John Wilder Tukey

American operations analyst, chemist, information scientist, educator, data analyst, statistician and topologist John Wilder Tukey (June 16, 1915 – July 26, 2000) played a key role in the development of 20th century statistics. Throughout his career at Bell Laboratories and Princeton University, he used his creativity, experience and energy to make matchless contributions to statistics and seamlessly bring together the work of scientific, governmental, technological and industrial worlds. Tukey and IBM's James Cooley developed the *Fast Fourier Transform Algorithm*, which was published in the *Mathematics of Communication* (1965). Fourier Transforms, which map information from one space to another, have applications in holograms, wave functions, radio astronomy, digital cell phones, and many other physical sciences and engineering problems. However, they were tremendously difficult to compute until Tukey and Cooley found a faster way. A few decades later, Tukey and others discovered that the algorithm could be used in switching signal processing from analog to digital, that is, in developing programmable digital computers in which the Fast Fourier Transform did the arithmetic.

Tukey made notable contributions to the language of computing. In 1944 he coined the term "bit," an abbreviation of "binary digit," to describe the 1s and 0s that are the basis of the binary code used in all digital computer programs. In a 1958 article in the *American Mathematical Monthly*, he became the first person to define the programs on which electronic calculators ran. Tukey noted that "software" as he called it, was gaining prominence. He wrote, it is "at least as important as the 'hardware' of tubes, transistors, wires, tapes, and the like." Many computer scientists considered Tukey an outsider, which he seemed to acknowledge when he told a colleague, "The best thing about being a statistician is that

you get to play in everyone's backyard."

Tukey was born in New Bedford, Massachusetts, the only child of Ralph H. Tukey and Adah Tasker Tukey. His mother was the valedictorian of the 1898 class of Maine's Bates College and his father was salutatorian. Their classmates voted them the couple most likely to give birth to a genius. Tukey's parents tutored him at home, and except for special subjects like French, he did not attend regular classes until he went to Brown University to study mathematics and chemistry. He graduated from Brown with a bachelor's degree in chemistry in 1936, and in the next three years earned a Master's from Brown in chemistry, and both a Master's and a Ph.D. in mathematics from Princeton. His doctoral thesis, directed by Solomon Lefschetz, was *Denumerability in Topology,* published as *Convergence and Uniformity in Topology* (1940). In 1939 Tukey was appointed an instructor at Princeton, where he remained for the rest of his career.

During WWII Tukey joined the Fire Control Research office, which was concerned with ballistic behavior of rocket power and the accuracy of anti-aircraft height and bomber range finders. His work involved statistics, which he found fascinating. Tukey could not discuss the details of his projects for the government, but his sister-in-law said he helped design the U-2 spy plane. After the war, besides returning to the Princeton mathematics department, he also joined the AT &T Bell Laboratories as a researcher. At the age of 35 he became a full professor and in 1965 was the founding chairperson of Princeton's statistics department. In later years, much of Tukey's work was in the field known as robust statistics, in which he developed theories of how to draw credible conclusions even from flawed data.

Tukey believed that statisticians had lost sight of the original objectives of the discipline, that is, finding methods of analyzing data that described patterns, trends, and relationships, and detected

anomalies. He developed exploratory data analysis, which returned to the original goals of statistics but relied on modern computer methods. Tukey emphasized graphic display to offer new ways of analyzing and presenting data clearly and pioneered what is now called data mining, divining the hidden patterns contained in large amounts of data. It has had a far-reaching impact in fields as diverse as electrical engineering, operations research, and financial risk management. He believed that mathematicians should start with their data and then look for a conclusion, rather than vice versa. Tukey invented numerous graphical and numerical methods that have proven extremely effective in statistical applications. As an example, his *Box-and-Whisker Plots* is a means of displaying groups of data. Typically, five values from a set of data are used: the extremes, the upper and lower quartiles, and the median.

In the 1950's Tukey was appointed to a committee to review the statistical methods used in Alfred C. Kinsey's work on sex research. The latter's 1948 book, *Sexual Behavior of the Human Male*, shocked many Americans by describing the country's sexual habits as being far more diverse than had been previously believed. The two scientists clashed from the time of their first meeting at which Kinsey ordered Tukey to stop singing a Gilbert and Sullivan tune aloud while he was working. Tukey found Kinsey's research methods and his conclusions hopelessly flawed, because of the absence of controlled randomness. Tukey claimed a random selection of three people would have been better than a group of 300 chosen by Kinsey. Kinsey's wife said of the meeting, "I never fed a group of men that I would have so liked to have poisoned…. Tukey was the worst."

Tukey's entire life was one of public service. He was a member of the President's Scientific Advisory Committee for Eisenhower, Kennedy and Johnson. He was a member of a statistical consulting group for RCA/NBC that developed a procedure of projecting election results on the basis of partial counts

and exit interviews. From 1965, he was a consultant for the Educational Testing Service at Princeton, and in the 1970s, Tukey was the chairman of a research committee that warned that aerosol spray cans damaged the ozone layer. The courses he taught at Princeton were on the cutting edge as he had major investigators visit his classes and share their latest work with the students. He retired from both Bell Labs and Princeton when he was seventy, but this barely slowed him down. His wife of 48 years, Elizabeth Rapp Tukey, died in 1998, at which time he expressed his grief in the words, "One is so much less than two." Tukey died of a heart attack after a short illness in New Brunswick, New Jersey on July 26, 2000.

Quotation of the Day: "An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem." – John W. Tukey