CHAPTER 11
ENDOCRINE GLANDS: SECRETION AND ACTION OF HORMONES

CHAPTER SCOPE

The last few chapters explored the nervous system and its complex anatomical connections using a variety of neurotransmitter chemicals to link body processes to a high-speed intertissue communications network. This chapter will study another, albeit slower, communication system that employs chemical messengers such as **hormones** that travel in the circulating bloodstream to unique target cells throughout the body. Target cells contain specific receptor proteins that await the hormone's arrival. Binding occurs and the formation of the hormone-receptor complex initiates a series of activities that act in concert with the nervous system to maintain overall body homeostasis.

You may recall from anatomy that tissues that secrete hormones are derived from specialized epithelium, known as *glandular* epithelium. During embryonic growth, glandular epithelium directs the formation of both **exocrine** (with ducts) and **endocrine** (without ducts) glands in various regions of the body. Also during this time, target cells are beginning to synthesize their own hormone-specific receptor molecules so that once hormones are released and circulated, these targets can be located and the hormonal messages can be delivered.

Steroid hormones and *thyroxine* (from the thyroid gland) are lipid-soluble (or lipophilic, "fat-loving") and can diffuse through the plasma membranes to bind with receptor molecules inside the cell. These hormones ultimately influence DNA in the target cell nucleus. *Protein* hormones, by contrast, and other related polar signal molecules cannot penetrate the phospholipid portion of plasma membranes. Upon arrival at the target cell, protein hormones must dock to specific receptor molecules that are exposed to the cell's exterior. Recognition and binding of the hormone at the membrane thereby activates **second messenger** molecules inside the target cells that initiate the proper hormone responses. Adenylate cyclase-cyclic AMP, phospholipase C-Ca^{2+}, and tyrosine kinase are second messenger systems for selected hormones that will be described in this chapter. Not surprisingly, the secretion of hormones and the responses of the target cells are largely controlled by complex negative feedback mechanisms and also by neurotransmitters of the nervous system.

The latter part of the chapter presents a guided tour of many endocrine glands of the body with descriptions of the hormones involved and their primary effects on the target cells. Starting with the *pituitary gland* and its complex interactions with the adjoining *hypothalamus*, the chapter moves on to the *adrenal gland* (both cortex and medulla), the *thyroid, parathyroids, pancreas, pineal, thymus, gastrointestinal* (GI) *tract, gonads,* and the *placenta.* Many of these glands and hormones will be studied in more detail later in this text with presentation of their corresponding organ systems.

The discussion of endocrine glands would not be complete without introducing the interesting chemical nature and fascinating physiological roles of important autocrine and paracrine regulator molecules. Included in this category are such molecules as prostaglandins, growth factors, nitric oxide, and neurotrophins, among others. Perhaps the most well known are the **prostaglandins**, whose synthesis and actions are described in detail.

I. ENDOCRINE GLANDS AND HORMONES

Hormones are regulatory molecules secreted into the blood by endocrine glands. Chemical categories of hormones include steroids, amines, polypeptides, and glycoproteins. Interactions between the various hormones produce effects that may be synergistic, permissive, or antagonistic.

A. Multiple Choice

___ 1. All hormones can be grouped into the following general chemical categories, *except*
   a. catecholamines (epinephrine and norepinephrine).
   b. polypeptides and glycoproteins.
   c. nucleic acids.
   d. steroids.

___ 2. The steroid hormones
   a. are derived from cholesterol.
   b. are lipid molecules.
   c. are not water-soluble.
   d. include the sex hormones and corticosteroids.
   e. All of these describe steroid hormones.

___ 3. The hormones that contain the element *iodine* are
   a. triiodothyronine (T_3) and tetraiodothyronine (T_4).
   b. catecholamines (epinephrine and norepinephrine).
   c. sex steroids.
   d. corticosteroids.
   e. glycoproteins.

___ 4. Which of the following is *not* required for a particular chemical, such as a neurotransmitter or hormone to function as a physiological regulator in the body?
   a. target cells with specific receptor proteins to which that chemical must bind
   b. the chemical must open specific ion channels for the rapid diffusion of ions to occur
   c. the chemical-receptor combination must cause a specific sequence of changes in the target cells
   d. there must be a mechanism for quickly turning off the action of the chemical

___ 5. Polypeptide hormones called *prohormones*
   a. are often derived from prehormones.
   b. include proinsulin from the endocrine beta cells of the pancreas.
   c. are usually less active "parent" or precursor molecules.
   d. are usually longer-chained molecules than those of the active hormone.
   e. All of these statements about prohormones are correct.

___ 6. Which of the following statements does *not* describe the *synergistic* effects of hormones?
   a. two or more hormones working together to produce a particular result
   b. effects that may be additive or complementary
   c. enhancing the activity of a second hormone at a target cell
   d. the action of epinephrine and norepinephrine on the heart rate

___ 7. The interaction between which of the following hormone pairs is *not* an example of the *permissive* effect of a first hormone for a second hormone?
   a. estrogen for prolactin on the mammary glands
   b. parathyroid hormone (PTH) for vitamin D_3 on blood Ca^{2+} levels
   c. estrogen for progesterone on the uterus
   d. All of these hormone pairs display permissive effects.

___ 8. The half-life period of most hormones ranges from
   a. seconds to minutes.
   b. minutes to hours.
   c. hours to days.
   d. days to weeks.
   e. weeks to months.

___ 9. Pulsatile (discontinuous) secretion of hormones
   a. describes how many polypeptide and glycoprotein hormones are released.
   b. is needed to prevent desensitization of target cells.
   c. includes the release of GnRH and LH as examples.
   d. All of these statements describe pulsatile secretion.

