Biochemistry IN PERSPECTIVE

Mammalian Hormones and the Hormone Cascade System

How does the brain area called the hypothalamus control the body's endocrine glands? Synthesis of many mammalian hormones is controlled by a complex cascade mechanism that originates in the brain. The hormone cascade (Figure 16A) begins in the hypothalamus, an area in the brain just above the brainstem that integrates the nervous and endocrine systems. Sensory signals received by the hypothalamus results in the synthesis and release of specific hypothalamic releasing hormones, which in turn either stimulate or inhibit the secretion of hormones from the pituitary gland. The releasing hormones enter a specialized capillary bed surrounding the pituitary gland, which is attached to the hypothalamus by the pituitary stalk. The pituitary consists of two distinct lobes: the anterior lobe, which receives hormonal signals from the hypothalamus via a capillary system, and the posterior lobe, which receives neurosecretory signals directly from the hypothalamus. The hypothalamus-releasing hormones target specific clusters of cells in the anterior lobe and stimulate the secretion of trophic ("turning" or "changing") hormones. Once secreted into the bloodstream, these trophic hormones stimulate the synthesis and release of specific hormones from other endocrine glands. For example, the tripeptide thyrotropin-releasing hormone (TRH) stimulates the secretion of TSH. TSH in turn stimulates the thyroid gland to release the thyroid hormones T3 and T4.

In anatomy and function, the posterior pituitary differs from the anterior lobe. The hormones secreted (i.e., the peptides vasopressin and oxytocin) are actually synthesized in neurons of separate types that originate in the hypothalamus. After their synthesis, both hormones are packaged into secretory granules. The granules then migrate down the axons into the posterior lobe. They are secreted into the bloodstream when an action potential reaches the nerve endings and initiates exocytosis. Oxytocin is secreted as a response to nerve impulses initiated by the stretching of the uterus late in pregnancy and suckling during breast feeding. Vasopressin (antidiuretic hormone) is secreted in response to neural signals from specialized cells called osmoreceptors, which are sensitive to changes in blood osmolality.

Table 16.1 lists the most important mammalian hormones regulated directly or indirectly by the hypothalamus. Note that these hormones fall into three categories—peptide or polypeptide, steroid, and amino acid derivatives.

