

SECTION 4

ENDOCRINE SYSTEM

ENDOCRINE SYSTEM AND HYPOPHYSIS

1. OVERVIEW OF THE ENDOCRINE SYSTEM

The endocrine system regulates the functioning of all cells, tissues and organs in the body. It consists of a widely distributed group of glands that secrete hormones. Hormones are regulatory chemical substances which circulate in the blood and modify the activity of distant organs. The blood carries the hormones to target organs that can affect growth, reproductive activity and metabolism.

Hormones can be divided into three groups based on their chemical structure:

1) Protein- and polypeptide- derived hormones

The hormones that belong in this group are usually synthesized as prohormones, which are inactive molecules that are converted into active hormones prior to or after their secretion in the blood.

They are divided into two subgroups. The glycoprotein-derived hormones are molecules with a long polypeptide chain of more than 200 amino acids. Examples of such hormones are the follicle-stimulating hormone (FSH), luteinizing hormone (LH), and thyroid-stimulating hormone (TSH) produced by the anterior lobe of the pituitary gland and several others produced in different organs.

Polypeptide-derived hormones are molecules with either a short polypeptide chain, such as the antidiuretic hormone (ADH), oxytocin and insulin, or small proteins, such as growth hormone (hGH) and prolactin (PRL). This subgroup includes all the hormones secreted by the hypothalamus, thymus, pancreas, digestive tract, posterior lobe of the pituitary gland and some hormones secreted by the anterior lobe of the pituitary gland (Figure 14.1).

2) Amino acid-derived hormones

These hormones are small molecules that are structurally derived from the amino acids tyrosine and tryptophan.

Tyrosine-derived hormones are the thyroid hormones thyroxine and triiodothyronine and the hormones secreted by the adrenal medulla such as epinephrine, norepinephrine and dopamine.

The most important tryptophan-derived hormone is melatonin, which is produced by the pineal gland and synchronizes the circadian rhythms of the body (Figure 14.1).

3) Steroid hormones

Steroid hormones are lipids derived from cholesterol. They are secreted, among others, by the male and female reproductive organs or gonads (testosterone by the testes, estrogen and progesterone by the ovaries and placenta), and by the adrenal cortex which secretes cortisol and aldosterone. The steroid hormones are released in the bloodstream, where they bind to transport proteins of the plasma and thus remain in circulation for long periods of time (Figure 14.1).

