University of Jordan - Faculty of Medicine
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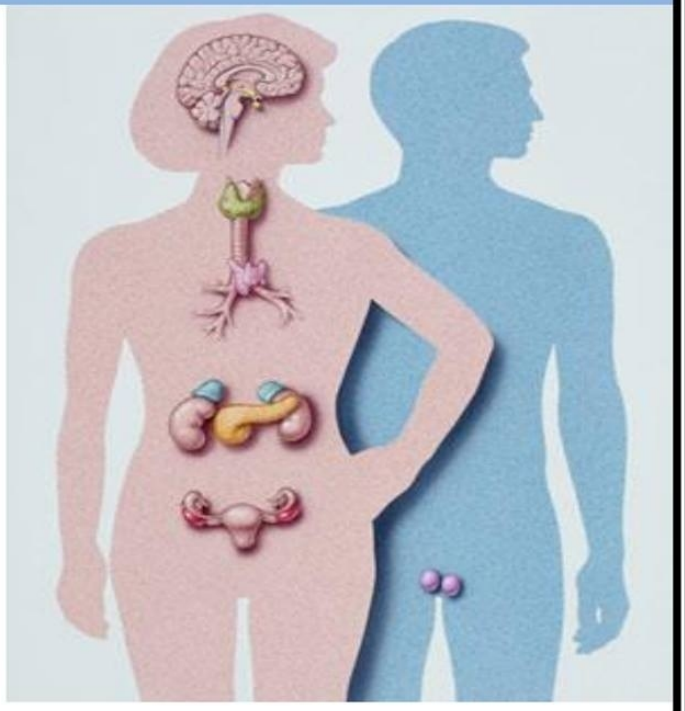
Medical Committee
The University of Jordan

Endocrine System



- [ ] Anatomy/Embryology/Histology
- [ ] Biochemistry
- [x] Physiology
- [ ] Pharmacology
- [ ] Pathology
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Lecture #: **1**

Date:

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ENDOCRINE PHYSIOLOGY 1

السلام عليكم
الشيت هيه تقريبا نفس اول شيتين للسنة الماضية

تقريبا=95%

- The systems of the body are:the nervous system, skeletal, cardiovascular, respiratory, digestive, urinary, endocrine, reproductive, lymphatic, and immune. These systems form the body of the humans and mammals.

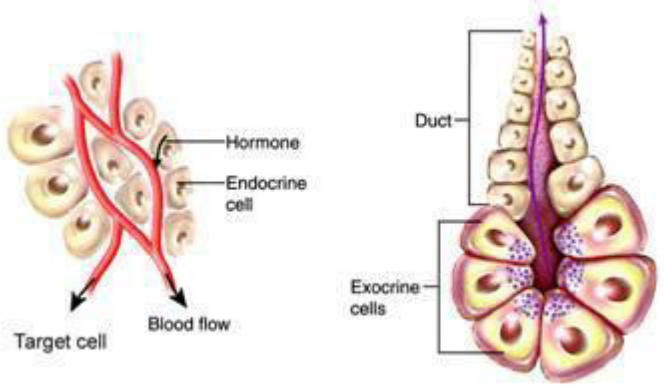
- From these systems just two systems control the human body and are called control systems.
  They are: **the nervous system** and **the endocrine system**, the first for immediate action and the second for delayed action.

- The Endocrine system is usually for delayed action but is sometimes for immediate action like the release of adrenaline from the adrenal medulla. Thenervous system however is usually for immediate action.

