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The Mathematics of Society: Variation and Error in Quetelet's Statistics

Theodore M. Porter*

"LET us apply to the political and moral sciences the method founded upon observation and upon calculus, the method which has served us so well in the natural sciences."[1] The social sciences have known no truer follower of Laplace's dictum than Adolphe Quetelet. His *mécanique sociale*, later *physique sociale*, was conceived as the social analogue to Laplace's *mecanique celeste*, and embodied the results of an unswerving commitment not only to the presumed method of celestial physics, but even to its concepts and vocabulary. It is too weak to say that Quetelet's goal was the transmission of the achievements of celestial physics into the social sphere. He aspired to nothing less than imitation.

Quetelet's social physics won no important converts, and it has never been seen as a viable approach to the human sciences. Like so many other admirers of astronomy and physics among students of the social disciplines, Quetelet was unable to lay hold of that essential element of scientific method that would enable him to extend the domain of scientific certainty into the social sphere. Historians of the mathematicization of the social sciences have been able to make little more of Quetelet as social physicist than a precursor, and the failure even of enthusiastic admirers to take up his program requires no deeper explanation than the observation that Quetelet himself never carried it beyond the programmatic, or even indicated how that could be done.

Yet the story of Quetelet's social physics is not one of failure, but of irony. His determined attempt to bring together mathematics and social science brought little direct benefit to social science, but much to applied mathematics, for the formulas that Quetelet sought to carry over from the domain of physics to that of society invariably took on new meanings when

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The following abbreviations will be used: *NMB: Nouveaux mémoires de l'académie royale des sciences et belles-lettres de Bruxelles* (after 1840, *de Belgique*); *AO: Annuaire de l'observatoire de Bruxelles; BCC: Bulletin de la commission centrale de statistique* (of Belgium).

Translations from works cited in French are my own.

[1] Pierre Simon de Laplace, *Philisophical Essay on Probabilities*, 2d ed., New York, 1917, pp. 107–8.

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applied to new referents. In particular, Quetelet's unwitting reinterpretation of the astronomer's error curve was a major step in converting it into the normal distribution. To understand this fundamental contribution to mathematical statistics as the outcome of Quetelet's peculiar approach to social science is the principal object of the present essay.

I. *Quetelet, Astronomer and Statistician*

The significance of Quetelet's statistical writings arises precisely from the impossibility of placing them in a single well-defined tradition, for his achievement was first of all an act of synthesis. The character of the traditions that he inherited is full of interest for its own sake, but our present purposes are best served by observing them through the prism of Quetelet's own experience.

Born in 1796, "in the aftermath of the revolutionary troubles that agitated France and the provinces of our kingdom,"[2] Quetelet grew up a citizen of the Belgian portion of the French empire. Though initially attracted to art, he did not fail to note the "munificence" with which Napoleon bestowed upon the sciences "a part of the prestige that surrounded him,"[3] and when circumstances led him to seek a degree in mathematics at the new university of Ghent under the old French revolutionary and examiner at the Ecole polytechnique, J. G. Garnier, he was not slow to seek public support for his own scientific endeavors. Indeed, from 1820 on his highest goal was to create a strong scientific movement in Belgium by establishing a network of institutions and positions.

In many ways the time was ripe for a creative Belgian scientific entrepreneur to undertake such a task. The Brussels Academy, refounded in 1816, was only a small group of elderly gentlemen when the energetic young Quetelet was elected to membership in 1820, and he was able quickly to establish a dominant place in it. Already in the early 1820s he began to envision an academy devoted principally to research on his special interests, corresponding roughly with what Cannon has called "Humboldtian science"—the quantitative natural history of stars, tides, weather, plant blooming times, terrestrial magnetism, and human population.[4] The government of the newly-united Netherlands, set up by the Congress of Vienna as a bulwark against future French expansion, was eager to support institutions that were visible to the public, especially in the southern provinces, where it needed to promote a sense of loyalty. The state

[2] Quetelet, "Notice sur Pierre-Joseph Braemt," *Annuaire de l'académie royale des sciences et belles-lettres de Belgique*, 23 (1867), 108–120, p. 108. The colleague of whom this was written was born just a few months after Quetelet in the same Belgian city, Ghent.

[3] Quetelet, *Histoire des sciences mathématiques chez les Belges*, Bruxelles, 1864, p. 312.

[4] Susan Faye Cannon, "Humboldtian Science," in *Science in Culture: The Early Victorian Period*, New York, 1978. On Quetelet's scientific ambitions, see Quetelet, *Sciences mathématiques et physiques chez les Belges au commencement du XIX^e siècle*, Brussels, 1866, p. 9; *Histoire* (n. 3), pp. 375–6; *Physique sociale, ou essai sur le développement des facultés de l'homme*, 2 vols., Brussels, 1869, t. 2, 446 ff.

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created a network of universities, lycees, and museums, and candidates sponsored by Quetelet came to fill many of the science positions.[5] It also provided essential financing for a scientific journal set up jointly by Quetelet and Garnier in 1825, the *Correspondance mathématique et physique*.[6]

The scientific institution of the most direct importance for Quetelet's own career was the Brussels Observatory, which he headed from the early phases of its construction in the 1820s until his death fifty years later. As early as 1823 Quetelet was given money to travel to Paris and to learn enough about the methods and instruments of observational astronomy so that he could direct the construction of the observatory in Brussels. In Paris he was taken in by Bouvard at the Observatory of France, and introduced to many of the great men of French science, including Laplace, Poisson, Fourier, and Lacroix. From these men, Quetelet tells us, he acquired his taste for statistics.[7]

Thus the young man who ventured to Paris to learn observational astronomy returned to Belgium an enthusiast for the nineteenth-century empirical science of society, statistics. The vehicle for this extension of his interests is easy to surmise: mathematical probability. By the 1830s the probabilistic method of least squares was an essential tool for the reduction of astronomical observations. Related techniques were championed by Fourier and by Laplace's circle as indispensable for appreciation of the accuracy of statistical measures in social science. Laplace himself, whom Todhunter deemed the single most important figure in the history of probability theory, wrote extensively on the use of probability to estimate the size of a population from birth or death records, and to determine whether the difference between two mean numbers—such as the male to female birth ratios of London and Paris—indicated the existence of a fixed cause or could have been produced by chance. Indeed, he developed much of the apparatus of error analysis, including his use of the astronomer's error curve, $1/\sqrt{2\pi}\ e^{-x^2/2}$ (now known as the Gaussian or normal distribution), precisely in the context of such problems.[8]

Here was a style of statistics that was congenial to an ambitious young astronomer. These were the men, along with Pascal, Fermat, Halley, DeMoivre, Wargentin, Lambert, Kersseboom, Condorcet, and Lagrange, whose names most often appear in Quetelet's sketches of the history of

[5] Quetelet, "Aperçu de l'état actuel des sciences mathématiques chex les Belges," *British Association for the Advancment of Science, Reports* (1835), 35–59.

