Endocrine System
Endocrine System

• A major controlling system of the body through hormones.
• ENDOCRINOLOGY : the scientific study of hormones and endocrine organs.
• Processes that hormones control:
  – Control reproduction
  – Growth and development
  – Mobilizing body defenses against stressors
  – Maintaining electrolyte, water and nutrient balance of the blood
  – Regulating cellular metabolism
  – Energy balance
Overview of Endocrine System and Hormone Function

• Endocrine organs are small and widely separated in the body. It lacks the structural or anatomical continuity typical of most organ system.

• HORMONE: chemical substances that are secreted by endocrine cells into the ECF and regulate the metabolic activity of other cells in the body.
Hormones

Types:
1. Amino acid-based molecules (proteins, peptides and amines).
2. Steroids. (made from cholesterol. E.g. hormones of the gonads and the adrenal cortex)

* They arouse or bring about their effects on the body cell primarily by altering cellular activity i.e. by increasing or decreasing the rate of a normal or usual metabolic process rather than by stimulating a new one.
Mechanism of Hormone Action

A given hormone affects only certain tissue cells or organs. (target cells/target organs)

Hormone bind/attach to a specific protein receptor inside the cell or in its plasma membrane.

Only through binding or attachment can the hormone influence the working of the cell.

- Changes in plasma membrane permeability or electrical state.
- Synthesis of proteins or certain regulatory molecules or enzymes in the cell.
- Activation or inactivation of enzymes
- Stimulation of mitosis
- Promotion of secretory activity.
Mechanism of Hormone Action

A. Direct Gene Activation

- For steroid hormones (+ thyroid hormone)
- Mechanism:

  Lipid soluble steroid hormone diffuse through the plasma membrane of their target cell
  ↓
  Once inside, steroid hormone enters the nucleus
  ↓
  Inside the nucleus, the hormone will bind to a specific receptor protein.
  ↓
  Hormone-receptor complex bind to the specific site on the cell’s DNA.
  ↓
  Activation of certain genes to transcribe mRNA.
  ↓
  mRNA is translated in the cytoplasm resulting to a new protein.
For water-soluble, nonsteroidal hormones.

Mechanism:

Hormone binds to the membrane receptor.

↓

The activated receptor sets off a series of reaction that activates an enzyme

↓

Activated enzyme catalyses reactions that produce second-messenger molecules

↓

Second-messenger molecule produce oversee additional intracellular changes that promote the typical response of the target cell to the hormone.
Control of Hormone Release

• What prompts the endocrine glands to release or not release their hormones?
• Negative Feedback Mechanism
• Endocrine Gland Stimuli
  – Three Categories:
    • Hormonal Stimuli (hormone stimulates other hormone)
    • Humoral stimuli (hormone levels in the blood)
    • Neural stimuli (nerve fibers stimulate hormone release)
Major Endocrine Organs

- **Hypothalamus**
- **Pituitary gland**
  - Anterior Pituitary Gland (Adenohypophysis)
  - Posterior Pituitary Gland (Neurohypophysis)
- **Pineal gland**
- **Thyroid gland**
- **Parathyroid gland**
- **Thymus gland**
- **Pancreas**
- **Adrenal gland**
  - Adrenal Medulla
  - Adrenal Cortex
- **Gonads**
  - Testes
  - Ovaries
Hypothalamus

- Hormones released by the neurohypophysis.
- The releasing and inhibiting hormones that regulate the adenohypophysis.
Pituitary Gland

• Size of a pea.

• Surrounded by the sellaturcica of the sphenoid bone. Connected to the hypothalamus via the infundibulum.

• Two functional lobes;
  – Anterior Pituitary Gland (Adenohypophysis)
  – Posterior Pituitary Gland (Neurohypophysis)
HORMONES OF THE ANTERIOR PITUITARY GLAND
Hormones of the APG

• GH and PRL: exert major effects on nonendocrine gland.

• TSH, ACTH, LH, FSH – tropic hormones.
  Tropic hormones: stimulate their target organs (endocrine) to secrete their hormones which in turn exert their effects on other body organs and tissues.

