Outline

I. Function of endocrine system
II. Hormones and neurotransmitters
III. Types of hormones and their actions
IV. Endocrine glands/organs and hormones
The function of the endocrine system is to work with the nervous system to regulate and control other systems and maintain homeostasis.

The endocrine system functions by releasing hormones, which travel through the body (usually through the bloodstream) to reach target cells.
Glands are secretory cells or structures derived from:

1. Muscle
2. Connective tissue
3. Epithelial tissue
4. Nervous
These glands do not have tubes or ducts, and they secrete hormones directly into the bloodstream:

1. Exocrine glands
2. Endocrine glands
Endocrine System Communication

The hormone diffuses into the bloodstream.

Capillary

Hormone

The hormone travels throughout the body.
What is a hormone?

- **Hormones** are chemical messengers that are secreted by one cell and travel to another cell:
  - They affect **only** target cells that have the correct receptor.

- Target cells have receptors that bind to the hormone.

- Non-target cells do not have these receptor and are unaffected by the hormone.
Hormones and Target Cells

1. Endocrine cells release hormone.

2. Hormone enters circulation.

3. Hormone is carried throughout the body.

Hormone will not bind to cells that are not target cells.

4. Binding occurs, hormonal effects take place.

receptor

target cell (skeletal muscle)
Hormones versus Neurotransmitters

- **Similarity**: the endocrine system and the nervous system are both controlled by negative feedback.

- Endocrine and nervous systems work together to maintain homeostasis, but there are differences…
<table>
<thead>
<tr>
<th></th>
<th>Neurotransmitters</th>
<th>Hormones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where is it located?</td>
<td>Localized to nerve synapse</td>
<td>Distributed throughout body in bloodstream</td>
</tr>
<tr>
<td>How long does it take to act?</td>
<td>Quick-acting</td>
<td>Slow to act</td>
</tr>
<tr>
<td>How long does it last?</td>
<td>Taken away quickly</td>
<td>Remain longer in body</td>
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</tbody>
</table>
Types of Hormones

- There are two general types of hormones:

  1. Water Soluble (Hydrophilic)
  2. Lipid Soluble (Hydrophobic)
Amino Acid Hormones

- A single amino acid
  - Example: epinephrine

- Polypeptides (a chain of amino acids)
  - Example: human growth hormone
Are amino acids hydrophilic or hydrophobic?

1. Hydrophilic
2. Hydrophobic
Can an amino acid freely cross the plasma membrane?

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 bloodstream, and it 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 receptor is on the plasma membrane.

- The binding of the hormone epinephrine to the receptor triggers the formation of a secondary messenger (ex: cAMP).

- The secondary messenger triggers a cascade of events ending in cellular activity (ex: the breakdown of glycogen to glucose).

- **Note:** this type of hormone does not cross the plasma membrane and enter the cell!
Water Soluble Hormones – cAMP Mediated

**Step 1:** The water-soluble hormone (first messenger) binds to a receptor on the surface of the plasma membrane.

**Step 2:** Binding activates the enzyme responsible for producing cAMP (the second messenger) from ATP.

**Step 3:** cAMP initiates an enzyme cascade.

**Step 4:** Enzyme 3 stimulates the breakdown of glycogen to glucose.

Figure 10.4
Steroid Hormones

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

(a) 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
When DNA is copied to make mRNA this is:

1. Translation
2. Transcription

[Bar chart showing 50% for both Translation and 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, because they can freely pass through the plasma membrane.

- Inside the cell, the hormone binds with a receptor.

- 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.
Lipid Soluble Hormones

Step 1: The steroid hormone diffuses through the plasma membrane of the target cell.

Step 2: The steroid hormone binds to a receptor in the cytoplasm.

Step 3: The hormone-receptor complex enters the nucleus.

Step 4: The hormone-receptor complex binds to DNA.

Step 5: Certain genes are activated.

Step 6: Proteins, including enzymes, are synthesized.

