Chapter 16

HUMAN ENDOCRINE SYSTEM

STUDENTS'LEARNING OUTCOMES

After studying this chapter, the students will be able to:

- State the role of hormones as chemical messengers.
- Describe the chemical nature of hormones and correlate it with important hormones.
- Locate the endocrine glands in human body name the hormones they release and their functions; (pituitary, thyroid, parathyroid, pancreas, adrenal, gonads).
- Relate the problems associated with their imbalance of these hormones.
- Explain the neurosecretory role of hypothalamus.
- Outline the concept of feedback mechanism of hormones and describe positive feedback with reference to Oxytocin and negative feedback with reference to Insulin and Glucagon.

While our nervous system carries out high-speed nervous coordination, the endocrine system controls long-term processes like growth, metabolism, and reproduction. It performs its job by sending chemical instructions, in the form of hormones, to the target body parts. It is called chemical coordination. In this chapter we will study the hormones of endocrine glands, and their functions.

16.1- Hormones – The Chemical Messengers

A hormone is a regulatory chemical that is secreted into the blood or tissue fluid by an endocrine gland. The blood carries the hormone to every cell in body, but it shows its effects only in its specific target cells. When the target cells receive a hormone, they respond in specific way. That's why, hormones are referred to as **chemical messengers** or signalling molecules.

For Information

Glands are the tissues that produce and release secretions. There are two types of glands in body. Exocrine glands secrete their secretion in ducts attached with them. While, endocrine glands are ductless. They secrete their secretions called hormones directly in blood or tissue fluid.

16.1.1- Chemical Nature of Hormones

We can group hormones into three main chemical categories.

1. Peptide and Protein Hormones

These are made of chains of amino acids. They are water-soluble, meaning they dissolve easily in blood. However, they cannot pass through cell membranes. So, they bind to receptors on the cell surface. Examples include;

Hormone	Source (Gland)	Main Function
Insulin	Pancreas	Lowers blood glucose levels.
Glucagon	Pancreas	Raises blood glucose levels.
Growth Hormone	Anterior Pituitary	Stimulates growth and cell reproduction.
Oxytocin	Hypothalamus (released by Posterior Pituitary)	Stimulates muscle contractions during childbirth.

2. Glycoprotein Hormones

Glycoproteins are "conjugated proteins". They consist of a protein combined with a carbohydrate (sugar) group. They are large, complex, and polar molecules. So, they also cannot pass through the cell membrane. Examples include;

Hormone	Source (Gland)	Main Function
Thyroid Stimulating Hormone	Anterior Pituitary	Stimulates the thyroid gland to produce thyroxine.
Follicle Stimulating Hormone	Anterior Pituitary	Stimulates sperm production or egg development.
Luteinizing Hormone	Anterior Pituitary	Triggers ovulation in females and secretion of testosterone in males.

3. Amino Acid Derivatives Hormones

These are small molecules derived from a single amino acid (usually Tyrosine or Tryptophan). Their ability to pass through cell membranes depends on whether they behave more like a protein or more like a lipid. Epinephrine and norepinephrine cannot cross membranes while thyroxine and tri-iodothyronine can cross. Examples include;

Tidbit

In 1902, two British scientists, Bayliss and Starling, discovered hormone during their research on digestive system. They found that when acidic gastric juice comes in small intestine, a substance (which they called "secretin") was released into blood. Secretin reaches the pancreas and stimulates it to secrete pancreatic juice.

Hormone	Source (Gland)	Main Function
Epinephrine (Adrenaline)	Adrenal Medulla	Immediate "fight or flight" response.
Norepinephrine (noradrenaline)	Adrenal Medulla	Increases blood pressure and alertness.
Thyroxine (T4)	Thyroid Gland	Controls the speed of metabolism.
Triiodothyronine (T_3)	Thyroid Gland	Regulates body temperature and heart rate.

4. Steroid Hormones

These hormones are derived from cholesterol (a type of lipid). Unlike proteins, steroids are lipid-soluble (fat-soluble). This means they can move through the cell membrane to give instructions directly to the nucleus. Examples include;

Hormone	Source (Gland)	Main Function
Cortisol	Adrenal Cortex	Regulates metabolism and helps the body respond to stress.
Aldosterone	Adrenal Cortex	Helps the kidneys manage salt and water balance.
Testosterone	Testes	Regulates male reproductive tissues and traits.
Estrogen / Progesterone	Ovaries	Regulate the female reproductive system and cycle.

