In the Name of Eugenics

GENETICS AND THE USES OF HUMAN HEREDITY

Daniel J. Kevles

ALSO BY DANIEL J. KEVLES

The Physicists:
The History of a Scientific Community
in Modern America (1978)

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by Daniel J. Kevles

University of California Press
Berkeley and Los Angeles

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First California Paperback 1986
Published by arrangement with Alfred A. Knopf, Inc.

Portions of this work originally appeared in *The New Yorker.*

Grateful acknowledgement is made to The Society of Authors Ltd. on behalf of the Estate of Bernard Shaw for permission to quote from Bernard Shaw's letters.

Library of Congress Cataloging in Publication Data

Kevles, Daniel J.
In the name of eugenics: genetics and the uses of human heredity.

Includes index.
1. Eugenics—History. 2. Heredity, human.
3. Race discrimination. 4. Genetic engineering.
I. Title.
HQ751.K48 1985 304.5 84-47810
ISBN 0-520-05763-5

Manufactured in the United States of America

For my mother and father,
with thanks

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PREFACE

THE WORD "eugenics" was coined in 1883 by the English scientist Francis Galton, a cousin of Charles Darwin. Galton, who pioneered the mathematical treatment of heredity, took the word from a Greek root meaning "good in birth" or "noble in heredity." He intended it to denote the "science" of improving human stock by giving "the more suitable races or strains of blood a better chance of prevailing speedily over the less suitable."[1] Since Galton's day, "eugenics" has become a word of ugly connotations—and deservedly. In the first half of the twentieth century, eugenic aims merged with misinterpretations of the new science of genetics to help produce cruelly oppressive and, in the era of the Nazis, barbarous social results. Nonetheless, in recent years, Galtonian premises have continued to figure in social discourse—notably in the claims of those arguing for a racial basis of intelligence, in certain tenets of human sociobiology, and in some proposals for human genetic engineering.

I was led to write this history of eugenics partly by the recognition that the subject casts a shadow over all contemporary discourse concerning human genetic manipulation. The history of modern physics (a field in which I have previously worked) reveals how unprepared we were to deal with the momentous issues that the release of nuclear energy—a feat requiring only a few years of concentrated effort—suddenly compelled us to confront in 1945. In 1963 the great British biologist J. B. S. Haldane declared that the genetic modification of man was likely to be still millennia away, but he added: "I remember that in 1935 I regarded nuclear energy as an improbable source of power."[2] Acquisition of the knowledge and techniques for human genetic intervention would pose challenges which, while different in kind from those of the nuclear revolution, may be comparable in magnitude, and it is none too soon to examine them in historical context.

I was also convinced that eugenics held a rich variety of opportunities for historical investigation as such. There have been a number of important studies of the subject, but most have dealt with it in only one country or another, tended to view it through the lens of the Holocaust, and halted the story in the early 1930s. I have made this book a comparative history of eugenics in the United States and Britain from the late nineteenth century to the present day, giving attention to its expressions elsewhere, especially in Germany, insofar as they affected Anglo-American developments. The comparative approach has helped to explain certain important features of this history—for example, why a eugenic legislative program succeeded at least partially in the United States but not at all in Britain—that would otherwise have remained puzzling. I have also attempted a critical assessment of Anglo-American eugenicists as they diversely recognized themselves before the Nazis came to power; and the assessment has led me to depart from prevailing interpretations to advance the view instead that eugenics involved not only scientific rationalizations of class and race prejudice but a good deal more, including disputes over how men and, especially, women of the modern era were to accommodate to changing standards of sexual and reproductive behavior.

So much was said and done in the name of eugenics that this book of necessity merges history of science with social, cultural, and political history. It explores the interplay between, on the one hand, the social assertions made by eugenicists and, on the other, advances in pertinent sciences, particularly genetics in relation to man. Since about 1930, that interplay has been strongly affected by research in human genetics. I have here ventured the first historical account of the development of that field through the early sixties, and I have also sketched its remarkable progress since then, not to provide a comprehensive handbook of its specialties—the contemporary state of gene therapy, say—but to deal with such topics in a way that is indicative of emerging problems and possibilities.

This book is thus not an up-to-the-minute technical guide, and it is certainly not a tract for the times. I am under no delusion that a history of eugenics will provide any detailed moral or political map to follow in the uncharted territory of human genetic engineering. What I do expect from such an exploration is at least some assistance in disentangling the benefits we might aim for from the pitfalls we might legitimately fear. I hope that this historical journey will suggest to the reader—as it has to me—how one might think about the human genetic future, and how one might thread a path into it of good sense, reason, and decency.

D.J.K.
Pasadena, California
December 1984

IN THE NAME OF EUGENICS

Chapter I

FRANCIS GALTON, FOUNDER OF THE FAITH

Francis Galton, innocent of the future, confidently equated science with progress. All around him the technology of the industrial revolution confirmed man's mastery over inanimate nature. To be sure, in the mid-Victorian era, heredity in plants and animals was less a science than a body of lore based on empirical practice. In the common understanding, scientific and otherwise, like tended to produce like, although in fact like often produced something quite different. Ideas of human heredity were particularly vague and contradictory. The science of genetics—indeed, the word "genetics" itself—had not yet been invented. Gregor Mendel's paper, the foundation of that discipline, was not only unappreciated but generally unnoticed by the scientific community. Nevertheless, it was well known that by careful selection farmers and flower fanciers could obtain permanent breeds of plants and animals strong in particular characters. "Could not the race of men be similarly improved?" Galton wondered. "Could not the undesirables be got rid of and the desirables multiplied?"[1] Could not man actually take charge of his own evolution?

