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THE MODERN CONCEPT OF MORPHOLOGICAL AND FUNCTIONAL FEATURES OF THE ENDOCRINE GLANDS

Lecture is the important link of submission of theoretical material. Lecture on the endocrine system in the course of histology introduces students to new insights on the morphological and functional features of the endocrine glands and their hormonal activity and the effect on the body. The endocrine system, along with the nervous and immune system, is among the regulatory and integrating systems of the body. It controls the regulation of the body's most important functions: growth, reproduction, proliferation and differentiation of cells, metabolism and energy, secretion, excretion, absorption, and other behavioral reactions. In general, the function of the endocrine system is defined as the maintenance of homeostasis.

Key words: endocrine glands, hormones.

Lecture in higher education is the lead part of course of study. It is a method of presentation of the bulk theoretical material [0].

Lecture on the features of the histological structure of the endocrine system is designed to give students basic concepts about the structure of the endocrine glands and the hormones that they produce, and their effect on the human body.

The endocrine system is very closely associated with the nervous system and is much like the nervous system in some ways. The endocrine system produces various secretions called hormones [Gr. hormaein, to excite, to set in motion] that serve as effectors to regulate the activities of various cells, tissues, and organs in the body. Its functions are essential in maintaining homeostasis and coordinating body growth and development and are similar to that of the nervous system: both communicate information to peripheral cells and organs. Communication in the nervous system is through transmission of neural impulses along nerve cell processes and the discharge of neurotransmitter. Communication in the endocrine system is through hormones, which are carried to their destination via connective tissue spaces and the vascular system. These two systems are functionally interrelated [10].

The endocrine system includes (1) endocrine glands, such as the pituitary gland, thyroid and parathyroid glands, adrenal glands, and the pineal gland; (2) clusters of endocrine cells located in the organs such as islets of Langerhans in the pancreas; and (3) isolated endocrine cells in certain tissues, such as the enteroendocrine cells in the epithelium of the respiratory and digestive tracts [0].

Endocrine glands are aggregates of epithelioid cells (epithelial cells that lack free surface) that are embedded within connective tissue. Despite the fact that the endocrine glands vary in size, shape, and location in the body, they still have several common characteristics. Endocrine glands do not possess excretory ducts; therefore, their secretion is discharged into the extracellular matrix of connective tissue usually near the capillaries. From there, the secretory products (i.e., hormones) are transported into the lumen of the blood (or lymphatic) vessels for body-wide distribution. These secretory products influence target organs or tissues at some distance from the gland. For this reason, endocrine glands are well vascularized and surrounded by rich vascular networks. The exception is the placenta, where hormones produced by the syncytiotrophoblast pass directly into the maternal blood surrounding the placental villi [10, 2].

Endocrine system is classifying under following basic components: I. Central regulatory formation of endocrine system: 1. Hypothalamus. 2. Pituitary gland. 3.Pineal gland II. Peripheral endocrine glands: 1. Thyroid gland. 2.Parathyroid gland. 3.Adrenal glands: a) cortex, b) medulla, III. Organs, having both endocrine and non-endocrine functions: 1. Gonads: a) testis, b) ovary. 2. Placenta. 3. Pancreas IV. Solitary hormone producing cells: 1.APUD-cells (of nervous origin). 2. Solitary hormone producing cells (not of nervous origin) [2].

Endocrine secretions (hormones) are delivered through the capillary network of the vascular system to the target organs rather than through a series of ducts as in the exocrine system. The timing of hormone release is controlled by the hypothalamus. The hypothalamus acts as a command center, controlling the activity of the pituitary gland. The pituitary gland functions as a master gland, releasing hormones to control other endocrine glands and organs. The organs or tissues that are activated by released hormones are called target organs or tissues. The cells in the target organ/tissue have appropriate receptors, which are able to recognize and respond to specific hormones [0].

