

Unit Fourteen: Endocrinology and Reproduction

Chapter 74: Introduction to Endocrinology

Guyton and Hall, Textbook of Medical Physiology, 12 edition



Coordination of Body Functions by Chemical Messengers

- **Neurotransmitters** –released by axon terminals into synaptic junctions and act locally to control nerve cell functions
- **Endocrine Hormones** –released into the blood and affect target cells at another location in the body
- **Neuroendocrine Hormones** –secreted by neurons into the blood and affect target cells at another location



Coordination of Body Functions by Chemical Messengers

- **Paracrines** –secreted by cells into the ECF and affect neighboring target cells
- **Autocrines** –secreted by cells into the ECF and affect the function of the same cells that produced them
- **Cytokines** –peptides secreted into the ECF and can function as paracrines, autocrines, or endocrine hormones

Coordination of Body Functions by Chemical Messengers

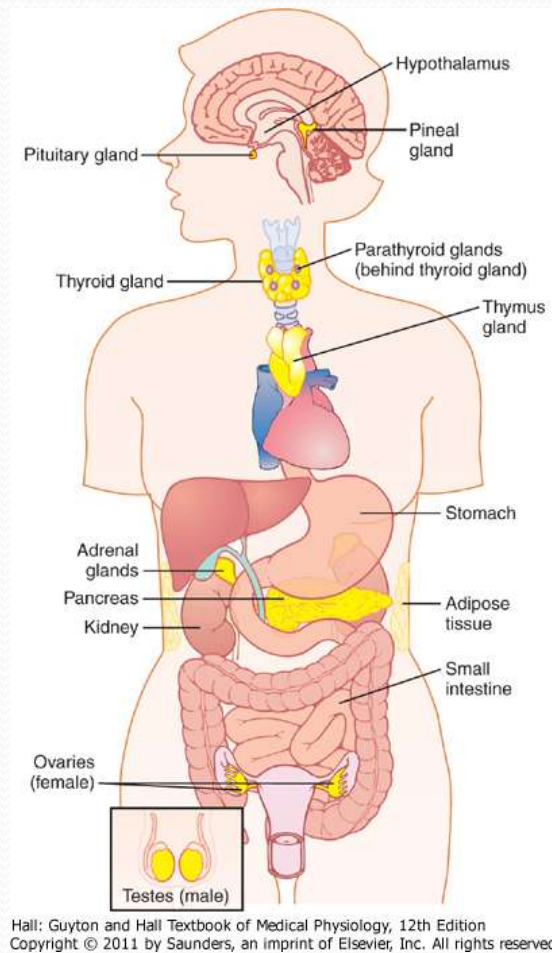


Fig. 74.1 Anatomical location of the principal endocrine glands and tissues



Chemical Structure and Synthesis of Hormones

- **Three General Classes of Hormones**
 - a. Proteins and polypeptides
 - b. Steroids
 - c. Derivatives of the amino acid tyrosine



Chemical Structure and Synthesis of Hormones

- **Proteins and Polypeptides**
 - a. Synthesized on the rough ER
 - b. First made as a preprohormone which is cleaved into a prohormone
 - c. Stored in vesicles as an active hormone and are released by exocytosis
 - d. Trigger for release can be cAMP, calcium, or some other chemical



Chemical Structure and Synthesis of Hormones

- **Steroid Hormones**

- a. Derived from cholesterol
- b. Very little storage
- c. Because they are lipid soluble, they diffuse across the cell membrane into the interstitial fluid and then the blood



Chemical Structure and Synthesis of Hormones

- **Amine Hormones**

- a. Derived from tyrosine
- b. Includes thyroid and adrenal medullary hormones
- c. Thyroid is stored in the thyroglobulin
- d. Adrenal medullary hormones include epinephrine and norepinephrine

