Al-Mustaqbal University

College of Medical and Health Techniques

Medical Laboratories Techniques Departments

Biochemistry Lectures for 2nd Year Students

(2 Credit Hrs. Theory + 2 Credit Hrs. Practice / Week = 3 Credit Unit

Academic Year: 2024 - 2025

Course Organizers:

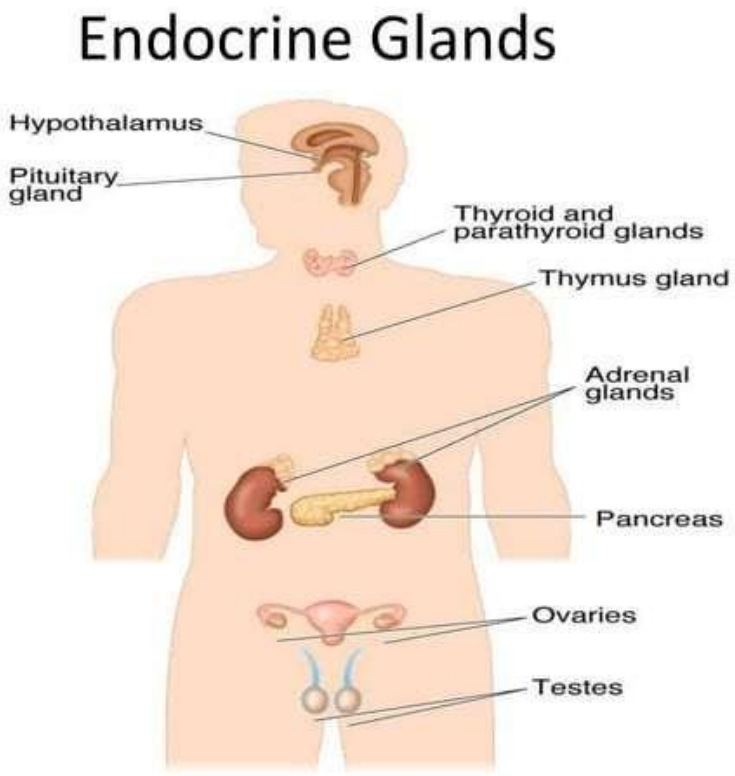
1. **Prof. Dr. Fadhil Jawad Al-Tu'ma, Ph.D., Professor of Clinical Biochemistry.**
2. **Assistant Prof. Dr. Ali M. A. Al-Kufaishi**
3. **Dr. Dalya Shakir Obaida, Ph.D. Lecturer of Clinical Biochemistry.**

Lecture No. 1

Date: Jan, 18th, 2025

Biochemistry of Hormones:

Hormones, Receptors, Target Cells and Regulation:



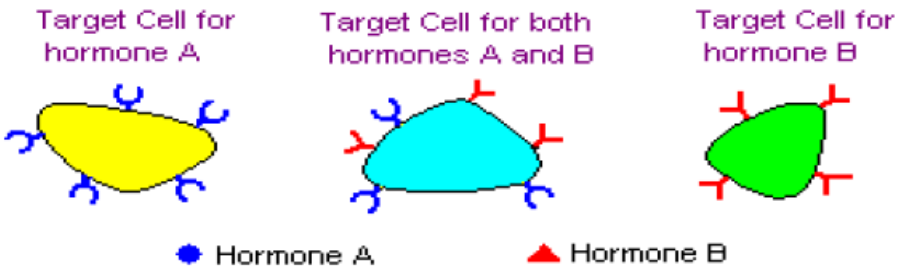
The endocrine system is one of the two coordinating and integrating systems of the body. It acts through chemical messengers - hormones – carried in the circulation.

Two systems control all physiologic processes:

1. **The nervous system** exerts point-to-point control through nerves, similar to sending messages by conventional telephone. Nervous control is electrical in nature and fast.
2. **The endocrine system** broadcasts its hormonal messages to essentially all cells by secretion into blood and extracellular fluid. Like a radio broadcast, it requires a receiver to get the message - in the case of endocrine messages, cells must bear a receptor for the hormone being broadcast in order to respond.

