Book Review

The Triumph of Numbers:
How Counting Shaped Modern Life
and
Karl Pearson:
The Scientific Life in a Statistical Age

Reviewed by Brian Blank

The Triumph of Numbers: How Counting Shaped Modern Life
I. Bernard Cohen
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Karl Pearson: The Scientific Life in a Statistical Age
Theodore M. Porter
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"We live in a world of numbers." So begins *The Triumph of Numbers*, the posthumously published book of the eminent historian of science, I. Bernard Cohen. The numbers he refers to are wages, taxes, consumer prices, financial records, economic reports, demographic data, sports statistics, and the like. When did this numerical deluge begin? Too long ago for us to know! Even before the formation of the first civilizations, several Neolithic communities scattered about the Mediterranean left behind stones and ostraca bearing numerical archives of trade, personal services, interest rates, and gambling debts. As civilizations emerged, societies and governments increasingly relied on numbers to manage the ever greater complexities of daily life. Archeologists have unearthed thousands of Sumerian tablets bearing records of commercial transactions that took place more than 5,000 years ago. It is not surprising that numbers are found so frequently in prehistoric artifacts: these numerical symbols predate writing precisely because they played a crucial part in the development of writing. As the historian Will Durant once remarked, "The berated bourgeoisie may take consolation in the thought that literature originated in bills of lading."

Cohen begins his study of numbers with the Narmer Macehead, which dates from the thirty-first century B.C.E. and is now housed in Oxford's Ashmolean Museum. It has much to excite different sorts of historians. The writing it bears is among the earliest yet found. The king it depicts is one of the earliest named historical persons, the pharaoh Narmer. The event it commemorates is thought to have taken place shortly after the unification of Upper and Lower Egypt and the establishment of the first Egyptian dynasty. All very important to some, but to a historian like Cohen the relic contains another lesson that should not be overlooked: the census figures that are carved in relief on the macehead—120,000 (adult men), 400,000 (cattle), and 1,422,000 (small animals)—show that the ancient Egyptians were able to write very large numbers. Such capabilities were essential for the construction of the Great Pyramid at Giza, which was erected according to a meticulous design requiring some 2,300,000 stone blocks. After discussing the Great Pyramid in thorough numerical detail, Cohen concludes his first chapter by outlining those aspects of the world of numbers that are the focus

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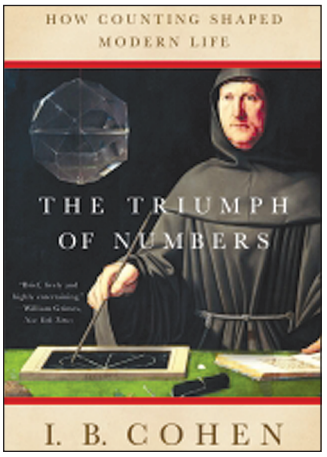
of his investigation: "Our mission from here on is to explicate some of the important and interesting steps whereby the analysis of society, the conduct of government, the regulation of daily life, and the understanding of nature came to be."

The second chapter provides a good illustration of Cohen's plan and execution, his successes and failures. After a capsule treatment of Kepler's third law, Cohen turns to Galileo's study of constantly accelerated motion. Here, as elsewhere, the discussion is aimed at a general reader. Thus, when Galileo is said to have confirmed his formula for free fall by experimenting with a ball rolling down an inclined plane, Cohen assumes that the reader will not notice that the second dynamical problem involves rotational kinetic energy, which is not present in the first. Cohen's survey of the seventeenth century, an era with which he was particularly associated, continues with William Harvey's investigation of the circulation system, Anton Van Leeuwenhoek's estimate of Earth's carrying capacity, Edmond Halley's contributions to insurance annuities, John Graunt's analysis of London's *Bills of Mortality*, and William Petty's advocacy of "Political Arithmetick". It is a tribute to Cohen's narrative skill that he is able to string together such a hodgepodge of case studies so coherently. Moreover, he has enlivened each topic with fascinating, unsuspected details. Thus, even the reader who is well acquainted with elementary mechanics may be surprised to learn Galileo's own description of his discovery: "The distances traversed during successive equal intervals of time by a body falling from rest stand to one another in the same ratio as the odd numbers beginning with unity." Leeuwenhoek's pioneering contributions to microscopy are well known, but how did they lead to an interest in demography? The answer, we discover, is that Leeuwenhoek found it difficult to convey the minuteness of spermatozoa at a time when microscopes were in the hands of only a few scientists. He solved his problem by estimating that the Earth could support a maximum of 13,385,000,000 human beings, a population dwarfed by the number of "little animals in the milt of a cod".