Step 7: Enzymes alter the activity of the cell.
- 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
Endocrine System

- Thyroid gland
- Stomach
- Pancreas
- Small intestine
- Testis (one of a pair)
- Uterus
- Ovary (one of a pair)
Hypothalamus

- Hypothalamus: regulates the internal environment through the autonomic nervous system.
  - Helps control heart rate.
  - Helps control body temperature.
  - Helps control water balance.
Hypothalamus

- Hypothalamus: controls glandular secretions of the pituitary gland.

- Produces:
  1. Antidiuretic hormone (ADH)
  2. Oxytocin
  3. Hypothalamic-releasing hormones
  4. Hypothalamic-inhibiting hormones
(a) Side view of the pituitary gland
(b) Close-up of the pituitary gland showing how it is attached to the hypothalamus by a short stalk.
Nerve cells in the hypothalamus produce antidiuretic hormone (ADH) and oxytocin (OT).

ADH and OT travel to the ends of the cells in the posterior pituitary, where they are released into the bloodstream to influence target tissues.

Nerve cells in the hypothalamus secrete releasing hormones and inhibiting hormones.

Releasing and inhibiting hormones travel by way of the bloodstream to the anterior pituitary and cause it to modify secretion of its six hormones (FSH, LH, GH, PRL, ACTH, and TSH).

Antidiuretic hormone (ADH)

Kidney tubules

Oxytocin (OT)

Smooth muscle in uterus

Mammary glands

Thyroid-stimulating hormone (TSH)

Adrenocorticotropic hormone (ACTH)

Prolactin (PRL)

Cortex of adrenal gland

Mammary glands

Bones, muscles

Follicle-stimulating hormone (FSH) and Luteinizing hormone (LH)

Ovaries, testes

Growth hormone (GH)
Hypothalamus and Posterior Pituitary Gland: ADH and Oxytocin

- Neurosecretory cells of the hypothalamus produce antidiuretic hormone (ADH) and oxytocin.

- ADH and oxytocin are stored in the posterior lobe of the pituitary gland.

- Posterior pituitary gland releases these hormone when needed.
Antidiuretic Hormone (ADH)

- **Function**: regulates water reabsorption in the kidneys (H₂O is returned to the bloodstream).

- **Target**: kidneys
ADH-Related Disorder

- **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 of oxytocin that is administered to induce labor.
Anterior Pituitary Gland

- There are two sections of the pituitary gland: posterior and anterior.
- The **anterior** pituitary gland *produces*:

1. Thyroid-stimulating hormone (TSH)
2. Adrenocorticotrophic hormone (ACTH)
3. Gonadotropic hormones – (FSH and LH)
4. Prolactin (PRL)
5. Growth hormone (GH)
ANTERIOR PITUITARY GLAND...

...releases the hormones it has produced after receiving hypothalamic-releasing hormones from the hypothalamus.
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: stimulate the anterior pituitary gland to release (secrete) its hormones.
  - Hypothalamic-inhibiting hormones: inhibit the anterior pituitary gland from secreting its hormones.
Anterior Pituitary Hormones: Thyroid-Stimulating Hormone (TSH)

- **Function**: stimulates the thyroid gland to produce **thyroxine** (one of the thyroid hormones).

- **Target**: thyroid gland
Anterior Pituitary Hormones: Adrenocorticotropic Hormone (ACTH)

- **Function:** stimulates the adrenal cortex to produce **cortisol**.

- **Target:** adrenal cortex
Anterior Pituitary Hormones: Gonadotropic Hormones

- **Function**: stimulate the gonads to produce gametes and hormones.
- The two gonadotropic hormones are:
  - **Follicle Stimulating Hormone (FSH)** – stimulates gamete development in males and females.
  - **Luteinizing Hormone (LH)** – stimulates ovaries to produce estrogen and progesterone in females, and testosterone in males.
Anterior Pituitary Hormones: Prolactin (PRL)

- **Function**: causes mammary glands to develop and **produce** milk.

- **Target**: mammary glands
Anterior Pituitary Hormones: Growth Hormone (GH)

- **Function**: promotes skeletal and muscular growth.

- **Target**: bones, muscles, and cartilage
Gigantism: too much GH during childhood can result in rapid growth, where an individual attains 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.
Gigantism
Disorders: Pituitary Dwarfism

- Pituitary dwarfism: insufficient GH production results in sterility, and affected individuals attain a maximum height of about 4 feet.