Path of the chemical message carried by hormones

The endocrine glands secrete their hormones on receiving particular stimuli. They release hormones in blood, which carries the hormone to all cells. Each hormone affects only its target cells. Target cells have receptors. Each receptor binds to a specific hormone. When a hormone binds to a receptor, the binding triggers events that lead to changes within the cell. Receptors can be found on the cell membrane, in the cytoplasm, or in the nucleus of a cell.

Tidbit

Hormones and neurotransmitters are both chemical messengers. However, hormones are part of endocrine system, while neurotransmitters are part of nervous system. Hormones are often slower acting and have longer effects than neurotransmitters.

16.2- Endocrine System of Man

The endocrine system of human beings consists of glands and organs that produce and secrete hormones for regulating various body functions. The locations of major endocrine glands have been shown below.

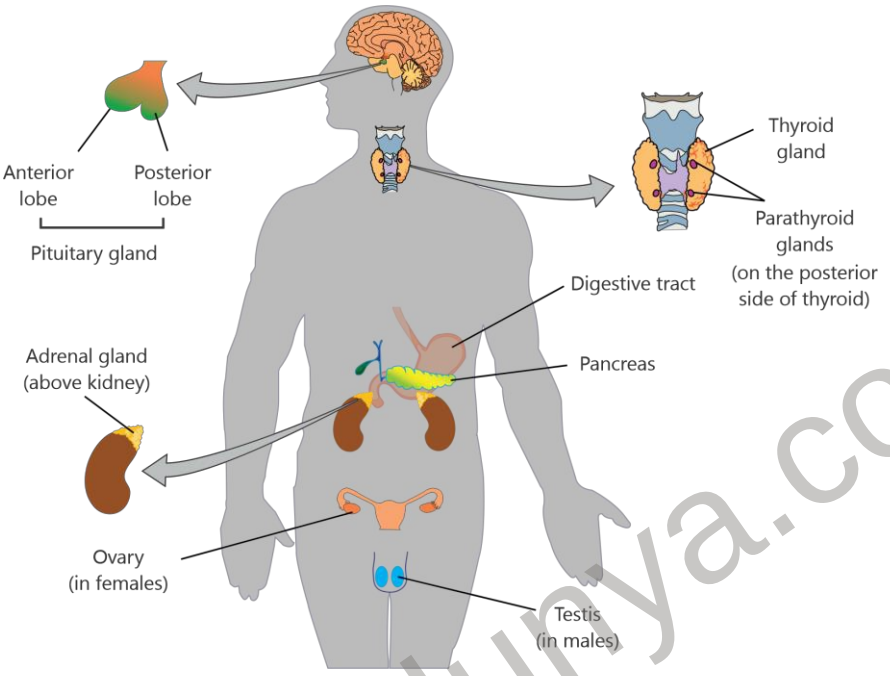

Figure 16.1: Locations of major endocrine glands in human body

16.2.1- Neurosecretory Role of Hypothalamus

Many endocrine glands of the body are controlled by the master gland i.e., pituitary gland. However, the master gland is itself controlled by a part of the brain i.e., hypothalamus. Hypothalamus contains special neurosecretory cells, which not only conduct nerve impulses but also secrete hormones.

Control of Posterior Pituitary

Two hormones i.e., oxytocin and antidiuretic hormone (ADH) are made by neurosecretory cells of hypothalamus. The axons of neurosecretory cells transport oxytocin and ADH to the posterior pituitary, where they are stored for eventual release into blood.

Control of Anterior Pituitary

Blood vessels connect hypothalamus with the anterior pituitary. Neurosecretory cells of hypothalamus secrete hormones that travel to the anterior pituitary through these blood vessels. These hormones are of two kinds

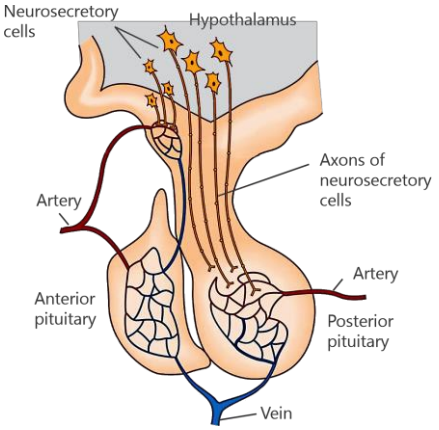

Figure 16.2: Hypothalamus and pituitary

- **Releasing hormones** stimulate the anterior pituitary to make and secrete hormones.
- **Inhibiting hormones** inhibit production and secretion of anterior pituitary hormones.

