

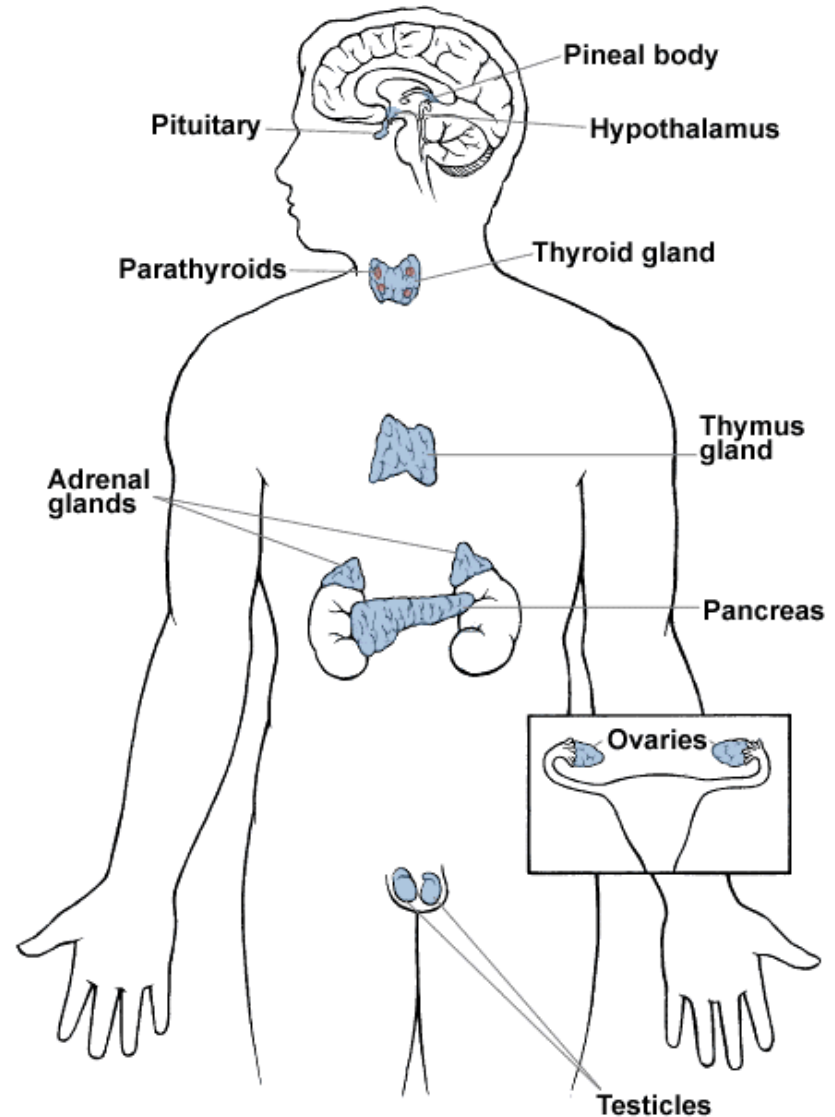
Ch45: Endocrine System

Endocrine System

- Homeostasis is the tendency to maintain a stable internal environment.
- Function = coordinate and control the body with hormones to maintain homeostasis
 - Works with nervous system

Anatomy

- Location:
 - Small areas of endocrine tissue found throughout the body



Types of Signaling Molecules

- Hormones: act through blood over long distances
- Local regulators: act over short distances
 - Paracrine – target cells lie near the secreting cell
 - Autocrine – secreted molecules effect the cell itself
- Neurotransmitters: synaptic signaling

- Neurohormones: nerve releases chemicals to blood and then act on target cells
- Pheromones: chemicals released to environment and used for communication

Hormones

- Definition: chemical substance produced and secreted by cells into the extracellular space that has a specific effect on other target cells that contain special receptors
- Transported through the blood or hemolymph (in invertebrates)

Hormone Types

- *Steroid Hormones*
 - Formed from cholesterol, which makes them soluble in lipids
 - This allows easy access to the cells they are activating
 - Responses: triggers the production of many proteins and may speed or slow processes in the body
 - Ex) sex hormones like estrogen, testosterone, and progesterone as well as aldosterone and cortisol from the adrenal gland

- Diffuse across plasma membrane into cell –
lipid-soluble
 - Enters nucleus
 - Binds to specific receptor proteins
 - Binds to DNA
 - Activates certain genes to transcribe into RNA
 - RNA leaves nucleus and makes a protein in the ribosome

