The Endocrine System (chp. 13)

p. 422-423
- releases chemical hormones into the blood which help maintain homeostasis by causing or preventing changes in specific organs or tissues of the body.
- works in conjunction with the nervous system
- slower in producing its effects than nervous system since the hormones are carried by way of the blood, the speed of hormone action is normally slower than a response to nervous control which tends to be much more immediate.

- hormone. (p. 422)
- A substance that is secreted directly into the bloodstream and that produces a specific effect on a particular tissue.

Target cell (p. 422)
- type of cell that contains receptors for a certain type of hormone.
- Endocrine control is the result of the action of hormones on target organs.

How Protein and Steroid Hormones cause changes in Target Cells (p. 424-425)

Hormones do not seek out organs. Target cells that react to a particular hormone have specific receptors for that particular hormone. The receptors combine with the hormone in a lock and key fashion.

There are 2 main types of hormones:

1) steroid hormones - are manufactured from cholesterol. e.g. cortisol. These are made in the smooth ER and combine with a protein carrier to be transported through the bloodstream. They are fat soluble so they can pass directly through the cell membrane into the cell where they attach to a protein receptor molecule in the cytoplasm. It then enters the nucleus and activates a specific gene to produce a specific enzyme which will start up the desired reaction in the cell.
2) **Non-steroid hormones** - e.g. adrenaline. are made of either proteins, peptides or amino acids. They are not fat soluble so they usually cannot diffuse through the cell membrane. They bind with receptor proteins molecules embedded in the surface cell membrane of target cells. This triggers a chain reaction of chemical reactions inside of the cell, called an **enzyme cascade** (e.g. the cell converts glycogen to glucose).... see diagram p. 425

**Distinguish between endocrine and exocrine glands.**

**Endocrine glands** do not have ducts. For this reason, endocrine glands are known as ductless glands. They normally secrete their product directly into the blood passing through nearby capillaries.

**Exocrine glands** do have ducts and their products pass from the gland, through the duct to a specific location. Examples of exocrine glands include the salivary glands, tear glands, and pancreas.

**Identify the location in the body and the general function of each of the following endocrine glands: (refer to diagram p. 422).**

- **Pineal gland** - small pine cone-shaped structure located deep in the center of the brain. It produces melatonin.

- **Hypothalamus** - part of the brain that acts as the main control center for the autonomic nervous system, re-establishes homeostasis, and coordinates the endocrine system.

- **Pituitary gland** - often called the master gland because it secretes hormones that control other endocrine glands, such as the thyroid. (see p. 427 diagram)

- **Thyroid gland** - butterfly-shaped gland located below the larynx in the neck that produces the hormone thyroxine.
parathyroid - are located in the back of the thyroid gland. The hormone which is released through the parathyroid glands is Parathyroid hormone (PTH) which raises the calcium level in the blood.

adrenal gland - there are two of these. They sit on top of each kidney, like a cap. They produce the hormone adrenaline. The adrenal gland has two layers, the outer adrenal cortex and the inner adrenal medulla. Each produces different hormones and is independent of the other.

Islets of Langerhans - are inside of the pancreas. They produce the hormone insulin.

Thymus - located between the lobes of the lungs in the upper chest cavity. Secrete several hormones that function with the immune system.

Ovaries - reproductive organs of a female found in the abdomen.; produce the eggs. Also produce hormones such as estrogen, which are involved in the menstrual cycle.

Testes - male reproductive organs that produce sperm. Located in the scrotum. Also produce the male hormone testosterone.

Identify the following hormones, their source gland, and explain their general effect on the human organism:

1. melatonin (p. 440)

Source gland: pineal gland

General Effects:

- participates in the regulation of sleep and quality of sleep so normally mostly secreted only at night.

- connection between melatonin secretion and sleep disorders.

- abnormal production may result in mood disorders and depression
- e.g. SAD (seasonal affective disorder) persons become depressed and want to sleep all of the time when winter starts; affects as much as 20% of northern residents.

- has strong antioxidant effects, helping us to battle the daily wear and tear effects of free-radicals and thereby slow cellular aging. It is also a powerful regulator of sex hormone production.

extra info: students read for interest only: not responsible for this material

The trigger for melatonin secretion each evening is decreased light exposure; at the end of the day, when our sunlight exposure decreases, melatonin begins to switch on. This sleep-inducing quality which melatonin possesses is why many people use melatonin supplementation to help them manage nightshift work, counteract occasional insomnia, or minimize jet lag when traveling to different time zones. It is such a powerful regulator of sex hormones production that for many animals it is the seasonal variability in light exposure and the resulting variability in melatonin secretion throughout the year that produces the animal's seasonal breeding patterns. Interestingly, clinical trials of a new and novel female contraceptive drug which contains high levels of melatonin, called B-Oval, are currently underway in Holland.

2. **thyroxine** (see p. 431 - 432)

*Source gland:* Thyroid Gland

*General effects:*

- increases basal metabolic rate and oxygen consumption, especially in heart, skeletal muscles, kidneys, liver by stimulating sodium potassium pump activity in the cell membrane of target cells.

3. **adrenaline**

*Source Gland:* adrenal medulla of the adrenal gland

*General Effects:*

- called the stress hormone; it prepares the body for the fight or flight syndrome.
- serves as an excitatory neurotransmitter in the sympathetic nervous system.
- increase heart rate, blood pressure, increase vasodilation of blood vessels in the heart and respiratory system.
- also stimulates the liver to break down stored glycogen into glucose and release it into the bloodstream as an extra source of energy for muscles.

