ON LAWRENCE STARK AND BIOMEDICAL ENGINEERING

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Abstract. We provide a brief overview of Lawrence Stark's fundamental contributions to Biomedical Engineering.

Lawrence Stark (1926–2004) was a neurologist with a vast knowledge including a solid scientific and engineering training. He pioneered in what is nowadays sometimes called *Biomedical Engineering*, with an emphasis on the quantitative description of human brain control of movement and vision. In this note, I would like to outline some of his main achievements. Further information may be found, e.g., in [1, 2, 3] and references therein.

Stark was interested in science since early childhood. He obtained B.A. at Columbia in 1945, where he majored in English, biology and zoology in only one year and a half. During the war he enrolled in the Navy, who sent him to Albany Medical College, where he earned MD in 1948. He was later awarded Sc.D.h.c. at SUNY in 1988 and Ph.D.h.c. at Tokushima University, Japan, in 1992. He received the Morlock Award in Biomedical Engineering in 1977, and the Franklin V. Taylor Award, Systems Man and Cybernetics Society in 1989.

Lawrence Stark held faculty positions at Yale, 1954–1960, as an Assistant Professor of Medicine (Neurology) and Associate Physician; at Massachusetts Institute of Technology, 1960–1965, as Head of the Neurology Section of the Center for Communication Sciences, Electronic Systems Laboratory and Research Laboratory for Electronics; at the University of Illinois at Chicago Circle, 1965–1968, as Professor of Bioengineering, Neurology and Physiology and Chairman of the Biomedical Engineering Department at the Presbyterian St. Luke's Hospital; at the University of California at Berkeley, 1968–2004, as Professor of Physiological Optics; at the University of California at San Francisco, 1974–2004, as Professor of Neurology and Neuro-Ophthalmology.

One of Stark's major achievements was the introduction of the idea of *feedback* in neurology. His interest in neurology and neurophysiology had developed particularly during his stay in England, in the laboratory of Bernard Katz. Stark felt that classical neurology was inadequate to make sense of the disorder of motor coordination, and therefore he turned to engineering science and cybernetics. Inspired by the quantitative work of Alan Hodgkin and Andrew Huxley, whom he had also met in England, Stark tried to introduce quantitative methods in the study of the central nervous system. Since the motion of the hand was too difficult to start with, he analyzed the pupil of the eye, a one dimensional system, and particularly how the muscle of the iris changes size as a feedback to light. He measured the eye movements by means of the first electronic pupillometer, which provided a quantitative description of the eye movements in the language of the Laplace Transform. His analyses also emphasized the existence of saccadic eye movements and showed that they are nearly time optimal. Thus, he truly pioneered in Bioengeineering, or Biomedical Engineering:

The terms Bioengineering or Biomedical Engineering were not yet in common usage, although Henning von Gierke of Wright Patterson had introduced the name Bionics to describe the process of translating biological principles into technology. Around 1961 or

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1962 Larry organized a one week summer course at MIT on Biological Control Systems—with laboratory demonstrations. All of us in the lab worked assiduously on the project and it was truly a landmark. The attendance list would surely support my recollection that "anybody who was anybody—or was to become somebody" in the field attended it to learn about the analytical methods and success stories for linear control systems. (From L. Young, [3])

Stark's intellectual entourage included such people as mathematical genius Norbert Wiener, information theorist Claude Shannon, biomedical engineer Jerome Lettvin, psychiatrist, mathematician and genius Warren McCulloch, mathematical genius Walter Pitts, motor systems and pain neurophysiologist Pat Wall, neuroanatomist Valentino Braitenberg ... just to mention a few.

Larry Stark (second from the left) at the University of Michigan Willow Run Laboratories together with Prof. Larry Young (standing next to Stark) and other researchers on eye movement models. (taken by Leonard McCombe of Life Magazine in April 1967, Courtesy of Larry Young)

Stark authored or co-authored (he often encouraged his students to be first authors of their joint works) over 400 publications, one book and three edited books. Here is what Warren McCulloch wrote in his foreword to Stark's book *Neurological Control Systems—Studies in Bioengineering*, Plenum Press, New York, 1968:

Concerned with an engineering science approach to four neurological motor feedback systems—the pupil, the lens, eyeball rotation, and hand movement—this volume explores new, ethical methods to deal with the awake, intact brain rather than classical decerebrate and anesthetized animals. Using digital and analog computers to make mathematical models of neurological systems, the work suggests quantitative formulations for deeper interpretation and understanding. Important to all researchers in neurophysiology and allied areas, it indicates the vital strides being made toward increased precision in neurological research. The extraordinary impact of engineering science on neurology is a relatively recent devel-

opment. Reflecting this influence, Dr. Stark's book notes that classical neurophysiology has been found largely inadequate in explaining many encountered in a variety of neurological syndromes. The field has recently attracted many young neurologists who seek to define, measure, quantify, analyze, and form concepts with the same mathematical precision found in the physical sciences.

Lawrence Stark was also an enthusiast teacher. His teaching spanned over neurology, physiological optics, biomedical engineering and telerobotics. He supervised more than three dozen Ph.D. students and tutored numerous post-docs, particularly from Japan (including myself). He always tried to communicate his great enthusiasm to students, and encouraged them to try to imagine new experiments which "would make them famous", and which other people "would consider crazy". He considered "scientists" to be very different from "scientific workers".

Stark's achievements reached well beyond the academic world. His pupillometer was used in the popular film *Blade Runner*. He designed the optics for the rover *Sojourner*, which travelled to Mars.

Larry Stark

References

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[3] L. Young, *Remembering Larry*, May 2005.

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