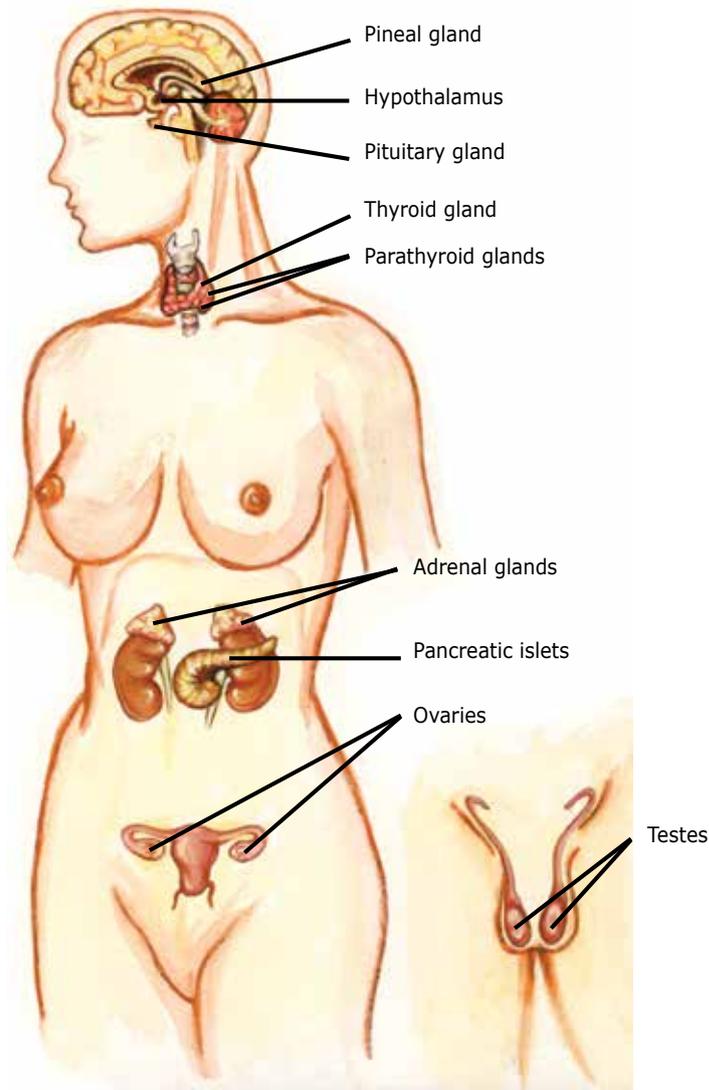


FIGURE 14.1: *Glands of the endocrine system.*

2. PITUITARY GLAND OR HYPOPHYSIS

The pituitary gland or hypophysis is located just below the hypothalamus at the base of the brain. It is a small gland of 1cm in diameter and 0.5-1g in weight. The pituitary stalk connects the pituitary gland to the hypothalamus. This stalk regulates the secretion of pituitary hormones.

Anatomically, the pituitary gland is divided into the anterior lobe or adenohypophysis and the posterior lobe or neurohypophysis.

The anterior lobe has no direct nerve connection to the hypothalamus, but receives blood directly from the hypothalamus via the hypophyseal portal system. The blood perfusion plays a crucial role in regulating the secretion of hormones from the anterior lobe due to the hypothalamic inhibitory and stimulatory hormones that are transferred to the anterior pituitary. These hormones are the thyroid-releasing hormone (TRH), corticotrophin-releasing hormone (CRH), gonadotropin-releasing hormone (GnRH), growth hormone-releasing hormone (GHRH), prolactin-inhibiting hormone (PIH) and somatostatin (Table 14.1).

TABLE 14.1: Abbreviations of Hormones produced in Hypothalamus

Abbreviation	Full Name of Hormone
CRH	Corticotrophin-Releasing Hormone
TRH	Thyrotropin-Releasing Hormone
GHRH	Growth Hormone-Releasing Hormone
GnRH	Gonadotropin-Releasing Hormone
SS	Somatostatin
PIH	Prolactin-Inhibiting Hormone

The posterior lobe consists of nerve fibers and nerve endings of the hypothalamus. It stores two hormones synthesized in the hypothalamus.

Anterior lobe of the pituitary gland:

The anterior pituitary secretes the following hormones: growth hormone (hGH) or somatotropin, thyroid-stimulating hormone (TSH) or thyrotropin, adenocorticotrophic hormone (ACTH) or corticotrophin, follicle-stimulating hormone (FSH) or folliculotropin, luteinizing hormone (LH) or luteotropin, and prolactin (PRL) or mammotropin (Table 14.2).

TABLE 14.2: Hormone Abbreviations

Abbreviation	Full Name of hormone
FSH	Follicle-Stimulating Hormone
LH	Luteinizing Hormone
TSH	Thyroid-Stimulating Hormone
ACTH	Adrenocorticotrophic Hormone
PRL	Prolactin
hGH	Growth Hormone
ADH	Antidiuretic Hormone
OT	Oxytocin
T ₄	Thyroxine
T ₃	Triiodothyronine
PTH	Parathyroid Hormone

Growth hormone (hGH): It promotes the growth of all cells of the body that have the potential to grow. The growth hormone stimulates the increase in size, proliferation and differentiation of cells. It also increases the cellular uptake of amino acids to form proteins, whereas it restricts the use of glucose for energy supply. It also increases the mobilization of fatty acids released from adipose tissue that are used for energy. Growth hormone stimulates the growth of cartilage and bone.

Thyroid-stimulating hormone (TSH): It controls the excretion rate of thyroxine by the thyroid gland. Thus, the role of the thyroid-stimulating hormone is to stimulate the thyroid gland.

Adenocorticotrophic hormone (ACTH): It stimulates the adrenal cortex to produce corticosteroid hormones such as hydrocortisone (cortisol).

