Brain Evolution—The Triune Brain Theory

Paul D. MacLean coined the concept of the limbic system in 1952 and went on to place the limbic system into an evolutionary context. He proposed that the human brain is really three brains in one, a "triune brain." Although the general concept and accompanying illustration used to depict the triune brain remains elegantly simple for instructional and educational purposes, MacLean's contribution to our understanding of brain function has been considerable.

"There appear to have been relatively long periods of stability in vertebrate brain evolution, followed by bursts of expansion," writes Jaak Panksepp in Affective Neuroscience: The Foundations of Human and Animal Emotions (1998). "The three evolutionary strata of the mammalian brain reflect these progressions." The strata to which Panksepp refers are reflected in MacLean's illustration below right (image links to source).

I derived the following Triune Brain Summary from several sources, especially including Panksepp's Affective Neuroscience. Any errors are my own. Please note that we discuss at length the innate emotional systems that emerge within the paleomammalian formation in Part 2 of MyBrainNotes.com, in Emotions are Hard-Wired in the Brain: Introduction to Ancestral Brain Systems.

Protoreptilian formation (including basal ganglia, mid-brain, and brainstem): Genetically encoded instinctual action plans related to primitive survival issues such as exploration, feeding, aggression, dominance, and sexuality.

Paleomammalian formation (including the amygdala, hippocampus, hypothalamus and other structures in the so called limbic system): Innate emotional and motivational systems shape behavioral responses to incoming stimuli based on instincts and past experience; mediates the social emotions, playfulness, and maternal nurturance.

Neomammalian formation (neocortex): Declarative Knowledge about the world derived especially from sight, sound and touch.

MacLean's triune brain theory illustration from a Rockefeller University web page. Panksepp summarizes the strata as follows: "The basic reptilian core is of similar relative size in all mammals (as long as we account for body size). Other vertebrates also have an abundance of this tissue in their small brains. While the limbic system is comparatively small in reptiles, it is large in all mammals and also of similar relative size across different mammalian species. On the other hand, the degree of mushrooming of neocortex varies widely among mammalian species, being modest in rodents and reaching massive proportion in the cetaceans (whales and porpoises) and great apes (the gibbons, orangutans, gorillas, chimpanzees) and attaining its pinnacle in humans. It is the storehouse of our cognitive skills."

In my view, MacLean helped to refine one of Charles Darwin's ideas, expressed in Descent of Man in 1871: "The difference in mind between man and the higher animals, great as it is," wrote Darwin, "certainly is one of degree and not of kind." For a comprehensive review of the MacLean's work, see his 1990 book, The Triune Brain in Evolution, New York: Plenum Press. Protoreptilian brain:

Regarding the human brain, MacLean labeled the oldest part, from an evolutionary perspective, the protoreptilian formation. This part of the human brain corresponds in anatomy with the brains of lizards and—through what we call an autonomic nervous system in humans—regulates basic life-support functions. MacLean's protoreptilian formation includes the brainstem and the cerebellum, as well as some of the oldest, from an evolutionary perspective, subcortical nuclei, including the corpus striata complex (also called the basal ganglia). We discuss the corpus striata complex in greater detail later, in both Parts 2 and 3 of MyBrainNotes.com. Part 3 addresses the role of the corpus striata complex in generating obsessions, compulsions, and tics.

In regard to MacLean's protoreptilian brain, Panksepp explains in Affective Neuroscience that "The innermost reptilian core of the brain elaborates basic instinctual action plans for primitive emotive processes such as exploration, feeding, aggressive dominance displays, and sexuality." Panksepp also states that the protoreptilian brain is responsible for "basic instinctual action tendencies and habits related to primitive survival issues."
Paleomammalian brain:

As illustrated in the diagram above, MacLean proposed that over eons of evolutionary time, a second brain evolved over the reptilian-like brain. The paleomammalian formation, or limbic system as it is often called, should not be confused with the midbrain. Forebrain, midbrain, and hindbrain are terms designed to help describe developing embryonic brains. In triune brain theory, the midbrain is actually part of the protoreptilian formation.

The prefix paleo- means early or old. Mammals, as most of us know, came into existence after reptiles were already crawling the earth but before primates began swinging from tree to tree in forests. Regarding the paleomammalian brain, Panksepp writes: "The old-mammalian brain, or the limbic system, adds behavioral and psychological resolution to all of the emotions and specifically mediates the social emotions such as separation distress/social bonding, playfulness, and maternal nurturance." Panksepp also describes the function of the paleomammalian brain as "subjective feelings and emotional responses to world events interacting with innate motivational value systems." You have to remember here that a rabbit's world is much different from a chimpanzee's world or a human's world. Every mammal has its own world view so to speak. As mentioned earlier, we will discuss innate emotional systems at length as part of the discussion on ancestral brain systems.
Neomammalian brain:

MacLean labeled the newest part of the human brain the neomammalian formation. I like neocortex because it is short and descriptive. The neocortex is, however, enormously sophisticated. For now, MyBrainNotes.com focuses on the paleomammalian and protoreptilian formations, those subcortical structures responsible for many of our primal emotions and motivations of which we may not be fully aware. We will, however, discuss the neocortex later in this Part 1 narrative and provide links for more information. Panksepp describes the neocortex as handling "propositional information about world events derived especially from sight, sound and touch." He writes: "The highly expanded neomammalian cortex generates higher cognitive functions, reasoning, and logical thought." Robert M. Sapolsky in his video course, Biology and Human Behavior: The Neurological Origins of Individuality, 2nd edition, calls the neocortex a "primate specialization."

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