The Endocrine System

Biol 105
Lecture Packet 12
Chapter 10

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Quiz

1. Muscle cells are bundled together, these bundles are called ____?
2. What is the plasma membrane called in muscle cells?
3. What is the oxygen binding protein similar to hemoglobin, but found only in muscles?
4. Where is Ca++ stored in muscle cells?
5. What does Ca++ bind to when it is released?

Outline

I. Function of Endocrine System
II. Hormones and Neurotransmitters
III. Types of Hormones and their actions
IV. Endocrine glands/organs and hormones

Function of the Endocrine System

• The function of the endocrine system is to work with the nervous system to regulate and control other systems and maintain homeostasis.

Endocrine System

• The endocrine system functions by releasing hormones which travel through the body (usually using the bloodstream) to target cells

Glands are secretory cells or structures derived from

1. Muscle
2. Connective
3. Epithelial tissue
4. Nervous

These glands do not have tubes or ducts, they secrete hormones directly into blood stream.

1. Exocrine glands
2. Endocrine glands

Endocrine System Communication

What is a hormone?

• Hormones are chemical messengers that are secreted by one cell and travels to another cell and affects other only the target cells that have the correct receptor.
Target Cells

- Target cells have receptors that bind the hormones.
- Non-target cells do not have these receptors and are unaffected by the hormone

Hormones vs Neurotransmitters

- Similar: Endocrine system and the nervous system both are controlled by negative feedback
- Endocrine and nervous system work together to maintain homeostasis but there are differences

Hormones vs Neurotransmitters - Differences

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<th>Neurotransmitters</th>
<th>Hormones</th>
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<tr>
<td>Where is it located</td>
<td>Localized to nerve synapse</td>
<td>Distribute throughout body in blood stream</td>
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<tr>
<td>How long does it take to act?</td>
<td>Quick acting</td>
<td>Slow to act</td>
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<tr>
<td>How long does it last?</td>
<td>Taken away quickly</td>
<td>Remains longer in body</td>
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Types of Hormones

- There are two types of hormones:
  1. Water Soluble (Hydrophilic)
  2. Lipid Soluble (Hydrophobic)

Amino acid hormones

- A single amino acid – ex: epinephrine
- Polypeptides (a chain of amino acids) – ex: human growth hormone

Amino Acid

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<th>Central carbon</th>
<th>Hydrogen atom</th>
<th>Amino group</th>
<th>Carboxyl group</th>
<th>Side chain</th>
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Are Amino Acids Hydrophilic or Hydrophobic?

1. Hydrophilic
2. Hydrophobic

1. Yes
2. No
**Water Soluble Hormones**

- Amino acids and polypeptides are examples of water soluble hormones
  - Example: Epinephrine
  - Adrenal glands release epinephrine into the blood stream, travels throughout the body

**Water Soluble Hormones**

- Water soluble hormones bind to a receptor on the surface of the target cells (ex: muscle cells).
  - The binding of the hormone epinephrine to the receptor triggers the formation of a secondary messenger (ex: cAMP).

**Steroid hormones**

1. Steroid hormones have a structure similar to cholesterol.
   - Examples: estrogen, testosterone

**Steroid Structure**

- Four-ring steroid structure

**Steroids are...**

1. Sugars
2. Proteins
3. Lipids
4. Complex carbohydrates

**Are Steroids Hydrophilic or Hydrophobic?**

1. Hydrophilic
2. Hydrophobic

**Can steroids freely cross the plasma membrane?**

1. Yes
2. No
Lipid Soluble Hormones - Steroids

- Steroids are examples of lipid soluble hormones
- Example: Estrogen
- The ovaries produce estrogen.

When DNA is copied to make mRNA this is:

1. Translation
2. Transcription

What is the product of translation?

1. DNA
2. RNA
3. Protein/polypeptide
4. Nucleotides

Lipid Soluble Hormones - Steroids

- Lipid soluble hormones enter the target cells, they can freely pass through the plasma membrane.
- Inside the cell, the hormone binds with a receptor.