Galton first published his eugenic ideas in 1865—well before he coined the word itself—in a two-part article for *Macmillan's Magazine* which he subsequently expanded into a book, *Hereditary Genius*, published in 1869.[2] The line of attack was to investigate the origins of "natural ability." By this phrase Galton meant "those qualifications of intellect and disposition which . . . lead to reputation"—not the reputation enjoyed by "the lion of a London season" but that commanded by "a leader of opinion . . . an originator."[3] The definition conveniently permitted Galton to take as an index of natural ability the appearance in such handbooks of eminence as *Dictionary of Men of the Time.* From these biographical encyclopedias Galton drew a sample population, spanning two centuries, of distinguished jurists, statesmen, military commanders, scientists, poets, painters, and musicians. He found that a disproportionately large fraction of them were blood relatives. Families of reputation, he concluded, were much more likely than ordinary families to produce offspring of ability. In Galton's striking claim, heredity governed not only physical features but also talent and character.[4]

That conviction made Galton confident that it would be "quite practicable to produce a highly gifted race of men by judicious marriages during several consecutive generations."[5] Quite necessary, too, since in Galton's opinion, the complexity of modern English life required more brains than even the statesmen or philosophers of the day possessed. In the article for *Macmillan's* he suggested that the state sponsor competitive examinations in hereditary merit, celebrate the blushing winners in public ceremony, foster wedded unions among them at Westminster Abbey, and encourage by postnatal grants the spawning of numerous eugenically golden offspring. (Some years later, he would urge that the state rank people by ability and authorize more children to the higher- than to the lower-ranking unions.) The unworthy, Galton hoped, would be comfortably segregated in monasteries and convents, where they would be unable to propagate their kind.[6]

Galton's hereditary analysis proceeded from the premise that reputation—especially the kind that earned a place in a dictionary of eminence—truly indicated ability, that the lack of it just as reliably bespoke the absence of ability, that neither outcome depended upon social circumstance. In defense of the premise, he insisted that high reputation could not be won by social advantage alone. Men of moderate ability descended from the peerage might become "influential members of Parliament and local notabilities," but at death they received "no Westminster Abbey and no public mourning." Similarly, he claimed that talent was rarely impaired by social disadvantage: witness the men of achievement who came from humble families; indeed, witness the effect of the removal of social disadvantage in the New World. "Culture is far more widely spread in America than with us, and the education of their middle and lower classes far more advanced; but, for all that, America most certainly does not beat us in first-class works of literature, philosophy, or art," he wrote. "If the hindrances to the rise of genius were removed from English society as completely as they have been removed from that of America, we should not become materially richer in highly eminent men."[7]

Galton's defense of reputation as an index of ability was seriously flawed. He brushed aside the idea that without social advantage professional men of moderate ability might not have got as far as they did, or that without social hindrance those of high ability might have traveled a good deal farther. Had he been more acute about the cultural incentives of behavior, he might have recognized that in America untold talent had been drawn away from "literature, philosophy, or art" into the forming of a nation and the conquest of a continent. And had he been more self-aware he might have understood that his proto-eugenic pronouncements celebrated the social milieu—and met the psychic needs—of Francis Galton.

GALTON WAS BORN in 1822, the same year as Gregor Mendel, into a Birmingham family made rich originally by gun manufacture and in his father's day by banking. His father, Samuel Tertius Galton, was a Quaker when he married Violetta Darwin, a daughter of the famed physician, naturalist, and freethinker Erasmus Darwin. He remained a stern Quaker spirit even though he became a convert to the Anglican Church—a step he took at his wife's plea following the death of one of their children. A devotional religiousness pervaded the Galton household, but Francis remembered his mother, at least, as "joyous and unconventional." His adoring sister Adèle, twelve years his senior and confined to a couch by curvature of the spine, doted on Francis, the youngest of seven children, and taught herself enough to administer his lessons until he went away to school. At two and a half, Galton could read; at four, he could write and do arithmetic; at eight, he was comfortable with classical Latin texts.[8]

The Galton family invested considerable hopes in Francis's intellectual future. Like other British families caught up in the industrial revolution, the Galtons had been following a social trajectory that led from manufacturing and trade to the higher respectability that could be either bought, married, or won by entering an esteemed profession. Francis's two older brothers displayed no ambition beyond lives of ease among the local landed gentry. His parents wished their youngest son to attain Erasmus Darwin's medical eminence. Besides, Francis had been raised an Anglican, and so was eligible for entry to England's leading universities, which were still restricted to members of the Church of England. At age four, Francis, who recognized quickly what was expected of him, announced that he was saving his pennies "to buy honours at the University."[9]