• All APG hormones are:
  • Proteins (or peptides)
  • Act through second-messenger system
  • Regulated by hormonal stimuli and in most cases, negative feedback.
1. Growth Hormone (GH)

- Effects are directed to the growth of skeletal muscle and long bone and plays an important role in determining body size.
- Homeostatic imbalance:
  - Hyposecretion in childhood: Pituitary dwarfism
  - Hypersecretion in childhood: Gigantism
  - Hypersecretion after the end of long-bone growth: Acromegaly
2. Prolactin

- Target organ in humans: breast.
- After childbirth, it stimulates and maintains milk production by the mother’s breasts.
- Function in men is not known.
3. ACTH. Regulate the endocrine activity of the adrenal cortex.

4. Thyroid-stimulating hormone (TSH) or Thyrotropic hormone (TH). Influences growth and activity of the thyroid gland.

5. Gonadotropic hormone. Regulate the hormonal activity of the gonads.

<table>
<thead>
<tr>
<th>Follicle-stimulating Hormone (FSH)</th>
<th>Luteinizing Hormone (LH)</th>
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<tbody>
<tr>
<td>F: stimulates follicle dev’t. in the ovaries. As follicle matures, they produce estrogen and eggs and readied for ovulation.</td>
<td>F. Triggers ovulation of an egg from the ovary and causes the ruptured follicle to produce progesterone and some estrogen.</td>
</tr>
<tr>
<td>M. Stimulates sperm production by the testes.</td>
<td>M. Stimulates testosterone production by the interstitial cells of the testes.</td>
</tr>
</tbody>
</table>
Posterior Pituitary Gland

• Serve as storage for the hormones OXYTOCIN and ANTIDIURETIC HORMONE created by the hypothalamic neurons.
• Oxytocin
  – Released significantly at childbirth and to breastfeeding women.
  – Stimulates powerful uterine contraction during;
    • Labor
    • Sexual relations
    • Breastfeeding
  – Causes milk ejection (let-down reflex) in breastfeeding women.
  – Used to induce labor or hasten labor for progressing but slow labor pace.
  – Less frequently, to stop postpartum bleeding.
  – *Pitocin*
• **Antidiuretic hormone (ADH)**
  – A chemical that inhibits or prevents urine production or (Diuresis).
  – Causes the kidney to reabsorb more water from the forming urine leading to decrease urine volume hence increase blood volume.
  – In large quantity, it increases BP by causing constriction of the arterioles hence sometimes called **VASOPRESSIN**.
  – Drinking alcoholic beverage inhibits ADH secretion.
  – *Diuretics* antagonize the effects of ADH.
  – Diabetes Insipidus(excessive urine output) result from the hyposecretion of these hormone.
Thyroid Gland

- Makes two hormones:
  1. Thyroid Hormones
     - T3 triiodothyronine
     - T4 Thyroxine
  2. Calcitonin

Thyroid hormone production is dependent on the hormones’ essential and unique component: iodine.
A butterfly-shaped organ, the **thyroid gland** is located anterior to the trachea, just inferior to the larynx. The medial region, called the isthmus, is flanked by wing-shaped left and right lobes. Each of the thyroid lobes are embedded with parathyroid glands, primarily on their posterior surfaces. The tissue of the thyroid gland is composed mostly of thyroid follicles. The follicles are made up of a central cavity filled with a sticky fluid called **colloid**. Surrounded by a wall of epithelial follicle cells, the colloid is the center of thyroid hormone production.
Thyroid Hormone

1. Controls the rate of glucose oxidation → conversion to body heat → chemical energy.
   • Since every cell in the body needs chemical energy, every cell is the target cell of the thyroid hormone.

2. Essential for normal tissue growth and development (esp. the reproductive and nervous systems).
The thyroid hormones, T3 and T4, are often referred to as metabolic hormones because their levels influence the body’s basal metabolic rate, the amount of energy used by the body at rest. Thyroid hormones increase the body’s sensitivity to catecholamines (epinephrine and norepinephrine) from the adrenal medulla by upregulation of receptors in the blood vessels. When levels of T3 and T4 hormones are excessive, this effect accelerates the heart rate, strengthens the heartbeat, and increases blood pressure. Because thyroid hormones regulate metabolism, heat production, protein synthesis, and many other body functions, thyroid disorders can have severe and widespread consequences.
A classic negative feedback loop controls the regulation of thyroid hormone levels.

1) Metabolic rate and/or $T_3$ and $T_4$ concentration in blood...

Low?
- Hypothalamus releases TRH. This triggers TSH release by the pituitary.

