# Frederick Mosteller

1916–2006

BIOGRAPHICAL *Memoirs*

*A Biographical Memoir by*
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*and Judith M. Tanur*



NATIONAL ACADEMY OF SCIENCES

# CHARLES FREDERICK **MOSTELLER**

*December 24, 1916-July 23, 2006*

Elected to the NAS, 1974

*By Stephen E. Fienberg, David C. Hoaglin, and Judith M. Tanur*

Frederick Mosteller was one of the twentieth century's most influential statisticians, through his research and educational contributions, his leadership of statistical and scientific organizations, and perhaps most importantly, his involvement in collaborative projects across the scientific landscape, wherever data had an influence on research and policy.

We were each privileged to have Fred (as he was known to his friends, collaborators, colleagues, and students) as a mentor, colleague, and collaborator. We are just three of the many whom he influenced directly by his scientific activities and personal interactions, and indirectly through their colleagues and students. The special volume *A Statistical Model* (Fienberg et al. 1990), published in honor of Fred's 75th birthday, gives an extensive review of many of his contributions and includes an especially noteworthy biography by John Tukey.

Charles Frederick Mosteller was born in Clarksburg, West Virginia, on December 24, 1916, to Helen Kelley Mosteller and William Roy Mosteller. The Mostellers later moved to the Pittsburgh area, and their marriage broke up.

Fred lived mostly with his mother, but he often spent summers working for his father, a highway builder. Those summer experiences included a profound lesson about finishing a job that is nearly done. The highway crew had completed the wooden framing for a large culvert, and pouring the concrete would have required work during the three-day Fourth of July weekend. They were given the weekend off, against Fred's father's judgment, and a severe rainstorm wrecked everything. The effort to re-do the work was greater and more costly than the original project. About that experience, Fred wrote (Mosteller 2010, 132):

*Ever since, when a project comes near to completion, I have an irresistible urge to move heaven, earth, and colleagues to complete it. I am comfortable with a project that has a three-year plan, but if it is within two months of completion, absolutely every effort should be bent to completing it.*

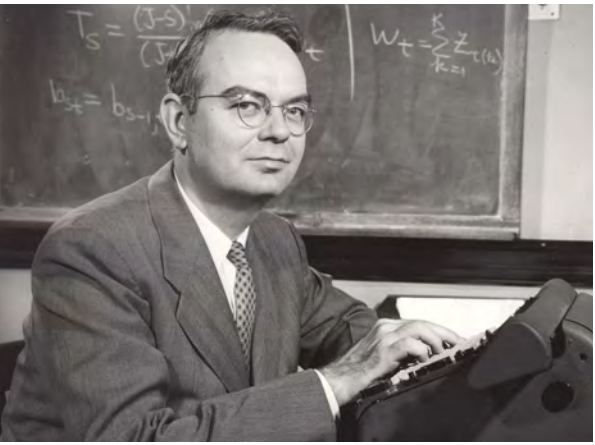
In Pittsburgh, Fred attended Schenley High School and later Carnegie Institute of Technology (now Carnegie Mellon University). During college, his interest in mathematics and, in particular, combinatoric problems led him to the statistician Edwin C. Olds, who in turn steered him into the field of statistics. Fred completed his ScM degree at Carnegie Tech in 1939 and then enrolled at Princeton University to work on a PhD with Samuel S. Wilks. In addition to starting a thesis, he assisted Wilks in his role as editor of the *Annals of Mathematical Statistics*.

Mosteller as a young child.

After the United States entered World War II, Fred taught algebra and trigonometry to Navy and Marine Corps students, consulted for the Research Branch of the War Department on sample surveys, and later moved to New York City to be part of a branch of the Statistical Research Group of Princeton (Wallis 1980), created to support the strategic air force. Working as part of a team on concrete problems with strict deadlines was valuable preparation for service on many committees and panels throughout his career. Returning to Princeton after the war, he resumed his thesis research and had frequent conversations with John Tukey, whom the wartime work had converted from a topologist into a statistician. Those interactions launched their lifelong collaboration, decribed in part by Brillinger (2002).

Fred met his wife, Virginia Gilroy, when he was a college freshman (they rode the same streetcar from Wilkinsburg to the campus each day), and they married in 1941.