Galton compiled an outstanding record in his initial year at King's College Medical School, in London, but he hated the study of medicine and was beset by constant headaches. In 1840, he matriculated at Cambridge University to read mathematics.[10] He tried hard for an honors degree until, in his third year, he suffered a nervous breakdown. "It would have been madness to continue the kind of studious life that I had been leading," he recalled in his autobiography, *Memories of My Life*. "I had been much too zealous." Recovered after a term's rest, Galton contented himself with a pass degree and returned unenthusiastically to his medical studies. Then, in 1844, the death of his father and a large inheritance freed him from honors competitions and most other obligations.[11]

In 1845, the estate having been settled, Galton took himself to Egypt, where with two friends he sailed up the Nile, lazing the days away half dressed and barefoot. The party went ashore above the first cataract and there met a Frenchman named Arnaud, an exiled Saint-Simonian who had become a bey in the service of the potentate Mehemet Ali. Years later, Galton remembered the bey's modest mud hut, "perfectly simple, clean, matted, with a barometer and thermometer hung up and other scientific gear, books, etc., like a native philosopher."

"Why do you follow the English routine of just going to the second cataract and returning?" Arnaud asked. "Cross the desert and go to Khartoum."[12]

Galton and his party crossed the Bishari Desert on camelback in eight days, rejoining the Nile at Abu Hamed; they rode along its banks to Berber, then hired a boat that took them to Khartoum. After Khartoum, Galton made his way to Beirut, ultimately to Jerusalem, and in between to Salihieh, near Damascus, where he learned to speak Arabic fluently and established a household that included two Sudan monkeys and a mongoose. Returning to England in the fall of 1846, he divided his time between London society and sporting in Scotland.[13] But he was unable to remain at ease with such a life. In his late twenties, brooding and dispirited, Galton consulted the London Phrenological Institution. The chief phrenologist reported that men of his head type—his skull measured twenty-two inches around—possessed a sanguine temperament, with considerable "self-will, self-regard, and no small share of obstinacy," and that "there is much enduring power in such a mind as this—much that qualifies a man for 'roughing it' in colonising." The report added, "The intellectual capacities are not distinguished by much spontaneous activity in relation to scholastic affairs."[14]

Galton did indeed relish travel to colonial outposts, and Arnaud Bey had exemplified the joining of foreign adventure with scientific study. In 1850, at his own expense but under the auspices of the Royal Geographical Society, Galton explored southern Africa, which was at the time largely unknown to Europeans and was inhabited by the warring Damara and Namaqua peoples. He traversed some seventeen hundred miles of the interior, to the east and northeast of Walvis Bay. He confronted the unruly Namaquan chief (wearing a pink hunting coat, Galton rode an ox directly into his doorway), negotiated a measure of British law and order among the Damara and Namaqua, and established peaceful relations with the Ovampo, to the north. He returned to England in 1852 with numerous determinations of latitude and longitude from the hitherto unmapped region. The Royal Geographical Society awarded him a gold medal, and the Royal Society soon elected him to its fellowship.[15] Some thirty years later, Galton recorded in an autobiographical fragment that Arnaud's admonition to cross the desert to Khartoum had marked "a division of the ways in my subsequent life."[16]

Not long after his return from southern Africa, Galton met and married an intellectually able young woman named Louisa Butler, a daughter of the longtime headmaster of Harrow and then Dean of Peterborough Cathedral. In 1857, the Galtons settled into a handsome Georgian house in Rutland Gate, off Hyde Park. "Certainly we led a life that many in our social rank might envy," Galton remembered. "Among our friends were not a few notable persons, a full half of whom were first known to me through the connections of my wife." The friendship of many of the others —including Herbert Spencer and Thomas Henry Huxley—reflected Galton's increasingly eminent scientific position. Because of his geographical exploits, he had already been, to his special pleasure, taken into the Athenaeum Club, to which members were ordinarily admitted only after many years of waiting.[17]

Like other Victorian scientists, Galton gave lectures and wrote books for the general public—"Take great pains to describe the subject in tersely forcible language," he once advised a young scientist—and achieved a wide audience with a book on his adventures in southern Africa; another, *The Art of Travel*, rapidly went through five editions.[18] The writings, both popular and scientific, reveal a keen, sometimes eccentric curiosity and sharp powers of observation. At Epsom on Derby Day, Galton scrutinized through an opera glass the "sheet of faces" in the stands opposite, thinking "what a capital idea it afforded of the average tint of the complexion of the British upper classes." He reported to *Nature* that after the horses thundered past, the sheet of faces was "uniformly suffused with a strong pink tint, just as though a sun-set glow had fallen upon it." From Africa, he had informed his oldest brother, Darwin, with obvious relish, that Hottentot women were "endowed with that shape which European milliners so vainly attempt to imitate," adding that "I have seen figures that would drive the females of our native land desperate—figures that could afford to scoff at Crinoline." Unwilling to ask the women for permission to measure what bountiful nature had supplied, Galton sat at a distance with his sextant and "as the ladies turned themselves about, as women always do, to be admired, I surveyed them in every way and subsequently measured the distance of the spot where they stood—worked out and tabulated the results at my leisure."[19]

