The roots of industrial engineering – Francis Galton: The gentleman explorer

Compiled by Prof Paul Kruger

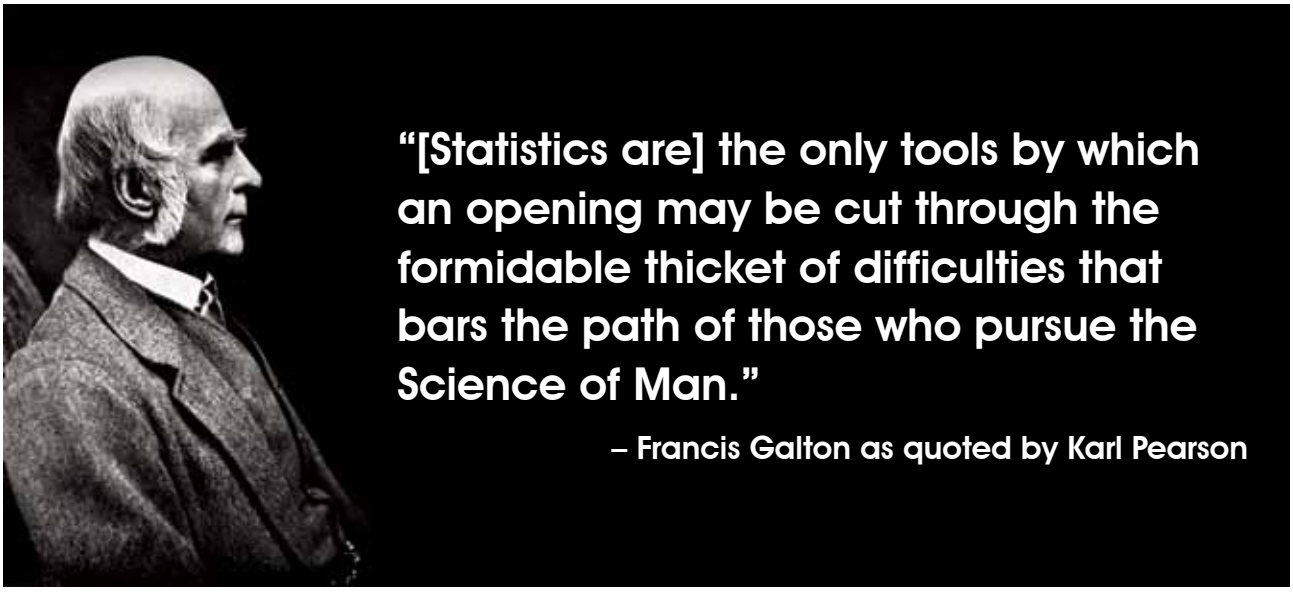
Galton is mainly, possibly unfortunately, known as the father of eugenics. This name was coined by Galton for his theory that the physical and mental makeup of the human species may be improved by selected parenthood. This theory has been severely misinterpreted and misused to the detriment of Galton's otherwise immaculate reputation. Using numerous observations and experiments, he proved his own theory wrong, and in the process discovered and formulated the very important statistical concept of regression to the mean. This concept is sometimes used, wrongly so, as the reason why the human race, countries and even business enterprises are doomed to regress over time to a state of mediocrity.

Francis Galton (1822–1911) was born in Sparkbrook (near Birmingham), England. He was raised in a high-class intellectual environment and was the youngest of nine children. The Galtons were a famous and highly successful Quaker family of gun manufacturers and bankers. His father, Samuel Tertius Galton, was a wealthy banker with close family links to both the Barclay and the Wedgeworth families. Galton's grandfather, Samuel John Galton, was principally responsible for the family fortune and was a Fellow of the Royal Society. His other grandfather, Erasmus Darwin, was a medical doctor, polymath and naturalist of repute. Erasmus Darwin and Samuel Tertius Galton were founding members of the famous Lunar Society of Birmingham.

