## Introduction to the Endocrine System Dr. Chinmoy Chatterjee

The <u>endocrine system</u>, along with the <u>nervous system</u>, functions in the regulation of body activities. The endocrine system acts through chemical messengers called hormones that influence growth, development, and <u>metabolic</u> activities.

### **Endocrine Glands**

The endocrine glands do not have ducts to carry their product to a surface. They are called ductless glands. The word endocrine is derived from the Greek terms "endo," meaning within, and "krine," meaning to separate or secrete. The secretory products of endocrine glands are called hormones and are secreted directly into the <u>blood</u> and then carried throughout the body where they influence only those cells that have <u>receptor</u> sites for that <u>hormone</u>.

### **Glands and their Hormones**

### **Pituitary Gland**

The <u>pituitary gland</u> or <u>hypophysis</u> is a small <u>gland</u> about 1 <u>centimeter</u> in <u>diameter</u> or the size of a pea. It is nearly surrounded by <u>bone</u> as it rests in the <u>sella</u> <u>turcica</u>, a <u>depression</u> in the <u>sphenoid bone</u>. The gland is connected to the <u>hypothalamus</u> of the <u>brain</u> by a slender stalk called the <u>infundibulum</u>.

### The Pituitary and Its Target Organs

The pituitary has two distinct parts:

- Front (anterior) lobe, which accounts for 80% of the pituitary gland's weight
- Back (posterior) lobe

The lobes are connected to the hypothalamus by a stalk that contains blood vessels and nerve cell projections (nerve fibers, or axons). The hypothalamus controls the anterior lobe by releasing hormones through the connecting blood vessels. It controls the posterior lobe through nerve impulses.

### **Pituitary: The Master Gland**

| Hormone                             | Target Organ or Tissue  |
|-------------------------------------|-------------------------|
|                                     |                         |
| Adrenocorticotropic hormone( ACTH)  | Adrenal glands          |
|                                     |                         |
| Beta-melanocyte-stimulating hormone | Skin                    |
|                                     |                         |
| Endorphins                          | Brain and immune system |
|                                     |                         |
| Enkephalins                         | Brain                   |
|                                     |                         |
| Follicle-stimulating hormone        | Ovaries or testes       |



| Growth hormone                      | Muscles and bones         |
|-------------------------------------|---------------------------|
|                                     |                           |
| Luteinizing hormone                 | Ovaries or testes         |
|                                     |                           |
| Oxytocin*                           | Uterus and mammary glands |
|                                     |                           |
| Prolactin                           | Mammary glands            |
|                                     |                           |
| Thyroid-stimulating hormone         | Thyroid gland             |
|                                     |                           |
| Vasopressin (antidiuretic hormone)* | Kidneys                   |

# **Anterior lobe hormones**

The anterior lobe of the pituitary produces and releases (secretes) six main hormones:

- Growth hormone, which regulates growth and physical development and has important effects on body shape by stimulating muscle formation and reducing fat tissue
- Thyroid-stimulating hormone, which stimulates the thyroid gland to produce thyroid hormones
- Adrenocorticotropic hormone (ACTH), also called corticotropin, which stimulates the adrenal glands to produce cortisol and other hormones
- Follicle-stimulating hormone and luteinizing hormone (the gonadotropins), which stimulate the testes to produce sperm, the ovaries to produce eggs, and the sex organs to produce sex hormones (testosterone and estrogen)
- Prolactin, which stimulates the mammary glands of the breasts to produce milk

The anterior lobe also produces several other hormones, including one that causes the skin to darken (betamelanocyte–stimulating hormone) and ones that inhibit pain sensations (enkephalins and endorphins) and help control the immune system (endorphins).

## **Posterior lobe hormones**

The posterior lobe of the pituitary produces only two hormones:

- Vasopressin
- Oxytocin

Vasopressin (also called antidiuretic hormone) regulates the amount of water excreted by the kidneys and is therefore important in maintaining <u>water balance in the body</u>.

