The Endocrine System

The Pituitary Gland
The **pituitary gland** is a pea-sized gland located just inferior to the hypothalamus. It is connected to the hypothalamus by a stalk called the **infundibulum**.
The pituitary isn’t just “under” the hypothalamus, it’s also under the control of the hypothalamus. For the most part, the hormones of the anterior pituitary are regulated by the hypothalamus. Many pituitary hormones, in turn, are tropic hormones, which regulate other endocrine glands in the body. For this reason, the pituitary is sometimes called the “master gland.”
Pituitary Gland

- Two glands for the price of one

- **Anterior pituitary:**
  - Hypothalamic-pituitary portal.
  - Releasing hormones

- **Posterior pituitary:**
  - Extension of hypothalamus

The pituitary has two distinct lobes: the **anterior pituitary** and the **posterior pituitary**. The anterior pituitary is made of epithelial tissue (as are most glands). The hypothalamus regulates anterior pituitary hormones by secreting **releasing hormones** into the **hypothalamic-pituitary portal** (a channel of blood vessels that runs through the infundibulum). The releasing hormones then stimulate or inhibit the release of particular anterior pituitary hormones.

The posterior pituitary is actually an extension of the hypothalamus and, therefore, is nervous tissue. Axons from certain neurons in the hypothalamus run the length of the infundibulum and their axon endings secrete posterior pituitary hormones directly into the blood stream.

All pituitary hormones are amino-acid based. They cannot enter their target cells and must act through second messengers.
This figure shows the relationship between the anterior pituitary, the posterior pituitary, the hypothalamus, and the blood stream. Identify the hypothalamic-pituitary portal vessels in the infundibulum.
Hormone Catalog

➤ For each hormone, memorize...
  • Gland that secretes it
  • Target tissues
  • Response of the target tissues
  • How it’s controlled.

➤ You should also know pathology for selected hormones.

For each hormone, these are the things you should know backwards and forwards.
Hormones of the Anterior Pituitary

- **Growth hormone (GH)**
  - Main target tissues:
    - Bone, muscles (growth)
    - Liver (fat metabolism)
  - Control: GHRH, GHIH (hormonal)

Effect: Stimulates bone and muscle growth as well as the growth of all internal organs (except the brain). Also promotes the breakdown of adipose tissue throughout the body.

Control: Two hypothalamic releasing hormones are involved: **growth hormone releasing hormone** (GHRH) stimulates GH release from the anterior pituitary. GHRH release is inhibited by high GH levels. **Growth hormone inhibiting hormone (GHIH)** is another hypothalamic releasing hormone, but it inhibits GH release. GHIH is released when high levels of GHRH are detected.
Hormones of the Anterior Pituitary

- **Growth hormone (GH)**
  - Disease states:
    - Giantism (↑ in childhood)
    - Acromegaly (↑ in adulthood)
    - Dwarfism (↓ in childhood)

Overproduction of GH in children causes **giantism** (extreme height & overly-thick bones and other organs). In adults, overproduction GH causes **acromegaly**, which results in metabolic problems as well as pathological thickening of the bones. Underproduction of GH in childhood can results in **dwarfism**, in which normal growth does not occur.
Hormones of the Anterior Pituitary

- **Tropic hormones**
  - Thyroid stimulating hormone (TSH)
  - Adrenocorticotropic hormone (ACTH)
  - Follicle-stimulating hormone (FSH)
  - Lutenizing hormone (LH)

Four of the anterior pituitary’s hormones are classified as *tropic hormones* because they stimulate the release of hormones in other glands in the body. This is why the pituitary gland is sometimes called the “master gland.” All of the tropic hormones are released by the hypothalamus secretes a releasing hormone (a different one for each tropic hormone) into the hypothalamic-pituitary portal.

**Thyroid stimulating hormone (TSH):** Stimulates the production and secretion of thyroid hormones by the thyroid gland.

**Adrenocorticotropic hormone (ACTH):** Stimulates the secretion of cortisol (as well as other hormones) by the adrenal cortex.

**Follicle stimulating hormone (FSH) and lutenizing hormone (LH):** Stimulate the production of sex steroids by the gonads (testes or ovaries). These last two hormones have other effects as well. Rising levels of FSH, for example, cause a protective “follicle” (ball of cells) to form around an egg to prepare it for possible fertilization. LH stimulates sperm production in males and is involved in the timing of puberty in both sexes.
Hormones of the Anterior Pituitary

**Tropic hormones**

- Control: releasing hormones (hormonal inhibition)
  - TRH → TSH
  - CRH → ACTH
  - GnRH → FSH, LH

All of the tropic hormones are controlled through simple negative feedback loops and are under hormonal control. In each case, a hypothalamic releasing hormone causes the secretion of the tropic hormone, then the tropic hormone causes secretion of the final hormone by another gland. Rising levels of this final hormone feedback on the hypothalamus and inhibit further production of the releasing hormone.