Follicle-stimulating hormone (FSH): It controls the growth of gonads and their activity in reproduction. In adults, FSH stimulates the production of gametes, that is the growth of ovarian follicles in females and the production of sperm cells in the testes of males.

Luteinizing hormone (LH): In females, it stimulates the ovulation and promotes the secretion of estrogens and progesterone by the ovaries and placenta in order to prepare the body for possible pregnancy. In males, the luteinizing hormone stimulates the secretion of androgens, such as testosterone, by the Leydig cells in the testes.

Prolactin (PRL): It stimulates mammary gland development and milk production from breasts. It is secreted at low levels in both females and males with the exception of pregnant women and those who are breastfeeding. During pregnancy, prolactin together with estrogen and progesterone stimulate the alveolar and lobular breast development that will start producing milk immediately after birth.

Posterior Lobe of the Pituitary Gland

The posterior lobe of the pituitary gland secretes two hormones, the antidiuretic hormone (ADH) or vasopressin, and oxytocin. These hormones are produced in the hypothalamus which are then transported and stored in the posterior lobe of the pituitary gland.

Antidiuretic hormone (ADH) or vasopressin: This hormone controls the rate of excretion of water via urine and hence contributes to the adjustment of the concentration of water in body fluids. Thus, its main role is to prevent wide fluctuations of water balance in the body. The main target of ADH is the renal tubules where they cause increased quantities of water to be reabsorbed from the urine and restored into the blood (hence reducing urine output and increasing blood volume). A drop in blood pressure also stimulates the secretion of ADH.

Oxytocin: In females, it acts on the smooth muscle cells of the breasts and the uterus, promoting contraction during parturition (childbirth) aiding the extrusion of the fetus and milk production after parturition. In men and women who are not pregnant, oxytocin plays a role in sexual arousal and orgasms.

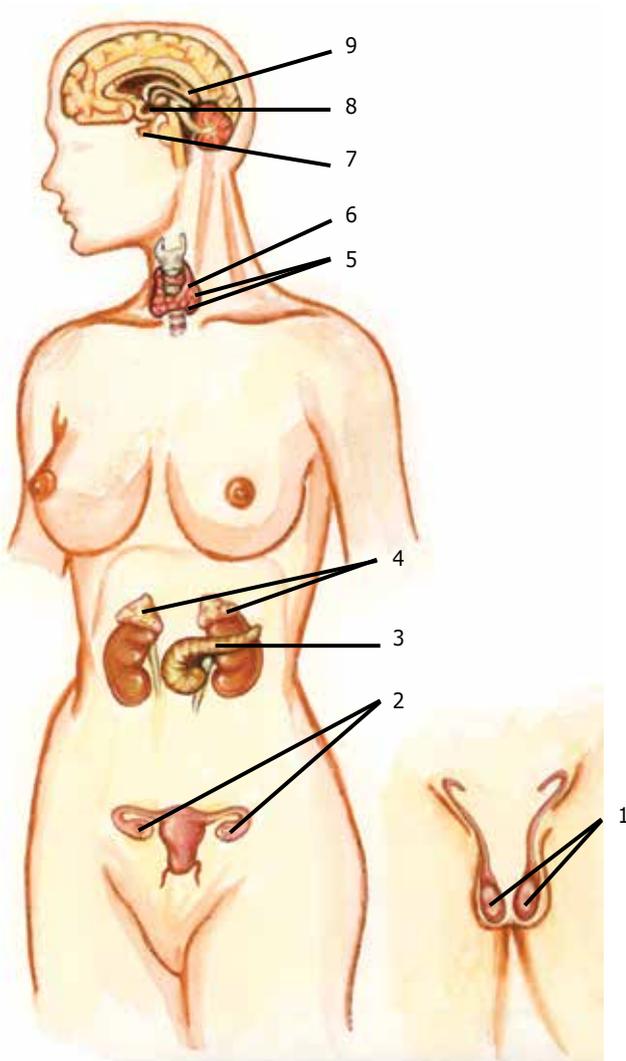
EXERCISES

Exercise 1: Use the terms given below to label the various parts of the endocrine system in the following figure:

Adrenal glands
Pancreatic islets
Thyroid gland

Ovaries
Parathyroid glands
Pituitary gland
(hypophysis)

