INTRODUCTION TO ENDOCRINE SYSTEM

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Introduction to endocrine system

Classes of Chemical Messengers

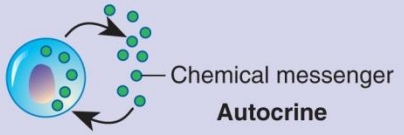
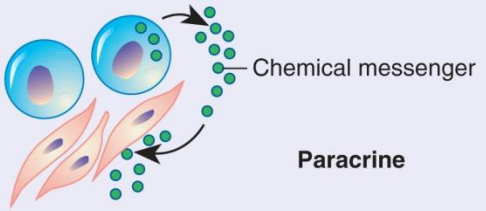
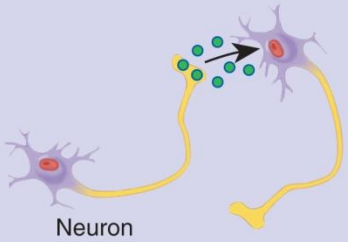
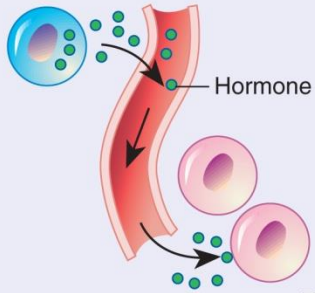
1. **Autocrine chemical messengers**: released by cells and have a local effect on the same cell type from which chemical signals released; e.g., prostaglandin

2. **Paracrine chemical messengers**: released by cells and affect other cell types locally without being transported in blood; e.g., somatostatin

3. **Neurotransmitter:** produced by neurons and secreted into extracellular spaces by presynaptic nerve terminals; travels short distances; influences postsynaptic cells; e.g., acetylcholine.

4. **Endocrine chemical messengers**: type of intercellular signal. Produced by cells of endocrine glands, enter circulatory system, and affect distant cells; e.g., estrogen

TABLE 17.1 Classes of Chemical Messengers

Chemical Messenger	Description	Example	
Autocrine	Secreted by cells in a local area; influences the activity of the same cell from which it was secreted	Eicosanoids (prostaglandins, thromboxanes, prostacyclins, leukotrienes)	 **Autocrine**
Paracrine	Produced by a wide variety of tissues and secreted into extracellular fluid; has a localized effect on other tissues	Somatostatin, histamine, eicosanoids	 **Paracrine**
Neurotransmitter	Produced by neurons; secreted into a synaptic cleft by presynaptic nerve terminals; travels short distances; influences postsynaptic cells	Acetylcholine, epinephrine	 **Neurotransmitter**
Endocrine	Secreted into the blood by specialized cells; travels some distance to target tissues; results in coordinated regulation of cell function	Thyroid hormones, growth hormone, insulin, epinephrine, estrogen, progesterone, testosterone, prostaglandins	 **Endocrine**

Principal functions of the endocrine system

- Maintenance of the internal environment in the body (maintaining the optimum biochemical environment).
- Integration and regulation of growth and development.
- Control, maintenance and instigation of sexual reproduction, including gametogenesis, coitus, fertilization, fetal growth and development and nourishment of the newborn.

Endocrine System

Helps to maintain homeostasis by Integration & control.

Secretion of chemical signals called *hormones* that travel through the bloodstream to act on *target cells.*

Endocrine versus Nervous system

Nervous System

- performs short term crisis management
- sends electrical messages to control and coordinate the body
- Nerve impulse is delivered by the axon of a nerve cell called neuron

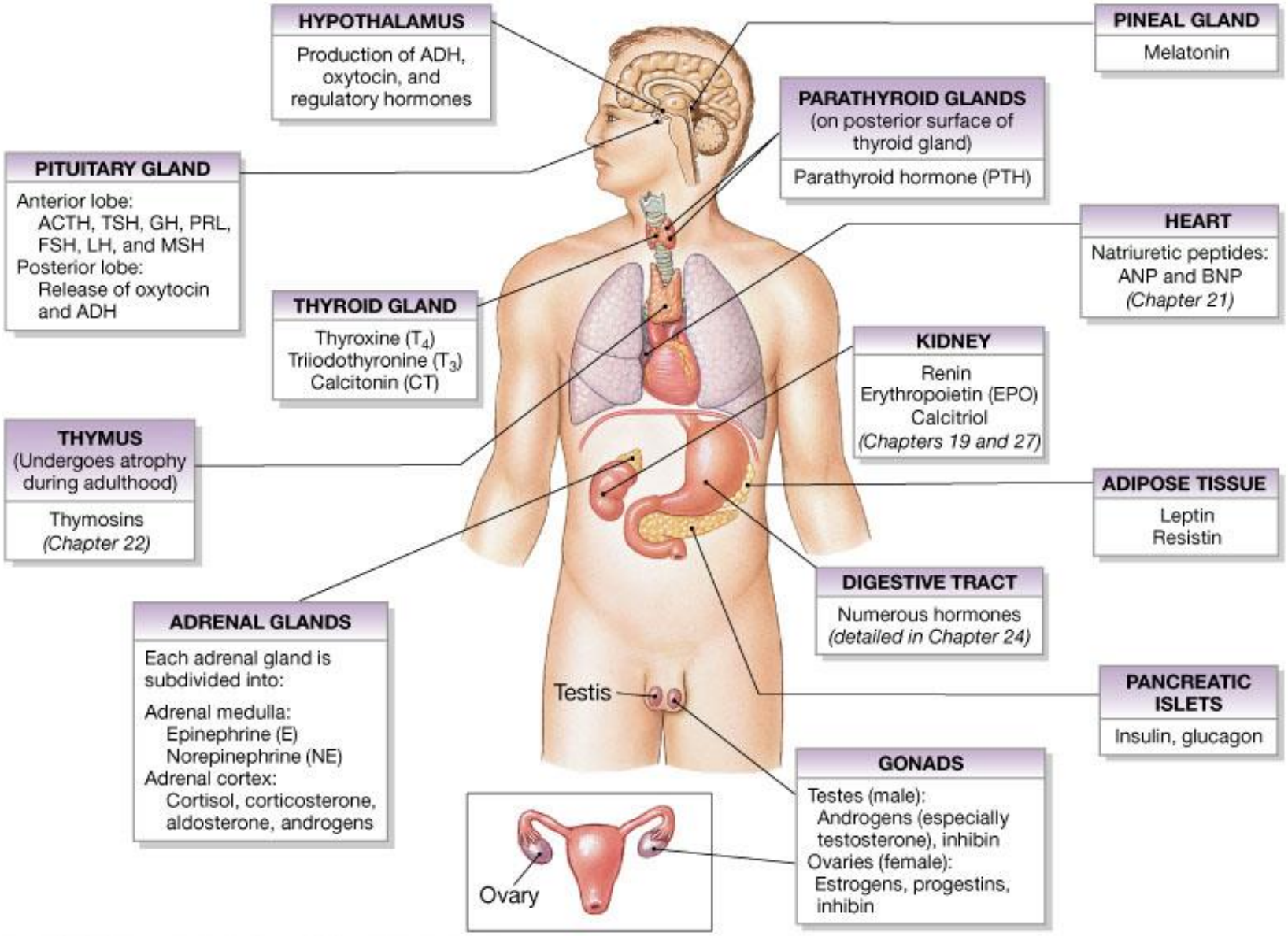
Endocrine System

- regulates long term ongoing metabolic activity
- uses chemicals messenger called hormones to “communicate”.
  - Hormones alter metabolic activities of tissues
- A hormone is secreted by a group of specialized cells called gland
- Hormones are transported by the blood vessels
- Paracrine communication involves chemical messengers between cells within one tissue