B. True or False/Edit

___ 10. A list of endocrine glands should include the heart, liver, hypothalamus, kidneys, and adipose tissue.

___ 11. Although these hormones are *not* steroids, T_3 and T_4 are small and nonpolar; and thus can be taken orally without being inactivated by enzymes in the digestive tract.

___ 12. In most respects, the actions of neurotransmitters and hormones on their respective target cells are distinctly different.

___ 13. After stimulation of their target receptors, hormones do not generally remain in the area and accumulate in the blood.

___ 14. To help excrete "old" steroid hormones in urine and in bile, the liver must first convert them into more polar, water-soluble metabolites.
___ 15. A "pharmacological" dose is one that results in an abnormally high concentration of a substance; more than would normally be present in the bloodstream.
___ 16. The priming effect of hormones may actually decrease the number of receptor proteins in their target cells, thereby causing a phenomenon called downregulation.

II. MECHANISMS OF HORMONE ACTION

Each hormone exerts its characteristic effects on target organs by acting on the cells of these organs. Hormones of the same chemical class have similar mechanisms of action. Lipid-soluble hormones pass through the target cell's plasma membrane, bind to intracellular receptor proteins, and act directly within the target cell. Polar hormones do not enter the target cells, but instead bind to receptors on the plasma membrane. This results in the activation of intracellular second-messenger systems that mediate the actions of the hormone.

A. Multiple Choice

For questions 17-19, select the correct ***location*** (a, b, or c) for *hormone receptor proteins*.

a. within the nucleus of the target cell
b. within the cytoplasm of the target cell
c. on the outer surface of the target plasma membrane

___ 17. The receptors for most steroid hormones are found here.
___ 18. The receptors for thyroid hormones are found here.
___ 19. The receptors for catecholamine and polypeptide hormones are found here.
___ 20. Which statement about thyroxine is *false*?
a. It is the major hormone secreted by the thyroid gland; and also known as triiodothyronine, or T_3.
b. About 99.96% of thyroxine is attached to carrier proteins in the plasma and the rest is free or unbound.
c. Its carrier protein in the blood is named thyroxine-binding globulin (TBG) with a high affinity for thyroxine.
d. It is *not* the active thyroid hormone within the target cells.

For questions 21-23, select the *intracellular enzyme* involved with second messengers, to its best description.

a. protein kinase
b. phosphodiesterase
c. adenylate cyclase

___ 21. The membrane enzyme that is activated by G-protein subunits to catalyze the synthesis of cAMP as the second messenger of target cells.
___ 22. The normally inactive enzyme that is activated by newly formed cAMP - acting to stimulate the phosphorylation of proteins.
___ 23. The enzyme that inactivates the second messenger cAMP by hydrolyzing it into useless fragments.
___ 24. Which of the following does *not* describe *calmodulin*?
a. It is a protein found in the cytoplasm of specific target cells.
b. It activates transcription and directs the formation of new proteins in the target cells.
c. It is activated by Ca^{2+} entering the cytoplasm from the endoplasmic reticulum or from outside the cell.
d. It activates specific protein kinase enzymes that phosphorylate other proteins to affect target cell activity.
e. It is activated by the hormone insulin in adipose cells to direct the synthesis of fat.

B. True or False/Edit

___ 25. Hormones are delivered by the circulation of blood to every cell in the body but only the target cells with receptor proteins specifically able to bind to that hormone are able to respond.
___ 26. Hormones bind to receptor proteins with high capacity (receptors per target cell) and low affinity (bond strength).
___ 27. Because they are polar and thus water-soluble, most steroid and thyroid hormones are transported in the blood stream bound to large plasma carrier proteins.
___ 28. Using classic *genomic action*, most steroid hormones attach to receptor proteins located either in the cytoplasm or within the nucleus of target cells and thereby direct the production of specific new proteins through genetic transcription and translation.

___ 29. Each nuclear hormone receptor molecule has a DNA-binding region or domain that must bind to a hormone-response element on the DNA molecule before the hormone response can occur.
___ 30. Research in molecular biology has identified approximately seventy different nuclear receptors, with about half of these known as *orphan receptors*.
___ 31. The receptors for all lipophilic steroid and thyroid hormones are located in the cytoplasm and from there are translocated into the nucleus for expression of the hormone ligand.
___ 32. Unlike the nonsteroid hormone receptors, the nuclear receptors in the steroid family bind to DNA as heterodimers rather than as homodimers.
___ 33. Cyclic AMP activates previously inactive protein kinase enzymes to modulate the activity of other enzymes already present in the target cell.
___ 34. Caffeine (in coffee) and theophylline (in tea) act as phosphodiesterase inhibitors that produce their effects by raising the cAMP concentrations within target tissue cells.
___ 35. The regulatory molecule nitric oxide (NO) can relax the smooth muscle of blood vessels by stimulating the production of the second messenger, cyclic guanosine monophosphate (cGMP).
___ 36. Calcium ions (Ca^{2+}) may act as second messengers inside the cell where active transport membrane pumps maintain very high intracellular calcium ion concentrations.
___ 37. Two different hormones can act on the same target cell, in which one activates cAMP production as a second messenger while the other activates the phospholipase C-IP_3-Ca^{2+}-calmodulin system.
___ 38. In the case of insulin and the many kinds of growth factors, the receptor protein is located in the plasma membrane and is itself a kind of enzyme known as *tyrosine kinase*.
___ 39. Tyrosine kinase is both a receptor and an enzyme that adds a phosphate group to proteins and can thereby initiate a hormone response.
___ 40. The synthesis of glycogen from glucose (glycogenesis) in liver cells is stimulated by cAMP second messengers whereas the opposite—the breakdown of glycogen and secretion of glucose (glycogenolysis)—is mediated by tyrosine kinase second messengers.

