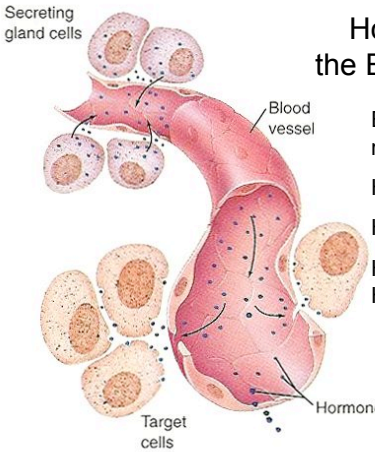


Hormones and the Endocrine System

Extracellular chemical messengers

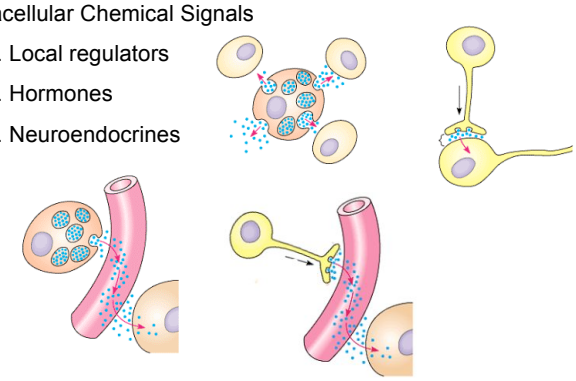
Hormone Dynamics

Human Endocrine System

Homeostatic Regulation by Hormones

Extracellular Chemical Signals

1. Local regulators
2. Hormones
3. Neuroendocrines



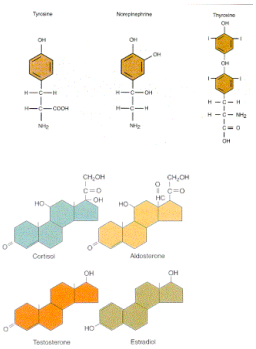
Hormones reaches all parts of body; only act on cells with appropriate receptors = target cells

Chemical Classification of Hormones:

More than 50 known hormones in humans

3 major classes:

1. Peptide & Protein hormones
2. Amino acid derivatives
   - Derived from tyrosine
3. Steroid hormones
   - Derived from cholesterol



Blood concentrations of hormones

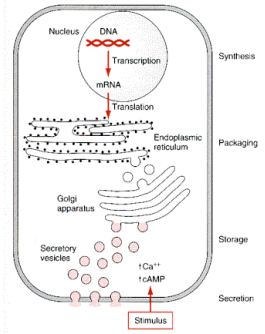
between a few picograms (10^{-12} g; pg) and a few micrograms (10^{-6} g; μg) per ml of serum

Concentration depends on the

rate of secretion (usually mg or μg per day)
rate of inactivation
mechanism of transport in the bloodstream

Protein and peptide hormone synthesis

Small peptides as small as three amino acids (TRH) to proteins up to 200 amino acids long (GH, PRL).

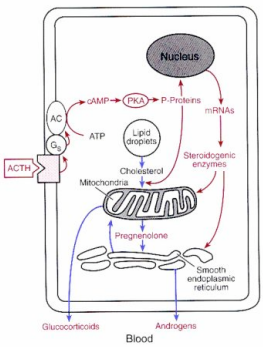


Usually stored in secretory vesicles.

Rate of hormone secretion is usually determined by the rate of exocytosis.

Steroid hormone synthesis

Derived from cholesterol.



Steroidogenic enzymes are located in the cytosol, smooth ER and mitochondria.

Steroid hormones are usually secreted as they are synthesized.

Rate of secretion is proportional to the rate of synthesis.

Depends on enzyme activity and the availability of precursors.

Regulation of hormone secretion

Most hormones are continually secreted into the bloodstream.