Table: Hypothalamic hormones and their effect on pituitary gland	
Hormones of hypothalamus	**Effect on Anterior pituitary**
Growth Hormone Releasing-Hormone	Secretion of growth hormone
Somatostatin	Inhibition of growth hormone
Thyrotropin releasing hormone (TRH)	Secretion of thyroid stimulating hormone (TSH)
Adreno-corticotropin releasing hormone	Secretion of adrenocorticotrophic hormone
Prolactin inhibiting factor – which is actually dopamine	Inhibits secretion of prolactin
Gonadotropin releasing hormone	Secretion of FSH and LH

16.2.2- Pituitary Gland

Pituitary gland is attached to hypothalamus by a stalk called **infundibulum**. Pituitary gland is divided into three lobes called the anterior pituitary, posterior pituitary and intermediate / median pituitary.

Anterior Pituitary

Anterior pituitary secretes many hormones, many of which regulate the activity of other endocrine glands.

1. **Growth Hormone** (GH, or somatotropin) stimulates the growth of muscles, bones (indirectly), and other tissues. It is also essential for proper metabolic regulation.
2. **Adrenocorticotropic Hormone** (ACTH, or corticotropin) stimulates the adrenal cortex for the secretion of corticosteroids (cortisone and aldosterone), which regulate glucose and salt homeostasis.
3. **Thyroid-stimulating Hormone** (TSH, or thyrotropin) stimulates the thyroid gland to produce thyroxine, which in turn stimulates oxidative respiration.
4. **Luteinizing Hormone** (LH) In females, it stimulates ovaries to produce progesterone and estrogen hormones. It

Tidbit

Growth Hormone Treatment

GH treatment is given to children have short stature due to GH deficiency. It improves their growth rate.

However, every dwarf person does not have GH deficiency. So, GH therapy may not be appropriate for everyone.

Some people use GH because they believe it will build muscle or slow aging. However, doctors do not support the use of GH for these purposes.

also initiates ovulation. In males, it stimulates testes for testosterone production.

5. **Follicle-stimulating Hormone** (FSH) stimulates the development of ovarian follicles in females. In males, it stimulated the development of sperms. FSH and LH are both referred to as gonadotropins.
6. **Prolactin** stimulates the mammary glands to produce milk. It is produced in both male and female but functions only in female.

Posterior Pituitary

The posterior pituitary contains axons that originate in hypothalamus and extend to posterior pituitary. It does not synthesize any hormone but only stores and releases the hormones made by hypothalamus. The following are the hormones released by posterior pituitary.

1. **Antidiuretic Hormone** (ADH or vasopressin) stimulates water retention by the kidneys.
2. **Oxytocin** stimulates the milk-ejection by stimulating the contraction of smooth muscles of mammary glands. It also stimulates uterine contractions in women during childbirth.

For Information

During embryonic development, posterior pituitary is formed from an outgrowth of neural tissue. That's why, hypothalamus of brain and posterior pituitary remain interconnected by a tract of axons.

For Information

Oxytocin secretion continues after childbirth in breast-feeding mothers. That's why, the uterus of a nursing mother returns to its normal size after pregnancy more quickly than the mothers who do not breast-feed.

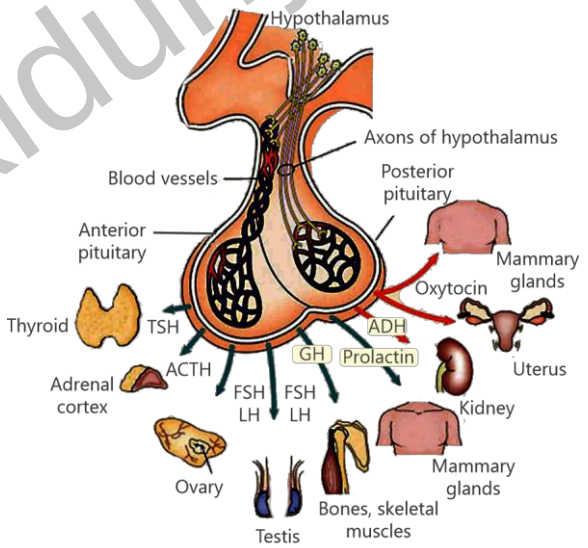

Figure 16.3: Hormones of anterior & posterior pituitary and their target sites

Intermediate Pituitary

In humans, intermediate pituitary is a thin layer of cells between the anterior and posterior pituitary. It produces **melanocyte stimulating hormone** (MSH). MSH stimulates the production and release of melanin by melanocytes in skin and hair.