Lipid Soluble Hormones - Steroids

- The hormone-receptor complex binds to DNA in the nucleus and activates the transcription of DNA to make mRNA.
- The mRNA leaves the nucleus, binds to a ribosome and is translated to make proteins.

Water Soluble vs Lipid Soluble Hormones

- Note that the lipid soluble hormones will take longer to act than the water soluble hormones since they cause DNA transcription and translation to make a protein.
- Also remember that water soluble hormones do not enter the target cell, they work through secondary messengers, whereas lipid soluble hormones enter the cell.

Endocrine Glands and Organs that Secrete Hormones

- Pituitary
- Thyroid
- Parathyroid
- Adrenals
- Pineal
- Hypothalamus
- Thymus
- Pancreas
- Ovaries
- Testes
- Heart
- Placenta
- Stomach
- Intestines
- Kidneys

Lipid-soluble Hormones

- Animation—How Hormones Influence Target Cells

cAMP Mediation

- Animation—How Hormones Influence Target Cells
Figure 10.2 (1 of 2)

Parathyroid glands (two of four)

Pineal gland

Thymus gland

Kidney

Adrenal gland (one on each kidney)

Adrenal cortex

Adrenal medulla

Heart

Figure 10.2 (2 of 2)

Uterus

Thyroid gland

Pancreas

Testis (one of a pair)

Ovary (one of a pair)

Small intestine

Stomach

Hypothalamus

— regulates the internal environment through the autonomic nervous system.

Helps control heartbeat.

Helps control body temperature.

Helps control water balance.

Hypothalamus

— Controls glandular secretions of the pituitary gland.

Produces:

1. antidiuretic hormone (ADH)
2. Oxytocin
3. hypothalamic-releasing hormones
4. hypothalamic-inhibiting hormones

Hypothalamus – ADH and Oxytocin

Neurosecretory cells of the hypothalamus produces antidiuretic hormone (ADH) and Oxytocin.

Antidiuretic hormone (ADH) and oxytocin are stored in the posterior lobe of the pituitary gland.

Posterior pituitary gland releases these hormone when needed.

A Diuretic Will Make Your Urine:

1. More dilute
2. More concentrated

50% 50%

An Antidiuretic Will Make Your Urine:

1. More dilute
2. More concentrated

50% 50%
### Antidiuretic hormone (ADH)
- **Function**: regulates water reabsorption in the kidneys (H₂O is returned to the bloodstream).
- **Target**: Kidneys

### Disorders
- **Diabetes insipidus**: Caused by a deficiency of ADH.
- Results in excessive urine production, leading to dehydration.
- **Treatment**: administer synthetic ADH

### Oxytocin
- **Function**: stimulates uterine contraction during childbirth and milk release (ejecting milk from the glands).
- **Target**: Uterus and mammary glands
- **Pitocin**: Synthetic form or OT, given to induce labor.

### Hypothalamic-releasing and hypothalamic-inhibiting Hormones
- The hypothalamus produces hypothalamic-releasing and hypothalamic-inhibiting hormones.
- These hormones travel a short distance in the bloodstream to the Anterior Pituitary Gland.

### Hypothalamic-releasing Hormones
- The hypothalamic-releasing hormones stimulate the Anterior Pituitary Gland to release (secrete) its hormones.

### Hypothalamic-inhibiting Hormones
- The hypothalamic-inhibiting hormones inhibit the Anterior Pituitary Gland from releasing (secreting) its hormones.

### Pituitary Gland – Anterior
- The anterior pituitary gland produces:
  1. Thyroid-stimulating hormone (TSH)
  2. Adrenocorticotropic hormone (ACTH)
  3. Gonadotropic hormones – (FSH and LH)
  4. Prolactin (PRL)
  5. Growth hormone (GH)

### Pituitary Gland – Anterior and Posterior
- There are two sections of the pituitary gland: anterior and posterior.
- The posterior pituitary gland receives ADH and oxytocin from the hypothalamus, stores these hormones and releases them.
Pituitary Gland – Anterior
- The anterior pituitary gland releases hormones after receiving hypothalamic-releasing hormones from the hypothalamus.