Receptors and Target Cells

A given hormone usually affects only a limited number of cells, which are called target cells. A target cell responds to a hormone because it bears receptors for the hormone.



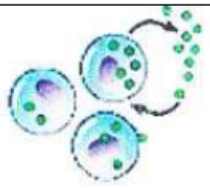
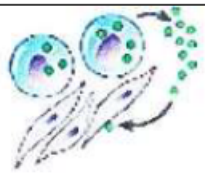
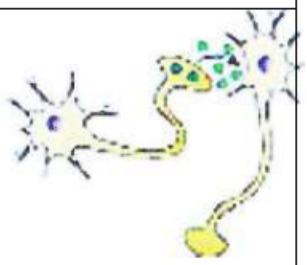
Hormone receptors are found either exposed on the surface of the cell or within the cell, depending on the type of hormone. In very basic terms, binding of hormone to receptor triggers a cascade of reactions within the cell that affects function. Hormone receptors have two essential qualities:

1. The receptor must be able to recognize a unique binding site within the hormone in order to discriminate between the hormone and all other proteins.

2. The receptor must be able to transmit the information gained from binding to the hormone into a cellular response.

Hormones may be secreted into blood and affect cells at distant sites. Some hormones known to act and affect neighboring cells or even have effects on the same cells that secreted the hormone. Three actions are defined:

1. Endocrine action: the hormone is distributed in blood and binds to distant target cells.
2. Paracrine action: the hormone acts locally by diffusing from its source to target cells in the neighborhood.
3. Autocrine action: the hormone acts on the same cell that produced it.

Types of hormones			
Chemical messengers			
Intracellular chemical signal	Description	Example	
Autocrine	Secreted by cells in a local area and influences the activity of the same cell from which it was secreted	Prostaglandins	
Paracrine	Produced by a wide variety of tissues and secreted into tissue spaces; has a localized effect on adjacent cells	Histamine, Prostaglandins	
Hormone	Secreted into the blood by specialized cells; travels by the blood to target tissues	Thyroxine, Insulin	
Neurohormone	Produced by neurons and functions like hormones	Oxytocin, Antidiuretic hormone	
Neurotransmitter	Produced by neurones and secreted into extracellular spaces by nerve terminals; travels short distances, influences postsynaptic cells or effector cells.	Acetylcholine, norepinephrine	

Hormones:

Hormones are the chemical messenger produced in small amount by endocrine glands, secreted into blood stream to control metabolism and biological activities in target cell or organs. Characteristics or properties of hormone Low molecular weight Small soluble organic molecules Rate of diffusion is very high and are readily oxidized but the effect does not remain constant. It is effective in low concentration, travels in blood, it has its target site different from where it is produce and is specific to a

particular target. Functions of hormones Regulatory and homeostasis functions.

Classification of hormone Hormones: are classified

A. On the basis of chemical nature

B. On the basis of mechanism of hormone action

- Group I hormone
- Group II hormone.

A. On the basis of chemical nature

1. **Peptides and proteins**
2. **Amino acid derivatives**
3. **Steroids**
4. **Fatty acid derivatives - Eicosanoids**

1. Peptides and Proteins Hormones

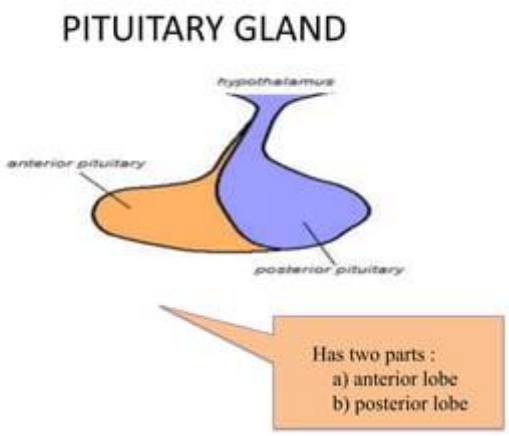
Peptide and protein hormones are products of translation. Peptide hormones are synthesized in endoplasmic reticulum, transferred to the Golgi and packaged into secretory vesicles for export. They can be secreted by one of two pathways:

Regulated secretion: The cell stores hormone in secretory granules and releases them in "bursts" when stimulated. This is the most commonly used pathway and allows cells to secrete a large amount of hormone over a short period of time.

