Animal physiology- /2022-2023/2nd semester

Lecture 5

Endocrine glands

Glands that secrete hormones into the circulation (fig.5-1) rather than into a duct; also called ductless glands. These glands by their hormones, providing a second mechanism (in addition to nervous systems) for regulating and coordinating distant organs. Fig.5-2 shows major endocrine glands in human being.

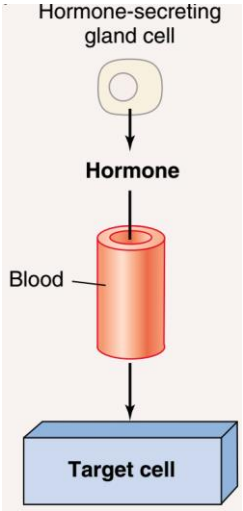


Figure 5-1: chemical messengers that enter the blood and act on target cells are classified as hormones

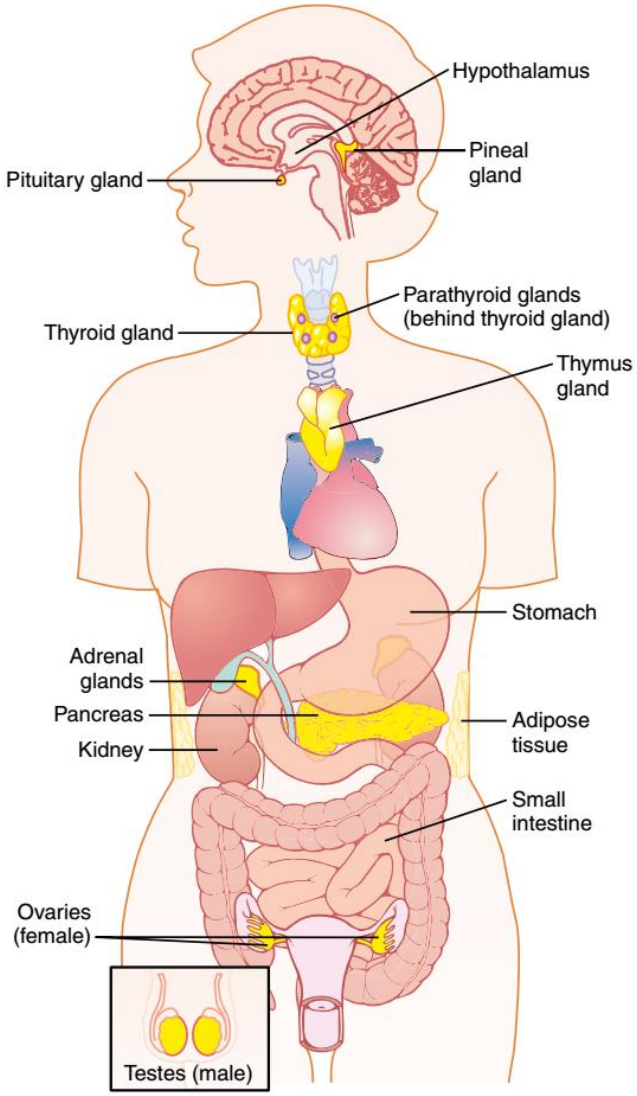


Figure 5-2: Anatomical loci of principal endocrine glands and tissues of the body

