Operation of the Endocrine System

What is the Endocrine System?
The endocrine system is comprised of the hormone – producing glands and tissues of the body.

Functioning of the Endocrine System

- The endocrine system functions along with the nervous system to help maintain homeostasis.
- Endocrine system functions slower than nervous system but gives a more sustained effect.
- The endocrine system carries out its functions based upon messages received from the Hypothalamus.
  - The hypothalamus monitors the blood and sends hormones from glands into the blood when needed.
  - Organs await the arrival of hormones.
  - Specific hormones attach to specific receptors in cells. This happens in a “lock-and-key” fashion.
  - Organs that contain receptors for specific hormones are called target organs.

For example: Vigorous exercise triggers endocrine glands in the brain to release several different hormones to regulate oxygen consumption, basal metabolic rate and the metabolizing carbohydrates and fat for energy. As a result, the rate and depth of breathing increases, heart rate and muscle contraction increases and energy stores are quickly mobilized. Therefore, fuel is available for an increase in skeletal muscle, heart, and brain activity, while at the same time maintaining normal physiological processes.

The endocrine system also controls: blood sugar, metabolism, growth, reproductive development and function and other physiological activities.
Components of the Endocrine System

The endocrine system is composed of glands and tissues.

2 Types of Glands

A.  *Endocrine* - Glands that do not have ducts. Hormones are dumped directly into the bloodstream for transport to target cells.

B.  *Exocrine* - Glands that have ducts. Hormones are secreted into ducts. Ex: Sweat glands and Salivary glands
**Hormones**

These are chemicals that circulate throughout the blood and exert some measure of control over most every organ and tissue in the body.

**TYPES OF HORMONES**

Hormones are either Steroidal or Nonsteroidal.

1. **Steroid Hormones** – Hormones manufactured from a fatty substance called Cholesterol. These substances are “fat soluble”.
   Ex: Cortisol.

   *How Steroid Hormones Work*
   - These hormones enter a cell and binds to a protein receptor in the cell. This creates a hormone-receptor complex.
   - The hormone-receptor complex enters the nucleus where it activates a specific gene in the DNA.
   - Activated gene produces an enzyme (protein) that initiates a chemical reaction within the cell.

2. **Non-Steroid Hormones** – Hormones composed of proteins, peptides or amino acids. These hormones are NOT fat soluble. They are unable to enter cells because they are not soluble in the cell membrane.

   *How Non-steroid Hormones Work*
   - A Hormone (called a ‘first messenger’) binds to receptors on *surfaces* of target cell.
   - The binding causes ATP to be changed into Cyclic AMP(cAMP).
   - Cyclic AMP (Second messenger) causes chemical reactions to occur within the cell.

   Ex: Adrenaline, ACTH, LH, FSH, ADH

**Summary of Steroidal vs. Nonsteroidal Hormones**

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Solubility in Cell Membrane</th>
<th>Location of Receptors</th>
<th>End Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steroidal</td>
<td>Soluble</td>
<td>Within cell</td>
<td>Gene produces a Protein</td>
</tr>
<tr>
<td>Nonsteroidal</td>
<td>Insoluble</td>
<td>Surface of cell</td>
<td>cAMP causes chain reactions</td>
</tr>
</tbody>
</table>

Biology 3201 _Unit 1_ Endocrine System Notes
**Antagonistic Hormones**

These are hormones that work against each other or they have opposite effects on the body.

- Ex: Insulin and glucagon
  Parathyroid Hormone and Calcitonin

**Tropic Hormones**

These are hormones that regulate the hormone production of many other glands.

- Ex: Thyroid Stimulating hormone, HGH

**Endocrine/Hormone Disorders**

Problems with most endocrine glands are either caused by Hyposcretion or Hypersecretion of a hormone.

- Hyposcretion: An under secretion of a hormone within the body.
- Hypersecretion: An over secretion of a hormone within the body.
Feedback Mechanisms and Operation of Hormones

Hormones regulate endocrine function on the basis of feedback mechanisms. There are two types of feedback mechanisms.

1. **Negative feedback Mechanism/loop**
   A mechanism that works to “reverse” or “decrease” changes in the body.

   Ex: Hypothalamus – Pituitary Feedback Mechanism

   *Operation of the Hypothalamus-Pituitary Feedback mechanism*

   ![Feedback Mechanism Diagram]

   Feedback **inhibits** release of hormone 1

   Feedback **inhibits** release of hormone 2
2. **Positive Feedback Mechanism**
   A mechanism that serves to “increase” the effect of an action.

   Ex: Oxytocin Feedback loop.