Thyroid-stimulating hormone (TSH)
- **Function:** stimulates the thyroid gland to produce thyroxine.
- **TSH** is produced by the Anterior Pituitary
- **Target:** Thyroid gland

Adrenocorticotropic hormone (ACTH)
- **Function:** stimulates the adrenal cortex to produce cortisol.
- **ACTH** is produced by the Anterior Pituitary
- **Target:** adrenal cortex

Gonadotropic hormones
- **Gonadotropic hormones** - stimulate the gonads to produce gametes and hormones.
  - **FSH**
  - **LH**

Growth hormone (GH)
- **Function:** promotes skeletal and muscular growth.
- **GH** is produced by the Anterior Pituitary
- **Target:** Bones, muscles, and cartilage

Disorder - Gigantism
- **Gigantism** – Too much GH during childhood can result in rapid growth and attaining heights of 8 – 9 feet.
- **Treatment** – if caused by a pituitary tumor then treatment is to remove or reduce the tumor using surgery, radiation or chemotherapy.

Prolactin (PRL)
- **Function:** causes mammary glands to develop and produce milk.
- **PRL** is produced by the Anterior Pituitary
- **Target:** Mammary glands

Gigantism
**Disorder - Acromegaly**

- Acromegaly – Too much GH in adulthood can result in a thickening of the bones of the extremities and face as well as the tongue.
- Same treatment as gigantism

**Disorder - Pituitary dwarfism**

- Pituitary dwarfism – Insufficient GH production results in sterility and attaining maximum height of about 4 ft.
- Treatment – Administer GH during childhood.

**Disorder - Pituitary dwarfism**

Which of the following hormones stimulates water reabsorption by the kidneys?

1. insulin
2. thyroxin
3. ADH
4. calcitonin

Which of the following hormones stimulates the adrenal cortex to produce cortisol?

1. insulin
2. thyroxin
3. ADH
4. ACTH

Which gland produces oxytocin?

1. Anterior Pituitary
2. Posterior Pituitary
3. Hypothalamus
4. Adrenal Cortex

Which gland produces prolactin?

1. Anterior Pituitary
2. Posterior Pituitary
3. Hypothalamus
4. Adrenal Cortex

- Animation – The Hypothalamus and Pituitary
Thyroid Gland Hormones

- Thyroid gland - large gland located below the larynx. Requires iodine to make hormones
- Produces:
  1. Thyroid Hormones (TH):
     - Thyroxine (T4)
     - Triiodothyronine (T3)
  2. Calcitonin

Disorders – Simple goiter

- Simple goiter
  - Results in an enlarged thyroid gland
  - May be caused by a diet deficient in iodine, which is needed for the production of TH
  - Can be treated by iodine supplements or administration of TH

Disorders - Cretinism

- Cretinism
  - Caused by too little TH during fetal development or infancy
  - Results in dwarfism and delayed mental and sexual development
  - Treatment: Administer TH

Disorders - Myxedema

- Myxedema
  - Caused by too little TH in adulthood
  - Results in a condition in which fluid accumulates in facial tissues and a decrease in alertness, body temperature, and heart rate
  - Treatment: Administer TH

Disorders - Graves’ disease

- Caused by an oversecretion of TH
- Results in an autoimmune disorder due to the production of antibodies that mimic the action of TSH

- Symptoms include
  - Increased metabolic rate and heart rate accompanied by sweating, nervousness, and weight loss
  - Many also have exophthalmos
- Treatment: Administer drug that blocks the synthesis of TH, thyroid gland may be reduced by surgery or radioactive iodine

Exophthalmos

- (c) Exophthalmos
**Thyroid Gland - Calcitonin**

- Calcitonin - lowers blood calcium levels.
- Target:
  - Bones: Stimulates osteoblasts (type of bone cells) to deposit calcium.
  - Kidneys: Stimulates kidneys to excrete more calcium in the urine.