[6] See H. Elkhadem, "Histoire de la *Correspondance mathématique et physique* d'après les lettres de Jean-Guillaume Garnier et Adolphe Quetelet," *Académie royale de Belgique: Bulletin de la classe des lettres et des sciences morales et politiques*, [5] 64 (1978), 316–366.

[7] Quetelet, "Des lois concernant le développement de l'homme," *AO*, 38 (1871), 205–216.

[8] Laplace, "Mémoire sur les probabilités" (1781), *Oeuvres complètes*, 14 vols., Paris, nouvelle ed., 1878–1912, t. 9, 383–485; "Mémoire sur les approximations qui sont fonctions de très grands nombres" (1785), *Ibid.*, t. 10, 195–338; "Sur les naissances, les mariages, et les morts à Paris depuis 1771 jusqu'en 1784, et dans toute l'étendue de la France pendant les années 1781 et 1782" (1786), *Ibid.*, t. 11, 35–46.

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statistics. These were his teachers and models, he maintained; their work demonstrated that statistics was worthy of the highest scientific minds, the most recondite methods, and the most honored institutions. "The laws that concern man, and those that govern social development have always had a special attraction for the philosopher, and perhaps most especially for those who have directed their attention to the system of the universe."[9]

The tradition of astronomer-statisticians with which Quetelet wished to associate himself was a real one, and a dozen prominent nineteenth-century names could easily be added to the above list. It must be understood, however, that most of Quetelet's own statistical activity fell outside this tradition, for the work on social statistics of astronomers was ordinarily limited to the calculation of life tables for the business of insurance and annuities, and virtually never extended beyond the domain of population and mortality.[10] To be sure, Quetelet also was deeply interested in population matters, and his first statistical paper was justified as a contribution to the study of insurance.[11] Even in the domain of population, however, much of his attention was dedicated to Malthusian questions never discussed by most astronomer-statisticians. More generally, Quetelet aimed to create a science that would be indispensable to the legislator and whose domain would include education, crime, human growth, agriculture, and industry, as well as population matters. This commitment to a general, reform-oriented statistical science of society placed Quetelet in a very different company from the august physicists and astronomers of the Académie des sciences whom he so earnestly admired.

Quetelet's chosen science, statistics, was no branch of applied mathematics in the nineteenth century, but an empirical study, dominated by bureaucrats, doctors, and men of affairs. Descended from the descriptive German science of states, *Statistik* or *Staatenkunde*,[12] statistics was a science of society that had only come to be associated specifically with the collection of numerical information during the 1820s and 1830s. Quetelet's introduction to statistics corresponded in time with the beginning of what a leading historian of the subject has designated its "era of enthusiasm," a period of fetishistic tabulations, as Ian Hacking puts it, during which there was an extraordinary increase in the collection and publication of numbers of all sorts.[13] Statistics was as much a movement as a science, and the

[9] Quetelet, "Notice scientifique," written for his own book, *Sur l'homme* (n. 49), and published in *AO*, 7 (1840), 230–247, p. 230.

[10] Typical is the *Annuaire presenté au gouvernement par le bureau des longitudes*, Paris. 1807 et seq., published annually, which contained population figures for France and the world, tables of mortality, and the like. See also papers by Dupin, Demonferrand, Civiale, Double, Bienaymé, Mercier, Moreau de Jonnès, and Poisson in *Comptes rendus hebdomadaires des séances de l'académie des sciences* (1835 et seq.)

[11] Quetelet, "Mémoire sur les lois des naissances et de la mortalité à Bruxelles." *NMB*, 3 (1826), 493–512.

[12] On the tradition of *Statistik* see Vincenz John, *Geschichte der Statistik*, Bd. 1, Stuttgart, 1884, and, in relation to Quetelet, Frank H. Hankins, *Adolphe Quetelet as Statistician*, New York, 1908, ch. 2.

[13] See Ian Hacking, "Biopower and the Avalanche of Printed Numbers," *Humanities in Society*, 5 (1982); 279–295; Harald Westergaard, *Contributions to the History of Statistics*, London, 1932.

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scientific status claimed for it by Quetelet's contemporaries was based not on the use of advanced probability techniques, but on the objectivity and reliability of the facts it collected.[14]

Official activity made up a large component of the statistical movement. The first wave of censuses was conducted in Europe around 1800, in part because of manpower needs during the Napoleonic wars. In France, an incredibly ambitious and largely fruitless statistical survey of every département was attempted under the Consulate. The Bureau de statistique was subsequently abolished by Napoleon (in 1811), and only restored under the July Monarchy, but a wealth of official information was assembled and published during the intervening years, most notably the *Compte général de l'administration de la justice criminelle*, beginning in 1827, and the *Recherches statistiques sur la ville de Paris et le département de la Seine* of 1821, 1823, 1826, and 1829.[15] Quetelet, like so many of the best-known statisticians in France, Germany, and England, was actively involved in official statistics, first under the government of the united Netherlands, then under the Belgian state, whose Commission Centrale de Statistique came to be regarded as a model by statisticians of other countries.

The immense and thoroughly miscellaneous corpus of private statistical writing was little more than propaganda. The Sociéte française tion. Often one cannot imagine what could have inspired an author to collect numbers about the subject he treats. On the other hand, much statistical writing was little more than propaganda. The Sociéte francaise de statistique universelle, in announcing a prize in the first volume of its *Bulletin* (1830) for the best memoir on the abolition of the death penalty, explained itself as follows: "By attaining statistical certainty that fewer crimes are committed where the penalty of death has been abolished, the influence that a gentler and more genuinely philosophical legislation exerts on the criminality of human actions can be better appreciated."[16] Supporters of public instruction in both Britain and France issued report after report demonstrating statistically that the spread of education led to a decrease in crime,[17] until a chart published by A. Balbi and A. M. Guerry indicating that, on their face, the results supported the opposite viewpoint compelled writers of the educationalist persuasion to portray statistical

[14] See Louis René Villermé's remarks, quoted by William Coleman, *Death is a Social Disease: Public Health and Political Economy in Early Industrial France*, Madison, 1982, 273–4, and the notorious exclusion of opinions by the London Statistical Society, discussed by Victor L. Hilts, "Aliis Exterendum, or, the Origins of the Statistical Society of London," *Isis*, 69 (1978), 21–43.