Imbalance of Pituitary Hormones

1. If there is an over-secretion of growth hormone (GH) in a growing child, it causes **gigantism** i.e., height that is well above average, enlarged hands, feet, and facial features. Over-secretion of GH in adult life causes **acromegaly** in which bones are no longer capable of increasing in length but grow in thickness. Acromegaly is characterised by enlarged hands, feet, skull, nose and jawbone.
2. Deficiency of GH results in **dwarfism** in which development is much slower and individual has short stature. However, the body parts stay in proportion and brain development and IQ are unaffected.
3. Over secretion of TSH causes **hyperthyroidism** i.e., excess of thyroxine and its under secretion causes **hypothyroidism** i.e., lack of thyroxine.
4. Under secretion of ADH causes **diabetes insipidus**. It is characterized by excessive production of dilute urine and frequent thirst. Over secretion of ADH may lead to kidney problems.
5. Over secretion of oxytocin causes rupturing of uterine wall while under secretion of oxytocin inhibits normal labour process.

16.2.3- Thyroid Gland

It is a butterfly-shaped gland located on either side of the trachea in the front of neck. It is composed of two connected lobes. It secretes following hormones;

Tidbit
Thyroid gland is often called the body's "Master Controller of Metabolism" because its hormones dictate how fast or slow every cell in body works.

1. **Tetra-iodothyronine (T_4) or thyroxine and tri-iodothyronine (T_3):** Thyroid produces much more T_4, which eventually converts into T_3, which is the more "active" and powerful. These hormones increase heart rate and breathing rate. They stimulate cellular respiration and set the body's basal metabolic rate. They also enhance glucose catabolism and synthesis of cholesterol in liver. In children, they promote growth of the skeleton and the development of brain.
2. **Calcitonin** hormone: It plays a role in maintaining proper levels of calcium in blood. When the blood calcium concentration rises too high, calcitonin stimulates the absorption of calcium into bones, thus lowering its level in blood.

For Information
Graves' disease is an autoimmune disease that causes hyperthyroidism. It also often results in an enlarged thyroid. Its symptoms include irritability, muscle weakness, sleeping problems, fast heartbeat, poor tolerance of heat, diarrhoea, weight loss, thickening of skin on the shins. Exophthalmia (protrusion of the eyeballs) may also result from Graves' disease.

Imbalance of Thyroid Hormones

1. The deficiency of thyroid hormones (**hypothyroidism)** causes growth retardation, lethargy, weight gain, constipation, high cholesterol, and low heart rate and body temperature.
2. If the hypothyroidism occurs during foetal and childhood development, it causes **cretinism** i.e., a condition of stunted growth and mental retardation.
3. Severe hypothyroidism result in is a rare, life-threatening complication known as **myxoedema**. It is characterized build-up of mucopolysaccharides in the connective tissues, which causes swelling and thickening of the skin and tissues.
4. If hypothyroidism is caused by iodine deficiency, it results in **goitre** i.e., swelling of thyroid gland.
5. Excessive secretion of thyroid hormones **(hyperthyroidism)** causes weight loss; and high blood pressure, heart rate, and body temperature.

16.2.4- Parathyroid Glands

These are four small glands attached to the posterior surface of thyroid gland. Parathyroid glands secrete hormone **parathormone**. When blood calcium level falls, parathormone is released. It stimulates the osteoclasts (bone cells) to dissolve the calcium crystals of bone matrix and release calcium into the blood. It also stimulates the kidneys to reabsorb calcium from the urine. It causes the activation of vitamin D, needed for the absorption of calcium from food in the intestine.

Imbalance of Parathyroid Hormone

Over secretion of parathormone (which may be due to parathyroid gland tumour) results in excessive release of calcium from bones. It leads to bones deformation and soft bones. Blood calcium level elevates (**hypercalcemia**) which depresses nervous system and causes weakness of muscles. Under secretion of parathormone causes **hypocalcaemia**. This increases the excitability of neurons. Also, it can lead to tetany in which muscles remain in contracted state.

16.2.5- Pancreas

Pancreas mostly contains exocrine cells, which produce and secrete pancreatic juice in pancreatic duct. But pancreas also has specialized cells, which function as an endocrine gland. These cells are distributed in the form of patches in the pancreas. These patches are called Islets of Langerhans. Each islet is composed of two types of cells. **Beta (β) cells** are larger in number and they secrete insulin hormone. **Alpha (α) cells** secrete glucagon hormone.

Insulin is one of the most important hormones of human body. It reduces the blood sugar (glucose) level. It is secreted when the level of blood glucose rises. It increases the rate of glucose uptake by body cells (e.g., skeletal muscles and fat cells). It also promotes **glycogenesis** (conversion of glucose to glycogen) in liver, increases the use of glucose in cellular respiration, promotes the conversion of excess glucose to fats and inhibits **gluconeogenesis** (glucose synthesis).