- Now we compare these two systems:

Characteristic	Endocrine system	Nervous System
Mechanism of control	Hormones are delivered usually directly in the blood to tissues.	Neurotransmitters released in response to nerve impulse move: from neuron to neuron, from neuron to muscle cell, or from neuron to gland cells.
Affected cells	Almost all the cells of the body.	Nerves, muscles, gland cells.
Types of actions	Changing in metabolism either anabolism or catabolism.	Neuron to neuron: action potential in the second nerve. Neuron to muscle: muscle contraction. Neuron to glandular cells: secretions of enzymes or hormones.
Time to onset of action	Usually delayed sometimes immediate	Usually immediate
Duration of action	Generally longer	Generally brief

Types of glands:



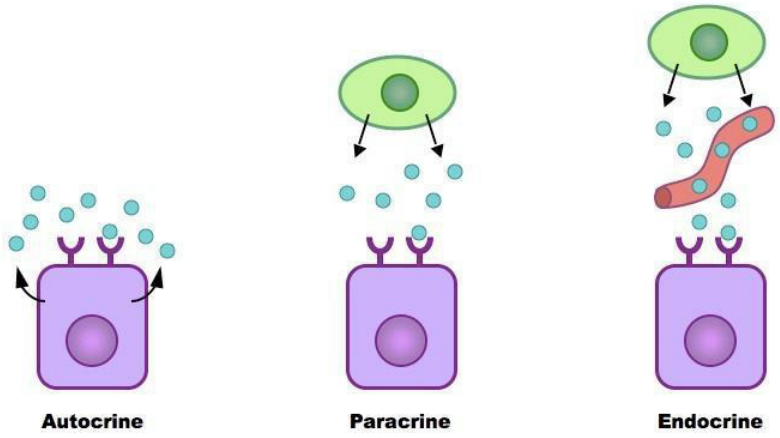
- **Exocrine glands** their secretions are released into a duct open either inside the body into a lumen such as the intestine or outside the body such as sweat glands.

- **Endocrine glands**, there are two types of endocrine glands

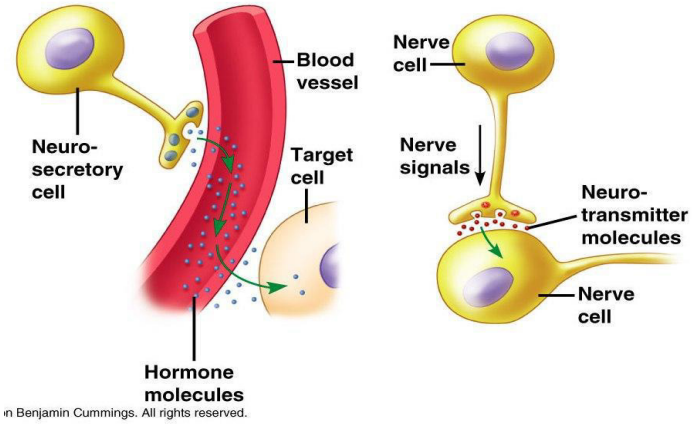
➢ **Classic endocrine glands**(ductless): glands which secrete their hormones directly into the blood and the hormones are called also classic hormones.

➢ Other endocrine glands do not release their hormone directly into the blood, but these are minor glands:

- **Autocrine glands**: hormones synthesized in endocrine cells and sometimes released into the interstitial spaces, bind to specific receptor on the cell of origin.
- **Paracrine glands**: hormones synthesized in endocrine cells and sometimes released into the interstitial spaces, bind to specific receptor of nearby cells affecting their function.



❖ **Neuroendocrine**: two subtypes; the first subtype is hormone produce by neurons and release directly into the blood, example: posterior pituitary. The second subtype is hormone produce by neurons and release into the cleft affecting the post synaptic neurons, so these hormones are neurohormones either release into the blood or into the synaptic cleft, example: Adrenalin from the sympathetic nervous system.



✓ **Pheromones**: are volatile hormones –these hormones evaporate rapidly- released into the environment act on olfactory cells of another individual, so they are substance produced by an animal usually that act at distance to produce hormonal, behavioral, or other physiologic changes in another animal of the same species :

- In animals, male deer produce and amberis produced by whales in their intestines.
- And these pheromones might be present in human beings, people getting attracted to each other by these pheromones and this is what's called "chemistry". Females usually produce more than males do. DrSaleem advises you to find your chemistry, kay?

❖ Some important points about the endocrine system:

- A single endocrine gland may produce many hormones under different control mechanisms and with different functions, such as the anterior pituitary andthe pancreas.