In the classic definition, a hormone is a secretory product of endocrine cells and organs that passes into the circulatory system (bloodstream) for transport to target cells. For years, this endocrine control of target tissues became a central part of endocrinology. However, a variety of hormones and

hormonally active substances are not always discharged into the bloodstream but are released into connective tissue spaces. They may act on adjacent cells or diff use to nearby target cells that express specific receptors for that particular hormone. This type of hormonal action is referred to as paracrine control. In addition, some cells express receptors for hormones that they secrete. This type of hormonal action is referred to as autocrine control. These hormones regulate the cell's own activity [0, 11, 2]. Cells of the endocrine system release more than 100 hormones and hormonally active substances that are chemically divided into three classes of compounds: 1) Peptides (small peptides, polypeptides, and proteins) form the largest group of hormones. They are synthesized and secreted by cells of the hypothalamus, pituitary gland, thyroid gland, parathyroid gland, pancreas, and scattered enteroendocrine cells of the gastrointestinal tract and respiratory system. This group of hormones (insulin, glucagon, growth hormone (GH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), antidiuretic hormone (ADH), oxytocin, interleukins, and various growth factors), when released into the circulation, dissolve readily in the blood and generally do not require special transport proteins. 2) Steroids, cholesterol-derived compounds, are synthesized and secreted by cells of the ovaries, testes, and adrenal cortex. These hormones (gonadal and adrenocortical steroids) are released into the bloodstream and transported to target cells with the help of plasma proteins or specialized carrier proteins such as androgen-binding protein. Hormone-binding carrier proteins protect the hormone from degradation during transport to the target tissue. 3) Amino acids and arachidonic acid analogs, and their derivatives, including the catecholamines (norepinephrine and epinephrine–phenylalanine/tyrosine derivatives) and prostaglandins, prostacyclins, and leukotrienes (arachidonic acid derivatives), are synthesized and secreted by many neurons as well as a variety of cells, including cells of the adrenal medulla. Also included in this group of compounds are thyroid hormones, the iodinated derivatives of the amino acid tyrosine that are synthesized and secreted by the thyroid gland. When released into the circulation, catecholamines dissolve readily in the blood, in contrast to thyroid hormones, the majority of which are bound to three carrier proteins: a specialized thyroxine-binding globulin (TBG), prealbumin fraction of serum proteins (transthyretin), and a nonspecific fraction of albumins [10, 11].

Regulation of hormonal function is controlled by feedback mechanisms. Hormonal production is often controlled through feedback mechanisms from the target organ. In general, feedback occurs when the response to a stimulus (action of a hormone) has an effect on the original stimulus (hormone-secreting cell). Two types of feedback are recognized: negative feedback occurs when the response diminishes the original stimulus and is much more common than positive feedback, which occurs when the response enhances the original stimulus [2].

The pituitary gland and the hypothalamus, the portion of the brain to which the pituitary gland is attached, are morphologically and functionally linked in the endocrine and neuroendocrine control of other endocrine glands. Because they play central roles in a number of regulatory feedback systems, they are often called the master organs of the endocrine system. In the past, the control of pituitary hormone secretion by the hypothalamus was classically regarded as the major function of the neuroendocrine system. However, the field of neuroendocrinology today has expanded to encompass multiple reciprocal interactions between the central nervous system (CNS), autonomic nervous system (ANS), endocrine system, and immune system in the regulation of homeostasis and behavioral responses to environmental stimuli [10].

The hypothalamus is a portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland (hypophysis). The neurons in the periventricular area called parvocellular neurosecretory cells synthesize and secrete certain neurohormones (releasing hormones or hypothalamic hormones) and these in turn stimulate or inhibit the secretion of anterior pituitary hormones [0]. The neurosecretory cells of anterior part of hypothalamus form the paraventricular nucleus and the supraoptic nucleus. The cells of the supraoptic nucleus synthesize vasopressin (the antidiuretic hormone or ADH). This hormone controls reabsorption of water by kidney tubules. The cells of paraventricular nucleus produce oxytocin which controls the contraction of smooth muscle of the uterus and also of the mammary gland [0, 2].

