**Exercise 1: Endocrine System**



**Figure 1.1** Post office boxes and the unique keys needed to unlock each one provides an analogy for how hormones act like ‘keys’ in the body to promote or inhibit biological processes.

# **Exercise 1 Learning Goals**

**After completing this lab, you should be able to:**

* Explain the relationship between the endocrine and nervous systems in maintaining homeostasis
* Identify and locate the major organs of the endocrine system
* Understand the basic functions of the major endocrine organs
* Explain the fundamental differences between water- and lipid-soluble hormones
* Identify the stimuli for release or inhibition of major hormone
* Identify the target tissue and general outcome of major hormones

The endocrine system, along with the nervous system, is how organ systems throughout the body communicate with each other. Above all others, the endocrine and nervous system together have the primary responsibility of maintaining homeostasis throughout the body.

# **Nervous vs. Endocrine Signaling**

The nervous system communicates throughout the body via either electrical or chemical signals. The electrical signals occur via electrical potentials sent along nerves based on ion flow and the chemical signals are via **neurotransmitters**. Neurotransmitters (NT) are small molecules or neuropeptides which, when stimulated by an action potential, are released from the synaptic terminal of a neuron. Neurotransmitters then diffuse across the synaptic cleft and may interact with receptor proteins on neurons or muscle cells immediately adjacent to that they will be acting upon. When a neurotransmitter binds with its post-synaptic receptor, it results in the continued propagation of electrical signaling or induces a change in cellular functioning. Due to the limited distance and extremely brief period of time they are active, neurotransmitters are the body’s rapid response system. Recall that the sympathetic division of the autonomic nervous system is often called the “fight-or-flight” response- this is an example of when neurotransmitters are rapidly being released and allow an individual to respond to a threatening situation. When a physiological situation requires an immediate and rapid response, neurotransmitters are involved. Therefore, the nervous system, and the release of neurotransmitters are associated with physiological reactions to the external environment (i.e., when a bear is chasing you; you hear a scary noise in the middle of the night; or if you show up unprepared to your A&P lab practical).

In contrast to the immediate, lightning-quick response of the nervous system- the **endocrine system** works more slowly. Since it uses only chemical signals, called **hormones**, and not electrical potentials- the endocrine system does not react as rapidly. Furthermore, hormones must travel through the body via the bloodstream to reach their target cells. This means that even the quickest endocrine responses can take several minutes to hours, and most are even slower acting, taking several days to induce a change. Additionally, many hormones can interact with a variety of target cells throughout the body and therefore can produce a wide range of physiological outcomes depending on the tissue involved. Due to its slower, more measured pace of response- the endocrine system is associated with physiological reactions to the internal environment of the body (i.e., stimulating the release of a hormone when blood glucose levels are low; regulating changes in blood pressure; or responding to major events like childbirth).

# **Structures of the Endocrine System**

In contrast to the *exocrine* system of glands which secrete their products into ducts and then convey these to their site of action (i.e., sweat, sebum, milk, salivary & digestive enzymes), the glands of the endocrine system secrete their hormones in a ductless manner directly into the interstitial fluid around them or into the bloodstream for transportation elsewhere in the body. There are many glands with primarily endocrine functions like the pituitary, thyroid, parathyroid, adrenal, and pineal glands. Others like the hypothalamus, pancreas, and most others have both endocrine and non-endocrine functions.