Chemical Structure and Synthesis of Hormones

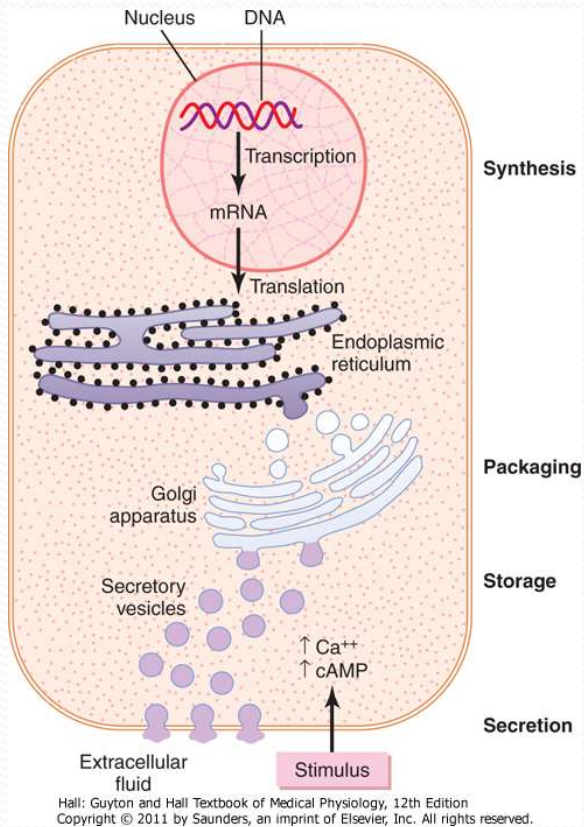


Fig. 74.2 Synthesis and secretion of peptide hormones

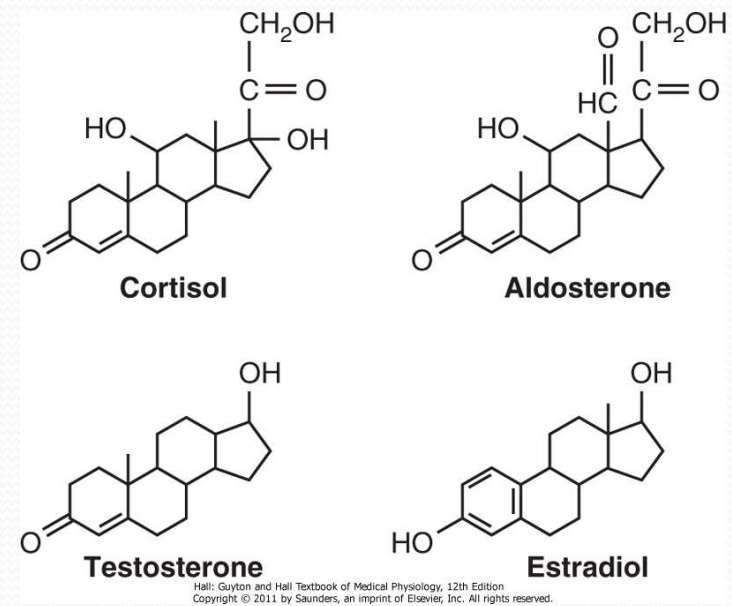


Fig. 74.3 Chemical structures of several steroid hormones



Hormone Secretion, Transport, and Clearance

- **Onset of Hormone Secretion After a Stimulus, and Duration of Action of Different Hormones**
 - a. Each hormone has its own characteristic onset and duration of action; epinephrine and norepinephrine are secreted within seconds and develop full action within another few seconds; thyroxine may require months for full effect



Hormone Secretion, Transport, and Clearance

- **Concentration of Hormones in the Circulating Blood and Hormonal Secretion Rates**
 - a. Range from 1 picogram to a few micrograms
 - b. Rates are measured in micrograms or milligrams/day



Hormone Secretion, Transport, and Clearance

- **Feedback Control**

- a. Negative feedback prevents overactivity of hormone systems
- b. Surges of hormones can occur with positive feedback (i.e. LH)
- c. Cyclical variations occur in hormone release (seasonal changes, aging, diurnal cycles, and sleep)



Hormone Secretion, Transport, and Clearance

- **Transport of Hormones in the Blood**
 - a. Water soluble hormones are dissolved in plasma and diffuse into the interstitial spaces to the target cell
 - b. Steroid and thyroid hormones-circulate in the blood bound to plasma proteins; must dissociate from the carrier to be active (can act as hormone reservoirs)

Hormone Secretion, Transport, and Clearance

- **Clearance of Hormones from the Blood-** two factors affect the increase or decrease of hormone concentration in the blood
 - a. Rate of hormone secretion into the blood
 - b. Rate of removal of the hormone from the blood (metabolic clearance rate)

$$\text{Metabolic clearance rate} = \frac{\text{Rate of disappearance of hormone from the plasma}}{\text{Concentration of hormone}}$$