Constitutive secretion: The cell does not store hormone, but secretes it from secretory vesicles as it is synthesized.

Most peptide hormones circulate unbound to other proteins, but exceptions exist; for example, insulin-like growth factor-1 binds to one of several binding proteins. In general, the half-life of circulating peptide hormones is only a few minutes. Several important peptide hormones are secreted

from the pituitary gland they include:



A. The anterior pituitary secretes:

1. Luteinizing hormone and follicle stimulating hormone, which act on the gonads (ovaries and testis).
2. prolactin, which acts on the lactating mammary gland,
3. adrenocorticotropic hormone (ACTH), which acts on the adrenal cortex to regulate the secretion of glucocorticoids, and mineralocorticoids.
4. growth hormone, which acts on bone, muscle and liver.

B. The posterior pituitary gland secretes:

1. antidiuretic hormone, also called vasopressin.
2. Oxytocin

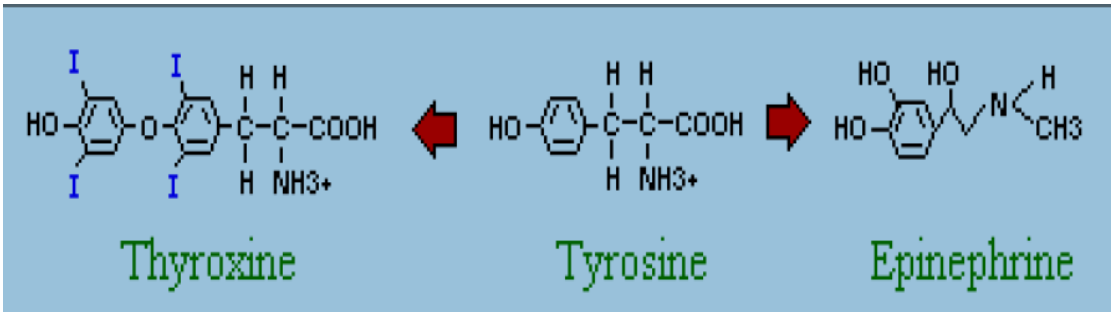
Peptide hormones are produced by many different organs and tissues, however, including:

1. the heart (atrial-natriuretic peptide (ANP) or atrial natriuretic factor (ANF)
2. pancreas (insulin and somatostatin).
3. the gastrointestinal tract cholecystokinin, gastrin.
4. fat stores (leptin).

2. Amino acid derivatives

There are two groups of hormones derived from the amino acid tyrosine:

1. Thyroid hormones are basically a "double" tyrosine with the critical incorporation of 3 or 4 iodine atoms.
2. Catecholamines include epinephrine and norepinephrine, which are used as both hormones and neurotransmitters

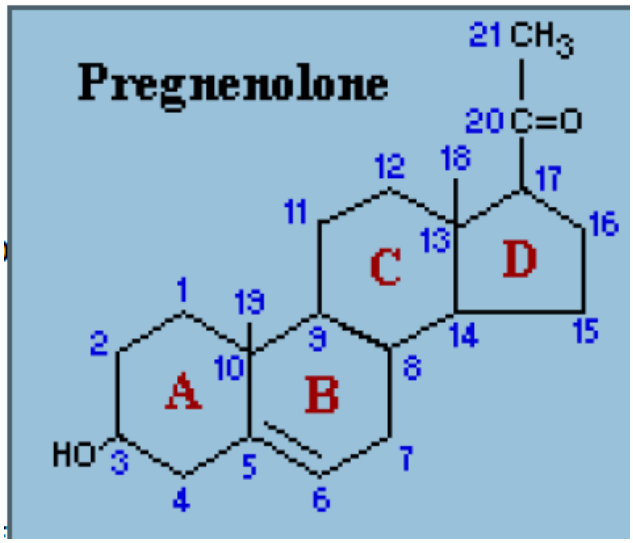


Two other amino acids are used for synthesis of hormones:

