and leucine
Composed of 2 polypeptide chains

- **A-chain** of 21 aa, that presents a disulphide bond (-S-S-) between Cys in position 6 and Cys in position 11 and C-terminal asparagine, essential for the biological activity

- **B-chain** of 30 aa linked through disulphide (-S-S-) bridges between:
  - Cys in position 7 on A-chain and 7 on B-chain
  - Cys in position 20 on A-chain and 19 on B-chain
Insulin Mechanism of Action

Insulin exists as:
- free insulin - influences all the insulin-sensitive tissues (muscles, connective tissue, including fat tissue) and
- bound to plasma proteins – influences only fat tissue;
- less sensitive is the liver; not sensitive is the nervous tissue

Insulin binds to membrane receptor (a glycoprotein)
The insulin-receptor complex changes the permeability of the membrane for the glucose, aminoacids, Ca$^{2+}$, K$^+$, Na$^+$, accelerating their transport into the cell.

Peptide second messenger(s) activate cAMP-phospho-diesterase, decreasing cAMP; this inhibits the glycogenolysis, gluconeogenesis, lipolysis, ketogenesis

A lower cAMP/cGMP ratio facilitates the glycogenogenesis, lipogenesis, protein synthesis

Through cGMP and Ca$^{2+}$, accelerates the DNA synthesis (replication) and RNA (transcription), favoring the proliferation, growth and differentiation of cells

The result is an anabolic action with a positive nitrogen balance:
- In blood: Glucose↓, FA↓, glycerol↓, aminoacids↓, K$^+$↓
- In urine: aminoacids↓, K$^+$↓,
DISTURBANCES OF ENDOCRINE PANCREAS

Excessive insulin in insulinoma (tumors with β-cells) or in overdose in insulin therapy $\rightarrow$ **Hypoglycemia** $\rightarrow$ syncopal states, convulsions, fatal outcome

Deficient insulin $\rightarrow$ diabetes mellitus:
- **Hyperglycemia** $(G \uparrow)$, glycosuria
- FA, glycerol, cholesterol $\uparrow$ in blood
- Aminoacids $\uparrow$ in blood and urine
- Ketone bodies $\uparrow$ in blood and urine $\rightarrow$ acidosis $\rightarrow$ fatal outcome
Practical application of insulin:

- Treatment of diabetes mellitus
- Anabolic stimulators in dystrophy of organs, malnutrition, starvation
- Restoration of metabolism after heavy muscular work
Somatostatin

- Polypeptide hormone
- Inhibits the secretion of insulin and glucagon
- It is secreted also by the hypothalamus and certain intestinal cells
HORMONES OF ADRENAL GLANDS

ADRENAL MEDULLA produces and stores into chromaffin cells
- Adrenalin / epinephrin
- Noradrenalin / norepinephrin

Adrenalin secretion is influenced by
- hypoglycemia
- stress (physiologic activity of the organism increases faster than the adaptive responses)

Effect on adrenoreceptors
- $\alpha \rightarrow$ stimulates the guanidino cyclase $\rightarrow$ cGMP
- $\beta \rightarrow$ stimulates the adenylate cyclase $\rightarrow$ cAMP

cAMP has a similar effect as glucagon on the liver, muscle, fat tissue

Affects the function of cardiovascular system (amplitude and frequency of heart contraction $\uparrow$, blood pressure $\uparrow$) relaxes smooth muscles of the intestine, bronchi, uterus.
Adrenaline (epinephrine)

Noradrenaline (norepinephrine)

Metanephrine

Normetanephrine

3-methoxy-4-hydroximandelic acid
vanylmandelic acid
ADRENAL CORTEX produces steroid hormones (corticosteroids) subdivided in:
- Glucocorticosteroids – affecting the carbohydrate metabolism
  - hydrocortisone
  - corticosterone
- Mineralocorticosteroids - affecting the mineral metabolism
  - aldosterone
- Sex hormones (androgens, estrogens) in small amounts
Glucocorticoids: hydrocortisone, corticosterone

Controlled by corticotropin released from the pituitary gland as a response to stress; it is bound to the adrenocortical cell membrane, stimulates the production of cAMP, triggering the delivery of cholesterol esters for the synthesis of glucocorticoids; they inhibit the corticotropin (negative feed-back mechanism)

Mechanism of action:
- Transported in the plasma by transcortin (protein)
- Targets: liver, kidney, lymphoid tissue (spleen, lymph nodes, lymphoid plaques in the intestin, lymphocytes, thymus), connective tissue (bones, subcutaneous tissue, adipose tissue) muscle

Result:
- In the blood: glucose, fatty acids, glycerol, aminoacids, ketone bodies↑
- In urine: glucose, aminoacids, ketone bodies↑
- In the kidneys: ↑ Na+ reabsorption, K+ excretion;
- Na and H₂O are retained in extracellular space (edema)
- In bones: ↓ protein synthesis, deossification, Ca and P → blood → urine
Glucocorticosteroids

