Chapter 9: The Endocrine System

Glands and Changes and Hormones, Oh My!
Endocrine vs Exocrine Glands

- Endocrine glands are:
  - Ductless
  - Full of blood
  - Release chemicals directly into the fluid of blood or lymph
  - Made of epithelial tissue

- Exocrine glands are:
  - Ducted
  - Release chemicals into cavities (digestive juices in small intestine) or surfaces (sebaceous glands on skin)
  - Made of epithelial tissue, too
Endocrine System Overview

• Next to the Nervous System this system controls, coordinates and directs the activity of our cells.
• Nervous system uses nerve impulses.
• Endocrine system uses hormones.
• Which do you think is faster?
Endocrine System Overview

- Major processes controlled by the endocrine system:
  - Reproduction
  - Growth and development
  - Mobilizing body defenses against stressors
  - Maintaining electrolyte, water and nutrient balance of blood
  - Regulating cellular metabolism
  - Energy balance
Hormones!

- Hormones: chemical substances, secreted by cells into the extracellular fluids, that regulate the metabolic activity of other cells.
- Classified as either:
  1. amino acid based (proteins/derivatives)
  2. Steroids (cholesterol – lipids)
  3. Prostaglandins (lipids in cell membranes)
Hormones!

• Hormones travel through the blood, but only work on specific cells.
• Target cells/target organs: cells or organs that respond to specific hormones.
• Bacteria/virus analogy
• Protein receptors on cell membranes attach to specific hormones like a lock and key.
Hormones!

• Hormone means “arouse”; they arouse changes in cellular activity.
• These changes are to increase or decrease ever present activities, not necessarily bring about new activities.
• Examples:
  – Change plasma membrane permeability
  – Synthesis of proteins/enzymes
  – Activating or inactivating those enzymes
  – Stimulation of mitosis
Hormones!

- Steroidal hormone mechanism (fig 9.1a page 281)
  1. hormone diffuses through the membrane of target cell
  2. hormone diffuses through the nuclear membrane
  3. hormone binds to a receptor protein forming a complex
  4. complex binds to a spot on the DNA
  5. this activates specific genes to be translated into mRNA
  6. mRNA is translated into a protein in the cytoplasm
Hormones!

- Nonsteroidal hormone mechanism (see fig 9.1 b, page 281)
  1. hormone binds to receptor on target cell’s membrane
  2. this sets off a series of reactions to activate an enzyme
  3. this enzyme catalyzes a the production of another messenger molecule
  4. this molecule causes other cellular activity (the specific activity is different for different cell types)
Controlling Hormones!

• Negative feed back mechanisms: hormone secretion from either internal or external stimuli.

• Three categories of stimuli: (figure 9.2, p282)
  – Hormonal* most common
  – Humoral – body fluids (ion, nutrient levels)
  – Neural – nerve impulses
Negative Feedback Mechanisms

• A trigger will stimulate the production and/or secretion of hormones.

• The production/secretion continues to a specified level.

• Once the level has been reached, the production/secretion ceases until triggered again.

• Example: thermostat
Major Endocrine Organs

- Pituitary
- Hypothalamus
- Thyroid
- Parathyroid
- Adrenal
- Pineal
- Thymus
- Pancreas
- Gonads
Major Endocrine Organs

• Pituitary Gland: (p 284, fig 9.4)
• Size of a grape
• Below the hypothalamus, in the brain
• Anterior pituitary is glandular
• Called the “master gland”
• Posterior pituitary is neural
Major Endocrine Organs

Hypothalamus & the pituitary:

• Anterior pituitary is controlled by the hypothalamus’ releasing and inhibiting hormones.