In 1946, Fred accepted a position in the Department of Social Relations at Harvard University, where he remained, in various faculty positions, for the rest of his career. The Mostellers moved to their home in Belmont after the birth of their son Bill in 1947. Their daughter Gale was born in 1953. Fred became professor of mathematical statistics



Mosteller in 1955.

at Harvard in 1951, led the effort to create the Department of Statistics in 1957, and served as the department's first chair from 1957 to 1969.

During his years in the Statistics Department, Fred formally supervised seventeen PhD dissertations, but he served on the committees of numerous others in Statistics, Social Relations, and other parts of Harvard. Over the years he was always available to offer comments on works in progress and unpublished manuscripts; wise students took advantage of his generosity.

Fred later served as chair of two other Harvard departments, Biostatistics (1977–81) and Health Policy and Management (1981–87), both in the School of Public Health, and he also taught courses in the Harvard Law School and the John F. Kennedy School of Government.

On retirement in 1987, Fred's base was the Department of Statistics, where he continued his usual array of multidisciplinary projects, working and publishing almost as if there had been no change. From the 1950s until his departure from Harvard in 2003, he worked with his statistical assistant, Cleo Youtz, who was a constant presence in the Department of Statistics and a participant in almost all of Fred's projects.

Following the death of his wife in 2001, Fred moved to Arlington, Virginia, in January 2004 to live closer to his children and grandson. He died on July 23, 2006, after a brief illness, just six months before his 90th birthday. Recognition of his accomplishments came in many forms. He received honorary doctorates from the University of Chicago (1973), Carnegie Mellon University (1974), Yale University (1981), Wesleyan University (1983), and Harvard University (1993). He was an honorary fellow of the Royal Statistical Society and an elected member of the National Academy of Sciences (in 1974), the American Academy of Arts and Sciences, and the American Philosophical Society. Later sections of this memoir describe some of his awards and leadership positions.

## Mosteller as statistical researcher

From his wartime experience onward, Fred's style emphasized collaboration. Coupled with broad interests, it produced important impacts on a wide range of areas. We summarize several major ones. His bibliography (Fienberg and Hoaglin 2006) lists 57 books, 365 papers in journals and books, and 25 reviews. Many of these publications had co-authors or co-editors, totaling more than 200 individuals.

### Early contributions to mathematical statistics

Before he moved toward applications, Fred's research focused on mathematical statistics. Results from his dissertation appeared in a 1946 paper on useful "inefficient statistics," which are functions of order statistics, as alternatives to the more-traditional means, variances, and correlations.

Another paper published the same year, with Girshick and Savage, was on a more classical topic in statistical theory, unbiased estimates for certain binomial sampling problems, which was an outgrowth of a problem they had worked on during the war. Fred followed up in 1948 with a paper describing a $k$-sample slippage test to detect a sample from an extreme population relative to samples from $k - 1$ other populations. This paper also included careful calculations of the size and the power of the test for various values of $k$, an indication of Fred's shifting attention to practical aspects. Another paper on the topic (with John Tukey) appeared in 1950.

### Combining data

Fred's publications on combining data in various settings began with a paper on pooling data (1948), written from a frequentist perspective. He returned to the topic many times in research and applications, using both frequentist and Bayesian perspectives to "borrow strength" for local estimates from more-global (or average) ones.

In the 1970s and especially from the 1980s onward, he led developments in meta-analysis and various medical applications. One major organizational effort was the Technology Assessment Group in the Harvard School of Public Health, which Fred directed, with Thomas C. Chalmers as the associate director.

### Mathematical psychology

Fred's interest in psychological methods led to a sequence of three papers on the method of paired comparisons (1951). When Robert R. Bush (who was trained as a physicist) joined the Department of Social Relations at Harvard in 1949, he and Fred discovered a shared interest in mathematical learning theory.

Their close collaboration produced papers on models and culminated in the book *Stochastic Models for Learning* (1955), which opened a new area of research: mathematical psychology.

Mosteller, right, with W. Allen Wallis and Richard Nixon in the Oval Office, 1971.

### Applied Bayesian inference

During the 1954–55 academic year, while he was a visiting faculty member in the Department of Statistics at the University of Chicago, Fred struck up long-term collaborations with William Kruskal and David Wallace.

