

Endocrine System

The nervous system sends electrical messages to control and coordinate the body. The endocrine system has a similar job, but uses chemicals to “communicate”. These chemicals are known as **hormones**. A hormone is a specific messenger molecule synthesized and secreted by a group of specialized cells called an **endocrine gland**. These glands are **ductless**, which means that their secretions (hormones) are released directly into the bloodstream and travel to elsewhere in the body to **target organs**, upon which they act. Note that this is in contrast to our digestive glands, which have ducts for releasing the digestive enzymes.

Pheromones are also communication chemicals, but are used to send signals to other members of the same species. Queen bees, ants, and naked mole rats exert control of their respective colonies via pheromones. One common use for pheromones is as attractants in mating. Pheromones are widely studied in insects and are the basis for some kinds of Japanese beetle and gypsy moth traps. While pheromones have not been so widely studied in humans, some interesting studies have been done in recent years on pheromonal control of menstrual cycles in women. It has been found that pheromones in male sweat and/or sweat from another “dominant” female will both influence/regulate the cycles of women when smeared on their upper lip, just below the nose. Also, there is evidence that continued reception of a given man’s pheromone(s) by a woman in the weeks just after ovulation/fertilization can significantly increase the chances of successful implantation of the new baby in her uterus. Pheromones are also used for things like territorial markers (urine) and alarm signals.

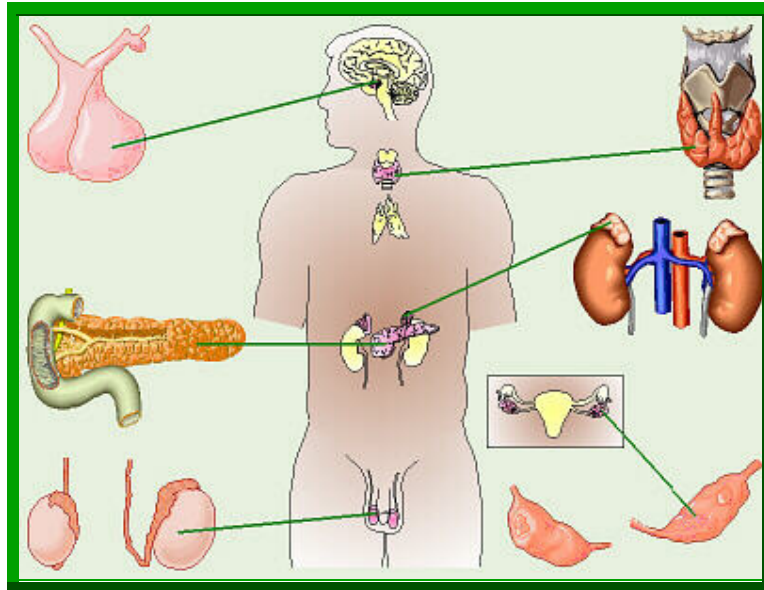
Each hormone’s shape is specific and can be recognized by the corresponding target cells. The binding sites on the target cells are called **hormone receptors**. Many hormones come in antagonistic pairs that have opposite effects on the target organs. For example, **insulin** and **glucagon** have opposite effects on the liver’s control of blood sugar level. Insulin lowers the blood sugar level by instructing the liver to take glucose out of circulation and store it, while glucagon instructs the liver to release some of its stored supply to raise the blood sugar level. Much hormonal regulation depends on **feedback loops** to maintain balance and homeostasis.

There are three general classes (groups) of hormones. These are classified by chemical structure, not function.

- **steroid hormones** including **prostaglandins** which function especially in a variety of female functions (aspirin inhibits synthesis of prostaglandins, some of which cause “cramps”) and the sex hormones all of which are lipids made from cholesterol,
- **amino acid derivatives** (like epinephrine) which are derived from amino acids, especially tyrosine, and
- **peptide hormones** (like insulin) which is the most numerous/diverse group of hormones.

