John Farquhar Fulton (1899–1960)

Citation:
Accessed: date

Neurophysiologist, Bibliophile and Medical Historian

Don Todman

John Farquhar Fulton was an influential figure in neuroscience in the twentieth century. He established the first primate physiology laboratory in the United States and his original investigations in neurophysiology included seminal studies on functional localization in the cerebral cortex. He was also renowned as a bibliophile and scholar of medical history and was a leading advocate for the integration of science and the humanities (Figure 1).

Figure 1: John Farquhar Fulton (1899-1960)

John Fulton was born in St Paul, Minnesota where his father was a prominent ophthalmologist and one of the founders of the University of Minnesota Medical School (Denny-Brown, 1960). From his earliest years, he had a love of books. Whilst a high school student, he secured a job as a stack boy at the St Paul public library. Partly because of his avid reading of Tolstoy and Nietzsche, he
failed his initial entrance examination to Harvard but after military service in the army during World War I, he entered Harvard as a veteran and graduated with honors in 1921. He studied zoology as an undergraduate and came under the influence of Edward Laurens Mark (1847-1946), Hersey professor of anatomy. Mark included him in summer trips to the Bermuda Biological Station where his research led to the publication of five papers in fields including the origin of pigment cells, phagocytosis and the permeability of the corpuscle membrane. His last publication examined neuromuscular transmission.

Fulton received a Rhodes scholarship and traveled to Magdalen College, Oxford in 1923 where he enrolled in the mammalian physiology course of Sir Charles Sherrington (1857-1952). A contemporary student was Howard Florey (1898-1968), fellow Rhodes scholar from Australia with whom Fulton shared a life-long friendship (Todman, 2008). He completed his BA with first class honors and completed his DPhil in 1925. Subsequently he worked as a university demonstrator in the physiology laboratory under Charles Sherrington and also pursued his interest in books at the libraries of Oxford. At Oxford he met Lady Osler who gave him access to Osler's library and introduced him to Harvey Cushing (1869-1939). Fulton's doctoral thesis on muscle contraction extended over 644 pages and contained over 1000 references. It was published in 1926 as his first book, *Muscular Contraction and the Reflex Control of Movement*, and included a comprehensive historical review of muscle physiology as it was then known (Fulton, 1926).

He returned to Boston and entered Harvard Medical School completing his medical doctorate in 1927 (magna cum laude). Because of his association with Harvey Cushing, Fulton was able to complete his medical degree in only three years. He interned in neurosurgery with Cushing at Peter Bent Brigham Hospital and learned many neurosurgical techniques that were later employed in his experimental work. Although Cushing was 30 years his senior, the two men shared a friendship that was founded on their shared scientific and historical interests. Fulton returned to Sherrington's laboratory in Oxford between 1928 and 1930 before being offered a position in New Haven as a Sterling professor and head of Yale's department of physiology. John Sterling professorships at Yale were the most distinguished and his appointment to a department chair at age 31 was unique. Fulton remained at Yale for the remainder of his professional life as chair of physiology until 1951 and subsequently as Sterling professor of the history of medicine.

**Neurophysiologist**

At Yale, Fulton utilized the neurosurgical techniques learned from Harvey Cushing to develop a primate research laboratory. This was the first laboratory in the United States using monkeys in laboratory research that had previously been regarded as prohibitively costly. By utilizing modern operating techniques he was able to minimize mortality in the experimental animals. Building on his doctoral thesis of muscle contraction, his desire was to examine the neural control of movement through a series of experiments where he devised stimulation and ablation techniques to establish the motor representations in the cerebral cortex.

The 1930s were the golden years of Fulton's primate laboratory. With numerous collaborators including physiologists and neurosurgeons, the cyto-architectural patterns of the motor cortex were elucidated. His early years at Yale focused on the problem of spasticity after cortical lesions in primates. With Margaret Kennard his group demonstrated the importance of the premotor cortex to explain the spasticity of hemiplegia. From their ablation studies they concluded: "It is probable that spasticity following a capsular hemiplegia in man is brought about by interruption of fibers from the premotor area which pass in the anterior end of the internal capsule in addition to involving the fibers of the pyramidal tract" (Fulton, 1932). The autonomic representation in the cerebral cortex was also an important subject of research in Fulton's laboratory. Cerebral lesions in primates demonstrated altered vasomotor reactions in the side opposite the lesion. In addition a number of parasympathetic effects associated with the premotor cortex were reported; stimulation of premotor cortex was associated with slowing of heart rate and increased gastrointestinal motility while ablation of the premotor cortex led to intestinal stasis and at times intussusception (Kennard, 1934, Watts, 1934).