# **Alternate Methods of Chemical Signaling**

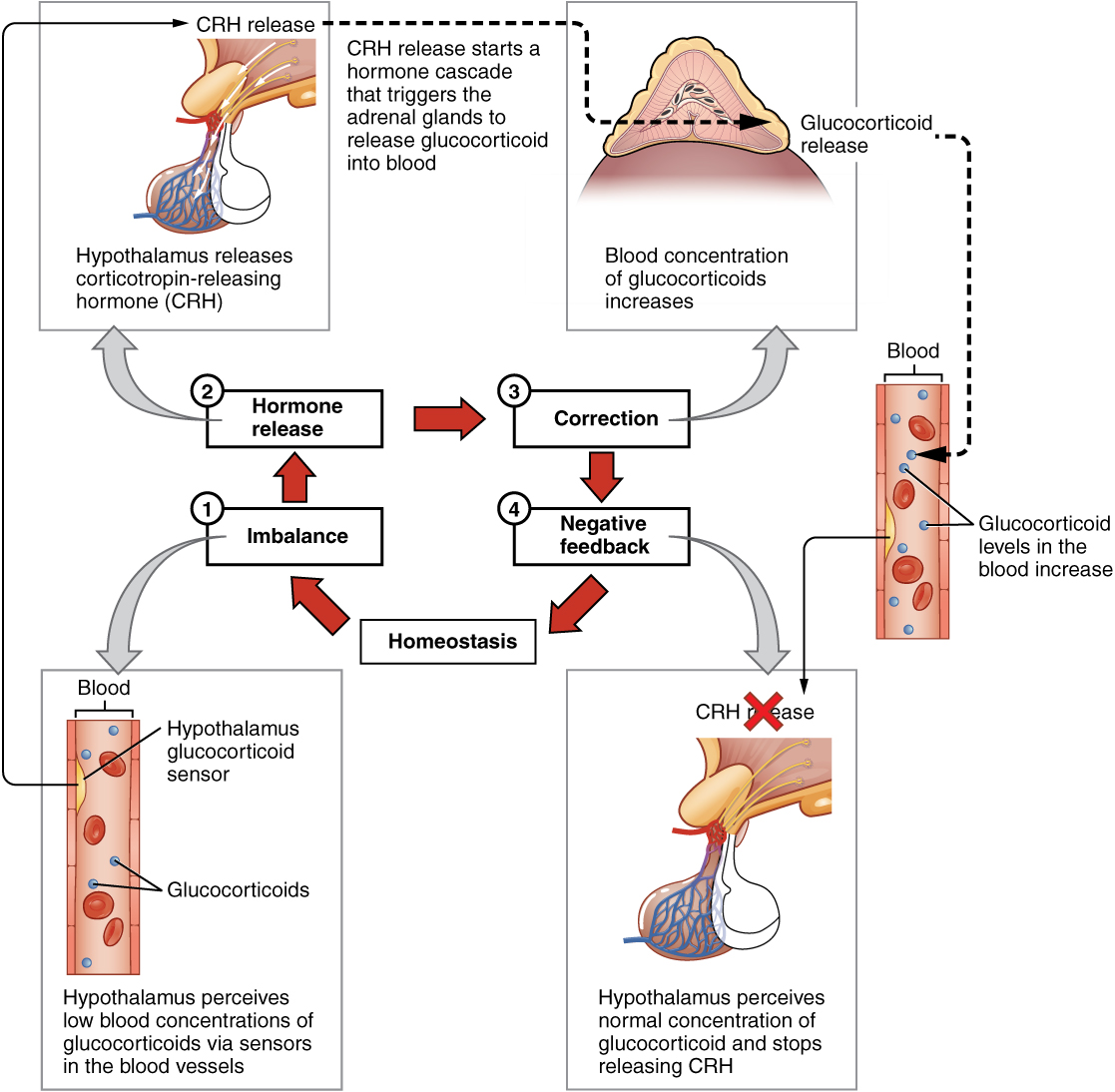
When an endocrine organ or tissue secretes its hormonal products into the interstitial (or extracellular) fluid surrounding it, the hormone may enter a blood vessel and travel in a classic endocrine signaling fashion and is thus known as a circulating hormone. If the hormone remains nearby and exerts its effects on cells within the same area where it was released, it is acting as a **paracrine hormone** (para- = “nearby”). If acting only on a directly adjacent cell, it is a **juxtacrine hormone** (juxta-=” next to”). When a hormone is produced but only acts upon the cell which created it, it is called an **autocrine hormone** (auto- = “self”).