Oxytocin causes the uterus to contract during childbirth and immediately after delivery to prevent excessive bleeding. Oxytocin also stimulates contractions of the milk ducts in the breast, which move milk to the nipple (the let-down) in lactating women. Oxytocin has some additional roles in both men and women.

# **Pituitary gland malfunction**

The pituitary gland can malfunction in several ways, usually as a result of developing a noncancerous tumor (adenoma). The tumor may overproduce one or more pituitary hormones, or the tumor may press on the normal pituitary cells, causing underproduction of one or more pituitary hormones.

The tumor may also cause <u>enlargement of the pituitary gland</u>, with or without disturbing hormone production. Sometimes there is overproduction of one hormone by a pituitary tumor and underproduction of another at the same time due to pressure.

Sometimes excess cerebrospinal fluid can fill the space around the pituitary gland and compress it (<u>resulting in</u> <u>empty sella syndrome</u>). The pressure may cause the pituitary to overproduce or underproduce hormones.

Too little or too much of a pituitary hormone results in a wide variety of symptoms. Disorders that result from overproduction of pituitary hormones include

- <u>Acromegaly or gigantism</u>: Growth hormone
- <u>Cushing disease</u>: Adrenocorticotropic hormone ( ACTH),
- <u>Galactorrhea</u> (the secretion of breast milk by men or by women when not pregnant): Prolactin
- <u>Erectile dysfunction</u>: Prolactin
- <u>Infertility</u> (particularly in women): Prolactin

Disorders that result from underproduction of pituitary hormones include

- <u>Central diabetes insipidus</u>: Vasopressin
- <u>Hypopituitarism</u>: Multiple hormones

## **Pineal Gland**

The <u>pineal gland</u>, also called <u>pineal body</u> or <u>epiphysis cerebri</u>, is a small cone-shaped structure that extends posteriorly from the <u>third ventricle</u> of the brain. The pineal gland consists of portions of neurons, neuroglial cells, and specialized secretory cells called pinealocytes. The pinealocytes synthesize the hormone <u>melatonin</u> and secrete it directly into the <u>cerebrospinal fluid</u>, which takes it into the <u>blood</u>. Melatonin affects reproductive development and daily <u>physiologic</u> cycles.

## Thyroid Gland

The <u>thyroid gland</u> is a very <u>vascular organ</u> that is located in the <u>neck</u>. It consists of two lobes, one on each

side of the <u>trachea</u>, just below the <u>larynx</u> or <u>voice box</u>. The two lobes are connected by a narrow <u>band</u> of <u>tissue</u> called the <u>isthmus</u>. Internally, the <u>gland</u> consists of follicles, which produce <u>thyroxine</u> and <u>triiodothyronine</u> hormones. These hormones contain <u>iodine</u>.

About 95 percent of the active <u>thyroid hormone</u> is thyroxine, and most of the remaining 5 percent is triiodothyronine. Both of these require iodine for their <u>synthesis</u>. Thyroid hormone secretion is regulated by a negative feedback mechanism that involves the amount of circulating <u>hormone</u>, <u>hypothalamus</u>, and adenohypophysis.



If there is an iodine <u>deficiency</u>, the <u>thyroid</u> cannot make sufficient hormone. This stimulates the <u>anterior</u> pituitary to secrete <u>thyroid-stimulating hormone</u>, which causes the thyroid gland to increase in size in a vain attempt to produce more hormones. But it cannot produce more hormones because it does not have the necessary raw material, iodine. This type of thyroid enlargement is called simple <u>goiter</u> or iodine deficiency goiter.

<u>Calcitonin</u> is secreted by the parafollicular cells of the thyroid gland. This hormone opposes the action of the parathyroid glands by reducing the <u>calcium</u> level in the <u>blood</u>. If blood calcium becomes too high, calcitonin is secreted until calcium <u>ion</u> levels decrease to normal.

## **Adrenal Gland**

The adrenal, or suprarenal, <u>gland</u> is paired with one gland located near the upper portion of each <u>kidney</u>. Each gland is divided into an outer <u>cortex</u> and an inner <u>medulla</u>. The cortex and medulla of the <u>adrenal gland</u>, like the <u>anterior</u> and <u>posterior</u> lobes of the pituitary, develop from different embryonic tissues and secrete different hormones. The <u>adrenal cortex</u> is essential to life, but the medulla may be removed with no life-threatening effects.

