FUNDAMENTALS OF BIOCHEMISTRY

Topic: Animal Harmones

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References:

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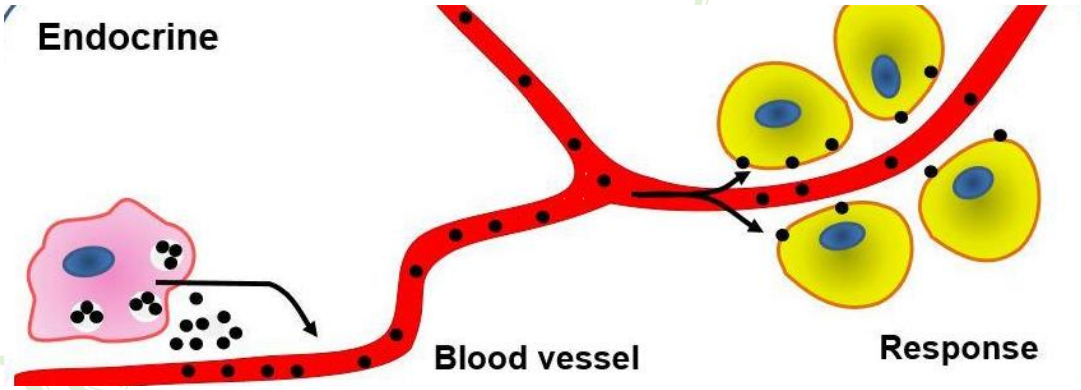
In endocrine signaling , the signaling molecules are synthesized and secreted by endocrine cells, transported through the circulatory system or the tissue fluid of the organism and finally act on target cells distant from their site of synthesis. Endocrine signals are called hormones.

The target cells have receptors for binding specific hormones and thereby "pull" the appropriate hormones from the extracellular fluid. Endocrine hormones, for example, insulin and epinephrine, are synthesized and released in the bloodstream by specialized ductless endocrine glands.

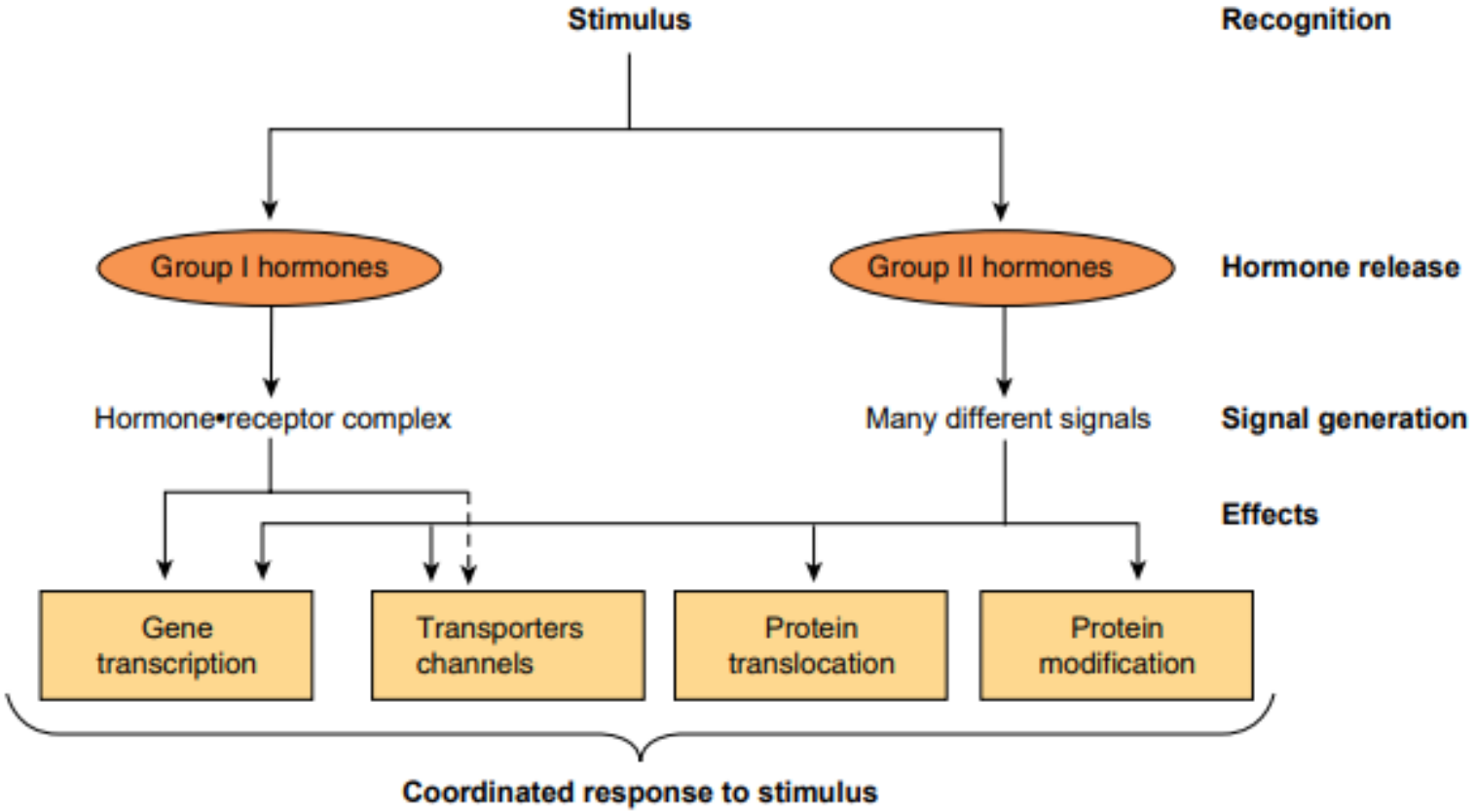
Endocrine signaling : Signaling molecules are synthesized and secreted by endocrine cells, transported through the circulatory system or the tissue fluid of the organism and finally act on target cells distant from their site of synthesis