Stimulated by conversations with Jimmie Savage and others, Fred and Wallace set out to develop a major application of the Bayesian approach to a scientific problem. They ultimately settled on the puzzle of the disputed *Federalist* papers: whether Alexander Hamilton or James Madison was the author of twelve unattributed papers. This work culminated in a groundbreaking paper in the *Journal of the American Statistical Association* in 1963 and the now-classic book *Inference and Disputed Authorship: The Federalist* (1964), summarized in lay terms in Tanur et al. (1972) and republished in 1984 in expanded form. Their intriguing analyses of the text of the *Federalist* papers include one of the first major uses of Bayesian methods and an early exposition of Laplace's method for approximating distributions, which gained popularity in the 1980s as statisticians began to take large-scale Bayesian computation seriously. Fred's autobiography (Mosteller 2010, Chapter 4) tells the personal story of the collaboration and includes a semi-technical summary of their analyses and conclusions.

### Contingency tables

In 1968, Fred organized a group of advanced and recent graduate students and junior faculty to develop a book built around recent developments in categorical data analysis, especially linked to the use of log-linear models. He had already reviewed some of the contributions in his presidential address to the American Statistical Association (1968):

> *This project ultimately produced* Discrete Multivariate Analysis: Theory and Practice *(Bishop et al. 1975). He was the guiding light behind the*

> *project and our constant editor and sometimes contributor, but in typical fashion he insisted that only Yvonne Bishop, Paul Holland, and I be listed as "authors." Ultimately, he agreed to let us acknowledge his efforts by listing him as a "collaborator" on the title page. (Fienberg in Fienberg and Hoaglin 2006, 2)*

### Exploratory data analysis

Fred kept in close touch with the many statistical developments that led to John Tukey's 1977 book *Exploratory Data Analysis* and contributed to their book *Data Analysis and Regression* (1977). In addition to publishing various examples of exploratory analysis, Fred played a key role in organizing the team effort that produced the two volumes of "The Statistician's Guide to Exploratory Data Analysis": *Understanding Robust and Exploratory Data Analysis (1983) and Exploring Data Tables, Trends, and Shapes* (1985).

### Interdisciplinary projects

Interdisciplinary projects formed a strong thread throughout Fred's career, starting with the committee that examined the failure of the pre-election polls to predict Harry Truman's victory over Thomas Dewey in the 1948 U.S. presidential election (Mosteller 2010, Chapter 1). A sampling illustrates the numerous other examples: the National Halothane Study (1969) (Mosteller 2010, Chapter 5); the Harvard University faculty seminar on the 1966 Coleman report, *Equality of Educational Opportunity* (Mosteller 2010, Chapter 6); the Panel on Weather and Climate Modification; *Costs, Risks, and Benefits of Surgery* (1977); the National Assessment of Educational Progress; and the Institute of Medicine's Committee for Evaluating Medical Technologies in Clinical Use.

### Statistics in sports

Combine a long-term interest in sports with a statistician's curiosity, and what do you get? Statistical analyses of data from baseball, professional football, and golf. Fred was an avid Boston Red Sox fan, and his 1952 paper on the World Series in baseball and his later papers on football helped to launch a sub-discipline in statistics associated with sports, now represented by a separate section of the American Statistical Association.

### Other areas

Fred's research interests took him into many other areas. A partial list includes clinical trials, interpretations of "representative sample" (a major collaboration with William Kruskal 1979–1980), the meanings of probabilistic expressions, coincidences (1989), and number theory (often with a data-analytic component).

## Honors

In honor of his contributions, Fred received numerous awards: the Evaluation Research Society's Gunnar and Alva Myrdal Prize in the Field of Science Research (1978), the Council for Applied Social Research's Lazarsfeld Prize for Applied Social Research (1979), the American Statistical Association's Samuel S. Wilks Award (1986), the Committee of Presidents of Statistical Societies' R. A. Fisher Award and Lectureship (1987), the Medallion of the Centers for Disease Control (1988), and the Harvard School of Public Health's Marvin Zelen Leadership Award in Statistical Science (1997), among others.

## Mosteller as educator

Fred was a master teacher who cared enormously about statistical education at all levels. Those whom he mentored, including many who were not formally his students, learned from his positive attitudes toward teaching and the importance of careful preparation.

Fred in 1980.