III. PITUITARY GLAND

The pituitary gland includes the anterior pituitary and the posterior pituitary. The posterior pituitary stores and releases hormones that are actually produced by the hypothalamus, whereas the anterior pituitary produces and secretes its own hormones. The anterior pituitary, however, is regulated by hormones secreted by the hypothalamus, as well as by feedback from the target gland hormones.

A. Multiple Choice

___ 41. Which of the following is *not* considered part of the *adenohypophysis*, or anterior pituitary gland?
a. pars distalis
b. pars nervosa
c. pars tuberalis
d. pars intermedia
e. All of these are parts of the anterior pituitary.

___ 42. The pituitary hormone associated with dwarfism, gigantism, pituitary cachexia, and acromegaly is
a. FSH.
b. GH.
c. ACTH.
d. TSH.
e. LH.

___ 43. The supraoptic nuclei and paraventricular nuclei are clusters of neuron cell bodies located in the hypothalamus, responsible for secreting the hormones
a. LH and FSH.
b. GH and ACTH.
c. TSH and prolactin.
d. oxytocin and ADH.

___ 44. Which of the following is *not* a feature characteristic of the anterior pituitary?
a. It synthesizes and releases tropic hormones that can regulate other endocrine glands.
b. It is controlled by releasing and inhibiting hormones from the hypothalamus.
c. It serves as part of the hypothalamo-hypophyseal tract.
d. Its hormones may influence other endocrine glands.

___ 45. The two inhibiting hormones from the hypothalamus are
a. GnRH and PIH.
b. TRH and CRH.
c. GnRH and GRH.
d. PIH and somatostatin.
e. None of these are hypothalamic inhibiting hormones.

___ 46. A rare classic *positive* feedback effect is demonstrated by
a. increased TSH production during goiter.
b. increased estradiol, causing the LH "surge" in females.
c. increased GnRH and FSH following castration in males.
d. increased ACTH, causing increased cortisol secretion.

B. True or False/Edit

___ 47. The anterior pituitary develops as a downgrowth of the brain (hypothalamus), while the posterior pituitary is derived from embryonic epithelium (Rathke's pouch).

___ 48. The anterior lobe of the pituitary is more a storage organ for hormones rather than a true gland.

___ 49. The hypothalamus rather than the anterior pituitary may be considered the true "master gland" in the body.

___ 50. Anterior pituitary secretion of ACTH, TSH, and the gonadotropins (FSH and LH) is controlled by *negative feedback loops* from hormones produced and released by their target cells.

___ 51. Toward the middle of the female menstrual cycle, rising levels of estradiol cause a temporary "surge" in the blood levels of LH that results in ovulation – a unique example of *positive feedback control* of target gland secretion.

___ 52. The synchronization of female menstrual cycles (the "dormitory effect") and circadian rhythms are good examples of the influence of higher brain centers on the anterior pituitary-adrenal regulation of hormone secretions.

C. Label the Figure — Anterior Pituitary Hormones

Study the following figure and label the *structures* and the *hormones* indicated by the blank lines. Check your work *after* you finish by comparing your answers to those in figure 11.14 in your text.