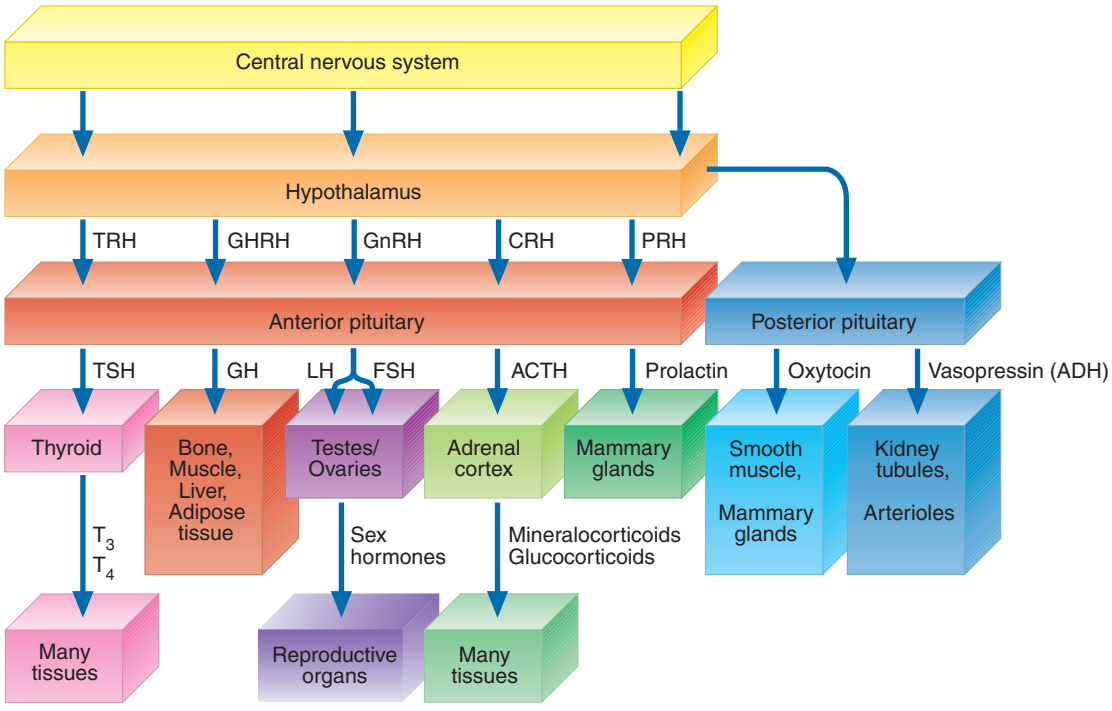

FIGURE 16A

The Endocrine Hormone Cascade System

Hormone synthesis and secretion are ultimately controlled by the central nervous system. Neurons in the hypothalamus either stimulate or inhibit hormone synthesis and/or secretion in the pituitary. Pituitary hormones initiate metabolic activities in their target cells.

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TABLE 16.1 Selected Mammalian Hormones

Source	Hormone	Function
Hypothalamus	Gonadotropin-releasing hormone* (GnRH)	Stimulates LH and FSH secretion
	Corticotropin-releasing hormone* (CRH)	Stimulates ACTH secretion
	Growth hormone-releasing hormone* (GHRH)	Stimulates GH secretion
	Somatostatin*	Inhibits GH and TSH secretion
	Thyrotropin-releasing hormone* (TRH)	Stimulates TSH and prolactin secretion
Pituitary	Luteinizing hormone* (LH)	Stimulates cell development and synthesis of sex hormones in ovaries and testes
	Follicle-stimulating hormone* (FSH)	Promotes ovulation and estrogen synthesis in ovaries and sperm development in testes
	Corticotropin* (ACTH) (adrenocorticotropic hormone)	Stimulates steroid synthesis in adrenal cortex
	Growth hormone* (GH)	Exerts general anabolic effects in many tissues
	Thyrotropin* (TSH) (thyroid-stimulating hormone)	Stimulates thyroid hormone synthesis
	Prolactin*	Stimulates milk production in mammary glands and assists in the regulation of the male reproductive system
	Oxytocin*	Stimulates uterine contractions and milk ejection
	Vasopressin*	Regulates blood pressure and water balance
Gonads	Estrogens† (estradiol)	Regulates maturation and function of reproductive system in females
	Progestins† (progesterone)	Facilitates implantation of fertilized eggs and maintenance of pregnancy
	Androgens† (testosterone)	Regulate maturation and function of reproductive system in males
Adrenal cortex	Glucocorticoids† (cortisol, corticosterone)	Exert diverse metabolic effects, as well as inhibiting the inflammatory response
	Mineralocorticoids† (aldosterone)	Regulate mineral metabolism
Thyroid	Triiodothyronine‡ (T_3)	Stimulates many cellular reactions
	Thyroxine‡ (T_4) (after conversion to T_3)	
Gastrointestinal tract	Gastrin*	Stimulates secretion of stomach acid and pancreatic enzymes
	Secretin*	Regulates pancreatic exocrine secretions
	Cholecystokinin*	Stimulates secretion of digestive enzymes and bile
	Somatostatin*	Inhibits secretion of gastrin and glucagon
Pancreas	Insulin*	Exerts general anabolic effects including glucose uptake and lipogenesis
	Glucagon*	Promote glycogenolysis and lipolysis
	Somatostatin*	Inhibits the secretion of glucagon

*Peptide or polypeptide.

†Steroid.

‡Amino acid derivative.

SUMMARY: The brain controls the body's endocrine glands via a hormone cascade system that is regulated by hormones released by the pituitary gland, which is in turn controlled by the hypothalamus.