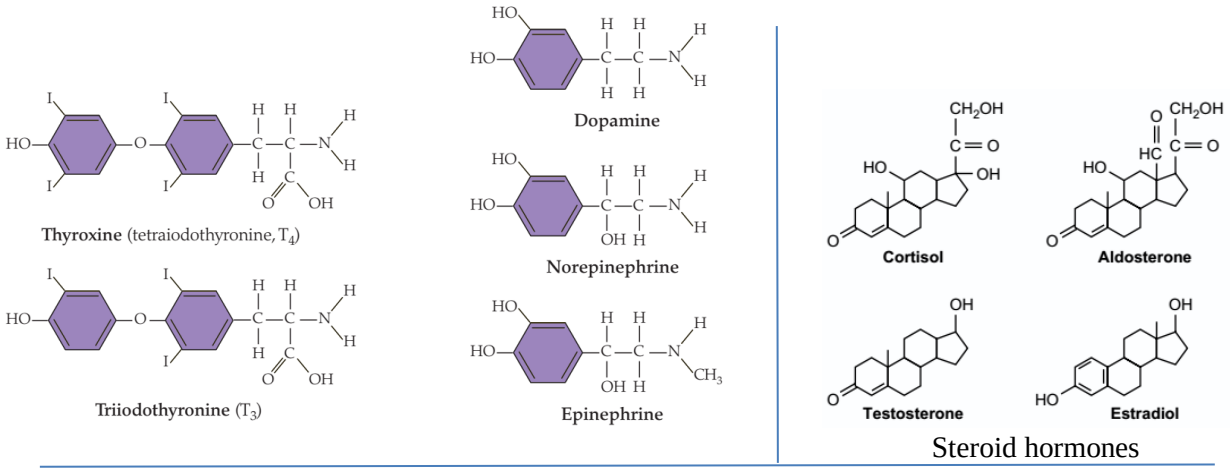
Characteristics of hormones

1-Hormones are chemical messengers secreted into the circulation in law concentrations.

2- Hormones are transported with blood stream to target cells (or organs), where they bind with receptors to cause physiological responses.
3- Some hormones are water soluble, their receptors are located in cell membrane. others are lipid soluble, their receptors are located in cytoplasm or nucleus.
4-The same chemical messenger may be either a hormone or a neurotransmitter, depending on its source and mode of delivery to the target cell.

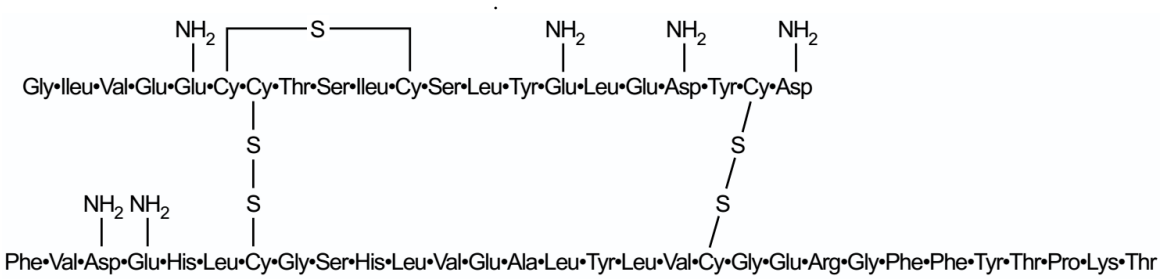
Chemical classification of hormones

In terms of chemical structure, hormones are divided into the following groups
1- Derivatives of the amino acid: including the catecholamines (adrenaline, nor-adrenaline, and dopamine), thyroxine (T4), Triiodothyronine (T3).
2- peptide and protein hormones: including antidiuretic hormone (ADH), Oxytocin, growth hormone (GH), adrenocorticotropic hormone (ACTH), Insulin, gonadotropin releasing hormone (GnRH), Prolactin, Luteinizing hormone (LH), Follicle stimulating hormone (FSH), Thyroid stimulating hormone (TSH). etc.
3-Steroid hormones: Aldosterone, Cortisol, Estradiol, Progesterone, Testosterone.



Vasopressin: Cys-Tyr-Phe-Gln-Asn-Cys-Pro-Arg-$GlyNH_2$
Oxytocin: Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-$GlyNH_2$

Human insulin molecule:



Regulation of hormone secretion

The secretion of hormone is modulated up or down by signals acting on the endocrine tissue. These signals often are neurohormones, which are released from specialized neurons and act directly on the endocrine tissue. In some cases, the endocrine tissue responds directly to conditions of the extracellular environment (e.g., changes in osmolarity).

The secretory activities of endocrine tissues generally are modulated by **negative feedback** (fig.5-3). That is, the increasing concentration of the hormone itself or a response to the hormone by the target tissue (e.g., reduced blood glucose levels in the insulin loop), has an inhibitory effect on either the synthesis or release of the same hormone. Such feedback can involve either a short loop or long loop. In short-loop feedback, the concentration of the hormone itself, or an effect produced by it, acts directly back on the endocrine tissue to reduce secretion. Long-loop feedback operates on similar principles, but it includes more elements in series.

When an extremely rapid response is required, the endocrine tissue may be subject to **positive feedback**; that is, the secretion of a hormone leads directly or indirectly to its increased secretion.