The discourse on John Graunt touches upon two of Cohen's themes: the analysis of society and the conduct of government. Following an episode of plague that struck London in 1603, the government published broadsides called *Bills of Mortality* at regular intervals. By listing the number of deaths per week according to cause, these advisories alerted rich Londoners to any increase of disease that might suggest a precautionary retreat to the shelter of the countryside. Graunt's study of the *Bills*, originally published in 1661 or 1662, is considered to be the first statistical analysis ever undertaken. In addition to calling attention to numerous unsuspected societal regularities, such as the near constant percentage of deaths attributable to suicide, Graunt published credible estimates of London's population and its growth rate. Allowing for plagues, he found that "in eight times eight years the whole People of the City shall double without the access of Foreigners." Graunt, it should be noted, was well aware that a constant doubling time is not indefinitely sustainable. As he quaintly explained, "One couple, viz. Adam and Eve, doubling themselves every 64 years of the 5610 years, which is the age of the World according to the Scriptures, shall produce far more People, than are now in it."



Kepler, Galileo, Harvey, Leeuwenhoek, Halley, Graunt, and Petty—all these essays are packed into a mere twenty-one pages of text. It is inevitable that such brevity results in missed opportunities and incompleteness. Petty's political arithmetic, a statistically based statecraft using algebra for its analysis, is explained in theory, but no application is mentioned. It might have interested the reader to learn that Petty advised the government to combat the plague on economic rather than humanitarian grounds. Funds devoted to fighting the plague, Petty argued, would be profitably invested: the money used to save adult lives would preserve the far greater sums that had already been expended in rearing those individuals to maturity. We are familiar with similar public policy reasoning in modern life, but other suggested uses of political arithmetic now seem startling. As Theodore Porter relates in his study of social statistics [9], "Petty proposed that all Irishmen, save a few cowherds, should be forceably transported to England, for since the value of an English life far surpassed that of an Irish one, the wealth of the kingdom would thereby be greatly augmented."

The last six of Cohen's nine chapters are largely concerned with social and medical statistics. One chapter is devoted to the Belgian sociologist and statistician Adolphe Quetelet (1796–1874), who has been receiving his due in recent years [9], [12], [13]. Less well known is the Parisian lawyer and amateur statistician André-Michel Guerry (1802–1866), who is the subject of Cohen's shortest chapter. Simultaneously but independently, both men analyzed the records of criminal activity that the French government began to publish in 1827. Both were astonished by the regularity with which lawbreaking occurred. Guerry found it difficult to reconcile the constant crime rate with "the infinite number of circumstances that can cause the commission of a crime." Quetelet, believing that the puzzling data could be explained only by a societal component of criminality, concluded that

"Society prepares the crime and the guilty person is merely the instrument by which it is executed." There were many other unsuspected patterns for Guerry and Quetelet to pry from the data. Contrary to expectation, regions with the most educated inhabitants had the highest incidences of crime. One curious correlation noticed by Guerry when he scrutinized suicide records was paraphrased by an astounded English contemporary in this way: "The method by which a person destroys himself is almost as accurately and invariably defined by his age as the seasons are by the sun."

By contrasting nineteenth-century France with seventeenth-century London, we recognize the dawning of a new age of numerical information, an era characterized not only by the assiduousness with which nineteenth-century governments collected and disseminated demographic, social, and medical data but also by a heightened awareness that useful information could be gleaned from a careful study of the tables that were pouring forth. Whereas the *Bills of Mortality* waited nearly sixty years for a John Graunt, the *Compte Général…de la Justice Criminelle* was mined almost instantly by Guerry and Quetelet. Nevertheless, as the bandying of statistics grew, so did the number of critics. In *The Triumph of Numbers*, Cohen uses Charles Dickens, depicted as a well-meaning reactionary who "abhorred the introduction of numbers into discussions of human affairs," to represent the opposition to statistics. Other historians are more receptive to the contention of Dickens that statistics were being manipulated to discount the plight of the working poor. According to Michael Cullen [3, pp. 136, 144], to cite one example, "the statisticians were uniformly committed to policies of economic laissez-faire" and, in order to block labor reform, "disguised propaganda as facts." It was in the nineteenth-century, after all, that Saint Thomas Aquinas's long-standing classification of lies into three kinds—namely the jocose, the officious, and the malicious—evolved into the jibe "There are liars, there are outrageous liars, and there are scientific experts," which in turn mutated into the surviving barb "There are three kinds of lies: lies, damned lies, and statistics." (Cohen's assertion that "scholars now assume that this saying was invented by Mark Twain" is misleading: some scholars cite earlier uses [5], [6].)

