Summary

The amygdala mediates learned somatic and visceral responses to environmental stressors. Subregions of the amygdala, called the central nucleus (Ce), and an associated region, known as the bed nucleus of the stria terminalis (BSTL), are thought to integrate stress-induced cardiovascular and other autonomic reactions. These amygdalar areas have been implicated in the development of hypertension and gastric ulcers in animal models. The Ce and BSTL are unique among amygdalar nuclei in that they exhibit strong reciprocal anatomic connections with various "central autonomic" nuclei located throughout the brainstem and contain an especially high density of several neuropeptides. Amygdalar corticotropin-releasing factor (CRF)-, somatostatin- and neurotensin-containing cell bodies are the main contributors to descending pathways that innervate the midbrain central gray, the parabrachial nucleus and the dorsal vagal complex. Substance P and galanin cells within the amygdala also connect to these brainstem regions. The three brainstem areas receive projections from all the above types of amygdalar peptide-containing neurons. Thus, autonomic effects seen after amygdalar stimulation may be due to the release of the same peptides at multiple sites within the brainstem. In contrast, some peptidergic terminals within the amygdala arise from specific regions of the brainstem. For example, calcitonin gene-related terminals within the amygdala originate from neurons in the parabrachial region and cholecystokinin terminals project from cells in the substantia nigra/ventral tegmental areas, suggesting that the release of certain peptides from terminals within the amygdala is related to the functional actions of specific brainstem inputs. Thus, in terms of peptidergic coding, there are distinct differences in the organization of amygdalar input and output pathways. The peptidergic pathways of the amygdala are discussed with respect to their possible function in mediating autonomic responses during stress.
Introduction

The amygdala consists of a group of nuclei located within the temporal lobe of the brain in mammals. Along with other limbic system structures, the amygdala responds to changing environmental conditions by inducing emotive behaviors that are linked to past experiences. Any alterations in ongoing behavior involve concomitant modifications in somatic and visceral activity. This chapter focuses primarily on the role of the amygdala and neuropeptides in visceral or autonomic changes. It is of clinical significance that chronic exposure to stress-evoking stimuli can damage the integrity of organ systems in the body. Some of the more common pathologies include hypertension and gastrointestinal ulcers. Not surprisingly, considerable evidence indicates that the amygdala participates in the development of these disorders.

Organization of Amygdalar Neuropeptides and Neuronal Connections

Specific subregions of the amygdala, known as the central nucleus (Ce), and another limbic system structure, the lateral division of the bed nucleus of the stria terminalis (BSTL), are part of a network of brain nuclei that are important in the regulation of various autonomic functions. The Ce is linked anatomically with the BSTL through the substantia innominata and the stria terminalis. For example, a continuum of cells extending between the Ce and BSTL project to the parabrachial nucleus and dorsal vagal complex. Cytoarchitectural, hodological and immunocytochemical studies have provided evidence that the dorsal and ventral BSTL are homologous to the lateral and medial Ce, respectively. Thus, in this chapter, we will consider the BSTL along with the Ce as an amygdalar nucleus.

One of the characteristics that distinguishes the Ce and BSTL from other amygdalar nuclei is their extensive, largely reciprocal anatomic connections with various other nuclei concerned with adjustments of autonomic or nociceptive responses. These include certain hypothalamic nuclei (e.g., the lateral hypothalamus), the substantia nigra-ventral tegmental region, the midbrain central gray, the parabrachial nucleus, the locus coeruleus, the A5 catecholaminergic region, the nucleus tractus solitarius, the dorsal vagal nucleus, and the ventrolateral medulla. Figure 8.1 summarizes the major anatomic connections of the Ce and BSTL. Their projections to the parabrachial nucleus, the midbrain central gray and dorsal vagal complex are especially heavy and have received the most attention. Recently, the Ce was shown to project directly to the cervical spinal cord in the region of phrenic motor neurons. BSTL projections