**Parathyroid Glands**

- Parathyroid glands - embedded in the lobes of the thyroid gland.
- Secretes: Parathyroid hormone (PTH)

**Parathyroid Glands - Parathyroid hormone**

- Parathyroid hormone (PTH) - functions to increase blood calcium levels.

**Parathyroid Glands - Parathyroid hormone**

- Targets:
  - Bone: Stimulates the osteoclasts (type of bone cell) to release calcium
  - Kidneys: Stimulates the kidneys to reabsorb calcium
  - Intestine: Stimulates the intestine to increase absorption of calcium.

**What is the target of thyroxine?**

1. Bone
2. Muscle
3. Kidneys
4. Most cells in the body

**Calcium levels in blood too low:**
- PTH is released from parathyroid gland,
- Effects: PTH causes the:
  - Bone to release calcium
  - Kidney to reabsorb calcium and
  - Intestine to absorb more calcium

**Calcium levels in blood too high:**
- CT is released from thyroid gland,
- Effects: CT cause the:
  - Bone to deposit calcium
  - Kidney to excrete more calcium

**Regulation of Calcium Levels in Blood**
Calcitonin **lowers** or **raises** the blood’s calcium level?

1. Lowers
2. Raises

Calcitonin is produced by the

1. Hypothalamus
2. Thyroid
3. Parathyroid

Adrenal Glands

- **Adrenal cortex**
  - Mineralocorticoids
  - Glucocorticoids

- **Adrenal medulla**
  - Epinephrine
  - Norepinephrine

Adrenal Medulla - Epinephrine

- Hormone secreted by adrenal medulla:
  - Epinephrine - prepares the body for quick action. “fight or flight” / short-term response to stress.
  - Effects: Increases blood pressure, increases heart rate, increases blood glucose levels

Adrenal Cortex

- Two types of hormone secreted by adrenal cortex:
  1. Mineralocorticoids
  2. Glucocorticoids

Adrenal Cortex - Mineralocorticoids

- **Mineralocorticoids** – example: aldosterone
- Effects: Mineral homeostasis and water balance.
Adrenal Cortex - Mineralocorticoids

- Effects of Aldosterone:
  - Promotes renal absorption of Na⁺ and renal excretion of K⁺.
  - Increases blood pressure.
- Target: Kidneys

Adrenal Cortex - Glucocorticoids

- Glucocorticoids – ex: cortisol. Influences carbohydrate, protein, & fat metabolism, suppress the immune system

- Effects of Cortisol:
  - Affect glucose homeostasis
  - Act on the liver to promote the conversion of fat and protein into intermediate substances available to the body’s cells
  - Inhibit the inflammatory response

What effect does the presence of epinephrine have on blood pressure?

1. increases
2. decreases
3. has no effect

Which of the following affects the adrenal cortex?

1. ACTH
2. TSH
3. FSH
4. Nerves

The complex carbohydrate stored in humans is:

1. Cellulose
2. Starch
3. Glycogen
4. Triglycerides

Where is glycogen stored in the body:

1. Adipose tissue
2. Muscle
3. Liver
4. 2 and 3

Which of the following glands secretes cortisol?

1. pituitary
2. pancreas
3. adrenal medulla
4. adrenal cortex

Pancreas

![Pancreas Image]

*Figure 10.17a*

Structure of the pancreas and associated ducts. Exocrine cells of the pancreas secrete digestive enzymes into the pancreatic duct, which unites with the common bile duct before entering the small intestine.
Hormones of the pancreas
- Secreted from the pancreatic islets (Islets of Langerhans)
- Regulate blood glucose levels through two hormones:
  1. glucagon
  2. insulin

**Glucagon**
- Raises blood glucose levels of the blood.
- Target and effects:
  - Liver: stimulates the breakdown of glycogen to glucose, and to form glucose from lactic acid

**Insulin**
- Lowers blood glucose levels of the blood.
- Target and effects:
  - Stimulates transport of glucose into muscle cells, white blood cells, and connective tissue cells.
  - Liver: inhibits the breakdown of glycogen to glucose.
  - Prevents conversion of amino and fatty acids into glucose.
  - Adipose tissue: stimulates formation of triglycerides from glucose.