Statistical applications in healthcare also had to overcome entrenched resistance. Physicians, striving for the ideal of certitude, often regarded probabilistic reasoning as unscientific. Furthermore, when the first attempts to introduce statistics into medical practice were made, the general public was not ready to place its trust in numbers. The deadly scourge of smallpox in the American colonies is a case in point. Before Edward Jenner discovered vaccination in 1796, the only preventive measure against smallpox was deliberate exposure to a mild case with the goal of survival and future immunity. This procedure, known as *variolation*, originated in seventeenth-century China and reached colonial America by the early 1700s. Despite some fervent advocates, the Puritan minister Cotton Mather included, variolation was distrusted by the public. As a result, waves of smallpox epidemics ravaged the colonies; one outbreak in 1736 took Benjamin Franklin's four-year-old son. In 1756 and 1759, Franklin, who bitterly regretted not having inoculated his child, published pamphlets in support of variolation. To "Parents who omit that Operation on the Supposition that they should never forgive themselves if a child died under it," Franklin cautioned, "my Example [shows] that the Regret may be the same either way, and that therefore the safer [option] should be chosen."

Franklin's strategy for convincing parents of the wiser choice was to analyze the relevant mortality statistics. Of course, his tactic now seems obvious, so far has our acceptance of statistical argument come, but it was inventive for its time. At one smallpox hospital Franklin found the death rate from inoculation to be 6 out of 1,601. At the same hospital 1,002 patients out of 3,856 who contracted smallpox "in the common way" died. Cohen does not directly say whether Franklin published or even determined the incidence of smallpox in the population, a statistic that is necessary for deciding the more prudent course. However, Cohen does quote Franklin's claim that the chance in favor of inoculation was as high as *thirty* to *one* (Franklin's emphasis). Given that epidemics in Boston in 1752 and Charleston in 1738 infected, respectively, 37.5 percent and 50 percent of the inhabitants of those cities, we see that Franklin's analysis was on the mark [1], [4]. The question then becomes, Did Franklin's advocacy of variolation have any measurable effect? Cohen is silent on the subject, but the evidence suggests that Franklin's efforts did *not* result in any triumph of numbers. Smallpox continued to decimate America for decades. Four years after Franklin's first pamphlet, Charleston suffered an epidemic that afflicted 75 percent of its citizens. In 1776, during Benedict Arnold's siege of Quebec in the American Revolutionary War, 1,200 of his 3,200 troops suffered from smallpox—the same incidence rate found in Boston a quarter of a century earlier [2].

The Triumph of Numbers concludes with a chapter that is entirely devoted to Florence Nightingale. Her interest in statistics, although fairly well known, is usually covered so perfunctorily in the mathematical literature (and often only for her commentary on Quetelet) that it is good to have Cohen's lengthier discussion. In 1854 Nightingale was dispatched to the Crimea in response to reports that appalling conditions were prevalent in British military hospitals. To convince the authorities that lives were being needlessly lost on a tragic scale,

Nightingale carefully collected hospital records and analyzed the causes of death. In one finding, she determined that the annual mortality rate in British hospitals in Turkey and the Crimea was 1,174 deaths per 10,000 patients, of which 1,023 per 10,000 were the result not of battle wounds but of disease. Her recommendations called for clean water, improved ventilation, proper sewage disposal, and hot water for laundering, measures that sharply reduced hospital mortality within one month of their implementation. This lesson should have been learned once and for all, but Nightingale had to repeat her algorithm of mortality analysis, nagging, and cajolery in order to win sanitary reform in other locales. Realizing that "none but scientific men ever look into the appendices of a Report," she took pains to augment her tabulated data with graphical presentations. To that end she introduced a type of pie chart, which she called a coxcomb, in which the sectors have equal angles but variable radii.