- Most hormones have multiple actions in their target tissues and are said to have pleotrotropiceffects. This phenomenon occurs when a single hormone regulates several functions in the target tissue.

For example: in skeletal muscles insulin stimulates glucose uptake, glycolysis, glycogenesis, inhibit glycogenolysis, stimulates amino acids uptake, stimulates protein synthesis and inhibit protein degradation.

- Some hormones are known to have several effects in several different target cells.

For example: testosterone, the male sex steroid hormone, is responsible for normal sperm formulation in the testes, stimulation of growth of accessory sex organs or glands such the prostate and the seminal vesicles, and promotion of the development of several secondary sex characteristics such as beard growth and deepening of the voice.

- The same chemical messenger can be classified as a hormone or a neurotransmitter depending on the source of secretion. When somatostatin is secreted from the hypothalamus it's a neurotransmitter, while when it's secreted form the pancreas it's a hormone.

- Multiplicity of regulation in the endocrine system is also common.The input of information from several sources allows a highly integrated response to many stimuli which is of ultimate benefit to the whole animal.

For example, several different hormones including insulin, glucagon, epinephrine, thyroid hormones, andadrenal glucocorticoids may regulate liver glycogen metabolism.

- Single target cell may be influenced by more than one hormone; some cells contain many types of receptors responding in different ways to different hormone.To illustrate this, insulin promotes the conversion of glucose into glycogen within the liver cells by stimulating hepatic enzymes, whereas Glucagon enhances the degradation of liver glycogen and thus the production of glucose.

- Some organs in the body specialize in hormonal secretion only. Some other organs produce hormones in addition to other nonendocrinefunctions, such as intestine, stomach, pancreas, ovaries, testes, lungs, heart, kidney, etc.

- In addition to changing of receptor number, many target cells can regulate receptor function. Chronic exposure to a hormone may cause the cells to become less responsive to subsequent exposure by desensitization. There is no life without desensitization.

If the exposure of the cells to a hormone had a desensitizing effect on terminal action of that same hormone, the effect is termed homologous desensitization. However, if the exposure of the cells to one hormone had desensitizing effect with regard to a different hormone, the effect is termed heterologous desensitization.

❖ The general functions of the hormones:

- **Metabolism:** hormones regulate the metabolism either anabolism or catabolism.
- **Reproduction:** there is no reproduction without hormones, no sperms without testosterone and other androgens or estrogen (because the estrogen also it has role in the production of the sperms), no ova without estrogen and progesterone.
- **Digestion:** digestive system does not function without hormones; it needs hormones to function properly.
- **Blood circulation:** cardiac output, blood pressure, vasoconstriction, vasodilatation and control the blood volume and consequently the body fluid volume, all these are controlled by hormones, and any wrong especially in some specific hormones all previous mentioned things are disturbed.
- **Transport of substances to tissues:** many substances are transported by hormones or increased or decreased its concentration in the blood.
- **Defense against pathogens:** immune system responses are regulated by hormones, such as inflammation, antibody production and fever.
- **Growth:** it is does not occur properly without growth hormones, deficiency in GH lead to dwarfism as well as cretinism.
- **Stress response:** regulate the body's response to stresses.
- **Behavior:** hormones affect the behavior; the behaving of the females is different from the behaving of the males because of hormones, females shy and cannot fight because of the estrogen, males fight because of testosterone.

❖ The chemistry of hormones:

In physiology we classify hormones into 3 categories:

1- Proteins: Mainly the hormones are proteins. Proteins are either small molecules or large molecules (below or above 20 amino acids).

2- Amino acid derivatives: catecholamines (adrenaline, noradrenalin and dopamine) and Thyroid hormones (T3,T4).

3- Steroids: two types: adrenal cortex hormones and sex hormones.

❖ Regulation of hormones secretion:

A. Feedback control:

So feedback controls the relation between the response and the stimulus. Almost all hormones are regulated this way.