Endocrine system

- Includes all cells and endocrine tissues that produce hormones or paracrine factors
- Following are important endocrine glands
  - Hypothalamus
  - Pituitary gland
  - Pineal Gland
  - Thyroid gland
  - Parathyroid gland
  - Thymus
  - Adrenal Gland
  - Gonads (testes/ovaries)
  - Pancreatic Islet
  - Heart
  - Kidney
  - Digestive Tract

The Endocrine System



Hormone structure

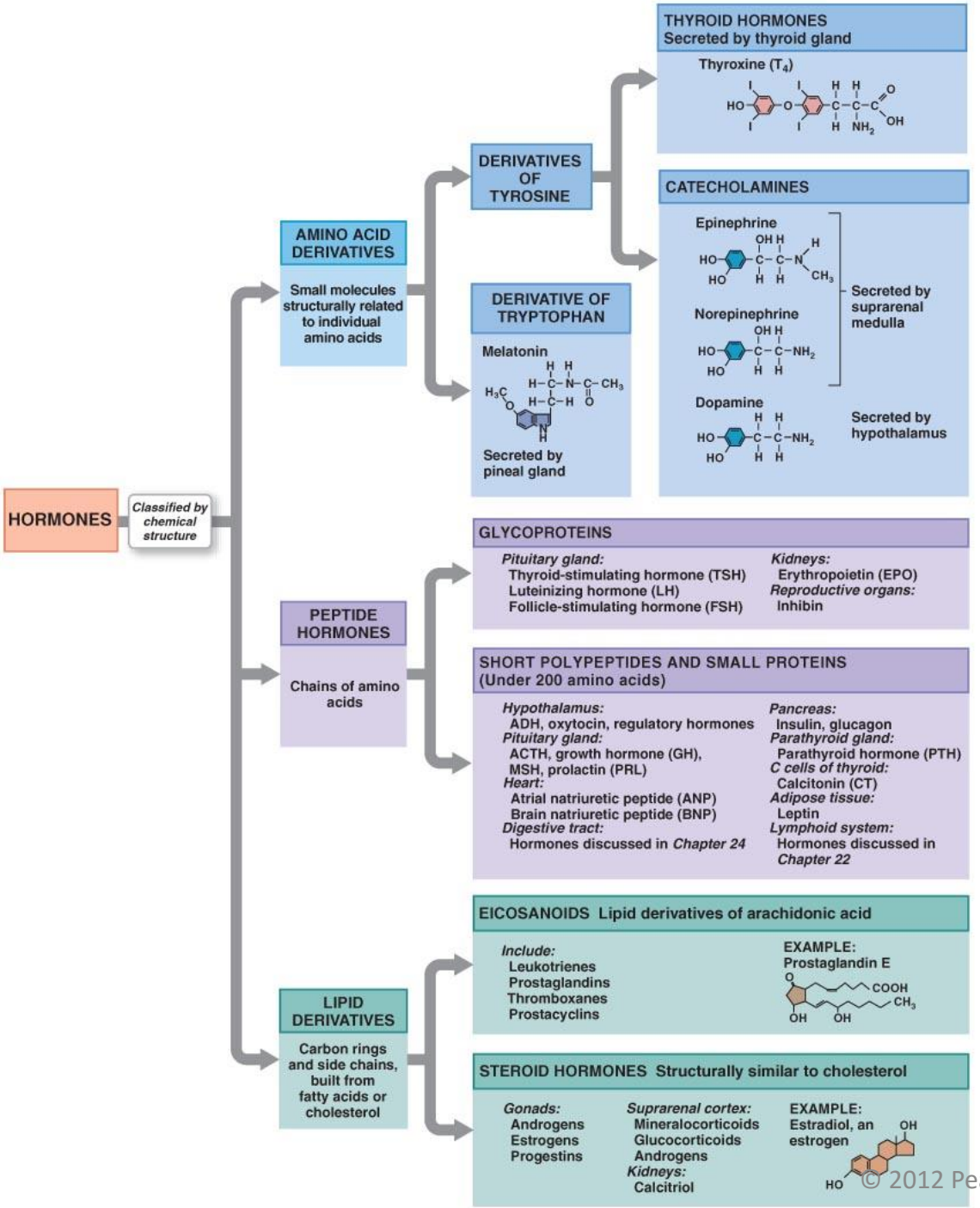
1) Amino acid derivatives hormones e.g. epinephrine

Structurally similar to amino acids

2) Peptide hormones e.g. insulin

Chains of amino acids

3) Lipid derivatives hormones e.g. eicosanoids and steroid hormones (prostaglandin is an example of a steroid hormone)



General characteristics of hormones

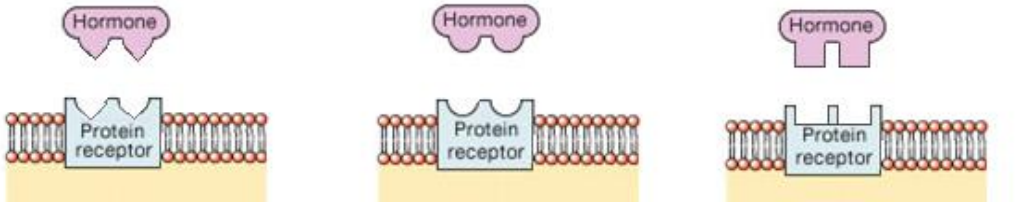
A. Stability
   1. **Half-life**: The length of time it takes for half a dose of substance to be eliminated from circulatory system
   2. Long half-life: regulate activities that remain at a constant rate through time. Usually lipid soluble and travel in plasma attached to proteins
   3. Short half-life: water-soluble hormones as proteins, epinephrine, norepinephrine. Have a rapid onset and short duration

B. Communication
   1. Interaction with target cell
   2. Lipid soluble hormones pass through cell membrane and usually travel to nucleus
   3. Water soluble hormones generally attach to a receptor site on cell membrane

C. Distribution
   1. Hormones dissolve in blood plasma and are transported in unbound or are reversibly bound to plasma proteins.
   2. Hormones are distributed quickly because they circulate in the blood.