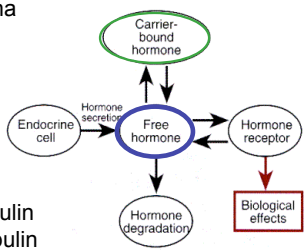
The secretion of hormones is controlled by three general mechanisms:

1. regulation by other hormones
2. regulation by the nervous system
3. regulation by changes in plasma solute concentrations
   a. ions
   b. organic nutrients

Transport of hormones in the bloodstream

Protein and peptide hormones and the **catecholamines**
water-soluble
transported dissolved in plasma

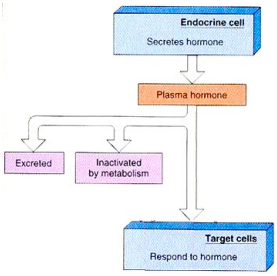
Steroid and **thyroid hormones**
low water solubility
majority are bound to protein carriers in the blood
- albumin is non-specific
- thyroxine binding globulin
- sex hormone binding globulin
- corticosteroid binding globulin



Only the free fraction is biologically active
usually less than 10%

Hormone catabolism and excretion

Catabolized - Control concentration by regulating secretion.



Protein and peptide hormones are degraded by breaking peptide bonds.

Steroid hormones are hydroxylated and then conjugated to glucuronides or sulfate to increase their water solubility.

Most are catabolized by the liver and kidneys, but may be inactivated in target tissues.

Degraded hormones are excreted in the feces and urine.

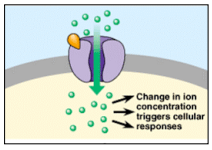
Hormone half life

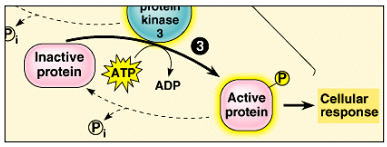
Peptides and catecholamines generally have a very short half life = seconds to minutes.

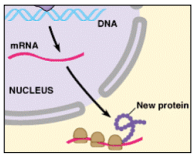
Steroids and thyroid hormone, which are bound to plasma proteins, have a long half life = hours.

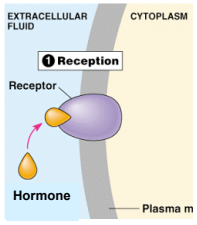
Mechanism of Hormone Action

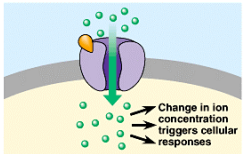
1. Alter ion permeability by regulating ion channels
2. Activate second messenger systems to change the activity of pre-existing proteins
3. Activate specific genes to cause formation of new proteins



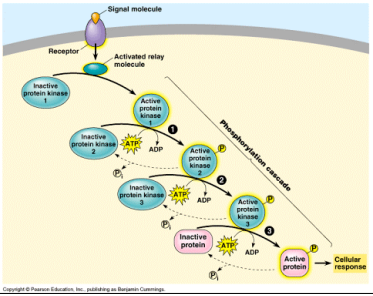


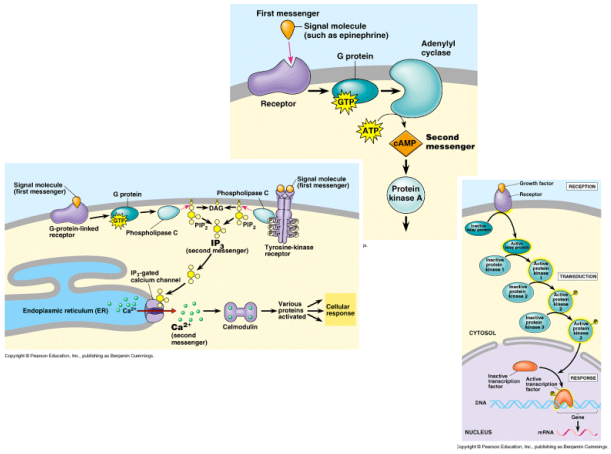


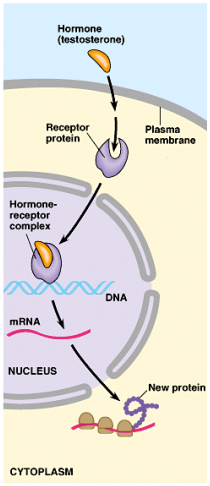




- **Peptide hormone** and **catecholamine** receptors are located on the cell membrane.
- Open ion channels or activate signal transduction pathways.
- Rapid response, usually within one minute.