Hormone Types

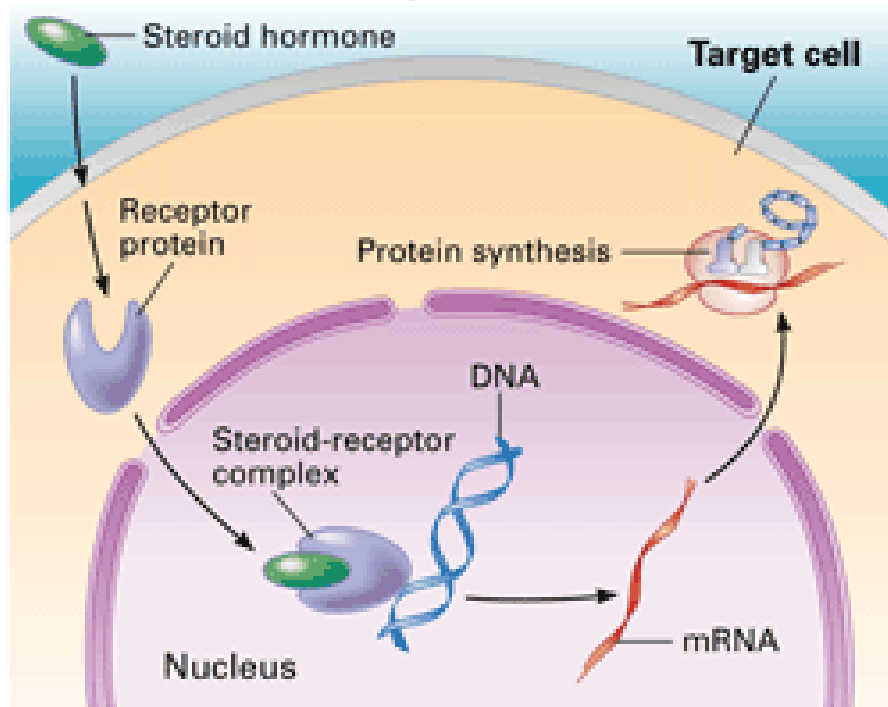
- *Non-steroid Hormones*
 - Consists of many types of hormones that need assistance in entering cells
 - They may cause a secondary reaction that will eventually lead to the production of proteins or secretions of other hormones

Non-steroidal Hormones

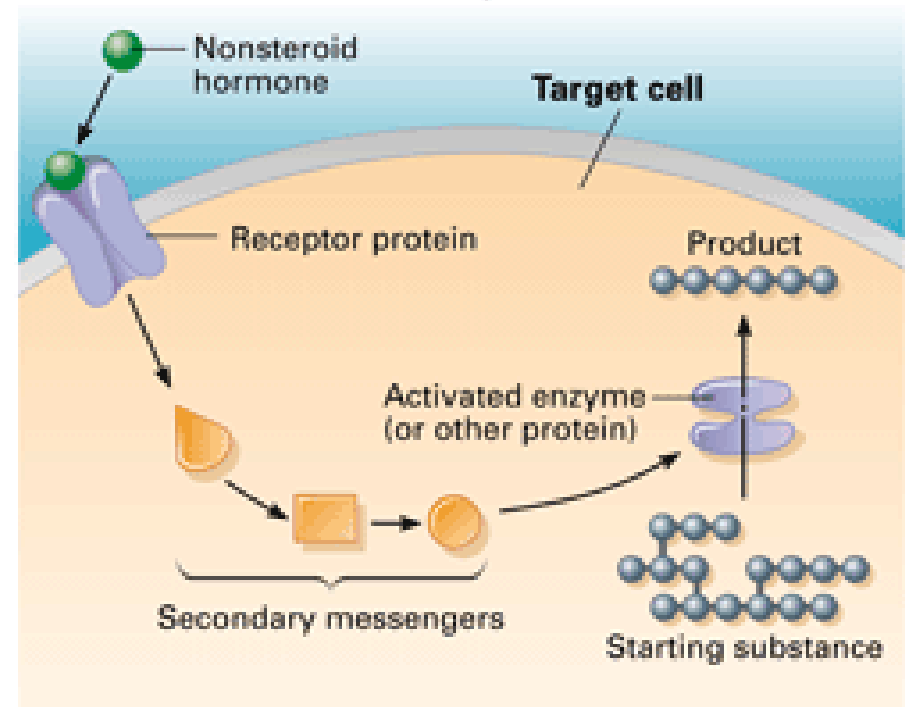
- Binds to receptors on plasma membrane – **water-soluble**
 - Sets off a series of reactions that activates enzymes
 - Enzymes cause production of second messenger
 - Second messenger causes additional changes to promote the reaction by the cell
 - Ex: epinephrine

- Non-steroid hormones will use the G protein reception pathway and various second messengers
- Hormones whose actions depend upon cyclic AMP include releasing-hormones from the hypothalamus, TSH, ACTH, FSH, LH, ADH, PTH, norepinephrine, epinephrine, glucagon, and calcitonin.

