Endocrine System -Training Handout

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The endocrine system is a chemical control system. It functions in conjunction with the nervous system to control the internal environment (homeostasis).

Nervous System vs. Endocrine System – both systems enable cells to communicate with other by using chemical messengers.

	Nervous System	**Endocrine System**
Chemical Messenger	neurotransmitters	hormones
Location of message	synapses	target cells
Effects	rapid & short-lasting	slower & longer lasting
Controls	muscles & glands	activities of cells

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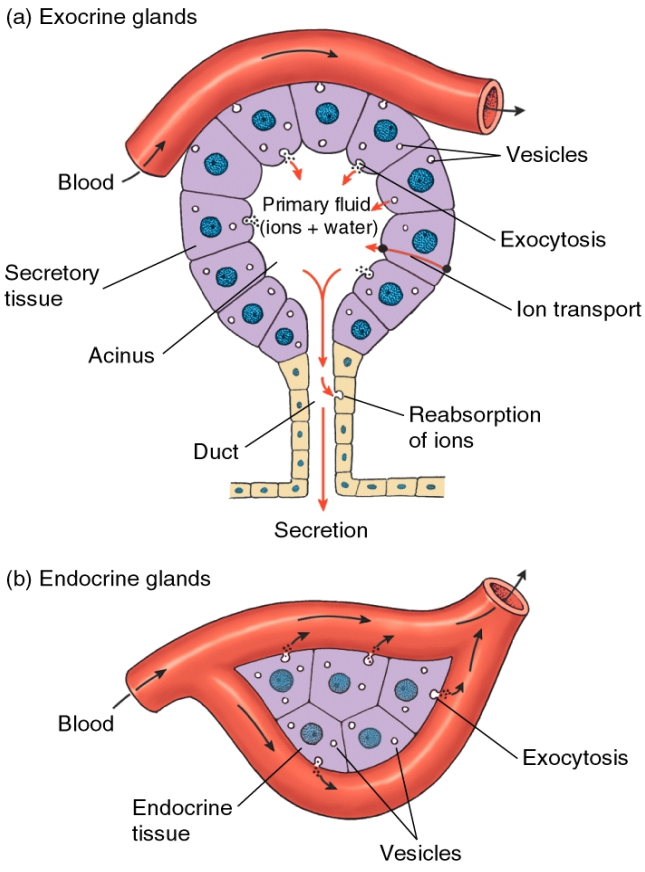
Type of Glands

- **Endocrine Glands** – discharge secretions through a duct to a targeted tissue such as digestive glands

- **Endocrine Glands** – release secretions directly into the blood stream so they are ductless.
  - The secretions are chemical messengers or hormones
  - Each hormone has a specific target tissue which may increase or decrease its activity such as insulin
  - They are not secreted at a constant rate – the rate will vary with the needs of the body



Endocrine Glands

- The endocrine system is in charge of processes that happen slowly, such as the growth of cells.

- The glands and hormones of the endocrine system influence almost every cell and organ in the body

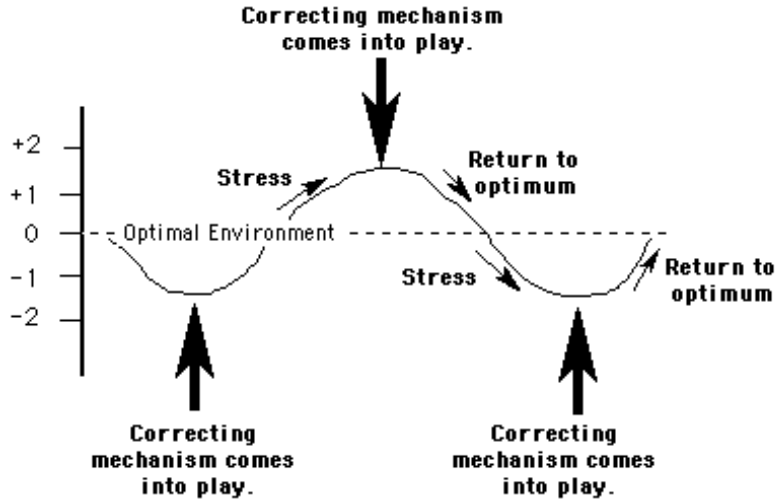
ENDOCRINE SYSTEM AND HOMEOSTASIS

Homeostasis – a stable internal environment - (nutrition, metabolism, excretion, water and salt balances).