# **Mechanism for Control of Hormone Secretion**

Because hormones can induce such a wide variety of and potentially lethal physiological responses, it is important for the body to be able to control their secretion with great precision. The processes involved in controlling a specific hormone’s secretion is called a **feedback loop**. Feedback loops determine how the body, and a hormone will respond in each physiological situation and what outcome will occur. These are typically used in the frame of how to return the body to homeostasis when an imbalance has occurred and may be caused by disease or normal everyday healthy disruptions.

Feedback loops fall into one of two categories- negative or positive. The least common of the two is the **positive feedback loop**. A positive feedback loop is reserved for special physiological circumstances because of its method of action where the release of a specific hormone causes MORE of the same hormone to be released. Examples of positive feedback loops are the release of oxytocin during childbirth which stimulates the uterine contractions necessary for the progression of labor or a nursing infant stimulating the production of prolactin for continued milk production by nursing. In both situations, a continuation (and potentially an increase) of the physiological response is desirable.

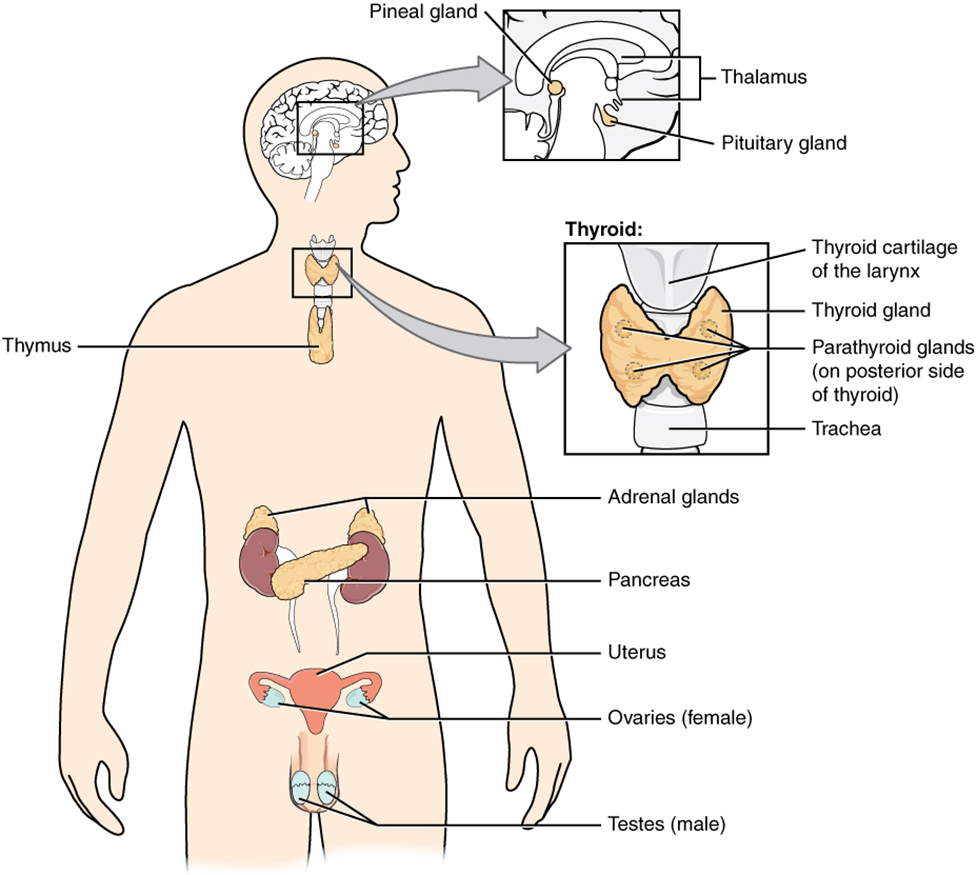
**Figure 1.2** Example of a negative feedback loop in the secretion control of cortisol.