4. **somatotrophin (also called HGH - human growth hormone)**

*source gland:* anterior pituitary gland; nonsteroid hormone (locate this on diagram p. 428, 427, and 422.

*General effect:* see p. 428 - 429 for details

- regulates normal growth and development
- triggers the production of growth factors in the liver and other tissues.

**The Hypothalamus - Pituitary Complex and its Function in Feedback Control**

- see pp. 427 - 428
- hypothalamus - monitors the state of the body's internal environment by analyzing negative feedback (eg. various concentrations of chemicals in the blood) and regulates the pituitary gland (see diagram p. 427, also p. 422)
- both pituitary and hypothalamus secrete hormones that control other hormone - producing glands. Their interaction with each other is a key factor in maintaining body homeostasis.
- portal system of blood vessels extends from the hypothalamus into the pituitary. It forms the critical link between the nervous system and the endocrine system.
- hypothalamus secretes hormones called *releasing factors*. These influence the activity of the pituitary by stimulating or inhibiting its secretions.
- pituitary hormones control other endocrine glands so it is often called the master gland

**An example of the Hypothalamus - Pituitary Feedback Mechanism - the Regulation of Thyroxine Secretion**

- done by *negative feedback* - a cycle in which the last step in a sequence inhibits the first step in a sequence. (see fig. 13.13, p. 432.)
- 1. Low thyroxin in the blood is detected by the hypothalamus. Releasing factors from the hypothalamus stimulate the anterior pituitary to release TSH, thyroid stimulating hormone.
- 2. TSH affects target cells in the thyroid gland, stimulating thyroid cells to secrete thyroxine into the blood.
- 3. As thyroxine levels build up in the bloodstream, high levels are detected by the hypothalamus. The hypothalamus stops secreting releasing factors. This stops the production of TSH by the anterior pituitary, which halts the secretion of thyroxin
The Regulation of Blood Sugar (pp. 435 - 437)
- another example of a negative feedback system.
- accomplished by controlled release of two hormones: insulin and glucagon. They are antagonistic hormones. Each counteracts the actions of the other.

- insulin - hormone produced by the islets of Langerhans in the Pancreas. It converts glucose into glycogen and lowers blood sugar.
- glycogen - a carbohydrate made of glucose molecules. used as a food storage molecule in our livers.

- glucagon - hormone secreted by endocrine cells f the pancreas into the bloodstream which converts stored glycogen into glucose sugar, causing an increase in blood sugar.

(see diagram p. 438)

steps:
1. Low levels of blood glucose stimulates the secretion of hormone glucagon.
2. Increased glucagon levels cause stored Glycogen in the liver to be converted into glucose and released into the bloodstream.
3. As blood sugar levels rise, the secretion of glucagon stops but triggers release of hormone insulin.
4. Increased insulin levels causes the intake of glucose into muscle cells and also converts any excess glucose into glycogen to be stored in the liver.
5. When blood sugar levels become lower again, the feedback loop starts over again.

Some Disorders of the Endocrine System:

1. Diabetes:
- occurs when the negative feedback loop fails. Cased by a low or lack of production of insulin.
- two types of diabetes:
  A. Type 1 (Diabetes mellitus)
    - autoimmune disorder which destroys the insulin producing B- cells in the pancreas.
- injection of daily insulin required

B. Type II diabetes

- occurs in adults
- mostly treated by oral medication and exercise.

2. **pituitary dwarfism** lack of HGH in childhood causes abnormally short stature but in perfect proportion. Caused by tumor in pituitary gland or having no pituitary gland. Treatment is injection of manufactured HGH hormone.

3. **giantism** caused by excess HGH in childhood prior to puberty (fig. 13.9). It causes the abnormal growth of long bones

Note: **tumour in the pituitary gland** is the most common cause of **giantism and acomegaly**. Treatments are surgical removal of tumour, radiation therapy, injection of a drug which blocks the effects of HGH.

4. **Hyperthyroidism**: (also called Grave's disease)

- thyroid gland disorder
- autoimmune disease; antibodies attach to receptors on thyroid gland which stimulates **excess production of thyroxine**
- enlargement of thyroid, muscle weakness, increased metabolic rate, excessive heat production, sweating due to dilation of blood vessels in the skin
- increased appetite but continued weight loss
- over time, eyes may bulge out due to buildup of fluid
- **treatment:**
  - surgical removal of the thyroid gland
  - thyroid blocking drugs
  - treatment with radioactive iodine that destroys overactive thyroid tissue
  - injections of thyroid hormone.

5. **Hypothyroidism**:

- thyroid gland disorder
- Deficiency of thyroxine production
- can be caused by an iodine deficiency
- lack of energy (weakness), reduced tolerance to cold, decreased heart rate and weight gain even with a decreased appetite.
Out of interest only: acomegaly students are not responsible to know this:

acomegaly excess HGH production in adulthood. Results in excessive thickening of bone tissue causing excessive growth of the bones in the head, hands and feet. (see fig. 13.10, p. 430)

The Role of Dr. Frederick Banting Charles Best in the Discovery of Insulin

read p 439. See text for highlight notes.

- a Canadian discovery (University of Toronto)
- persons with diabetes prior to 1922 had no cure; all patients would eventually die
- discovered treatment for diabetes in 1922. Has saved millions of people all around the world
- illustrates Canadian contributions to technology and science