Feedback Mechanisms

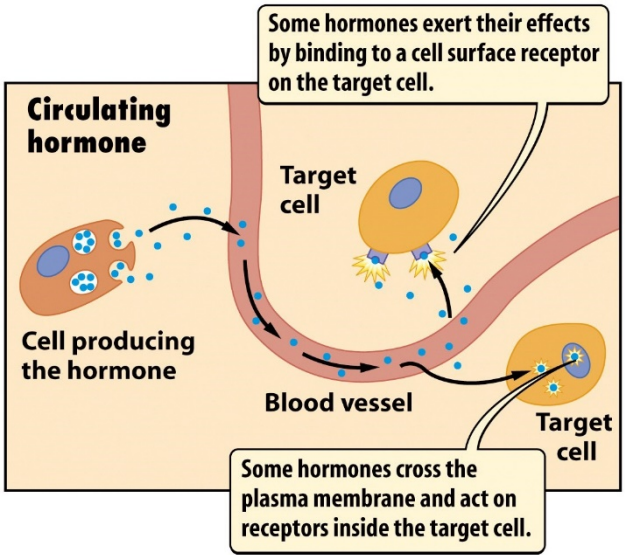
Stimulus
- change in homeostatic environment
- signal sent to CNS

Response
- signal sent from CNS
- produce effect & body returns to homeostasis



Hormones are the body's chemical messenger.

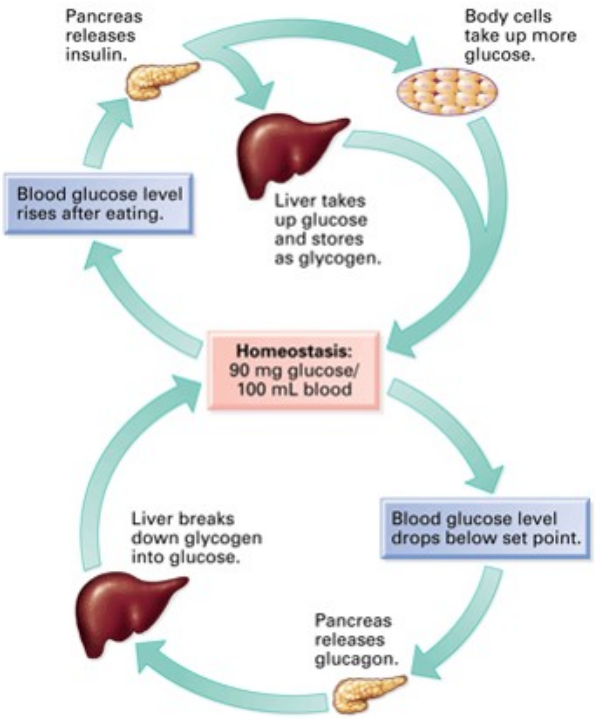
- They send important information from one set of cells to another.
- Each hormone only affects cells that are programmed to receive a specific hormone's message.
- Glands are groups of cells that produce chemical products for our body to use.
- For example, salivary glands produce saliva.
- Once hormone levels reach a certain amount, endocrine system glands will produce less of a specific hormone.
- Endocrine glands are told to produce less of a hormone by substances in the blood or by the very hormone the gland is about to stop producing a large amount of.
- Most hormones use a "turnoff" process is called a **negative feedback or a closed loop system**.