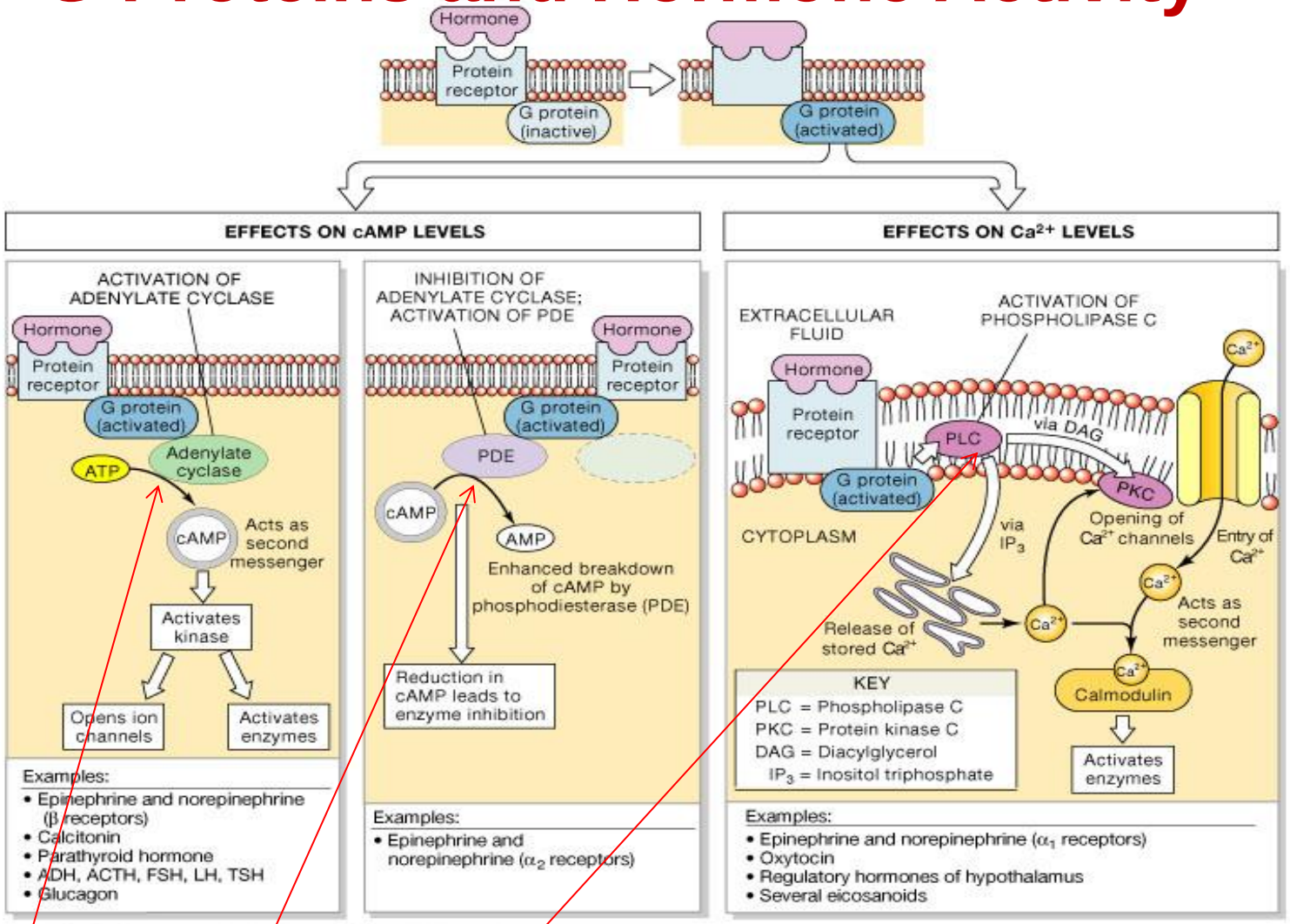
Mechanisms of hormone action

- Each hormone's shape is specific and can be recognized by the corresponding target cells



- The binding sites on the target cells are called hormone receptors.
  - Receptors for peptide hormones, are located on the surface of cell membranes because they can not cross the membrane to enter the cell
  - Thyroid and steroid hormones can cross the membrane and bind to receptors in the cytoplasm or nucleus