High?
- Hypothalamus stops TRH release
- Anterior pituitary stops TSH release

4) Negative feedback:
- Elevated $T_3$ and $T_4$ levels inhibit release of TRH and TSH

2) Effects of TSH release:
- Triggers release of $T_3$ and $T_4$ by thyroid follicle cells

3) Effects of $T_3$ and $T_4$ release:
- Increased basal metabolic rate of body cells
- Rise in body temperature (calorigenic effect)
Homeostatic Imbalance r/t TH

• Goiter. Enlargement of the thyroid gland r/t deficient iodine in the diet.
• Cretinism.
• Hypothyroidism (Myxedema)
• Hyperthyroidism (Grave’s Disease → exophthalmos
As discussed above, dietary iodine is required for the synthesis of T3 and T4. But for much of the world’s population, foods do not provide adequate levels of this mineral, because the amount varies according to the level in the soil in which the food was grown, as well as the irrigation and fertilizers used. Marine fish and shrimp tend to have high levels because they concentrate iodine from seawater, but many people in landlocked regions lack access to seafood. Thus, the primary source of dietary iodine in many countries is iodized salt. Fortification of salt with iodine began in the United States in 1924, and international efforts to iodize salt in the world’s poorest nations continue today.

Dietary iodine deficiency can result in the impaired ability to synthesize T3 and T4, leading to a variety of severe disorders. When T3 and T4 cannot be produced, TSH is secreted in increasing amounts. As a result of this hyperstimulation, thyroglobulin accumulates in the thyroid gland follicles, increasing their deposits of colloid. The accumulation of colloid increases the overall size of the thyroid gland, a condition called a goiter. A goiter is only a visible indication of the deficiency. Other iodine deficiency disorders include impaired growth and development, decreased fertility, and prenatal and infant death. Moreover, iodine deficiency is the primary cause of preventable mental retardation worldwide. Neonatal hypothyroidism (cretinism) is characterized by cognitive deficits, short stature, and sometimes deafness and muteness in children and adults born to mothers who were iodine-deficient during pregnancy.
In areas of the world with access to iodized salt, dietary deficiency is rare. Instead, inflammation of the thyroid gland is the more common cause of low blood levels of thyroid hormones. Called hypothyroidism, the condition is characterized by a low metabolic rate, weight gain, cold extremities, constipation, reduced libido, menstrual irregularities, and reduced mental activity. In contrast, hyperthyroidism—an abnormally elevated blood level of thyroid hormones—is often caused by a pituitary or thyroid tumor. In Graves’ disease, the hyperthyroid state results from an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland. Hyperthyroidism can lead to an increased metabolic rate, excessive body heat and sweating, diarrhea, weight loss, tremors, and increased heart rate. The person’s eyes may bulge (called exophthalmos) as antibodies produce inflammation in the soft tissues of the orbits. The person may also develop a goiter.
Calcitonin

- Decreases blood calcium levels by causing calcium to be deposited in the bones.
- Made by the parafollicular cells (connective tissue between follicles).
- Released directly to the blood in response to increased levels of blood calcium.
- $\text{Ca}^{++} : 9-11\text{mg/100ml}$
Parathyroid Gland

• Mostly four tiny masses of glandular tissue posterior to the surface of the thyroid gland.
• Seretes parathyroid hormone (PTH) or parathormone which is the most important regulator of calcium ion homeostasis in the blood.
• Hence, PTH is a hypercalcemic hormone while Calcitonin is a hypocalcemic hormone.
1) Blood calcium concentration drops

2) Release of PTH:
   - Chief cells of the parathyroid gland release parathyroid hormone (PTH).

3a) Effects of PTH on bone:
   - Inhibits osteoblasts
   - Stimulates osteoclasts
   - Bone is broken down, releasing calcium ions into bloodstream

3b) Effects of PTH on kidneys:
   - PTH stimulates kidney tubule cells to recover waste calcium from the urine.
   - PTH stimulates kidney tubule cells to release calcitriol.

3c) Effects of calcitriol on intestine:
   - Stimulates intestines to absorb calcium from digesting food

4) Blood calcium levels increase

5) Calcitonin release:
   - High concentrations of calcium stimulate parafollicular cells in the thyroid to release calcitonin.

5) Effects of calcitonin on bone:
   - Stimulates osteoblasts
   - Inhibits osteoclasts
   - Calcium is removed from blood and used to build bone
Homeostatic Imbalance

• Tetany: increased neuroexcitability and sustained muscle contraction (muscle spasms) associated with hypocalcemia.
• Severe hyperparathyroidism causes massive bone destruction.
Adrenal Gland

• Two bean shaped organs curve over the top of the kidneys.