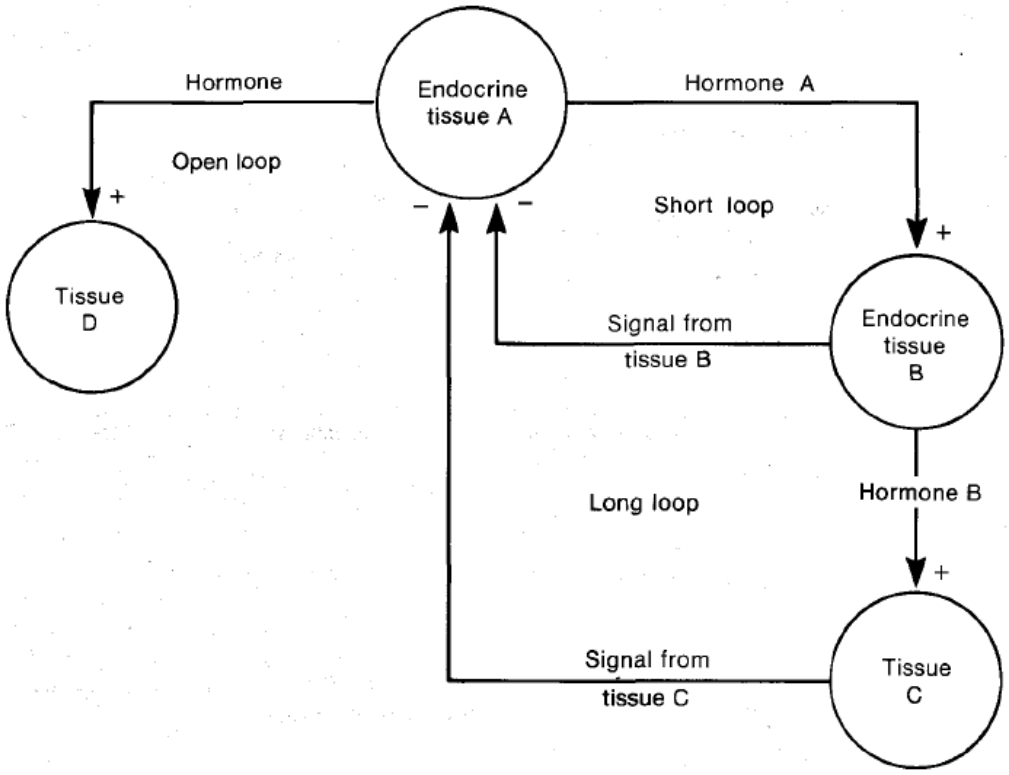


Figure 5-3: Negative feedback control, in short-loop feedback, the response of the primary target tissue (B) feeds back onto the endocrine gland. In long-loop feedback, a signal from secondary target tissue (C) control secretory activity. In an open loop there is no feedback.

Mechanism action of lipid-soluble hormones

The hormone such as steroids, enter the cell. After the hormone binds to the receptor in the cytoplasm or in the nucleus, the hormone receptor complex binds to the hormone response element (promoter) on the DNA. This either activates or inhibits gene transcription, formation of messenger RNA (mRNA), and protein synthesis (fig. 5-4).