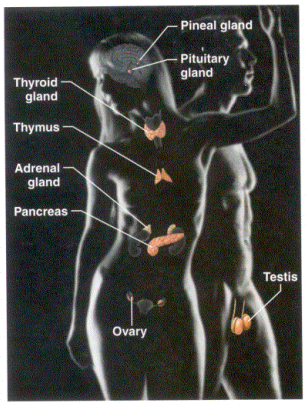






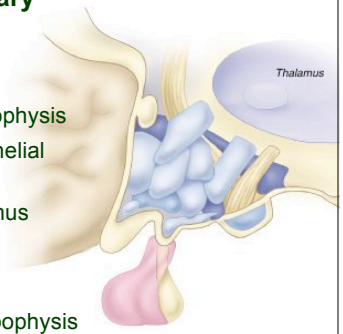
- **Steroid** and **thyroid hormones** receptors are located inside the cell.
- Hormone-receptor complexes are transcription factors.
- Stimulate the transcription of specific gene(s) and thus increase the synthesis of certain proteins.
- Onset of steroid hormone action is slow (30-60 min).

Human Endocrine System



Hypothalamus
Pituitary
Thyroid
Parathyroid glands
Adrenal glands
Pancreas
Gonads

Hypothalamus and Pituitary



Pituitary - 2 major divisions:

Anterior pituitary = adenohypophysis

- Endocrine secretory cells (epithelial tissue)
- Hormones from the hypothalamus control secretion by the anterior pituitary.

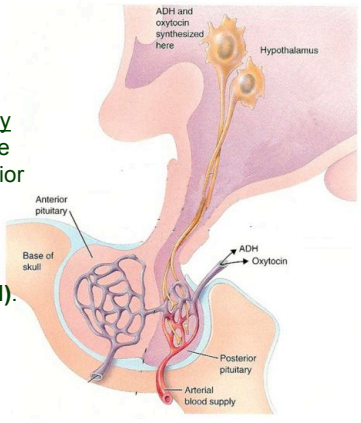
Posterior pituitary = neurohypophysis

- Nerve fibers, axon terminals and support cells (neural tissue)
- Hypothalamic nervous output terminates in the posterior pituitary and controls secretion.

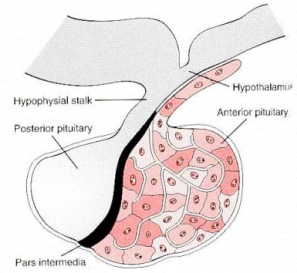
Posterior pituitary

Hypothalamic neurosecretory cells send axons to terminate near capillaries in the posterior lobe of the pituitary.

Produces the small peptide hormones **oxytocin** and **antidiuretic hormone (ADH)**.



Anterior Pituitary



At least five different kinds of endocrine cells, each of which secretes a different hormone.

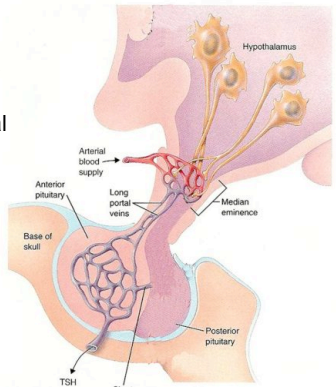
thyroid-stimulating hormone (TSH)
adrenocorticotropic hormone (ACTH)
growth hormone (GH)
luteinizing hormone (LH)
follicle-stimulating hormone (FSH)
prolactin (PRL)

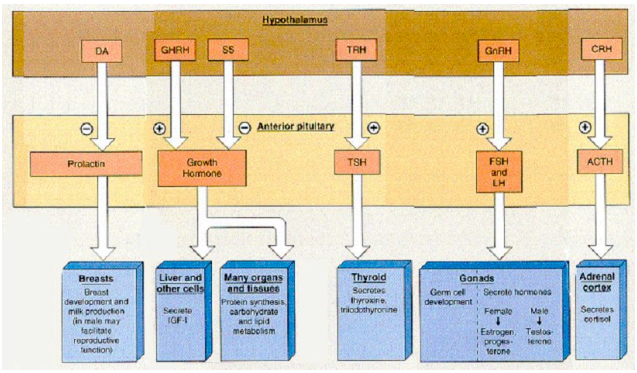
All protein hormones

Hypothalamic neurons secrete hormones that are carried to the anterior pituitary by a venous portal system.