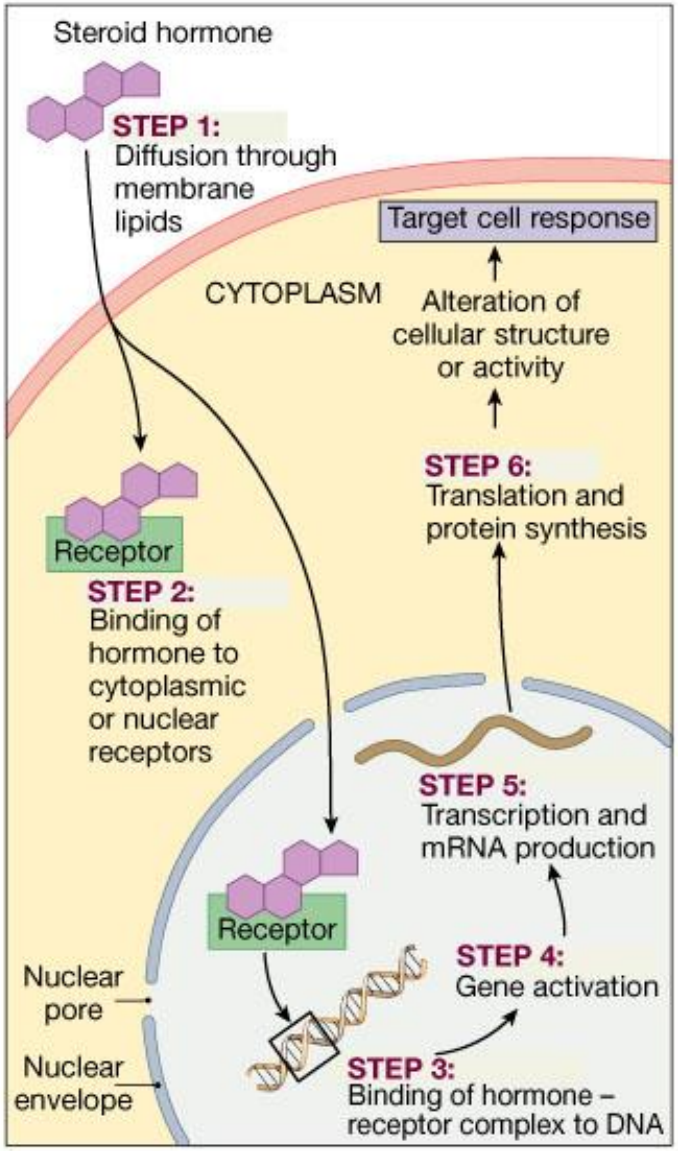
G Proteins and Hormone Activity

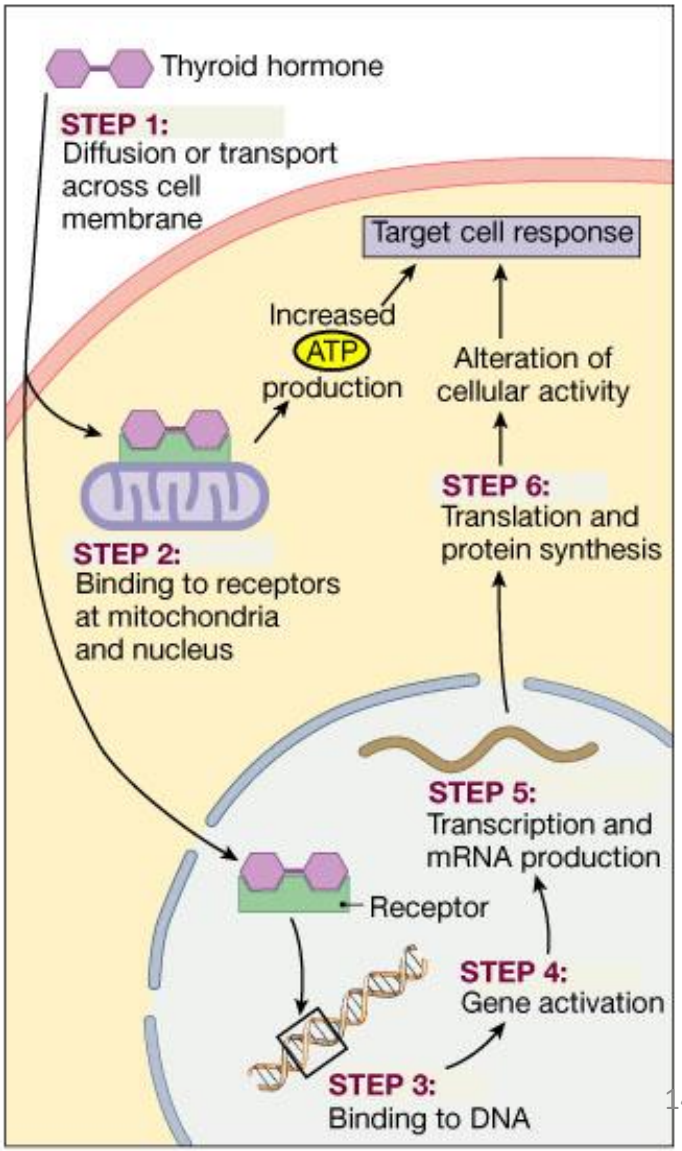


- Hormones that can not cross the membrane (e.g. Peptide hormones) bind to the receptor on the surface of the cell
- Binding of hormones to the receptor activate secondary messenger (in this figure binding of hormone activates G protein, and activated G protein activates adenylcyclase or activate PDE or activates PLC

Hormone Effects on Gene Activity

Hormones that can cross the membrane (e.g. steroid hormones) bind to the receptor inside the cell, at the cytoplasm, or they will enter the nucleus and bind to the receptor at the nucleus and initiate transcription)





Control of Hormone Synthesis and Release

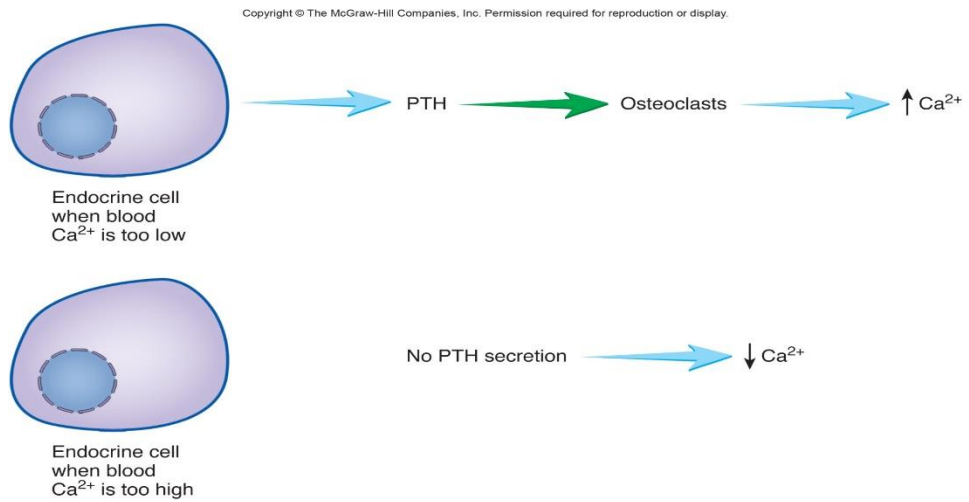
- Blood levels of hormones:
  - Are controlled by negative feedback systems
  - Vary only within a narrow desirable range

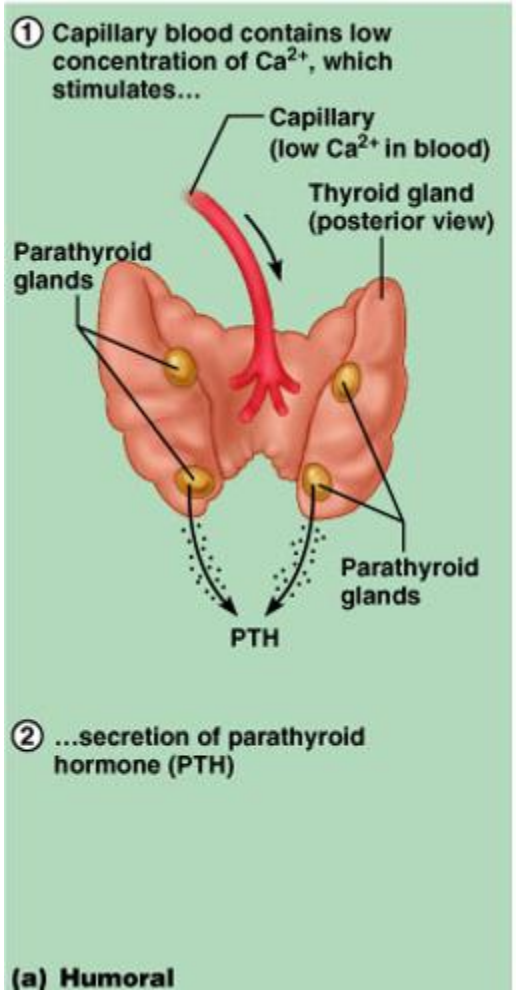
- Hormones are synthesized and released in response to:
  - Humoral stimuli
  - Neural stimuli
  - Hormonal stimuli

Control by Humoral Stimuli

Humoral stimuli – secretion of hormones in response to changing levels of ions or nutrients in the blood.