Testes
Pineal gland
Hypothalamus



- 1)
- 2)
- 3)
- 4)
- 5)
- 6)
- 7)
- 8)
- 9)

Exercise 2: Use the terms given below to fill in the blanks found in the paragraph.

adenohypophysis	antidiuretic	growth hormone
thyroid stimulating hormone	hypothalamus	oxytocin
pituitary gland	breasts	neurohypophysis
vasopressin	pituitary stalk	pituitary portal system
prolactin	axonal transport	thyroid
adrenal cortex	follicle stimulating hormone	corticotropin
luteinizing hormone	gametogenesis	

The and regulate most of the functioning of the endocrine system. The hypothalamus is connected to the pituitary gland via the The pituitary gland consists of two lobes, the anterior pituitary gland or and the posterior pituitary gland or

The posterior lobe of the pituitary gland stores and secretes the hormone known as and These hormones are formed in the hypothalamus and transported by to the posterior pituitary.

The anterior lobe of the pituitary gland is not directly linked to the hypothalamus but is connected to vessels of the The principal hormones secreted by the anterior pituitary gland are 1) the that stimulates the synthesis of thyroid hormone released by the, 2) which stimulates the formation of steroids in the, 3) gonadotropins, known as the and, which promote by the testes and ovaries, 4) which stimulates milk production from the, 5) which stimulates the growth of all cells and bones that can have the potential to grow.

Exercise 3: Match the following terms in Column A with the contextual meanings in Column B:

Column A	Column B
Antidiuretic hormone	Hormone derived from cholesterol
Gonadotrophic releasing hormone	Hormone that stimulates the growth of all cells
Oxytocin	Hormone that promotes the secretion of estrogens and progesterone
Growth hormone	Hormone that stimulates corticosteroid hormones
Thyroid-stimulating hormone	Hormone produced by the ovaries and placenta
Prolactin	Hypothalamic hormone that stimulates LH and FSH
Melatonin	Vasopressin

Steroid hormone	Hormone synchronizing circadian rhythms
Luteinizing hormone	Hormone that promotes milk production from breasts
Adrenocorticotrophic hormone	Hormone that promotes muscle contraction of the uterus
Follicle-stimulating hormone	Hormone that promotes the production of gametes
Progesterone	Hormone that controls thyroxine production

Exercise 4: Match the following terms in Column A with the contextual meanings in Column B:

Column A	Column B
Gonad	The location where a substance attaches itself to cell membrane
Parturition	Human being before it is born
Pituitary gland	Neurohypophysis
Hypothalamus	Specific tissue on which a hormone exerts its action
Fetus	Childbirth
Anterior pituitary gland	Hypophysis
Hypophyseal portal system	It releases stimulatory and inhibitory hormones that affect the anterior pituitary gland
Target tissue	Primary sex organs such as ovaries and testes
Receptor	Direct blood connection between the hypothalamus and anterior pituitary gland
Posterior pituitary gland	Adenohypophysis

Exercise 5: Multiple choice questions.

- 1) Steroid hormones are excreted by the:
 - a) thyroid
 - b) adrenal cortex
 - c) gonads
 - d) b and c are correct
 - e) a and c are correct

- 2) Oxytocin:
 - a) is stored in the posterior pituitary
 - b) is produced by the neurosecretory cells of the hypothalamus
 - c) promotes milk production
 - d) promotes muscle contraction of the uterus during parturition
 - e) all of the above are correct

