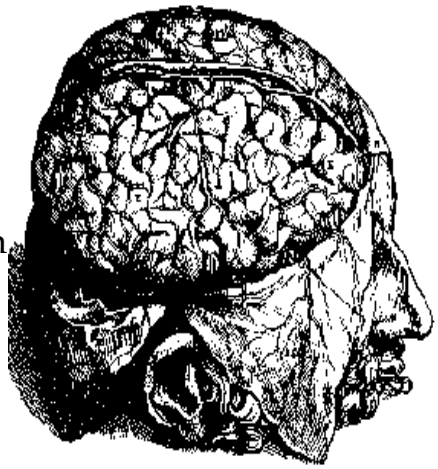
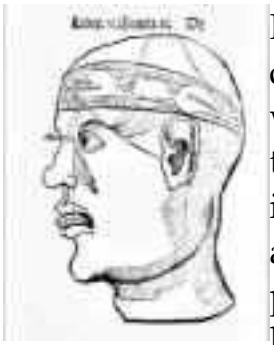
A HISTORY OF THE BRAIN



"The brain, the masterpiece of creation, is almost unknown to us." -- Nicolaus Steno, 1669

Ancient medical practitioners had conflicting views of the significance of the brain. In the fourth century B. C., Aristotle considered the brain to be a secondary organ that served as a cooling agent for the heart and a place in which spirit circulated freely. He designated the space in which all the spirits came together as the *sensus communis* -- the origins of our much more metaphorical term, "common sense." Aristotle had famously written, "There is nothing in the intellect that is not in the senses." As we can see, he meant this quite literally.

By the first century A. D., Alexandrian anatomists such as Rufus of Ephesus had provided a general physical description of the brain. Basic structures such as the *pia mater* and *dura mater* (the soft and hard layers encasing the brain) were identified in addition to the basic divisions of the brain itself. Building upon this research in the next century, the Roman physician Galen concluded that mental actively occurred in the brain rather than the heart, as Aristotle had suggested. His observations of the effects of brain injuries on mental activity formed an important practical basis for his conclusions. Galen concluded that the brain was the seat of the animal soul -- one of three "souls" found in the body, each associated with a principal organ. The brain was a cold, moist organ formed of sperm.



In the Middle Ages, the anatomy of the brain had consolidated around three principle divisions, or "cells," which were eventually called ventricles. Each cell localized the site of different mental activity. Traditionally imagination was located in the anterior ventricle, memory in the posterior ventricle, and reason located in between. Yet where was the *sensus communis*? The Islamic medical philosopher

Avicenna wrote in the early eleventh century that it was housed in the "faculty of fantasy," receiving "all the forms which are imprinted on the five senses." Memory preserved what common sense received. By contrast, the great anatomist Mondino de' Liuzzi wrote in his *Anatomy* (1316) that common sense lay in the middle of the brain. Aware of the contractions that had proceeded him, he affirmed that "there is only the *sensus communis* which is variously called fantasy and imagination." Look at the image to the left and right, both from the early Renaissance. How did such ideas get transformed into a diagram -- a cultural anatomy of the brain?

Other problems remained open to debate. For instance, Avicenna chastised physicians for favoring Galen over Aristotle. A century later, Master Nicolaus of Salerno marveled at the confused humoral accounts of the brain. "The brain ... is, according to some, of hot complexion; according to others, cold; according to others, moist." Such differences of opinion underscore how little was known of the brain's anatomy, let alone its physiology.

Renaissance physicians began to dissect the brain with greater frequency at the end of the fifteenth century, as this illustration from Charles Estienne's mid-sixteenth century anatomy demonstrates. " If you should cut an onion through the middle," wrote Jacopo Berengario da Carpi, "you could see and enumerate all the coats or skins which circularly clothe the center of this onion. Likewise if you should cut the human head through the middle, you would first cut the hair, then the scalp, the muscular flesh (*galea aponeurotica*) and the pericranium, then the cranium and, in the interior, the *aura mater*, the *pia mater* and the brain, then again the pia, the aura mater, the *rete mirabile* and their foundation, the bone." The penultimate item -- an arterial net found in animals such as sheep and cows -- was decidedly not human, as Vesalius was to observe in 1543.

During this same period, Leonardo da Vinci drew and dissected the brain. Look at the drawing to your right. How does it compare to medieval diagrams of the brain? By the first decade of the sixteenth

century, Leonardo's images were considerably more anatomical. He began to examine the relationship between the brain and the olfactory and optical nerves through experimenting with wax injections that helped him to model the ventricles. He sketched the brain from many different perspectives, looking closely at the ventricles and the origins of the nerves in the medulla. The more Leonardo looked, the less he was sure about the function of each ventricle. One of his goals was to find the location of the *sensus communis*. But most importantly he hoped to locate the seat of the soul as did most investigators of the brain. " In the walls of the ventricles also there is some portion of the *pia mater* that carries blood and spirit," wrote Berengario, "blood to nourish the parts nearby to it, spirit for the operations of the soul...." In 1520, Alessandro Achillini followed in the metaphysical tradition of examining the brain when he affirmed, with Galen, that the sutures of the cranium allowed the vapors of the brain to escape periodically.

Sixteenth and early seventeenth-century anatomists contributed a great deal to the physical description of the brain -- terms such as cerebrum, cerebellum and medulla were commonly used -- but made few significant advances in their understanding of its function. Not until the 1660s did the anatomy of the brain change significantly. Within a few years of each other, the English physician Thomas Willis published his *Anatomy of the Brain* (1664) and the Danish anatomist Nicolaus Steno published his *Lecture on the Anatomy of the Brain* (1669). Both launched powerful criticisms of Galen's idea of animal spirits which, Steno wrote, were "words without any meaning." He further argued for a more careful exploration of the cortex and the ventricles, writing about *sensus communis*: "that beautifully arched cavity does not exist." Willis brought this point further home by arguing that the ventricles were not formed as part of God's design to house the spirits but "accidentally from the complication of the brain." Given that, "the supreme seat of the Soul" could hardly be there. Nor could it be in the pineal gland, as Descartes had proposed. Look at these two images of the brain,

from the late sixteenth and mid-seventeenth centuries. How is the brain becoming a more anatomical object?

Willis' most important contribution, a discussion of cerebral circulation, was based on ingenious use of india ink injections and inspired by Harvey's ideas of the circulation of the blood. The brain had a new physiology and the beginnings of a neurology. But the soul no longer had an easily identifiable home.

QUESTIONS: WHY DID PEOPLE THINK THAT THE BRAIN HAD THREE CELLS? WHAT MADE THEM RELUCTANT TO GIVE UP THIS AND RELATED IDEAS, EVEN AS ANATOMICAL RESEARCH SUGGESTED OTHERWISE?