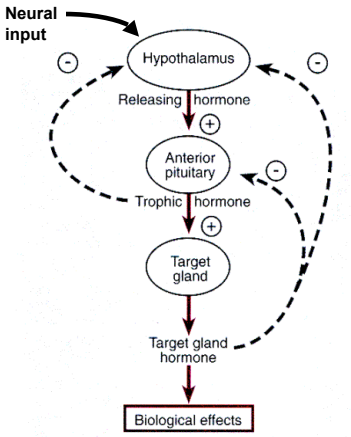
1. Releasing factors
2. Inhibiting factors

Most are peptides





Negative feedback regulation of anterior pituitary



Releasing hormone from the hypothalamus.

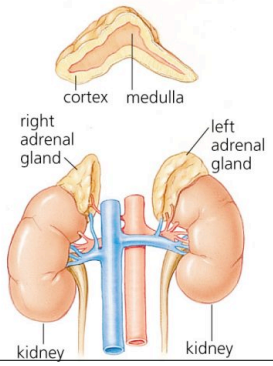
Tropic hormone from the anterior pituitary.

Target gland hormone from the target gland.

Adrenal Glands

Located on superior surface of kidneys

1. **Adrenal Cortex**
2. **Adrenal Medulla**



Adrenal Medulla

Stimulated by sympathetic activity

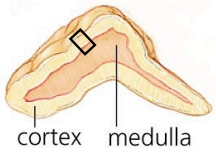
Secretes **epinephrine and norepinephrine**

Same actions as **sympathetic NS** activity –

- Increase heart rate;
- Vasoconstriction;
- Increases blood pressure;
- Increased blood sugar;
- Decreased intestinal activity

Adrenal Cortex

1) Zona glomerulosa
2) Zona fasciculata
3) Zona reticularis



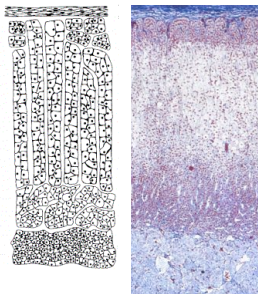
1. Secretes **aldosterone** = **mineralocorticoid**

   Regulates blood pressure and plasma volume

2. Secrete **glucocorticoids** (mainly **cortisol**) and sex steroids.

   Glucocorticoids regulate metabolism – anti insulin effects.

   Regulated by ACTH.



Thyroid Gland

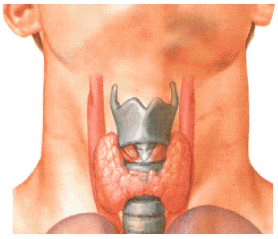
1. **Follicles**

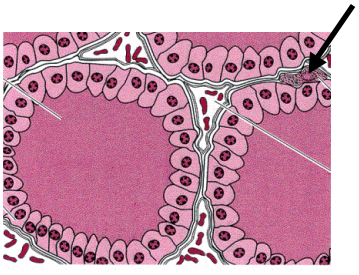
   Simple cuboidal epithelial cells **= follicular cells**

   Surround **colloid** – storage form of thyroid hormone

2. **C cells = parafollicular cells**

   Clusters of cells found between follicles; secrete calcitonin





Follicular cells

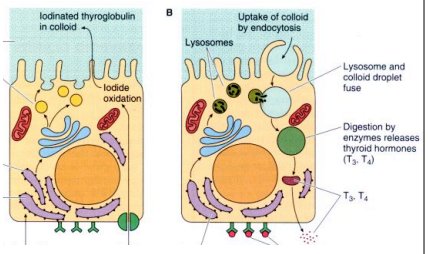
Synthesizes and secretes **thyroglobulin** (protein of colloid) to center of follicle

Phagocytosis and degradation of colloid releases **thyroid hormone** to interstitium