[15] On French official statistics see Coleman, *Death* (n. 14); Marie-Noelle Bourguet's thesis at the Université de Reims (1983); and, more generally, John Koren, ed., *The History of Statistics* (1918), repr. New York, 1970.

[16] "Introduction," *Bulletin de la societé française de statistique universelle*, t. 1 (1830–31), p. 33.

[17] For example, Lucas, "Influence morale de l'instruction et de la civilisation en général sur la diminution des délits et des crimes," *Bulletin universal des sciences et de l'industrie*, 6ème section, *Bulletin des sciences géographiques*, t. 15 (1828), 105–117, and a number of other papers in the same journal. On Britain see Michael Cullen, *The Statistical Movement in Early Victorian Britain: The Foundations of Empirical Social Research*, Sussex 1975.

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inference in this domain as an immensely subtle and intricate business.[18]

The quality of statistical work varied considerably. On one side, we find A. Taillandier and a host of others producing statistical demonstrations like this (Taillandier had no information on the general literacy of the population): "Thus, the definite result of these researchers on the instruction of prisoners reveals that 67 out of 100 are able neither to read nor write. What stronger proof could there be that ignorance, like idleness, is the mother of all vices?"[19] In contrast, the same compilation as that reviewed by Taillandier provided the information for a book full of impressive graphs and restrained, plausible reasoning by A. M. Guerry. The cutting edge of statistical research in France during the 1820s was the work of public-health writers, whose studies of death rates at hospitals, prisons, and poor-houses often produced figures so startling that the unhealthfulness of the institution in question could hardly be doubted. The statistical commission of the Royal Academy of Medicine used the available materials with great resourcefulness in order to show that mortality in the poorer quarters of Paris was much higher than in wealthy areas.[20]

That much of the popular literature on statistics was blatantly tendentious and thoroughly contrived could not but have bothered the ambitious Quetelet. Moreover, statistical writings in the reformist tradition displayed neither the trappings nor the substance of the most impressive and recondite sciences, like astronomy and mechanics. In particular, advanced mathematics was wholly absent, except in insurance studies. Quetelet's friend and correspondent Villermé knew no mathematics, and told him so;[21] one seeks in vain for more than an occasional mention of probability in the writings even of statisticians whose work Quetelet acknowledged to be of high quality, like Benoiston de Châteauneuf and William Farr. And Quetelet himself, while invoking the crucial importance of probability for statistics at every opportunity, never performed a test of significance, or even computed a standard error, in all the volumes on social statistics that he wrote. Nineteenth-century statisticians relied primarily on censuses, not samples, and they based their claims for the scientific character of their enterprise on the proposition that

[18] A. Balbi and A. M. Guerry, *Statistique comparée de l'état de l'instruction et du nombre des crimes dans les divers arrondissements des académies et des cours de France*, Paris, 1828, a set of charts; also A. M. Guerry, *Essai sur la statistique morale de la France*, Paris, 1833. Among the more sophisticated reactions was that of Alphonse DeCandolle, "Considérations sur la statistique des délits," *Bibliothèque universelle des sciences, belles-lettres et arts*, t. 104 (1830), section de litterature, 159–186; and "De la statistique criminelle," *Ibid.*, t. 110 (1832), 23–59. Quetelet's explanation for why the correlation suggested by Guerry's tables was false appeared in "Recherches sur le penchant au crime aux différens ages," *NMB*, 7 (1832), separate pagination, pp. 26–44, 78.

[19] A. Taillandier, (Review of) "Compte général de l'administration de la justice criminelle en France," *Revue encyclopédique*, 40 (1828), 600–612, p. 612.

[20] See Coleman, *Death* (n. 14), part II, and Bernard-Pierre Lécuyer, "Médecins et observateurs sociaux: les *Annales d'hygiène publique et de médecine légale* (1820–1850)," *Pour une histoire de la statistique*, t. 1, Contributions, Paris, 1976, 445–476.

[21] Quetelet papers in Bibliothèque royale de Belgique, folder 2561, letter of 18 Feb., 1846.

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a complete and reliable enumeration produces facts, not probabilities.[22] To be sure, Poisson used error analysis in his work on the reliability of judicial decisions,[23] as had Laplace in estimates of population, but for ordinary statistical purposes nobody, Quetelet included, had any idea how probability techniques could be of much help. If mathematical ability was needed in statistics, it was the genius to create, and not merely the skill to employ useful procedures.

In brief, Quetelet belonged to two different statistical traditions. On the one side was error analysis, astronomy, and the mathematical study of insurance; on the other, the concrete business of taking and presenting the census, and "the noble task of diminishing the number of social infirmities."[24] The tangled metaphors of social physics and the constant exhortation for statisticians to use mathematics reflect Quetelet's desire to bring those separate traditions together, to make the urgent business of social reform as scientifically profound as the *Mécanique celeste*, as well-ordered as the *Système du monde*. When the mathematical principles of society were uncovered, statistics would be liberated from its bondage to the unnamed enthusiasts whose ridiculous mistakes Quetelet routinely denounced. Here already was one incentive for Quetelet to find the astronomer's error law in the phenomena of society as well as nature.

II. *The Physics of Society*

Analogies were central to Quetelet's scientific thinking from the beginning. He saw in nature a remarkable unity, and believed it could be demonstrated by patient research. First there was the reign of numbers—*Mundum regunt numeri*; the young Quetelet was greatly impressed that the same probability calculus regulated the outcome of coin tosses, the accuracy of stellar observations, the reliability of testimonies and historical records, the validity of judicial decisions, and the justness of elections.[25] Quetelet's more lasting infatuation with periodic phenomena is also evident in his earliest papers. He was especially intrigued by the effect of diurnal and annual cycles on the life of man, and he wondered at the circumstance that the revolution of the earth about the sun seemed to impel a certain number of people to get married, others to commit suicide, and so forth. In his early researches Quetelet sometimes fit sine curves to the variation of births or marriages by season, always including enough undetermined parameters to adapt to almost any cyclical phenomenon.