Galton often said, "Whenever you can, count." The kind of observation he liked best was numerical. Phrenological measurements fascinated him. Although he came to disbelieve the phrenological claim that bumps in the head expressed individual character, he always marveled over the large skulls of many men whom he admired—they included the physicists Lord Rayleigh and Lord Kelvin as well as the mathematician James J. Sylvester—and was puzzled that ability could not be shown mathematically to correlate with head size. Galton rarely took a walk or attended a meeting without counting something, even if it was merely the frequency of fidgets among the audience—which he found inversely related to the degree of audience attentiveness.[20] He had derived particular pleasure from his determinations of latitude and longitude in southern Africa, and at a meeting of the Royal Geographical Society he attacked the explorer Henry M. Stanley for regaling the audience with stories of his adventures on a trek to Lake Tanganyika instead of supplying hard facts. A colleague in the Geographical Society once described Galton's mind as "mathematical and statistical with little or no imagination," and characterized him as "a doctrinaire not endowed with much sympathy."[21] Nevertheless, Galton displayed rich imagination in the adaptation of numerical techniques to scientific subjects, among them the newly developing science of meteorology. In the eighteen-sixties, he published what were probably the first British weather maps. Later in the century, he attempted numerical analysis of fingerprint configurations, became a pioneer in the cataloguing of fingerprints, and campaigned to make them part of the British system of criminal identification.[22] But his propensity for counting and tabulation worked to greatest scientific advantage in his studies of inheritance.

WHY GALTON TURNED to the eugenic analysis of heredity is not at all clear. In *Memories of My Life*, he remarked that the publication of the *Origin of Species*, in 1859, had helped stimulate his thinking along these lines, and so had certain ethnological investigations he had undertaken.[23] But the theory of evolution by natural selection hardly leads directly to research in the heredity of mental characteristics, and Galton was at best vague about the ethnological inquiries. Indeed, though his African travels had confirmed his standard views of "inferior races," racial differences occupied only a minuscule fraction of his writings on human heredity.[24] More influential, perhaps, was an unspoken desire to assert, against lingering self-doubt, the validity of his own success by discovering the origins of success in lines of descent. Moreover, now that he had arrived he may have felt an impulse to social meliorism not atypical among the scions of wealthy, onetime religiously dissenting families.

Like many social improvers a generation or more removed from the manufacturing source of their incomes, Galton had no particular respect for barons of industry; his analyses of ability omitted achievement in commerce or business. He also thought the hereditary aristocracy a "disastrous institution" for "our valuable races"; the younger sons of the peerage, unable to afford a family and simultaneously maintain their position, inclined either not to marry at all or to wed heiresses, who were likely to come from families that were not notably prolific. Hardly a liberal, he did not believe in natural equality; he held that people deserved equal protection but not equal political rights, and he considered mass man the prey of the demagogue.[25] Through emigration, England happily lost "turbulent radicals and the like." (No wonder, Galton wrote, that Americans were "enterprising, defiant, and touchy; impatient of authority; furious politicians; very tolerant of fraud and violence; possessing much high and generous spirit, and some true religious feeling, but strongly addicted to cant.")[26] For Galton the scientist, the professional classes were the prime repository of ability and civic virtue, and his eugenics made them the keystone of a biological program designed to lead to the creation of a conservative meritocracy.

Another factor in Galton's turn to eugenics and heredity may have been the increasingly probable infertility of his marriage. Certainly he took pains to assert the manhood (as Victorians understood the term) of intellectuals. Galton himself was physically powerful and endowed with remarkable endurance; he argued that intellectual capacity was ordinarily associated not with men of "puny frames and small physical strength" but with "vigorous animals . . . exuberant powers." (Had not Queen Elizabeth cast "an eye to the calves . . . of those she selected for bishops?") He insisted that there was "no reason to suppose that, in breeding for the highest order of intellect, we should produce a sterile or a feeble race." He attacked Malthus's preaching of restraint in procreation, on the ground that it would lead to a "pernicious" decline in the numbers of the prudent, abler classes. Galton may well have diverted frustration over his own lack of children into an obsession with the eugenic propagation of Galton-like offspring.[27]

Emotionally, Galton seems never to have been entirely at peace. He was continually plagued by varying degrees of nervous breakdown, including giddiness, dizziness, and palpitations, though he displayed no such symptoms of anxiety in the face of physical danger. On the contrary, during his African travels, his confrontation with the Namaquan chief, and a steamer accident on the Thames that carried him downstream underwater for some two hundred yards, his behavior indicated cool presence of mind.[28] The initial breakdown, at Cambridge, was brought on by his failure to score a first—he ranked a high second—in the intense mathematical competition. (It ought to be discontinued, Galton told his father, because "the satisfaction enjoyed by the gainers is very far from counterbalancing the pain it produces among others.") The later breakdowns were caused by intense absorption in the hard work of learning, in which his family had expected him to excel, and in which—as his friend, acolyte, and biographer Karl Pearson once observed—he was strongly apt to feel himself inferior.[29]

The division in Galton's life marked by the crossing of the desert to Khartoum thus takes on a metaphoric meaning. As he had chosen to explore an uncharted region, so he selected arenas of science without competitors. Although Galton resembled the typical scientific amateur of the nineteenth century in that he was untrained in the research he eventually pursued, he was atypically drawn throughout his scientific career to largely unpopulated fields, which in his day included both statistics and studies in human heredity. If at times he embarked on a subject to which others had contributed, he did not begin his research by analyzing the existing body of scientific literature; his library contained hardly two dozen volumes acquired to forward his various inquiries. He learned from the work of others but did not approach it systematically. He came upon useful treatises by chance or sought them out as he happened to need them.[30] Save for a brief debate with Darwin regarding evolutionary mechanisms, he took no part in the late-nineteenth-century disputes on issues related to the theory of evolution. He was a rough-cut genius, a pioneer who moved from one new field to the next, applying methods developed in one to problems in another, often without rigor yet usually with striking effectiveness. Galton's innovativeness in science was intimately bound to his relative intellectual solitude—a propensity that arose from a measure of doubt in his abilities combined with a compulsion to excel.

