

The Formation of Reticular Theory

In the nineteenth century, reticular theory aimed to describe the properties of neurons, the specialized cells which make up the nervous system, but was later disconfirmed by evidence. Reticular theory stated that the nervous system was composed of a continuous network of specialized cells without gaps (synapses), and was first proposed by researcher Joseph von Gerlach in Germany in 1871. Reticular theory played a significant role in developmental neurobiology as it enabled scientists to theorize how the form of neural cells functioned in the context of the broader nervous system, and although disproven, reticular theory contributed to the foundation of the neuron doctrine that informed the modern field of neurobiology.

In the mid-nineteenth century, scientists studying neural cells began to develop a theory that proposed characteristics of those particular cells that appeared much different from normal cells of the body. At the time, cell theory established that cells were fundamental discrete units of life. However, scientists studying neural cells with microscopes noted that neural cells did not look like other cells throughout the body. In addition to a cell body, scientists saw neurons had matter extending off the cell body in both directions, later called dendrites and axons. Researchers later determined the dendrites received signals from other nerve cells, whereas axons transmitted those signals to the next nerve cell. The cell staining methods used during this time prevented scientists from studying neurons in their complete form and see how dendrites and the axon connected to the cell body. Under a microscope, scientists saw cell bodies surrounded by a network of nerve extensions without a definite beginning and end. Because scientists could not explain the function of those nerve extensions, they hypothesized that neurons depended on each other to function, as described by reticular theory.

In 1858, at the University of Erlangen in Erlangen, Germany, Gerlach created a staining technique that yielded evidence to support his reticular theory. Gerlach stained brain tissue with a solution of carmine, a red dye, and gelatin, a colorless protein. He accidentally left the tissue in the dye overnight, and when he returned to his laboratory the next morning, he found the tissue stained more clearly than before. Although Gerlach's staining technique increased the clarity of cells under a microscope, Gerlach still saw only the cell body and parts of the nerve extensions, later called axons and dendrites.

For the next decade, using his staining technique, Gerlach observed and described neural cells as containing two nerve extensions that extended off the cell body and connected to nearby cells. He hypothesized that the cells formed a network of continuous fibers. Unable to see the complete nerve cell, and the ends of the dendrites and axons, Gerlach suggested that the nervous system was composed of a continuous network of nerve cells connected to and dependent upon one another. In 1871, he proposed his reticular theory in a chapter of *Handbuch der Lehre von den Geweben des Menschen und der Thiere* (Guide to the Teaching of the Tissues of Humans and Animals).

Although Gerlach proposed the reticular theory in 1871 after examining evidence of his staining techniques on neurons, other scientists conducted their own neuron staining experiments during mid-nineteenth century and did not come to the same conclusions. A researcher working at the University of Bonn in Bonn, Germany, Otto Friedrich Karl Deiters used a different neuron staining technique to study nerve cells. Deiters used Gerlach's carmine stain to add color and increase visibility of the neurons. After staining the tissue, Deiters immersed the sample in a potassium dichromate solution to harden the nerve tissue and reduce the amount of damage done to the cells when analyzing them under the microscope. Deiters then separated individual neurons using a needle under a microscope, which often resulted in tearing the axons. Deiters recorded his findings

as detailed depictions of neurons but died of typhus in 1863 before he could publish his drawings.

Deiters's illustrations were posthumously published in 1865 in *Untersuchungen über Gehirn und Rückenmark des Menschen und der Säugethiere* (Studies of Brain and Spinal Cord of Humans and Mammals). Because Deiters's depictions of the neuron were similar to Gerlach's findings, scientists used Deiters's illustrations of neural cells as evidence to support reticular theory. However, Deiters didn't isolate and view the cellular extremities in their full forms and didn't see their beginnings and ends.

Scientists improved the clarity of neuron staining techniques, but until 1873, the techniques developed did not enable scientists to view the nerve extensions. In 1873, in Abbiategrosso, Italy, researcher Camillo Golgi created the black reaction, a staining technique that enabled scientists to view the complete form of neurons and their cellular extensions. Like Deiters, Golgi used a potassium dichromate solution to harden the neural tissue. After hardening the neural tissue, Golgi immersed the tissue in silver nitrate, which reacted with the potassium dichromate to form fragments of silver chromate. The chemical fragments appeared black on the cell membrane, thus acting as a black stain. Only 1 to 5 percent of neurons were stained using the black reaction technique, and that selective staining enabled scientists to view an entire neuron without having to tear it away from the other neurons and damaging its extensions in the process.

Golgi used his discovery to support the theory that all nerve cells were connected through a network of nerve extensions. However, working at the University of Barcelona in Barcelona, Spain, during the 1880s and 1890s, Santiago Ramón y Cajal used Golgi's black reaction to support an alternate theory on the composition of the nervous system, the neuron doctrine. That theory stated that nerve cells developed and existed as independent and discrete units. The use of the black reaction in support for both theories caused a great debate at the turn of the twentieth century. Both Golgi and Ramón y Cajal shared the 1906 Nobel Prize in Physiology or Medicine for their work on the structure of the nervous system. In the twentieth century, the neuron doctrine gained more support after the invention of more powerful microscopes that enabled scientists to observe the space between neural cells (synapses).

Sources

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