Thyroid hormone

Increases **metabolic rate**

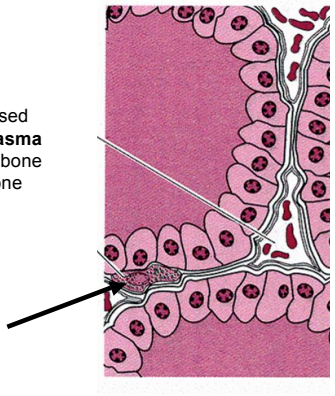
Influences mental acuity, and growth & development of CNS, and of tissues in general



C cells = parafollicular cells

Calcitonin

Secreted in response to increased plasma calcium **Decreases plasma calcium** mainly by decreasing bone reabsorption and increasing bone deposition



Parathyroid glands

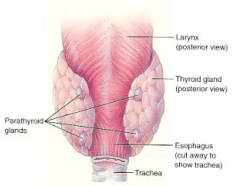
4 small glands located on dorsal aspect of lobes of thyroid gland

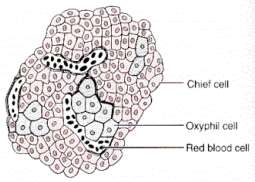
Parathyroid hormone

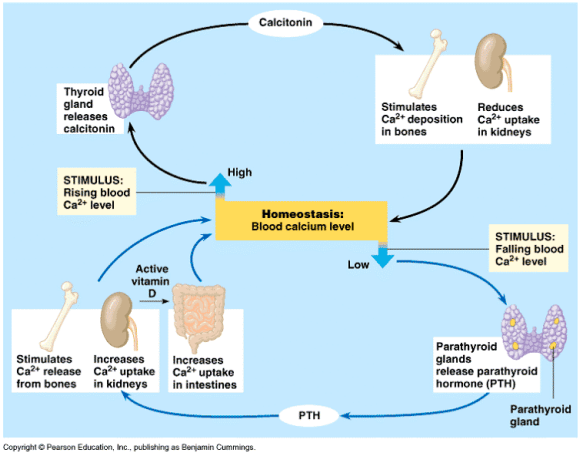
Released in response to decreased plasma calcium.
Increases plasma calcium.

Calcitonin from the thyroid gland:

Secreted in response to increased plasma calcium.
Decreases plasma calcium.

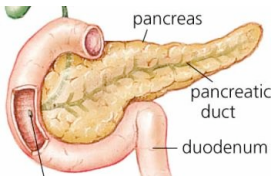


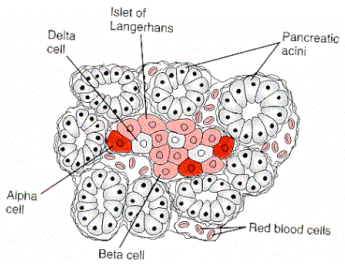




Pancreas

Islets of Langerhans



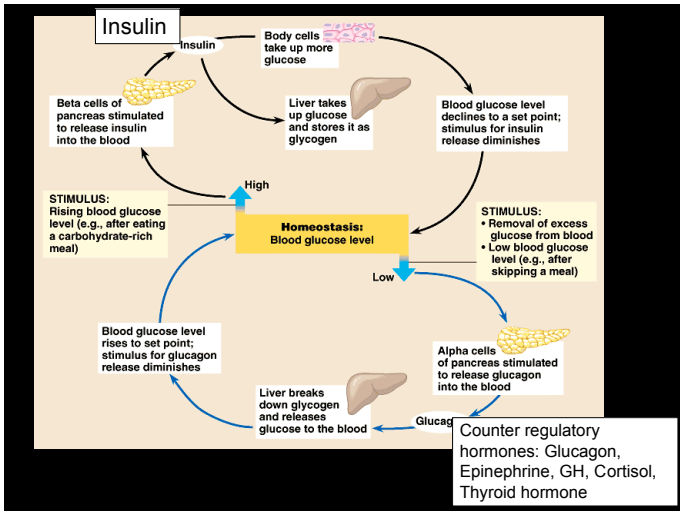


Beta (B) cells secrete **insulin.**

Decreases plasma glucose by increasing movement of glucose into cells and its metabolic utilization; inhibits metabolism of lipids.

Alpha (A) cells secrete **glucagon.**

Increases plasma glucose by increasing synthesis and release of glucose by the liver.



Counter regulatory hormones: Glucagon, Epinephrine, GH, Cortisol, Thyroid hormone