• Posterior pituitary is controlled by the hypothalamus’ neurosecretory cells that are stored in the posterior pituitary.
Major Endocrine Organs

- Hormones of the anterior pituitary
- Tropic hormones: stimulate target organs (4 of the 6 pituitary hormones)
- Thyrotropic, adrenocorticotropic and two gonadotropic hormones
- Growth and prolactin do not have target organs
  - 1. are all protein based
  - 2. act through second-messenger systems
  - 3. regulated by negative feedback
Pituitary Gland Hormones

• Growth hormone (GH):
  • targets skeletal muscle and long bones for growth
  • Synthesizes proteins
  • Stimulates target cell growth and division
  • Decomposes lipids for energy release, in turn regulating glucose levels in the blood
  • Pituitary dwarfism/gigantism/acromegaly
Pituitary Gland Hormones

- Prolactin (PRL): structurally similar to GH, but only targets mammary glands.
- Adrenocorticotropic hormone (ACTH): controls cortex portion of adrenal gland.
- Thyroid-stimulating hormone (TSH) or thyrotropic hormone (TH): influences growth and activity of the thyroid gland.
Pituitary Gland Hormones

Gonadotropic hormones: regulates the activity of ovaries and testes.

• Follicle-stimulating hormone (FSH):
  – In females, stimulates follicle development in the ovaries that will produce estrogen and prepare eggs for ovulation.
  – In males, stimulates sperm development in testes.

• Luteinizing hormone (LH):
  – In females, triggers ovulation of an egg and produces progesterone and estrogen
  – In males, stimulates testosterone production by the interstitial cells of the testes.
Pituitary Gland Hormones

- Posterior pituitary hormones (storage)
  - Oxytocin: mainly seen during childbirth and nursing by stimulating powerful uterine and mammary contractions.
  - Antidiuretic hormone (ADH): (diuresis is urine production) this hormone inhibits urine production and can increase blood pressure.
  - Alcohol decreases the production of ADH leading to increased urine production and “hangovers”.
Pituitary Gland Recap:

- Controls the growth of cells and body
- Controls other glands, like adrenal and mammary glands and the thyroid.
- Stimulates the production of sex hormones, ovulation of eggs and production of sperm and controls uterine contractions
- Regulates water levels and blood pressure.
Thyroid Gland

• Just below the larynx in the neck. (butterfly shape)

• Inside are follicles (tubes) that store the colloidal material the two hormones come from.
Thyroid Gland

1. thyroid hormone: a metabolic hormone made of two chemicals (thyroxin T4 and triiodothyronine T3)

Thyroid sends out mainly T4 to target tissues where it is converted to the usable T3 version.

Controls the metabolic rate of glucose.

Important in normal growth of nervous and reproductive tissues.
Thyroid Gland

• Goiters: low iodine levels
• Hypothyroidism:
  – cretinism (weird dwarfism) can result in retardation
  – myxedema, in adults, creates a sluggish mind
• Hyperthyroidism:
  – Generally from a tumor that results in Graves’ disease (weight loss, increased heart rate)
Thyroid Gland

• 2. calcitonin: moves calcium in blood to bones.
• Not made in the follicles of the thyroid, but in the C cells between them.
• Decreases with age.
Parathyroid Gland

• Parathyroid Glands
• Tiny masses of glandular tissue found posterior on the thyroid. Typically 4 – 8.
• Parathyroid hormone (PTH): the most important blood/calcium ion regulator. Bring calcium levels back up in the blood.
• Negative feedback loop example.
• Calcium and muscles and bones
Adrenal Glands

- These glands sit on top of each kidney
- They are similar to the pituitary gland in that they have a glandular portion (adrenal cortex) and a neural portion (adrenal medulla).
- *Remember…the pituitary also controls this gland…
  - Adrenocorticotropic hormone (ACTH): controls cortex portion of adrenal gland.
Adrenal Glands

Transverse Section
- Capsule
- Cortex
- Medulla

Microscopic Section
- Capsule
- Zona Glomerulos
- Zona Fasciculata
- Zona Reticularis
- Medulla
Adrenal Glands

Hormones of the adrenal cortex:

- Corticosteroids: three types that are all steroid based (the first we’ve seen)
  1. Mineralcorticoids
  2. Glucocorticoids
  3. Sex hormones
Adrenal Glands

1. Mineralocorticoids (aldosterone):
   • Controlled by outermost layer of cells
   • Regulate minerals (salt ions) in the blood, thus under humoral control, but can also be stimulated by the enzyme renin or the hormone atrial natriuretic peptide.
   • Target organ is the kidney where it reclaims sodium ions and water and releases potassium ions in the urine causing an increase in blood pressure.
Adrenal Glands

2. Glucocorticoid (cortisone & cortisol):
   • Controlled by the middle layer of cells
   • Increase blood glucose levels (hyperglycemia) promoting normal cell metabolism and help resisting long-term stressors. Can even break down lipids and proteins to create more glucose. (humoral response and ACTH)
   • Anti-inflammatory, anti-pain
3. Sex hormones (androgen & estrogen)
   • Controlled by the inner most layer of cells.
   • Androgens: male sex hormones produce muscle mass and hair growth.
   • Estrogen: female sex hormones that produce female sexual characteristics.
   • We all produce both hormones.
   • Hypersecretion produces masculinization.
Adrenal Glands

• Hyposecretion: low salt, water and glucose levels, can be fatal
• Hypersecretion: usually due to cancer of the gland, edema, weird looking face/neck, diabetes, high blood pressure
Adrenal Glands

Hormones of the adrenal medulla

• Neural tissue stimulated by the sympathetic nervous system.

• Release epinephrine (adrenaline) and norepinephrine (collectively called catecholamines)

• Allow the body to deal with short term stressors.
Pancreas

• Located near the stomach
• Is both exocrine and endocrine in function.
• Exocrine portion does much work with the digestive system
• Endocrine portion are specific tissue inside the pancreas called pancreatic islets
Pancreas
Pancreas

• Beta cells: produce insulin when blood sugar levels are high (hypoglycemic).
• It is the ONLY hormone that decreases blood sugar levels.
• Alpha cells: produce glucagon when blood sugar levels are low (hyperglycemic).
• Glucagon travels to the liver to break down glycogen, producing more glucose in the blood.
Pancreas

• Diabetes mellitus: disease where insulin is not produced; sugar cannot be used for energy so proteins and fats are used instead.
• Leads to acidic blood, low body weight, lower immunity and eventually coma.
• Three cardinal signs include: frequent urination, excessive thirst, hunger
• Two types: type 1 and type 2
Pineal Gland (Body)

• Found deep within the brain; small, cone shaped.
• Produces mainly melatonin (the sleep hormone).
• Regulates our day/night cycle and sexual maturity.
Thymus

- Behind the sternum and in front of the thorax.
- Mainly produces thymosin which programs special white blood cells called T lymphocytes or T cells.
Gonads: Ovaries

- Found in the pelvic cavity; shape and size of almonds.
- They produce the steroid hormones progesterone and estrogen.
- Don’t really function until puberty.
Gonads: Ovaries

- Estrogens: (also produced by adrenal cortex) and Graafian follicles in the ovaries and, when pregnant, the placenta.
- Gives female features, pubic hair, helps regulate menstrual cycle, maintains pregnancy, & prepares for lactation.
Gonads: Ovaries

- Progesterones: (produced by adrenal cortex) and the corpus luteum in the ovaries.
- Helps regulate the menstrual cycle, calms uterine muscles to accept an embryo and prepares for lactation.
Gonads: Testes

- Suspended in the scrotum outside the body in the pelvic region.
- Produce sperm (male sex cells) and testosterone (a type of androgen).
- Produced in the interstitial cells of testes and adrenal cortex.
- Bring out male characteristics, prepares the body for sexual activity and stimulates the male sex drive.
- Hyposecretion = sterility
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<td>Adrenocorticotropic H*</td>
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