Fred practiced every one of his own lectures at least once, speaking out loud, so that he could judge the timing and would not be tempted to speak quickly in order to fit in more material; instead, he cut out chunks of the lecture. Later, he advised others to limit the number of transparencies for their lectures and to put a paper clip on the ones that they could do without (which they would then inevitably not have time to include).

He carefully explained that a topic in a lecture should always follow the PGP prescription: begin with a Particular example to pique student interest, continue with a General point, and then end with a Particular example to drive home the general point. This philosophy was the basis of exposition in Fred's numerous textbooks.

Even in the final year of his formal teaching career, prodded by an example from former Harvard President Derek Bok, Fred systematically changed how he ended a lecture by asking the students to write down what they thought was the muddiest point in the lecture. In the next class he cleared up the muddy points with a more-careful and often in-depth discussion or with a carefully prepared handout (Mosteller 1989).

Beginning in the 1950s, Fred helped lead an effort to bring probability and statistics to American high schools. He was instrumental in producing teachers' manuals, and this led to one of the early elementary statistics texts, *Probability with Statistical Applications* (Mosteller, Rourke, and Thomas 1961).

A version of this book served as the text for his pioneering 1961 televised course on NBC's "Continental Classroom," which was supported by the Ford Foundation. More than 75,000 students took the course for credit at 320 colleges and universities around the country, and 1.2 million watched the lectures on 170 stations, despite its being broadcast at 6:30 a.m.

The 30-minute programs on Monday, Wednesday, and Friday covered the statistical material, and Tuesday and Thursday were problem sessions. Fred wondered "how many [viewers] owed their presence to the six o'clock feeding, or to dialing in a morning news program a bit early" (Mosteller 1962).

Indeed, one of us (JT) had her first introduction to Fred when she was a young mother of two who had had to drop out of graduate school and hoped to return eventually to study statistics. Although not registered in the course, she watched it faithfully, did all the assignments, and was dazzled to find herself just a few years later working directly with Fred on his article about nonsampling errors for the *International Encyclopedia of the Social Sciences* (Mosteller 1968). Fred's account (Mosteller 2010, 258–264) of how he prepared for each episode of "Continental Classroom" offers fascinating insights into both the process of teaching and the workings of early television.

Many textbooks on varied topics followed. Though Fred scratched his itch to teach in all but his most technical work, in particular we note *Sturdy Statistics: Nonparametrics and Order Statistics* (1973), written with Robert Rourke; *Data Analysis and Regression: A Second Course in Statistics* (1977), written with John Tukey; and *Beginning Statistics with Data Analysis* (1983), written with Stephen Fienberg and Robert Rourke.

When the American Statistical Association set up a joint committee with the National Council of Teachers of Mathematics (NCTM) in the 1960s to change the statistical content of the secondary school mathematics curriculum, Fred led the effort once again. He helped to organize, and goaded others into contributing to, the preparation of the ASA-NCTM Committee's early products, including the four-volume collection *Statistics by Example* and *Statistics: A Guide to the Unknown* (Tanur et al. 1972), which has now appeared in multiple forms and editions. *Statistics by Example* was an early instance of

"freeware," designed to give teachers material for use in their classrooms. *Statistics: A Guide to the Unknown* aimed to answer Fred's own recommendation to the NCTM for "a sequence of articles that explained just what the value of probability and statistics is in the real world, outside the sphere of gambling and urn problems—and explain this in much more concrete terms than we have given in the past. Exactly how are these ideas used?" (Mosteller 1967, 829).

In order to convince lay people, especially school board members and school superintendents, of the usefulness of statistics and hence the advisability of including statistics courses in the secondary school curriculum, the essays in these books were written in nontechnical language and described statistical investigations that contributed to advances in a variety of fields including medicine, social science, accountancy, and weather forecasting. The authors were investigators who had done the original research.

