Puberty and secondary sex characteristics of males and females:

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth spurts</td>
<td>Growth of body hair</td>
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<tr>
<td>Growth of body and facial hair</td>
<td>Growth of body hair</td>
</tr>
<tr>
<td>Deepening of their voice</td>
<td>Onset of their menstrual cycle</td>
</tr>
<tr>
<td>Development of genitals</td>
<td>Development of breast and broader hips</td>
</tr>
</tbody>
</table>

All body changes are timed and controlled by hormones. Hormones are produced by cells in one part of the body, released into the circulatory system to regulate the processes of other cells (target cells) found in another location of the body.

Local Regulator hormones impact near by cells while other hormones are chemical messengers to cells in other area of the body to perform a function.

Hormones are secreted from cells, tissues and organs of the endocrine system. The endocrine system regulates and coordinates the function of organs throughout the body, similar to the nervous system. The endocrine system controls growth, development, reproduction, behaviour, energy metabolism and water balance.

The nervous is a fast response, using electrochemical impulses, to make a change, while the endocrine system is a slower response to change, and is longer acting. The nervous system regulates and controls the endocrine system.

The endocrine glands secret their hormones directly into the circulatory system, therefore they do not require ducts to deliver hormones. Since the hormones are released into the circulatory system many cells are exposed to a continuous supply of hormones. Only the target cells, with the appropriate protein receptors, are actually stimulated by the hormones. The hormones
are broken down by enzymes, so the hormones are not continuously stimulating the cells.

**Figure 1:** Hormones are produced by the cells of the endocrine glands and released into the bloodstream, where most of the body cells are exposed to them. Only the target cells with the appropriate receptor proteins respond to a hormone.

### Types of Hormones

**Protein Hormone** – is a hormone composed of chains of amino acids that is water soluble; usually acts on cell membrane receptors.

**Steroid Hormone** – is a hormone composed of cholesterol that is not very water soluble; usually passes through the cell membrane and acts on receptors inside the cell.

There are more than 60 known hormones and regulators secreted from the endocrine system. Hormones are identified by their structure. There are two main types; protein and steroid.

### Hormone Mechanisms

Most hormones are secreted in an inactive state, called prohormones. When the target cells receive these hormones, the hormones are converted to the active form. Some hormones are converted by the source cells.

Angiotensin is a hormone that regulates blood pressure. The liver produces the inactive form known as angiotensinogen. An enzyme cleaves an inactive form, releasing the active form angiotensin. The enzyme responsible for this is called angiotensin-converting enzyme (ACE).
Hormones are secreted in small amounts, but are amplified to increase their impact on target cells. Once the target cell and its proteins are stimulated, they in turn stimulate adjacent cells, amplification.

**Pathways for Water Soluble Hormones**

*Glucagon* – is a hormone produced by alpha cells in the pancreas that raises the blood glucose level by promoting the breakdown of glycogen in the liver.

Water soluble hormones, although dissolved in water, they cannot easily pass through a cell membrane. They usually stimulate external receptors found on the cell membrane. The receptor molecule changes shape, activating a signal that stimulates changes within the cell. These hormones can initiate changes in the cytosol or the nucleus.

Glucagon is one hormone that stimulates surface receptors, of the liver cell to trigger the breakdown of glycogen stores into glucose.

**Pathways for Lipid-Soluble Hormones**

Hormones that bind to receptors inside the cell are usually steroid hormones. Steroids are lipid based molecule, therefore they are readily able to pass through a phospholipid membrane of a cell. The hormones stimulate receptors within the cytosol or the nucleus of the cell; binds to the control sequence of specific genes, turning them on or off.

Aldosterone is a hormone that controls blood pressure, as blood pressure drops aldosterone is secreted from the adrenal glands, traveling through the circulatory system to their target cells within the kidneys, sweat glands, and colon. Aldosterone stimulates the increase of sodium reabsorption, which then draws water back into the circulatory system, increasing blood pressure.
Summary, Mechanism by which Hormones work:

1. **Only the cells that contain surface or internal receptors for the hormones respond to the hormones.**
2. **Once bound to their receptors, hormones produce a response by turning cellular processes on or off. They do this by altering the proteins that are functioning in or produced by the cell.**
3. **Hormones are effective in very small concentrations because of the amplification that occurs in both surface and internal receptor mechanism.**
4. **The response to a hormone differs among target organs and among species.**
**Hormones as Part of Feedback Mechanisms**

Most of the hormones are regulated by the negative feedback system. The hormone produced at the end of a chemical pathway is usually an inhibitor at an earlier chemical reaction.

The hypothalamus releases thyroid–releasing hormone (TRH). This hormone signals the release of hormones from the pituitary and thyroid gland. When the thyroid hormone increases in concentration in the blood it inhibits the secretion of thyroid-stimulating hormone (TSH) by the pituitary to stop the chemical sequence.

![Negative feedback loop diagram](image)

**Figure 3:** A simple negative feedback loop regulates the secretion of hormones.

**Regulation of Body Processes by Hormones**

Several hormones can regulate and coordinate activities of many body processes. Blood glucose, fatty acids, and ion ([Ca]^{2+}, [K]^{+} and [Na]^{+}) concentrations are regulated by many hormones interacting. Negative feedback loops adjust the levels of secretion. This maintains homeostasis within the body.