In 1935, Fulton and graduate student Carlyle Jacobson first reported their experiments on ablation
of the frontal lobes (lobotomy) in chimpanzees and noted the emotional calming effect. They presented their work at a full-day symposium in August 1935 at the second International Neurological Congress in London. In their presentation they reported the findings on bilateral frontal lobe ablation in two chimpanzees, 'Becky' and 'Lucy'. Their paper published the following year recorded: "When the animal was rendered a bilateral frontal preparation, a profound change occurred ... Thus while the animal repeatedly failed and made far greater number of errors than it had previously, it was impossible to evoke even a suggestion of experimental neurosis" (Jacobson, 1936).

Participating in the London conference was Egas Moniz (1874-1955), Professor of neurology at the University of Lisbon. He was impressed by the calming effect especially in 'Becky' and within four months began performing human leucotomies with the aid of neurosurgeon Almeida Lima. At first they employed alcohol injections into the frontal lobes but later used a steel leucotome (Moniz, 1936). The procedure interrupted the limbic association connections isolating the orbital frontal cortex. Subsequently prefrontal lobotomy was widely employed for various psychiatric conditions including schizophrenia and depression (Fulton, 1951). The procedure was initially acclaimed and Moniz received the Nobel Prize in physiology or medicine in 1949 for his research. In the United States the principal proponents were Walter Freeman, neuropsychiatrist and James Watts, neurosurgeon. The Freeman-Watts prefrontal leucotomy was performed via two frontal burr holes and later an 'ice pick' method was used through the roof of the orbit. Partly because of its indiscriminate use and also with the development of chlorpromazine in the early 1950s, the use of the procedure declined dramatically.

Fulton's 1949 monograph, *Functional Localization in the Frontal Lobes and Cerebellum*, represented the culmination of almost two decades of work and was awarded a Pulitzer Prize (Fulton, 1949). He also published the first edition of his physiology of the nervous system in 1936, which soon became the definitive text. It had a worldwide success and was translated into six languages (Fulton, 1936). Subsequently he was asked to take over the revision of Howell's *Textbook of Physiology*. Fulton and J.G. Dusser de Barenne (1855-1940) founded the *Journal of Neurophysiology* in 1938. Fulton became editor in chief in 1940 and enlarged its editorial board with many of the leading neuroscientists of the 1940s and 1950s. He was also one of the founders of the *Journal of Neurosurgery* in 1944 and in 1951 became editor of the *Journal of the History of Medicine and Allied Sciences*.

During World War II Fulton became chairman of the committee of the national research council and subcommittees on decompression sickness. His own laboratory made important contributions to aviation medicine and he edited an important bibliography on many aspects of research in this area in 1951 (Fulton, 1951).

**Bibliophile and medical historian**

Throughout his life reading and book collecting were John Fulton's passions. His personal library was extensive and included much of the scientific literature from the sixteenth to the eighteenth century. On his international travels, he visited many bookshops to enhance his collection. As his colleague Arnold Klebs (1870-1943) remarked, "To him a Boyle, a Priestly, a Lavoisier, Fracastoro were not dead historical personages, but very alive, stimulating contemporaries" (Thomson, 1962).

Before the war Fulton began his biography of Harvey Cushing which was later published in 1946 and represents the pinnacle of historical writing (Fulton, 1946). Fulton's long association with Cushing and his access to an immense wealth of primary sources provided the material for his comprehensive volume. Cushing's own Life of Osler set a high standard for medical biography but Fulton's work successfully captures the life and times of this fiery genius and pioneering neurosurgeon. Fulton also authored or co-authored biographies of Benjamin Silliman, Michael Servetus and bibliographies of Fracastoro's poem, 'Syphilis', Luigi Galvani, Richard Lower and John Mayo, Joseph Priestly and Robert Boyle and early works on anesthesia (Fulton, 1930, 1959). His biographies consistently evoke the personality of his subjects from the anonymity of scientific ideas.
Fulton's bibliography of the Hon Robert Boyle published in 1932 was the most complete text on this famous seventeenth century natural philosopher (Fulton 1932). His authoritative study enabled him to catalogue all of Boyle's work and identify it by a 'Fulton number'. Robert Boyle was a founder of the Royal Society in London and made many discoveries and writings in the area of chemistry, physics and physiology. Although Boyle was not a medical doctor, he made several contributions to medicine including the description of a pneumatic machine used in animal respiration.

Fulton collected many works on early anesthesia in medicine and dentistry. He had original works from James Young Simpson, pioneering gynecologist, and Horace Wells who first used nitrous oxide anesthesia in his dental practice in 1844 pre-dating the description of ether anesthesia by William Morton in 1846.