Galton showed promising mathematical skills at an early age, but originally attended King's College in London to study medicine. He became frustrated and discontented with his studies when he was confronted with his first cadaver, much like his first cousin Charles Darwin, and in 1840, went to study the Mathematical Tripos at Trinity College, Cambridge. After suffering through three years of studying, he obtained a BA and was awarded an MA, but a nervous breakdown terminated his further studies. In February 1844, Galton became a freemason at the Scientific Lodge, held at the Red Lion Inn in Cambridge. In the same year, his father died and left him and his siblings a large inheritance.

Galton was therefore independently wealthy and became a charming social snob who never had to work a day in his long life to earn a living. However, he probably did more than anyone else in history to transform mathematical statistics. It changed from a somewhat esoteric mathematical pastime, mainly applied to gambling and astronomical problems, to a tool for analysing the technological and social problems of the everyday world. He was obsessed with counting, measuring and making observations. This included counting the number of times people fidgeted as they listened to a lecture, measuring and comparing the height of fathers and their sons, and classifying the degree of attractiveness of the girls he passed on the streets of London. As a maniac for classification, he developed a "Beauty Map" of the British Isles, based on how many pretty women he encountered. He gave London the highest score and Aberdeen the lowest. He made statistical inquiries into the efficacy of prayer, which attracted some criticism from the religious Victorian society. He found that those people frequently prayed for, like monarchs, lived no longer than anyone else. In a letter to *Nature* in 1879, entitled "The average flush of excitement", Galton recounts a visit to the derby. He noted that he was able to assess what he called "the average tint of the complexion of the British upper classes" by observing the distant crowd through his opera glasses. He observed that, after the race started, the crowd became "suffused with a strong pink tint, just as though a sunset glow had fallen upon it". Galton claimed that he could work out the mood of a mass of people even without being able to distinguish one person from the next. Although somewhat weak in mathematics or any other scientific discipline, his ideas strongly influenced the development of statistics. These ideas include his formulation and application of regression analysis and his proof that, as a consequence of the central limit theorem, a mixture of normal distributions is in itself normal.

> "Whenever you can, count."
> – Francis Galton



"[Statistics are] the only tools by which an opening may be cut through the formidable thicket of difficulties that bars the path of those who pursue the Science of Man."

– Francis Galton as quoted by Karl Pearson

After quitting university, Galton, possibly having inherited some athletic abilities from his Barclay ancestors, spent two years being a full-time athlete. Thus, he may have been one of the first semi-professional athletes. Thereafter, he decided to become an explorer and travelled extensively through Europe, the Middle East and North Africa. The famous trip by his first cousin, Charles Robert Darwin, on the HMS Beagle, may have inspired him to explore southern Africa. He used his own money to fund two expeditions in 1849 with the purpose of opening the way to Lake Ngami in what is now northern Botswana. On both occasions, he didn't set out from the Cape as would be expected, but from Walvis Bay. He claimed he was warned about the "fierce Boers" that he might encounter in the interior. He was accompanied by Karl Johan Andersson, the Swedish explorer, but both expeditions failed.

Nevertheless, he had some interesting experiences on which he reported in detail. For example, he went in search of "a remarkable nation" that was deficient in joints both at the elbows and knees. They were therefore unable to lift anything to their mouths by themselves, but "when they dined, they did so in pairs, each person feeding his *vis-à-vis*". While he was in Damaraland, he was intrigued by the physical characteristics of some of the women he encountered. He remarked that they seemed to be very well adapted to one of the ladies' fashions (the "Victorian Bustle") that were in vogue in England at the time. As he was a keen amateur anthropologist, he was interested in obtaining some measurements. Since he was a gentleman as well as an innovator and he didn't want to cause offence or suffer embarrassment, he took measurements from a distance using his knowledge of trigonometry and his sextant.