• Structurally and functionally two endocrine organs in one
  – Adrenal cortex (glandular)
  – Adrenal medulla (neural tissue)
Adrenal Cortex

• The **adrenal cortex**, as a component of the hypothalamic-pituitary-adrenal (HPA) axis.

• The HPA axis involves the stimulation of hormone release of adrenocorticotropic hormone (ACTH) from the pituitary by the hypothalamus.

• Adrenal cortex produces three major groups of steroid hormones collectively called CORTICOSTEROIDS.
  – Mineralocorticoid
  – Glucocorticoid
  – Sex Hormones
Mineralocorticoids (maj. Aldosterone)

- Produce by the outermost adrenal cortex.
- Important in regulating mineral content of the blood (Na and K).
- Help regulate both water and electrolyte balance in the body.
- Aldosterone is also a key component of the renin-angiotensin-aldosterone system (RAAS) in which specialized cells of the kidneys secrete the enzyme renin in response to low blood volume or low blood pressure.
- Release of these hormone is regulated by humoral factors.
Stressor: Elevated blood K+, low blood Na+, low blood pressure, or low blood volume

↓

Hypothalamus (CRH)

↓

Anterior Pituitary Gland release ACTH

↓

ACTH to adrenal cortex particularly on the zona glomerulosa to activate the release of mineralocorticoid aldosterone

↓

Aldosterone increases the excretion of K+ and the retention of Na+

↓

Increases blood volume and blood pressure
Aldosterone’s role in RAAS

Stressor; low blood volume or low blood pressure

Stimulation of the specialized cells of the kidneys to secrete the enzyme renin.

Renin catalyzes the conversion of the blood protein angiotensinogen, produced by the liver, to the hormone angiotensin I.

Angiotensin I is converted in the lungs

Angiotensin-converting enzyme (ACE)

Angiotensin II

Angiotensin II has the following effects:

1. Initiating vasoconstriction of the arterioles, decreasing blood flow
2. Stimulating kidney tubules to reabsorb NaCl and water, increasing blood volume
3. Signaling the adrenal cortex to secrete aldosterone, the effects of which further contribute to fluid retention, restoring blood pressure and blood volume
• **Atrial Natriuretic peptide**: prevents aldosterone release, its goal being to reduce blood volume and blood pressure.

• For individuals with hypertension, or high blood pressure, drugs are available that block the production of angiotensin II. These drugs, known as **ACE inhibitors**, block the ACE enzyme from converting angiotensin I to angiotensin II, thus mitigating the latter’s ability to increase blood pressure.
Glucocorticoid

- Produce by the middle cortical layer, zona fasciculata.
- Glucocorticoid includes cortisol and cortisone.
- Promotes normal cell metabolism and help the body resist long-term stressors by increasing blood glucose levels.
- Control unpleasant effects of inflammation by decreasing edema.
- Reduce pain by blocking prostaglandins.
- Its ant-inflammatory effect is prescribed as drug to suppress inflammation of RA.
Sex Hormones

• Particularly androgens (but some estrogens are also formed.)

➢ Zona reticularis.
Homeostatic Imbalance

• Hyposecretion of all adrenal cortex hormone: **ADDISON’S DISEASE**. (bronze tone skin, hypoglycemia, electrolyte and water imbalance.

• Hypersecretion due to ACTH-releasing tumor: **CUSHING’S SYNDROME**. (moon face, buffalo hump.

• Hypersecretion of the hormone of the zona reticularis or sex hormone leads to _regardless of sex._
ADDISON’S DISEASE

- Bronze Pigmentation of Skin
- Changes in Distribution of Body Hair
- Hypoglycemia
- Postural Hypotension
- GI Disturbances
- Weight Loss
- Weakness

**Adrenal Crisis:**
- Profound Fatigue
- Dehydration
- Vascular Collapse (↓BP)
- Renal Shut Down
- ↓Serum NA
- ↑Serum K

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Hormones of the Adrenal Medulla

• The adrenal medulla is an extension of the autonomic nervous system, which regulates homeostasis in the body.
• The medulla is stimulated to secrete the catecholamine hormones epinephrine (adrenaline) and norepinephrine (noradrenaline).
• One of the major functions of the adrenal gland is to respond to stress. Stress can be either physical or psychological or both.
• The body responds in different ways to short-term stress and long-term stress following a pattern known as the general adaptation syndrome (GAS).
General Adaptation Syndrome

1. Stage of ALARM. Their function is to prepare the body for extreme physical exertion. Once this stress is relieved, the body quickly returns to normal.