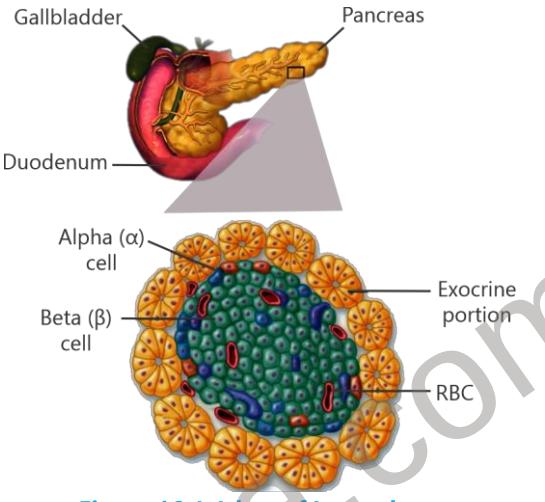

Figure 16.4: Islets of Langerhans (surrounded by exocrine portions)

Glucagon raises the blood glucose level. It is secreted when blood glucose level is below normal. It mainly promotes the hydrolysis of stored glycogen in liver. As a result, glucose is released into blood and can be taken up by cells and used for energy.

Imbalance of Pancreas Hormones

1. The under secretion of insulin leads to **diabetes mellitus (hyper-glycaemia)** in which cells are unable to obtain glucose from blood. It results in above normal blood glucose level. This excess glucose in blood inhibits water reabsorption by the kidneys. So large amounts of urine are produced. It leads to dehydration and kidney damage.
2. The over secretion of insulin results below normal blood glucose level i.e., **hypoglycaemia**. Symptoms of hypoglycaemia include lethargy, dizziness, nervousness, and in extreme cases, unconsciousness.

For Information

In **Type I diabetes** (insulin-dependent diabetes mellitus), the patients lack insulin-secreting β cells. It is generally is treated with daily injections of insulin (because insulin is a peptide hormone, it would be digested if taken orally and must be injected into blood). This injectable insulin is produced by genetically engineered bacteria.

The patients of **Type II diabetes** (non-insulin dependent diabetes mellitus) have normal levels of insulin in their blood, but their cells have a reduced sensitivity to insulin. These patients do not require insulin. They control their diabetes through other medicines, diet and exercise.

16.2.6- Adrenal Glands

One adrenal gland is located just above each kidney. Each gland is composed of an inner portion, the adrenal medulla, and an outer layer, the adrenal cortex.

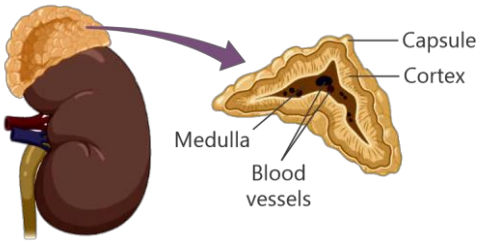

Figure 16.5: Adrenal gland

Adrenal Medulla

The adrenal medulla produces two hormones i.e., **epinephrine** and **norepinephrine** (also known as adrenaline and noradrenaline, respectively). When a person is stressed, the medulla secretes epinephrine and norepinephrine. The hormones prepare the body for "fight or flight". In this response, there is increased heart rate, increased blood pressure, dilation of the bronchioles, elevation in blood glucose, and reduced blood flow to skin and digestive organs.

For Information
Secretion of hormones from adrenal medulla is controlled by nervous system, whereas secretion of hormones from adrenal cortex is controlled by the hormones of anterior pituitary.

Adrenal Cortex

The hormones from adrenal cortex are called **corticosteroids**. These include:

1. **Glucocorticoids** e.g., cortisol and related steroids maintain glucose homeostasis. They stimulate the breakdown of muscle protein into amino acids, which are carried by blood to liver. They also stimulate liver for gluconeogenesis (conversion of amino acids into glucose).
2. **Mineralocorticoids** e.g., aldosterone helps to regulate mineral balance in blood. It stimulates the kidneys to reabsorb sodium from urine. In this way, water is also reabsorbed from urine. Thus, normal blood volume and pressure is maintained. Aldosterone also stimulates the kidneys to secrete the excess of potassium into urine.

Imbalance of Adrenal Gland Hormones

1. Over secretion of hormones of adrenal medulla may cause hypertension and aggressive behaviour during routine life. Under secretion causes failure to combat with emergency situation.
2. Over secretion of cortisol from adrenal cortex causes **Cushing disease**. It occurs when pituitary gland produces too much ACTH, which causes the adrenal glands to produce cortisol in high levels. In Cushing disease there is excessive protein

breakdown. It results in high blood sugar, high blood pressure, thin bones, muscle loss, thin and fragile skin, depression, and too much facial hair (in women).