- Example: concentration of calcium ions in the blood
  - Declining blood Ca^{2+} concentration stimulates the parathyroid glands to secrete PTH (parathyroid hormone)
  - PTH causes Ca^{2+} concentrations to rise and the stimulus is removed

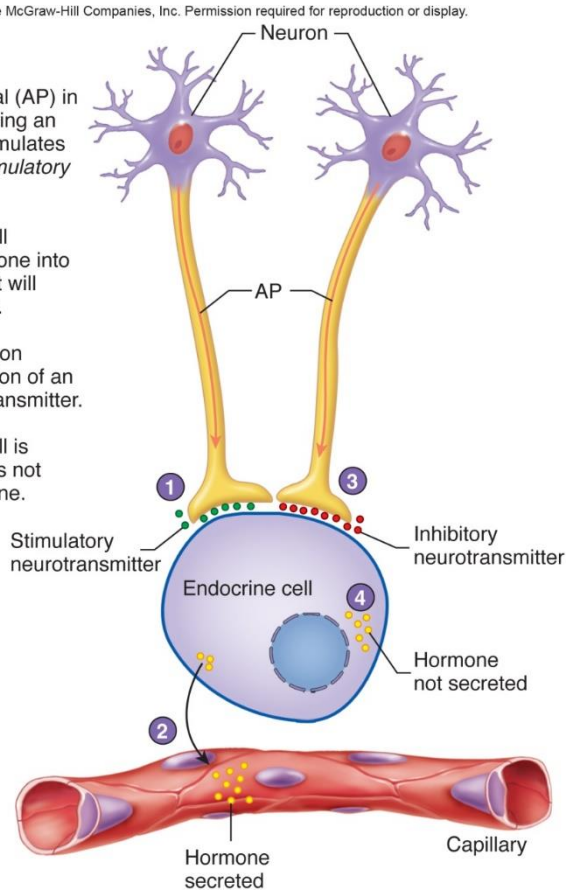




Control by Neural Stimuli

Neural stimuli – nerve fibers stimulate hormone release

- Preganglionic sympathetic nervous system (SNS) fibers stimulate the adrenal medulla to secrete catecholamines



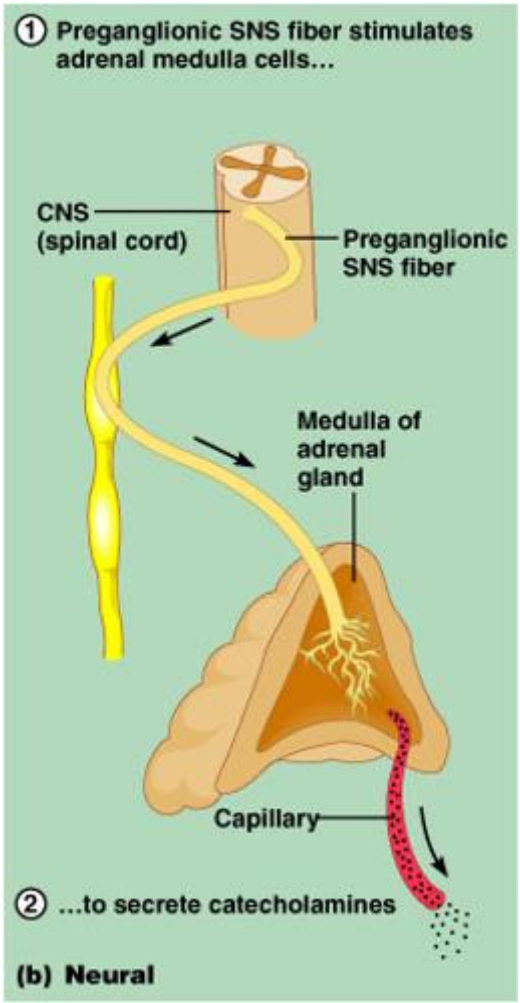
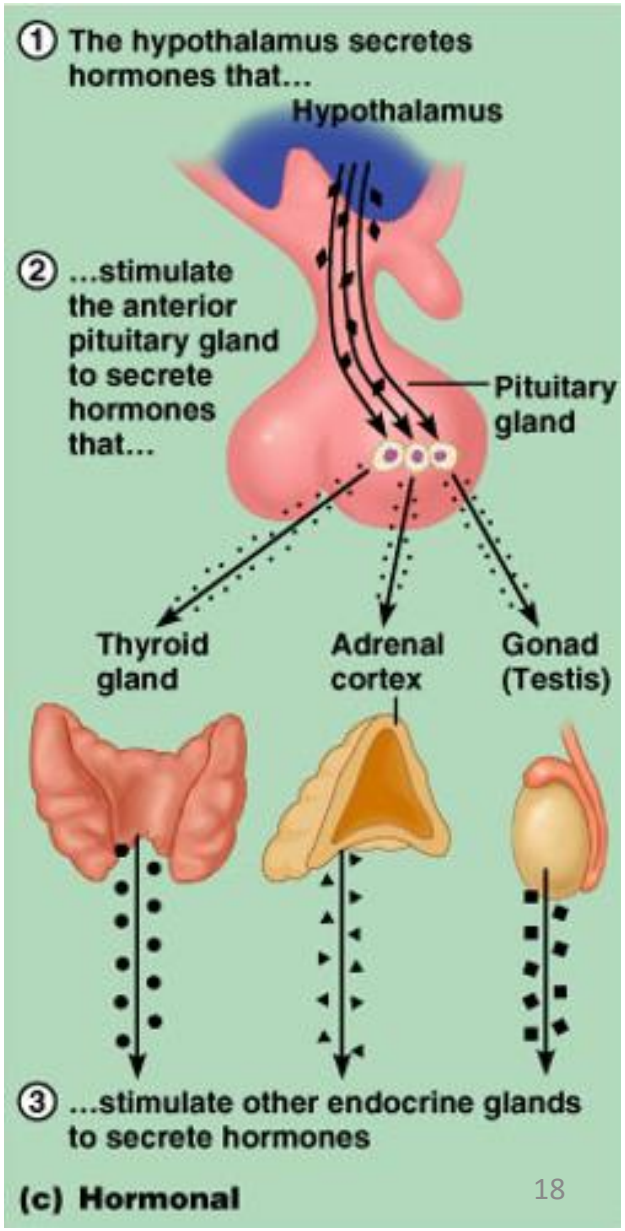