The [stimulus – response] could be:

a) Hormone - hormone (the stimulus is a hormone and the response is a hormone)
b) Substrate - hormone e.g. Glucose-insulin
c) Mineral - hormone e.g. Calcium - parathyroid hormone

1-P*ositive feedback control*: is when the response increases the stimulus.
Example: the response is secreting oxytocin, the stimulus is the sucking of milk by the infant. More and more sucking results in more and more oxytocin, and this continues till the process ends.
Another example: in delivery, more and more uterine contractions result in more and more oxytocin till the process ends.
When these processes end the oxytocin release stops. If it continues then it will turn into destructive process.

***2- Negative feedback control*:**is when the response decreases the stimulus.

Feedback control occurs in three loops:
1- Ultra short loop: e.g. Hypothalamus secretes hormone and the hormone affects the hypothalamus (autocrine).

2- Short loop: e.g. Hormone from pituitary affects the hypothalamus.

3- Long loop: e.g. Thyroid hormone affects hypothalamus and the pituitary.

B. Neural control :

Hormones are secreted neurally during special conditions like:pain, emotion, sexual excitement, fright, injury and stress.All these can modulate hormone secretion through neural mechanism.
e.g. adrenalin, acetylcholine, dopamine, serotonin ...etc

C. Chronotropic control:

This control is dictated by rhythms that may be genetic or acquired. So it's related to time, duration, season.

1- **diurnal rhythm/ sleep-wake cycle:** the secretion of growth hormone during the 24 hours). It is higher at 12 mid noon (wake) and 12 mid night (sleep), and in between there is variation.

2- **Menstrual rhythm**:the level of hormones is genetically determined in this case.The levels of estrogen, progesterone, LH and FSH vary during the 28 days of the cycle.

3-**Seasonal rhythm:** mostly seen in mammals where some hormones are high just in spring or winter or summer or autumn. Also secretion of these hormones especially sexual hormones and gonadotropin hormones is genetically encoded.

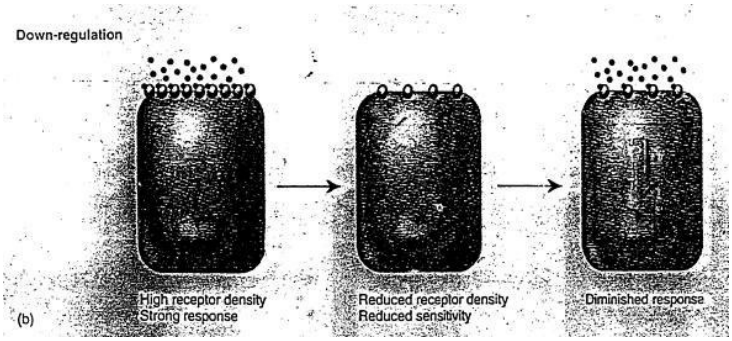
4-**Developmental rhythm:** secretion of growth hormone during childhood, puberty, adulthood, and old age, there is variation in secretion of growth hormone during all these stages.

❖ Receptor Desensitization :

long exposure of the cells to a hormone results in either reduction in the number of hormone receptors or reduction in the affinity of the receptors to the hormone .

Down regulation and up regulation of the receptors:

In the picture: The number of the receptors is decreased, and the concentration of the hormone is relatively high, but because the receptors number is low the hormone doesn't function properly. This is down regulation.



Example: many old obese individuals (usually obese)have high concentration of insulin but still there is a high concentration of glucose.This means that insulin doesn't function properly because of the low number of the receptors or their decreased affinity, resulting in diabetes mellitus type 2. These individual are advised to have exercise and control their meals and to restore their weight to normal, after that and within a short time, thenumber of receptors increases as well as the affinity of the receptors towards the hormone via **upregulation**.
There are many types of exercises; the best in energy expenditure is cycling, followed by swimming and jogging. However, the most practical exercise is walking; especially about 6km/hour for about one month. Sometimes exercise is the only medication needed to treat diabetes type 2.
Another thing to note is that eating is a habit, and if an individual starts to control his portions and balances his energy input with his energy output he would control his weight very efficiently. One extra spoon of sugar in one year will increase your weight by 1 kg, this extra weight is very hard to carry around.
Extra weight is very dangerous on your weight :P