Galton once remarked, in a study of English scientists, that "men who leave their mark on the world are very often those who, being gifted and full of nervous power, are at the same time haunted and driven by a dominant idea, and are therefore within a measurable distance of insanity."[31] Yet what Galton perceived about others he declined to confront in himself. Neither in his autobiography nor anywhere else did he attempt to puzzle out why immersion in work should have caused him breakdowns. Nervous breakdowns were by no means uncommon among nineteenth-century intellectuals. John Stuart Mill's led him to the introspective conclusion that "the habit of analysis has a tendency to wear away the feelings," and he resolved to give proper place to "the internal culture of the individual." Galton merely reported that a period of rest would cure the affliction, and he diminished its significance by proposing a strong similarity between "a sprained brain and a sprained joint." In general, Galton seems not to have been given to self-analysis. He remained forever reticent about the details of his personal life.[32] An account of domestic matters would interest no one, he noted in his autobiography, shrouding his wife's mixture of genuine illness and hypochondria and also her discontent with his deep absorption in scientific matters.[33]

Galton also neglected to reveal what contributed to his ideas about religion, a subject that preoccupied many mid-Victorians. His religious attitudes ranged from skepticism to hostility. While he tolerated Louisa's practice of religion in the home, he rarely missed an opportunity to gibe at the clerical outlook. He once tested the efficacy of prayer by investigating whether or not groups for whom people prayed a good deal—for example, members of the royal family—outlived others, and he embarrassed his family by publishing the conclusion that since they did not, prayer must be inefficacious. He indicted the Roman Church for its insistence upon celibacy for clerics and the Anglican Church for its strictures against marriage for Oxbridge dons, because these measures diminished the propagation of the intellectually able.[34] In part, Galton's religious dissent exemplified the pro-scientific rebellion of the day against religious dogmatism, which, in Galton's words, "crushed the inquiring spirit, the love of observation, the pursuit of inductive studies, the habit of independent thought." In part, his beliefs had been shaped by his travels, particularly in the Middle East, where he developed a deep respect for Islam.[35] But what seemed especially to bother Galton about orthodox Christianity was its emphasis on original sin, an emphasis that he seems to have felt with special force.

Galton was troubled during the aimless years after his return from the Middle East. In Syria, established with his Sudan monkeys and his mongoose, he had led what he later called a "very oriental life." His family, who kept everything else he wrote, seems to have kept none of his letters from this period.[36] Enough clues remain, however, to form a plausible interpretation of his later disturbance. One of the few surviving items in Galton's correspondence of the time is a letter from Montagu Boulton, a fellow Englishman also traveling in the Middle East. Boulton reported that he was negotiating for a pretty Abyssinian slave, and added, "The Han Houris are looking lovelier than ever, the divorced one has been critically examined and pronounced a virgin." No doubt such practices and attitudes were common among young Englishmen sowing their oats in the region, probably including Galton. The report of the London Phrenological Institution found men of his head type not only suitable for colonization but also likely to "spend the earlier years of manhood in the enjoyment of what are called the lower pleasures, and particularly of those which the followers of Mahomet believe to form the chief reward of virtue in the realms above"; such reports must have been based on independent knowledge of the subject.[37] One need not assume that Galton's Middle Eastern sojourn was exotically carnal to argue that he occasionally indulged in sybaritic pleasures and was plagued by some degree of guilt on his return. Although he apparently overcame the guilt for a time, it may well have returned to nag him in the eighteen-sixties, as it became more and more likely that his marriage would prove barren. While in the Middle East, Galton seems to have suffered a bout of venereal disease. (Boulton's letter commiserated: "What an unfortunate fellow you are, to get laid up in such a serious manner for, as you say, a few moments' enjoyment.")[38] The effects of such disease were little understood at the time. Galton, with his partial medical training, may have wondered whether venereal afflictions rendered men sterile, and so have blamed himself for the lack of children in his marriage.