   ![Feedback Mechanism Diagram]

   - Uterine Water Breaks
     - Pressure exerted on Cervix
       - Uterine Contractions Increase
         - Increase Oxytocin released
Glands of the Endocrine System

1. **Pituitary Gland**
   - Located at the base of the brain. Called the “Master Gland”
   - Connected to the Hypothalamus
   - Nervous system sends signals via the hypothalamus to exert control over the pituitary.
   - Comprised of two glands \( \rightarrow \) Posterior Pituitary and Anterior Pituitary.

   **Anterior Pituitary**
   - Located toward front of head.
   - Makes up largest portion of pituitary gland.
   - Produces 6 different hormones.

   **Hormones of the Anterior Pituitary**

<table>
<thead>
<tr>
<th>Hormone Name/Acronym</th>
<th>Target Cell/organ</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatotropin or Human Growth Hormone -- HGH</td>
<td>Bones, Tissues</td>
<td>• Regulates growth and development of body tissues.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increases intestinal absorption of calcium increasing cell division and growth in bones and cartilage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stimulate protein synthesis and lipid metabolism</td>
</tr>
<tr>
<td>Adrenocorticotropic Hormone (ACTH)</td>
<td>Adrenal Cortex</td>
<td>• Causes the adrenal cortex to produce cortisol and aldosterone.</td>
</tr>
<tr>
<td>Prolactin (PRL)</td>
<td>Mammary Glands</td>
<td>• Stimulates milk production (lactogenesis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stimulates development of mammary tissue</td>
</tr>
<tr>
<td>Thyroid Stimulating Hormone (TSH)</td>
<td>Thyroid Gland</td>
<td>• Stimulates the release of Thyroxine</td>
</tr>
<tr>
<td>Follicle Stimulating Hormone (FSH)</td>
<td>Ovaries, Testes</td>
<td>• Causes the maturation of a follicle within an ovary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Starts development of sperm in males</td>
</tr>
<tr>
<td>Lutenizing Hormone (LH)</td>
<td>Ovaries, Testes</td>
<td>• Causes follicle to release an egg. Forms a corpus luteum.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stimulates production of testosterone in males</td>
</tr>
</tbody>
</table>
**Posterior Pituitary**

- Located on back of pituitary gland.
- Smaller of two glands making up the pituitary.
- Stores hormones, but does not create any.
- Secretes 2 hormones

<table>
<thead>
<tr>
<th>Hormones of the Posterior Pituitary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hormone Name/Acronym</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Oxytocin</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Antidiuretic Hormone (ADH)</td>
</tr>
<tr>
<td>or Vasopressin</td>
</tr>
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<td></td>
</tr>
</tbody>
</table>

**Note:** ADH and Oxytocin are created by the HYPOTHALAMUS and STORED in the posterior pituitary.

**Problems associated with the Pituitary Gland**

**a. Dwarfism**

Cause: Insufficient production of HGH during childhood.

Effect: Causes an abnormally short stature.

Treatment: Injections of HGH

**b. Giantism**

Cause: Excess production of HGH prior to puberty.

Effect: abnormal growth of long bones in the skeleton.

Treatment: microsurgery of pituitary, radiation treatment of gland tissue.
c. **Acromegaly**

   **Cause:** Excess HGH production during adult years.

   **Effect:** Causes thickening of bone tissue. Causes abnormal growth of head, hands and feet. Also causes spinal deformities.

   **Treatment:** Surgical removal of tumor causing too much HGH to be released. Radiation of tumor. Injection of HGH blocking drug.

d. **Diabetes Insipidus**

   **Cause:** Insufficient production of ADH.

   **Effect:** increased thirst and dehydration  
   Production of high amounts of dilute urine  
   Enlarged urinary bladder.

   **Treatment:** Injections of ADH to reverse effects.

2. **Thyroid Gland**

   • Located in the throat
   • Butterfly shaped

   **Function** → produces Thyroxine and Calcitonin

   **Note:** Iodine is needed in diet in order to produce Thyroxine.

   **Function of Thyroxine**
   Thyroxine increases metabolism rate and oxygen consumption.

   Thyroxine is released from the thyroid gland when stimulated by TSH from the pituitary.

   TSH -------- >  Thyroid Gland -------- > releases Thyroxine

   TSH and Thyroxine work on a negative feedback loop.
**Function of Calcitonin**

- Moves *calcium* from the blood and into the bones. This lowers amount of calcium in the blood.

**Problems associated with Thyroid Gland**

**A. Hyposecretion of Thyroxine**

1. **Myxedema**
   - Condition where adults become obese, lose appetite and are often tired because of under production of thyroxine.

   Treatment: drugs that have Thyroxine in them

2. **Congenital Hypothyroidism or Cretinism**
   - Condition in children where they are often short/stalky and often mentally delayed.

   Treatment: drugs having thyroxine

3. **Goiter**
   - A condition caused by a *lack of iodine* in the diet. This causes a decreased production of Thyroxine.
   - Patients end up with swollen thyroid gland. Looks like a large growth on the neck.