Figure 17.3b

Control by Hormonal Stimuli

Hormonal stimuli – stimulation received from other hormones

- The hypothalamic hormones stimulate the anterior pituitary
- In turn, pituitary hormones stimulate targets to secrete still more hormones



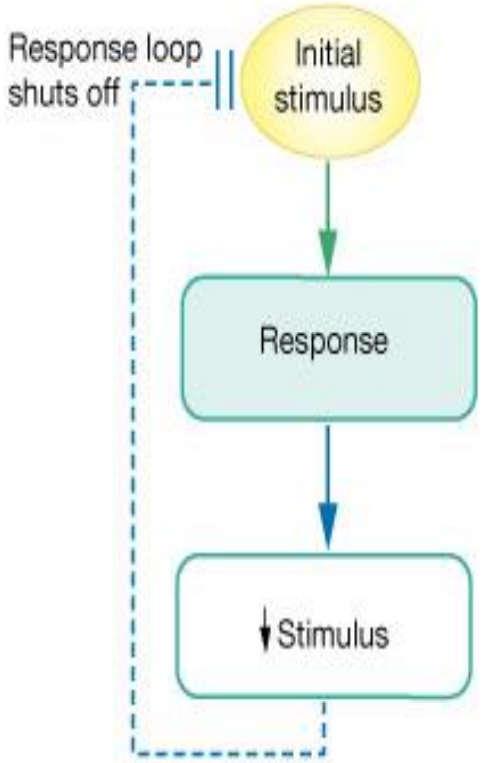
Feedback control of hormone secretion

1) Negative feedback: Prevents over secretion of the hormone or over activity at the target tissue.

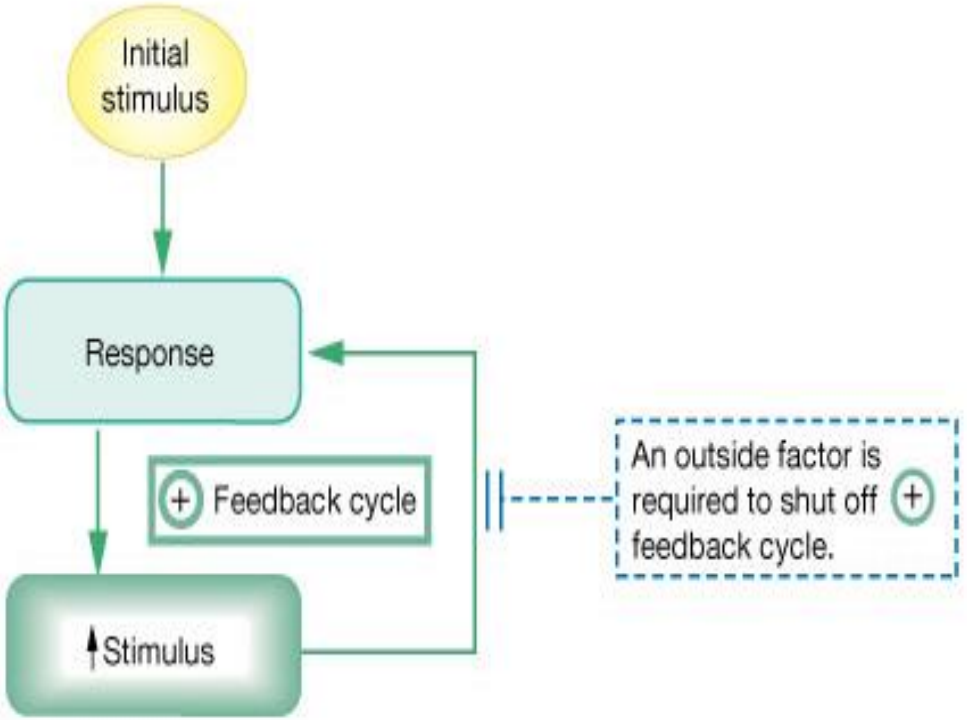
2) Positive feedback: There are two or more variables, if one increases the second one ,the second one in turn increases the first one or the 3rd one. E.g. Ovulation.

3) Cyclical variations occur in hormone release

(a) Negative feedback: the response counteracts the stimulus shutting off the response loop.

