The Endocrine Glands and their hormones
The Endocrine System

• A body system that works in parallel with the nervous system to maintain homeostasis by releasing chemical hormones from various glands.

• This system is comprised of the hormone producing glands and tissues of the body.
Hormones and their Target Organ

• **Hormones**: are chemical signals released into the body/blood to initiate a response in their target cell.
  – Adrenaline/noradrenaline are released from the neurons of the adrenal gland to trigger “fight or flight”

• **Target Cell/Organs**: are the areas of the body containing the specific receptors for a particular hormone. These hormones bind to the receptors in a very specific “lock and key” fashion.
Steroid vs. Non Steroid - Pg 425

- **Steroid hormones** - are fat soluble so they have the ability to enter the cell membrane.
- The target receptors are inside the cell and these hormones target the DNA for activation.
Non- Steroid

- Non-steroid hormones are water soluble, so they must trigger the “enzyme cascade” to relay the message.
- The receptors for these hormones are on the outer surface of the cell.
- cAMP acts as the second messenger to relay the message to the nucleus.
The Pituitary Gland (The Master Gland)

- The pituitary gland is suspended from the hypothalamus and is connected to it by a complex network of vessels called the Portal System.

- The hypothalamus and Pituitary gland manufacture and secrete hormones that act on other glands of the body.
  - Tropic Hormones are hormones that act on and influence other hormone producing glands
The Glands of the Endocrine System

The Endocrine System

Hypothalamus
Pituitary gland
Pineal gland (epiphysis)
Thyroid gland
Parathyroid gland
Adrenal (suprarenal)
Pancreas
Ovaries
Testicles

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The Pituitary Gland (The Master Gland)

- The Pituitary gland is actually composed of two glands:
  - Anterior Pituitary - epithelial tissues
  - Posterior Pituitary - composed of neural tissue.
The Posterior Pituitary Lobe

No hormones are made here. They are made in the hypothalamus and just released here.

Two peptide hormones are released from the posterior pituitary lobe

- ADH *(antidiuretic hormone or vasopressin)*
- OT *(oxytocin)*
Function of Posterior Pituitary Hormones

**ADH:**
- Regulates sodium levels. As sodium increases ADH is secreted.
- As an “antidiuretic,” ADH decreases urine formation by having kidneys conserve water.
- ADH also contracts blood vessels to cause an increase in blood pressure.
- ADH release triggered by osmoreceptors:
  - Low blood pressure = release ADH
  - High blood pressure = inhibited the release of ADH
OT (Oxytocin):

- In females:
  - contracts the uterine wall smooth muscles (positive feedback loop)
  - helps to eject milk when lactating

- In males:
  - A factor in erections!!
The Anterior Pituitary

• Composed of tissues from the roof of the mouth during embryonic development.
• The ant. pit. manufactures and secretes 6 of its’ own hormones:
  – TSH (thyroid stimulating hormone)
  – ACTH (adrenocorticotropic hormone)
  – Prolactin
  – HGH (Human Growth Hormone)
  – 2 Gonadotropins (LH and FSH)
6 Anterior Pituitary Hormones

• TSH – acts on the thyroid to secrete thyroxine.
• ACTH – acts on the adrenal cortex to secrete cortisol and aldosterone.
• Prolactin – acts on mammary glands
• HGH – acts on liver and bones
• LH & FSH – act on the gonads (ovaries/testes)
Anterior Pituitary Hormone – TSH - see pg. 432

**TSH:**

- Is a tropic hormone that targets the thyroid gland regulating its’ development and regulates thyroxine levels using negative feedback loops
Negative Feedback Loop Regulation

**TSH:**

- Levels of TSH works on thyroid gland to either cause or decrease the secretion *thyroxine (a non-steroid iodine containing peptide)*
ACTH: (corticotropin)

- works on the cortex of the adrenal gland, influencing the release of cortisol
- Stress increases CRH secretion which will increase ACTH secretion
- Hormones are controlled with negative feedback
More Anterior Pituitary

**Prolactin**: (non-steroid)

- In females, prolactin promotes mammary gland development and lactation (milk production)
  - Inhibited by the hypothalamus through dopamine
  - Stimulation of the nipples during breast feeding trigger the release of secreting hormones from the hypothalamus
    - Increasing estrogen levels also trigger secretion
- Increased prolactin levels inhibits LH (luteinizing hormone) – this prevents ovulation
Anterior Pituitary Hormones

**HGH**: (non-steroid)

- stimulates cells to grow and divide and triggers release of growth factors from the liver.
- increases amino acid transport rate and protein synthesis
- increases fat metabolism and calcium absorption in intestines

Typically, GH is secreted during sleep.
Problems with GH

- Too much GH in children leads to gigantism

Too much GH in adults leads to acromegaly

**Biggest** (mind the pun) cause of gigantism and acromegaly is a tumour in the pituitary
Problems with GH

• Too little GH in children leads to dwarfism
Other Anterior Pituitary Hormone Functions

**LH & FSH:**

- LH in males and females acts on the gonads to secrete the sex hormones, estrogen and testosterone.
- FSH – Follicle stimulating hormone.
  - females - causes growth and development of the egg (ovum).
  - Males - initiates sperm production.
The Thyroid Gland