Feedback Mechanisms

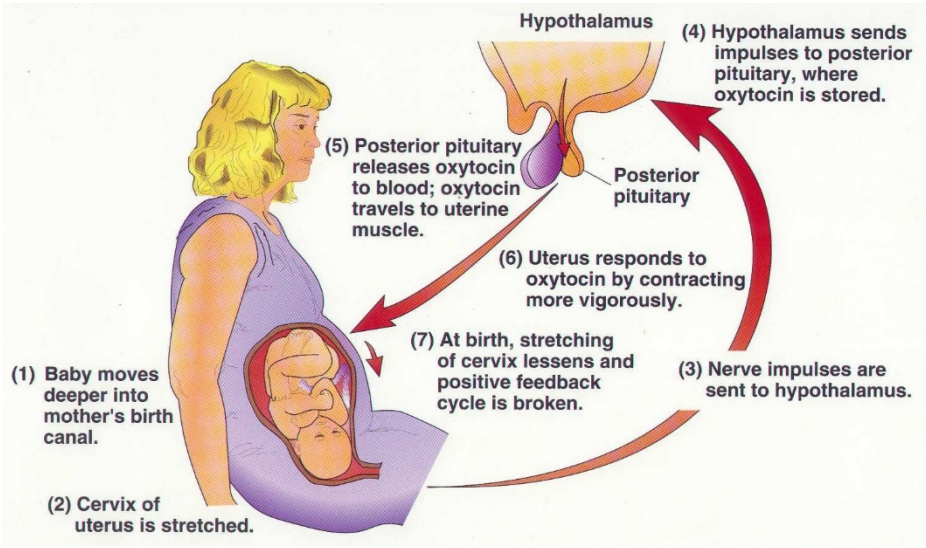
Negative Feedback - response that opposes the original change – **an increase in A will decrease in B.**

- **Most common** control mechanism
- Level of hormone in blood or body's return to homeostasis shuts off loop at hypothalamus and pituitary
- Examples – body temperature and sugar metabolism