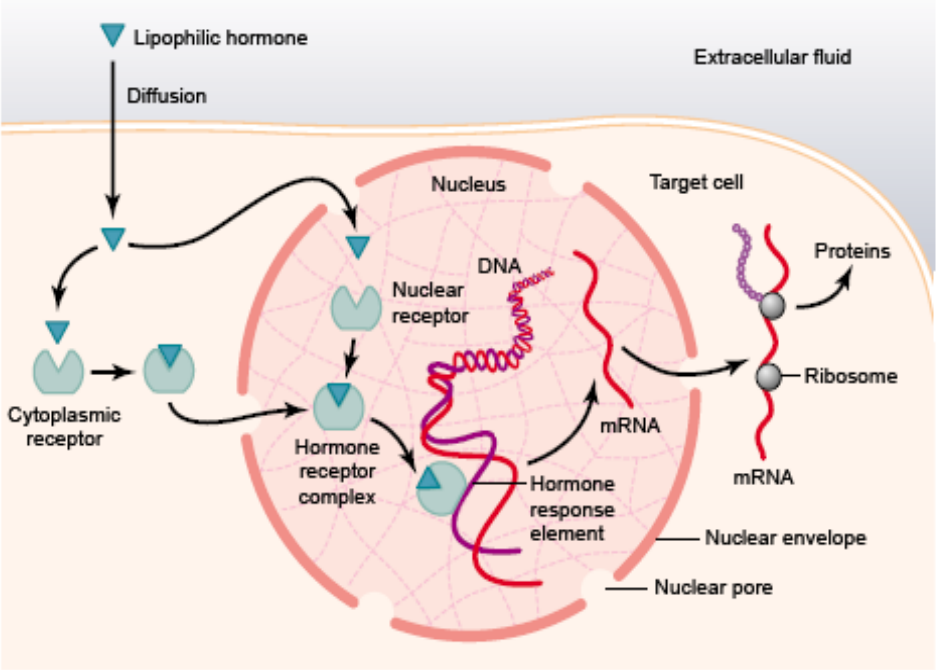


Figure 5-4: Mechanism action of lipid soluble hormones

Mechanism action of water-soluble hormones

Peptide hormones and catecholamines (hydrophilic hormones) cannot penetrate into a target cell, so They bind to cell-surface receptors, which are linked to second-messenger systems on the other side of the plasma membrane (fig. 5-5 shows mechanism action of catecholamines and some peptide hormones).

(1) The binding of a hormone to a membrane receptor activates a G protein.
(2) The G protein activates adenylate cyclase.
(3) Adenylate cyclase produces cAMP.
(4) cAMP activates protein kinases.
(5) Protein kinases phosphorylate enzymes and other proteins in the cytoplasm. Some enzymes are activated and others are deactivated by this phosphorylation.
(6) Activated enzymes catalyze metabolic reactions with a wide range of possible effects on the cell, such as synthesis, secretion, and changes in plasma membrane potential. Some hormones acting through cAMP are listed in the box.

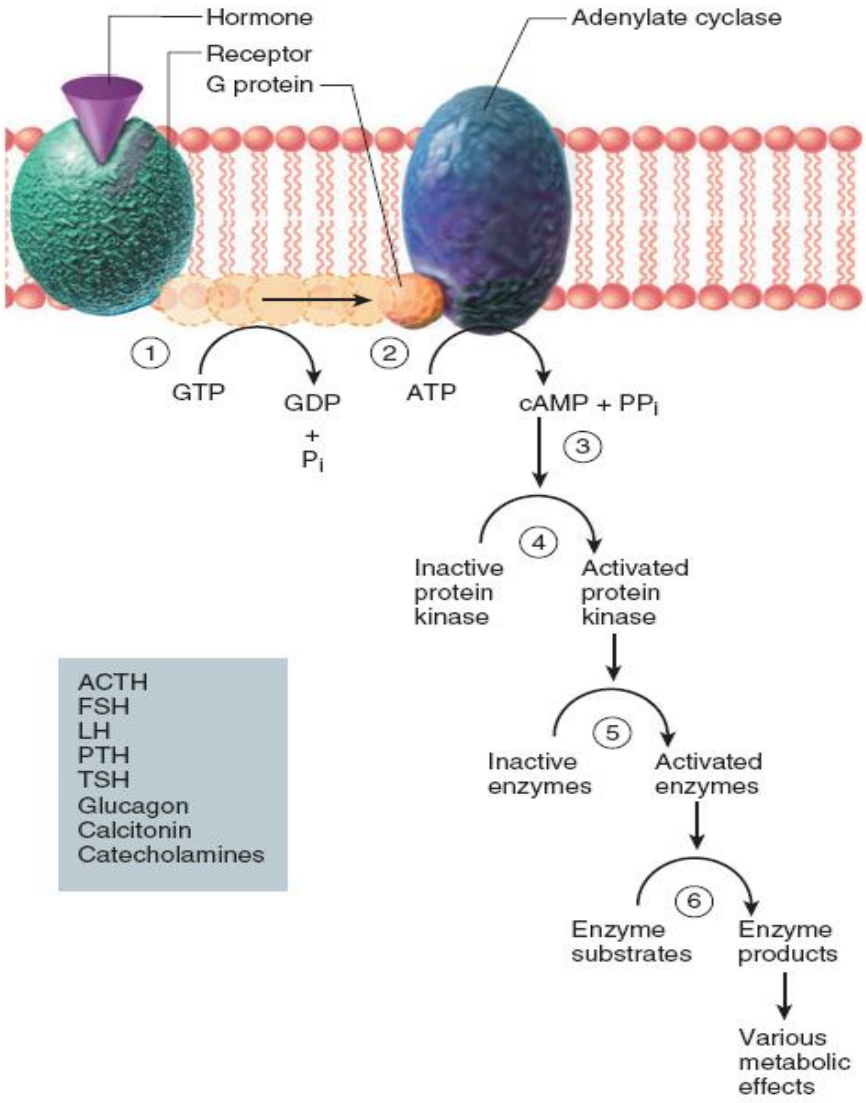


Figure 5-5: Mechanism action of water soluble hormones, includes catecholamines and some peptide hormones