The pituitary gland is a neuroendocrine organ located inside the skull and considered a part of the brain. It consists of two divisions: the adenohypophysis (anterior lobe) and the neurohypophysis (posterior lobe). The pituitary gland produces various types of hormones that act on many target organs, many of which also secrete hormones.

The adenohypophysis, also called the anterior pituitary, is the anterior division of the gland and is derived from the ectoderm of the roof of the developing oral cavity (Rathke pouch). It is composed of glandular tissue. The adenohypophysis can be divided into three regions based on their anatomic positions: the pars distalis, pars tuberalis, and pars intermedia.

The pars distalis is the main body of the adenohypophysis, containing blood vessels, a capillary network, and two main types of secretory cells supported by a network of reticular connective tissues. These secretory cells are classified as chromophobes and chromophils. The chromophobes do not effectively take a stain, so they appear clear in the Mallory trichrome stain. These cells are undifferentiated cells but are capable of differentiating into chromophils [11, 2]. The chromophils include basophils and acidophils. Basophils appear blue in Mallory stain and include three subtypes of hormone secretory cells: corticotrophs, thyrotrophs, and gonadotrophs. Various hormones are produced by these cells, including adrenocorticotropic hormone (ACTH), thyroid-stimulating (thyrotropic) hormone (TSH; thyrotropin), follicle-stimulating hormone (FSH), and luteinizing hormone (LH). These hormones stimulate various target organs including the cortex of the adrenal glands, the thyroid, the testes, and the ovaries. The secretion of hormones by cells in the adenohypophysis is controlled by hypothalamic releasing hormones and inhibitory hormones. Acidophils appear red in Mallory stain and contain two subtypes of hormone secretory cells: somatotrophs and mammotrophs. Somatotrophs secrete somatotropin (growth hormone), which stimulates the liver to produce the insulin-like growth factor (IGF-1) that promotes cartilage and bone growth, protein deposition, and cell reproduction. Mammotrophs secrete prolactin, which increases mammary gland size and promotes milk production [2, 0].

The pars tuberalis is the neck of the adenohypophysis; it wraps around the infundibular stalk of the pituitary gland. It contains a rich capillary network and some low columnar basophilic cells that are commonly arranged in cords.

The pars intermedia is located between the pars distalis and pars nervosa. It contains cuboidal follicular cells and colloid cysts called Rathke cysts, which are lined by follicular cells. The function of the pars intermedia cells in humans remains unclear. In frogs, the basophils produce melanocytestimulating hormones (MSH), which stimulates pigment production in melanocytes and pigment dispersion in melanophores. In humans, MSH is not a distinct, functional hormone. Because MSH is found in the human pars intermedia in small amounts, the basophils of the pars intermedia are assumed to be corticotropes [10].

The neurohypophysis is derived from the inferior surface of the developing diencephalon. It is considered to be nervous tissue. It can be divided into the infundibular stalk, the median eminence, and the pars nervosa. The infundibular stalk connects the median eminence to the pars nervosa. The median eminence connects the inferior portion of the hypothalamus to the infundibular stalk of the neurohypophysis. It contains long axons that carry antidiuretic hormone and oxytocin hormone produced by nuclei in the hypothalamus. These axons pass through the median eminence and terminate in the pars nervosa. The median eminence also contains short axons and axon terminal endings from the hypothalamus that release neurosecretory hormones (hypothalamic releasing and inhibiting hormones). These hormones are transported through the hypophyseal portal system from the primary capillary plexus to the secondary capillary plexus, thereby regulating the secretion of the secretory cells in the adenohypophysis. The pars nervosa is the main body of the neurohypophysis. It contains a fenestrated capillary plexus, pituicytes (glial cells), and axons and axon terminal endings from neuron cell bodies in the hypothalamus. Pituicytes provide support and nutrition to the axons of the neurons. The enlarged axon terminal endings are filled with neurosecretory granules that are called Herring bodies. The neurosecretory hormones released in the pars nervosa include vasopressin, oxytocin hormone [0, 11].