Hormone Secretion, Transport, and Clearance

- **Clearance of Hormones from the Blood**
 - c. Hormones are cleared from the plasma in several ways:
 1. Metabolic destruction by the tissues
 2. Binding with the tissues
 3. Excretion by the liver into the bile
 4. Excretion by the kidneys into the urine



Mechanisms of Action

- **Hormone Receptors and Their Activation**
 - a. First step is to bind at a specific receptor at the target cell
 - b. Cells without receptors do not respond to a given hormone
 - c. Receptors may be
 - 1. In or on the surface of the cell membrane- mostly for the protein, peptide, and catecholamine hormones



Mechanisms of Action

- **Hormone Receptors and Their Activation**
 2. In the cell cytoplasm- primary receptors for steroid hormones
 3. In the cell nucleus- receptors for thyroid hormone



Mechanisms of Action

- **Number and Sensitivity of Hormone Receptors Are Regulated**
 - a. Down Regulation- increased hormone concentration and increased binding with its receptors causes the number of active receptors to decrease; occurs as a result of:
 1. Inactivation of some of the receptor molecules
 2. Inactivation of some of the intracellular signals
 3. Temporary sequestration of the receptor to the inside of the cell



Mechanisms of Action

- **Number and Sensitivity of Hormone Receptors Are Regulated**
 - 4. Destruction of the receptors by lysosomes
 - 5. Decreased production of the receptor
 - b. Up Regulation- the stimulating hormone induces greater than normal formation of receptor or signaling molecules; the target tissue becomes progressively more sensitive to the hormone



Mechanisms of Action

- **Intracellular Signaling After Hormone Receptor Activation**
 - a. Ion channel linked receptors-most neurotransmitters combine with receptors at the surface of the post-synaptic membrane
 - b. Binding usually opens or closes channels (i.e. Na, K, or Ca ions)
 - c. Altered movements of ions may cause the effects or more commonly attach to G-proteins or enzyme-linked receptors