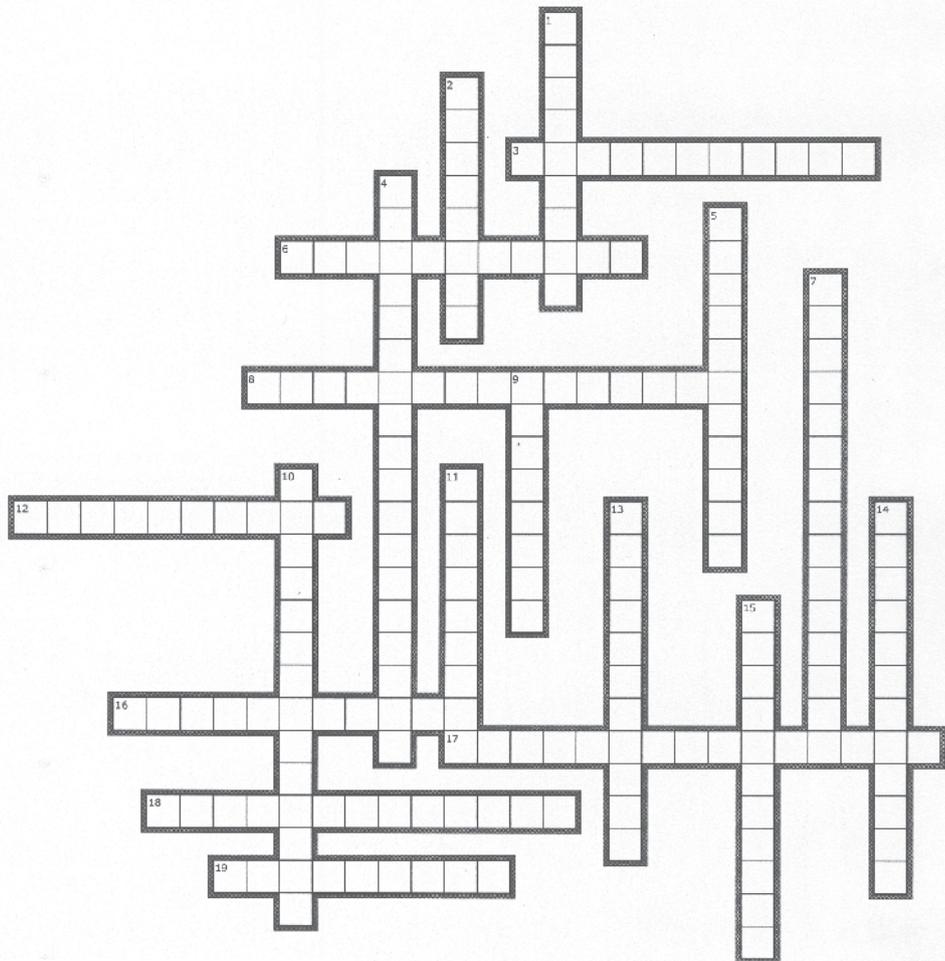
- 3) All the following hormones are derivatives of amino acids except for:
 - a) melatonin
 - b) norepinephrine
 - c) follicle-stimulating hormone
 - d) thyroxine
 - e) triiodothyronine
- 4) The endocrine system:
 - a) regulates the activities of most tissues and organs in the body
 - b) releases chemicals into the blood which are then transported throughout the body
 - c) can alter the reproductive activity of cells
 - d) produces effects that can last for long periods
 - e) all of the above are correct
- 5) The hormone oxytocin is stored and secreted by the:
 - a) neurohypophysis
 - b) adenohypophysis
 - c) hypothalamus
 - d) zona glomerulosa
 - e) zona fasciculata
- 6) The hormone vasopressin is also called:
 - a) oxytocin
 - b) antidiuretic hormone
 - c) prolactin
 - d) oxytocin
 - e) growth hormone
- 7) All the following glands belong to the endocrine system except for:
 - a) thyroid
 - b) parathyroid
 - c) salivary
 - d) adrenal
 - e) pituitary
- 8) All the following chemicals are steroids except for:
 - a) progesterone
 - b) adrenalin
 - c) testosterone
 - d) aldosterone
 - e) cholesterol
- 9) Releasing hormones are synthesized and released by the:
 - a) anterior pituitary