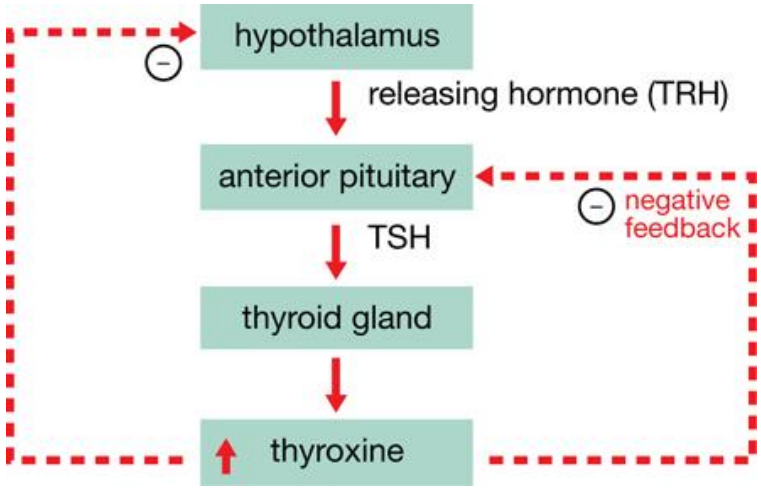


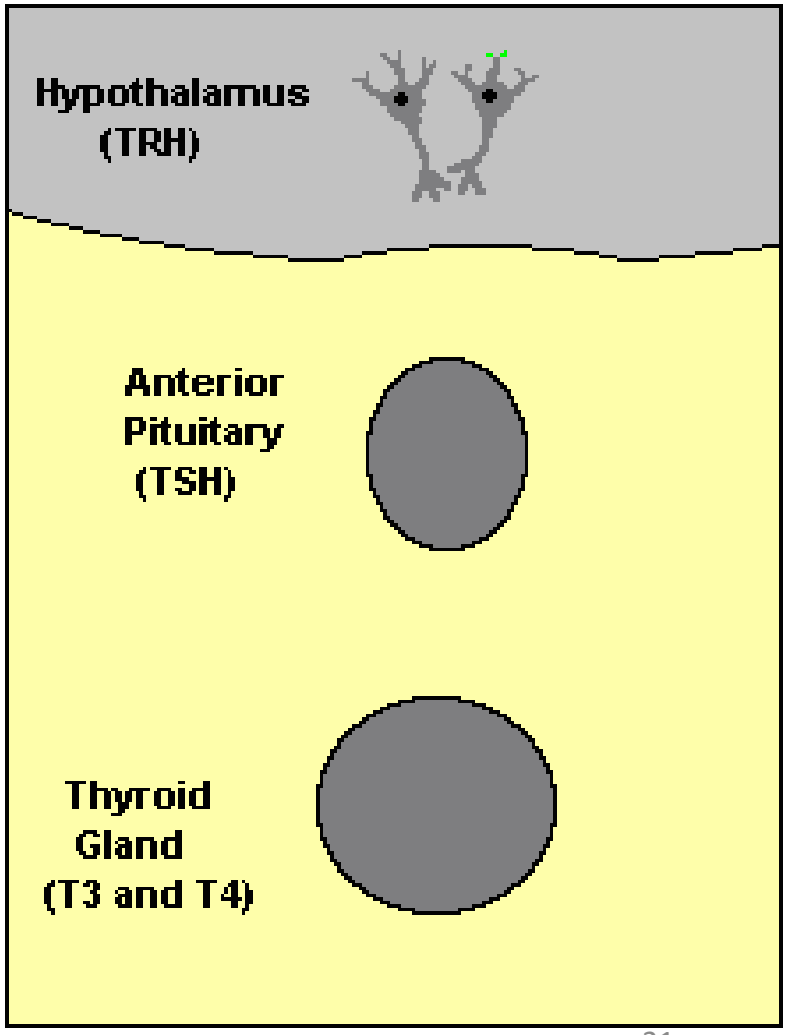
(b) Positive feedback: the response reinforces the stimulus sending the parameter farther from the setpoint.



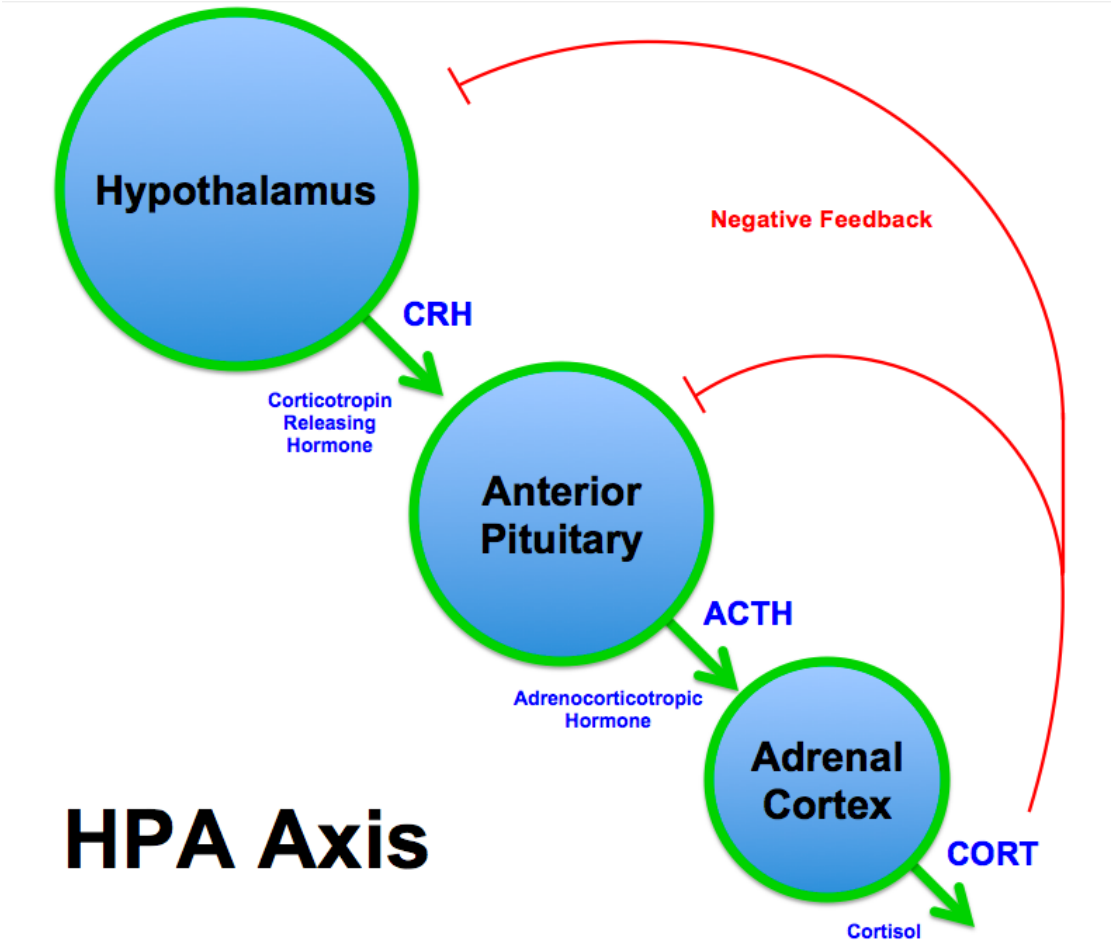
Feedback Control of Hormone Production

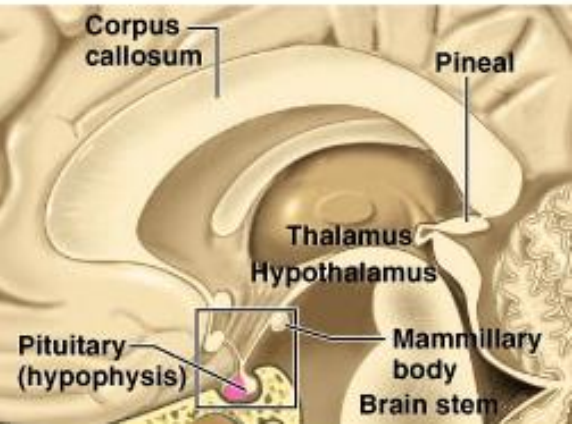
Feedback loops are used extensively to regulate secretion of hormones in the hypothalamic-pituitary axis. An important example of a negative feedback loop is seen in control of thyroid hormone secretion