**Structure:** Bilobed gland containing many follicles.

**Hormones Produced:**
- Thyroxine and Calcitonin

**Thyroxine:**
- Function: Increases metabolic rate and oxygen consumption (break down carbohydrates and fats, synthesize proteins)
- Can only be made by follicular cells when iodide is available
- Controlled by anterior pituitary lobe through TSH levels.
Problems with the Thyroid Gland

Hyperthyroidism:
- high metabolic rate, hyperactivity, sensitivity to heat, protruding eyes
- **Grave’s disease:** when hyperthyroidism is due to an autoimmune problem (TSH is mimicked by autoantibodies)
Problems with the Thyroid Gland

Hypothyroidism:

• in the adult: low metabolic rate, sensitivity to cold, sluggishness

• in an infant: cretinism—stunted growth, mental retardation, abnormal bone formation
More Anterior Pituitary Hormone Functions

- Iodine deficiency leads to the inability to synthesize thyroxine. TSH production heightens stimulating development of the thyroid gland tissue.
Thyroid cont. the “other” hormone

**Calcitonin**: (thyroid)

- **Function**: decrease blood calcium levels and blood phosphate levels (by helping them get deposited in bone, and by stimulating excretion of them by kidneys)
- **Controlled by blood calcium levels**
Parathyroid Gland

- Four nodules found within the thyroid gland that synthesize Parathyroid Hormone (PTH)
- PTH functions to increase blood calcium (Ca$^{2+}$) levels through bone release and kidney/intestinal absorption.
- See pg 434
Antagonistic Hormones

**PTH: (Parathyroid)**
- Function: Increase blood calcium levels by releasing the calcium from bones and re-absorbing it from the kidneys and intestines.
- See pg. 435 on Vitamin D (importance of)

**Calcitonin: (thyroid)**
- Function: decrease blood calcium levels and blood phosphate levels (by helping them get deposited in bone, and by stimulating excretion of Calcium by kidneys)
- Controlled by blood calcium levels and digestive chemicals
The Pancreas

• This gland has both endocrine and exocrine functions... we’ll only cover the endocrine portion now (exocrine is for digestion)

• The endocrine portion of the gland contains different types of cells, each making a different hormone, arranged into groups called Islets of Langerhans
  – *alpha cells*: secrete glucagon
  – *beta cells*: secrete insulin

• Note that these pancreatic hormones are involved in blood glucose regulation, and problems with them can lead to diabetes.
Blood Glucose Regulation by the Pancreas

**Glucagon:**
It works on the liver to cause the production of glucose via:
- breaking down glycogen

It is regulated by blood glucose levels directly:
- secreted when blood glucose drops (before next meal)

Prevents hypoglycemia

**Insulin:**
It works on the liver to remove glucose from the blood via:
- making glycogen
- increasing glucose transport into cells

It is also regulated by blood glucose levels directly
Prevents hyperglycemia

Note: glucagon and insulin work in opposition, and their combined effects control blood glucose.
Diabetes Mellitus

• Two Types:
  – Type 1 - the beta cells of the pancreas no longer make insulin because the body's immune system has attacked and destroyed them
  – Type 2 - usually begins with insulin resistance, a condition in which fat, muscle, and liver cells do not use insulin properly (can occur at any age)
What are the signs of diabetes?

- being very thirsty
- urinating often
- feeling very hungry or tired
- losing weight without trying
- having sores that heal slowly
- having dry, itchy skin
- losing the feeling in your feet or having tingling in your feet
- having blurry eyesight
Pineal Gland

Secretes only one hormone: melatonin

Involved in your circadian rhythm (your recognition of day and night times):
- melatonin secretion decreases in the day
- melatonin secretion increases at night

Melatonin is also involved in longer rhythms, like monthly and seasonal... and is thought to be involved in the female menstrual cycle and maybe in the onset of puberty
Thymus Glands

• Thymus Gland: secretes thymosins which are involved in white blood cell production
Adrenal Glands
The Adrenal Cortex

Acts like a regular endocrine organ

Secretes many hormones, but most importantly secretes the following steroids:

– aldosterone
– cortisol
– sex hormones

Aldosterone and cortisol require further explanation (while sex hormone production will be covered later this semester)
Hormones of the Adrenal Cortex
The Adrenal Medulla

Acts very much like a part of the sympathetic nervous system (fight or flight)

Secretes two amines:

- norepinephrine (20%)
- epinephrine (80%)
Responses to Stress

**Stress results from changes in the external environment**

Signals from sensory receptors

**Hypothalamus**

**Sympathetic impulses**

- **Adrenal medulla**
  - Epinephrine and norepinephrine released
  - Short term “fight or flight” or alarm stage
    - Blood glucose increases.
    - Blood glycerol and fatty acids increase.
    - Heart rate increases.
    - Blood pressure rises.
    - Breathing rate increases.
    - Air passages dilate.
    - Pupils dilate.
    - Blood flow redistributes.

- **Norepinephrine released**

**CRH released**

**Anterior pituitary**

- ACTH released

**Adrenal cortex**

- Cortisol released

**Long term adjustment or resistance stage**

- Increase in blood concentration of amino acids.
- Increased release of fatty acids.
- Increased glucose formed from non-carbohydrates—amino acids (from proteins) and glycerol (from fats).
Gonads - two types: Ovaries & Testes

- The **gonads** are the main source of the sex hormones.
  - Estrogen (females)
  - Testosterone (males)