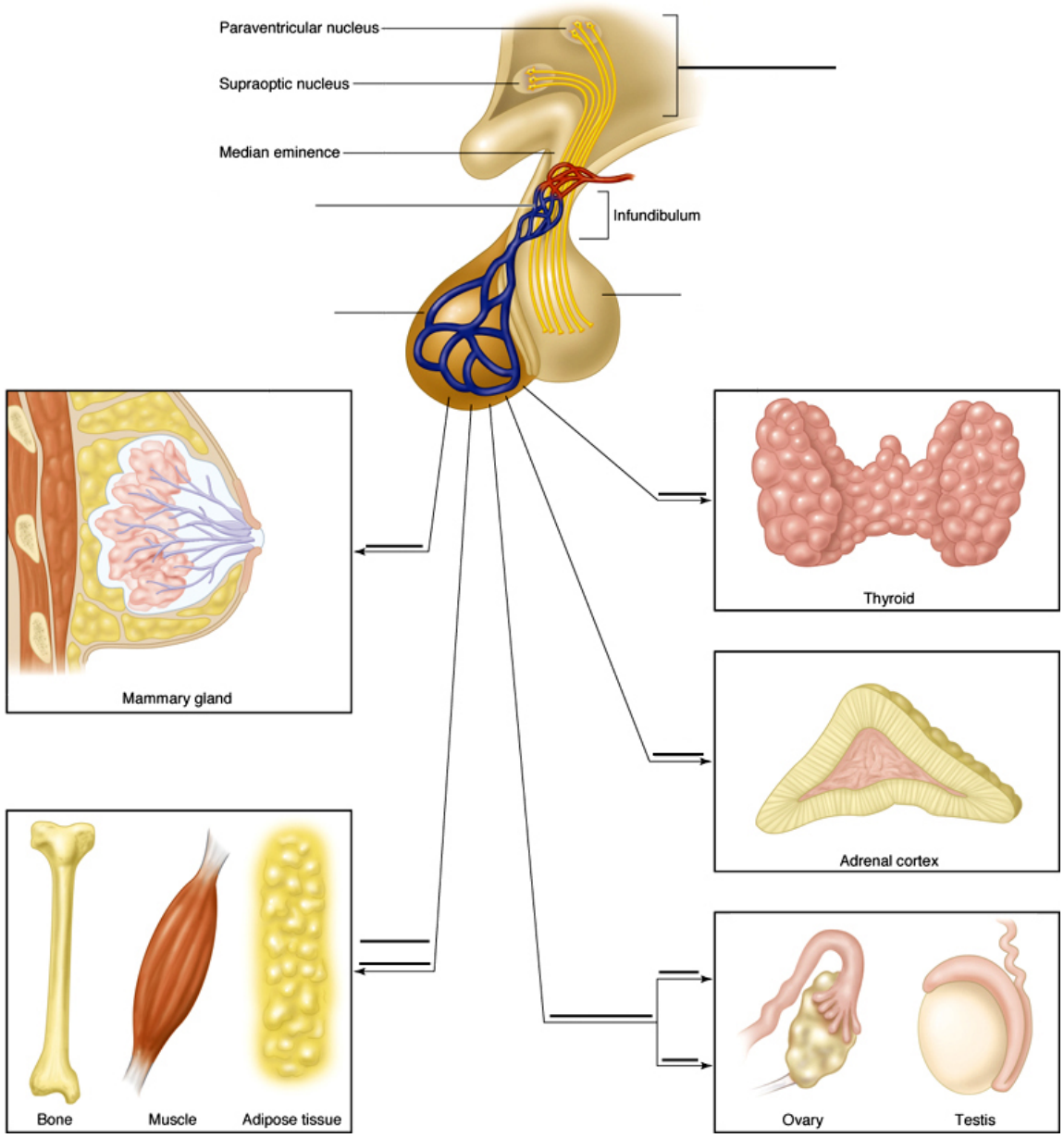

Figure 11.1 Anterior pituitary.

IV. ADRENAL GLANDS

The adrenal cortex and adrenal medulla are structurally and functionally different. The adrenal medulla secretes catecholamine hormones, which complement the sympathetic nervous system in the "fight-or-flight" reaction. The adrenal cortex secretes steroid hormones that participate in the regulation of mineral and energy balance.

A. Multiple Choice

___ 53. Which of the statements about the adrenal *cortex* is *false*?
a. It is derived from mesoderm tissue in the embryo.
b. It can be stimulated by the hormone ACTH (secreted by the anterior pituitary gland).
c. It secretes catecholamine hormones — mostly epinephrine.
d. It is divided into three zones — an outer, middle, and inner — that appear to have different functions.
e. All of these statements about the adrenal cortex are true.

___ 54. Which of the following hormones are *not* secreted by the adrenal *cortex*?
a. aldosterone and other mineralocorticoids
b. sex steroids: weak androgens and some estrogens
c. hydrocortisone and other glucocorticoids
d. epinephrine and some norepinephrine catecholamines
e. All of these are secreted by the adrenal cortex.

___ 55. Which statement about the hormone aldosterone is *false*?
a. It is the most potent adrenal glucocorticoid hormone.
b. It is secreted by the zona glomerulosa region of the adrenal cortex.
c. Its secretion is controlled by alterations in blood volume and electrolyte balance.
d. Its lack in Addison's disease may lead to electrolyte imbalance, dehydration, and death, if not treated.
e. All of these statements about aldosterone are true.

___ 56. Hans Selye's general adaptation syndrome (GAS) does *not* include
a. exhaustion, sickness, or death if adaptations or corrective changes aren't made.
b. activation of the pituitary-adrenal axis causing an initial alarm reaction.
c. the formation of a tumor of the adrenal medulla (pheochromocytoma) that secretes large amounts of epinephrine and norepinephrine.
d. a stage of resistance or readjustment to the demands of the stressors.

___ 57. Which function of glucocorticoids (such as hydrocortisone), is best related to the suggestion that prolonged stress results in an increased incidence of cancer and other diseases?
a. They stimulate an increase in heart rate and in cardiac output.
b. They cause generalized vasoconstriction that elevates blood pressure.
c. They stimulate the secretion of aldosterone hormones that regulates blood volume and electrolyte balance
d. They can inhibit the ability of the immune system to protect against disease
e. All of these statements regarding glucocorticoid function are true.

B. True or False/Edit

___ 58. The adrenal medulla is derived from embryonic mesoderm, whereas the adrenal cortex is derived from embryonic ectoderm (neural) tissue.

___ 59. The three functional categories of steroid hormones secreted by the adrenal cortex are the sex steroids, the glucocorticoids, and the mineralocorticoids.

___ 60. The anatomy of the adrenal medulla reveals three distinct zones that contain cells responsible for the synthesis of specific hormones.

___ 61. Cortisol (hydrocortisone) in humans is the predominant glucocorticoid hormone secreted by the adrenal cortex.

___ 62. Glucocorticoids are often taken as pills, injections, sprays, and topical creams to suppress the immune response (asthma) and to inhibit inflammation (arthritis).

___ 63. Former President John F. Kennedy had a condition called Cushing's syndrome that he kept well controlled by taking prescribed corticosteroids.

___ 64. The adrenal medulla receives stimulation from preganglionic sympathetic axons resulting in the release of epinephrine and norepinephrine hormones during "fight or flight" responses.

___ 65. Under stressful conditions, there is increased secretion of ACTH and, thus, increased secretion of adrenal corticosteroids.

___ 66. Many pleasant life changes such as marriage, graduation, or job promotion can be forms of "stress" — activating the pituitary-adrenal axis and causing an increase in the secretions of ACTH and corticosteroids.

___ 67. Hormones secreted from the adrenal medulla are expected to increase cardiac rate and cardiac output, respiratory rate, and other major functions.

___ 68. *Pheochromocytoma* is a tumor of the adrenal cortex, releasing large quantities of epinephrine and norepinephrine.