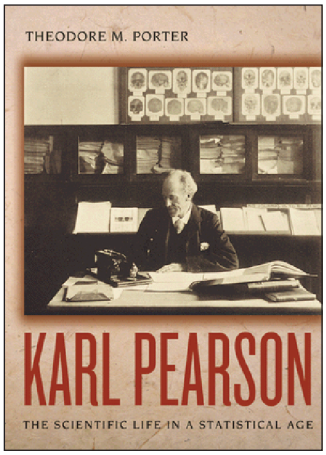
With the story of Florence Nightingale drawing to a close, the reader may sense that a triumph of numbers is near at last. Up until this point, Cohen's case studies have represented the significant steps that are promised in the first chapter but not the triumph that is announced in the title. Thus, when Cohen relates Nightingale's reduction of mortality in India from 69 British troops per 1,000 to 18 per 1,000, it appears that he is finally ready to drive home George Sarton's maxim "Humanity must be protected by the watchful Statistician." Instead, Cohen concludes with a less decisive message sent by Nightingale to Francis Galton in 1891, a letter that thirty years later prompted Karl Pearson to despair, "We are only just beginning to study social problems—medical, educational, commercial—by adequate statistical methods, and that study has at present done very little in influencing legislation." It is a dispiriting note on which to end and an enigmatic one too: why did Cohen bring his story to an abrupt halt a decade short of the twentieth century? A two-page epilogue mentions the punch card that Herman Hollerith invented to process the American census data of 1890, but this brief reference is not a convincing bridge between Florence Nightingale and the digital age. Perhaps a clue to Cohen's seemingly arbitrary close may be found in his *New York Times* obituary, which states that *The Triumph of Numbers* was originally envisioned as *The Fate of Mankind in a World of Numbers* [11]. The *Times* writer goes on to say that the manuscript was mailed the week before its 89-year-old author died. We are left to wonder if Cohen had planned a somewhat different book but wrapped it up when time grew short.

Whatever the case may be, what we do have is a well-written, engaging work that requires few allowances for the adverse conditions under which it was completed. Despite declining health and loss of vision, Cohen was able, for the most part, to bring to his last book the care and scholarship with which he was long associated. The *Numbers in History* section of the first chapter does, however, require some caution. Here Gaspard Monge is said to have invented projective geometry rather than descriptive geometry. Several factoids, apparently repeated from inaccurate secondary sources, are misleading or wrong. Dates are sometimes incorrect (the Narmer Macehead) or inconsistent (the Great Pyramid). Few miscues appear after this section, but several of Cohen's opinions may strike the reader as questionable. Christiaan Huygens, for example, is described as "really comparable with Isaac Newton." Fourier, according to Cohen, is "particularly remembered for his contributions to the mathematical theory of probability." The assertion that Laplace was "the most important mathematician since Isaac Newton" will be considered heretical by readers who see it as a demotion of Euler in the pantheon.

The Triumph of Numbers is neither the capstone of a long, distinguished career nor a technical history of statistical methods. Cohen has written a modest book aimed at the nonspecialist who has never noticed the prevalence of numerical data in modern society or who, having taken such notice, has wondered how society came to be so quantified. Because *The Triumph of Numbers* demands nothing more of its readers than a desire to be entertained and informed, it will reward a wide audience. For the mathematically sophisticated, its greatest value will lie in stimulating an interest in the rise of statistics. To those who wish to delve deeper, the books by Porter [9], [10] and Stigler [12], [13] are especially recommended.

For readers of the *Notices*, Theodore Porter's newest book, a study of Karl Pearson, also comes to mind as a natural follow-up to *The Triumph of Numbers*. Indeed, the continuation of the timeline is perfect: Pearson began his statistical work the year after the Nightingale letter with which Cohen's history concludes. From that time until the arrival of Ronald Aylmer Fisher decades later, Pearson dominated (in more than one sense) the statistical scene. During its first ten years his biometric school contributed about half of Britain's statistical work. Before these efforts only about 2 percent of papers presented to the Royal Statistical Society dealt with statistical methods [7]. It was largely Pearson who transformed statistics into a branch of mathematical analysis.