a. Steroid Hormone Response



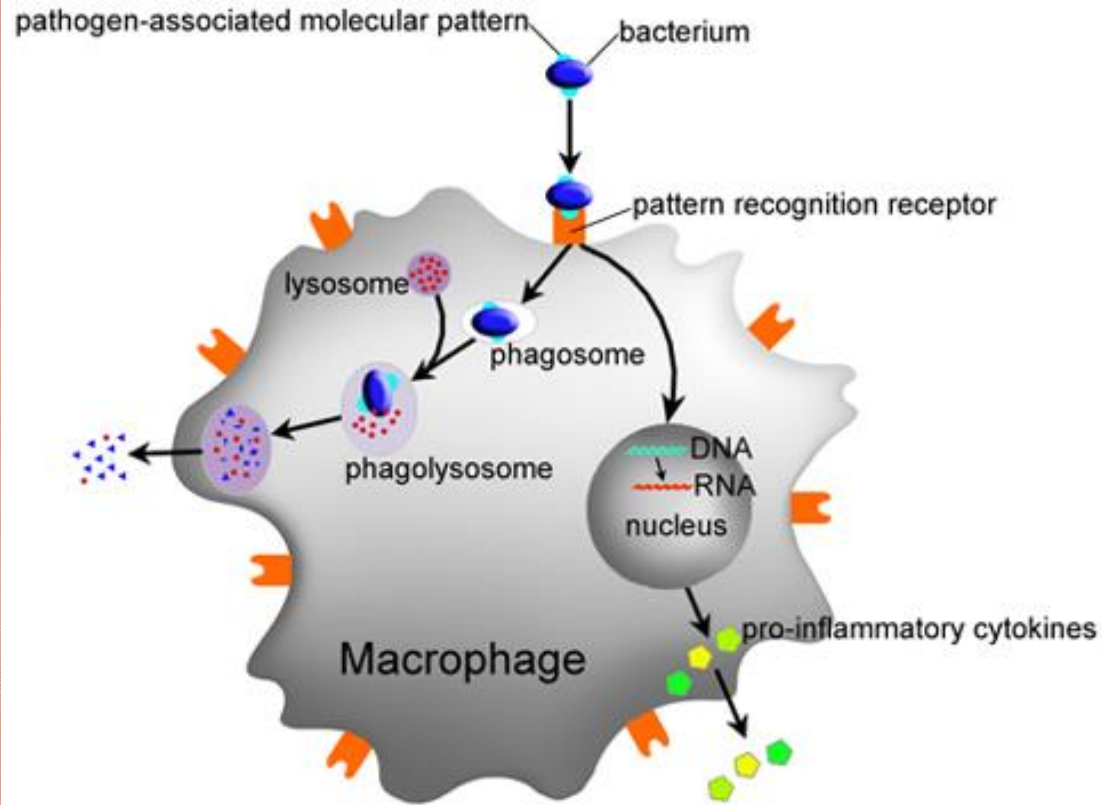
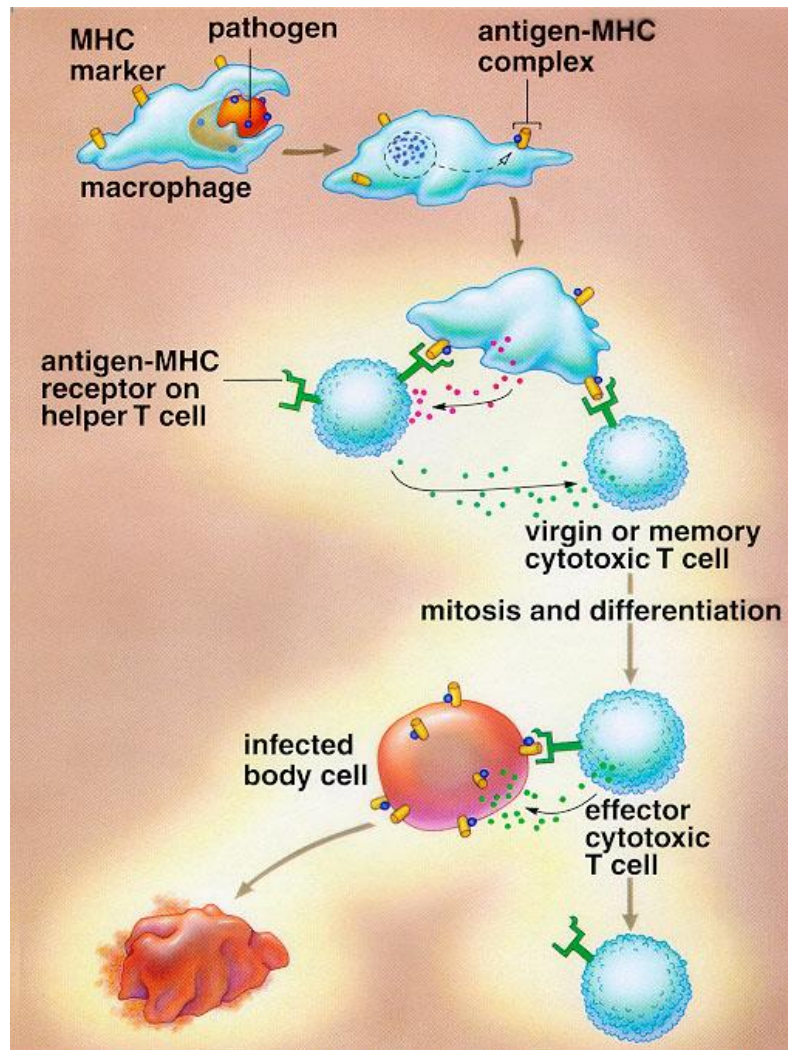
b. Nonsteroid Hormone Response



