Overview

- endocrine system
  - invertebrate
  - vertebrate
- endocrine glands
- hormones
  - mode of action of hormones
    - second messengers
    - gene activation
- summary

Endocrine system

- consists of endocrine glands that secrete hormones
- hormones are broadcast to all parts of the body
Hormones
- chemical secretions by a specialized endocrine structure
- metabolic effects on target structures
- effective at low concentrations
- exert their effects by:
  1. altering gene function
  2. directly affecting metabolic pathways
  3. controlling the development of specific organs or their secretory products

Early endocrine system
- in invertebrates, hormones control sexual cycles and often the shedding of eggs
- arthropods demonstrate extensive endocrine systems, which play a role in:
  - water balance
  - migration of pigments for protective discoloration
  - growth
- ex. The endocrine system of insects which undergo metamorphosis

Metamorphosis
- stages include:
  - larvae stage
  - molting stage
  - pupal stage
  - adult stage
Early role of insulin

- insulin was a primitive feeding hormone
- in most invertebrates insulin promotes food gathering
- in invertebrates still functions as a feeding hormone but in a more complex way
  - regulates carbohydrate metabolism
  - promotes the storage and utilization of carbohydrates to control sugar levels in blood

Same hormones in unicellular and multicellular organisms

- E. coli
  - insulin
- Protozoans
  - pituitary hormones

Vertebrate endocrine system

- endocrine gland functions:
  - exclusively endocrine
  - endocrine and nonendocrine
    - ex. pancreas
    - solely nonendocrine
    - ex. kidney and liver
- approximately 15 glands
  - secretions of four basic types
    - proteins
    - less complex peptides
    - catecholamines
    - steroids
**Stomach**
- hormone gastrin
  - stimulates gastric glands to release gastric juice

**Pancreas**
- dual gland → ducted (exocrine) properties and ductless functions
  - exocrine → digestive juices which reach the duodenum through the pancreatic duct
- insulin – ↓ sugar
  - made by the beta cells
- glucagon – ↑ sugar
  - made by the alpha islet cells
- somatostatin
  - made within the islet tissue in the delta cells.
  - nerve impulse transmission
  - insulin and glucagon production

**Adrenals**
- lies above or beside each kidney
  - arise from a different germ layer
  - surrounded by a protective capsule
**Adrenal cortex**

- outer layer arises from the mesoderm
- consists of three distinct layers:
  - zona glomerulosa
    - aldosterone
    - increased when blood potassium levels ↑
    - and when blood pressure in arterioles ↓
    - ex. Renin-angiotensin system
  - zona fasciculata
    - cortisol and corticosterone
    - raise blood glucose levels
    - stress in release factor
  - zona reticularis
    - glucocorticoids, masculinating androgens, and small amounts of female sex steroids
- medulla of the adrenal gland arises from the ectoderm
  - epinephrine (adrenaline) and norepinephrine (noradrenaline)

**Renin-angiotensin model**

**Renin-angiotensin-aldosterone system**

**Thyroid**

- arise from the embryonic gill slits
- rate at which carbohydrates are oxidized in the body and the amount of body heat produced
  - resting level of oxidation is referred to as the basal metabolic rate
- hormones thyroxin(T4) and triiodothyronine (T3)
- sexual maturation of all vertebrate species
- in amphibians → metamorphosis
**Parathyroids**
- parathormone (PTH)
  - regulator of calcium and phosphate levels in the blood
- parathormone acts in 2 ways:
  - release calcium into the bloodstream
  - reabsorption of calcium and excretion of phosphate

**Thymus**
- thymosin → induces functional maturity in lymphocytes.

**Gonads**
- male → sex steroids produced by the testes
  - testosterone
- female → sex steroids produced by the ovary
  - estrogen
  - progesterone
  - hypothalamus and pituitary regulate ovarian hormones
Pituitary
- known as the master gland
- consists of a posterior and anterior lobe
  - posterior lobe:
    - neuronal
    - receives, stores, and releases 2 different hormones:
      - oxytocin
      - antidiurectic hormone

Pituitary continued
- anterior lobe:
  - hormone producing structure adenohypophysis
    - primary and tropic hormones
      - ex. of primary hormones:
        - growth hormone (GH)
        - prolactin hormone
        - melanocyte stimulating hormone (MSH)
        - endorphins
        - enkephalins
      - ex. of tropic hormones:
        - thyroid stimulating hormone (TSH)
        - adrenocorticotropic hormone (ACTH)
        - follicle stimulating hormone (FSH)
        - luteinizing hormone (LH)

Hypothalamus
- a part of the brain located above the pituitary
- sensory stimuli of the nervous system are converted into hormonal responses.
Hypothalamus and pituitary

- connected with the pituitary gland
- connected to the posterior lobe by a stalk of nerves
  - oxytocin and ADH are produced in the hypothalamus and travel down the nerves to the posterior lobe for storage and release by nerve impulses
  - it is connected by a capillary system

Hypothalamus and pituitary interaction

- releasing hormones
  - corticotropin releasing hormone
  - thyroid releasing hormone
  - leutinizing hormone releasing hormone
  - follicle stimulating hormone releasing hormone
  - growth hormone releasing hormone
  - growth hormone inhibiting releasing hormone
  - prolactin release-inhibiting hormone
  - prolactin releasing hormone

Pineal gland

- melatonin
  - circadian rhythms
Damaged tissue

- acts as an endocrine gland when it releases histamines
  - histamines relax the muscles of the blood vessels
  - increases blood vessel permeability allowing the elements of the immune system to reach the injured site

Prostaglandins

- group of chemicals → fatty acids that resemble hormones in function
- produced by most cells of the body
- seven broad classes:
  - PGA - known to reduce blood pressure and may act directly on vascular smooth muscle.
  - PGD - involved in vasodilatation, stimulate the increase of cAMP and inhibit the aggregtion of platelets.
  - PGI - same as PGD
  - PGE - influence acid secretion in the stomach and have been implicated in fever reactions
  - PGF - involved in responses of the reproductive tract and have been used to induce labor
  - PGG
  - PGH

Mode of action of hormones

- exert effects on target tissues directly or indirectly by:
  - alteration of metabolic activity of specific cells
  - turn genes on or off or to modulate their activity
- to carry out their function hormones must:
  - either penetrate the cell
  - attach to cell membrane
- hormone methods of cell interaction:
  - pass directly across boundary and internal membranes of the cell
  - pass along preexisting channels
  - create new channels
Second messengers

- many hormones attach to specific receptors on the cell membranes of target cells and invoke the aid of a second messenger
- second messenger is the "accomplice" to a hormone in the cell cytoplasm
  - ex. of second messengers
    - calcium ions
    - cyclic AMP (cAMP)

Second messenger model

Gene activation by a hormone
Summary - The Endocrine System

Hypothalamus
- Regulates hunger, thirst, and sleep
- Controls body temperature

Pancreas
- Helps regulate blood glucose levels

Parathyroid
- Regulates calcium levels in the body

Thyroid
- Produces hormones for metabolism

Adrenal Glands
- Responds to stress
- Produces hormones for energy production

Estrogen
- Influences the menstrual cycle and development of reproductive organs

Metabolism - The conversion of nutrients into energy and building materials for repair of body tissues

Prostaglandins
- Inhibitors of blood clotting