The pertinent facts of Karl Pearson's life can be outlined as follows. He was born in 1857; was educated at Cambridge, where he took third wrangler in 1879; was appointed Goldsmid Professor of Applied Mathematics and Mechanics at University College London in 1884; and was selected for the Gresham Lectureship of Geometry in 1891. After being influenced by the economist Francis Ysidro



Edgeworth in 1891 and the biologist Walter Frank Raphael Weldon in 1892, Pearson took up statistics as his vocation in 1892, published his first paper in statistics and coined the term *standard deviation* in 1893, introduced the product-moment correlation formula in 1896, developed the χ^2 test for goodness of fit in 1900, cofounded the journal *Biometrika* in 1901, founded the Biometric Laboratory in 1903, became the first director of Galton's Eugenics Laboratory in 1907, became the first Galton Professor of Eugenics in 1911, founded the *Annals of Eugenics* in 1925, retired in 1933, and died in 1936. His son, Egon Sharpe Pearson (1895–1980), also a leading statistician, became Karl's first biographer in 1936. (For the remainder of this review, "Pearson" will refer to Karl.)

As Stigler has remarked, throughout his adult years Pearson did the work of three men, but before his conversion to statistics it was always in three different fields [12]. In fact, German history, literature, folklore, philosophy, intellectual politics, applied mathematics, physics, and engineering all occupied Pearson to some extent before he turned to biometry, heredity, and other topics that share a statistical theme. Prior to his first paper on statistics, Pearson's publication list numbered one hundred items, nine of which were books (including a fictionalized autobiography and a passion play). Porter describes the Pearson of these years as a "thoroughly restless intellectual." Toward the end of this formative period, Pearson expressed misgivings that he was regarded as a "second-rate mathematician who indulges in extreme views & dabbles in journalism." He confessed to his fiancée, "I look back & round on all the odds & ends of careless & superficial work, which mark my life & make me shudder sometimes at the energy & time frittered away attempting what was not within my powers." Nearly forty years later, a few years after he had been offered the Order of the British Empire, which he refused, and a few years before he was offered a knighthood, which he also refused, Pearson continued to express doubts about his research: "Twenty years hence a curve or a symbol will be called 'Pearson's' & nothing more remembered of the toil of the years."

Pearson was prescient in that *his* name is commemorated primarily by the Pearson correlation coefficient—it is Egon who is remembered when Neyman-Pearson is cited. However, the toil of Karl's years, far from being forgotten, has inspired a vast literature scattered among the journals of diverse fields such as sociology, economics, psychology, genetics, medicine, and epidemiology (in addition to more obvious ones such as statistics and the history of science). For some time now, an expert synthesis has been overdue. Although Egon's memoir [8], written in the year of Karl's death when memories were fresh and documents handy, remains a valuable resource, it is more of a guide to Karl's career in statistics than a proper biography. Furthermore, Egon lacked three important advantages that are available to a modern scholar: the passage of enough time to assess the lasting value of Karl's contributions to science, the objectivity that so polemical a subject as Karl requires in a biographer, and the extensive historical and sociological research that has appeared in the seventy years since Karl's death.

For the connoisseur of biography, the first six chapters of Porter's *Karl Pearson* will prove impressive. Such a reader is bound to marvel at the extent to which Porter immersed himself in Pearson's world, studying the cultural and intellectual currents that Pearson navigated, absorbing the books that influenced Pearson, and travelling down the many dead ends of Pearson's wander years. This part of *Karl Pearson* can be recommended as a self-contained Bildungsroman to both the historian of the Victorian era and the aficionado of biography. The last of these chapters, "Intellectual Love and the Woman Question", presents a particularly intriguing account of Pearson's courtships, all of which were pursued with characteristic eccentricity. In the wooing of Maria Sharpe, for example, Pearson followed his marriage proposal with written confessions of his personality defects. The tactic of admitting hypersensitiveness, self-consciousness, selfish tendencies, and "an almost equally vicious tendency to periods of depression & moroseness" did not disarm Maria immediately, but after nearly a year of anxious deliberation she did accept his offer.