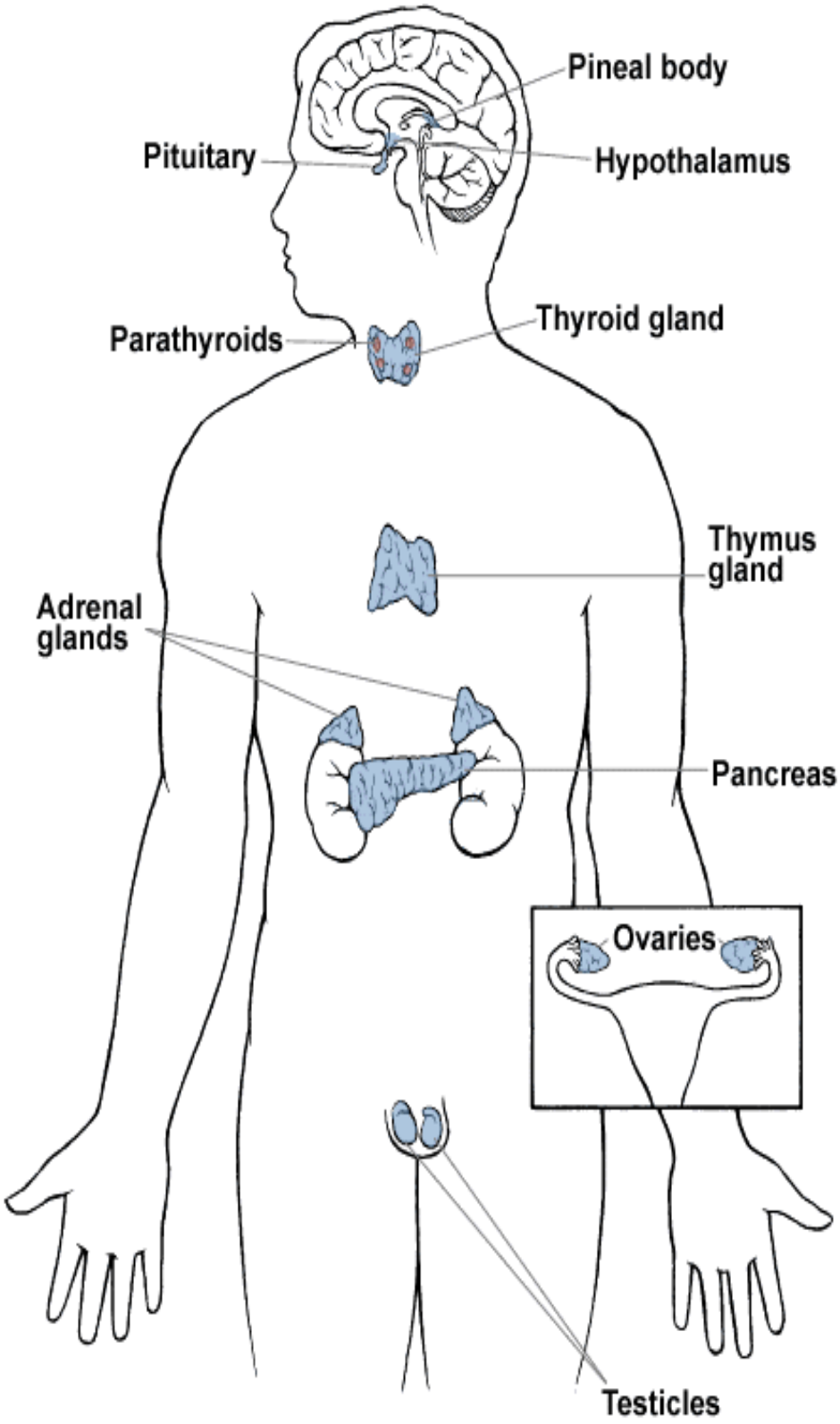


Positive Feedback- reinforces the original change – **an increase in A will cause an increase in B.**

- **Not common – examples – lactation and labor contractions**
- Action of OXYTOCIN on uterine muscle during birth.
  - Baby pushes on cervix
  - Nervous signal to Hypothalamus
  - Hypothal. manufactures OXY
  - OXY transported to POSTERIOR PITUITARY & released
  - OXY stimulates uterine contraction
  - Loop stops when baby leaves birth canal



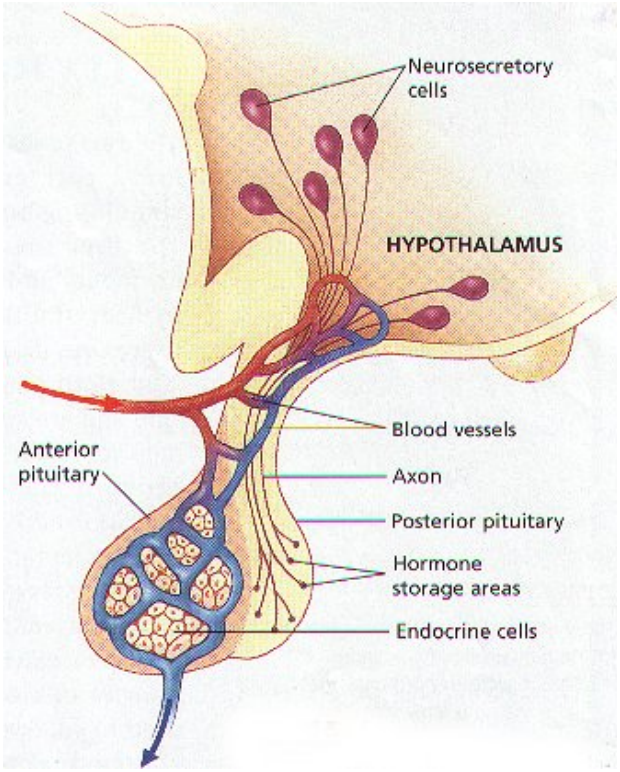
Glands of the Endocrine System



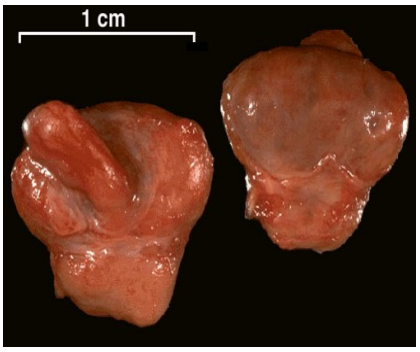
- **Hypothalmus:**
  - Also part of the brain, attached to the posterior pituitary gland
  - Its function is to synchronize the information from the brain and the secretions of hormones
  - **Neurosecretory cells –** specialized neurons that synthesize & secrete hormones
  - The hypothalamus controls the secretions of the pituitary gland through nervous stimulation (posterior pituitary) and releasing hormones secreted to the anterior pituitary
  - Neuronal to POSTERIOR PITUITARY
  - Endocrine to ANTERIOR PITUITARY