Local Regulators

- *Cytokines*
 - Chemicals that help in the immune response to activate white blood cells
- *Nitric oxide*
 - Acts of smooth muscle in blood vessels to dilate the vessels

- *Prostaglandins*
 - Modified fatty acids (discovered in prostate gland) that is produced when it is needed and act as a paracrine signaling pathway
 - Used in movement of sperm through female reproductive system, released from placenta to trigger labor, helps promote fevers and inflammatory response, and maintains protective lining in stomach



Mechanism of Hormone Activity

- One or more of the following occurs when a hormone binds to a cell:
 - Changes in membrane permeability or electrical state
 - Synthesis of proteins or certain regulatory molecules (enzymes)
 - Activation or inactivation of enzymes
 - Stimulation of mitosis

Feedback Mechanism

- *Negative Feedback System:*
 - Maintains dynamic homeostasis by returning the changing condition back to the body's set point
 - Ex: blood glucose and calcium level regulation, temperature regulation



Feedback Mechanism

- Positive Feedback
 - Amplifies responses and processes in biological organisms by creating a response to a stimuli that moves further away from the set point
 - Ex: child birth, blood clotting, lactation

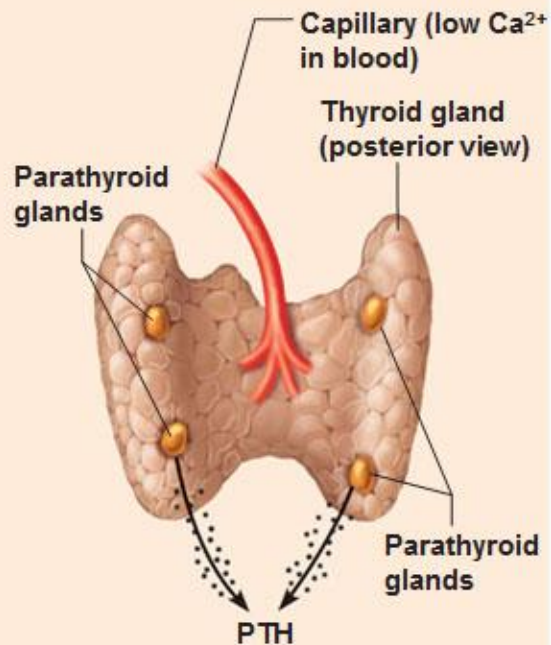
Endocrine Stimulation

- Hormonal stimulus – endocrine organs are prodded into action by other hormones
 - Ex) Hypothalamic hormones activate the anterior pituitary hormones
- Humeral stimulus – changes in blood levels of certain chemicals
 - Ex) release of parathyroid hormone is triggered by low blood calcium levels
- Neural stimulus – nerve fibers stimulate hormone release
 - Ex) sympathetic nervous system releases norepinephrine during times of stress

Types of Endocrine Gland Stimuli

(a) Humoral stimulus

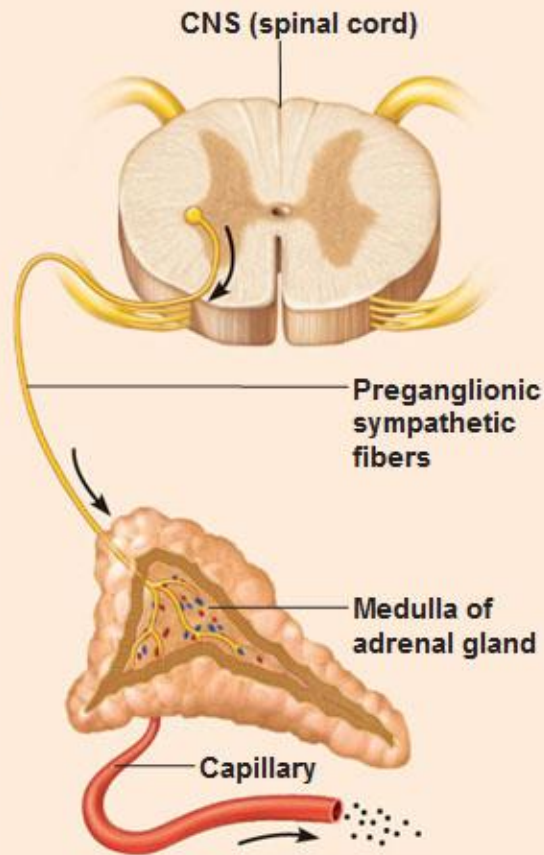
- ① Capillary blood contains low concentration of Ca^{2+} , which stimulates...



