NEURAL REGULATION OF DIGESTION

Our knowledge of autonomic nervous system control of digestive activities precedes even that of hormonal control. Pavlov, the Russian physiologist and Nobel laureate, made many discoveries in this area.

AUTONOMIC CONTROL OF THE DIGESTIVE SYSTEM. The digestive system is innervated profusely with the nerve fibers of both the sympathetic and parasympathetic divisions, but the parasympathetic division's regulatory role, carried out primarily by the vagus nerve, seems to be paramount. In general, the parasympathetic system increases gastrointestinal activity (secretion and motility), and the sympathetic system has a net inhibitory effect.

The parasympathetic vagus nerve contains both motor and sensory fibers. The motor fibers enhance digestive activities by stimulating local neurons of the intrinsic nervous system, located in the gut wall. The smaller intrinsic neurons in turn stimulate the smooth muscles and gland cells. Although the sympathetic fibers directly influence the smooth muscle and secretory cells in certain instances, the sympathetic system's general inhibitory effects on digestion are caused indirectly, by constricting the blood vessels in the digestive tract. The reduction in blood flow diminishes both secretory and contractile activity. The numerous afferent sensory fibers in the vagus nerve inform the brain about the condition of the gut and its content.

INTRINSIC (ENTERIC) NERVOUS SYSTEM. The intrinsic nervous system consists of two sets of ganglia or plexi: the superficial submucosal plexus mainly regulates the digestive glands, and the myenteric plexus, located deeper within the muscle layers, is primarily concerned with gut motility. The plexi, function in part, as the peripheral ganglia of the parasympathetic system within the gut (see plate 25). The plexi contain local sensory and motor neurons as well as interneurons. Sensory neurons are connected to the sensory chemoreceptors, which detect different substances in the gut lumen, and stretch receptors, which respond to the tension in the gut wall caused by the food and chyme bulk. The short effector motor neurons increase digestive gland activity or induce smooth muscle contraction. The myenteric and submucosal plexi in the same region communicate with each other, as well as with plexi farther in the gut, through interneurons. The vast numbers of neurons and neuronal connections in the plexi constitute the enteric nervous system, which carries out many digestive reflexes independently, in addition to mediating brain influence on digestive functions.

PHASES IN NEURAL REGULATION OF DIGESTION. Nervous system regulation of digestive activities is traditionally divided into three consecutive phases: cephalic (brain, mental), gastric (stomach), and intestinal.

CEPHALIC PHASE. When one is hungry, odors or even thoughts of foods commonly evoke salivary secretion (mouth watering). Experiments have shown that this anticipatory response also involves the secretion of a small amount of gastric juice. When food is placed in the mouth, gastric juice production is substantially increased, as is salivary secretion. There is also an increase (albeit a small one) in the secretion of pancreatic juice. These gastric and pancreatic secretions during the cephalic phase prepare the gut to receive food. One function of this step may be regulatory: the presence of some acid and pepsin in the stomach will help form peptides, which stimulate more juice production when food arrives in the stomach.

These anticipatory and reflex activations of digestion, particularly the stomach activity, have been labeled the "cephalic" (brain) phase because both the higher and the digestive centers of the brain play essential roles here. The main brain centers regulating digestive functions are in the medulla oblongata, where the taste fibers also have their primary centers and where the cell bodies of the vagus and salivary nerves are located. The higher cortical and olfactory centers influence these medullary motor centers in order to regulate digestion. All the cephalic responses, including those of the vagus and nerves to the salivary glands, are conducted by the parasympathetic outflow.

GASTRIC PHASE. When food enters the stomach, the mechanical stretch receptors sense the increase in bulk, and the chemoreceptors detect the presence of peptides in the food. These sensors signal the information to two targets: (1) the effector neurons in the local enteric plexi and (2) the brain medullary centers for digestion. Both these targets reflexly increase the stomach's secretion and motility over that occurring during the preceding cephalic phase (SO% of gastric juice secretion compared to 10%), because this secretion deals with the bulk of the stomach's digestive functions. Also during this gastric phase, gastrin becomes active.

INTESTINAL PHASE. The arrival of the chyme in the duodenum initiates the intestinal phase of nervous control, during which gastric secretion and motility are at first increased to promote further digestion and emptying. As the small intestine becomes filled with acidic and fatty chyme, inhibitory signals (mostly hormonal) decrease stomach activity to prolong emptying and allow time for intestinal digestion.