- b) adrenal cortex
 - c) hypothalamus
 - d) posterior pituitary
 - e) thyroid
- 10) Which of the following hormones directly stimulates mitosis?
- a) Corticotropin
 - b) Growth hormone releasing hormone
 - c) Insulin
 - d) Thyroid releasing hormone
 - e) Somatotropin
- 11) Which of the following hormones decreases the production of urine?
- a) Oxytocin
 - b) Vasopressin
 - c) Cortisol
 - d) Thyroxine
 - e) None of the above
- 12) Which of the following hormones is involved in ovulation?
- a) Estrogen
 - b) Follicle-stimulating hormone
 - c) Adrenocorticotrophic hormone
 - d) Prolactin
 - e) Luteinizing hormone
- 13) Melatonin is secreted by the:
- a) pineal gland
 - b) anterior pituitary gland
 - c) thymus
 - d) posterior pituitary gland
 - e) thyroid gland
- 14) Growth hormone functions by stimulating the:
- a) uptake of amino acids to synthesize proteins
 - b) cartilage and bone formation
 - c) mobilization of fatty acids for energy use
 - d) cell division
 - e) all of the above are correct
- 15) The endocrine gland that is responsible for the circadian rhythms in the body is the:
- a) parathyroid
 - b) anterior pituitary
 - c) thyroid

- d) posterior pituitary
- e) pineal

Exercise 6: Complete the following crossword.

Endocrine system



Across

- 3. Hormone that prevents wide fluctuations of water balance in the body
- 6. Hormone that stimulates the ovulation in females
- 8. The anterior lobe of the pituitary gland
- 12. Gland that is located below the hypothalamus
- 16. Another word for childbirth
- 17. It consists of a group of glands that secrete hormones (two words)
- 18. It stimulates the proliferation and differentiation of all cells (two words)
- 19. Tryptophan-derived hormone that is produced by the pineal gland

Down

1. Hormone that stimulates the development of mammary glands
2. Chemical substances that modify the activity of distant organs
4. Hormone that stimulates the adrenal cortex
5. Steroid hormones are derived from this lipid
7. The posterior lobe of the pituitary gland
9. Hormone that promotes muscle contraction of the uterus during parturition
10. Structural feature that connects the pituitary gland to the hypothalamus (two words)
11. Tyrosine-derived hormone that is produced in the thyroid gland
13. Tyrosine-derived hormone that is secreted by the adrenal medulla
14. Steroid hormone that is secreted by the male reproductive organs
15. Steroid hormone that is secreted by the adrenal cortex

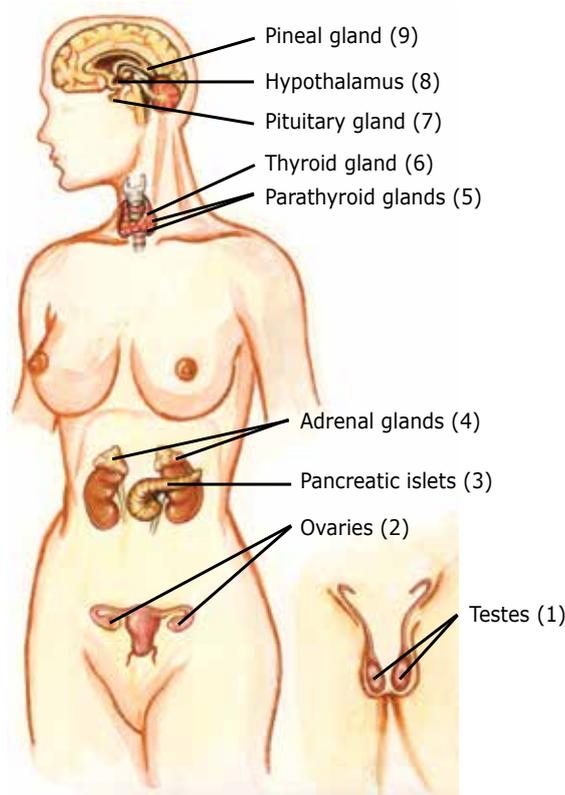
SOLUTIONS TO EXERCISES

Exercise 1: Use the terms given below to label the various parts of the endocrine system in the following figure:

Adrenal glands
Pancreatic islets
Thyroid gland

Ovaries
Parathyroid glands
Pituitary gland
(hypophysis)

Testes
Pineal gland
Hypothalamus



Exercise 2: Use the terms given below to fill in the blanks found in the paragraph.

adenohypophysis
thyroid stimulating hormone
pituitary gland
vasopressin
prolactin
adrenal cortex
luteinizing hormone

antidiuretic
hypothalamus
breasts
pituitary stalk
axonal transport
follicle stimulating hormone
gametogenesis

growth hormone
oxytocin
neurohypophysis
pituitary portal system
thyroid
corticotropin