Mechanisms of Action

- G-Protein Linked Receptors

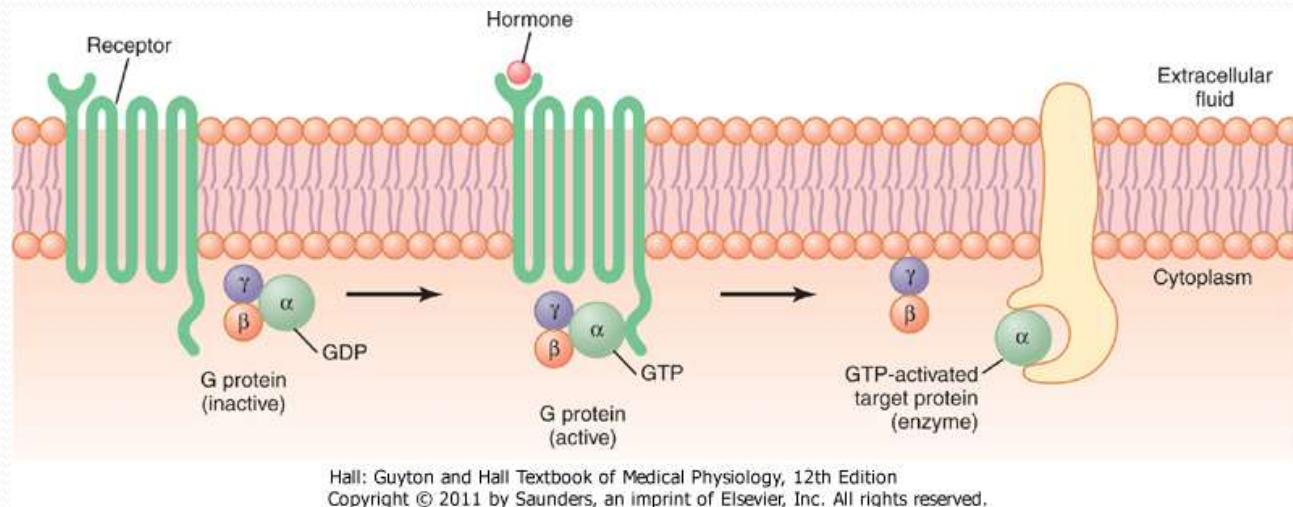


Fig. 74.4 Mechanism of action of G-protein coupled receptor

Mechanisms of Action

- **Enzyme Linked Hormone Receptors**

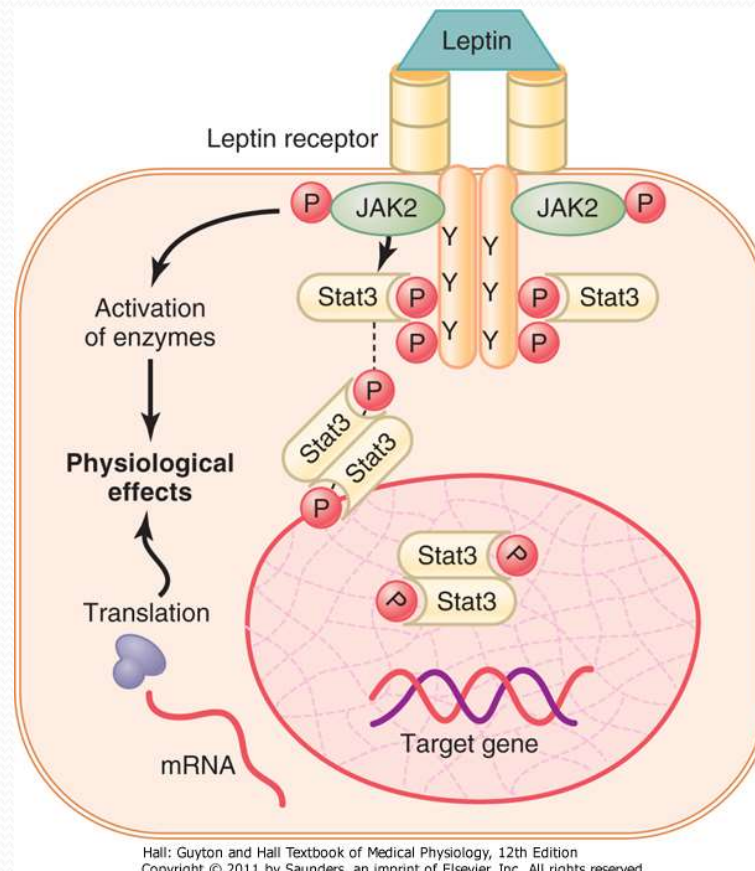


Fig. 74.5

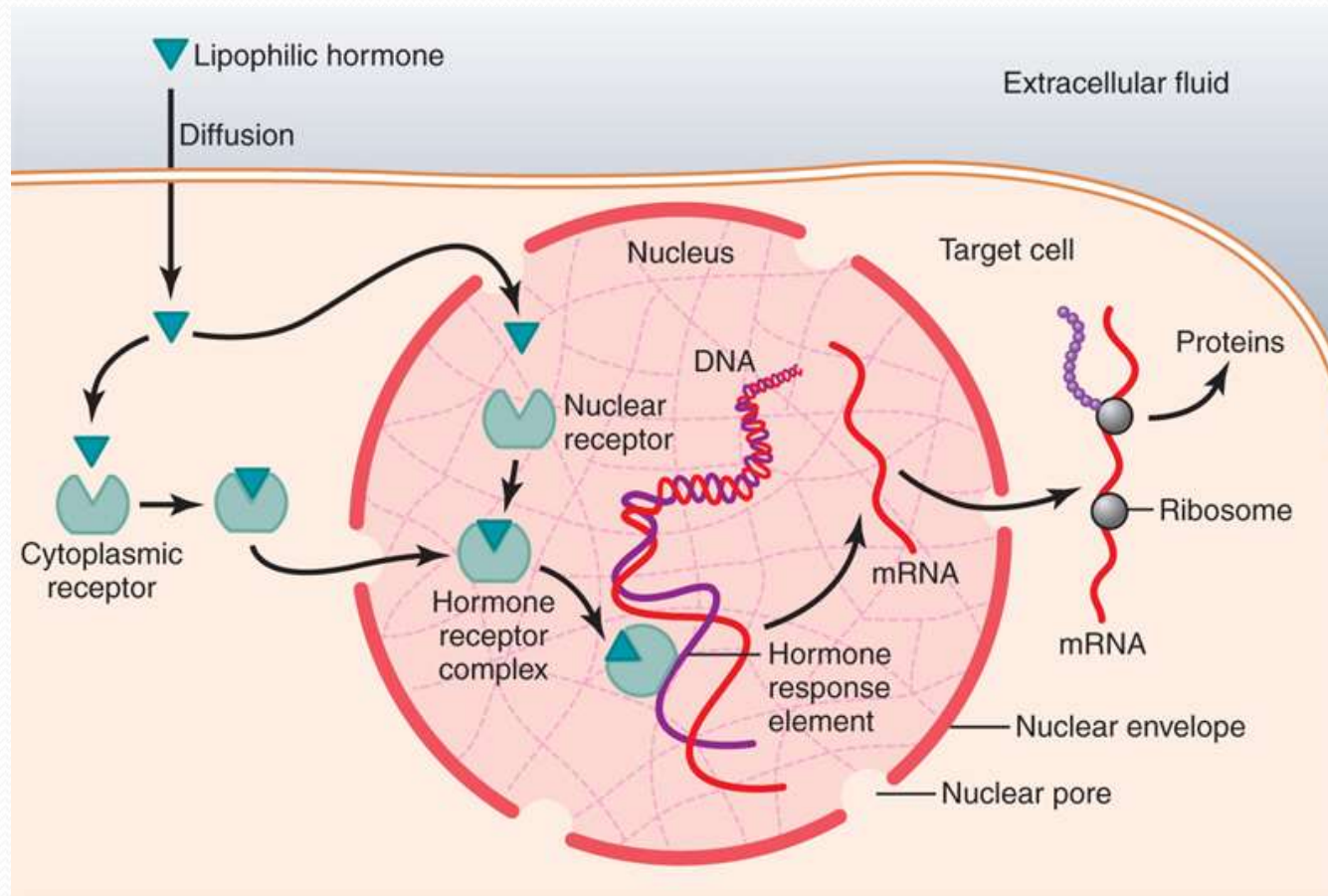


Mechanisms of Action

- **Enzyme Linked Hormone Receptors**
 - a. Hormone binding site is on the outside of the membrane and their catalytic or enzymatic binding site is on the inside of the membrane
- **Intracellular Hormone Receptors**
 - a. Adrenal and gonadal steroid hormones, thyroid, retinoid, and vitamin D bind with receptors inside the cell or nucleus
 - b. These are all lipid soluble

Mechanisms of Action

- Intracellular Hormone Receptor**



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Fig. 74.6



Mechanisms of Action

- **Second Messenger Mechanisms for Mediating Intracellular Hormonal Functions**
 - a. cAMP-adenyl cyclase system
 - b. Calcium and associated calmodulin
 - c. Products of membrane phospholipid breakdown

Mechanisms of Action

- Hormones That Use the cAMP System**

ACTH	HCG
Angiotensin II	LH
Calcitonin	PTH
Catecholamines	Secretin
CRH	Somatostatin
FSH	TSH
Glucagon	Vasopressin