2. Stage of RESISTANCE. If the stress is not soon relieved, the body adapts to the stress.
   E.g. If a person is starving, the body may send signals to the gastrointestinal tract to maximize the absorption of nutrients from food.

3. Stage of EXHAUSTION. If the stress continues for a longer term however, the body responds with symptoms quite different than the fight-or-flight response. Individuals may begin to suffer depression, the suppression of their immune response, severe fatigue, or even a fatal heart attack.
Adrenal Medulla

- Both epinephrine and norepinephrine signal the liver and skeletal muscle cells to convert glycogen into glucose, resulting in increased blood glucose levels.
- These hormones increase the heart rate, pulse, and blood pressure to prepare the body to fight the perceived threat or flee from it.
- In addition, the pathway dilates the airways, raising blood oxygen levels. It also prompts vasodilation, further increasing the oxygenation of important organs such as the lungs, brain, heart, and skeletal muscle.
- At the same time, it triggers vasoconstriction to blood vessels serving less essential organs such as the gastrointestinal tract, kidneys, and skin, and downregulates some components of the immune system.
- Other effects include a dry mouth, loss of appetite, pupil dilation, and a loss of peripheral vision.
Pancreatic Islets

• The **pancreas** is a long, slender organ, most of which is located posterior to the bottom half of the stomach.

• Although it is primarily an exocrine gland, secreting a variety of digestive enzymes, the pancreas has an endocrine function.

• Its **pancreatic islets**—clusters of cells formerly known as the islets of Langerhans—secrete the hormones glucagon, insulin, somatostatin, and pancreatic polypeptide (PP).
Regulation of Blood Glucose Levels by Insulin and Glucagon

- Glucose is required for cellular respiration and is the preferred fuel for all body cells. The body derives glucose from the breakdown of the carbohydrate-containing foods and drinks we consume.
- Glucose not immediately taken up by cells for fuel can be stored by the liver and muscles as glycogen, or converted to triglycerides and stored in the adipose tissue.
- Hormones regulate both the storage and the utilization of glucose as required. Receptors located in the pancreas (particularly the ISLET CELLS) sense blood glucose levels, and subsequently the pancreatic cells secrete glucagon or insulin to maintain normal levels.
INSULIN

- The primary function of insulin is to facilitate the uptake of glucose into body cells. *(Red blood cells, as well as cells of the brain, liver, kidneys, and the lining of the small intestine, do not have insulin receptors on their cell membranes and do not require insulin for glucose uptake.)*

- Although all other body cells do require insulin if they are to take glucose from the bloodstream, **skeletal muscle cells and adipose cells are the primary targets of insulin.**

- The presence of food in the intestine triggers the release of gastrointestinal tract hormones such as **glucose-dependent insulinotropic peptide** (previously known as gastric inhibitory peptide). This is in turn the initial trigger for insulin production and secretion by the beta cells of the pancreas.

- Once nutrient absorption occurs, the resulting surge in blood glucose levels further stimulates insulin secretion.

- Insulin triggers the rapid movement of a pool of glucose transporter vesicles to the cell membrane, where they fuse and expose the glucose transporters to the extracellular fluid. The transporters then move glucose by **facilitated diffusion** into the cell interior.

- Insulin is hypoglycemic.
GLUCAGON

- It stimulates the liver to convert its stores of **glycogen back into glucose**. This response is known as **glycogenolysis**. The glucose is then released into the circulation for use by body cells.

- It stimulates the liver to take up **amino acids** from the blood and **convert** them into **glucose**. This response is known as **gluconeogenesis**.

- It stimulates **lipolysis**, the **breakdown of stored triglycerides into free fatty acids and glycerol**. Some of the free glycerol released into the bloodstream travels to the liver, which converts it into glucose. This is also a form of **gluconeogenesis**.

Taken together, these actions increase blood glucose levels. The activity of glucagon is regulated through a negative feedback mechanism; rising blood glucose levels inhibit further glucagon production and secretion.
Homeostatic Imbalance

• Diabetes mellitus;

3 cardinal signs;
Polyuria, Polydipsia, Polyphagia.