- ② ...secretion of parathyroid hormone (PTH) by parathyroid glands. PTH acts to increase blood Ca^{2+} .

(b) Neural stimulus

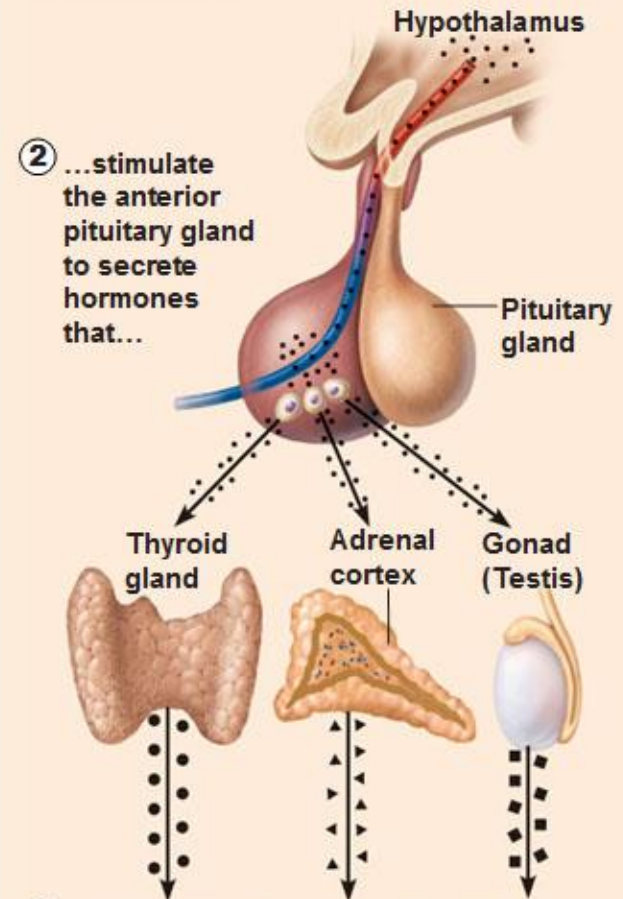
- ① Preganglionic sympathetic fibers stimulate adrenal medulla cells...



- ② ...to secrete catecholamines (epinephrine and norepinephrine)

(c) Hormonal stimulus

- ① The hypothalamus secretes hormones that...