1. **Tryptophan** is the precursor to serotonin and the pineal hormone melatonin
2. **Glutamic acid** is converted to histamine

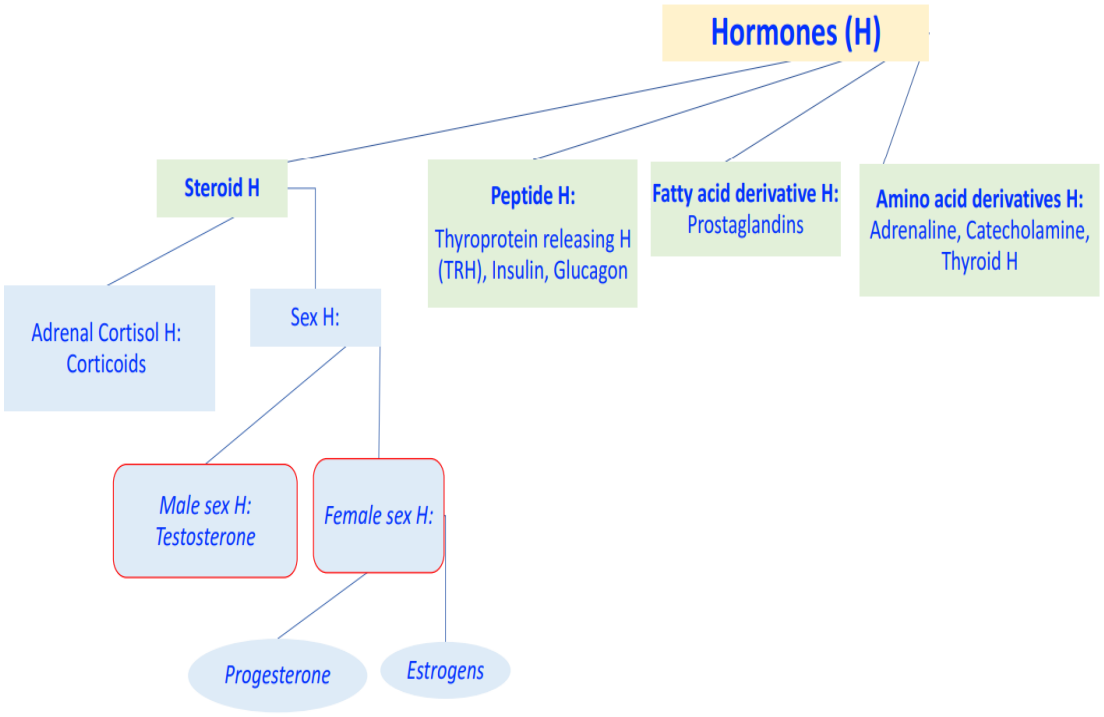
3. Steroids

Steroids are lipids and, more specifically, derivatives of cholesterol. Examples include the sex steroids such as testosterone and adrenal steroids such as cortisol. The first and rate-limiting step in the synthesis of all steroid hormones is conversion of cholesterol to pregnenolone.Newly synthesized steroid hormones are rapidly secreted from the cell, with little if any storage. Increases in secretion reflect accelerated rates of synthesis. Following secretion, all steroids bind to some extent to plasma proteins.



4. Fatty Acid Derivatives - Eicosanoids

Eicosanoids are a large group of molecules derived from polyunsaturated fatty acids. The principal groups of hormones of this class are prostaglandins, prostacyclin, leukotrienes and thromboxane. Arachidonic acid is the most abundant precursor for these hormones. Stores of arachidonic acid are present in lipids membrane and released through the action of various lipases. A great variety of cells produce prostaglandins, including those of the liver, kidneys, heart, lungs, thymus gland, pancreas, brain, and reproductive organs. In contrast to hormones, prostaglandins usually act locally, affecting only adjacent cells or the very cell that secreted it.



B. On the basis of mechanism of hormone action

1. Group I hormone (lipophilic hormone): These hormones are lipophilic in nature. They are mostly derivatives of cholesterol. These hormones bind to intracellular receptors Example: Steroid hormones, Estrogen, androgen, glucocorticoids, cholecalciferol, thyroxine etc .