    RH = Pituitary releasing hormones

    RIH = Pituitary release inhibiting hormones

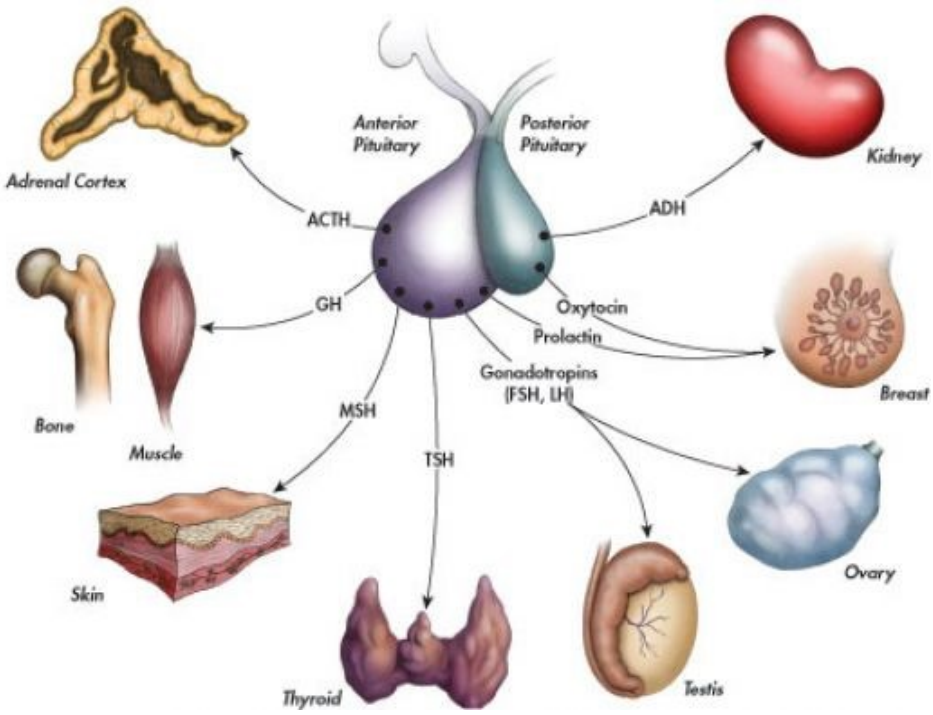


- **Pituitary:**
  - Located at the base of the brain and is no larger than the size of a pea.
  - Considered the most important part of the endocrine system and is often called the "***master gland***".
  - Controls many other endocrine system glands. The pituitary gland helps control body and tissue growth.
  - Also secretes endorphins, chemicals that reduce sensitivity to pain.
  - Divided into anterior and posterior sections

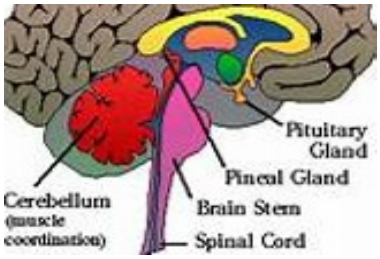


- **Anterior Pituitary:**
  - This is considered the master gland because its secretions regulate many other glands
  - It secretes:
  - **Follicle stimulating hormone (FSH)** and **luteinizing hormone (LH)** which regulate production of estrogen and progesterone
  - **Thyroid stimulating hormone (TSH)** which stimulates the thyroid to release thyroxin
  - **Adreno-corticotropic hormone (ACTH)** which stimulates release of chemicals from the adrenal cortex
  - **Growth hormone (GH)** stimulate cell growth
  - **Melanocyte-stimulating hormone (MSH)** which increases production of the skin pigment melanin
  - **Prolactin** stimulates production of milk in nursing mothers

- **Posterior Pituitary:**
  - The posterior pituitary secretes two hormones:
  - **Oxytocin** which stimulates contractions of the uterus during childbirth and allows the milk to be released from the breast tissue
  - **Antidiuretic hormone (ADH)** which stimulates the kidneys to reabsorb more water from the collecting ducts in the kidneys so there is more water in the blood

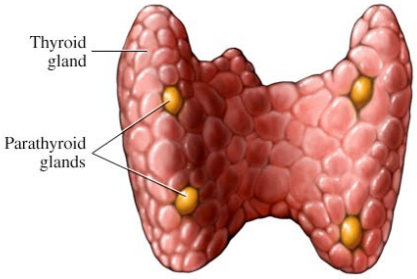


- **Pineal:**
  - The pineal gland is located in the brain
  - It secretes **melatonin,** which regulates our internal clocks and any rhythmic activities
  - It plays a large role in our sleep and wake cycles