___ 69. People under chronic stress release higher levels of cortisol that not only increases their risk of illness but also appears to shrink memory areas of the brain (hippocampus) and may contribute to anxiety and depression.

V. THYROID AND PARATHYROID GLANDS

The thyroid secretes thyroxine (T_4) and triiodothyronine (T_3), which are needed for proper growth and development and which are primarily responsible for determining the basal metabolic rate (BMR). The parathyroid glands secrete parathyroid hormone, which helps to raise the blood Ca^{2+} concentration.

A. Multiple Choice

___ 70. Which statement about thyroid hormones is *false*?
   a. Thyroxine is synthesized by simple cuboidal epithelial cells called follicular cells.
   b. The name, thyroxine, includes both the hormones T_4 and T_3.
   c. *Calcitonin* is a hormone produced by parafollicular cells located outside and between follicles.
   d. Thyroxine is ultimately formed from the precursor amino acid called tyrosine.
   e. Thyroxine is vital for normal central nervous system development and regulation of energy utilization by the body.

___ 71. The abnormal growth of the thyroid gland, called *goiter*, is
   a. caused by the over secretion of thyroxine.
   b. caused by abnormally high levels of TSH secretion.
   c. successfully treated with radioactively labeled iodine.
   d. caused by abnormally low levels of TRH secretion.

___ 72. Which statement about the parathyroid glands is *false*?
   a. They usually include four small, paired glands.
   b. They are embedded in the posterior surfaces of the lateral lobes of the thyroid gland.
   c. They secrete only one hormone called parathyroid hormone (PTH).
   d. PTH acts on tissues such as bone, kidney, and intestines to raise the levels of calcium in the blood.
   e. All of these statements regarding parathyroid glands are true.

B. True or False/Edit

___ 73. The thyroid is the largest of the endocrine glands, weighing between 20 and 25 grams.

___ 74. **Basal metabolic rate** (BMR) can be defined as the minimum number of calories burned or expended by the body each hour just to stay alive.

___ 75. Blood concentrations of calcium are lowered by the hormone calcitonin (thyrocalcitonin) secreted from parafollicular cells of the thyroid gland.

___ 76. The nutrient required in the diet for the normal synthesis of the hormone thyroxine is iron.

___ 77. One of the hallmark features of people suffering from hyperthyroidism is their intolerance to cold.

___ 78. Undersecretion of thyroxine (hypothyroidism) in infants results in *myxedema*, whereas hypothyroidism in adults causes *cretinism*.

___ 79. *Graves' disease*, or toxic goiter, is an autoimmune disease in which antibodies are made that function like TSH, resulting in over stimulation of the thyroid gland.

___ 80. The parafollicular cells of the thyroid gland secrete the hormone calcitonin.

___ 81. There are usually four parathyroid glands embedded in the posterior surfaces of the lateral lobes of the thyroid gland.

VI. PANCREAS AND OTHER ENDOCRINE GLANDS

The pancreatic islets secrete two hormones, insulin and glucagon. Insulin promotes the lowering of blood glucose and the storage of energy in the form of glycogen and fat. Glucagon has antagonistic effects that act to raise the blood glucose concentration. Additionally, many other organs secrete hormones that help regulate digestion, metabolism, growth, immune function, and reproduction.

A. Multiple Choice

___ 82. Which statement about *glucagon* is *false*?
   a. It is a hormone secreted by the alpha cells within the islets of Langerhans of the pancreas.
   b. It is a hormone that is secreted when blood glucose levels are low.
   c. As a hormone it stimulates both glycogen breakdown (glycogenolysis) and fat breakdown (lipolysis.)
   d. It is a hormone that is secreted during times of fasting (not eating).
   e. All of these statements regarding glucagon are true.

___ 83. Which statement about *diabetes mellitus* is *false*?
a. It is characterized by fasting hyperglycemia and the presence of glucose in the urine.
b. Type I, or insulin-dependent diabetes is the more common form.
c. Type II, or non-insulin-dependent diabetes is caused by decreased tissue sensitivity to insulin so that more is required for normal effect.
d. Type I diabetes is caused by the destruction of beta cells that produce insulin.
e. Both types of diabetes mellitus are associated with abnormally high levels of glucagon secretion from the alpha cells of the islets of Langerhans.

___ 84. The hormone, *insulin*
a. is secreted by the alpha cells of the pancreas.
b. promotes the entry of glucose and amino acids into tissue cells.
c. promotes the breakdown of glycogen (glycogenolysis) and fat (lipolysis).
d. levels fall immediately after a meal is eaten.

___ 85. Which statement about *melatonin* is *false*?
a. It is secreted by the pineal gland, a small, cone-shaped gland located in the roof of the third ventricle.
b. Its secretion is highest in children aged one to seven years and decreases thereafter.
c. It may have an important role in the onset of puberty.
d. More melatonin is secreted in the daytime than at night.

___ 86. Which statement about the *testes* is *false*?
a. The seminiferous tubules produce sperm, the male gamete.
b. The interstitial tissue (Leydig) cells secrete the primary androgen, testosterone.
c. Testosterone is needed for the development of the male sex accessory organs, that include the prostate, seminal vesicles, epididymis, and ductus deferens.
d. Testosterone is required for the development of male secondary sexual characteristics.
e. All of these statements regarding the testes are true.

___ 87. During the menstrual cycle in females
a. the hormone, progesterone is secreted by ovarian follicles.
b. many follicles within the ovary will undergo ovulation each month.
c. luteinizing hormone converts the empty follicle into a corpus luteum, which secretes progesterone and estradiol.
d. that critical event, ovulation, occurs near the end of the cycle.