   Treatment: increase iodine intake. Governments have added iodine to salt for years (Iodized salt) to counteract this problem.

**B. Hypersecretion of Thyroxine**

i. **Grave’s Disease**
   - Condition where there is an increased metabolism (“hyperness”) in a person.
   - Increased sweating
   - Muscle weakness
   - Protruding eyes

   Treatment: Surgical removal of thyroid gland
   Thyroid blocking drugs.
3. **Parathyroid Gland(s)**

- Located on the surface of thyroid gland.
- Produces PTH (Parathyroid Hormone)

**Function of PTH (Parathyroid Hormone)**

- Causes bones to release calcium into the blood stream.
- Causes kidneys to reabsorb calcium from blood thus increasing amount of calcium in the body.

4. **Pancreas (Islets of Langerhans)**

- Located near the small intestine.
- Contains specialized endocrine cells called Islets of Langerhans.
- Islets of Langerhans is made up both *Alpha* and *Beta* cells.
- Secretes Insulin and Glucagon

**Function of Insulin (Created by the Beta cells of the Islets of Langerhans)**

- Causes the conversion of Glucose into Glycogen that is stored in the liver.
- Causes excess glucose to be changed into fats.
- Helps regulate blood-sugar levels.

**Function of Glucagon (Created by the Alpha cells of the Islets of Langerhans)**

- Causes the conversion of Glycogen (liver) into Glucose that is released into the blood as needed.

\[
\text{Glycogen} \xrightarrow{\text{Glucagon}} \text{Glucose}
\]
Operation of Insulin and Glucagon in sugar (glucose) regulation.

Insulin and glucagon are antagonistic hormones. They work opposite each other to maintain proper blood sugar levels.

They work by either increasing or decreasing the amount of glucose (sugar) in the blood.

If the amount of glucose in the blood is high then insulin is secreted by the pancreas. This causes cells to uptake the glucose from the blood and the blood glucose level decreases. When the blood glucose level decreases glucagon is secreted and this causes the liver to convert glycogen into glucose. Glucose is released into the blood stream and the blood glucose level rises.

Disorders of the Pancreas

a. Type 1 Diabetes (Diabetes Mellitus)

- Known as Juvenile or Insulin Dependent diabetes. Occurs in individuals under 20 yrs old.

  Cause: Beta cells of Islets of Langerhans do not produce enough insulin.

  Result: abnormally high levels of sugar (glucose) in blood.

  Symptoms: Fatigue, thirst, weight loss, frequent urination, blindness

  Treatment: Insulin injections (usually for rest of life)
b. **Type 2 Diabetes**
   - Known as “adult onset diabetes”. Occurs in individuals over 40 yrs old.
   - Insulin is produced by pancreas but cells “do not recognize” it. Cells do not use
     the sugar found in the blood.

   Treatment: Strict control of carbohydrate intake to reduce amount of sugar in blood.

5. **Pineal Gland**
   - Located deep in the brain.
   - Produces *Melatonin*

   **Function of Melatonin**
   - Causes a feeling of “sleepiness” and aids with sleep.

6. **Thymus Gland**
   - Located between the lobes of the lung in the upper chest.
   - Produces *thymosin*

   **Function of Thymosin**
   - Causes the production and maturation of lymphocytes into T-cells.

7. **Adrenal Glands**
   - Located on top of the kidneys.
   - Composed of two layers
     - Outside ➔ Adrenal Cortex (outside of gland)
     - Inside ➔ Adrenal Medulla (inside of gland)
   - Both the Adrenal Medulla and Adrenal Cortex are controlled by the Hypothalamus.

   **Adrenal Cortex**
   - Releases **three** major hormones.
     - **Aldosterone** (mineralocorticoids) ➔ Regulates blood pressure and salt
       levels in the blood.
     - **Cortisol** (Glucocorticoids) ➔ Reduces inflammation and causes glucose to
       be made by the liver.
     - Sex Hormones
       - Males ➔ hormones called “Androgens”
- Females → hormones called “Estrogens”

**Adrenal Medulla**

- Releases two major hormones
  - Adrenaline (epinephrine) and Noradrenaline (norepinephrine) → Released during times of stress. The “Fight or Flight” hormone.
    - Increases heart rate, respiration rate, release of glucose by liver etc.

8. **Gonads → Ovaries and Testes**

a. Ovaries – found in females

  - Produces *estrogen* and *progesterone*
    - Estrogen → controls secondary sex characteristics in females
      Prepares the uterus for pregnancy
    - Progesterone → Maintains uterus during pregnancy

b. Testes – found in males

  - Produces *testosterone*
    - Controls secondary sex characteristics in males.