- **Treatment**: administer GH during childhood.
Pituitary Dwarfism

Figure 10.9
Which of the following hormones stimulates water reabsorption by the kidneys?

1. Insulin
2. Thyroxin
3. ADH
4. Calcitonin
Which hormone 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
(a) The thyroid gland lies over the trachea, just below the larynx.
Thyroid Gland

- Thyroid gland: large gland located below the larynx.
  - Requires iodine to make hormones.

- Produces:
  1. Thyroid Hormones (TH):
     - Thyroxine (T4) – stimulated by TSH from anterior pituitary gland
     - Triiodothyronine (T3)
  2. Calcitonin
Thyroid Gland: Thyroid Hormones (TH)

- **Function**: regulates metabolism by stimulating protein synthesis, the breakdown of lipids, and the use of glucose for the production of ATP.

- **Target**: most cells in the body!
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:
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.
Disorders: Graves’ Disease

- Symptoms include:
  - Increased metabolic rate and heart rate, accompanied by sweating, nervousness, and weight loss.
  - Many also have *exophthalmos (= bulging or protruding eyeballs)*.

- Treatment: administer drug that blocks the synthesis of TH, and thyroid gland may be reduced by surgery or radioactive iodine.
Exophthalmos

(c) Exophthalmos

Figure 10.12c
Thyroid Gland: Calcitonin

- **Function**: 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.

- Secrete: parathyroid hormone (PTH)
  - PTH functions to increase blood calcium levels.

- **Targets:**
  - **Bone** – stimulates the osteoclasts (type of bone cell) to release calcium.
  - **Kidneys** – stimulates the kidneys to reabsorb calcium.
  - **Intestines** – stimulates the intestines to increase absorption of calcium.
Regulation of Calcium Levels in Blood

- If calcium levels in blood are too low:
  - PTH is released from parathyroid gland.

- Effects: PTH causes the…
  - bones to release calcium,
  - kidneys to reabsorb calcium, and
  - intestines to absorb more calcium.
Calcium Regulation

When levels of calcium are low, the parathyroid glands release PTH. In response, calcium is released by bones, reabsorbed by kidneys, and absorbed by the intestines.
Regulation of Calcium Levels in Blood

- If calcium levels in blood are too high:
  - CT is released from thyroid gland.

- Effects: CT causes the...
  - **bones** to deposit calcium, and
  - **kidneys** to excrete more calcium.
When levels of calcium are high, the thyroid gland releases CT, and calcium is taken up by the bones.

Thyroid gland secretes CT

CT

Bones take up calcium

High blood calcium

Blood calcium decreases

Homeostasis
Normal blood calcium
Calcitonin lowers or raises the blood's calcium level?

1. Lowers
2. Raises
Calcitonin is produced by the:

1. Hypothalamus
2. Thyroid
3. Parathyroid

[Bar chart showing 33% for each category: Hypothalamus, Thyroid, Parathyroid]
(a) Each adrenal gland sits on top of a kidney.
Adrenal Glands

(b) A section through the adrenal gland reveals two regions, the outer adrenal cortex and the inner adrenal medulla. These regions secrete different hormones.

Adrenal cortex
- Mineralocorticoids
- Gonadocorticoids
- Glucocorticoids

Adrenal medulla
- Epinephrine
- Norepinephrine
Control of the Adrenal Glands

- The adrenal glands are controlled by both nerves and hormones.
  - **Adrenal medulla**: controlled by nerves from the hypothalamus.
  - **Adrenal cortex**: controlled by ACTH (a hormone) secreted by the anterior pituitary gland.
Hormone secreted by adrenal medulla:

- **Epinephrine** – prepares the body for quick action.
  - “Fight or flight” situations and 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
An example of a mineralocorticoid is **aldosterone**: 
- Promotes renal absorption of \( \text{Na}^+ \) and renal excretion of \( \text{K}^+ \).
- Increases blood pressure.
- **Target**: kidneys

**Effects**: mineral homeostasis and water balance.
An example of a glucocorticoid is cortisol:

- Affects glucose homeostasis.
- Acts on the liver to promote the conversion of fat and protein into intermediate substances available to the body’s cells.
- Inhibits the inflammatory response (suppresses the immune system).
What effect does the presence of epinephrine have on blood pressure?