The pineal gland (pineal body, epiphysis cerebri) is an endocrine or neuroendocrine gland that regulates daily body rhythm. It develops from neuroectoderm of the posterior portion of the roof of the diencephalon and remains attached to the brain by a short stalk. In humans, it is located at the posterior wall of the third ventricle near the center of the brain. The pineal gland is a flattened, pine cone–shaped structure, hence its name. The pineal gland contains two types of parenchymal cells: pinealocytes and interstitial (glial) cells. Pinealocytes are the chief cells of the pineal gland. They are arranged in clumps or cords within lobules formed by connective tissue septa that extend into the gland from the pia mater

that covers its surface. These cells have a large, deeply infolded nucleus with one or more prominent nucleoli and contain lipid droplets within their cytoplasm. The interstitial (glial) cells constitute about 5% of the cells in the gland. They have staining and ultrastructural features that closely resemble those of astrocytes and are reminiscent of the pituicytes of the posterior lobe of the pituitary gland. In addition to the two cell types, the human pineal gland is characterized by the presence of calcified concretions, called corpora arenacea or brain sand. These concretions appear to be derived from precipitation of calcium phosphates and carbonates on carrier proteins that are released into the cytoplasm when the pineal secretions are exocytosed. The concretions are recognizable in childhood and increase in number with age [2].

The pineal gland is a photosensitive organ and an important timekeeper and regulator of the day/night cycle (circadian rhythm). It obtains information about light and dark cycles from the retina via the retinohypothalamic tract, which connects in the suprachiasmatic nucleus with sympathetic neural tracts traveling into the pineal gland. During the day, light impulses inhibit the production of the major pineal gland hormone, melatonin. Melatonin is released in the dark and regulates reproductive function in mammals by inhibiting the steroidogenic activity of the gonads. In addition to melatonin, extracts of pineal glands from many animals contain numerous neurotransmitters, such as serotonin, norepinephrine, dopamine, and histamine, and hypothalamic-regulating hormones, such as somatostatin [2].

The thyroid gland is a bilobate endocrine gland located in the anterior neck region and consists of two large lateral lobes connected by an isthmus, a thin band of thyroid tissue. The thyroid gland is covered by a fibrous capsule. Septa extending into the gland from the capsule divide it into lobules. On microscopic examination each lobule is seen to be made up of an aggregation of follicles. Each follicle is lined by follicular cells, that rest on a basement membrane. The follicle has a cavity which is filled by a homogeneous material called colloid. The spaces between the follicles are filled by a stroma made up of connective tissue in which there are numerous capillaries and lymphatics. The capillaries lie in close contact with the walls of follicles. A part from follicular cells the thyroid gland contains C-cells (or parafollicular cells) which intervene (here and there) between the follicular cells and the basement membrane. They may also lie in the intervals between the follicles. Connective tissue stroma surrounding the follicles contain a dense capillary plexus, lymphatic capillaries and sympathetic nerves [3, 0].

The follicular cells vary in shape depending on the level of their activity. Normally (at an average level of activity) the cells are cuboidal, and the colloid in the follicles is moderate in amount. When inactive (or resting) the cells are flat (squamous) and the follicles are distended with abundant colloid. When the cells are highly active they become columnar and colloid is scanty [2].

With the electronic microscope a follicular cell shows the presence of apical microvilli, abundant granular endoplasmic reticulum, and a prominent supranuclear Golgi complex. Lysosomes, microtubules and microfilaments are also present. The apical part of the cell contains many secretory vacuoles [11].

The activity of follicular cells is influenced by the thyroid stimulating hormone (TSH or thyrotropin) produced by the hypophysis cerebri. There is some evidence to indicate that their activity may also be increased by sympathetic stimulation.