3. Under secretion of cortisol leads to **Addison's disease**. It is characterized by general metabolic disturbance, weakness of muscles and loss of salts. The symptoms usually happen slowly.

16.2.7- Gonads

Gonads (ovaries in females and testes in males) are gamete-producing organs. They also produce sex hormones under the influence of LH and FSH of anterior pituitary.

Ovaries

Ovaries secrete female sex hormones i.e., estrogen and progesterone.

1. **Estrogen** is secreted by Graafian follicle in response to FSH. Its functions include development of secondary sexual characteristics (e.g., breast development, widening of the pelvis, fat distribution in hips and thighs etc.), regulation of the menstrual cycle, repair of the uterine lining after menstruation, ovulation (release of an egg from ovary), maintenance of bone density, lowering "bad" cholesterol (LDL), maintenance of healthy blood pressure, regulation of mood and memory.

For Information

Puberty is the adolescent stage during which the sex organs mature and secondary sex characteristics appear. During puberty in males, sperm production begins, the voice deepens, the chest broadens, and hair grows on the body and face. In females, the menstrual cycle begins, the breasts grow, and the hips widen.

For Information

Small amounts of estrogen and testosterone are also released by adrenal glands.

A very small amount of testosterone is produced in females.

2. **Progesterone** is produced by corpus luteum in response to LH during menstrual cycle. It is also produced and released from placenta during pregnancy. It inhibits further FSH secretion from pituitary, thus preventing more follicles from ripening. It causes further thickening and vascularisation of the uterus wall for maintaining pregnancy. Progesterone suppresses ovulation.

Testes

LH stimulates the testes to secrete a group of sex hormones called **androgens**. **Testosterone** is an androgen which is secreted by the interstitial cells among seminiferous tubules. It initiates the maturation of male reproductive organs and

appearance of secondary sex characteristics and sex drive. In addition, testosterone is necessary for normal sperm production.

Imbalance of Hormones of Gonads

1. Due to estrogen deficiency in the young females, they fail to mature sexually. Deficiency of estrogen in adults leads to sterility. Its over-secretion may lead to the development of **fibroids** (abnormal growth) in uterus and **polycystic ovaries**.
2. Under secretion of progesterone during menstrual cycle, decreases the chance of pregnancy and may cause early menstruation. Under secretion during pregnancy may leads to the **miscarriage**.
3. Under secretion of testosterone in males causes the development of feminine characteristics and male sterility.

For Information

Artificially Synthesized Steroids

Artificially synthesized steroids, also known as anabolic steroids, have been widely used by athletes to enhance performance in sports. These steroids are synthetic versions of the testosterone. They increase muscle mass, strength, and endurance. However, the use of anabolic steroids in sports is illegal and banned. It can lead to long-term health problems including:

- Anabolic steroids can cause damage to liver, leading to hepatitis and liver tumors.
- They can increase the risk of heart disease, stroke, and blood clots.
- Prolonged use of can disrupt the body's natural hormone balance, leading to infertility, impotence, and breast development in men.
- Their use can also cause mental health issues such as depression, anxiety, and aggressive behaviour.

16.2.8. Other Endocrine Glands/Tissues

There are several other glands in the endocrine system. There are also specialized endocrine cells in brain, stomach, small intestine, liver, and other organs.

1. **Thymus gland** is located beneath the sternum and between the lungs. It secretes **thymosin** hormone that stimulates maturation of T cells, which help defend the body from pathogens.
2. **Pineal gland** is located near the base of brain. It secretes **melatonin** hormone. It regulates sleep patterns.

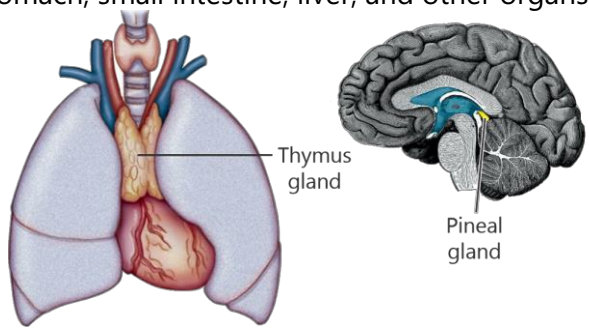

Figure 16.6: Locations of thymus and pineal glands

3. Endocrine cells within the walls of some **digestive organs** also secrete hormones that control digestive processes. For example, when food is eaten, endocrine cells in the stomach walls secrete **gastrin** hormone that stimulates the gastric glands to release gastric juice. Endocrine cells of the small intestine wall release **secretin** hormone that stimulates the pancreas to release pancreatic juice. The small intestine wall also secretes **cholecystokinin** hormone which stimulates gallbladder to release bile.
4. **Kidneys** produce **renin** hormone that controls the production of aldosterone in adrenal glands. Kidneys also produce **erythropoietin** hormone that stimulates bone marrow for the production of RBCs. Another hormone of kidneys, **calcitriol** increases blood calcium level by absorption of calcium from intestines.
5. **Brain** produces hormones called **endorphins**. Endorphins bind to pain receptors and so block sensation of pain.
6. **Prostaglandins** are hormone-like substances that are produced by almost all cells of the body. They are powerful, locally-acting vasodilators and are involved in inflammation.