With the creation of *mécanique sociale* early in 1831, a new set of models

[22] Alexandre Moreau de Jonnès, *Eléments de statistique*, 2me ed., Paris, 1856, pp. 45, 132.
[23] Siméon-Denis Poisson, *Recherches sur la probabilité des jugements*, Paris, 1837.
[24] "Prospectus," *Annales d'hygiène publique et de médecine légale*, 1 (1828), p. vii. See also Michelle Perrot, "Premières mesures des faits sociaux: les débuts de la statistique criminelle en France (1790–1830)," *Pour une Histoire* (n. 20), 125–137.
[25] Quetelet, *Popular Instructions on the Calculation of Probabilities*, (Richard Beamish, trans.), London, 1839, p. 108. French ed., 1828.

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and metaphors came to dominate Quetelet's explanation of statistical matters. Best-known of these is the idea of *l'homme moyen*, the average man, which took shape in his very first paper on social mechanics. Scarcely less prominent in the post-1830 papers were Quetelet's deliberations about societal stability, and about gradual versus revolutionary change. There is every reason to think that the new turn of his thinking arose out of an effort to come to terms with his experience during the revolution of 1830, in which Belgium gained its independence.

That Quetelet viewed the revolution as a great calamity is manifest from his subsequent references to it. Not only are general remarks about the damage to society caused by sudden changes scattered throughout Quetelet's writings, but virtually every éloge for a Belgian scientist or writer that he produced in his capacity as permanent secretary of the Brussels Academy included comments on the damage to that person's career produced by the events of 1830. More than mere sympathy was involved here, for these were Quetelet's protegés. The migration of many young scientists out of science, often into the military, the reorganization of the universities in a manner not to Quetelet's liking, the suppression of the science faculties and destruction of museum positions all threatened the "intellectual movement" that he believed to have been taking hold in Belgium and that he attributed mostly to his own labors.[26] Moreover, his most cherished project, the observatory, was also threatened by the events of 1830. At the time of the Belgian Revolution Quetelet had been in Italy on a tour to meet astronomers and purchase instruments; he returned to discover that the most radical of all revolutionary groups, the Liège volunteers, had occupied the observatory to assist in the defense of Brussels. The volunteers had surrounded the structure, by then nearly complete, with ramparts and ditches, and fired shots through the windows. Afterwards, Quetelet's post as royal astronomer was called into question, and the conversion of the observatory into a magazine seriously contemplated.[27] In short, the revolution constituted for Quetelet a great professional setback, and not merely an abstract threat to social order of the sort that troubled so many contemporary European thinkers.

Quetelet's first post-revolution paper, delivered just a few months after his return to Belgium, introduced a battery of metaphors linking the social order to planetary astronomy, in which political concerns are transparently visible beneath the mechanical language. Among the most

[26] See Quetelet, "Aperçu" (n. 5); *Histoire* (n. 3), *passim.*; and various biographies in *Sciences* (n. 4).

[27] Quetelet, "Lettre à M. le Bourgmestre, 15 dec., 1831," *AO*, t. 1 (1834), 284–287; Ed. Mailly, "Essai sur la vie et les ouvrages de Lambert-Adolphe-Jacques Quetelet," *Ann. de l'acad.* (n. 2), 41 (1875), 109–297, pp. 186–187; Joseph Lottin, *Quetelet: statisticien et sociologue*, Paris, 1912. On Quetelet's politics and his ideas on revolution see John Bartier, "Quetelet politique," in Académie royale de Belgique, *Adolphe Quetelet, 1796–1874 (Mémorial)*, 4 vols., Bruxelles 1974, t. 4, 20–45; also Naúm Reichesberg, "Der berühmte Statistiker Adolf Quetelet, sein Leben und sein Wirken: Ein Biografische Skizze," *Zeitschrift für schweizerische Statistik*, 32 (1896), 418–460.

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prominent of these metaphors was the distinction between constant forces, which "pertain to the nature of the human species,"[28] and perturbational forces, which are generated by the conscious decisions of man. Quetelet invested in the forces of perturbation all the ambivalence that social change could evoke in a nineteenth-century liberal. On the one hand, the living perturbational forces of man were the source of progress, providing the impetus to overcome the dead hand of nature which threatened to render society "stationary and incapable of amelioration." On the other, these moral forces were prone to generate instability and dangerous disorder. Laplace had shown that planetary movements, governed solely by an inverse square law of gravitation, were stable, and required no Providential intercession or correction. Quetelet, writing in the aftermath of 1830, wondered whether the same law applied to the "social body." "Can the forces of man compromise the stability of the social system?"[29]

> These forces that characterize mankind are the living forces of his nature, but . . . does there exist something analogous to the principle of conservation of living force in nature? What, moreover, is their destination? Can they influence the march of a system, or imperil its existence? or, indeed, like the internal forces of a system, are they entirely unable to modify its trajectory or the conditions of its stability? Analogy would lead one to believe that in the social state one may anticipate finding again in general all the principles of conservation that one observes in natural phenomena.[30]

The implications of this moral force analogy had already been drawn by Laplace, who argued that "the theory of probability directs us to avoid all changes; especially is it necessary to avoid the sudden changes which in the moral as in the physical world never operate without a great loss of vital force."[31] Quetelet modified this to accord with a liberal viewpoint, arguing that the prevention of all change was impossible. Indeed, the forces of change are conserved, and any attempt to block their action could only result in an accumulation of grievances, a deep well of repressed forces that must inevitably escape in the form of revolution. Since the violence of the explosion would produce a loss of the more delicate moral forces that led to progress, gradual change became at once the key to progress and the cure for revolution. If allowed to operate freely, moral forces would lead steadily to the effacement of *homme physique* by *homme intellectuel*—the triumph of reason over passions and instincts. Unless obstructed, they would accomplish their task slowly, and hence could be guided by human wisdom and experience.

The main foundation of Quetelet's social physics was the construct

[28] Quetelet, "Recherches sur la loi de la croissance de l'homme," *NMB*, 7 (1832), separate pagination, p. 2.
[29] Quetelet, "Recherches sur le poids de l'homme aux différens ages," *NMB*, 7 (1832), separate pagination, pp. 11–12.
[30] Quetelet, "loi de croissance" (n. 28), p. 2.
[31] Laplace, *Essay* (n. 1), p. 108.