Galton's propensity for counting was no doubt reinforced by his inner turmoil. To plumb intangible human depths was to risk self-perception. To enumerate human characteristics required no penetration beneath the phenomenological surface and established a wall of numerical objectivity between the observer and the forces of the heart. Thus Galton reduced the Hottentot women to measurement with a sextant. Thus, a few decades later, he constructed a "beauty map" of Britain by noting the frequency with which he saw attractive women in various towns. His marriage seems to have been built on social and intellectual companionship rather than on passion. (His great-grandnephew Hesketh Pearson reported, "Galton's marriage, as far as I can make out, was not a particularly happy one. . . . I have been told that any comfort which might have given pleasure to his leisure hours was often denied him by [his wife].")[39] Yet at times Galton let slip the veil of enumeration and Victorian propriety. In "Kantsaywhere," an unpublished novel of a eugenic utopia, the women, unlike Louisa, were Rubensian figures—"thoroughly . . . mammalian," Galton called them—and bore their husbands many noble children.[40]

Galton never coped emotionally with his cluster of devils except by breakdown or fantasy. But intellectually, at least, he was able to deal with them after he read Darwin's *Origin*. He rejoiced to his cousin, "Your book drove away the constraint of my old superstition, as if it had been a nightmare." To Galton's mind, the scientific doctrine of evolution destroyed the religious doctrine of the fall from grace. He appropriated Darwin to argue that man, instead of falling from a high estate, was "rapidly rising from a low one."[41] Eugenics would accelerate the process, would breed out the vestigial barbarism of the human race and manipulate evolution to bring the biological reality of man into consonance with his advanced moral ideals. According to Galton, "what Nature does blindly, slowly, and ruthlessly, man may do providently, quickly, and kindly." He found in eugenics a scientific substitute for church orthodoxies, a secular faith, a defensible religious obligation.[42]

Galton eventually gave up on race improvement through the state regulation of marriage, but he continued to hope that the new religion would foster voluntary eugenic marriage practices. After all, religious marriage customs clearly varied across cultures and served particular social purposes. Might not people pursue a procreatively eugenic life, Galton wondered, once eugenics carried the full, authoritative weight of a secular religion?[43] But in the wake of *Hereditary Genius*, Galton came to realize that, whatever the future held, so little was reliably known about heredity that even a Spartan given dictatorial powers over marriage might well produce race degradation rather than improvement. Intent on making a true science of eugenics possible, Galton began trying to ferret out the laws of inheritance.[44]

He approached the problem through the infant science of statistics. At the time, no biologist dealt with any part of his subject mathematically; Galton's remarkable methodological departure was of considerable long-term significance for the discipline. It originated, however, not in a conviction on his part that biology needed mathematics but, rather, in something that came naturally to him—counting, and pondering the resultant numbers. The word "statistics" denoted, in Galton's time, "state" numbers—indices of population, trade, manufacture, and the like—the gathering of which aided the state in the shaping of sound public policy. In mid-Victorian Britain, the practice of statistics consisted mainly of the accumulation of socially useful numerical data, with neither theoretical underpinning nor mathematical analysis. But in the late eighteen-sixties, as a result of his meteorological interests, Galton came upon a quite different approach to statistics—the formulation now called the normal, or Gaussian, distribution.[45]

Known at the time as "the law of error," the formulation derived from the analysis by the German mathematician Carl Friedrich Gauss of errors made in the measurement of "true" physical quantities—for example, planetary positions in astronomy. Portrayed graphically, the Gaussian distribution formed the now familiar bell curve; a vertical line bisecting the bell in the center represented the mean of the measurements—which was taken to be the true value of the quantity—and the curve itself expressed the fact that the greater the deviation from the mean in a measurement, the lower the frequency with which such a measurement would occur. Galton's interest, however, was not in the mean but in the distribution of deviations from it. Though he drew upon the few existing authorities in mathematical statistics, he came independently to view the Gaussian distribution not primarily as a way of differentiating true values from false ones but as a tool for analyzing populations in terms of their members' variations from a mean—the kind of variations inevitably manifest in, for example, the heights or weights of a large, randomly selected group of people.[46] Eventually, he concluded that there was "scarcely anything so apt to impress the imagination as the wonderful form of cosmic order expressed by the 'Law of Frequency of Error,' " and added, "The law would have been personified by the Greeks and deified, if they had known of it."[47]

In *Hereditary Genius*, Galton assumed that talent was normally distributed—that deviations in either direction from the mean talent of the population would follow the Gaussian distribution. He used the law to try to estimate the number of men of genius—and of exceptional stupidity—among the British population of 1860.[48] But he made no further use of the law, not least because he lacked data concerning the distribution in human populations of even simple physical characteristics, let alone intelligence. "The work of a statistician is that of the Israelites in Egypt," he later remarked. "They must not only make bricks but find the materials."[49]

In the early eighteen-seventies, Galton began his search for materials by collecting information concerning physical characteristics of schoolboys. For hereditary data, he compared the seeds from a parental generation of *Lathyrus odoratus*, the sweet-pea plant, with those from its progeny. "It was anthropological evidence that I desired, caring only for the seeds as means of throwing light on heredity in Man," he later reported. To obtain human hereditary data, Galton hit upon the brilliant idea of establishing an Anthropometric Laboratory at the International Health Exhibition, which opened at the South Kensington Science Museum in 1884. Within a few months, some nine thousand people, including many parents and their grown children, were measured for height, weight, arm span, breathing power, and the like. At the same time, he published the *Record of Family Faculties*, a questionnaire on heredity, and offered prizes of up to five hundred pounds for the most detailed sets of family data.[50]

Galton scored his first advance in 1876, with the sweet-pea data. He had selected as the parental generation seven groups of seeds, each group containing the same number of seeds of a particular weight. The seven weights were the mean weight of all the seeds and the weights found at three statistical intervals on either side of the mean. He placed ten seeds from each group in separate packets and mailed sets of the seven packets, with detailed instructions for planting, to various friends (one was Darwin), in different parts of England. The sweet pea, a self-fertilizing plant, produces a large number of new seeds in pods. The friends were to harvest the daughter seeds and return them to Galton, placing them in the packets in which the original groups of parental seeds had arrived. When Galton received the complete produce, he was then able to weigh all the daughter seeds individually and analyze the statistical distribution of their weights.[51]