Hormone

- Hormone: The term hormone is derived from the Greek word ‘horman' which means ‘to excite' or ‘to activate'.
- Hormones are chemical signalling molecules in animals.
- Endocrine system consists of specialized glands known as endocrine glands which on stimulation secrete hormones into the blood stream.
- A hormone is a chemical messenger which is released by one or more cells that affects cells in other parts of the organism.
- Most hormones initiate a cellular response by initially combining with either a specific intracellular or cell membrane associated receptor protein.
- A cell may have several different receptors that recognize the same hormone and activate different signal transduction pathways, or alternatively different hormones and their receptors may invoke the same biochemical pathway.
- For example, insulin is a hormone that is made by the beta cells in the pancreas. When it's released into the blood, insulin helps to regulate glucose level in the body for energy.

Hormone



Hormone

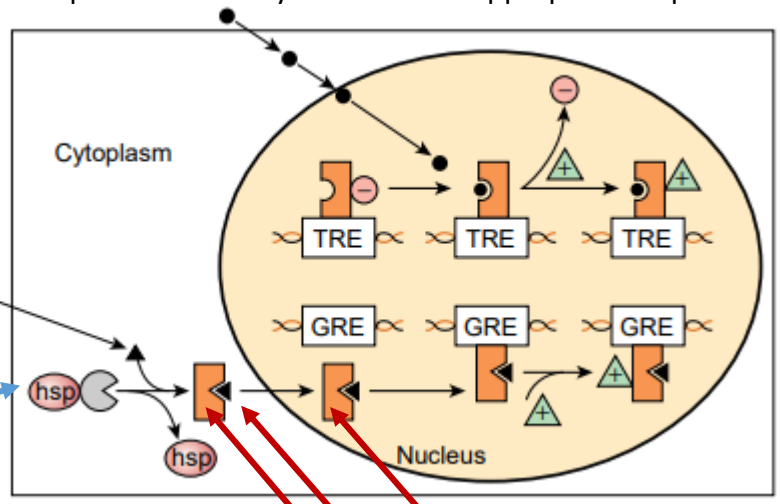
Biochemical nature of hormones: Hormones may belong to different biochemical nature. Accordingly, they are classified as:

- Peptide hormone
- Steroid hormone
- Monoamines

- **1. Peptide hormone:** Peptide hormone is a class of peptides which have endocrine functions and is secreted into the blood stream. Peptide hormones are synthesized in cells from amino acids.
- Numerous significant peptide hormones are secreted from the pituitary gland.
- Examples of peptide hormones are adrenocorticotrophic hormone (ACTH), growth hormone etc.
- Peptide hormones cannot pass through the plasma membrane of the cell.
- So the receptors for these hormones have to be on the plasma membranes of the peptide hormone sensitive cells.
- When contacted by hormone, these receptors activate a second messenger system i.e. a cascade of internal chemical signals that culminate in the secretion of the hormone into the bloodstream. These messengers enter the nucleus and influence gene expression