Mechanisms of Action

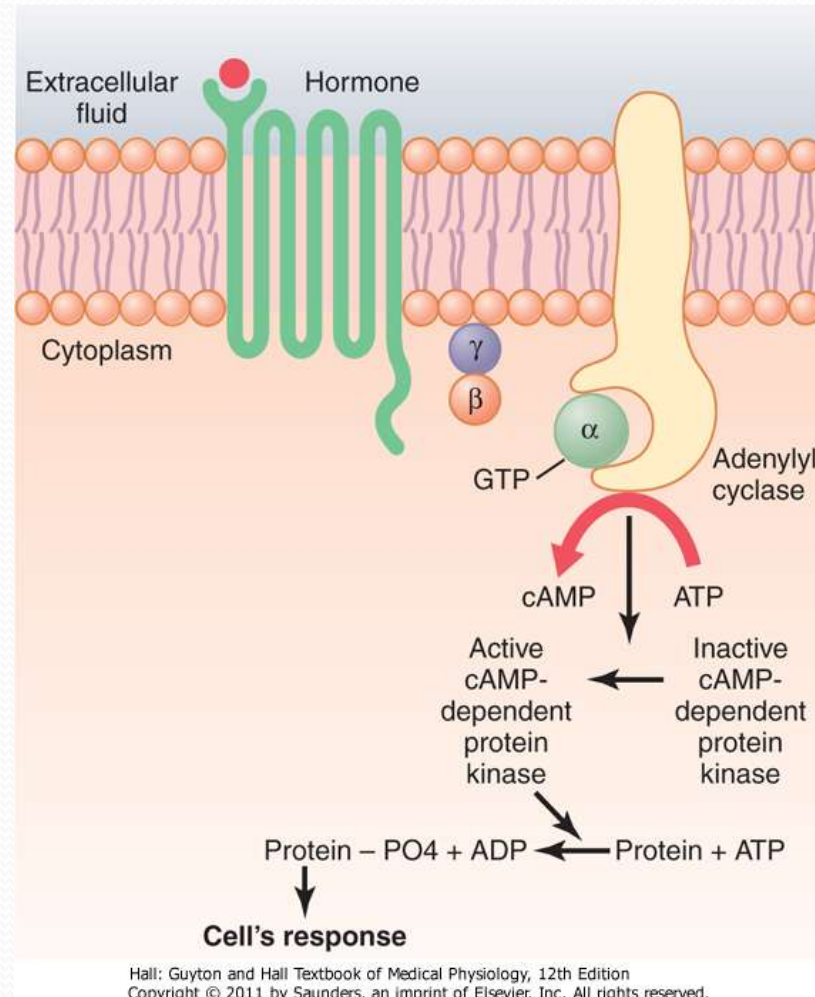


Fig. 74.7



Mechanisms of Action

- **Cell Membrane Phospholipid Second Messenger**
 - a. Activate phospholipase C attached to the membrane
 - b. Hormones that use this system include: angiotensin II, catecholamines, GnRH, GHRH, oxytocin, TRH, and vasopressin

Mechanisms of Action

- **Cell Membrane Phospholipid Second Messenger**

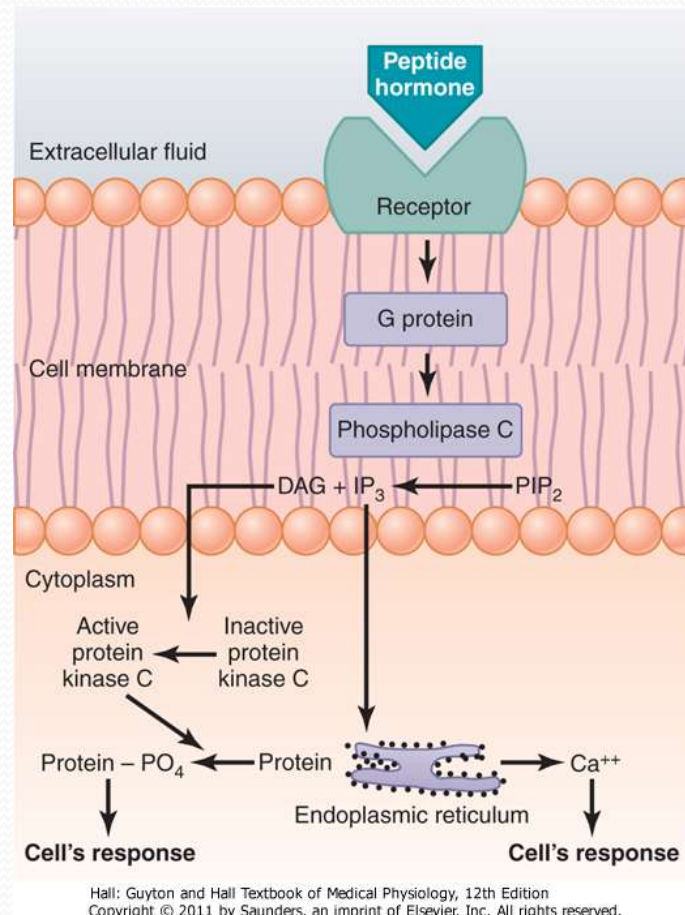


Fig. 74.8



Mechanisms of Action

- **Calcium-Calmodulin Second Messenger**
 - a. Calcium entry is initiated by (1) changes in the membrane potential that opens calcium channels, or (2) hormones that interact with membrane receptors and open the calcium channels
 - b. Calcium binds with calmodulin(has 4 binding sites)
 - c. When 3 binding sites are filled, the calmodulin initiates multiple effects inside the cell



Mechanisms of Action

- **Hormones That Act Mainly on the Genetic Machinery of the Cell**
 - a. Steroid hormones increase protein synthesis
 - b. Thyroid hormones increase gene transcription in the nucleus