The follicular cells secrete two hormones that influence the rate of metabolism. Iodine is an essential constituent of these hormones. One hormone containing three atoms of iodine in each molecule is called triodothyronine or T3. The second hormone containing four atoms of iodine in each molecule is called tetraiodothyronine, T4, or thyroxine. T3 is much more active than T4.

The synthesis of the two major thyroid hormones, thyroxine and triiodothyronine, takes place in the thyroid follicle in a series of discrete steps: 1. Synthesis of thyroglobulin. Thyroglobulin (a glycoprotein) is synthesized by granular endoplasmic reticulum and is packed into secretory vacuoles in the Golgi complex. 2. Resorption, diffusion, and oxidation of iodide. Follicular epithelial cells actively transport iodide from the blood into their cytoplasm using ATPase-dependent sodium/iodide symporters (NIS). Iodide ions then diffuse rapidly toward the apical cell membrane. From here, iodide ions are transported to the lumen of the follicle. Iodide is then immediately oxidized to iodine, the active form of iodide. 3. Iodination of thyroglobulin. One or two iodine atoms are then added to the specific tyrosine residues of thyroglobulin. This process occurs in the colloid at the microvillar surface of the follicular cells and is catalyzed by thyroid peroxidase (TPO). Addition of one iodine atom to a single tyrosine residue forms monoiodotyrosine (MIT). Addition of a second iodine atom to the MIT residue forms a diiodotyrosine (DIT) residue. 4. Formation of T3 and T4 by oxidative coupling reactions. The thyroid hormones are formed by oxidative coupling reactions of two iodinated tyrosine residues in close proximity. After iodination, T4 and T3 as well as the DIT and MIT residues that are still linked to a

thyroglobulin molecule are stored as the colloid within the lumen of the follicle. 5. Resorption of colloid. In response to TSH, follicular cells take up thyroglobulin from the colloid by a process of receptor-mediated endocytosis. After endocytosis, thyroglobulin follows at least two different intracellular pathways: 1) in the lysosomal pathway, thyroglobulin is internalized and transported within endocytotic vesicles to early endosomes; 2) in the transepithelial pathway, thyroglobulin is transported intact from the apical to the basolateral surface of follicular cells. 6. Release of T4 and T3 from follicular cells into the circulation [10].

C-cells (parafollicular Cells) are also called clear cells, or light cells. The cells are polyhedral, with oval eccentric nuclei. Typically, they lie between the follicular cells and their basement membrane. They may, however, lie between adjoining follicular cells; but they do not reach the lumen. With the electronic microscope the cells show well developed granular endoplasmic reticulum, Golgi complexes, numerous mitochondria, and membrane bound secretory granules. C-cells share features of the APUD cell system and are included in this system. C-cells secrete the hormone thyro-calcitonin. This hormone has an action opposite to that of the parathyroid hormone on calcium metabolism. This hormone comes into play when serum calcium level is high. It tends to lower the calcium level by suppressing release of calcium ions from bone. This is achieved by suppressing bone resorption by osteoclasts [0, 0].