The major human endocrine glands include:
(clipart edited from Corel Presentations 8)

1. the **hypothalamus** and **pituitary gland**
The pituitary gland is called the “master gland” but it is under the



control of the hypothalamus. Together, they control many other endocrine functions. They secrete a number of hormones, especially several which are important to the female menstrual cycle, pregnancy, birth, and lactation (milk production). These include **follicle-stimulating hormone (FSH)**, which stimulates development and maturation of a follicle in one of a woman’s ovaries, and **leutinizing hormone (LH)**, which causes the bursting of that follicle (= ovulation) and the formation of a **corpus luteum** from the remains of the follicle.

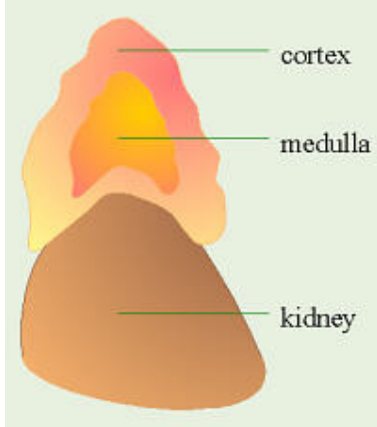
There are a number of other hypothalamus and pituitary hormones which affect various target organs.

One non-sex hormone secreted by the posterior pituitary is **antidiuretic hormone** or **ADH**. This hormone helps prevent excess water excretion by the kidneys. Ethanol inhibits the release of ADH and can, thus, cause excessive water loss. That’s also part of the reason why a group of college students who go out for pizza and a pitcher of beer need to make frequent trips to the restrooms. **Diuretics** are chemicals which interfere with the production of or action of ADH so the kidneys secrete more water. Thus diuretics are often prescribed for people with high blood pressure, in an attempt to decrease blood volume.

Another group of non-sex hormones that many people have heard of is the **endorphins**, which belong to the category of chemicals known as **opiates** and serve to deaden our pain receptors. Endorphins, which are chemically related to morphine, are produced in response to pain. The natural response to rub an injured area, such as a pinched finger, helps to release endorphins in that area. People who exercise a lot and push their bodies “until it hurts” thereby stimulate the production of endorphins. It is thought that some people who constantly over-exercise and push themselves too much may actually be addicted to their own endorphins which that severe exercise regime releases.

2. the **thyroid gland**

Thyroid hormones regulate metabolism, therefore body temperature and weight. The thyroid hormones contain iodine, which the thyroid needs in order to manufacture these hormones. If a person lacks iodine in his/her diet, the



thyroid cannot make the hormones, causing a deficiency. In response to the body's feedback loops calling for more thyroid hormones, the thyroid gland then enlarges to attempt to compensate (The body's plan here is if it's bigger it can make more, but that doesn't help if there isn't enough iodine.). This disorder is called **goiter**. Dietary sources of iodine include any "ocean foods" because ocean-dwelling organisms tend to accumulate iodine from the seawater, and would include foods

like ocean fish (tuna) and seaweeds like kelp. Because of this, people who live near the ocean do not have as much of a problem with goiter as people who live inland and don't have access to these foods. To help alleviate this problem in our country, our government began a program encouraging salt refiners to add iodine to salt, and encouraging people to choose to consume this **iodized salt**.

3. the **pancreas**

This organ has two functions. It serves as a ducted gland, secreting digestive enzymes into the small intestine. The pancreas also serves as a ductless gland in that the **islets of Langerhans** secrete **insulin** and **glucagon** to regulate the blood sugar level. The **-islet cells** secrete glucagon, which tells the liver to take carbohydrate out of storage to raise a low blood sugar level. The **-islet cells** secrete insulin to tell the liver to take excess glucose out of circulation to lower a blood sugar level that's too high. If a person's body does not make enough insulin (and/or there is a reduced response of the target cells in the liver), the blood sugar rises, perhaps out of control, and we say that the person has **diabetes mellitus**.