11-dehidrocorticosterona
11-dezoxicorticosteron
Dexamethasone (DOC)
Glucocorticosteroids
Mineralocorticoids

- **Aldosterone** secretion is controlled by
  - $\text{Na}^+$ and $\text{K}^+$ (stimulated by low $\text{Na}^+$ and high $\text{K}^+$ concentration)
- It is believed that the epiphysis produces
  - a tropic hormone = adrenoglomerulotropin that stimulates the secretion

**Mechanism of action:**
- Transported in the blood $\rightarrow$ tissue using plasma albumins
- Target: epithelial cells of the distal tubules of the kidney
- Bound to receptor, the complex penetrates the nucleus activating the transcription of the genes that carry information referring to a protein involved in the transport of $\text{Na}^+$ across the membrane of tubular epithelium:
  - ↑ reabsorption of $\text{Na}^+$, $\text{Cl}^-$ and water from the urine to the intercellular fluid and to the blood and
  - ↑ excretion of $\text{K}^+$ in the urine
DISTURBANCES OF ADRENAL GLANDS

Hyperfunction = hypercorticoidism

- Cushing's disease (hypersecretion of corticotropin)
  - “steroid” diabetes,
  - atrophy of subcutaneous connective tissue
  - osteoporosis
  - hypertension (due to secondary increase of adrenalin and noradrenalin)

- Hyperaldosteronism (Konn's disease)
  - Edema, high blood pressure, myocardial hyperexcitability

Hypofunction = hypocorticoidism = Addison's disease

- Glucocorticoid deficiency: reduced resistance to emotional stress and infections, chemical, mechanical factors; it determines hypoglycemia

- Aldosterone deficiency: disturbed water-salt imbalance - loss of Na+, H2O and accumulation of K+ → hypotension, myastenia, progressive fatigability, low muscular excitability
Practical use of corticosteroids

- Treatment of allergic and autoimmune diseases: rheumatism, collagenoses, nonspecific arthrites, bronchial asthma, dermatoses
- Desensitizing
- Antiinflammatory
- Immunodepressive agents (prophylaxis of rejection of transplanted organs)
SEX HORMONES

Sex glands:
in male testes or in female ovaries produce
  • sex cells: spermatozoa and respectively ova
  • sex hormones: androgens, estrogens and gestagens

In mature male
  • FSH controls spermatogenesis
  • LH controls the production of androgens (testosterone)

In female
  • Follicle cells secrete estrogens (estradiol, estrone, estriol)
  • Corpus luteus produces gestagens (progesterone)

Placenta, formed during pregnancy, produces:
  • chorionic gonadotropin (lutropin activity),
  • placental lactogen (somatomammotropin),
  • thyrotropin,
  • sex hormones.
Estrogens ensure the normal:

- development of genital organs
- formation of secondary sex characteristics in puberty (hair growth, laringeal cartilage, vocal apparatus, mammary glands, skeleton)
- regulation of endometrial proliferation, contraction of fallopian tubes and uterus in follicular phase of the ovarian cycle
- formation of sexual instinct and physic status of female
- gestation, lactation, development of mammary glands in pregnancy and parturition
FEMALE SEX HORMONES

**Progesterone** acts during the luteal phase of ovarian cycle:

- contractile inhibition of uterus and fallopian tubes
- pre-pregnancy changes of endometrium during sex cycles and implantation of fertilized ovum
- growth of milk ducts and lactation
- reduction of excitability of the hippocampus and heat center and sexual reactivity
Female sex hormones deficiency

In prepuberal period deficiency of estrogens determine:
- retardation of development of genital organs
- delayed formation of secondary sex characteristics
- late ossification of epiphyseal cartilage
- disturbance of sex cycle
- negative nitrogen balance, loss of calcium phosphate, hyperlipidemia

In adult the deficient progesterone determines:
- disturbances of ovarian cycle,
- habitual abortion
Practical application of female sex hormones

- Restoration of sex cycles disturbances
- Treatment of ovary insufficiency
- Pregnancy preservation (progesterone)
Male sex hormones

- Anabolic action
- Development of skeleton, muscles,
- Development of male genitals and accessory sex glands (prostate, seminal vesicles)
- Development of secondary male sex characteristics (hair, larynx, vocal apparatus) during puberty
- Activate spermatogenesis (with follitropin)
- Cerebral development, behavior, male character
Deficiency of male sex hormones

- Genital underdevelopment
- Failure to develop secondary sex characters
- Absence of libido
- Retardation of ossification, atrophy of muscles
- Excessive fat tissue
- Disturbed cortical inhibitory processes
Practical applications of male sex hormones

Treatment of

- Seminal hypofunction, disturbed sex differentiation, functional sexual disturbances
- Dystrophies, diabetes mellitus, thyrotoxicosis, steroid diabetes
- Stimulate growth and physical development in children
- Stimulate consolidation of fractured bone