The most common method for hormone regulation is through **negative feedback loops**. In contrast to positive feedback, negative feedback loops stop the secretion of a hormone once its levels have reached appropriate concentrations in the blood. It is a general rule that most every hormone is regulated through some version of a negative feedback loop.

# **Endocrine Structures to Know:**

* **Hypothalamus**
* **Pituitary gland**
  + **Anterior portion**
  + **Posterior portion**
* **Pineal gland**
* **Thyroid gland**
* **Parathyroid glands**
* **Pancreatic islets (Pancreas)**
* **Adrenal glands**
  + **Adrenal cortex**
  + **Adrenal medulla**



**Figure 1.3** Location and names of major endocrine organs.

# **Exercise 1 Activities: Identification of Organs and Tissues**

## Lab Activity1.1: Identifying Endocrine Organs and Tissues

Locate all the **structures listed above** on pictures in your required textbook or on models presented in lab. Label each structure from the list above using sticky-note tabs and placing them on each structure.

## Lab Activity 1.2: Matching Hormones to Site of Production

Complete the table of endocrine structures below.

|  |  |  |  |
| --- | --- | --- | --- |
| Endocrine Structure | Hormone | Abbreviation  Or N/A | Water- or Lipid-Soluble? |
| Hypothalamus | 1. Growth Hormone-Releasing Hormone | GHRH | Water |
| 2. |  |  |
| 3. |  |  |
| 4. |  |  |
| 5. |  |  |
| 6. |  |  |
|  | 7. |  |  |
| Anterior Pituitary | 1. |  |  |
| 2. |  |  |
| 3. |  |  |
| 4. |  |  |
| 5. |  |  |
| 6. |  |  |
| 7. |  |  |
| Posterior Pituitary | 1. |  |  |
| 2. |  |  |
| Pineal Gland |  |  |  |
| Thyroid Gland | 1. |  |  |
| 2. |  |  |
| 3. |  |  |
| Parathyroid Glands |  |  |  |
| Pancreas | 1. |  |  |
| 2. |  |  |
| 3. |  |  |
| 4. |  |  |
| Adrenal Cortex | 1. |  |  |
| 2. |  |  |
| 3. |  |  |
| Adrenal Medulla | 1. |  |  |
| 2. |  |  |

## Lab Activity 1.3: Defining Hormone Functions and Target Tissues

Complete the missing information from the table below. You will want to refer to this information throughout the semester as new organ systems and their major hormones are discussed.

|  |  |  |
| --- | --- | --- |
| Hormone | Produced by: | Physiological Action |
| Growth Hormone Releasing Hormone | Hypothalamus | Acts on somatotroph cells in the A.P.; stimulates release of Growth Hormone |
| Growth Hormone Inhibiting Hormone |  |  |
| Thyrotropin Releasing Hormone |  |  |
| Gonadotropin Releasing Hormone |  |  |
| Prolactin Inhibiting Hormone |  |  |
| Corticotropin Releasing Hormone |  |  |
| Prolactin Releasing Hormone |  |  |
| (Human) Growth Hormone |  |  |
| Thyroid-Stimulating Hormone |  |  |
| Follicle-Stimulating Hormone |  |  |
| Luteinizing Hormone |  |  |
| Prolactin |  |  |
| Adrenocorticotropic Hormone |  |  |
| Melanocyte-Stimulating Hormone |  |  |
| Anti-Diuretic Hormone |  |  |
| Oxytocin |  |  |
| Triiodothyronine |  |  |
| Thyroxine |  |  |
| Calcitonin |  |  |
| Parathyroid Hormone |  |  |
| Insulin |  |  |
| Glucagon |  |  |
| Erythropoietin |  |  |
| Calcitriol |  |  |
| Mineralocorticoids (Primary) |  |  |
| Glucocorticoids  (Primary) |  |  |
| Gonadocorticoids  (Primary) |  |  |
| Epinephrine |  |  |
| Norepinephrine |  |