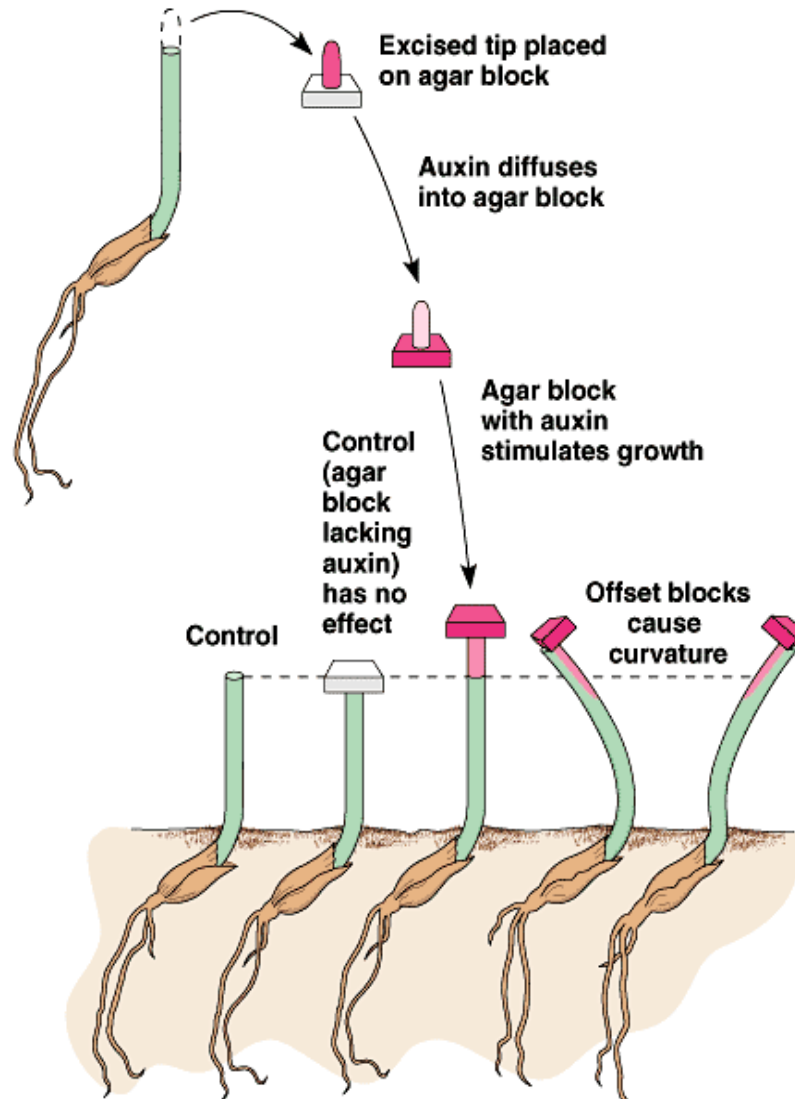


- ③ ...stimulate other endocrine glands to secrete hormones

Invertebrate (Insect) Hormones

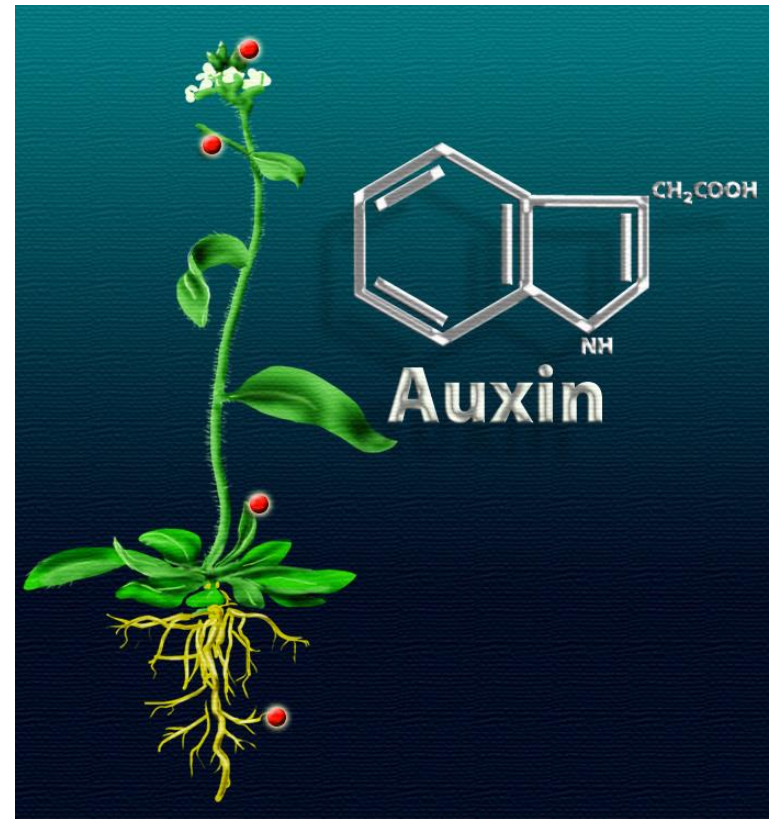
- Ecdysone = promotes molting and metamorphosis
- Prothoracicotropic hormone (PTTH) = signals the release of ecdysone
- Juvenile hormone (JH) = maintains larval characteristics

Plant Hormones



Auxin

- Location: ends of stems (apical meristems) and young leaves; seed embryo and fruits
- Function: **stem elongation, tropisms, and apical dominance**; root growth, differentiation, branching; fruit development; can be used as a herbicide at high levels