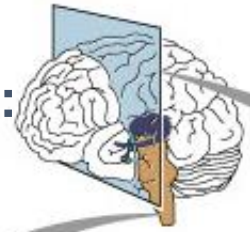


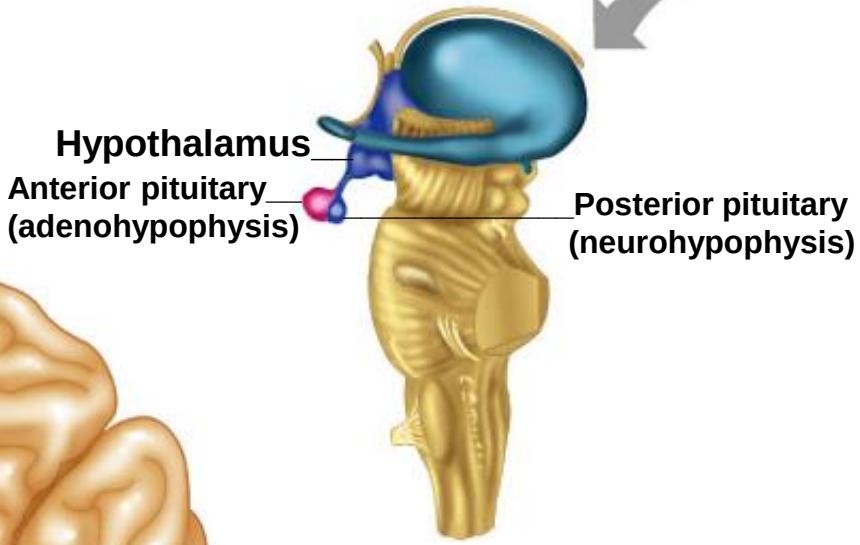
Negative feedback effects of cortisol

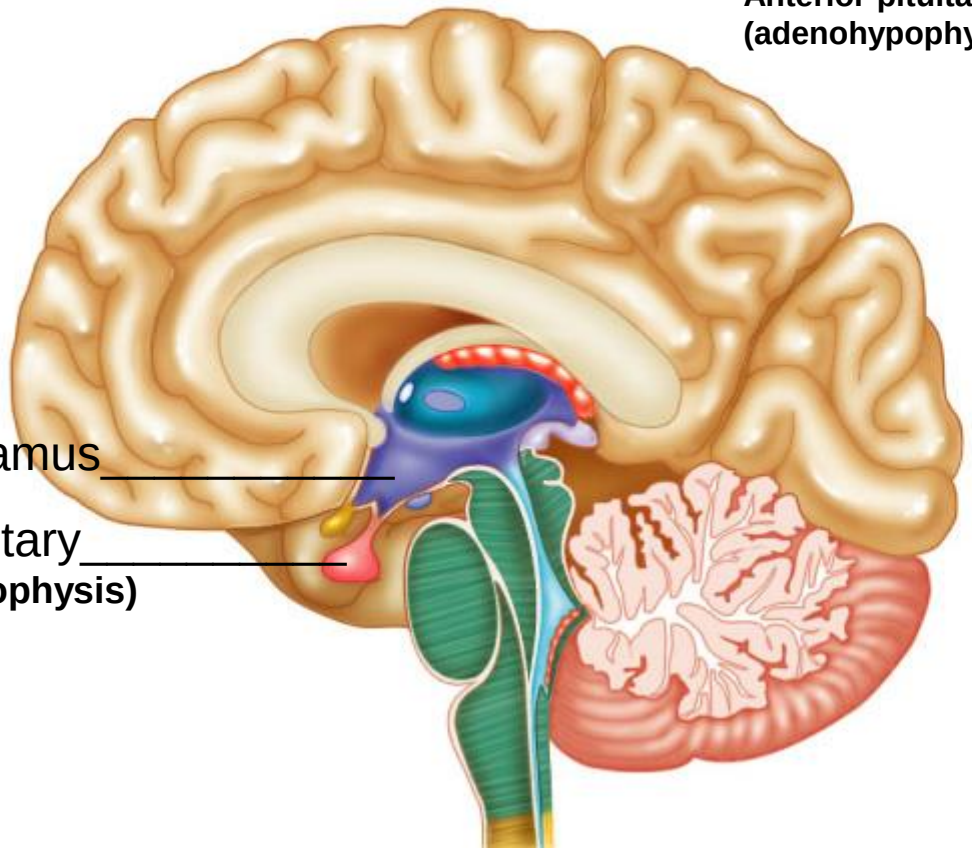




Learn the 2 endocrine glands on this slide:
Hypothalamus
Pituitary (hyophysis)







The Pituitary

Pituitary secretes 9 hormones

Two divisions:

- Anterior pituitary
  (adenohypophysis)

1. TSH
2. ACTH
3. FSH
4. LH

5. GH
6. PRL
7. MSH

The first four are "tropic" hormones, they regulate the function of other hormones

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- Posterior pituitary
  (neurohypophysis)

8. ADH (antidiuretic hormone), or vasopressin
9. Oxytocin

What the letters stand for…

- TSH: thyroid-stimulating hormone
- ACTH: adrenocorticotropic hormone
- FSH: follicle-stimulating hormone
- LH: luteinizing hormone
- GH: growth hormone
- PRL: prolactin
- MSH: melanocyte-stimulating hormone

- ADH: antidiuretic hormone
- Oxytocin

Hypothalamus controls anterior pituitary hormone release

- Releasing hormones (releasing factors) of **hypothalamus**

  Secreted like neurotransmitters from neuronal axons into capillaries and veins to anterior pituitary (adenohypophysis)

  TRH (thyroid releasing hormone) → TSH

  CRH (corticotropin releasing hormone) → ACTH

  GnRH (gonadotropin releasing hormone) → FSH and LH

  PRF (prolactin releasing hormone) → PRL

  GHRH (growth hormone releasing hormone) → GH

- Inhibiting hormones of **hypothalmus**

  PIF (prolactin inhibiting factor) → PRL

  GH (growth hormone) inhibiting hormone → GH

The hypothalamus controls secretion of hormones which in their turn control the secretion of hormones by the thyroid gland, the adrenal cortex and gonads: in this way the brain controls these endocrine glands

PITUITARY HORMONES FUNCTION

The four tropic ones regulate the function of other hormones:

- TSH stimulates the thyroid to produce thyroid hormone
- ACTH stimulates the adrenal cortex to produce corticosteroids: aldosterone and cortisol
- FSH stimulates follicle growth and ovarian estrogen production; stimulates sperm production and androgen-binding protein
- LH has a role in ovulation and the growth of the corpus luteum; stimulates androgen secretion by interstitial cells in testes

The others from the anterior pituitary…

- GH (somatrotropic hormone) stimulates growth
- PRL stimulates mammary glands in breast to make milk
- MSH stimulates melanocytes

From the posterior pituitary (neurohypophysis)

- ADH (antidiuretic hormone vasopressin) stimulates the kidneys to reclaim more water from the urine, raises blood pressure

- Oxytocin prompts contraction of smooth muscle in reproductive tracts, in females initiating labor and ejection of milk from breasts

Summary

- Endocrine glands throughout body are key to chemical integration and homeostasis
- Protein, polypeptide, amine and a few steroid hormones are plasma soluble and target membrane
- Surface receptors transduce signals into cell and activate via second messengers

Summary

- Most steroid and some amine hormones are lipophilic, can pass into cell, bind on cytoplasmic or nuclear receptors and activate DNA for protein synthesis

- Hypothalamus, pituitary trophic hormone pathways coordinate endocrine regulation

Thank you for your attention