

# Synapse

Don Todman

School of Medicine, University of Queensland, Brisbane, Australia

The origin of the word ‘synapse’ is from *synaptein* and was coined by the neurophysiologist Charles Sherrington in 1897. The word comes from the Greek *syn-* (‘together’) and *haptein* (‘to clasp’). The first use of the term was in the 7th edition of the *Textbook of Physiology* written by Michael Foster (1836–1907) [1] who was professor of physiology at Cambridge. His colleague and former pupil Charles Sherrington (1857–1952), then professor of physiology at the University of Liverpool, was a major contributor and co-author of part 3 on the central nervous system. Much of this expanded volume could be attributed to Sherrington himself. The text introduces the term in the section on the structure of the spinal cord: ‘So far as our present knowledge goes we are led to think that the tip of a twig of the arborescence is not continuous with but merely in contact with the substance of a dendrite or cell-body on which it impinges. Such a special connection of one nerve cell with another might be called a synapsis.’ In the same text, he describes the nerve impulse ‘sweeping along’ the axon of one neuron until it passes to another cell, ‘... the lack of continuity between the material of the arborisation of the one cell and that of the dendrite (or body) of the other cell offers an opportunity for some change in the nature of the nervous impulse as it passes from one cell to the other’.

Until the 1890s, it was generally thought that nerve impulses passed from one excitable cell to another by a continuous network of fibres. Utilizing the Golgi method of silver staining, Santiago Ramón y Cajal (1852–1934) [2] in Barcelona established that nerve cells are independent

elements, which do not anastomose, and that nervous action is made by contacts ‘at the level of certain apparatuses or dispositions of engagement’. Camillo Golgi (1842–1926) maintained that he could identify intracellular neurofibrils in nerves with his silver technique and that these extended from one nerve bulb to the next providing a continuous anastomosis. Cajal and Golgi shared the Nobel Prize in 1906 for their work on the neuron doctrine; yet even in his Nobel speech in December 1906, Golgi still spoke in favour of a continuous intermediary network of nerve fibres [3]. Other histologists confirmed the discoveries of Cajal and the basic structure of a nerve cell called a neuron was devised. In the early twentieth century, the discoveries of Edgar Adrian (1889–1977) on the electrical discharge of nerve cells and Henry Dale (1875–1968) and Otto Loewi (1873–1961) on chemical neurotransmission firmly established the neuron doctrine. The long nerve fibre previously known as an axis was termed an axon whilst the short processes from the cell body were called dendrites. There remained the junctions between neurons which lacked an appropriate name.

The nomenclature of this nerve junction received considerable attention from Sherrington in the 1890s. Cajal established the anatomical basis of nerve connections whilst Sherrington’s [4] work laid the foundation for the physiological principles of reflex activity in the central nervous system. His seminal studies on the reflex arc, originally at Liverpool and from 1913 at the chair of physiology at Oxford, established how nerve impulses con-

ducted in sensory nerves were transferred to dendrites and cell bodies of motor neurons that innervated muscle cells. He recognized that this transfer of nerve impulses differed from the propagation of impulses within the nerve axon. The unidirectional conduction of the reflex as well as evidence of wallerian degeneration established that there was a boundary or surface of separation between nerve cells.

Sherrington considered various terms for this nerve separation. From his correspondence and memoirs it is clear that he discussed these ideas with Michael Foster as well as the physiologist Edward Schäfer (1850–1935) [5]. The word ‘junction’ was considered, but Sherrington dismissed this as it implied a physical union and was incompatible with the neuron theory. ‘Conjunction’ was even worse for the same reasons. He suggested the term ‘syn-desm’ but felt it was inappropriate as it implied the idea of a bond and as a word was cumbersome. Michael Foster consulted the Greek scholar Arthur Verrall (1851–1912)

at Cambridge who suggested ‘synapse’ which conveyed the concept of a process of contact or clasp [6]. It also yielded a preferred adjectival form ‘synaptic’. After the introduction in the 1897 edition of Foster’s textbook the word ‘synapse’ was utilized in the chapter, ‘The nerve cell’, in Edward Schäfer’s [7] *Textbook of Physiology* published in 1900, which helped secure the new terminology.

Few concepts are as important to neuroscience as the synapse. Charles Sherrington, considered the father of modern neurophysiology, is credited with coining the term but he also consulted with colleagues including Michael Foster and Edward Schäfer and the classicist Arthur Farrell. His approach was physiological, but it was grounded on the anatomical evidence established by Cajal. Whilst many terms were considered for this connection, the term ‘synapse’ was deemed the most appropriate as it incorporated both the anatomical and physiological concepts of the neuron theory.

## References

- 1 Foster M, Sherrington CS: A Textbook of Physiology. 3. The Central Nervous System, ed 7. London, MacMillan, 1897.
- 2 Cajal SR: 1909, 1910, Histology of the Nervous System of Man and Vertebrates (transl. by Swanson N, Swanson LW). New York, Oxford University Press, 1995.
- 3 Bennett MR: The early history of the synapse: from Plato to Sherrington. *Brain Res Bull* 1999;50:95–118.
- 4 Sherrington CS: The Integrative Action of the Nervous System. Yale, Yale University Press, 1906.
- 5 Tansey EM: Not committing barbarisms. Sherrington and the synapse, 1897. *Brain Res Bull* 1997;44:211–212.
- 6 Sherrington CS, Fulton J: Letter 25 December 1937; in Swazey J (ed): *Reflexes and Motor Integrations: Sherrington’s Concept of Integrative Action*. Cambridge, Harvard University Press, 1969.
- 7 Schäfer EA (ed): *Textbook of Physiology*. Edinburgh, Portland, 1900, vol 2.