The <u>hypothalamus</u> of the <u>brain</u> influences both portions of the adrenal gland but by different mechanisms. The adrenal cortex is regulated by negative feedback involving the hypothalamus and adrenocorticotropic <u>hormone</u>; the medulla is regulated by <u>nerve</u> impulses from the hypothalamus.

### Hormones of the Adrenal Cortex

The adrenal cortex consists of three different regions, with each region producing a different group or type of hormones. Chemically, all the <u>cortical</u> hormones are <u>steroid</u>.

Mineralocorticoids are secreted by the outermost region of the adrenal cortex. The principal mineralocorticoid is <u>aldosterone</u>, which acts to conserve <u>sodium</u> ions and <u>water</u> in the body. Glucocorticoids are secreted by the middle region of the adrenal cortex. The principal <u>glucocorticoid</u> is <u>cortisol</u>, which increases <u>blood glucose</u> levels.

The third group of steroids secreted by the adrenal cortex is the gonadocorticoids, or sex hormones. These are secreted by the innermost region. Male hormones, androgens, and female hormones, estrogens, are secreted in minimal amounts in both sexes by the adrenal cortex, but their effect is usually masked by the hormones from the testes and ovaries. In females, the masculinization effect of <u>androgen</u> secretion may become evident after <u>menopause</u>, when <u>estrogen</u> levels from the ovaries decrease.

### Hormones of the Adrenal Medulla



The <u>adrenal medulla</u> develops from neural <u>tissue</u> and secretes two hormones, <u>epinephrine</u> and <u>norepinephrine</u>. These two hormones are secreted in <u>response</u> to stimulation by sympathetic nerve, particularly during stressful situations. A lack of hormones from the adrenal medulla produces no significant effects. Hypersecretion, usually from a <u>tumor</u>, causes prolonged or continual sympathetic responses.

**Disorders of the adrenal gland** can involve the secretion of too little or too much hormone.

When too little hormone is secreted, it may be because of a problem with the adrenal gland itself (a primary disorder, such as Addison disease). Or it may be due to a problem elsewhere in the body, such as the pituitary gland or the hypothalamus. For example, a problem with the pituitary gland could mean that the adrenal glands are not being stimulated to secrete hormones.

When too much hormone is secreted (oversecretion), the disorder that results depends on the hormone:

- Oversecretion of glucocorticoids: Cushing syndrome
- Oversecretion of aldosterone: Hyperaldosteronism
- Oversecretion of epinephrine and norepinephrine: Pheochromocytoma
- Oversecretion of androgens: Virilization

### Pancreas—Islets of Langerhans

The <u>pancreas</u> is a long, soft <u>organ</u> that lies transversely along the <u>posterior</u> <u>abdominal</u> wall, posterior to the <u>stomach</u>, and extends from the <u>region of the <u>duodenum</u> to the <u>spleen</u>. This <u>gland</u> has an exocrine **portion that secretes** digestive enzymes that are carried through a <u>duct</u> to the duodenum. The <u>endocrine</u> portion consists of the <u>pancreatic islets</u>, which secrete <u>glucagons</u> and <u>insulin</u>.</u>

<u>Alpha cells</u> in the pancreatic islets secrete the <u>hormone</u> glucagons in <u>response</u> to a low concentration of <u>glucose</u> in the <u>blood</u>. Beta cells in the pancreatic islets secrete the hormone insulin in response to a high concentration of glucose in the blood.

The pituitary is a pea-sized gland that is housed within a bony structure (sella turcica) at the base of the brain. The sella turcica protects the pituitary but allows very little room for expansion.

The pituitary controls the function of most other endocrine glands and is therefore sometimes called the master gland. In turn, the pituitary is controlled in large part by the hypothalamus, a region of the brain that lies just above the pituitary. By detecting the levels of hormones produced by glands under the pituitary's control (target glands), the hypothalamus or the pituitary can determine how much stimulation the target glands need.