Hormone

Thyroid hormones and retinoic acid (•) directly enter the nucleus, where their cognate heterodimeric (TR-RXR;) receptors are already bound to the appropriate response elements with an associated transcription repressor complex



Glucocorticoid hormones

cognate receptor (GR)

glucocorticoid response element (GRE).

receptor-ligand complex

conformational change of the cognate receptor (GR)

Regulation of gene expression by two different class I hormones, thyroid hormone and glucocorticoids.

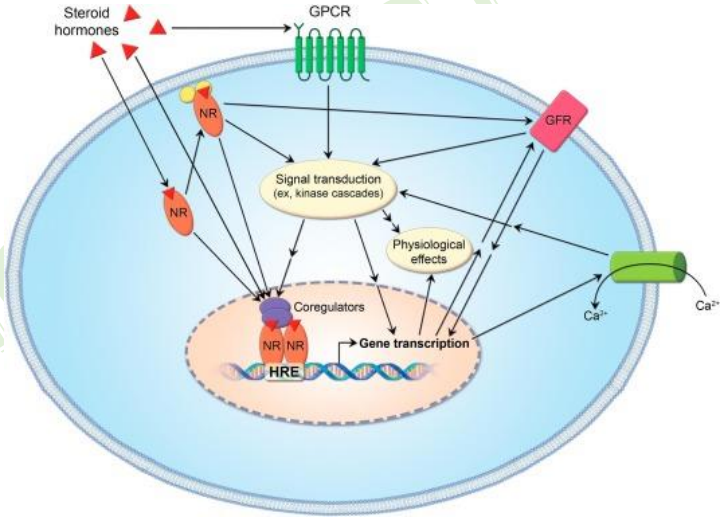
Steroid hormones readily gain access to the cytoplasmic compartment of target cells.

Hormone

Steroid hormone: Steroid hormones are derived from cholesterol and eicosanoids. They are lipid soluble. Examples of steroid hormones are testosterone and cortisol. The gonads and the adrenal cortex are the primary sources of steroid hormones.

Examples of eicosanoids are prostaglandins.

Steroid hormones being lipid soluble can diffuse through the plasma membrane of the cell very easily. The steroid hormone binds to its receptor in the cytoplasm and the activated hormone-receptor complex enters the nucleus influencing gene expression



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Monoamines: Monoamines are derived from the aromatic amino acids like tyrosine, tryptophan and phenylalanine by the action of aromatic amino acid decarboxylase enzymes. Examples of monoamines are epinephrine, norepinephrine etc.

Endrocrine system and function: The endocrine system consists of the system of glands. Each gland secretes different types of hormone directly into the bloodstream to regulate the body.

Hormones of the pituitary gland:

The pituitary is a small, pea-sized gland situated at the base of the brain. It sends signals to the thyroid and adrenal glands and the ovaries and testes, directing them to produce thyroid hormone, cortisol, estrogen, testosterone, and other hormones. These hormones have an effect on the metabolism, blood pressure, sexuality, reproduction and other essential functions of the body. In humans, the pituitary gland consists of three lobes:

- Anterior Lobe (Adenohypophysis)
- Posterior Lobe (Neurohypophysis)
- Intermediate lobe

1. Anterior Lobe : The anterior lobe contains six types of secretory cells. All of them secrete their hormone in response to hormones reaching them from the hypothalamus of the brain.The anterior pituitary gland secretes the following vital endocrine hormones:

(a) Thyroid stimulating hormone (TSH):

- Thyroid-stimulating hormone (thyrotropin) is a glycoprotein consisting of an alpha chain of 92 amino acids and a beta chain of 118 amino acids.
- TSH is synthesized and secreted by thyrotrope cells in the anterior pituitary gland.
- Thyroid stimulating hormone stimulates the thyroid gland to secrete the hormone thyroxine (T4).
- T4 is converted to triiodothyronine (T3), which is the active hormone that stimulates metabolism.
- The TSH receptor is found mainly on thyroid follicular cells. A deficiency of TSH causes hypo thyroidism.
- TSH deficiency has also been implicated as a cause of osteoporosis.