2. Group II hormones (water soluble hormone): These hormones bind to cell surface receptors and stimulates the release of certain molecules (secondary messengers) to perform biochemical functions.

On the basis of secondary messengers group II hormones are of 3 types;

1. Secondary messenger is cAMP: eg. Adrenocorticotropic hormone, FSH, LH, PTH, ADH, calcitonin, glucagon.
2. Secondary messenger is phosphatidylinositol/calcium or both: eg. Acetylcholine, vasopressin, cholecystokinin, gastrin, gonadotropin releasing hormone, thyrotropin releasing hormone, Insulin, chorionic

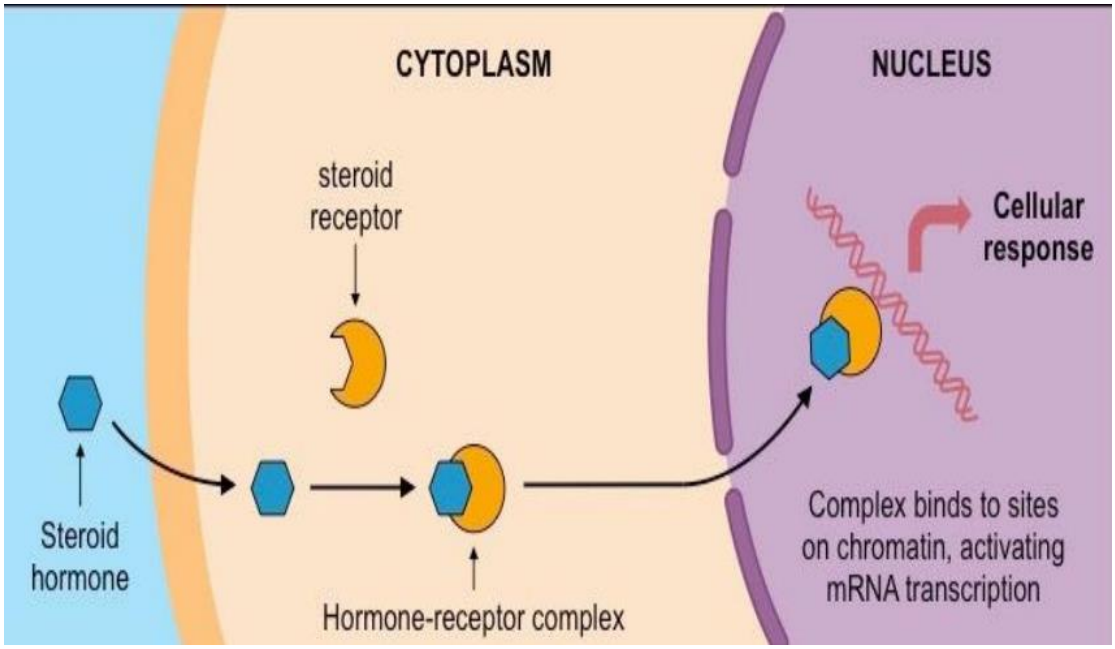
somatomammotropin, epidermal growth factors, fibroblast growth factors, GH, Prolactin.

3. Secondary messenger is cGMP: Atrial natriuretic peptide (ANP)

The different types of hormones will have different mechanisms of action due to their distinct chemical properties.