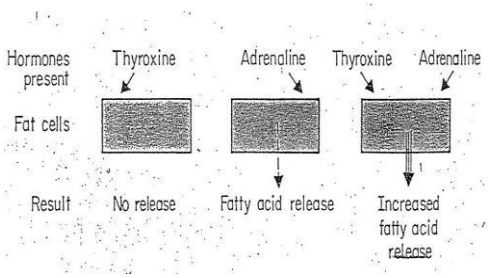
** when there is down regulation, most probably the receptors sink down inside the cell, or synthesis of receptors decreases, or both, and in up regulation the opposite happens.

So cells can regulate the number of their receptors as well as the function.
**Exposing the cells to an input of hormone for sustained period of time results in decreased number of receptors for that hormone per cell.
Example: Most probably, the reduction of the number of receptors on adipose tissue or muscle or liver or other cells in the body is because of the exposure of these cells for a long time to high concentration of insulin.
So when there is high insulin concentration and low receptors the cells don't respond to the high insulin concentration. This is called diabetes mellitus [we will take this later when the doctor explains the pancreas]

❖ Hormonal interactions:

Hormones don't function separately, there is interaction between hormones.

1- Permissive action:
These are fat cells affected by thyroxin > no result.
Same cells affected by adrenaline > little fatty acids released.
Thyroxin then adrenaline >increased fatty acid release
(Thyroxin either increases the number of the receptors or increases the affinity of the receptors to adrenaline or both.)



2- Synergistic effect (synergism):
The effects of two or more hormones complement each other in such a way that the target cell responds effectively to the sum of the hormones involved.
So Lactogenic hormones, galactokinetic hormones, galactopoietics hormones, mammogenic hormones, these hormones function together to produce best results, they complement each other.

3-Antagonistic effect (antagonism):
A hormone opposes the action of another hormone on the same target cell.
Example: parathyroid hormone increase PTH and calcitonin decreases it.
Another example: Insulin decreases glucose level and glucagon increases it.

❖ Mechanism of the action of hormones:

A) production of cAMP:
Protein hormones are large molecules , they can't penetrate the cell membrane or nuclear membrane, they need receptors, these receptors are in the cell membrane.
For the hormone to function it first needs a receptor and a second messenger. The hormone binds to the receptor, activates G protein in the cell membrane, alpha subunit binds to GTP and detaches from the beta and gamma subunits, activates adenylate cyclase.

Hormone receptor activates let's say 100 G proteins, and then adenylatecyclase activates 1000 ATP so we get 1000 cAMP. If there is a lot of cAMP, they activate an enzyme which leads to chemical response.

*some hormones that produce cAMP: ACTH, Angiotensin, Calcitonin, Catecholamines,…
"we have to know all of them"

B) Activation of phospholipase C:

Some of the protein hormones produce two second messengers. They need calcium to function;ca needs another messenger to be increased inside the cells either from the endoplasmic reticulum or the sarcoplasmic reticulum, therefore they have to produce a second messenger that increases calcium which is by activating phospholipase C.

Phospholipase C cleaves PIP2 into DAG for the activation of enzymes, and IP3 to increase calcium.

-We have to know all the hormones which need ca from angiotensin to vasopressin and ADH

C) Diffusion into the cells:

The amino acid derivatives (except catecholamines like adrenaline) and steroid hormones diffuse into the cells, and bind their receptors inside the cell; either in the cytoplasm or in the nucleus.

They bind to the receptors affecting the DNA; producing mRNA then physiological response.

*Progesterone and estrogen: these are steroids but sometimes we need fast action, therefore they have receptors in some cells in the cell membrane as to function immediately. We conclude that the action of the hormones that bind to receptors inside the cells is delayed action.

*Hormones that are not put in these 3 classes are exceptions like: insulin which is different in the receptor and the second messenger, and nitric oxide that has cGMP as a second messenger.