The parathyroid glands are small endocrine glands closely associated with the thyroid. They are ovoid, a few millimeters in diameter, and arranged in two pairs, constituting the superior and inferior parathyroid glands. They are usually located in the connective tissue on the posterior surface of the lateral lobes of the thyroid gland. The parathyroid glands are derived from the pharyngeal pouches (the superior glands from the fourth pouch and the inferior glands from the third pouch). Each parathyroid gland is contained within a capsule which sends septa into the gland, where they merge with reticular fibers that support elongated cordlike clusters of secretory cells. With increasing age many secretory cells are replaced with adipocytes, which may constitute more than 50% of the gland in older people. Two types of cells are present in parathyroid glands: chief (or principal) cells and oxyphil cells. The chief cells are small polygonal cells with round nuclei and pale-staining, slightly acidophilic cytoplasm. Ultrastructurally the cytoplasm is seen to be filled with irregularly shaped granules 200–400 nm in diameter. These are secretory granules containing the polypeptide parathyroid hormone (PTH), a major regulator of blood calcium levels. Much smaller, often clustered, populations of oxyphil cells are sometimes present, more commonly in older individuals. These are much larger than the principal cells and are characterized by acidophilic cytoplasm filled with abnormally shaped mitochondria. Some oxyphil cells show low levels of PTH synthesis, suggesting these cells are transitional derivatives from chief cells. Parathyroid hormone targets osteoblasts, which respond by producing an osteoclast-stimulating factor to increase the number and activity of osteoclasts. This promotes resorption of the calcified bone matrix and the release of Ca2+, increasing the concentration of Ca2+ in the blood, which suppresses parathyroid hormone production. Calcitonin from the thyroid gland inhibits osteoclast activity, lowering the blood Ca2+ concentration and promoting osteogenesis. Parathyroid hormone and calcitonin thus have opposing effects and constitute a dual mechanism to regulate blood levels of Ca2+, an important factor in homeostasis. Parathyroid hormone also indirectly increases the absorption of Ca2+ from the gastrointestinal tract by stimulating the synthesis of vitamin D, which is necessary for this absorption. In addition to increasing the concentration of Ca2+, parathyroid hormone reduces blood phosphate levels. This effect results from another target cell of parathyroid hormone, renal tubule cells, which reduce their absorption of phosphate and allow more phosphate excretion in urine [0, 10].

The adrenal (suprarenal) glands are paired organs that lie near the superior poles of the kidneys, embedded in the perirenal adipose tissue.

Embryologically, the cortical cells originate from mesodermal mesenchyme, whereas the medulla originates from neural crest cells that migrate into the developing gland.

Adrenal glands are each covered by a dense connective tissue capsule that sends thin septa to the interior of the gland as trabeculae. The stroma consists mainly of a rich network of reticular fibers that support the secretory cells. The gland consists of two concentric layers: a yellowish peripheral layer, the adrenal cortex, and a reddish-brown central layer, the adrenal medulla.

The suprarenal cortex is made up of cells arranged in cords. Sinusoids intervene between the cords. On the basis of the arrangement of its cells the cortex can be divided into three layers as follows: zona glomerulosa, zona fasciculate, zona reticularis.

The outermost layer is called the zona glomerulosa. Here the cells are arranged as inverted U-shaped formations, or acinus-like groups. The zona glomerulosa constitutes the outer one-fifth of the cortex. With the light microscope the cells of the zona glomerulosa are seen to be small, polyhedral or

columnar, with basophilic cytoplasm and deeply staining nuclei. The cells of the zona glomerulosa secrete the primary mineralocorticoid called aldosterone, a compound that functions in the regulation of sodium and potassium homeostasis and water balance. Aldosterone acts on the principal cells in the distal tubules of the nephron in the kidney, the gastric mucosa, and the salivary and sweat glands to stimulate resorption of sodium at these sites, as well as to stimulate excretion of potassium by the kidney. The secretion of hormones by the zona glomerulosa appears to be largely independent of the hypophysis cerebri [2].

The next zone is called the zona fasciculata. Here the cells are arranged in straight columns, two cell thick. Sinusoids intervene between the columns. This layer forms the middle three-fifths of the cortex. With the light microscope the cells of the zona fasciculata are seen to be large, polyhedral, with basophilic cytoplasm and vesicular nuclei. The cells of the zona fasciculata are very rich in lipids which can be demonstrated by suitable stains. The cells of the zona fasciculata produce the glucocorticoids - corticosterone and cortisol and small amounts of gonadocorticoids (adrenal androgens). Glucocorticoids get their name from their role in regulating gluconeogenesis (glucose synthesis) and glycogenesis (glycogen polymerization). Glucocorticoids have different, even opposite effects in different tissues: 1) in the liver, glucocorticoids stimulate conversion of amino acids to glucose, stimulate the polymerization of glucose to glycogen, and promote the uptake of amino acids and fatty acids; 2) in adipose tissue, glucocorticoids stimulate the breakdown of lipids to glycerol and free fatty acids; 3) in other tissues, they reduce the rate of glucose use and promote the oxidation of fatty acids; 4) in cells such as fibroblasts, they inhibit protein synthesis and even promote protein catabolism to provide amino acids for conversion to glucose in the liver [0, 10].