___ 88. Which hormone is *not* secreted by the endocrine tissues of the human placenta?
a. prolactin
b. estrogens
c. progesterone
d. human chorionic gonadotropin (hCG)
e. somatomammotropin

B. True or False/Edit

___ 89. After a meal, glucagon secretion is increased and insulin secretion is decreased – an example of antagonistic action between these two hormones.

___ 90. The pineal gland is both an endocrine and an exocrine gland.

___ 91. After the age of seven, the pineal gland begins to shrink and in an adult appears as a thickened strand of fibrous tissue.

___ 92. During the daytime, light stimulates the release of a newly found pigment in the retina called *melanopsin* that activates neurons to the suprachiasmatic nucleus (SCN) of the hypothalamus that in turn reduces sympathetic stimulation of the pineal gland and thereby reduces melatonin secretion.

___ 93. The hormone melatonin may inhibit the pituitary-gonad axis in some species, and perhaps, be associated with a delay in the onset of reproductive maturity.

___ 94. After puberty, the thymus gland continues to shrink in size and reduce its secretions.

___ 95. The thymus gland serves as the site for production of B-type lymphocytes (B cells) that are involved in cell-mediated immunity.

___ 96. Both the stomach and small intestine secrete a number of hormones that act both locally on the gastrointestinal tract itself and remotely on tissues of the pancreas and gallbladder.

___ 97. *Somatomammotropin* is a hormone secreted by the placenta that is similar in its action to both growth hormone and prolactin.

VII. AUTOCRINE AND PARACRINE REGULATION

Many regulatory molecules produced throughout the body act within the organs that produce them. These molecules may regulate different cells within one tissue, or they may be produced within one tissue and regulate a different tissue within the same organ.

A. Multiple Choice

___ 98. Which of the following autocrine and paracrine regulators are produced by lymphocytes (WBC) and are involved in *specific immunity*?
  a. nitric oxide
  b. endothelins
  c. neurotrophins
  d. bradykinins
  e. cytokines (interleukins)

___ 99. Which statement about *prostaglandins* is *false*?
  a. They are twenty-carbon fatty acids with a five-membered carbon ring.
  b. They are derived from arachidonic acid molecules that are released from phospholipids located in the plasma membrane.
  c. They are later converted into leukotrienes.
  d. They are made by the enzyme cyclo-oxygenase, and others.

___ 100. Prostaglandins
  a. are produced by very specific tissues in the body.
  b. are involved in only a few, very specific, regulatory functions.
  c. may function specifically as vasoconstrictors while others may function specifically as vasodilators.
  d. always produce the same effects, even when acting on different tissues of the body.

___ 101. Which of the following regulatory function does *not* involve prostaglandins?
  a. pain and fever control during the inflammatory response
  b. growth and development of skeletal muscles and long bones
  c. regulation of stomach secretions, intestinal motility, and fluid absorption in the gastrointestinal tract
  d. regulation of blood flow in the kidney and thus, some control of urine volume and content
  e. bronchiole dilation and constriction

B. True or False/Edit

___ 102. The major regulatory molecules in the body include hormones, neurotransmitters, and autocrine regulators such as prostaglandins and growth factors.

___ 103. All autocrine regulators in some ways control gene expression in their target cells that can, for example, result in the stimulation of cell division and proliferation of their target cells.

___ 104. Prostaglandins are the most diverse group of autocrine regulators.

___ 105. In the control of blood clotting, different prostaglandins can initiate antagonistic effects on the aggregation of platelets and the diameter of blood vessels.

___ 106. Aspirin is a nonsteroid anti-inflammatory drug (NSAID) that works by stimulating the synthesis of prostaglandins such as those that cause pain.

___ 107. Celebrex and Vioxx are examples of newer NSAIDs that selectively inhibit the type II isoform of the enzyme, cyclooxygenase resulting in the desired inflammation inhibition effects with fewer negative effects on the stomach mucosa.

___ 108. Acetaminophen (Tylenol) works to reduce fever and relieve pain by inhibiting the COX3 isoenzyme but is not an effective anti-inflammatory drug.

CHAPTER REVIEW

A. Completion

109. Many hormones become active only after conversion from less active precursors called _____ — (pre/pro) hormones; whereas _____ — (pre/pro) hormones are inactive until activated by the target cells. The overall effects of hormones depend on their _____, where pharmacological doses are abnormally _____ (high/low). 110. Interaction between different hormones are described as _____, _____, or _____. 111. Steroid and thyroid hormones _____ (do/don't) enter their target cells, whereas amine, polypeptide, and _____ hormones _____ (do/don't) enter the target cells. Receptors for thyroid hormones are located in the _____, steroid hormone receptors are usually located in the - _____ or the nucleus with protein-derived hormone receptors located in the _____. 112. Many protein-derived hormones activate second messengers such as _____ _____, _____, or _____ to carry out the action of the hormone. 113. List the eight pituitary hormones (use their abbreviated spellings where applicable): _____, _____, _____, _____, _____, _____, _____ and _____. (On your own, can you spell out these abbreviations? Try it!) 114. Six of these are from the _____ pituitary and are controlled by releasing hormones from the _____, which flow along the hypothalamo-hypophyseal _____ system. 115. The adrenal _____ secretes mineralocorticoids such as _____; and _____ such as cortisol; as well as _____ steroids (weak androgens). 116. The adrenal medulla secretes mainly _____ and lesser amounts of _____ hormones, which complement the action of _____ nervous system stimulation. 117. The major hormone of the thyroid is thyroxine or T _____ (3/4), which is assembled within the _____ of the thyroid follicles. The parafollicular cells of the thyroid secrete the hormone _____, which may act to _____ (raise/lower) blood levels of _____. 118. Insulin is secreted by the _____ cells of the _____ of Langerhans, whereas the hormone with the opposing action called _____ is secreted by the _____ cells. 119. Eating a meal _____ (raises/lowers) blood levels of glucose and stimulates the release of _____, which lowers blood glucose; whereas fasting stimulates _____ secretion, stimulating lipolysis and _____. 120. The pineal gland secretes _____, which may play a role in regulating _____ function. The thymus secretes hormones important in regulating the _____ system. 121. Testosterone is secreted by the _____ cells of the testes, whereas the _____ cells of the ovarian follicles primarily secrete the hormone _____. Both progesterone and estrogen are secreted by the _____ _____ and by the _____, if pregnant. 122. Prostaglandins are unique, twenty-carbon-long _____ acids produced by _____ (few/many) different tissues and appear to act primarily within the organ in which they are produced.