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with which his name has always been most closely associated, the average man or *l'homme moyen*. In terms of the usual analogy, the average man was the social correlate of the center of gravity. Just as the astronomer can, at least as a first approximation, neglect the infinitude of particles that make up any celestial body, and instead carry out calculations as if all its matter were located at the center, so the social physicist can resolve the trajectory of the "social body" simply by charting the progress of the average man. For this being, Quetelet explained, "all things will occur in conformity with the mean results obtained for a society. If one seeks to establish, in some way, the basis of a social mechanics, it is he whom one should consider, without disturbing oneself with particular cases or anomalies."[32] The moral and physical attributes of the average man were developed over his mean lifecycle; the changes in this mean lifecycle provided the best single measure of alterations in the condition of society.

That the average man was sufficient as a representative of his society was, Quetelet held, a deduction from mathematics. The central truth of probability theory, and hence the fundamental axiom of social physics, was the law of large numbers: over the long run, the frequency of events of any given description will conform to their underlying probabilities. Thus, general effects may always be attributed to general causes, for chance, or accidental causes, can have no influence upon events considered in large numbers. In particular, social facts can never be generated by the arbitrary, unmotivated, spontaneous, or otherwise inexplicable acts of human free will. However "capricious" and "disordered" may be its action, Quetelet wrote, "whatever concerns the human species, considered *en masse*, is of the order of physical facts; the greater the number of individuals, the more the individual will effaces itself and allows to predominate the series of general facts which depend on the general causes according to which society exists and is conserved."[33] This truth, he explained, has very remarkable philosophical implications: "it teaches that the action of man is restrained in such a circle, that the great laws of nature are never subject to his influence; it also shows that laws of conservation can exist in the moral world, just as they are found in the physical world."[34]

The metaphor of the average man, moving through history like an astronomical body through the heavens, conveniently provided an important role for the statistician in resolving the proper course of legislative action. "The whole art of governing," Quetelet asserted, consists in separating constant from accidental forces through a series of calculations on the average man, and then paralyzing the resultant of the accidental forces through the application of an equal and opposite one.[35] In

[32] Quetelet, "loi de croissance" (n. 28), p. 4.
[33] Quetelet, "penchant au crime" (n. 18), p. 80.
[34] Quetelet, "De l'influence de libre arbitre de l'homme sur les faits sociaux," *BCC*, 3 (1847), 135–155, p. 136.
[35] Quetelet, *Du système social et des lois qui le régissent*, Paris, 1848, p. 289.

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another vein, Quetelet argued consistently that his demonstration of the lawlikeness of society, far from leading to fatalism, furnished grounds for optimism about the prospects for reform. The legislator always appeared in Quetelet's system as one of the general causes that could alter the course of the social body, and the greatest merit of social physics was the assurance it provided that whatever measures were enacted would have predictable effects.

The basis for all of Quetelet's optimistic pronouncements, and the essential foundation for the concept of the average man, was the principle of statistical regularity. Quetelet often presented such constancy as a deduction from first principles, and on occasion he grounded claims about the regularity of some phenomenon on numbers which to a critic might seem to fluctuate rather widely.[36] It should not be supposed, however, that belief in "statistical law" was simply an invention of Quetelet's fevered intellect. For one thing, certain instances of statistical regularity—in particular, the uniformity in the number and ratio of male to female births—had been known since John Graunt's tabulations of the 1600s, and had delighted and amazed generations of political arithmeticians; mathematical probability and divine wisdom were alternately—or sometimes simultaneously—invoked to explain this order in the natural history of man. Natural theologians and mathematicians alike, however, were startled to learn that crime and suicide were also subject to statistical order. Quetelet himself, far from anticipating the order revealed by criminal statistics, was initially shocked at the "frightening regularity with which the same crimes are reproduced." "If we consider now the infinite number of circumstances that can cause the commission of crime," reflected A. M. Guerry, co-founder with Quetelet of moral statistics, "we will not know how to conceive that in the end result, their conjunction leads to such constant effects."[37]

Not mathematical intuition, but the *Compte géneral de l'administration de la justice criminelle*, was the initial source of Quetelet's statistical laws of crime. The regularity of natural or rational events like births, deaths, and marriages no longer seemed surprising in 1827, but crime was manifestly the result of human passions—indeed, of the most irregular, and ill-governed of the passions. It was as if the felon had no control over his actions, so that a stream of individuals was driven to criminal activity by some external power.

Quetelet soon accommodated himself to these matters, however. The stability of the numbers of moral statistics became a great selling point for this new science; Quetelet and his fellow statisticians never tired of pointing

[36] For example, to Eduard Rehnisch, "Zur Orientierung über die Untersuchungen und Ergebnisse der Moralstatistik," *Zeitschrift für Philosophie und philosophische Kritik*, 68 (1876), 213–264; 69 (1876), 43–115.

[37] Quetelet, "Recherches statistiques sur le Royaume des Pays-Bas," *NMB*, 5 (1829), 1–57, p. 28; Guerry, *Essai* (n. 18), p. 11.

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out that not only were murders and suicides committed in constant numbers from year to year, but there was uniformity even in those carried out with knives, or pistols, or poison. Equally impressive was a tidbit rarely omitted from any popular book or essay on statistics from Laplace to Buckle—all the more telling because of its triviality— that the same regularity was exhibited in the number of dead letters reported each year by the Paris postal system.

The alleged lawlikeness of moral statistics became a highly sensitive matter during the mid to late nineteenth century, and there was much discussion of the possible incompatibility of statistics with human free will. Quetelet took pains to exonerate his science from this charge. "We must recognize from the outset," he explained, "that whatever researches might deal with lone individuals would be absolutely without value. It would be absurd to consult a mortality table to find the age at which some person must cease to live, and it would be still more so to employ any tables whatever to form conjectures about his actions. The free will of man makes all such prevision impossible."[38] This individual freedom of action, however, is not inconsistent with the existence of statistical laws, for the solitary actor is unable to exert a significant influence on society as a whole. The possibility of moral statistics, Quetelet wrote, depends on this fundamental fact, "that free will cancels itself and remains without effect when observation is extended over a great number of men. All individual actions neutralize one another, and recede into the class of effects produced by purely accidental causes."[39]

In short, social effects are produced by social causes. From this standpoint, the regularity of crime ceases to be startling and becomes instead a consequence of the most elementary principle of scientific philosophy. Since the level of crime in a given country is subject to constant causes, it must necessarily exhibit constant effects. Indeed, Quetelet was able to specify the constant cause that produced crime; it was none other than the "state of society." Quetelet's insight may perhaps appear to be a modest contribution to criminology, since he never undertook to single out particular aspects of the social condition as the most flagrant causes of crime. His propensity to see these phenomena as preeminently social in nature, however, was the basis for his perception of individual variation as accidental, and hence for the extension of the domain of the error law that constituted his principal contribution to statistical mathematics.