The innermost layer of the cortex (inner one-fifth) is called the zona reticularis. It is so called because it is made up of cords that branch and anastomose with each other to form a kind of reticulum. The cells in this layer are smaller and more acidophilic than in other two layer. With the light microscope the cells of the zona reticularis are seen to be similar to those of the zona fasciculata, but the lipid content is less. Their cytoplasm is often eosinophilic. The cells often contain brown pigment. The principal secretion of the cells in the zona reticularis consists of gonadocorticoids (adrenal androgens), mostly dehydroepiandrosterone (DHEA), dehydroepiandrosterone sulfate (DHEAS), and androstenedione. The cells also secrete some glucocorticoids but in much smaller amounts than those of the zona fasciculata. Here, too, the principal glucocorticoid secreted is cortisol. DHEA and DHEAS are less potent than androgens produced by the gonads, but they do have an effect on the development of secondary sex characteristics. In males, adrenal androgens have negligible importance because testosterone produced by the testis is a much more powerful androgen. However, in women adrenal androgens stimulate growth of axillary and pubic hair during puberty and adolescence. DHEA can be converted into androstenedione and then more potent androgens, such as testosterone and estrogens in peripheral tissues [10, 2].

The adrenal medulla is composed of large, pale-staining polyhedral cells arranged in cords or clumps and supported by a reticular fiber network. A profuse supply of sinusoidal capillaries intervenes between adjacent cords and a few parasympathetic ganglion cells are present. Medullary parenchymal cells, known as chromaffin cells, arise from neural crest cells, as do the postganglionic neurons of sympathetic and parasympathetic ganglia. Chromaffin cells can be considered modified sympathetic postganglionic neurons, lacking axons and dendrites and specialized as secretory cells. These granules contain one or the other of the catecholamines, epinephrine or norepinephrine. Ultrastructurally the granules of epinephrine-secreting cells are less electron-dense and generally smaller than those of norepinephrine-secreting cells. The conversion of norepinephrine to epinephrine (adrenalin) occurs only in chromaffin cells of the adrenal medulla. About 80% of the catecholamine secreted from the adrenal is epinephrine. Medullary chromaffin cells are innervated by cholinergic endings of preganglionic sympathetic neurons. Epinephrine and norepinephrine are released to the blood in large quantities during intense emotional reactions, such as fright, and produce vasoconstriction, increased blood pressure, changes in heart rate, and metabolic effects such as elevated blood glucose. These effects facilitate various defensive reactions to the stressor (the fight-or-flight response). During normal activity, the adrenal medulla continuously secretes small quantities of the hormones [0, 11].

Conclusion

The endocrine system plays an important role in human organism. The endocrine system sends messages to control and regulate the metabolic activity of the body using chemical signals (hormones)

that are released by endocrine secretory cells and carried by the blood circulatory system. Regulation of hormonal function is controlled by feedback mechanisms from the target organs.