The releasing hormone that stimulates TSH secretion is **thyroid releasing hormone**.

The releasing hormone that stimulates ACTH secretion is **corticotropin releasing hormone**.

The releasing hormone that stimulates FSH and LH secretion is **gonadotropin releasing hormone**.
Hormones of the Anterior Pituitary

- **Prolactin (PRL)**
  - Target tissues: mammary glands (females)
  - Control:
    - PIH (dopamine), PRH, estrogens (+)
    - Physical stimulation

Effect: The main effect of prolactin is the development of the mammary glands in the female breast late in pregnancy and the production of breast milk during nursing. It may be involved in gamete formation in males, but prolactin’s specific role in males isn’t well-understood.

Control: Control of prolactin is more complex than most anterior pituitary hormones. First, the hypothalamus usually actively inhibits PRL release by secreting dopamine to the anterior pituitary. Late in pregnancy, though, rising levels of estrogen interfere with this inhibition, resulting in a rise in PRL production. As estrogen levels rise throughout pregnancy, so do prolactin levels.

After childbirth, though, estrogen levels drop and control of prolactin production becomes neural. At this point, further prolactin production is caused by stimulation of the nursing mother’s nipple by the baby. As the baby nurses, the stimulation causes the production of more milk. This encourages the baby to continue to nurse. This positive feedback loop continues until the baby is weaned and stops nursing. PRL levels decline over time, since there is no stimulation, and eventually milk production stops.

Note that in addition to the anterior pituitary a few other organs, such as the mammary glands themselves, secrete small amounts of prolactin.
This figure summarizes the main anterior pituitary hormones.
Hormones of the Posterior Pituitary

- **Antidiuretic hormone (ADH)**
  - Target tissues: kidney tubules, smooth muscles surrounding blood vessels
  - Control: Blood Concentration and volume (neural).

Now we move to the posterior pituitary. Recall that all posterior pituitary hormones are secreted by an extension of the hypothalamus directly into the blood stream.

The main effect of **antidiuretic hormone (ADH)** is that it prevents the loss of water into the urinary bladder. ADH causes the kidney tubules to become less permeable to water so that the body’s existing water is not lost. When ADH concentration becomes very high (as it might after significant blood loss), the blood vessels also constrict, which serves to increase blood pressure.

ADH is controlled neurally by two factors: When there is a low concentration of water in the blood, the blood becomes hypertonic. This is detected by the hypothalamus, which will then begin secreting ADH. In addition, blood volume (measured as blood pressure) is measured by stretch receptors in some of the body’s major arteries. When the arteries stretch less, the drop in blood pressure is countered by releasing large amounts of ADH.
Hormones of the Posterior Pituitary

**Oxytocin**

- **Target tissues:**
  - Uterus (childbirth)
  - Mammary glands (milk let-down reflex)
- **Control:** physical stimulation (positive feedback)
- “Cuddle hormone”

Recall that prolactin was the anterior pituitary hormone involved in milk production in a nursing mother. **Oxytocin** works together with prolactin to deliver milk to an infant. Release of oxytocin stimulates the milk “let down” reflex, in which smooth muscle surrounding the mammary glands contracts, ejecting breast milk for a nursing infant. The control is sensory and neural. Stimulation of the nipple by the nursing child results in oxytocin release. The resulting milk let down encourages the child to continue nursing, which results in more oxytocin release, etc. This *positive feedback loop* continues until the child becomes full and stops nursing.

In addition, oxytocin is involved in uterine contractions during childbirth. Rising oxytocin levels during the final stage of pregnancy result in the onset of labor contractions. Once they begin, stimulation of the uterine walls (by the unborn fetus as the walls squeeze) causes additional oxytocin release. This causes more labor contractions, which causes additional stimulation, etc. This *positive feedback loop* continues until the baby is born, which discontinues stimulation of the uterine walls. Labor contractions continue for several minutes afterwards, though, which help return the uterus to normal size.

In humans, oxytocin is released in small amounts as a result of pleasurable physical contact, too. (Kissing, hugging, holding hands, and even sexual contact) As a result, it is sometimes good-naturedly called a “cuddle hormone.”
This figure summarizes the posterior pituitary hormones and the relationship between the hypothalamus and the posterior pituitary.