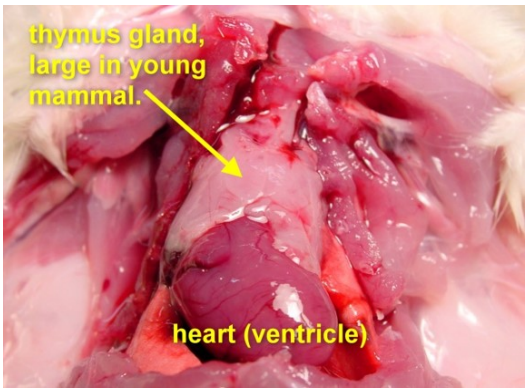


- **Thyroid:**
  - It wraps around the trachea at the base of the neck
  - Secretes a hormone called **thyroxine**
  - Thyroxine regulates the metabolic rates of almost all the cells in the body
  - As the thyroxine levels in the blood increase so does the rate of cellular respiration
  - The thyroid gland needs iodine to create thyroxine, that is why salt is iodized now

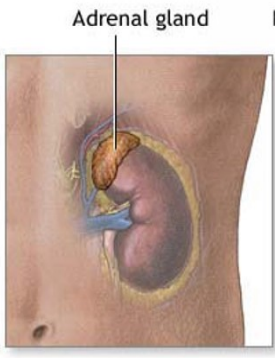
- **Parathyroid:**
  - These four little glands are embedded in the thyroid gland
  - They secrete **parathyroid hormone** which regulates the amount of calcium in the blood and its absorption by bones



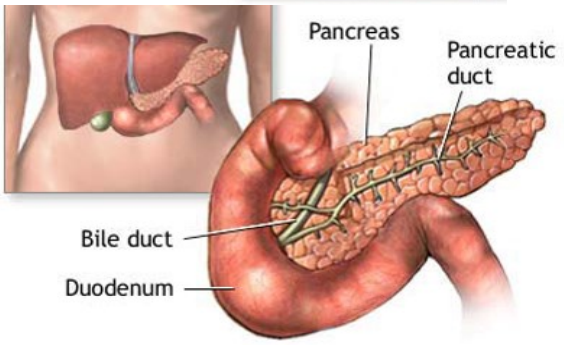
- **Thymus:**
  - Located below the thyroid between the right and left lung
  - Secretes **thymosin** which stimulates T-cell (that is a type of white blood cell) production in children.
  - This gland shrinks with age as we are exposed to more germs and build up our stores of antibodies



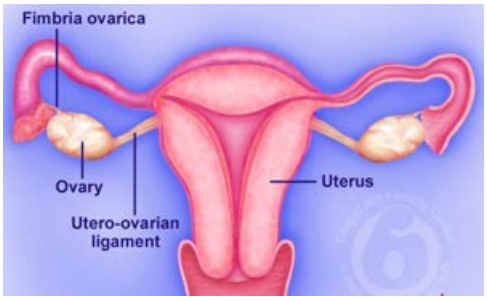
- **Adrenal:**
  - There are two located on top of the kidneys
  - Medulla secretes **epinephrine (adrenaline)** and **norepinephrine** which regulate our fight or flight response at times of extreme stress
  - Cortex secretes **aldesterone** which regulates reabsorption of nutrients from the kidney
  - It also secretes **cortisol** which controls the rate of metabolism of carbohydrates, fats, and proteins



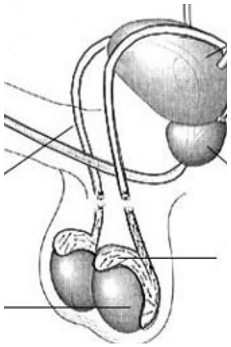
- **Pancreas:**
  - Located behind the right side of the stomach
  - Secretes **insulin** which tells the liver and muscles to remove sugar from the blood and store it as fat
  - Also secretes **glucagon** which tells the liver to break down fat stores and release sugar back into the blood



- **Ovaries:**
  - Secrete **estrogen** and **progesterone** which regulate the female menstrual cycle
  - Endometrium in the uterus also secretes a female hormone when a fertilized egg binds to it to stop the menstrual cycle from progressing to menstruation



- **Testicles:**
  - Secretes male steroid hormones such as **testosterone**.
  - Testosterone controls development of male characteristics such as formation of male sex organs in the womb, sperm development, and secondary sex characteristics at puberty (deep voice, facial hair, chest and armpit hair, etc)



ENDOCRINE SYSTEM DISORDERS

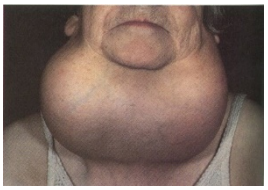
- **Hyper** = secretion of too much hormone
- **Hypo** = secretion of insufficient hormone
- Target cell insensitivity produces symptoms similar to hyposecretion.

