THE LIMBIC SYSTEM

The primary area of the brain that deals with stress is the limbic system. Because of its enormous influence on emotions and memory, the limbic system is often referred to as the emotional brain. It is also called the mammalian brain, because it emerged with the evolution with our warm-blooded relatives, and marked the beginning of social cooperation in the animal kingdom.

Whenever you perceive a threat, imminent or imagined, your limbic system immediately responds via your autonomic nervous system – the complex network of endocrine glands that automatically regulates metabolism. The brain is organized into three basic and highly interrelated parts and functions. The brain stem and hypothalamus monitor regulation of one’s internal environment and the fight and flight mechanisms. The limbic system balances the internal and external worlds and processes raw emotion. The neocortex analyzes and solves problems and is part of the brain through which we largely interact with the external world.

One of the major functions of the nervous system is to maintain constancy of the internal environment of the body, a process termed homeostasis. Although essentially the whole brain participates in this process, neurons vitally important to homeostasis are concentrated in the hypothalamus and in the limbic system. These neurons maintain homeostasis through three closely related processes:
1) The secretion of hormones
2) Central control of the autonomic nervous system
3) The development of emotional states

The hypothalamus and limbic system are responsible for sexual behaviors, hunger and thirst, thermoregulatory function, and also influence many aspects of emotional expression such as anger, rage, placidity, fear and social attraction.

The limbic system is comprised of the amygdala, hippocampus, mamillary bodies, hypothalamus, and other neurological structures. It operates by influencing the endocrine system and the autonomic nervous system.
Following the perception of a threat, the amygdala signals an alarm to the hypothalamus that turns on two systems:

1. It activates the sympathetic nervous system, which activates the adrenal glands to release adrenaline and noradrenaline to mobilize the body for fight or flight. This is accomplished by increasing respiration and heart rate.
2. It releases corticotrophin-releasing hormone (CRH), stimulating the pituitary gland to release adrenocorticotropic hormone (ACTH), which in turns activates the adrenal glands to release cortisol.

One of the functions of the limbic system, the center of emotions, is to store fear-based experiences. Part of the limbic system, the amygdala, records fearful experiences and feelings in intense sensory detail, and alerts the person to the possibility that the object is a snake, long before the word “snake” occurs in the person’s cortex. The amygdala also sends messages to the hypothalamus to activate the hypothalamus-pituitary-adrenal (HPA) axis and the fight or flight mechanisms, so that the person will stop, look and get ready to run if necessary before even knowing what the object is.

When death may be imminent, escape is impossible, or the traumatic threat is prolonged, the limbic system can simultaneously activate the Parasympathetic nervous system, causing a state of freezing called tonic immobility, like a mouse going dead when caught by a cat, or stiff, like a deer caught in headlights.
The **amygdala** is involved in signaling the cortex of motivationally significant stimuli such as those related to reward and fear in addition to social functions such as mating. The amygdala is the limbic structure that **assigns the sensory information an emotional interpretation and instructs the body in how to respond accordingly.** If the amygdala evaluates sensory information (what is seen, heard, smelled, etc.) as comprising danger, it will raise an alarm and instruct the body to run away or dive for cover (flight), fend off (fight), or go numb or faint (freeze).

Social processing is an area of cognition specific to the amygdala. More specifically, the evaluation of faces in social processing is of particular importance. The amygdala stimulates the hippocampus to remember many details surrounding the situation, as well.

When a person looks at the world, he or she is confronted with an overwhelming amount of sensory information—sights, sounds, smells, and so on. After being processed in the brain's sensory areas, the information is relayed to the amygdala, which acts as a portal to the emotion-regulating limbic system. Using input from the individual's stored knowledge, the amygdala determines how the person should respond emotionally—for example, with fear (at the sight of a burglar), lust (on seeing a lover) or indifference (when facing something trivial). Messages cascade from the amygdala to the rest of the limbic system and eventually reach the autonomic nervous system, which prepares the body for action. If the person is confronting a burglar, for example, his heart rate will rise and his body will sweat to dissipate the heat from muscular exertion. The autonomic arousal, in turn, feeds back into the brain, amplifying the emotional response.

Nadal and Zola-Morgan (1984) have found that the amygdala is mature at birth, and that the hippocampus matures later, between the second and third year of life. This provides one explanation for the fact that we usually don’t remember our infancy or the traumas that may occur during the first years of life. There may be emotional and physical sensation memories without context or sequence.

The **hippocampus** has been demonstrated to be involved in various processes of cognition. The first and most widely researched area concerns memory, **spatial memory** in particular. Required for the formation of long-term memories and implicated in maintenance of cognitive maps for navigation. It appears to be very important in converting things that are “on one's mind” at the moment (in short-term memory) into things that one will remember for the long run (long-term memory). **If the hippocampus is damaged, a person cannot build new memories and lives instead in a strange world where everything he or she experiences just fades away, even while older memories from the time before the damage are untouched.**

The hippocampus is very important for managing, remembering, and recovering from trauma. Among other things, **it is the hippocampus that registers and then informs the cortex about the time context of an event. It marks the memory of each event with a beginning, middle, and end.**

Take special note of that last step of hippocampal sequencing, recording that an event has ended. With regard to remembering trauma, this is vitally important. In fact, **typically PTSD is the result of a hippocampus that was not able to mark the end of the trauma. It was never able to tell the cortex that the trauma ended. Such a failure of the hippocampus is really the crux of PTSD, perhaps even the major cause.**

When the hippocampus is able to recognize and tell the cortex that a traumatic event has concluded, the cortex can then instruct the amygdala that the trauma is over. Once informed, the amygdala can then halt its alarm response, telling the body there is no further need for hypervigilance or flight, fight, or freeze. While the amygdala is immune to the rise in stress hormones that accompanies traumatic stress, the hippocampus is not so lucky. It is very vulnerable to high levels of stress hormones and will stop working correctly when adrenaline and other hormones reach a high level. Later traumatic experiences might be
remembered only as highly charged emotions and body sensations without a context in those with hippocampal suppression.

**LIMBIC SYSTEM & NEOCORTEX INTERACTION**

- Amygdala
- Hypothalamus
- Hippocampus
- Neocortex