References

1. Artyuhina A. I. Kompetentnostno-orientirovannoe obuchenie v meditsinskom vuze: uchebno-metodicheskoe posobie / A. I. Artyuhina, N. A. Getman, M. G. Golubchikova [i dr.]; pod red. E.V. Lopanovoy // – Omsk : OOO «Poligraficheskiy tsentr KAN», -2012. – 198 s.
2. Afanasev Yu. I. Gistologiya / Yu. I. Afanasev, N.A. Yurina, E. F. Kotovskiy [i dr.] // – M.: GEOTAR-Media, -2012. – 800 s.
3. Bykov V. L. Chastnaya gistologiya cheloveka (kratkiy obzornyiy kurs) / V. L. Bykov // – SPb.: SOTIS, -1997. –300 s.
4. Byikov V. L. Gistologiya, tsitologiya i embriologiya: atlas: ucheb. posobie / V. L. Byikov, S.I. Yushkantseva. – M.: GEOTAR-Media, - 2012. – 296 s.
5. Ulumbekov E. G. Gistologiya / E. G. Ulumbekov, N.V. Boychuk, I.I. Islamov [i dr.] // – M.: GEOTAR-Media, -2002. – 672 s.
6. Bear M. F. Neuroscience: exploring the brain / M. F. Bear, B. W. Connors, M. A. Paradiso // – Philadelphia: Wolters Kluwer, -2016. – 528 p.
7. Dongmei C. Atlas of histology: with functional and clinical correlations / Cui. Dongmei // – Philadelphia: Lippincott williams and wilkins, - 2011. – 439 p.
8. Gartner L. P. Color atlas and text of histology / L. P. Gartner, J. L. Hiatt // –Philadelphia: Wolters Kluwer Health, -2014. – 525 p.
9. Junqueira L. C. Junqueira's Basic Histology: text and atlas / L. C. Junqueira, A. L. Mescher // – New York: McGraw-Hill Medical, -2010. – 467 p.
10. Ross Michael H. Histology: a text and atlas : with correlated cell and molecular biology / Michael H. Ross, Wojciech Pawlina // – Philadelphia: Wolters Kluwer Health,-2016. – 984 p.
11. Vasudeva Neelam Textbook of human histology with colour atlas and practical guide / Neelam Vasudeva, Sabita Mishra. – New Delhi: Jaypee Brothers Medical Publishers, - 2014. – 440 p.

Реферати

СУЧАСНІ УЯВЛЕННЯ ПРО СТРУКТУРНО-ФУНКЦІОНАЛЬНІ ОСОБЛИВОСТІ ЕНДОКРИННИХ ЗАЛОЗ

Якушко О.С.

Лекція - важлива ланка подачі теоретичного матеріалу. Лекція з ендокринної системи в курсі гістології знайомить студентів з новими поглядами на морфофункціональні особливості ендокринних залоз, їх гормональну активність і вплив на організм. Ендокринна система, поряд з нервовою та імунною, відноситься до числа регуляторно-інтегруючих систем організму. Під її контролем перебуває регуляція найважливіших функцій організму: росту, репродукції, розмноження і диференціювання клітин, обміну речовин і енергії, секреції, екскреції, всмоктування, поведінкових реакцій і інших. У цілому, функцію ендокринної системи можна визначити як підтримання гомеостазу організму.

Ключові слова: ендокринні залози, гормони.

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СОВРЕМЕННЫЕ ПРЕДСТАВЛЕНИЯ О МОРФО-ФУНКЦИОНАЛЬНЫХ ОСОБЕННОСТЯХ ЭНДОКРИННЫХ ЖЕЛЕЗ

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Лекция - важное звено подачи теоретического материала. Лекция по эндокринной системе в курсе гистологии знакомит студентов с новыми взглядами на морфофункциональные особенности эндокринных желез, их гормональную активность и влияние на организм. Эндокринная система, наряду с нервной и иммунной, относится к числу регуляторно-интегрирующих систем организма. В ее ведении находится регуляция важнейших функций организма: роста, репродукции, размножения и дифференцировки клеток, обмена веществ и энергии, секреции, экскреции, всасывания, поведенческих реакций и других. В целом, функция эндокринной системы можно определить как поддержание гомеостаза организма.

Ключевые слова: эндокринные железы, гормоны.