Pituitary Gland Disorders:

- **Pituitary dwarfism** = hyposecretion of GH
- **Giantism** = hypersecretion of GH during childhood
- **Acromegaly** = hypersecretion of GH during adulthood
- **Diabetes insipidus** = hyposecretion of ADH which causes excretion of large amounts of dilute urine and subsequent dehydration and thirst

Thyroid Gland Disorders:

- **Cretinism** = hyposecretion of thyroid hormones during fetal life or infancy.
- **Myxedema** = hypothyroidism during adult years
- **Grave's Disease** = an autoimmune disease which is the most common form of hyperthyroidism
- **Goiter** = enlarged thyroid gland



Parathyroid Gland Disorders:

- **Hypoparathyroidism** results in muscle tetany
- **Hyperparathyroidism** produces osteitis fibrosa cystica which results in demineralization of the bone.

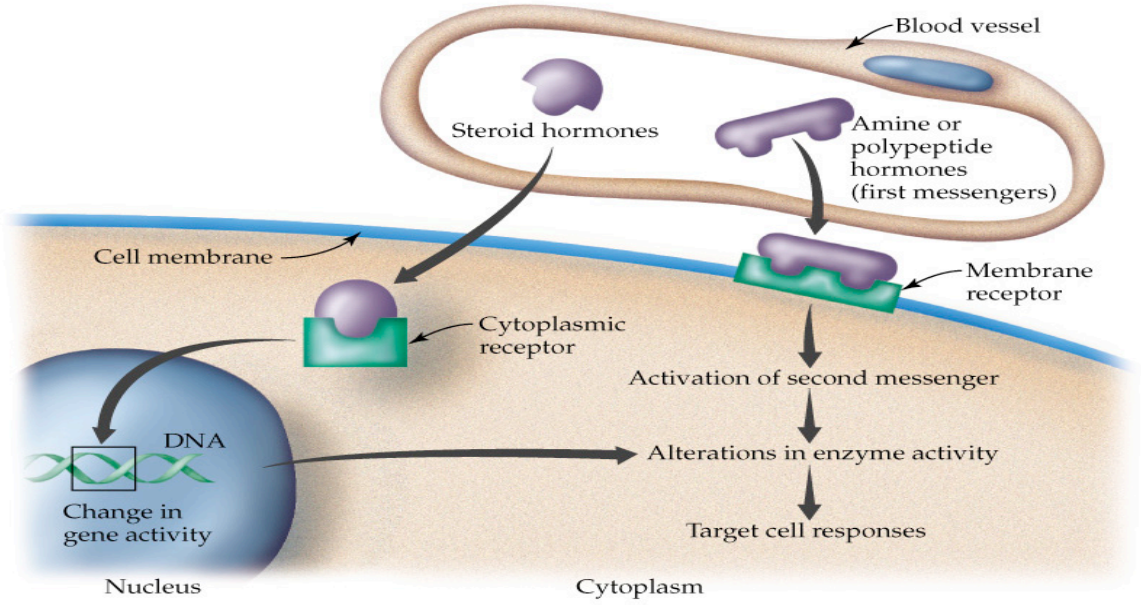
Adrenal Gland Disorders:

- **Cushing's Syndrome** = hypersecretion of cortisol by the adrenal cortex
- **Addison's Disease** = hyposecretion of glucocorticoids and aldosterone
- Tumors of the adrenal medulla can cause hypersecretion of medullary hormones and a prolonged "fight or flight" response.

Pancreatic Disorders:

- **Diabetes mellitus** = a group of disorders caused by an inability to produce or use insulin
- **Type I or insulin-dependent diabetes mellitus** is caused by an absolute deficiency of insulin
- **Type II or insulin-independent diabetes** is caused by down-regulation of insulin receptors
- **Hyperinsulinism** results when too much insulin is present and causes **hypoglycemia** (low blood sugar) and possibly insulin shock.

