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 to maintain homeostasis.

Function of the Endocrine System

- The endocrine system functions by releasing hormones which travel through the body (usually via the bloodstream) to target cells.
Glands are secretory cells or structures derived from which type of tissue?

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

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

1. Exocrine glands
2. Endocrine glands

Glands are secretory cells or structures derived from which type of tissue?

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

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

1. Exocrine glands
2. Endocrine glands
What is a hormone?

- **Hormones** are chemical messengers that are secreted by one cell, travel through the body and affect only the target cells that have the correct receptor.

Target Cells

- Target cells have receptors that bind the hormones (ex: Osteoclasts).
- Non-target cells do not have the proper receptor and are unaffected by the hormone (ex: Osteoblasts).
Hormones vs. Neurotransmitters

**Similarities:**
- Endocrine and nervous systems work together to maintain homeostasis.
- Both need to bind to a receptor to illicit an effect.

**Differences:**

<table>
<thead>
<tr>
<th></th>
<th>Neurotransmitters</th>
<th>Hormones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where it’s located</td>
<td>Localized to nerve synapse</td>
<td>Throughout body in blood stream</td>
</tr>
<tr>
<td>How long it takes to act.</td>
<td>Quick to act</td>
<td>Slow to act</td>
</tr>
<tr>
<td>How long it lasts.</td>
<td>Taken away quickly</td>
<td>Remains longer in body</td>
</tr>
</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 – ex: epinephrine.
- Polypeptides (a chain of amino acids) – ex: Anti-Diuretic Hormone
Are Amino Acids Hydrophilic or Hydrophobic?

1. Hydrophilic
2. Hydrophobic

Can an amino acid freely cross the plasma membrane?

1. Yes
2. No
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
- The adrenal gland releases epinephrine into the bloodstream, travels throughout the body.

Water Soluble Hormones

- Water soluble hormones bind to a receptor on the surface of the target cells (e.g., muscle cells).
- The binding of the hormone epinephrine to the receptor triggers the formation of a secondary messenger (e.g., cyclic AMP (cAMP)).

Water Soluble Hormones

- The secondary messenger triggers a cascade of events ending in cellular activity (e.g., the breakdown of glycogen to glucose).
- Note: this type of hormone does not cross the plasma membrane and enter the cell.
- The receptor is on the plasma membrane.
Steroid Hormones

1. Steroid hormones have a structure similar to cholesterol.

**Examples:** estrogen, testosterone.

Steroid Structure

(a) Four-ring steroid structure

Sugars  Proteins  Lipids  Complex Carbohydrates

25%  25%  25%  25%
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
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 (in the cytoplasm or nucleoplasm)

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.
Lipid-soluble Hormones

- Note that the lipid soluble hormones will take longer to act than the water soluble hormones since they activate 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.

Water Soluble vs. Lipid Soluble Hormones

Endocrine Glands and Organs that Secrete Hormones

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

Endocrine System

- Thymus gland
- Parathyroid glands (two of four)
- Adrenal gland (one on each kidney)
- Adrenal cortex
- Adrenal medulla
- Heart
- Kidney
Hypothalamus

- Hypothalamus — regulates the internal environment through the autonomic nervous system.
  - Helps control heartbeat.
  - Helps control body temperature.
  - Helps control water balance.

Hypothalamus

- Hypothalamus — Secretes its own hormones and controls glandular secretions of the pituitary gland.
  - Produces:
    1. antidiuretic hormone (ADH).
    2. Oxytocin.
    3. hypothalamic-releasing hormones.
    4. hypothalamic-inhibiting hormones.
A Diuretic Will Make Your Urine:

1. More dilute
2. More concentrated

A Diuretic Will Make Your Urine:

1. More dilute
2. More concentrated
An Antidiuretic Will Make Your Urine:

1. More dilute
2. More concentrated

Hypothalamus – ADH and Oxytocin

- Neurosecretory cells of the hypothalamus produce 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 hormones when needed.

Anti-Diuretic Hormone - ADH

- 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) also may play a role in social bonds.
- Target: Smooth muscle of the Uterus and mammary glands.
- Pitocin: Synthetic form of 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 blood stream 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)

1.) Prolactin (PRL)

- PRL is produced by the Anterior Pituitary.
- Target: Mammary glands.
- Function: causes mammary glands to develop and produce milk.
2.) Growth Hormone (GH)

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

**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.

**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.

3.) Thyroid-Stimulating Hormone (TSH)

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

- **Thyroid Hormones** - Regulate 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.

Thyroid Gland

- **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 - 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 from an autoimmune disorder leading 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 exopthalmos.
- Treatment: Administer drug that blocks the synthesis of TH, thyroid gland may be reduced by surgery or radioactive iodine.
4.) AdrenoCorticoTropic Hormone (ACTH)

- ACTH is produced by the Anterior Pituitary.
- Target: Adrenal Cortex.
- Function: stimulates the adrenal cortex to produce cortisol.
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 - Glucocorticoids

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

Adrenal Cortex - Mineralocorticoids

- Effects of Aldosterone:
  - Promotes renal re-absorption of Na⁺ and renal secretion of K⁺.
  - Increases blood pressure.
- Target: Kidneys.
Adrenal Cortex - Glucocorticoids

- 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.