1. Increases
2. Decreases
3. Has no effect
Which of the following effects 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

- Adipose tissue: 25%
- Muscle: 25%
- Liver: 25%
- 2 and 3: 25%
Which of the following glands secretes cortisol?

1. Pituitary
2. Pancreas
3. Adrenal medulla
4. Adrenal cortex
Cortisol: A Stress Hormone

- The pituitary gland produces and releases ACTH (adrenocorticotropic hormone).

- ACTH travels to the adrenal gland, where it stimulates the adrenal cortex to release glucocorticoids like cortisol.

- Cortisol plays a role in regulating how much free glucose there is in the body.
Cortisol

- Cortisol prompts the **muscles** to break down glycogen and release glucose.

- It also prompts the **adipose tissue** to break down fat.

- So basically it tells the body to take biomolecules out of storage so they can be used for energy!
Addison disease: hyposecretion from the adrenal cortex results in too few hormones being secreted.

- Cannot recover from stressful situations.
- Can lead to low blood pressure and dehydration.
- Can be fatal if not treated.

Treatment: supplement with glucocorticoids and mineralocorticoids.
Disorders of the Adrenal Glands: Cushing’s Syndrome

- **Cushing’s syndrome**: hypersecretion from the adrenal cortex results in too many hormones being secreted.
  - Can result in diabetes.
  - Can result in redistribution of fat and reduced muscle mass.

- Treatments: if caused by a tumor, surgical removal of the tumor (if possible).
  - Can treat with radiation and chemotherapy.
  - Can be treated with drugs to reduce the activity of the adrenal cortex.
Pancreas

(a) 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
(b) Section of pancreatic tissue. Endocrine cells of the pancreas are found in clusters called pancreatic islets. Surrounding the islets are exocrine cells.
Pancreas: Glucagon

- **Glucagon**: raises blood glucose levels.

- **Target and effects:**
  - Liver – stimulates the breakdown of glycogen to glucose, and the formation of glucose from lactic acid.
Glucose Regulation

When the level of glucose in the blood is low, the pancreas is stimulated to secrete glucagon, which, in turn, increases glucose in the blood by causing the liver to break down glycogen into glucose.
Pancreas: Insulin

- **Insulin**: lowers blood glucose levels.
- **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 acids and fatty acids into glucose.
  - **Adipose tissue**: stimulates formation of triglycerides from glucose.
Glucose Regulation

When the level of glucose in the blood is high, the pancreas secretes insulin. Insulin lowers blood glucose by its effects on the liver and cells of muscle and adipose tissue.

Liver stops breakdown of glycogen to glucose

Muscle cells take up glucose

Adipose tissue uses glucose to form fat

Pancreas secretes insulin

Insulin

High blood glucose (after meals)

Blood glucose decreases

Homeostasis Normal blood glucose
Disorders: Diabetes Mellitus Types 1 and 2

- 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 to not produce enough insulin.
  - Type 2 diabetes – inability of cells to respond to insulin. (Cells do not have enough insulin receptors.)
What type of diabetes mellitus is caused by the lack of insulin?

1. Type 1
2. Type 2
Glucagon _______ the blood glucose levels.

1. Lowers
2. Raises
Gonads: Ovaries and Testes

- They are controlled by the hypothalamus and the pituitary gland by 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 and vocal cords to enlarge.
  - Responsible for muscular strength of males.
Anabolic Steroids

- Some athletes take testosterone-like compounds to enhance their performance.

- There is a downside 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…
Gonads: Estrogen and Progesterone

- Effects:
  - During development, stimulates growth of female reproductive organs.
  - Responsible for secondary sex characteristics.
  - Necessary for egg maturation.
  - Regulates uterine cycle.
Thymus Gland

- Thymus gland: lies behind the sternum.
- Secretes the hormones thymosin and thymopoietin, which stimulate T-cell lymphocyte development.
  - Important in immune system function.
- **Target:** bone marrow
- Thymus is largest and most active in children.
Pineal Gland

Figure 10.19

Pineal gland
Cerebrum
Hypothalamus

Skull

Pituitary gland
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 in SAD = seasonal affective disorder.
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 increases blood pressure.
Adipose Tissue: Leptin

- **Leptin** is a hormone produced in adipose tissue and affects the hypothalamus:
  - Tells you that you are full and do not need to eat anymore.
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.
Which endocrine gland is the most involved in the immune response?