Other second messengers include diacylglycerol (diglyceride) and inositol triphosphate (IP3) (fig. 5-6).
(*1*) The binding of a hormone to a membrane receptor activates a G protein.
(*2*) The G protein activates a membrane enzyme, phospholipase.
(*3*) Phospholipase breaks down membrane phospholipids into diacylglycerol and inositol triphosphate (IP3). (*4*) Diacylglycerol activates protein kinases.
(*5*) Inositol triphosphate binds to gated calcium channels in the plasma membrane, admitting calcium to the cell from the ECF, or (*6*) it triggers calcium release from the smooth ER. Calcium ions can have a variety of effects:
(*7*) Ca^{2+} can open other ion channels in the plasma membrane,

(*8*) Ca^{2+}can function as a cofactor that activates enzymes, or (*9*) Ca^{2+}can bind to calmodulin, a protein that activates protein kinases.
(*10*) Protein kinases exert the same variety of metabolic effects here as they do in the cAMP system.. Some hormones acting through cAMP are listed in the box.

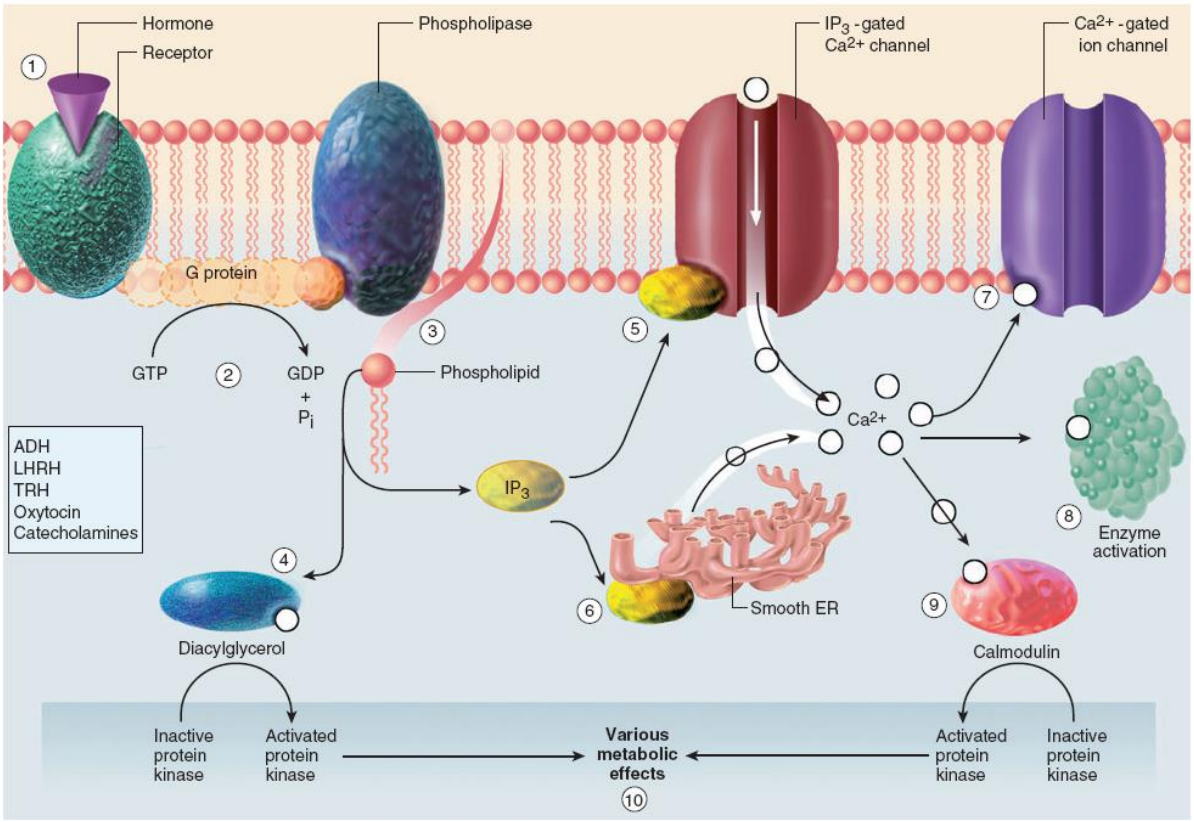


Figure 5-6: Diacylglycerol and Inositol Triphosphate (IP3) as Second messengers.

Questions

1- What are the major endocrine glands in the body
2- True or false: The receptors of oxytocin are located in nucleus
3- Explain negative feedback control
5- What does c-AMP do inside the cell ?

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