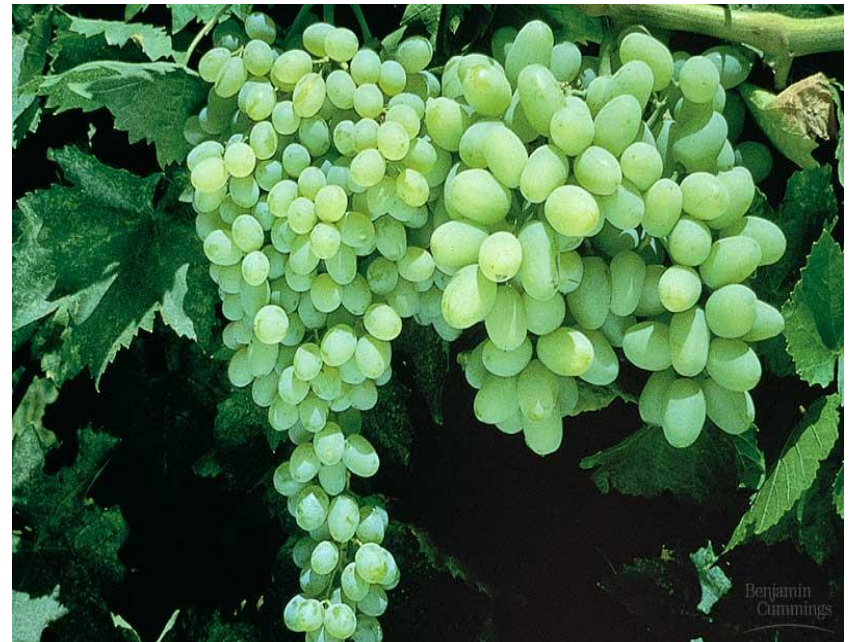
Cytokinins

- Location: roots (and actively growing tissues)
- Function: **cell division and differentiation**; root growth; germination; delay senescence (aging); apical dominance (w/ auxin)



Gibberellins

- Location: apical meristems and roots, young leaves, embryo
- Function: **germination of seed and bud**; stem elongation (w/ auxin); flowering and fruit development; leaf growth; root growth and differentiation



Brassinosteroids

- Location: all plant tissues
- Function: stimulates cell elongation; **inhibits root growth**, retard leaf abscission, promote xylem differentiation
- Once thought of as a type of auxin



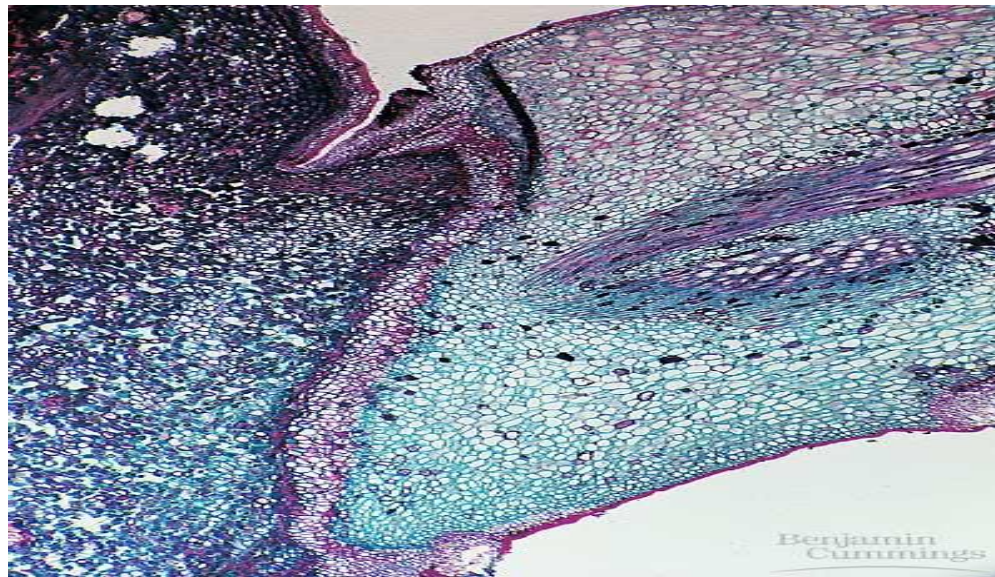
Abscisic acid

- Location: leaves, stems, roots, green fruit
- Function: **inhibits growth; closes stomata** (openings in leaves for gas exchange) during stress; promotes seed dormancy



Ethylene

- Gaseous hormone
- Location: ripening fruit tissue; stem nodes; aging leaves and flowers
- Function: **fruit ripening**; oppositional to auxin (leaf abscission); promotes/inhibits: growth / development of roots, leaves, and flowers; senescence and apoptosis



Plant Hormone Summary

- Auxin = stem elongation
- Cytokinin = cell division and differentiation
- Gibberellins = germination of seed and buds
- Brassinosteroids = inhibits root growth
- Abscisic acid = inhibits growth and closes the stomata
- Ethylene = fruit ripening

Pituitary Gland: “Master Gland”

- ***ANTERIOR*** - the anterior pituitary is controlled by hormones that are released by the hypothalamus in the brain.
 - All these hormones are proteins, act through second messengers, and are regulated by hormonal stimuli
- ***Growth hormone (GH)*** – GH controls growth of skeletal muscles and bones
 - Release of GH is controlled by either GH releasing hormone or GH inhibiting hormone, both of the hypothalamus
- ***Prolactin (PRL)*** - causes the continuing production of milk after birth. It is activated by the hypothalamus hormones.

