Behavioral and Motivational Mechanisms of the Brain—The Limbic System and the Hypothalamus:

Activating Driving Systems of the Brain

Signals from the brain stem activate the cerebrum in two ways: (1) by stimulating the background level of activity throughout wide areas of the brain and (2) by activating neurohumoral systems that release specific facilitatory or inhibitory hormone-like neurotransmit□ters into selected areas of the brain.

Functional Anatomy of the Limbic System; Key Position of the Hypothalamus:

The influence of the hypothalamus extends caudally to the brain stem and rostrally to the diencephalon, limbic cortex, and pituitary gland. The hypothalamus controls (1) vegetative and endocrine functions and (2) behavior and motivation.

Vegetative and Endocrine Control Functions:

The hypothalamus can be divided into a number of cell groups responsible for certain functions; however, localization of function is less precise than is suggested by these studies.

• Cardiovascular regulation involves control of arterial pressure and heart rate and is focused in general in the posterior and lateral hypothalamic areas, which increase blood pressure and heart rate, or in the preoptic area, which decreases blood pressure and heart rate. These effects are mediated by cardiovascular centers in the pontine and the medullary reticular formation.

• Body temperature regulation is controlled by neurons in the preoptic area that are able to sense changes in the temperature of blood flowing through the area. Increases or decreases in temperature signal the appropriate cells to activate body temperature-lowering or temperature-elevating mechanisms.

• Regulation of body water intake is controlled by mechanisms that create thirst or control excretion of water into urine. The thirst center is in the lateral hypothalamus; when the concentration of electrolyte levels here is elevated, a desire to “drink” is initiated.

The supraoptic nucleus is involved with mechanisms that control urinary excretion of water, and neurons here release antidiuretic hormone (ADH, or vaso□pressin) into the posterior pituitary gland that then enters the circulation and acts on the

collecting ducts in the kidney to cause reabsorption of water, making the urine more concentrated.
• Uterine contraction and milk ejection are stimulated by oxytocin, which is released by neurons of the paraventricular nucleus.
• Gastrointestinal and feeding regulation are controlled by several hypothalamic areas. The lateral hypothala□mus is responsible for the desire to seek out food, and damage to this area may result in starvation. In com□parison, the ventromedial nucleus is called the satiety center because its activity produces a "stop eating" signal. The mammillary nuclei are involved in certain reflexes related to food intake, such as lip licking and swallowing.
• Anterior pituitary gland regulation is achieved by the elaboration of releasing and inhibitory factors from the hypothalamus, which are carried by a portal system to the anterior lobe of the pituitary. Here they act on glandular cells that produce the anterior pituitary hormones. The hypothalamic neurons that produce these factors are found in the periventricular zone, the arcuate nucleus, and the ventromedial nucleus.

Behavioral Control Functions of the Hypothalamus and Associated Limbic Structures:

Emotional behavior is affected by stimulation of the hypothalamus or by lesions in the hypothalamus. Stimulation effects include
(1) increased general level of activity, leading to rage and aggression; (2) sense of tranquility, pleasure, and reward; (3) fear and feelings of punishment, aversion; and (4) sexual arousal. Effects caused by hypothalamic lesions include (1) extreme passivity and loss of drives and (2) excessive eating and drinking, rage, and violent behavior.

"Reward" and "Punishment" Function of the Limbic:

The major locations that evoke a pleasurable feeling or sense of reward when stimulated are found along the course of the medial forebrain bundle, especially in the lateral and ventromedial hypothalamus. Conversely areas that when stimulated evoke aversive behavior include the midbrain periaqueductal gray, the periventricular zones of the thalamus and hypothalamus, the amygdala, and the hippocampus.

Rage—Its Association with the Punishment Center:

In animals, intense stimulation of aversive centers in the lateral hypothalamus and periventricular zone evokes a rage response. This is characterized by a defense posture, extended claws, elevated tail, hissing and spitting, growling, and piloerection. Normally, the rage reaction is held in check by activity in the ventromedial hypothalamus.

Importance of Reward and Punishment in Behavior:

Much of our daily behavior is controlled by punishment and reward. Administration of tranquilizers inhibits both punishment and reward centers and thereby decreases behavioral affect in general. These drugs are not selective, however, and other hypothalamic functions may be depressed as well, thus creating potentially harmful side effects. Also, stimulation that affects either the reward or punishment center tends to build strong memory traces, and the responses to such stimulation are said to be reinforced. Stimulations that are essentially indifferent tend to become habituated.