Galton did not discuss how many daughter seeds the complete produce contained, nor at the time did he provide any other concrete numerical details of the outcome. Rather, he dwelt on the general statistical features of the results, which he found astonishing. Each group of parental seeds of the same weight produced a family of daughter seeds in which the weights were distributed around a mean in Gaussian fashion. What astonished Galton was that no matter what the weight of the parent seeds, heavy or light, all the distributions had the same statistical variability; that is, the same proportion of seeds could be found on the bell curve within a given distance from the family mean. He soon realized—"I forgot everything else for a moment in my great delight"—that the laws governing heredity, whether of sweet peas or of men, could be treated mathematically, in terms of units of statistical deviation.[52]

Galton took as the unit of deviation the so-called "probable error" of nineteenth-century scientists, which was arbitrarily defined as the distance along the horizontal axis, or baseline, of the bell curve where a vertical line would divide the area to one side of the bell's center into two equal parts. Twice this distance thus equaled two units of deviation; three times the distance, three units. Taking the sweet-pea data, Galton measured by how many units the mean weights of each parental seed group and its daughter family of seeds, respectively, deviated from the mean weight of the total seed population—the "race." He calculated the ratio for each pair of daughter-parent deviations and discovered that all the ratios were about the same. That striking result complemented another feature of the data: the mean weight of every daughter family fell closer to the mean of the total population than did that of its parent group. Galton interpreted this to suggest that the characteristics of offspring were products not only of the immediate parent but also of numerous forebears. He argued that the effect of ancestry caused the progeny of one generation to revert toward the center of the population, and he dubbed the measure of that tendency, expressed in the common ratio of the daughter-parent deviations, the "coefficient of reversion."[53]

Once Galton had the data from the Anthropometric Laboratory and the *Record of Family Faculties*, he was able to ruminate over the statistics of human heredity. He constructed a table marked with grades of parental height on the left-hand side and of the height of their grown children on the top. For parental height, he used an average of the maternal and paternal heights, which he called the height of the "midparent." An imaginary horizontal line drawn from a given midparental height on the left would intersect an imaginary line dropped vertically from a given child's height. At each point of intersection Galton entered a number denoting the frequency with which, according to his data, a midparent of the height marked on the left produced a child of the height designated at the top. Read across from left to right, the resulting array of numbers expressed the observations that midparents of, say, seventy-one inches in height produced four children with heights of sixty-seven inches, five children of sixty-eight inches, five of sixty-nine inches, and four of seventy inches; or that midparents of sixty-six inches produced four offspring of sixty-five inches, six of sixty-six inches, and four of sixty-seven inches.[54]

In his meteorological work, Galton had liked to connect points of equal temperature or pressure on a weather map. While puzzling over his table of height data, Galton noticed that points of equal frequency—for example, every point labeled "4"—formed a series of concentric ellipses. Equally arresting, a straight line that connected the horizontal tangent points had a slope—the ratio of the line's vertical to its horizontal rate of progress—equal to the coefficient of reversion of the children on the parents; one connecting the vertical tangent points had a slope equal to the coefficient of reversion of the parents on the children. Galton suspected, with considerable insight, that one could construct these ellipses knowing only three things: the probable errors of the parental and filial generations and the reversion coefficient of the latter on the former. Galton was rusty in analytic geometry and unable himself to prove his insight. Disguising the problem as one in abstract mechanics, so as not to prejudice the outcome, he set the task for J. D. Hamilton Dickson, a mathematician at St. Peter's College, Cambridge. Dickson derived Galton's ellipses and their interrelationships, using only analytic geometry and the laws of probability. The outcome was freighted with an implication that delighted Galton. Dickson's result held as a general relationship between any two appropriate variables, not only those linked by heredity. The coefficient of reversion was thus independent of heredity; it was purely a property of statistical manipulation itself. Galton, the onetime aspiring mathematician, had willy-nilly forged a contribution to mathematical statistics. To rid the reversion term of its hereditary flavor, he renamed it the "coefficient of regression."[55]

Not long afterward, Galton became interested in the Frenchman Alphonse Bertillon's system for the identification of criminals, which relied on taking their physical measurements—for example, head and limb size. Galton thought that Bertillon's system suffered from redundancy; it treated different dimensions of the same person as if they were independent, and many of them were not. A tall man, for example, was much more likely than a short one to have a long finger, arm, or foot. To find out whether such characters were in fact independent, Galton tabulated against each other such characteristics as height and arm length. In short order, he noticed that the results fell into a pattern similar to what he had previously found for the heights of parents and children. The tabulation could even be made to produce a similar set of concentric ellipses and mathematical relationships. In consequence, Galton realized that the relationship between measures of two different entities such as height and arm length could be expressed mathematically—just as in regression—by a coefficient of correlation. In fact, Galton concluded, regression was simply a special case of correlational analysis.[56]

