Physiology and Behavior

Realistically, all that the early physiologist and philosopher could do was speculate about the nature and locus of "mind," because the technology necessary to achieve valid insights into the operation of the nervous system were often centuries in the future. Within their limitations, some of the ancients guessed correctly, but others had ideas that were amusing and, from our 21st century perspective, nonsensical. Before we congratulate ourselves too quickly, we should bear in mind that our current theories may seem as outmoded to neuroscientists 100 years from now as many of the early theories of the nervous system structure and function seem to us today.

However, neuroscientists have made great strides in the last two centuries, today we will examine the people and the ideas that laid the foundation for our current knowledge. One of the threads running through 19th century neuroscience was interested in localization of function. Localizationists believed that specific functions residing in specific nervous system area, whereas nonlocalizationists (globalists) have been more impressed with the way the nervous system works as a coordinated unit. The central question is, Are neural functions tied to one specific nervous system locations?

Sir Charles Bell & François Magendie

Sir Charles Bell (1774-1842) in England and François Magendie (1783-1855) in France independently perform research that led to the distinction between sensory nerves and motor nerves, known as the Bell-Magendie Law. The law states that the dorsal roots of spinal nerves bring in sensory information and ventral roots of the spinal nerves carry motor fibers to the muscle.

In addition to differentiating the sensory and motor nerves, Bell anticipated Johannes Müller’s later doctrine of specific nerve energies. Bell said that each of the senses is mediated by its own kind of nerve. We don’t see or hear or feel or taste or smell anything directly. Instead, an object makes an impression upon a sense organ and then the sensory nerves act as an intermediary between the object and the brain.
Johannes Müller

Born in Koblenz, Germany, Johannes Müller (1801-1858) became professor of physiology at the University of Berlin in 1833.

He is best known for his *Handbuch der Physiologie des Menschen* (Handbook of Human Physiology), which appeared from 1833 to 1844.

The *Handbuch* summarize the physiology of the day and included many original observations and speculations.

In the *Handbuch*, Müller formulated the doctrine of specific nerve energies, whose central principle is that we are directly aware only of the activity in our nerves, not of the external world itself.

Müller’s doctrine of specific nerve energies also supports the concept of localization of function, because as we have indicated, visual sensation results from optic nerve stimulation alone, auditory sensations results only from stimulation of the auditory nerves, and so on.

For Müller, the doctrine of specific nerve energies differentiates the various sensory modalities.

For a while, localization of function in the nervous system received even greater support from the writing and lectures of Franze Joseph Gall.
Franz Joseph Gall (1758-1828) was born in Tiefenbrunn in Baden, a region in southwestern Germany. As a physician and anatomist, Gall made some excellent contribution to 19th century science. For example, Gall examined the brains of many different animal species and that of humans of different age and mental status and concluded that the higher mental functions are associated with the size and integrity of the brain and particularly with its outer covering, or cortex.

In fact, “Gall was the first to claim that mental activities were localized in the cortex alone, the white matter he relegated to the role of a system of conduction and projection.” Unfortunately, despite his scientific contribution Gall is most remember for founding the pseudoscience that became known as phrenology.

In his “research,” Gall made three questionable assumptions. First, he assumed that the skull outer contours correspond to the contours of the underlying brain. Gall believed that the form of the brain is determined early in life, and the skull conforms to the brain’s shape. Further, he thought that enlargements in a particular brain area are reflected in a bump on the skull, whereas the smaller than normal brain area might cause an indentation.

Gall’s second assumption was that mind can be analyzed or divided into limited numbers of faculties or functions. This assumption was neither novel or necessarily wrong, and Gall selected his faculties from the list of the Scottish philosophers Thomas Reid and Dugal Stewart. Gall’s third assumption, which is at least partly correct, was that the mind’s functions are located in different places in the brain.

Armed with these assumptions, Gall specifically studied the heads of people with special qualities.

Gall eventually settled on 27 highly specific faculties, including such abilities as acquisitiveness, benevolence, mercifulness, and secretiveness, in addition to amativeness.
Later phrenologists added more faculties to Gall’s list, and the arbitrary choice of faculties was one of the phrenology’s great defects. Another methodological defects was the way Gall tested his hypothesis. Observations that did not fit the system – for example, a generous person with a bulge in the acquisitiveness area – were explained a way rather than being allowed to cast doubt on the system’s validity.

Phrenology reinforce the idea that functions can be localized in the brain.

Although phrenologists were essentially incorrect about their choice of faculties and where the faculties were located, still it remained for empirical studies to prove them wrong.

Some of the most important of these studies were performed by Pierre Flourens, whose work is often viewed as supporting the nonlocalization position. In fact, Flourens handicapped the development of cortical localization theory by his successful attack on Gall and phrenological localization of function. Born near Montpellier in southern France, Pierre Jean Marie Flourens (1794-1867) graduated from Montpellier’s medical school at the age of 19, having already published his first scientific article.

An ardent opponent of phrenology, Flourens performed experiments to show that the function the phrenologists had assigned to specific brain area could not actually reside there. In his attack, Flourens use the ablation method, or, as it sometimes called, the extirpation method. Flourens’ method involves the complete surgical removal of one of what considered the nervous system’s six basic anatomical units: the cerebral hemisphere or the cerebrum, the cerebellum, the corpora quadrigemina.
Pierre Flourens
Nonlocalization (continued)

- of the cerebral lobes – the outer part of the brain, lying immediately beneath the skull –
  abolished voluntary movement and perception.
- Flourens concluded that the cerebrum was the site of perception, intelligence, and the will.
- Removing a dog's cerebellum (brain structure below and behind the cerebral lobes),
  Flourens observed that the animal still possess all its intellectual faculties and its perceptual abilities.
- What was destroyed was the animal's ability to coordinate its movements.
- Obviously, uncoordinated movement had nothing to do with Gall's amativeness organ.

Pierre Flourens
Nonlocalization (continued)

- Without corpora quadrigemina (an area in the center of the animal's brain)
  "a bird was blind" even though the cerebral lobes were intact and
  Flourens concluded that the structure were necessary for vision.
- Damage to the medulla oblongata – the first structure after the spinal cord – resulted in an animal's death.
  Thus, the medulla was called the "vital knot" even before Flourens' s investigations.

Pierre Flourens
Nonlocalization (continued)

- Flourens found evidence that animals subjected to ablation in which there was recovery of a lost function over time.
- Knowing that brain tissue does not regenerate, Flourens reasoned that other brain areas must have assumed some of the ablated areas' lost function.
- This phenomenon of neural plasticity is still investigated today.