B. Label the Figure — Negative Feedback Control of Gonadotropin Secretion

The endocrine system and the negative feedback control of hormone secretion is an excellent example of homeostasis. In figure 11.2 study the negative feedback control of gonadotropin secretion. Notice the hormonal connections between the hypothalamus, the anterior pituitary gland and the gonads. Then on the blank lines provided, label the proper hormones, their target organs and the negative feedback pathways. After you have finished, check your work with figure 11.17 in your text and save this worksheet for review before the next examination.

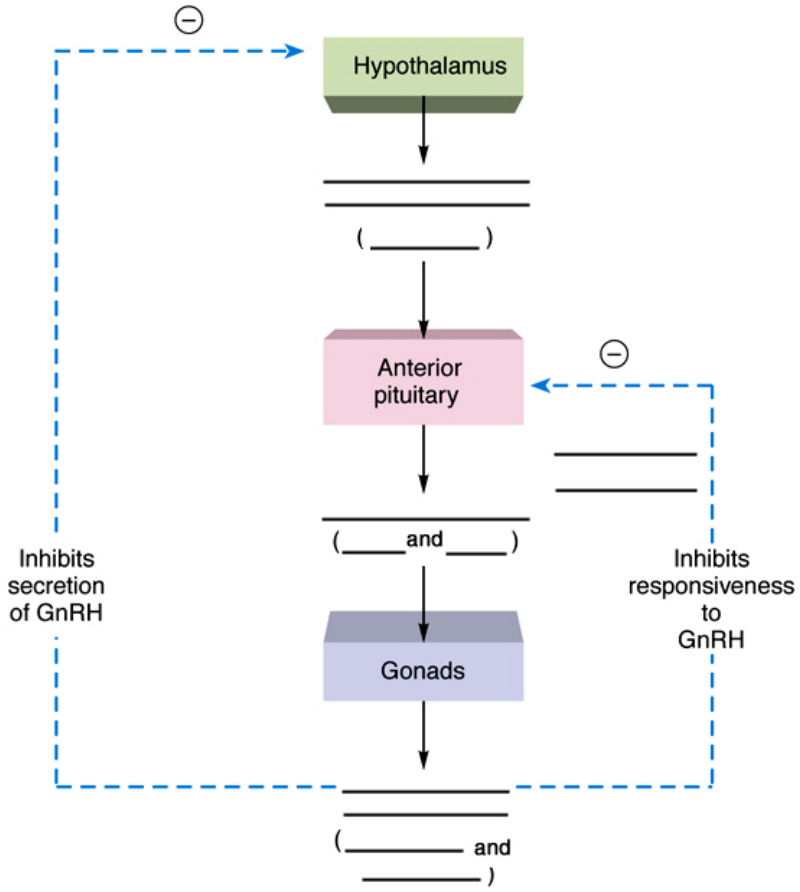

Figure 11.2 The hypothalamus-pituitary-gonad axis (control system).

C. Sequencer

123. In proper sequence, number the following seven events that occur when a hormone first arrives at the target plasma membrane and begins the activation of cAMP as a second messenger molecule in the cytoplasm. *Note:* The first event has been done for you. When you have finished, check your work with table 11.4 in your text.

_____Cyclic AMP activates protein kinase enzymes that were already present in the cytoplasm in an inactive state.

__*1*__The hormone binds to its receptor on the outer surface of the target plasma membrane.

_____The activity of specific enzymes is either increased or inhibited by specific enzyme phosphorylation.

_____Activated adenylate cyclase (enzyme) catalyzes the conversion of ATP to cyclic AMP (cAMP) within the cytoplasm.

_____Activated cAMP-dependent protein kinase transfers phosphate groups (phosphorylates) to other enzymes in the cytoplasm.

_____Altered enzyme activity mediates the target cell's response to the hormone.

_____Hormone-receptor interaction stimulates activation of adenylate cyclase on the cytoplasmic side of the membranes.

C. Essay

Essay Tutorial

This essay tutorial will answer the first essay question found in the "**Review Activities**" section of your *Human Physiology* textbook. Please read *Essay Question* 1 located in the "**Test Your Understanding of Concepts and Principles"** section at the end of chapter 11 and let me guide you through one possible answer. Watch for key terms in boldface type, helpful tips and general suggestions on writing the essay or short-answer questions. Enjoy!

124. Explain how the **regulation** of the **neuro**hypophysis and of the adrenal **medulla** are related to the **embryonic origins** of these organs.

Note: One way to format an answer to this question is to first state the embryonic origins for each of the two tissues, then describe the regulation of these tissues based on what information you have provided related to embryonic origins.