1. Adrenal medulla
2. Pancreas
3. Thymus
4. Ovaries
Which hormone tells us when we should stop eating?

1. Renin
2. Leptin
3. Melatonin
4. Thymosin
Which hormone is involved in our daily sleep-wake cycle?

1. Renin
2. Leptin
3. Melatonin
4. Thymosin
Important Concepts

- Read Chapter 10

- 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, and how do they affect the target cells?
  - Know the differences between the two types of hormones, and examples of each type of hormone.
Important Concepts

- For **ALL** the hormones in this lecture, you should be able to answer:
  - Where is the hormone produced and released from?
  - What is/are the function(s) of the hormone?
  - What is/are the target(s) of the hormone?

- Know the disorders discussed in the lecture:
  - What are the causes and effects of each disorder?
  - What are the treatments of each disorder?

- Know the location and names of the endocrine glands, and be able to label a drawing with the glands.
Important Concepts

- How does the hypothalamus control the pituitary gland?
- What is the function of the hypothalamus?
- How are the adrenal glands controlled?
- What are the two parts of the adrenal glands, and how is each part controlled? Which hormones are released from which part?
Important Concepts

- How are calcium levels in the blood regulated?
  - Which hormones and glands are responsible for blood calcium regulation?

- How are blood glucose levels regulated?
  - Which hormones and glands are responsible for blood glucose regulation?
  - What are the causes of the two types of diabetes?
Definitions

- Endocrine gland, hormones, receptor, target cell, non-target cell, pancreatic islets (Islets of Langerhans), negative feedback, water soluble, hydrophilic, lipid soluble, hydrophobic, secondary messenger, transcription, translation, produce, release, dilute, concentrated, extremities, deficient, sufficient, synthesis, reabsorption, inhibit, stimulate
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<th>Hormone</th>
<th>Where Produced</th>
<th>Released From</th>
<th>Target</th>
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<tr>
<td>ADH</td>
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<td>Post. Pit.</td>
<td>Kidney</td>
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<td>Oxytocin</td>
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<td>Hypothalamic-releasing hormones</td>
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<td>Ant. Pit.</td>
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<td>Thyroxine</td>
<td>Thyroid</td>
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<td>Tri-iodothyronine</td>
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<td>Pancreas</td>
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<td>Glucagon</td>
<td>Pancreas</td>
<td>Pancreas</td>
<td>Liver, muscle, adipose</td>
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<td>Testes (and other tissues)</td>
<td>Testes (and other tissues)</td>
<td>Throughout body</td>
</tr>
<tr>
<td>Estrogen</td>
<td>Ovaries</td>
<td>Ovaries</td>
<td>Throughout body</td>
</tr>
<tr>
<td>Thymosin</td>
<td>Thymus</td>
<td>Thymus</td>
<td>T Cells</td>
</tr>
<tr>
<td>Thymopoietin</td>
<td>Thymus</td>
<td>Thymus</td>
<td>T Cells</td>
</tr>
<tr>
<td>Melatonin</td>
<td>Pineal gland</td>
<td>Pineal gland</td>
<td>Throughout body</td>
</tr>
<tr>
<td>Hormone</td>
<td>Where Produced</td>
<td>Released From</td>
<td>Target</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------</td>
<td>---------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Erythropoietin</td>
<td>Kidneys</td>
<td>Kidneys</td>
<td>Bone marrow</td>
</tr>
<tr>
<td>Renin</td>
<td>Kidneys</td>
<td>Kidneys</td>
<td>Adrenal cortex</td>
</tr>
<tr>
<td>Leptin</td>
<td>Adipose</td>
<td>Adipose</td>
<td>Hypothalamus</td>
</tr>
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