Partly because of ill health, Fulton resigned his chairmanship of physiology at Yale in 1951 and took up a newly created position as Stirling Professor of the history of medicine. With Harvey Cushing and Arnold Klebs he established the Medical Historical Library at Yale, which included the donation of his own personal library. Following the death of Harvey Cushing in 1939 much of the architectural planning and internal organization of the library was organized by Fulton. The library has become one of the foremost resources in the history of science and medicine (www.med.yale.edu/library/historical). Prior to the opening of the library in 1941, Fulton wrote to his colleague Arnold Klebs: "The library of congress system makes strange bedfellows, such as putting Linne next to Vesalius; but I suppose if we are going to follow a system then we must follow it faithfully otherwise confusion will be worse confounded. I find it all fascinating nonetheless and I shall send you reports of progress from time to time" (Thomson, 1962).

**Fulton and penicillin**

When Howard Florey was endeavoring to develop commercial production of penicillin in the United States, he turned to his close friend John Fulton. During the war Florey's children moved to America and stayed in the Fultons' home. Fulton participated in the first use of penicillin in North America (Gariepy, 1997). In 1941 Florey and his colleague, Dr Norman Heatley, came to the United States to explore the possibility of commercial production of penicillin. The first patient was Mrs Ogden Miller, the wife of Yale University's athletic director, who developed streptococcal septicemia after miscarriage. She was treated at Yale Medical Centre where the same physician, Dr John Bumstead, was also treating John Fulton for coccidiomycosis. Fulton arranged for penicillin to be sent and was administered to Mrs Miller on Saturday, March 14, 1942. After weeks of high fevers, her first dose of penicillin led to normal temperatures and full recovery. Subsequently full-scale production of penicillin developed in the United States and by D-Day, June 6, 1944 penicillin was available to treat the allied casualties (Dohrmann, 1975).

**Conclusion**

Through his leadership at Yale and his editorship of the influential Journal of Neurophysiology, Fulton made important steps in the development of neuroscience in North America. One of the crucial issues during his tenure was the debate between proponents of chemical and electrical synaptic transmission. Fulton's position was strongly with the electrical mode of mediation. In his textbook of 1949 he expressed the prevailing view: "The study of the electrical science of nerve activity does not support the assumption that the transmission of the nerve impulse along the axon differs fundamentally from that across the synapse. The idea of a chemical mediator released at the nerve ending and acting directly on second neurone or muscle thus appears to be unsatisfactory in many respects" (Fulton, 1949). Following the publication of Eccles' experiments in 1951, Fulton and Eccles himself were quick to change their view on chemical neurotransmission, which became a fundamental concept of neuroscience (Todman, 2008).

John Fulton received many honors during his life. He was a member of many physiological and neuroscience organizations as well as many literary and historical associations. He received honorary degrees from Yale, Oxford, Louvain and other universities. The DLitt from University of Oxford gave him considerable pleasure. He influenced students from all over the world in both
neurophysiology and in the history of medicine and was a pioneer in the interdisciplinary collaboration of historians and scientists. In the modern era there are few who approach his distinction as a neuroscientist and scholar of medical history. Prior to his death in 1960 the Society for the History of Medical Science honored him in 1955 by establishing the John Fulton Medal, of which he was the first recipient. His professional life was characterized by the integration of science with a critical appreciation of the value of history and the humanities.

Don Todman
Department of Neurology
School of Medicine
University of Queensland, Australia
drtodman@optusnet.com.au

Selected quotations

1. On Harvey Cushing: "Harvey Cushing was widely known in three distinct capacities - as a great physician, as the founder of a school of neurosurgery, and as a humanist of unusual literary attainment" (Fulton, 1946).

2. Regarding the first use of penicillin in America: "It arrived airmail Saturday morning and a small trial dose was given 3.30 Saturday afternoon. This was tolerated so well they gave larger doses every 4 hours. By 9am Sunday her temperature was normal for the first time in 4 weeks and has stayed normal until this writing (noon Monday) ... It really looks as though Florey has made a 10 strike of the first order, and I am glad that we have had opportunity to make the first clinical trial of the American extract here" (Fulton diary note, 1942).

3. About John Fulton: "Virtue went out of him to help others, not only in the study of neurophysiology and of medical history but also in the perplexities and vicissitudes of life. That is why his students loved and revered him, and why he had countless friends and correspondents on both sides of the Atlantic. The love of mankind and of books was with him to the end" (Obituary BMJ, 1960).

Bibliography


Fulton JF (1930) Selected Reading in the History of Physiology. Springfield, Charles Thomas.


Yale Medical Historical Library (www.med.yale.edu/library/historical).