III. *The Rationalization of all Disorder*

It has been customary, especially since the advent of the quantum theory, to associate the growing importance of statistics in science with a

[38] Quetelet, "Sur la statistique morale et les principes qui doivent en former la base," *NMB*, 21 (1848), separate pagination, p. 4.
[39] Quetelet, "libre arbitre" (n. 34), p. 136.

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tendency toward probabilism or indeterminism. Quetelet, though an important pioneer in the use of statistical methods in science, was in no way party to such developments.[40] The statistical view of nature recognized by intelligent observers at the end of the nineteenth century like James Clerk Maxwell, Francis Galton, Francis Edgeworth, and J. T. Merz,[41] involved no metaphysical commitment to indeterminism, but simply the widespread adoption of an approach deriving from the social science of statistics. The statistical writer believed that individuals were both too capricious and too numerous to be made the primary objects of a science of society. It was unfeasible, perhaps impossible, to follow a traditional analytical approach—to ascertain the laws of individual behavior, then sum over the relevant population. It was much more promising to begin at the highest level, to find the number of persons who perform this or that action in a given period, and to ignore, at least provisionally, the various incentives that move them in each case. After all, the object of this study is not a science of individuals, but of society.[42]

The existence of unvarying social laws was, for Quetelet, an article of faith: "would it not be absurd to believe that among all the things that occur in accordance with such admirable laws, the human species alone rests mindlessly abandoned to itself . . .?"[43] Social law implied the existence of a deep social order, just as the paradoxical existence of laws of crime suggested something fundamentally rational and comprehensible about this most unsocial of human actions. The tenor of Quetelet's thinking is captured in the prefatory remark to his discussion of the "Analogies between physical and moral laws." He wrote: "In a moment when passions were acutely excited by political events, I sought, in order to distract myself, to establish analogies between the principles of modern mechanics and those that were passing before my eyes."[44] The consolation that Quetelet derived from his belief that disorder was only superficial appears more explicitly in a letter to Prince Albert of Britain in June, 1848.

> If it were possible to disbelieve the vast injuries that are done to society by sudden changes and theories of dreamers, events which are happening before our eyes would be quite suitable to serve as lessons. In seeing what is happening, one would almost despair of humanity; it is a veritable moral cholera, which spreads its ravages over the whole of Europe, with a violence

[40] See, for example, Quetelet, "Recherches" (n. 37), p. ii, a typical bit of rhetoric in which statistical research is applauded for ridding us "of the idea that events whose causes we cannot directly perceive are produced by chance."

[41] J. T. Merz, "On the Statistical View of Nature," in *A History of European Thought in the Nineteenth Century*, 4 vols., New York, 1965, vol. 2, 548–626; also T. M. Porter, "A Statistical Survey of Gases: Maxwell's Social Physics," *Historical Studies in the Physical Sciences*, 12 (1981), 77–116; idem., *The Calculus of Liberalism: The Development of Statistical Thinking in the Social and Natural Sciences of the Nineteenth Century*, PhD. dissertation, Princeton, 1981.

[42] See Lorraine J. Daston, *The Reasonable Calculus: Classical Probability Theory, 1650–1840*, PhD. dissertation, Harvard, 1979, 443–466.

[43] Quetelet, "penchant au crime" (n. 18), p. 4.

[44] Quetelet, *Du système social* (n. 35), p. 104.

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> that one would not have suspected in a century that is called the enlightened century. One must necessarily resign oneself and wait for society to return within its limits from which it has been so violently torn, before one accepts them as accidental causes or necessary effects.
>
> Scourges strike the moral as well as the physical structure of humanity, and however destructive their effects may be, it is at least consoling to think that they cannot in any way alter the eternal laws that guide us. Their action is transitory and time will soon have healed the wounds of the social body, but it is not the same with individuals.[45]

Quetelet's enthusiasm for the idea of the average man derived in part from similar considerations. Beyond the utility of mean values for calculating the trajectory of the social body, the essential basis for sound, scientific legislation, the average man was endowed by Quetelet with some "very remarkable properties."[46] As Maurice Halbwachs observed, Quetelet was inspired by the philosophy of Victor Cousin to develop the analogy between the mathematical idea of the average and the moral idea of the *juste milieu*.[47] Cousin had explicitly attached his eclectic philosophy to the style of politics of the constitutional monarchy; he described the restoration of the charter as the synthesis and "brilliant outcome of the bloody conflict of the two systems that by now have already seen their day, absolute monarchy, and the extravagances of democracy. . . . I ask whether philosophy can fail to be eclectic, when everything around it is."[48] Quetelet was enthralled by this enshrinement of moderation, and speculated that it might be possible to follow Cousin's insight and discover a mean philosophical and political position which "could conciliate the most advantageously the interests of the different parties." He quoted at length Cousin's reflection that each people must have some common type, which is most perfectly exemplified in their great men, and he argued that "an individual who epitomized in himself at a given time all the qualities of the average man, would represent at once all that is great, beautiful, and good." Cousin, he proposed, had been led by different considerations to the same conclusion.[49]

Thus the average man, whose value for social physics derived from his stability and unresponsiveness to small or local causes, became also the embodiment of a unified culture and, more specifically, of the ideal of moderation and gradual change. The fundamental idea of the mean, Quetelet proposed, had been grasped by Aristotle when he asserted that virtue is a just equilibrium between vices. Quetelet maintained that the

[45] Quoted in Harriet H. Shoen, "Prince Albert and the Application of Statistics to Problems of Government," *Osiris*, 5 (1938), 276–318, pp. 286–7.

[46] Quetelet, "poids de l'homme (n. 29), p. 2.

[47] Maurice Halbwachs, *La théorie de l'homme moyen: Essai sur Quetelet et la statistique morale*, Paris, 1913, p. 6.

[48] Victor Cousin, *Cours de philosophie: Introduction à l'histoire de la philosophie*, Paris, 1828, 13me Lecon, pp. 36, 42–43.