Pearson's marriage in 1890 is the last event in the biographical thread of Porter's book. Excluding a brief epilogue, the final quarter of Porter's study concerns the "statistical impulse" that seized Pearson soon after he wed. How Pearson discovered his vocation after so many false starts is an interesting question. In 1934 Pearson himself asserted that "It was Galton who first freed me from the prejudice that sound mathematics could only be applied to natural phenomena under the category of causation." As Porter has previously observed [9, p. 299], Pearson was either forgetful or disingenuous in this reference to Galton's *Natural Inheritance*. In fact, reporting on Galton's book in 1889, Pearson warned of the "considerable danger in applying the method of exact science to problems in descriptive science." Stigler has suggested that Edgeworth was the pivotal figure in Pearson's turn to statistics [12, p. 305], whereas Porter in his first book concluded that it was only through Weldon that Pearson came to accept Galton's statistical approach [9,

p. 299]. In his new book, Porter attributes Pearson's conversion to "a new vision, one that he acquired not through a single Eureka experience but episodically, over about three years." Porter continues, "Initially his new interest in statistics grew out of an ideal of education, the cultivation of a more effective citizenry." This judgment is reinforced pages later when Porter endorses the widely held view that eugenics motivated and even shaped Pearson's statistical work.

The two chapters that Porter allots to Pearson the statistician concentrate on Pearson's most creative period, the last decade of the nineteenth-century. Because of this narrow focus, very little is said about Pearson's final thirty years, a period of rapid progress in statistics during which Pearson continued to play a prominent though diminishing role. In contrast to the attention lavished on the cultural and social milieux that molded Pearson, the statistical enterprise that Pearson so greatly influenced is largely neglected. William Sealy Gosset, better known by the pseudonym "Student", is mentioned only once, even though he published almost exclusively in Pearson's *Biometrika*. Florence Nightingale David, an assistant of Pearson's who went on to have a distinguished independent career, is not mentioned at all. Pearson's professional disputes were too numerous to receive full coverage, but it is regrettable that Porter does not include a detailed account of Pearson's especially acrimonious and protracted feud with Fisher. Their squabble, which started during World War I, flared up in 1922, and occupied Pearson on multiple fronts in the last few months of his life, is of great interest not only for the many important statistical issues that were raised but also for the nature of the personal combat. "*Wasting your time fitting curves by moments, eh!*" was the opening salvo in one of Pearson's last papers, a public reply to Fisher's attacks on his method of moments and system of frequency curves.

Porter, in a reflexive epilogue concerning methodology and conclusions, confesses that contrary to the general view of scholars he has come to regard Pearson as a figure that is more tragic than malign. Porter's readers may be disinclined to share this assessment, particularly because Porter does not conceal Pearson's offensive beliefs and behaviors. Thus, Porter characterizes the personal insults that Pearson liberally inserted into *Biometrika* as "pointless and petulant" and describes Pearson's writings as "uncourtly", "unattractive", and "disturbing". Porter also exposes Pearson's smug racism and deeply held eugenic sentiments. Here, however, his analysis would have had even greater effect had he quoted Pearson more extensively. Consider, for example, the ideal of education and the cultivation of a more effective citizenry, the key factors Porter cites in Pearson's conversion to statistics. These seem to be benevolent motivations when Porter refers to them, but Pearson's own words reveal a more sinister intent: "It is cruel to the individual, it serves no social purpose, to drag a man of only moderate intellectual power from the hand-working to the brain-working group," "Intelligence can be aided and trained, but no training or education can create it. You must breed it," and "From a bad stock can come only bad offspring, and if a member of such a stock is, owing to special training and education, an exception to his family, his offspring will still be born with the old taint."

Though fairness may be in danger when a historical figure is judged by the ethos of a later era, the declaration of Pearson-trained statistician George Udny Yule that "Votes for women is for me nearly as loathworthy as eugenics" demonstrates the abhorrence of eugenics among even those of Pearson's contemporaries who do not seem enlightened by present-day standards. If nothing else, Pearson's biometric interests remind us that anthropometry and craniometry were flourishing at the end of the nineteeth-century. The cephalic index would soon be joined by other contentious numerical measures such as IQ, the general intelligence factor g, and Pearson's own *coefficient of racial likeness*. Cohen did not have to confront such argumentative quantities in his book because of his choice of time frame. Will future historians who update his story be able to speak of a *triumph* of numbers?

Because Porter's *Karl Pearson* is neither a conventional biography nor a thorough account of Pearson's career in statistics, it will seem to fall between two stools. If a classifying label is needed, then *microhistory*, the term Porter uses in his epilogue, is apt. Many readers of the *Notices* will regret that Porter did not write a different sort of book, but no reader of *Karl Pearson* will have cause to wish for a more successful book of its type. Of course, there is still much work for a Pearson scholar to do. Now that nineteenth-century Pearson has received so outstanding a treatment, we may hope for the arrival of another biographer to chronicle twentieth-century Pearson with equal mastery.

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