

## Santiago Felipe Ramon y Cajal (1852-1934)

Santiago Felipe Ramón y Cajal investigated brains in the nineteenth and twentieth centuries in Spain. He identified and individuated many components of the brain, including the neuron and the axon. He used chick embryos instead of adult animals, then customary in brain research, to study the development and physiology of the cerebellum, spinal cord, and retina. Ramón y Cajal received the Nobel Prize in Physiology and Medicine in 1906, along with Camillo Golgi, for his work on the structure of the nervous system.

Ramón y Cajal was born on 1 May 1852 to Antonia Cajal Puente and Justo Ramón Casasús in the village of Petilla de Aragón, Spain. He was their first of four boys and four girls. His father was a surgeon in Petilla before returning to his hometown, of Valpalmas, Spain, in 1854. When Ramón y Cajal started school in Valpalmas at age four, his father tutored him in geography, arithmetic, grammar, physics, and French. His parents noted that he preferred to wander around the countryside observing animals than to play with other children. Around age eight Ramón y Cajal began to draw and spend days sketching trees, animals, and landscapes. His parents treated artistic expression as a sinful amusement, so he hid his hobby. Years later, when his father found Ramón y Cajal's drawings and pencils, he confiscated them and began to prepare Ramón y Cajal for medical school.

Ramón y Cajal received his medical degree from the University of Zaragoza in Zaragoza, Spain, in 1873. After graduating, he served in the Spanish army's medical services and was sent to Cuba during the Ten Years War between Spain and Cuba, in which Cuban's fought the provincial Spanish government for independence. After two years, he was discharged when he fell ill with malaria and tuberculosis. Upon his return to Spain in 1875, Ramón y Cajal became an assistant to the medical faculty at University of Zaragoza. In 1878 he earned his doctorate in anatomy at the University of Madrid in Madrid, Spain, where he also acquiring professional skills in photography and microscopy.

In 1881, Ramón y Cajal became a professor at University of Valencia in Valencia, Spain, and the chair of the anatomy department in 1883. He transferred to the University of Barcelona in Barcelona, Spain, in 1887 to become professor and chair of histology. With the addition of a lab in his new Barcelona home the next year, he devoted more time to his scientific research. He studied the relationships between nerve cells, largely uninvestigated at the time, and he focused on the mechanisms of sensory and nervous impulse. An encounter in 1887 with the psychiatrist Luís Simarro Lacabra in Madrid furthered Remón y Cajal's research. Lacabra had just returned from France where he had learned to stain organic tissues from Camillo Golgi, a pathologist working at the University of Pavia, in Italy. Lacabra introduced Ramón y Cajal to the Golgi staining technique, which enhanced his ability to observe cells.

Ramón y Cajal altered the Golgi staining method by staining organic materials in two short soakings in the active compound, silver nitrate, rather than in one soaking for one or two days. He also noted that different types of tissues required different lengths of exposure to silver nitrate. Ramón y Cajal stained brain tissues to detect spaces between dendrites, which are the branches on the heads of neurons. At the time scientists debated about the reticular theory, which states that the neurons comprised one mass. The Golgi staining technique enabled clear observations of cells, which proved that neurons are individual cells. Scientists called the theory of the individuality of neurons the neuron doctrine. Remón y Cajal presented these findings in 1889 at a conference in Berlin, Germany. In the late 1880's Ramón y Cajal's published his *Manual of Normal Histology and Micrographic Technique*, and he married Silveria Fanañas Garcia, with whom he had three sons and four daughters.

At least three of Ramón y Cajal's theories persisted into the twenty-first century in neuroscience. His

theory of the growth cone, postulated in 1890, states that the direction of neurons grow and develop from the the parts of nerve cells called axons, which are long projections of the cell bodies that carry electro-chemical currents. In 1892 he developed his theory of dynamic polarization, which proposed that nerve impulses always travel from the dendrites and cell body down the axon. He determined that neurons had three parts, each with a specific function in cell communication: the cell body and dendrites, which process and distribute signals; the axon, which carries information in the form of electric impulse between the cell body and axon terminal; and the receiving axon terminal, which accepts and distributes electrochemical messages to other cells. Ramón y Cajal's third theory, called chemotaxis, contributed to his theory of the growth cone. According to his theory of chemotaxis, the growth cones of axons follow a direction corresponding to a gradient of concentration left by the chemical trails of other neurons. Those gradients enabled subsequent chemical signals to travel the trails easier than they would have without the gradients.

Ramón y Cajal also studied cells with microscopes. In 1893 he described a type of cell in the gastrointestinal tract that function to coordinate the movement of matter through the intestines. He studied various infectious diseases, including leprosy, syphilis, tuberculosis, cholera, rabies, and cancer. In 1896, he suggested that cancerous tumors are not completely separate entities, but that they connect to the tissue they grow around, a theory adopted by later pathologists.

In 1892 Ramón y Cajal became chair of histology and pathological anatomy at University of Madrid in Madrid, a position he held until his retirement in 1922. In 1894 he gave the honorary Croonian Lecture for the Royal Society in London, England. In 1906 he shared the Nobel Prize in Physiology or Medicine with Camillo Golgi, for their work on the structure of the nervous system. Three years later in 1909 he was elected a foreign member of the Royal Society in London. He was an honorary Doctor of Medicine at Cambridge University in England, and The University of Würzburg, Germany, respectively, and an honorary Doctor of Philosophy at Clark University in the US. Shortly before retirement in 1920, Ramón y Cajal founded the Spanish School of Histology in San Blas, Spain, which later was renamed the Cajal Institute. During his lifetime, Ramón y Cajal published more than 100 works.

Ramón y Cajal died in Madrid at age 82 on 17 October 1934. Although he had said he was an atheist, he received a Catholic burial at Cemetario de la Almudena in Madrid, Spain.

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