Because those professionals were accustomed to writing for their peers, Fred and the other editors had to do a great deal of rewriting to make the material comprehensible to the intended audience. The rewriting gave Fred a chance to exercise his special brand of diplomacy, tailored to the editing process. As he described it (Mosteller 2010, 272):

> *On the Commission [Commission on Mathematics of the College Entrance Examination Board], we had to do a lot of elementary mathematical writing and criticize it. I learned in working with Bob [Robert E. K. Rourke] and George [George B. Thomas, Jr.] how it should go. It was a great education for me. Bob knew that you couldn't tell people how to improve their writing until you had reassured them that their work was good and worth improving. And so he would take a few minutes at the beginning of a discussion to tell you how wonderful your material was. By the time he finished, one knew that the material under discussion would be most important. And so one was panting to hear whether there was any way to improve it, though this surely seemed doubtful in view of the remarks*

> "When a colleague gives you a paper to read, he or she wants to hear how wonderful it is. After you have told that and established yourself as a person of taste, discrimination, and intelligence, the author will be happy to hear your suggestions for improvement, no matter how extensive."

> *made so far. All the same, it would finally turn out that there were a few things that could be improved, several, quite a few, actually a lot; indeed, the whole thing needed a complete body-and-fender job—one of Bob's expressions. But by the time Bob got around to helping you in this way, you were eager to revise.*
>
> *Ever since then I have dinned into my graduate students, "When a colleague gives you a paper to read, he or she wants to hear how wonderful it is. After you have told that and established yourself as a person of taste, discrimination, and intelligence, the author will be happy to hear your suggestions for improvement, no matter how extensive." It works. And if you forget to tell people what you like, they won't listen to your complaints.*

Fred's 1980 article on presentation discusses in detail much of his advice on preparation and presentation (and gives advice on what to do when things go wrong despite careful preparation). It remains "must" reading, as it has been for generations of graduate students and faculty.

## Mosteller as scientific organizer and professional leader

Fred's talent as an organizer was recognized by many organizations that came to him for help with projects and to fill leadership positions. Among the societies he led as president are the Psychometric Society (1957–58), the American Statistical Association (1967), the Institute of Mathematical Statistics (1974–75), the American Association for the Advancement of Science (1980), and the International Statistical Institute (1991–93). He also held other society offices and served on numerous boards of directors.

In 1970–71 he served as vice-chair of the President's Commission on Federal Statistics, which led to the creation of the Committee on National Statistics at the National Research Council (NRC ). At the NRC and elsewhere he served on so many statistical and interdisciplinary committees and task forces that one observer (Lowrance 1985, 87) remarked:

> *Applied mathematicians are of course essential in most assessments, for help in designing tests, auditing calculations, and assisting in the drawing of conclusions. Much of this is routine craftwork. But one unusual, crucial*

*role should be recognized. It is my guess that statisticians Frederick Mosteller (Harvard) and John Tukey (Princeton) have served on or assisted more technical committees than anybody else alive....It is not just their ability to manipulate numbers that keeps these experts in demand, but sensibility in thinking through questions of macro-experimental design: how inquiries should be cast, what evidence and logic are applicable, how discrimination can be increased, how uncertainties and sensitivities should be probed, what inferences are allowable from evidence. Mosteller and Tukey outlined this role in an article in 1949 in which they called for education of "scientific generalists" who would master "science, not sciences" (Bode et al. 1949).*

An important early example is the American Statistical Association Committee to Advise the National Research Council Committee for Research in Problems of Sex, in which Fred joined William Cochran and John Tukey. Their report was published as the monograph *Statistical Problems of the Kinsey Report on Sexual Behavior in the Human Male* (1954).

Mosteller, left, with John Tukey and William Cochran.

The numerous other committees on which Fred participated include the NRC 's Oversight Committee on Radioepidemiologic Tables, the Institute of Medicine's Committee for Evaluating Medical Technologies in Clinical Use, the Committee to Review the Adverse Consequences of Pertussis and Rubella Vaccines (Institute of Medicine), the Committee for Guidance on Setting and Enforcing Speed Limits (NRC ), and the Committee on Equivalency and Linkage of Educational Tests (NRC ).

## Conclusion

At the age of 88, most people have been long retired and are engaged in leisure pursuits. Yet, even after Fred had been officially retired for 18 years, he remained active. The final publication in his full bibliography (Fienberg and Hoaglin 2006) was, fittingly,

a biographical memoir of his longtime collaborator, John Tukey, for the *Proceedings of the American Philosophical Society*, which was published in 2005.

He will remain a role model for statisticians and other scientists whom he mentored, taught, and otherwise influenced over the years. And those who were lucky enough to have had personal contact with him continue to pass that legacy on.

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