[49] Quetelet, *Sur l'homme et le développement de ses facultés, ou essai de physique sociale*, 2 vols., Bruxelles, 1836, t. 2; Cousin, *Cours* (n. 48), *Cours*, 10me Lecon, pp. 6–7.

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function of law is to preserve order by proscribing all actions that fall outside certain limits around customary standards of moral behavour.[50] He proposed that the higher classes live longer than the "low people" because of their temperance and moderation, their avoidance of rapid changes and their distaste for extremes.[51] He even hypothesized that the greater regularity of moral than of vital or economic statistics could be explained by a will to mediocrity, a tendency at least for the enlightened to exert their free will always in the direction of moderation.

Characteristically, Quetelet expressed all this in the metaphorical terms of social physics.

> The sage studies for himself the forces that act on him, in order to modify at his pleasure the magnitude and the direction of the resultant. In proceeding thus, he always goes where he wants to go, and only advances with the speed that he wants to have; master of the course that he freely rules, he follows, in order to move from one position to another, the straight line, and, rigorous partisan of the principle of least action that the Supreme Being follows in all things, he will set himself to destroy all the forces that might be able to make him deviate from the route or pivot around himself. In following the movement of his century he places himself near the center; and, while the ambitious seek to climb to the top of the wheel of fortune, he will place himself tranquilly at the axis, so as not to expose himself, like them, to be found crushed at the first turn of the wheel, or to be projected out into the dust.[52]

In essence, Quetelet's idealization of the mean as the standard of beauty and goodness implied that all variation—everything exceptional—was to be regarded as flawed, the product of error. "Deviations more or less great from the mean constitute ugliness in body, vice in morals, and a state of sickness with regard to the constitution."[53]

It is in this context that Quetelet's innovative use of the astronomical error law arose. Even his unflagging desire to incorporate advanced mathematics, and his continuing search for analogies between social science and astronomy, must be understood in part as a dim reflection of his belief that wherever mathematical laws could be shown to prevail, there must also exist some impeccable underlying order, which reduces manifest disorder to an epiphenomenon. Science, as Victor Cousin had pithily remarked, "is the suppression of all anomaly, the ordered substituted for the arbitrary, reality for appearance, reason for sense and for imagination, particular phenomena related and elevated to their general laws."[54] What, then, could be more satisfying than to show that errors and deviations are themselves subject to the most rigorous lawlike regularity? This the statistician can accomplish. While the casual observer, looking out at the ocean, is captivated by the pounding of the surf and the oscillation of the

[50] Quetelet, *Théorie des probabilitiés*, Brussels 1853, p. 49; *Du système social* (n. 35), p. 197.
[51] Quetelet, *Sur l'homme* (n. 49), t. 1, p. 237.
[52] Quetelet, *Du système social* (n. 35), p. 110.
[53] Quetelet, "penchant au crime" (n. 18), p. 16.
[54] Cousin, *Cours* (n. 48), 8me Lecon, p. 10.

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tides, the statistician undertakes to measure and calculate in order to reveal a sublime flatness.

As ever, Quetelet borrowed his law governing deviations from astronomy. The law of variation was precisely the "law of error," that tool of observational astronomy subsequently dubbed the "normal" distribution. To understand Quetelet's use of it, we must know something of its history. The error curve was first used to assess the precision of mean values by De Moivre and then by Laplace, who showed that under most circumstances the likelihood of any given difference between a mean calculated from many independent trials and the true underlying value would be governed by this law. For example, the likelihood of a specified excess of heads over tails after a finite number of fair coin tosses is given by the familiar binomial distribution; Laplace showed that this, and other related distributions, tend to converge to the error law, and become identical with it after an infinite number of trials.

The point here is that the error law results from the compounding together of a great number of independent error terms, like the excess of heads or tails in any particular coin toss. The same function was incorporated by Gauss and Laplace into the method of least squares, a technique for reducing a great number of independent stellar observations to the value that minimizes the expected error. It was later applied to individual errors of observation in astronomy and surveying, in which context the model of small errors summing to a regular distribution was brought out with great clarity by G. H. L. Hagen just a few years before Quetelet developed his constitutive application of it.[55] Joseph Fourier's conjectural physical model for the flow of heat conformed to this binomial schema, although his demonstration that this function governed the flow of heat in one dimension was based on a continuous, non-probabilistic model.[56] Still, he was greatly impressed by the extensive range of applications of the error law, and argued that it was "imprinted in all of nature—a preexistent element of universal order."[57]

Quetelet's importance for the history of mathematical statistics owes primarily to his role in the development of thinking about the probabilistic error function. Hitherto, it had been identified almost exclusively with deviations from true values—that is, with error. The curve was a characteristic not of things in the world, but of the imperfection of measurement techniques or the inaccuracy of inference from phenomena that occur in finite numbers to their underlying causes. Moreover, the mathematical operations used in conjunction with it invariably had a single purpose, to reduce the error to the narrowest bounds possible. When

[55] G. H. L. Hagen, *Grundzüge der Wahrscheinlichkeits-Rechnung*, Berlin, 1837.

[56] Joseph Fourier, *Analytical Theory of Heat*, Alexander Freeman, trans., New York, 1945, pp. 32, 460–1.

[57] Fourier, "Extrait d'un memoir sur la théorie analytique des assurances," *Annales de chimie et de physique*, 10 (1819), 177–189, p. 189.

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Quetelet applied the same function to natural variation, he did more than uncover a few more fields in which it could be utilized. The error curve became for the first time an attribute of nature itself.

Quetelet was not Galton, however, and he completely failed to anticipate the implications that others would draw from his work. As Victor Hilts has argued, Quetelet was so far from insisting on the importance of the distinction between error and variation that he used the error curve almost exclusively to exalt the mean, and never to analyze the causes of deviations from it.[58] It is scarcely an exaggeration to say that he conflated these two categories. Indeed, Quetelet's extension of the domain of the error function was made possible precisely by his belief that variation is ultimately a product of error. What seemed to Galton to demand both a new interpretation and new methods of statistical analysis was for Quetelet but a small step.