The coefficient of correlation, expressed as a number ranging from minus one to plus one, provided a measure of the degree, positive or negative, to which one variable might depend upon another. Statistical correlation could be of particularly powerful assistance in cases—legion in the disciplines of biology and sociology—involving two or more independent variables each of which might be only partly responsible for an observed outcome. Statistical correlation might suggest, for example, that academic performance was negatively correlated with class size—the smaller the class, the better the performance—and, at the same time, positively correlated with the teacher's years of experience. "Some people hate the very name of statistics, but I find them full of beauty and interest," Galton declared shortly after the work on correlation. "Their power of dealing with complicated phenomena is extraordinary. They are the only tools by which an opening can be cut through the formidable thicket of difficulties that bars the path of those who pursue the Science of man."[57]

Galton made a good case for that claim in 1889, when he brought together most of the results of his investigations in heredity and statistics in the scientifically influential *Natural Inheritance*. For all its merits, the book, like much of Galton's mathematical work, lacks rigor and is in places wrong. It is the sort of study to be expected from a pass-degree Cambridge graduate who was neither a formal mathematician nor an intellectually disciplined scientist. Galton proceeded by counting, pondering numerical arrays, constructing mechanical analogues, and relying on geometry and intuition. When he required rigorous mathematical proofs, he had to turn to others. Nevertheless, the core of his work in statistics constituted a sharp and irreversible departure from the mere data gathering that had characterized the science in midcentury. Galton insisted that statistics had to incorporate the theory and methods of mathematical probability. By doing precisely that, he produced, with regression and correlation, a seminally important innovation. His biographer Karl Pearson wrote in 1930, "Thousands of correlation coefficients are now calculated annually, the memoirs and textbooks on psychology abound in them; they form . . . the basis of investigations in medical statistics, in sociology and anthropology. . . . Formerly the quantitative scientist could think only in terms of causation, now he can think also in terms of correlation. This has not only enormously widened the field to which quantitative and therefore mathematical methods can be applied, but it has at the same time modified our philosophy of science and even of life itself."[58]

By "life itself" Pearson meant mainly heredity. *Natural Inheritance* contains numerous obiter dicta—most of them unsupported or erroneous —on aspects of the subject, including the heritability of disease, of the "artistic faculty," and of alcoholism.[59] Galton's mathematical analyses of ancestral or familial hereditary relationships were faulty. And he was in fact unable to shed any real light on the heritability of talent or intelligence—a problem he never solved. But he did contribute crucially to the study of heredity. While scientists before him, including Darwin himself, had spoken vaguely of some force of inheritance, of reversion and variation, or of like begetting like, Galton gave heredity a sharp—albeit, of course, a non-Mendelian—definition: the quantitative, hence measurable, relationship between generations for given characters.[60]

But Galton's heredity studies raised serious problems for his eugenics program. It was clear from his work that in any population the distribution of a given character remained the same from generation to generation; the bell curve for, say, height was the same for children as for parents.[61] More important, even if only members of the population at the extremes of the bell curve—for example, heavier sweet-pea seeds—were chosen for reproduction, Galton's results declared that their progeny, if they were left to reproduce without constraint, would ultimately regress toward the mean of the initial population. It seemed that only by selection of the weightier seeds in every generation could a line of heavy seeds be kept heavy. It was "in consequence impossible that the natural qualities of a race may be permanently changed through the action of selection upon mere variations," Galton believed. "The selection of the most serviceable variations" —presumably he included high ability—"cannot even produce any great degree of artificial and temporary improvement."[62]

If the evolution of new forms did not come about by the selection of small variations, however serviceable they might be, how did it come about? Theorists of evolution had debated the problem of evolutionary mechanisms long before Galton's statistical work. As the debate proceeded, Darwin had cited an early theory of his, called pangenesis, which stated that the environment induced advantageous organic modifications, and that these were transmitted, by particles he called gemmules, via the circulation of bodily fluids to the sexual organs and ultimately to succeeding generations. But in the eighteen-seventies, in an experimental challenge to the theory of pangenesis, Galton had found that gray rabbits whose blood—and, presumably, gemmules—had been mixed with that from whites nevertheless bore not mongrel rabbits but more grays. Heredity, Galton supposed, must be governed by some sort of "stirp" (he took the word from the Latin for "root")—a latent element responsible for the transmission of characters from one generation to the next.[63] In the eighteen-eighties, the German biologist August Weismann independently advanced a similar, though physiologically more substantial, hypothesis with his theory of the continuity of the "germ plasm." Weismann's work reinforced Galton's long-standing belief that race improvement could occur only when nature provided a distinct and heritable organic change—biologists of the day termed it a "sport"—upon which selection, natural or eugenic, could act.[64]

The inability to resolve the controversy over how evolution proceeded cast a certain doubt on Darwin's theory and raised obstacles to Galton's eugenics. In the preface of the 1892 edition of *Hereditary Genius*, Galton acknowledged that "the great problem of the future betterment of the human race is confessedly, at the present time, hardly advanced beyond the state of academic interest." Nevertheless, he insisted that human beings could at least hope to achieve eugenic improvement indirectly. "We may not be able to originate, but we can guide. The processes of evolution are in constant and spontaneous activity, some towards the bad, some towards the good. Our part is to watch for opportunities to intervene by checking the former and giving free play to the latter."[65]