(b) Follicle -Stimulating Hormone (FSH):

- FSH is synthesized and secreted by gonadotrophs present in the anterior pituitary gland.
- FSH is a heterodimeric glycoprotein consisting of an alpha chain of 92 amino acids and a beta chain of 118 amino acids.
- FSH regulates the development, growth, pubertal maturation, and reproductive processes of the body.
- Increase in FSH secretion causes ovulation.
- In males, FSH (assisted by testosterone) acts on spermatogonia stimulating the production of sperm. In females, FSH (assisted by LH) acts on the follicle to stimulate it to release estrogens .

(c) Luteinizing hormone (LH):

- Luteinizing hormone is a hormone produced by gonadotroph cells in the anterior pituitary gland. It is also a heterodimeric glycoprotein consisting of 92-amino acid alpha chain and a beta chain of 121 amino acids.
- In females, an acute rise of luteinizing hormone triggers ovulation and development of the corpus luteum.
- LH levels are normally low during childhood and high after menopause. In males, LH stimulates the Leydig cell to produce testosterone.
- Low secretion of LH can result in hypogonadism. These conditions lead to hypothalamic suppression, Kallmann syndrome, Hyperprolactinemia etc.

(d) Prolactin:

- Prolactin is also known as luteotropic hormone. It is a protein which is made up of 198 amino acids.
- During pregnancy it helps in enlargement of the mammary glands of the breasts and prepare for the production of milk.
- After birth, prolactin promotes the synthesis of milk. Prolactin promotes neurogenesis in maternal and foetal brains.
- Prolactin has important cell cycle related functions as a growth factor, differentiating factor and anti-apoptotic factor.

(e) Growth Hormone (GH):

- Growth Hormone is also known as somatotropin. GH is a protein made up of 191 amino acids.
- The growth hormone-secreting cells are stimulated to produce and release ggrowth hormone by the intermittent arrival of growth hormone releasing hormone from the hypothalamus.
- Growth hormone stimulates growth, cell reproduction and regeneration in vertebrates.
- Hypo secretion of growth hormone produces a short body.
- It can also cause delayed sexual maturity. In adults, deficiency causes pituitary adenoma or other structural lesions or trauma and rarely idiopathic GHD.
- Hyper secretion of growth hormone leads to gigantism in childhood. In adults, it leads to acromegaly .

(f) Adrenocorticotropic hormone (ACTH):

- ACTH is also known as corticotrophin. ACTH is a peptide of 39 amino acids. It is an important component of the hypothalamic-pituitary-adrenal axis.
- ACTH acts on the cells of the adrenal cortex and stimulates them to produce glucocorticoids, mineralocorticoids, androgens and in foetus, dehydroepiandrosterone sulphate.
- Rapid actions of ACTH include stimulation of delivery of cholesterol to mitochondria where P450scc enzyme (Cholesterol side-chain cleavage enzyme) is located.
- Hyposecretion of ACTH in the pituitary leads to hypocorticism, Addison's disease. Hyper secretion of ACTH causes Cushing's disease.

2. Posterior Lobe :

The posterior pituitary comprises the posterior lobe of the pituitary gland. It consists mainly of axons extending from the supraoptic and paraventricular nuclei of the hypothalamus. Posterior lobe of the pituitary releases two hormones into the circulation, both synthesized in the hypothalamus.

(a) Vasopressin: Vasopressin is also known as arginine vasopressin , argipressin or antidiuretic hormone. Vasopressin is a peptide made up of 9 amino acids. Vasopressin acts on the collecting ducts of the kidney to facilitate the reabsorption of water into the blood and reduce the volume of urine formed. Deficiency of vasopressin leads to diabetes insipidus, a condition where there is excessive loss of urine and hypernatremia. High levels of vasopressin secretion may lead to hyponatremia.

(b) Oxytocin : Oxytocin is a mammalian hormone that acts mainly as a neuromodulator in the brain. Oxytocin is a peptide of 9 amino acids. Oxytocin is best known for its roles in sexual reproduction, in particular during and after childbirth. It acts on certain smooth muscles stimulating contractions of the uterus at the time of birth and release of milk when the baby begins to suckle.

3. Intermediate lobe:

The intermediate lobe of the pituitary secretes the melanocyte-stimulating hormone.

The melanocyte-stimulating hormone stimulates the production and release of melanin by melanocytes present in the skin and hair.