Quetelet's identification of error and variation appears clearly in one of the earliest and most widely-read expositions of what he already regarded as a discovery of the highest importance for social science. He presented this discovery in a chapter on mean values, in a discussion of the difference between "true" and "arithmetic" means. The latter, he explained, may be typified by an average taken from measurements of the heights of the houses on some given street. Since the various structures were all designed differently, the average would have only a slight value in conveying an idea of their collective character. An average taken of discrepant measurements of the same house, on the other hand, would be a true mean, for it would gradually converge to the actual height of the house. Moreover, because the deviations from this value were accidental, they would tend to distribute themselves according to the error law. In the same way, he went on, the errors made in producing many copies of a statue would exhibit the same collective shape. To instance this, he referred to a study of "living statues"—in fact, to some published measurements of the chest sizes of 5,738 Scottish soldiers. Their distribution, he maintained, conformed perfectly to the same error curve.[59]

Why was human growth obedient to this remarkable law? Quetelet was of the opinion that live persons are flawed replicates of the average man. The soldiers had all been designed according to a uniform plan, Quetelet's conjectural archetype of Scottish soldierdom. Their growth had

[58] Victor L. Hilts, "Statistics and Social Science," in R. N. Giere, R. S. Westfall, eds., *Foundations of Scientific Method: The Nineteenth Century*, Bloomington, 1973, 206–233.

[59] Quetelet, *Lettres à S. A. R. le duc régnant de Saxe-Coburg et Gotha sur la théorie des probabilités, appliquées aux sciences morales et politiques*, Brussels, 1846, lettre XX; also Quetelet, "Sur l'appréciation des documents statistiques, et en particulier sur l'appréciation des moyennes," *BCC*, 2 (1844). See also C. C. Gillispie, "Intellectual Factors in the Background of Analysis by Probabilities," A. C. Crombie, ed., *Scientific Change*, New York, 1963, 431–453; Peter Buck, "From Celestial Mechanics to Social Physics: Discontinuity in the Development of the Sciences in the Early Nineteenth Century," in H. N. Jahnke, M. Otte, eds., *Epistemological and Social Problems of the Sciences in the Early Nineteenth Century*, Dordrecht, 1981, 19–33.

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been subject to a great array of accidental causes, however, just as astronomical observations diverge from the truth due to atmospheric distortions and temperature fluctuations. Both are like urn drawings; every individual ball is either black or red, and cannot represent the true proportions in the urn, but over the long run, the small error generated by each drawing becomes significant, and the binomial, which governs the probability of the residual error, converges to the continuous error distribution. Quetelet's originality was not mathematical; it arose from his inclination to regard deviations from the mean height not as innate diversity, but as error.

Scottish soldiers had no monopoly on the error curve. Quetelet soon proposed that 'the same law, so simple and so elegant, applies generally to all the physical laws, we add even the moral and intellectual laws of man."[60] He confidently asserted that the distribution of penchants for crime, marriage, and suicide over a population was also subject to the error function; he even maintained that their development over time in a typical individual would, if measured against the proper scale, exhibit an identical form. Moreover, the error function could serve as a definition of type, since it indicated a single fixed cause, obscured by the action of perturbing causes. On these grounds, Quetelet was able to refute those critics who denied that the concept of the average man was coherent, or who insisted that humans and their actions are so heterogeneous that to count them or to compute an average is utterly meaningless.[61] Similarly, he could turn anthropometry to the monogenist cause during the sensitive time of the American Civil War by proclaiming impressively that the law of errors applies to all of humanity—this despite the fact that he had only the measurement of a few stray American Indians and Negroes who had happened to pass through Belgium to support his assertion.[62]

Quetelet also permitted his metaphors to proliferate further, generating manifest contradictions but revealing again the images and concerns that he associated with the error law. Most interesting is his determination that "law of errors" and "law of accidental causes" were inappropriate titles for his wonderful formula. Neither error nor accident, he explained, had any place in a system governed by an expression so perfect and symmetrical, and the conformity of error to mathematical law proved that it was not error at all. Indeed, it virtually abolished error from the universe. Thus, for example, the variations in organic beings, "to which the

[60] Quetelet, *Anthropométrie, ou mesure des différentes facultés de l'homme*, Brussels, 1871, p. 253.

[61] The problem of homogeneity was often raised, e.g. by J. B. Say, "De l'objet et de l'utilité des statistiques," *Revue encyclopédique*, 35 (1827), 529–553, p. 548. The best-known critique of the coherence of the idea of *l'homme moyen* is A. A. Cournot, *Exposition de la théorie des chances et des probabilités*, Paris, 1843, p. 214. Stephen Stigler discusses these matters in "The Measurement of Uncertainty in Nineteenth-Century Social Science," Michael Heidelberger, et al., eds., *Probability Since 1800: Interdisciplinary Studies of Scientific Development*, Bielefeld, 1983, 131–138.

[62] See Quetelet, *Anthropométrie* (n. 60), p. 16; "Sur les proportions de la race noire," *Bulletin de l'académie royale des sciences et belles-lettres de Belgique*, 21, part 1 (1854), 96–100.

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influence of accidental causes gives birth, are ruled with such harmony and precision, that they can be classed in advance numerically. . . . All is foreseen, all is lawlike: only our ignorance leads us to suppose that all is subject to the whims of chance."[63]

Conclusion

That social physics was not taken up by late-century social scientists does not imply that Quetelet's social ideas were inconsequential. His pronouncements on statistical regularity and the representativeness of the mean were debated by two generations of German academic statisticians, and also by Durkheim and his school. Although Quetelet was strongly criticized, important aspects of his approach were sustained. Nevertheless, Quetelet's importance derives principally from his contribution to a different domain—to statistics, not as social science, but as applied mathematics. His idea that chaos must give way to large-scale statistical order, which can itself be used as the basis of a science, was taken over by the most important statistical writers of the century, and his related belief that the error law governs real variation in nature and society formed the foundation for work by Maxwell and Galton. The error law was central to the next half century of work involving statistical mathematics.[64]

Quetelet's career reveals much about the development of mathematical statistics in the nineteenth century. To begin, he exemplifies the importance of the other statistics, the social science, for the branch of mathematics that inherited its name. More generally, his work typifies the thoroughly interdisciplinary character of the new statistical mathematics. Quetelet's error curve only makes sense in the context of his proposed hybrid science, social physics. His originality arose not from intention, but from the impossibility of applying this idea of astronomy to the very different subject matter of social science without the concept itself undergoing a transformation. In the case of social physics, the mathematical tool was affected more powerfully than the science which it was to reconstruct. Quetelet did not import advanced mathematics into social science, so much as he built his social conception into the structure of statistical mathematics.

[63] Quetelet, *Du système social* (n. 35), p. 17.
[64] Porter, *Calculus of Liberalism* (n. 41).

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