Acidosis, Glycosuria, Ketones, Insulin resistance.
Pineal Gland

- Located posterior to the third ventricle of the brain.
- Releases melatonin which affects sleep as well as biological rhythms and reproductive behavior in other animals.
- In humans, it is believed to coordinate the hormones of fertility and to inhibit the reproductive system so that sexual maturation is prevented from occurring before adult body size has been reached.
- The secretion of melatonin varies according to the level of light received from the environment. At daytime, blood levels of melatonin fall, promoting wakefulness. In contrast, as light levels decline—such as during the evening—melatonin production increases, boosting blood levels and causing drowsiness.
Thymus Gland

• The **thymus** is an organ of the immune system that is larger and more active during infancy and early childhood, and begins to atrophy as we age.

• Its endocrine function is the production of a group of hormones called **thymosins** that contribute to the development and differentiation of T lymphocytes, which are immune cells.

• Although the role of thymosins is not yet well understood, it is clear that they contribute to the immune response.
Gonads

- Produces sex hormones that are identical to those produced by adrenal cortex cells. The difference is source and relative amounts produced.
- Hormones of the ovaries
  - Estrogen
  - Progesterone
- Hormones of the Testes
  - Androgens (Testosterone)
Hormone of the Ovaries

• Estrogen
  – Development of sex characteristics in women and the appearance of secondary sex characteristics.
  – Together with progesterone, it promotes breast development and menstrual cycle.

• Progesterone
  – One is noted above.
  – Prepares breast tissue for lactation.
  – Prepares and maintains the uterine lining for implantation and pregnancy.

*Hyposcretion of these hormones hampers the ability of a woman to conceive and bear children.*
Hormones of the Testes

- Testes produces both the male sex cells or sperm and the male sex hormones.
- Testosterone
  - promotes the growth and maturation of the reproductive system organs to prepare young man for reproduction.
  - Secondary sexual characteristics.
  - Stimulates male sex drives.
  - Necessary for continuous production of sperm.

Hypossecletion of testosterone hormone causes sterility in men.
Other Hormone-Producing Tissues and Organs

• Placenta
  – An organ temporary in the uterus of a pregnant woman.

  **Human Chorionic Gonadotropin (hCG)**
  - Produced by the developing embryo and by the fetal part of the placenta; it stimulates the ovaries to continue producing estrogen and progesterone

  **Human Placental Lactogen (hPL)**
  - Works cooperatively with estrogen and progesterone in preparing the breasts for lactation.

  **Relaxin**
  - Causes the mother’s pelvic ligaments and the pubic symphysis to relax and become more flexible which eases birth passage.
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<th>Organ</th>
<th>Hormone</th>
<th>Function</th>
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</thead>
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<tr>
<td>Kidneys</td>
<td>Erythropoietin</td>
<td>Triggers the formation of red blood cells in the bone marrow</td>
</tr>
<tr>
<td>Skeleton</td>
<td>FGF23</td>
<td>Inhibits production of calcitriol and increases phosphate excretion</td>
</tr>
<tr>
<td>Skeleton</td>
<td>Osteocalcin</td>
<td>Increases insulin production</td>
</tr>
<tr>
<td>Adipose tissue</td>
<td>Leptin</td>
<td>Promotes satiety signals in the brain</td>
</tr>
<tr>
<td>Adipose tissue</td>
<td>Adiponectin</td>
<td>Reduces insulin resistance</td>
</tr>
<tr>
<td>Skin</td>
<td>Cholecalciferol</td>
<td>Modified to form vitamin D</td>
</tr>
<tr>
<td>Thymus (and other organs)</td>
<td>Thymosins</td>
<td>Among other things, aids in the development of T lymphocytes of the immune system</td>
</tr>
<tr>
<td>Liver</td>
<td>Insulin-like growth factor-1</td>
<td>Stimulates bodily growth</td>
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<tr>
<td>Liver</td>
<td>Angiotensinogen</td>
<td>Raises blood pressure</td>
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<tr>
<td>Liver</td>
<td>Thrombopoetin</td>
<td>Causes increase in platelets</td>
</tr>
<tr>
<td>Liver</td>
<td>Hepcidin</td>
<td>Blocks release of iron into body fluids</td>
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Developmental Aspects of Endocrine System

- In the absence of disease, efficiency of the endocrine system remains high until old age.
- Decreasing function of female ovaries at menopause leads to such symptoms as osteoporosis, increased chance of heart disease and possible mood changes.
- Efficiency of all endocrine glands gradually decreases with aging, which leads to a generalized increase in incidence of DM, immune system depression, lower metabolic rate and in some areas, cancer rates.