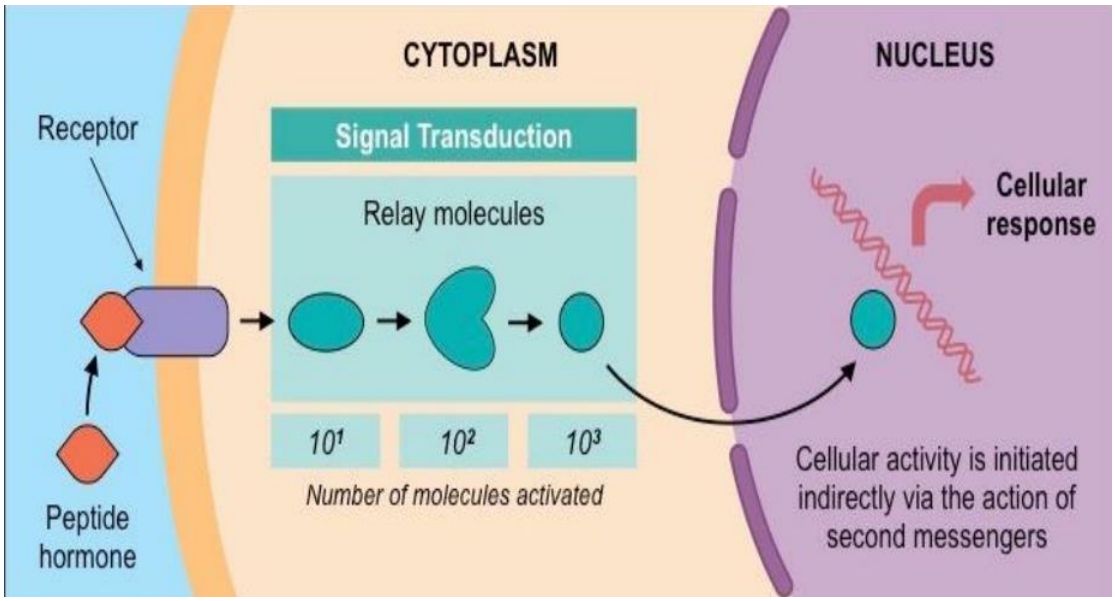
Group I (Steroid Hormones)

Steroid hormones are lipophilic (fat-loving) – meaning they can freely diffuse across the plasma membrane of a cell They bind to receptors in either the cytoplasm or nucleus of the target cell, to form an active receptor hormone complex This activated complex will move into the nucleus and bind directly to DNA, acting as a transcription factor for gene expression Examples of steroid hormones include those produced by the gonads (i.e. estrogen, progesterone and testosterone)



Group 2 (Peptide Hormones):

Peptide hormones are hydrophilic and lipophobic , they cannot freely cross the plasma membrane. They bind to receptors on the surface of the cell, which are typically coupled to internally anchored proteins (e.g. G proteins) The receptor complex activates a series of intracellular molecules called second messengers, which initiate cell activity. This process is called signal transduction, because the external signal (hormone) is transduced via internal intermediaries Examples of second messengers include cyclic AMP (cAMP), calcium ions (Ca2+), nitric oxide (NO) and protein kinases. The use of second messengers enables the amplification of the initial signal (as more molecules are activated) Peptide hormones include insulin, glucagon, leptin, ADH and oxytocin.



Amine Hormones

Amine hormones are derived from the amino acid tyrosine and include adrenaline, thyroxin and triiodothyronine Amine hormones do not all share identical properties and have properties common to both peptide and steroid hormones.

	Peptide	Steroid	Amino acid derivative
Synthesis	Synthesised as **prohormones**, requiring further processing (e.g. cleavage) to activate	Synthesised in a series of reactions from **cholesterol**	Synthesised from the amino acid **tyrosine**
Storage	Stored in vesicles (regulatory secretion)	Released immediately (constitutive secretion)	Stored before release (storage mechanism varies)
Solubility	Most are polar and water soluble, can travel freely in the blood	Generally non-polar and require carrier proteins to travel in blood	Some are polar (adrenaline), others must be protein-bound
Receptors	Bind receptors on cell membrane and transduce signal via the use of second messenger systems	Bind to intracellular receptors to change gene expression directly	Adrenaline acts on membrane receptors, while thyroid hormones act directly on nuclear receptors
Effects	Often fast onset transient changes in protein activity, though gene expression changes can occur	Alterations in gene expression; slower onset but longer duration than peptide hormones	Adrenaline functions like peptides, thyroid hormones function in a similar manner to steroids
Examples	Insulin, glucagon, prolactin, ACTH, gastrin parathyroid hormone	Cortisol, aldosterone, estrogen, progesterone, testosterone	Adrenaline, thyroxin, triiodothyronine