HYPOTHALAMUS & POSTERIOR PITUITARY: NEUROSECRETION

PITUITARY STRUCTURE. The pituitary gland, located underneath the hypothalamus of the brain, is vital to body physiology because its hormones not only exert direct action on body organs (e.g., prolactin on mammary glands and antidiuretic hormone on the kidney) but also regulate the activity of several target endocrine glands (e.g., thyroid and gonads). The pituitary gland is controlled by the brain and mediates the effects of the central nervous system on hormonal activity in the body, which explains its critical anatomic position in relation to the brain.

The pituitary (hypophysis) is divided into an anterior lobe (adenohypophysis), a posterior lobe (neurohypophysis), and an intermediate lobe. In humans, the intermediate lobe either does not exist or is vestigial, consisting of a few cells with no known functions. The pituitary is connected to the brain via the hypophyseal stalk. This plate focuses on the structure and functions of the posterior lobe, to illustrate the concept of neurosecretion. Neurosecretion is also essential for understanding of anterior lobe function, and is the cornerstone of the modern science of neuroendocrinology.

POSTERIOR PITUITARY AND HYPOTHALAMUS. The posterior lobe of the pituitary secretes two hormones, antidiuretic hormone (ADH) and oxytocin. The posterior pituitary is not an endocrine gland because it does not contain true secretory cells. In fact, the gland, being an extension of the brain hypothalamus, consists mainly of nerve fibers and nerve endings of the neurons of two hypothalamic nuclei. These neurons have their cell bodies in the hypothalamus and send their axons (hypothalamo-hypophyseal tract) to the posterior pituitary through the hypophyseal stalk.

NEUROSECRETION. These hypothalamic nuclei are the supraoptic and paraventricular. The neurons of these nuclei are typical examples of neurosecretory cells. The cell bodies of these special neurons are the site of the synthesis of the hormones which, in the case of the posterior pituitary, are synthesized as larger prohormone molecules. These molecules contain the true hormone and a nonhormonal portion called neurophysin, which may function in hormone transport. The prohormone complexes are packed within the vesicles (Herring bodies), which flow down the axon by rapid axoplasmic transport.

Before reaching the nerve terminals in the posterior lobe, the hormone is split off the larger prohormone and stored in the axon terminals, to be released into the blood capillaries and carried out to the target tissues. The stimulus for hormone release is the nerve impulse arriving from the cell body down the axon membrane to the terminal, which causes calcium ions to flow into the terminal. This leads the secretory vesicles to fuse with the terminal membrane and the hormone to be released into the extracellular fluid and blood capillary. ANTIDIURETIC HORMONES (VASOPRESSIN). The cells of the supraoptic nucleus make and secrete principally the antidiuretic hormone (ADH, also called vasopressin). Involved in regulating body water, ADH is secreted whenever the amount of water in the blood is decreased, as in dehydration due to excessive sweating or osmotic diuresis (caused by an increase in glucose or ketone bodies or sodium loss in the urine), as well as during hemorrhage and blood loss.

The signal for ADH release is believed to be an increase in the osmolarity of the blood mediated by an increase in the concentration of sodium ions in the plasma. The sodium elevation is sensed by specific osmoreceptor neurons in the hypothalamus, which in turn stimulate the supraoptic neurons to release ADH from the posterior pituitary. ADH acts principally on the collecting ducts in the kidney, by increasing their permeability to water. Water moves by osmosis from the kidney ducts to the plasma, decreasing plasma osmolarity. (See plate 62.) ADH is also secreted when mechanoreceptors (volume receptors) in the heart, and pressure receptors in the vasculature, are stimulated after hemorrhage and blood loss. After a hemorrhage, ADH causes vasconstriction, leading to an increase in blood pressure (vasopressive action).

OXYTOCIN HORMONE. Oxytocin is secreted principally by the cells of paraventricular nuclei, stimulated by sensory mechanoreceptors in the nipples of the breasts and cervix of the uterus, as part of neurohormonal reflex arcs. Sensory nerves convey the signals from the sensory receptors to the hypothalamus, leading to the secretion of oxytocin from the posterior pituitary. During labor, oxytocin acts on the myometrium of the uterus to cause massive contractions, eliciting the expulsion of the fetus (oxytocin = swift birth). During lactation, oxytocin acts on the myoepithelium of the mammary glands to elicit their contraction and cause the ejection of milk. (See also plates 150, 151.) There are no known functions for oxytocin in the male.

Oxytocin and ADH are both polypeptides containing nine amino acids. Their structures are identical except for the substitution, in ADH, of phenylalanine and arginine in place of one of the tyrosines and the leucine found in oxytocin.