

Medicine in Stamps

Camillo Golgi (1843-1926): Italian neuroscientist and Nobel laureate

Tan S Y, MD, JD and Gara N*, MD

Professor of Medicine, John A Burns School of Medicine, University of Hawaii

* Research carried out during internal medicine residency, University of Hawaii Integrated Residency Program.

The Golgi apparatus, that part of the cell organelle responsible for processing macromolecules, is named after Camillo Golgi, a remarkable Italian scientist who became in 1906, history's sixth Nobel laureate in medicine. Born in Corteno, a small mountain village in Italy's Lombardy area on July 7, 1843, Bartolomeo Camillo Golgi had his early education in nearby Pavia. Italy, then under Austrian rule, was experiencing a period of political turmoil. Young Golgi was reportedly arrested for expressing discontent with its rulers, and suspended from school for derisive comments about the German language. Still, he managed to graduate from the medical school at the University of Pavia in 1865 at the age of 22 years. Two mentors would shape Golgi's eventual growth into one of Europe's most prominent scientists. They were Cesare Lombroso, a prominent psychiatrist, who inspired Golgi to study the brain, and Giulio Bizzozero, the discoverer of the platelet, whose niece he married and from whom he learnt the art and science of histological investigation.

THE BLACK REACTION In 1872, Golgi became chief physician at the Pio Luogo degli Incurabili, a hospital for chronic diseases at Abbiategrasso near Milan. Reputed to be a skilled physician, Golgi declined private consultations, preferring instead to set up a laboratory in the kitchen of his small apartment. There, he used histological techniques as *"the direct means of penetrating the formidable unknown of the architecture of the nervous system."* His moment came in 1873. On February 16th, he wrote to his friend Nicolo Manfredi: *"I spend long hours at the microscope. I am delighted that I have found a new reaction to demonstrate even to the blind, the structure of the interstitial stroma of the cerebral cortex. I let the silver nitrate react with pieces of brain hardened in potassium dichromate. I have obtained magnificent results*

and hope to do even better in future." He was referring to the black reaction, known as "Golgi staining" or "Golgi impregnation," which was capable of highlighting the morphological complexities of nerve tissue. Using this breakthrough technique, he characterised the histological structure of the neuron, and demonstrated the repeated branching of nerve axons. He also identified dendrites as projections of neurons, which remained free and separate and did not fuse into a network.

With various staining methods and the expert use of the microscope, Golgi performed studies on the olfactory bulbs, and discovered "Golgi cells," which are multipolar inhibitory motor and sensory interneurons found in the cerebellar cortex and posterior horns of spinal cord. He identified two types of sensory corpuscles in skeletal muscle fibres at their tendinous insertions. These are now known as the Golgi tendon organ, which are proprioceptors, and the Golgi-Mazzoni corpuscles, which can transduce pressure stimuli.

GOLGI APPARATUS Golgi's best-known discovery is the Golgi apparatus, which came much later in his career in 1897. Using a variant of the black reaction

to stain neurons, he noticed within the cell a structure that had the appearance of stacked dinner plates. This cellular organelle, now termed the Golgi apparatus, is an integral part of a cell's function in processing, packaging, distributing and exporting synthesised macromolecules such as proteins and lipids. Consisting of half a dozen disc-like membranes called cisternae, the Golgi apparatus is a storehouse of enzymes that processes proteins as they travel to various parts of the cell and beyond its borders. In addition to glycosylation and phosphorylation, the Golgi apparatus is also thought to play a role in cell apoptosis. Ramon Cajal, a fellow neuroscientist from Spain, had earlier used the gold chloride staining method to identify this cell organelle, but failed to reproduce the results.



NOBEL PRIZE In 1906, Golgi received the highest honour in the field of science – the Nobel Prize for Physiology or Medicine, which he shared with Santiago Ramon Cajal for their work on the structure of the nervous system. Although dubbed “*Siamese twins joined at the shoulders*,” the two scientists sported fiercely opposing views, with Golgi insisting that nerve cells and their axons formed a network, while Cajal believed that neurons were structurally separate.

Golgi made numerous and diverse other contributions. During the First World War, he directed the Military Hospital Collegio Borromeo of Pavia, and promoted the rehabilitation of the war-wounded. Golgi’s research into malaria led to a description of the entire intra-erythrocytic cycle of the *Plasmodium* species, including the temporal relation between recurrent febrile bouts and segmentation of *Plasmodium*. His work extended to the urological system, and included descriptions of the mechanism of renal hypertrophy, Bright’s disease of the kidney, and the relationship between the vascular pole of the malphigian glomerulus and the distal tubule. Moreover, he independently observed and described the presence of canaliculi in gastric parietal cells, which are known as Muller-Golgi tubules (Erik Muller was a Swedish histologist).

BELOVED ALPS Golgi’s fame attracted many collaborating scientists, including Giovanni Martinotti,

who identified the small multipolar neurons in the cerebral cortex that bear his name; Adelchi Negri, who discovered the intraneuronal inclusions (Negri bodies) of rabies; and Fridtjof Nansen, a Norwegian zoologist and diplomat who won the Nobel Peace Prize in 1922 for his work as High Commissioner in the League of Nations. In 1918, Golgi retired as Rector of his beloved University of Pavia, a position to which he was first elected in 1893. On July 9, 1923, he celebrated his 80th birthday, an occasion marked by receipt of the prestigious honour of the Gran Cordone Mauriziano, bestowed by Mussolini himself. Death came on January 21, 1926 from septicaemia complicating influenza. In his biography “*The Hidden Structure*” by Mazzarello, Golgi is described as an “*ardent patriot*,” a shy man of “*calm disposition*” with a personality befitting “*the mysterious and austere beauty of the beloved Alps from which he came*.”

BIBLIOGRAPHY

- Camillo Golgi. Available at: //nobelprize.org. Accessed August, 2008.
- Golgi apparatus. Available at: //en.wikipedia.org/wiki/Golgi_apparatus. Accessed December 8, 2008.
- Mazzarello P. *The Hidden Structure: A Scientific Biography of Camillo Golgi*. New York: Oxford University Press, 1999.
- Van Gijn J. *The Hidden Structure: A Scientific Biography of Camillo Golgi*. Book Review. *New Engl J Med* 2001; 344:1102.