- ***Thyroid-stimulating hormone (TSH)*** - controls the secretions of the thyroid. It is activated by both the hypothalamus and thyroxine in blood.
- ***Adrenocorticotrophic Hormone (ACTH)*** - controls secretions of the adrenal cortex
 - Stress and the hypothalamus control the release of this hormone
- Gonadotropic hormones – ***Luteinizing hormone (LH)*** - control the gonads or sex organs and activated by hypothalamus hormones and ***Follicle Stimulating hormone (FSH)*** controls egg and sperm development
 - Females: produces estrogen, readies eggs for ovulation
 - Males: produces testosterone, sperm development
- Disorders:
 - Pituitary dwarfism – hyposecretion of GH during childhood
 - Gigantism – hypersecretion of GH

Pituitary Gland: “Master Gland”

- ***POSTERIOR*** - the posterior pituitary is controlled by nervous messages coming in from the hypothalamus.
- ***Antidiuretic Hormone (ADH)*** - formed in the hypothalamus and moves to the pituitary for secretion. Functions to decrease the diuretic process of the kidneys (keeps water in the body)
- ***Oxytocin (OT)*** - weak antidiuretic also helps in uterine contractions used in child birth and in breast feeding
- Disorders: Diabetes Insipidus – hyposecretion of ADH

Thyroid Gland

- Located in the anterior (front) part of the throat and wraps about $\frac{1}{2}$ way around the pharynx
- ***Thyroxine & Triiodothyroxine*** - these hormones share the same purpose and are activated by TSH
 - Controls metabolism – increases the rate at which cells release energy from carbohydrates and rate of protein synthesis
 - Important in maintaining proper growth
 - Proper amount of iodides are needed in the system for the thyroid to produce these hormones.

Thyroid Gland

- ***Calcitonin*** - acts to lower blood calcium and phosphate levels. This regulation is sensed and controlled by the body measuring the Ca^{2+} level in the body.
- Disorders:
 - Goiters – deficiency of iodine in diet causes an enlarged thyroid
 - Cretinism – hyposecretion of thyroxine that leads to dwarfism
 - Hyperthyroidism – results from a tumor of the thyroid

Parathyroid Glands

- Four total, two located on the posterior side of each of the thyroid lateral lobes.
- ***Parathyroid Hormone*** (PTH) - used to increase the amount of Ca^{2+} in the blood and decrease the concentration of phosphate.
 - PTH is activated on a negative feedback system between the blood and Calcitonin secretions.

Adrenal Glands

- Sits on top of the kidneys and is composed of two different parts (medulla and cortex).
 - The medulla (inner core) is related to the sympathetic nervous system and the cortex (outer layer) is responsible for producing over 30 hormones that carry out various functions in the body.

- Adrenal Medulla - ***Epinephrine and Norepinephrine***
 - They can cause increased heart rate, increased blood pressure, increased breathing rate and a decrease in digestive processes.
 - These hormones are one cause of the fight or flight reaction of the body.

Adrenal Cortex

- Aldosterone – ***mineralcorticoid*** produced and secreted from the outer layer of the cortex.
 - Maintains a Na and K balance through re-absorption and secretion.
 - This ultimately causes the blood volume to remain high and maintains a proper blood pressure.
- Cortisol – ***glucocorticoid*** that affects the metabolism of glucose, protein and fats.
 - This hormone aids in the maintenance of a normal blood sugar level that fluctuates according to the demands of the body.

Pancreas

- A dual functioning organ that secretes digestive enzymes into the intestine but also produces and secretes hormones used for regulating homeostasis.
- The pancreas is located behind the stomach attached to the beginning of the intestines.
 - The secretion of Glucagon and Insulin work on a negative feedback mechanism

Pancreas

- Endocrine portion of the pancreas is made up of two groups of cells (alpha and beta) that help regulate blood sugar levels.
 - Alpha cells—secrete **Glucagon**, causes liver to convert glycogen and some amino acids into glucose.
 - Function: raises blood glucose levels
 - Beta cells—release **Insulin**, causes the formation of glycogen in liver. Insulin also aids in the facilitated diffusion of glucose into certain cells.
 - Function: lowers blood glucose levels

Pineal Gland

- ***Melatonin*** - secreted in the absence of light controlled by nervous impulses coming from the eyes.
 - An imbalance or disruption of the release of this hormone may result in insomnia or tiredness which may be related to irritability and depression.
 - Melatonin is also believed to control many of the cycling functions of the body including the menstrual cycle involved in female reproduction.

Thymus Gland

- Releases **Thymosin** which aids in the production of white blood cells involved with the immune system.
- Located on top of the heart in the thoracic cavity

Ovaries and Placenta

- The female sex hormones ***Estrogen*** and ***Progesterone*** are produced in the ovaries
- Stimulates the uterine lining growth; development and maintenance of female secondary sex characteristics

Testes

- The male sex hormone ***Androgens*** (***testosterone***) is produced in the testes
- Support sperm formation; development and maintenance of male secondary sex characteristics

Disorders

- Alteration to the mechanisms of feedback often result in deleterious consequences
 - Ex: diabetes mellitus, dehydration with ADH, Graves disease (hyperthyroidism), blood clotting with hemophilia