Answer. The neurohypophysis, or pars nervosa, originates as neural tissue that grows down from the hypothalamic region of the brain. The hypothalamus has two important clusters of neurons, one called the supraoptic nuclei and the other, the paraventricular nuclei. The axons from these cell bodies project down the infundibulum stalk and terminate in the posterior pituitary where there respective hormones are stored in vesicles, awaiting release. The embryonic origin of the adrenal medulla is also from neural tissue, arising much like an enlarged ganglion at the end of preganglionic sympathetic neurons that emerge from the spinal cord.

Autonomic nerve activity regulates both of these glands. Sensory information sent to the hypothalamus (for example, from infant suckling) or the activation of receptors within the hypothalamus (for example, osmoreceptors by osmolality changes) stimulate reflex secretion of oxytocin and ADH hormones, respectively, which are released from vesicles into the posterior pituitary blood supply. Activation of the adrenal medulla (such as during stress) also starts from the hypothalamus as sympathetic nerve impulses that stimulate the release of epinephrine and norepinephrine catecholamine hormones into the bloodstream. This is part of the “fight-or-flight” response.

All right! How did you do with this one? Do you see how this question could also be answered using a two-column table format using neurohypophysis and adrenal medulla as column headings?

Keep up the good work! If time permits, try a few more of mine, OK?

125. Compare the steroid hormones to the thyroid hormones with regard to entry, binding sites, and activation of the target cells.

126. Distinguish between the two major types of diabetes mellitus — and include the causes of each and the effects on both insulin and glucagon concentrations in the blood.

127. Suppose a person's immune system makes antibodies that mimic thyroid-stimulating hormone (TSH). What effects would you expect to see on the thyroid, its release of hormones, and target cell response? Can you name this autoimmune disease?

128. Construct a diagram to distinguish between the activation of protein kinase by cAMP in liver cells and activation of calmodulin in contracting skeletal muscle. (You can check your diagram against figure 11.10 in the text.)

Answers — Chapter 11

I. Endocrine Glands and Hormones
   A. 1. c, 2. e, 3. a, 4. b, 5. e, 6. c, 7. a, 8. b, 9. d
   B. 10. T, 11. T, 12. F—Neurotransmitter and hormone actions are very similar, 13. T, 14. T, 15. T, 16. F—Replace "decrease" with "increase," and "downregulation" with "upregulation"

II. Mechanisms of Hormone Action
   A. 17. a & b, 18. a, 19. c, 20. a, 21. c, 22. a, 23. b, 24. b
   B. 25. T, 26. F—Switch "high" and "low," 27. F—Replace "polar" with "nonpolar"; they are "not" water-soluble, 28. T, 29. T, 30. T, 31. F—Some receptor molecules are already located in the nucleus, 32. F—Switch "nonsteroid" with "steroid," 33. T, 34. T, 35. T, 36. F—Replace "high" with "low," 37. T, 38. T, 39. T, 40. F—Switch "cAMP" with "tyrosine kinase"

III. Pituitary Gland
   A. 41. b, 42. b, 43. d, 44. c, 45. d, 46. b
   B. 47. F—Switch "anterior" and "posterior," 48. F—Replace "anterior" with "posterior," 49. T, 50. T, 51. T, 52. F—The "dormitory effect" is part of the pituitary-gonad axis (not adrenal)
   C. Label the Figure—Anterior Pituitary See figure 11.14 in the text.

IV. Adrenal Glands
   A. 53. c, 54. d, 55. a, 56. c, 57. d
   B. 58. F—Switch "medulla" and "cortex," 59. T, 60. F—Replace "medulla" with "cortex," 61. T, 62. T, 63. F—Replace "Cushing's syndrome" with Addison's disease," 64. T, 65. T, 66. T, 67. T, 68. F—Replace "cortex" with "medulla," 69. T

V. Thyroid and Parathyroids
   A. 70. b, 71. b, 72. e
   B. 73. T, 74. T, 75. T, 76. F—Replace "iron" with "iodine," 77. F—Replace "cold" with "heat," 78. F—Switch "infants" and "adults," 79. T, 80. T, 81. T

VI. Pancreas and Other Endocrine Glands
   A. 82. e, 83. b, 84. b, 85. d, 86. e, 87. c, 88. a
   B. 89. F—Switch "glucagon" and "insulin," 90. F—Replace "pineal" with "pancreas," 91. T, 92. T, 93. T, 94. T, 95. F—Replace "B" with "T," 96. T, 97. T

VII. Autocrine and Paracrine Regulation
   A. 98. e, 99. c, 100. c, 101. b
   B. 102. T, 103. T, 104. T, 105. T, 106. F—Replace "stimulating" with "inhibiting," 107. T, 108.T

Chapter Review
   A. 109. pro, pre; concentration, high, 110. permissive, synergistic, antagonistic, 111. do, glycoprotein, don't; nucleus, cytoplasm, membrane, 112. cyclic AMP, cyclic GMP, Ca^{2+}, 113. GH, TSH, ACTH, FSH, LH, prolactin, ADH, oxytocin, 114. anterior, hypothalamus, portal, 115. cortex, aldosterone, glucocorticoids, sex, 116. epinephrine, norepinephrine, sympathetic, 117. 4, colloid; calcitonin, lower, calcium, 118. beta, islets, glucagon, alpha, 119. raises, insulin, glucagon, glycogenolysis, 120. melatonin, reproductive; immune, 121. Leydig, granulosa, estrogen; corpus luteum, placenta, 122. fatty, many
   B. Label the Figure—Negative Feedback Control of Gonadotropin Secretion See figure 11.17 in the text.
   C. Sequencer 123. 4,1,6,3,5,7,2