16.3- Feedback Mechanism in Endocrine System

You have studied the concept of feedback mechanism in homeostasis. Feedback mechanism is the phenomenon in which a controlling mechanism is itself controlled by the product of the process it is controlling. Endocrine system also has feedback mechanisms, which control it. There are two types of feedback mechanism.

1- Positive Feedback

In positive feedback, the product or response made by the controlling system speeds up action of controlling system. An example of positive feedback is release of oxytocin hormone by posterior pituitary. During childbirth when uterus begins to contract, the sensory neurons send signals to hypothalamus. Hypothalamus triggers the release of oxytocin from posterior pituitary.

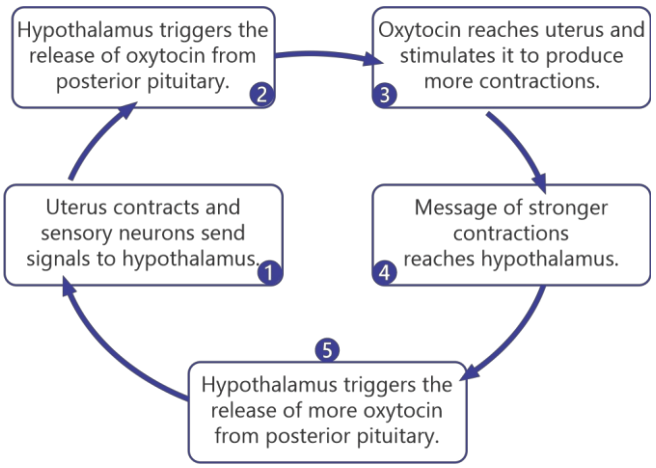

Figure 16.7: Positive feedback of oxytocin

Oxytocin stimulates uterus to produce more and stronger contractions. When hypothalamus receives message of stronger contractions, it triggers the release of more oxytocin. This series of positive feedback continues until the birth of baby.

2- Negative Feedback

In negative feedback, the end product stops the initial step of the process. Negative feedback is common in endocrine system. For example, when blood glucose goes above normal, the beta cells of the islets of Langerhans sense release insulin. Insulin lowers blood glucose by doing different actions. Due to these actions, blood glucose level falls to normal. This result i.e., normal blood glucose level stimulates the beta cells to stop releasing insulin. Similarly, the release of glucagon is also controlled by negative feedback. When blood glucose level goes low, the alpha cells of the islets of Langerhans secrete glucagon. This hormone takes actions to raise blood glucose. Due to these actions, blood glucose level rises to normal. This result i.e., normal blood glucose level stimulates the alpha cells to stop releasing glucagon.

