The Endocrine System

Hormones and Glands
Three examples of disorders caused by hormonal imbalances: “runaway bride” Jennifer Wilbanks (overproduction of thyroid hormone), Andre the Giant (overproduction of growth hormone), diabetes (underproduction of insulin).
A gland is epithelial tissue that produces and releases a substance. An endocrine gland secretes its substances (signal molecules called hormones) directly into the bloodstream while exocrine glands secrete substances onto a surface (like the skin) or into a cavity (like the stomach or intestines). This is an important distinction: since hormones travel through the bloodstream, they reach almost every cell in the body (though not all cells respond). A negative feedback loop maintains homeostasis by reacting to a change in the opposite direction of the change. For example, if blood calcium levels decrease too much, this is detected by the parathyroid gland and hormones are released to raise the calcium levels of the blood.
Both the endocrine system and the nervous system are regulatory systems: they influence the actions of other tissues all throughout the body through the use of chemical signals. In fact, some of the chemical signals used in the nervous system are the same as the chemical signals used in the endocrine system.
But there are important differences. The nervous system communicates across synapses (very short distances) whereas the endocrine system can influence organs far from the place where a hormone is secreted. Nervous communication is very specific: a neuron targets specific other neurons; endocrine communication is more general: hormones are released into the blood stream, where they reach all other tissues in the body. Hormones can also mediate changes that last longer than the nervous system can.
The major organs of the endocrine system are endocrine glands. Each endocrine gland secretes specific hormones directly into the blood stream. The major glands you should know at this point are the anterior and posterior pituitary glands, the thyroid gland, the adrenal cortex and medulla, the pancreas, the testes, and the ovaries.
Hormones

- Endocrine glands
- Target tissues

A very important point: since hormones are secreted directly into the blood stream, when a hormone is released it reaches every tissue in the body. But not every tissue has receptors for every hormone. Tissues that have receptors for a particular hormone are called target tissues (or target organs) for that hormone.
Hormones

- Example: Parathyroid hormone (increases blood calcium level)

Example: When parathyroid hormone is released into the blood stream the hormone circulates to all parts of the body. Only certain cells in bone and the kidneys (PTH’s target tissues) have receptors for PTH, though, so only those tissues respond. (Osteoclasts begin breaking down bone hydroxyapatite to release calcium into the blood, the kidneys stop moving calcium into the urine and start releasing vitamin D, which is required for calcium absorption in the small intestine.)
There are many, many hormones, but most fall into one of two categories. Most **amino acid-based hormones** (peptides, proteins, and modified amino acids) are polar molecules. Since they are polar, these hormones cannot cross the cell membrane and enter the cells of their target tissues. **Steroid hormones** are lipid-based cholesterol molecules and can enter their target cells, where they directly influence the cells’ activity. An additional category of hormone-like molecule is the **prostaglandins**. They are short-lived molecules released close to their target tissues that cannot enter the cell. We’ll discuss prostaglandins more when we look at the inflammatory response (lymphatic system).
Membrane-bound receptors stretch all the way across the cell membrane. Hormones that cannot enter their target cells bind to membrane-bound receptors (but do not ever enter the cell). The binding of the hormone to the receptor causes the receptor to activate a second messenger inside the cell. (A typical second messenger is cyclic AMP, or cAMP for short.) The second messenger triggers a series of reactions in the cell that results in changes in protein synthesis.
Hormones

- Hormone receptors:
  - **Intracellular receptors** (for hormones that can enter the cell).
    - Bound receptor: **transcription factor**

Intracellular receptors are, as the name suggests, inside the cell, either in the cytoplasm or in the nucleus. Since steroid hormones *can* enter the cell, they bind with the intracellular receptors inside. This activates the receptor. The hormone-receptor complex acts as a **transcription factor** – it physically bonds to the DNA and causes new proteins to be made (or stop being made). In other words, steroid hormones can directly turn selected genes on or off.
Release of most hormones is controlled by pretty simple negative feedback loops, and inhibition of a gland is often more important than stimulation of the gland. A typical example is thyroid hormone. The thyroid gland is stimulated to secrete thyroid hormone when circulating levels of another hormone, thyroid stimulating hormone (TSH), rise. TSH production is stimulated by rising levels of another hormone, called thyroid releasing hormone (TRH), produced by the hypothalamus. When the concentration of thyroid hormone in the blood rises high enough, it inhibits further production of TRH by the hypothalamus. Since TRH secretion stops, so does TSH production, which stops production of additional thyroid hormone. As the circulating thyroid hormone is used up, the concentration of thyroid hormone in the blood drops. When it gets low enough, it no longer inhibits TRH production, so the cycle starts all over.

The stimulus that stimulates or inhibits a gland and influences hormone secretion can be humoral, neural, or hormonal. Control is said to be **hormonal** when the presence of a hormone in the blood inhibits further production of additional hormones. (Thyroid hormone is controlled like this – the presence of thyroid hormone inhibits the release of further thyroid hormone.) Control is said to be **humoral** if the presence of some other (non-hormone) substance either stimulates or inhibits the gland. (Parathyroid hormone is an example: PTH release causes an increase in blood calcium levels and the presence of calcium inhibits further PTH release.) Control is said to be **neural** if the nervous system’s interpretation of stimuli causes stimulation or inhibition of the gland. (An example is adrenalin: the adrenal medulla secretes adrenalin when the brain interprets the situation as dangerous or exhilarating.)
This picture, from your book, summarizes the different types of glandular control.