# **Post-Lab 1 Review**

## Post-Lab Activity 1.1: Questions

1. Define using your own words and give an example of each:
   1. **Endocrine gland –**
   2. **Neuroendocrine cells–**
   3. **Hormones –**
   4. **Autocrine –**
   5. **Paracrine –**
   6. **Negative feedback loop –**
   7. **Positive feedback loop –**
2. How do water-soluble hormones travel through the body to their target tissue?
3. How do water-soluble hormones enter their target cell? Describe the general process.
4. Give several examples of water-soluble hormones in each category.
   1. Amine Hormones –
   2. Peptides & Protein Hormones –
   3. Eicosanoid Hormones –
5. How do lipid-soluble hormones travel through the body to their target tissue?
6. How do lipid-soluble hormones enter their target cell? Describe the general process
7. Give several examples of lipid-soluble hormones in each category.
   1. Steroid Hormones –
   2. Thyroid Hormones –

# **Post-Lab Activity 1.2: Matching**

Write the letter of the organ next to the hormone that the organ produces/secretes.

|  |  |  |
| --- | --- | --- |
| Letter | Hormone | Organ |
|  | Somatotropin | 1. Thyroid |
|  | Glucagon | 1. Pancreas |
|  | Androgens | 1. Pineal gland |
|  | Prolactin Inhibiting | 1. Pituitary |
|  | Follicle stimulating | 1. Parathyroid |
|  | T3 | 1. Hypothalamus |
|  | Insulin | 1. Adrenal glands |
|  | Mineralocorticoids |  |
|  | oxytocin |  |
|  | Thyrotropin releasing |  |
|  | Prolactin |  |
|  | Calcitonin |  |
|  | Melatonin |  |
|  | Parathyroid |  |
|  | Adrenocorticotropic |  |

Write the letter of the function next to the hormone that causes the physiological action.

|  |  |  |
| --- | --- | --- |
| Letter | Hormone | Function |
|  | **Thyrotropin** | a. conservers body water by decreasing urine volume, reducing water loss, and raising blood pressure |
|  | **Calcitonin** | b. raises blood glucose levels by increasing breakdown of glycogen into glucose |
|  | **Androgens** | c. stimulates the adrenal cortex to secrete cortisol |
|  | **Adrenocorticotropic** | d. initiates development of oocytes or spermatocytes and induces secretion of estrogens |
|  | **Pancreatic Polypeptide** | e. stimulates secretion of follicle stimulating hormone and luteinizing hormone |
|  | **T4** | f. enhances the effects of the sympathetic division of the autonomic nervous system when stressed |
|  | **Follicle stimulating** | g. inhibits secretion of insulin and glucagon, as well as, slowing absorption of nutrients from the GI |
|  | **Vasopressin** | h. assist in growth of axillary and pubic hair in men and women |
|  | **Oxytocin** | i. stimulates contraction of smooth muscle in the uterus during childbirth and cause milk ejection |
|  | **Glucocorticoids** | j. inhibits somatostatin secretion and secretion of digestive enzymes |
|  | **Glucagon** | k. controls secretions and activities of the thyroid gland |
|  | **Somatotropin** | l. increases basal metabolic rate, stimulates synthesis of proteins, and accelerates body growth |
|  | **Gonadotropin-releasing** | m. lowers blood calcium and phosphate by inhibiting osteoclast activity |
|  | **Somatostatin** | n. increase breakdown of protein stimulating gluconeogenesis and lipolysis, dampens inflammation and depresses immune response |
|  | **Norepinephrine** | o. stimulates liver, muscle, cartilage, and bone to synthesize and secrete insulin-like growth factors which promote tissue growth |