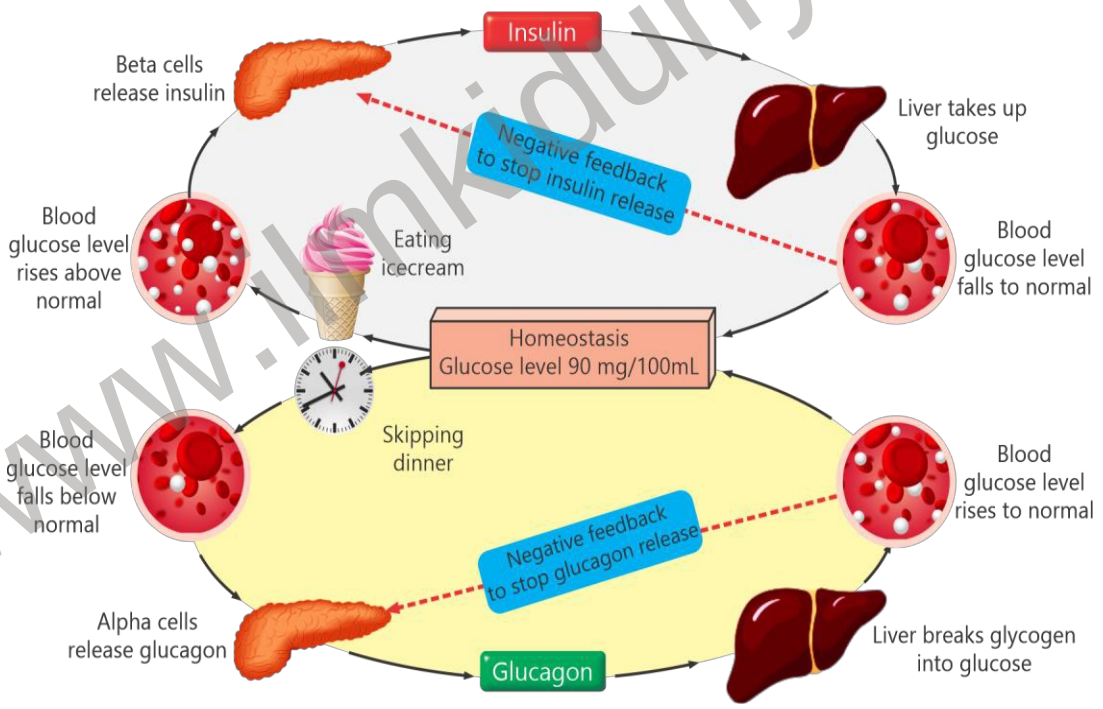

Figure 16.8: Negative feedback of insulin and glucagon

EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. Which of the following pair of hormones has antagonistic (opposing) effects?
   (a) Parathyroid hormone and calcitonin (b) Growth hormone and epinephrine
   (c) Estrogen and progesterone (d) Cortisol and aldosterone
2. Which gland produces hormones that control other endocrine glands?
   (a) Anterior pituitary (b) Posterior pituitary
   (c) Thyroid (d) Intermediate pituitary
3. Which of the following is NOT released by anterior pituitary?
   (a) Prolactin (b) ADH (c) FSH (d) TSH
4. Antidiuretic and oxytocin hormones are produced by
   (a) Anterior pituitary (b) Posterior pituitary
   (c) Intermediate pituitary (d) Hypothalamus
5. Which of the following hormones binds to the receptors located inside the cell?
   (a) FSH (b) Testosterone (c) Insulin (d) Growth hormone
6. Which of the following is a function of a hormone released by the posterior pituitary?
   (a) Maturation of egg and sperm (b) Decrease in calcium levels
   (c) Water retention (d) Increase in thyroid hormone level
7. Which of the following hormones would be expected to increase if you were studying all day for a test and skipped breakfast and lunch?
   (a) Glucagon (b) Insulin (c) Growth hormone (d) Calcitonin
8. Which of the following is both an endocrine and exocrine gland?
   (a) Anterior pituitary (b) Pancreas
   (c) Thyroid (d) Adrenal medulla
9. Which hormone increases basal metabolic rate in the body?
   (a) Thyroxine (b) Parathormone (c) Glucagon (d) Secretin
10. Which of the following is NOT a site of action of insulin?
    (a) Smooth muscles (b) Skeletal muscles
    (c) Adipose tissue (d) Liver

SECTION 2: SHORT QUESTIONS

1. State the role of hormones as chemical messengers.
2. Where are receptors located in amino acid-based hormones and steroid hormones?
3. What are neurosecretory cells?

4. Name the hormones of anterior pituitary gland.
5. Why the pituitary gland is called master gland?
6. How is the secretion of ADH controlled?
7. Write a note on parathyroid glands.
8. Write the names and functions of hormones secreted by ovaries and testes.
9. Differentiate between;
    - Exocrine and endocrine glands
    - Hypothyroidism and hyperthyroidism
    - Parathormone and calcitonin
    - Beta and alpha cells of pancreas
    - Insulin and glucagon
    - Diabetes insipidus and diabetes mellitus
    - Estrogen and progesterone
    - Positive and negative feedback

SECTION 3: LONG QUESTIONS

1. Explain the neurosecretory role of hypothalamus.
2. Describe the chemical nature of hormones.
3. State the names of the hormones secreted by pituitary gland. Write the function of each hormone and state the major abnormalities caused by the imbalance of pituitary hormones.
4. Describe the functions of thyroid hormones. What are major diseases due to their imbalance?
5. Write a detailed note on adrenal glands mentioning the hormones of adrenal context and adrenal medulla and their functions.
6. Write a note on pancreas as an endocrine gland.
7. Describe the functions of the hormones secreted by thymus glans, pineal gland, kidneys, and walls of digestive tract.

INQUISITIVE QUESTIONS

1. State the role of artificially synthesized steroids in sports and their long-term effects on its users.
2. Explain on what grounds some companies claim that growth is possible in people having short heights.