**Diabetes mellitus**
- Caused by the lack of insulin or by the inability of cells to respond to insulin as they should.
  - Type 1 diabetes: autoimmune disorder that causes the pancreas is not producing enough insulin.
  - Type 2 diabetes: inability of cells to respond to insulin (cells do not have enough insulin receptors).
Glucagon _______ the blood glucose levels
1. Lowers
2. Raises

Gonads – ovaries and testes
- They are controlled by the hypothalamus and the pituitary gland – see the Gonadotropic hormones
- Testes produce testosterone.
- Ovaries produce estrogen and progesterone.

Gonads - Testosterone
- Effects:
  - During development, testosterone stimulates growth of male reproductive organs
  - Responsible for male secondary sex characteristics.
  - Prompts larynx & vocal cords to enlarge.
  - Responsible for muscular strength of males.

Gonads - Estrogen and progesterone
- Effects:
  - During development, stimulates growth of female reproductive organs
  - Responsible for secondary sex characteristics.
  - Necessary for egg maturation.
  - Regulates ovarian and uterine cycles.

Anabolic Steroids
- Some athletes take testosterone like compounds to enhance their performance.
- There is a down side to taking steroids:
  - Increase in body odor, baldness, acne, breast enlargement in men, kidney disease, decreased testicular size, low sperm count, impotence, high cholesterol, high blood pressure, heart damage, liver dysfunction, liver cancer, stunted growth if taken during development, personality changes including rage and delusions.

Thymus gland
- Thymus gland – lies behind the sternum.
- Secretes the hormones: thymosin and thymopoietin which stimulates T-cell lymphocyte development – important in immune system function.
- Target: bone marrow
- Large and most active in children.

Pineal Gland
- Located in the brain.
- Secretes the hormone: melatonin
  - Involved in our daily sleep-wake cycle (circadian rhythms)
  - Regulates sexual development.
  - May play a role SAD – seasonal affect disorder
Which endocrine gland is the most involved in the immune response?

1. adrenal medulla
2. pancreas
3. thymus
4. ovaries

Kidneys

- The kidneys release the hormones:
  - Erythropoietin — stimulates the bone marrow to produce more red blood cells
  - Renin — through a series of reactions, stimulates the adrenal cortex to release aldosterone which increase blood pressure.

Adipose tissue - Leptin

- Leptin is a hormone produced in adipose tissue and effects the hypothalamus to tell them that they are full and don’t need to eat anymore.

Prostaglandins

- Prostaglandins – locally acting messengers

Homeostasis

- The nervous and endocrine systems exert control over the other systems and thereby maintain homeostasis.
- Both systems work closely together to govern the internal organs.

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**Important Concepts**

- What is the function of the endocrine system
- What are similarities and differences between neurotransmitters and hormones
- What are the two types of hormones; How do the two types of hormones work, how do they effect the target cells, know the differences between the two types of hormones, and examples of each type of hormone

**Important Concepts**

- Where are all the hormones in this lecture produced and released from, and what are the functions of the hormones, and what is the target of the hormones.
- Know all the disorders discussed in the lecture, what are the causes, effects of the disorder and what are the treatments of the disorders.
- Know the location and names of the endocrine glands, be able to label a drawing with the glands

**Definitions**

- Endocrine glands, Hormones, receptor, target cells, non-target cells, exophthalmos, pancreatic islets, negative feedback, water soluble, hydrophilic, lipid soluble, hydrophobic, secondary messenger, transcription, translation, produce, release, dilute, concentrated, extremities, deficient, sufficient, synthesis, reabsorption, inhibit, stimulate, extremities, prostaglandins, pancreatic islets, Islets of Langerhans