4. the **adrenal glands**

These sit on top of the kidneys. They consist of two parts, the outer **cortex** and the inner **medulla**. The medulla secretes **epinephrine** (= **adrenaline**) and other similar hormones in response to stressors such as fright, anger, caffeine, or low blood sugar. The cortex secretes **corticosteroids** such as **cortisone**. Corticosteroids are well-known as being anti-inflammatory, thus are prescribed for a number of conditions. However, these are powerful regulators that should be used with caution. Medicinal doses are typically higher than what your body would produce naturally, thus the person's normal feedback loops suppress natural secretion, and it is necessary to gradually taper off the dosage to trigger the adrenal glands to begin producing on their own again. Because the corticosteroids suppress the immune system, their use can lead to increased susceptibility to infections, yet physicians typically prescribe them for people whose immune systems are hard at work trying to fight off some pathogen. For example, back when I was in grad school, I was diagnosed with mono, and the campus doctor prescribed penicillin and cortisone. Since mono is a virus and penicillin only is effective against some bacteria, about all it did was kill off the friendly bacteria in my body, therefore causing me to develop a bad case of thrush. At the same time, the cortisone was suppressing my immune system so my body could not as efficiently fight off the mono and the thrush. People with high blood pressure should be leery of taking prescription corticosteroids: they are known to raise blood pressure, thus can cause things like strokes. My mother-in-law had high blood pressure and was being treated with diuretics. Her physician also had her on large doses of cortisone for her arthritis. While he was on vacation, she started having significant back pain

and was referred to an orthopedic surgeon. This man decided the back pain was just due to arthritis, and without carefully checking on what dosage she was already taking, prescribed more cortisone. Simultaneously, because of difficulty walking due to her arthritis, she decided to decrease the amount of diuretics she was taking so she didn't have to make as many "long" trips to the other end of the house. The combination of lowered dose of diuretics and high dose of cortisone raised her blood pressure to the point where a blood vessel in her brain burst, causing a stroke. When the EMTs took her blood pressure, as I recall the systolic was way over 200 mm Hg.

5. the **gonads** or sex organs

In addition to producing gametes, the female **ovaries** and male **testes** (singular = testis) also secrete hormones. Therefore, these hormones are called **sex hormones**. The secretion of sex hormones by the gonads is controlled by pituitary gland hormones such as FSH and LH. While both sexes make some of each of the hormones, typically male testes secrete primarily **androgens** including **testosterone**. Female ovaries make **estrogen** and **progesterone** in varying amounts depending on where in her cycle a woman is. In a pregnant woman, the baby's placenta also secretes hormones to maintain the pregnancy.

6. the **pineal gland**

This gland is located near the center of the brain in humans, and is stimulated by nerves from the eyes. In some other animals, the pineal gland is closer to the skin and directly stimulated by light (some lizards even have a third eye). The pineal gland secretes **melatonin** at night when it's dark, thus secretes more in winter when the nights are longer. Melatonin promotes sleep (makes you feel sleepy). It also affects reproductive functions by depressing the activity of the gonads. Additionally, it affects thyroid and adrenal cortex functions. In some animals, melatonin affects skin pigmentation. Because melatonin production is affected by the amount of light to which a person is exposed, this is tied to **circadian rhythm** (having an activity cycle of about 24 hours), annual cycles, and biological clock functions. **SAD** or **seasonal affective disorder (syndrome)** is a disorder in which too much melatonin is produced, especially during the long nights of winter, causing profound depression, oversleeping, weight gain, tiredness, and sadness. Treatment consists of exposure to bright lights for several hours each day to inhibit melatonin production. It has also been found that melatonin levels drop 75% suddenly just before puberty, suggesting the involvement of melatonin in the regulation of the onset of puberty. Studies have been done on blind girls (with a form of blindness in which no impulses can travel down the optic nerve and reach the brain and pineal gland), which showed that these girls tended to have higher levels of melatonin for a longer time, resulting in a delay in the onset of puberty. While some older people, who don't make very much melatonin, thus don't sleep well, might benefit from a melatonin supplement, I'm skeptical of the recent melatonin craze in this country. When so many people apparently are suffering from SAD, I question the wisdom of purposely ingesting more melatonin, especially since the pineal gland is one of the least-studied, least-understood of the endocrine glands.

Local regulators are hormones with target cells nearby or adjacent to the endocrine gland in question. For example, neurotransmitters are secreted in the synapses of our nervous system and their target cells are in the same synapses.