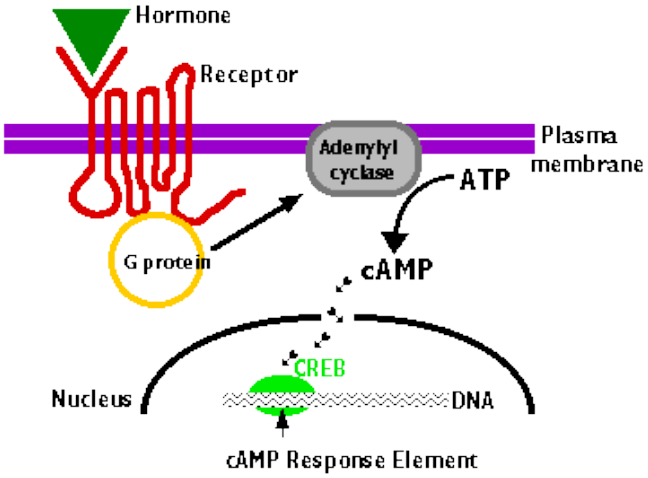
Mechanism of Hormone Action



Peptides and Amines – non-steroid water soluble – large & can't fit through membrane of target cell

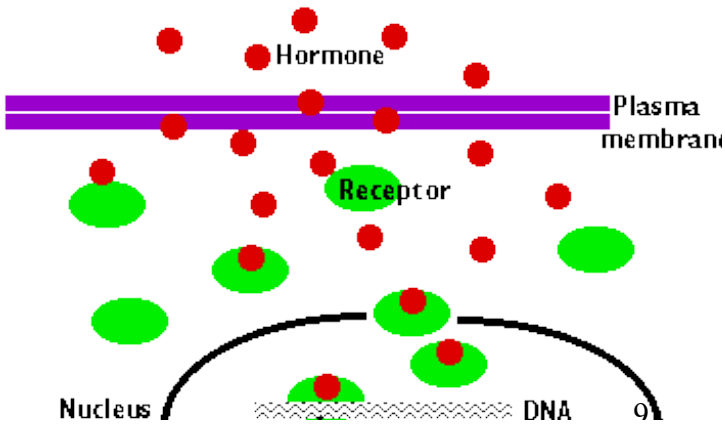
Protein hormones (1st messengers) - ***bind to receptor on target cell triggering 2nd messenger to affect cell's activity***

- hormone **(1st messenger)** does not enter the cell
- bind to receptor on the plasma membrane receptors
- hormone-receptor complex activates G protein
- generates chemical signal (2nd messenger) – most common is cAMP and IP_3
- **2nd messenger chemical signal** activates other intracellular chemicals to produce response in target cell
- responses may be phosporylation, activation of enzymes release of calcium ions into cytosol from ER, turn on transcription factor CREB for protein production.



Steroid hormones – **fat-soluble hormones** - ***bind to receptors within target cell*** and influence cell activity by acting on specific genes

- hormone diffuses freely into cell where cytoplasmic and/ or nuclear proteins serve as receptors
- hormone binds to receptor (hormone-receptor complex)
- complex bonds to steroid response element (sections of DNA receptive to the hormone-receptor complex



- hormone-receptor complex acts as transcription factor to turn target genes “on” or “off”

Classes of Hormones: (Division C)

peptides – short chains of amino acids (most hormones)
pituitary, parathyroid, heart, stomach, liver & kidneys
amines - derived from tyrosine and secreted by thyroid and adrenal cortex
steroids - lipids derived from cholesterol secreted by the gonads, adrenal cortex, and placenta
eicosanoid - produced from 20-carbon fatty acid, arachadonic acid, produced in all cells except RBCs -Prostaglandins and leukotrienes

Peptide/Protein

- Hydrophilic
- Large
- Can't fit through membrane
- Second messenger mechanism of action
- Most common hormone
- translated, packaged, & sent
- Hydrophilic/Lipophobic
- Bind surface receptors at target
- Binding mediates signal transduction/2nd messenger system
- Example: Insulin

Amine

- Synthesized from a single amino acid
- Melatonin from tryptophan
- Thyroid hormone from tyrosine
- Catecholamines (EPI, DA) from tyrosine

Eicosanoid

- Produced from 20-carbon fatty acid, arachadonic acid
- Produced in all cells except RBCs
- 2nd messenger
- Prostaglandins and leukotrienes
- inflammation

Steroid Hormones

- Small
- Hydrophobic/Lipophilic
- Travel in blood w/carrier
- Cytoplasmic or nuclear receptors
- change protein synthesis
- Example: estradiol