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
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

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 regulating how much free glucose there is in the body.
Cortisol

- Cortisol prompts the **muscles** to breakdown glycogen and release glucose.
- It also prompts the **adipose tissue** to breakdown fat.
- So basically it tells the body to take biomolecules out of storage so it can be used for energy.

Side Effects of cortisol

- It interferes with the functioning of the hippocampus (remember this functions to make long term memories).
- It weakens the immune system – inhibits inflammatory response.
- Constricts arteries (increasing risk of heart attacks).
- Interferes with insulin regulation of glucose (leads to adult on-set diabetes).

Which of the following glands secretes cortisol?

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

Which of the following glands secretes cortisol?

1. pituitary
2. pancreas
3. adrenal medulla
4. **adrenal cortex**
Disorders of the Adrenal Glands

- Two disorders:
  - Addison disease
  - Cushing’s syndrome

Addison Disease

- Addison Disease - Hyposecretion of the adrenal cortex. Not enough hormones are secreted. Can not recover from stressful situations, can lead to low blood pressure and dehydration. Can be fatal if not treated.

  - Treatments: supplement with glucocorticoids and mineralocorticoids.

Cushing’s Syndrome

- Cushing’s Syndrome - Hypersecretion of the adrenal cortex. Too much hormone is secreted. Can result in diabetes, and redistribution of fat and reduced muscle mass.

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

5.) Gonadotropic Hormones

- Gonadotropic Hormones - stimulate the gonads to produce gametes and hormones.
  - FSH
  - LH
Gonadotropic Hormones
- The two gonadotropic hormones are:
  - Follicle Stimulating Hormone (FSH) – stimulates gamete development in males and females.
  - Luteinizing Hormone (LH) – stimulates the production of estrogen and progesterone in females, and testosterone in males.

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 uterine cycle.
Which of the following hormones stimulates water reabsorption by the kidneys?

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

What 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 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

Which gland produces prolactin

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

  - **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.
Regulation of Calcium Levels in Blood

- Calcium levels in blood too low:
  - PTH is released from parathyroid gland.
  - Effects: PTH causes the...
    - bone to release calcium.
    - kidney to reabsorb calcium.
    - intestine to absorb more calcium.

Regulation of Calcium Levels in Blood

- 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.
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—sit on top of the kidneys.

There are two parts of the adrenal glands:
- **Adrenal medulla**
- **Adrenal cortex**

**Control of the Adrenal Glands**

- The adrenal glands is 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.
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.

Pancreas Gland Hormones

- Hormones of the pancreas
- Secreted from the pancreatic islets (Islets of Langerhans)
- Regulate blood glucose levels through two hormones:
  1. glucagon
  2. insulin
Pancreas - Glucagon

- **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.

Pancreas Gland Hormones

- **Insulin** - lowers glucose levels of the blood.

- **Insulin 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.
Disorders - Diabetes Mellitus – Type 1 & 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

50% 50%

Thymus Gland

- Thymus gland - lies behind the sternum.
- Secretes the hormones: **Thymopoietin** which stimulates T-cell lymphocyte production and **Thymosin** which stimulates T-cell lymphocyte development – important in immune system function.
- Target: Bone marrow and T-cells
- 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

---

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 the person 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.
<table>
<thead>
<tr>
<th>Hormone</th>
<th>Where Produced</th>
<th>Released from</th>
<th>Target</th>
</tr>
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<tbody>
<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>Post. Pit.</td>
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<td>Hypothalamic-releasing hormones</td>
<td>Hypothalamus</td>
<td>Hypothalamus</td>
<td>Anterior pituitary</td>
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<td>Hypothalamic-inhibiting hormones</td>
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<td>Hypothalamus</td>
<td>Anterior pituitary</td>
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<td>Ant. Pit.</td>
<td>Adrenal Cortex</td>
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<td>Ant. Pit.</td>
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<td>Ant. Pit.</td>
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<td>Thyroxine</td>
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<tr>
<td>Triiodothyronine</td>
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<tr>
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<td>PTH</td>
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<td>Cortisol</td>
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<td>Adr. Cortex</td>
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<td>Aldosterone</td>
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<td>Testosterone</td>
<td>Testes (and other tissues)</td>
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<td>Melatonin</td>
<td>Pineal gland</td>
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</table>
## 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.

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<td>Prostaglandins</td>
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## Important Concepts

- Read Chapter 11 for next lecture
- 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
- 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, and which hormones are released from which part.
- What are the side effects of cortisol.
Important Concepts

- How are calcium levels in the blood regulated, what hormones and glands regulate it.

- How are blood glucose levels regulated, what hormones and glands regulate it, know the causes of the two types of diabetes

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