On his return to England he wrote a book entitled *Narrative of an explorer in tropical South Africa* (1853). This book was very well written and illustrated with numerous colour plates produced from the sketches made by the artist that accompanied Galton. The book proved to be a huge success and may be one of the reasons why Galton was elected as a Fellow of the Royal Geographical Society in 1853 and a Fellow of the Royal Society in 1860. At this time, it was Galton's conviction that "character and ability are inherited". This conviction served him well, given his own impressive pedigree. He produced and published a family tree of his ancestry, featuring the Darwin, Galton and Wedgeworth families. He identified those members who, according to him, showed significant signs of genius. Galton seemed to have had no qualms about including himself in this illustrious group. On 1 August 1853, Galton married Louisa Jane Butler. Somewhat ironically, he had no children and therefore escaped the humiliation of seeing his own offspring possibly not conforming to his pet hereditary theories.

Galton is best known for his interest in inheritance. His book, *Hereditary genius,* is sometimes said to have founded the study of human genetics. Concentrating on the transference of "genius" from parent to child, he coined the phrase "nature versus nurture" in 1883 and invented the word "eugenics" (of good birth) for the process of improving the physical and mental makeup of the human species by selected parenthood. Eugenics fell into disfavour after the perversion of its principles by Nazi ideologists, and in the process, maybe unfairly, bringing Galton's work into disrepute. Galton first thought that breeding two smart people would produce an even smarter person. He also thought that breeding two tall people would produce an even taller person. In an effort to prove his theories, Galton established an anthropometric laboratory at the International Health Exhibition in London in 1884. Some 9 000 visitors to this laboratory were quite happy to pay three pennies apiece to undergo 17 body measurements (including height, skull size, hand strength and the power of one's punch), and in return, receive a "score" indicating the person's fitness and health. In this way, Galton was able to collect a large set of data for different individuals on which to base his research. However, the results of the analysis he performed proved that the idea of eugenics was not plausible. Galton used experiments with peas to augment his observations of the stature of parents and their children. With what may only be described as

a brilliant "mind experiment", Galton discovered and formulated the phenomenon known as "regression to the mean" or, according to the title of the relevant publication, *Regression towards mediocrity in hereditary stature*. However, the most important part of Galton's work had nothing to do with eugenics, for he was one of the first to realise that science (biology as much as physics) needs mathematics rather than words. The collection, classification and analysis of large amounts of anthropometric data may be seen as the beginning of the science of ergonomics. In a similar way, one may see his penchant for collecting, storing, analysing and using huge amounts of data as a contribution to the science of information technology.

Galton maintained a close friendship with Darwin despite occasional strain. Galton accepted Darwin's theory of evolution, but decisively refuted Darwin's theory of pangenesis. Darwin adhered to a blood-mixing account of inheritance, in which "gemmules" in the blood transmitted human traits and characteristics. Galton put this to the test by performing blood transfusions on rabbits; experiments that Darwin enthusiastically followed. The rabbits paid no attention to "pangenesis" and Galton was forced to conclude that Darwin was wrong. Darwin took this painfully.

Although he was a life-long sufferer of occasional bouts of severe depression, it seems as if Galton never considered a possible link between depression and genius, but made some remarks concerning a possible relationship between genius and insanity: "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." When he was suffering from depression, Galton referred to himself as "the man with the sprained brain". For somewhat different reasons, his wife referred to him as "the man who counted everything except calories".

Galton developed a system consisting of a set of three dice and a table for the generation of standard normal random variates. As a result, he laid some of the foundations for stochastic simulation modelling. He discovered the uniqueness of human fingerprints, using some of the data he collected in his laboratory. He was able to show that fingerprint patterns remained constant as the person grew older, and he devised characteristics of the fingerprints that could be used as unique identifiers of the person, based on grouping the patterns into arches, loops and whorls. His identification system became the basis for the classification system of Sir Edward R Henry, who later became Chief Commissioner of the London Metropolitan Police. The Galton-Henry system of fingerprint classification was published in June 1900, and began to be used at Scotland Yard in 1901 as an identifier on criminal records. It was soon used throughout the world in criminal investigations. Galton was also a meteorologist and the first person to identify the anticyclone (as opposed to the cyclone). In 1875, he was the first person to publish a weather map in the *Times* newspaper. His book, *Meteorographica* (1863), was the first systematic attempt to gather, chart and interpret weather data on a continental scale, a fundamental work of modern scientific meteorology. Interested in measuring human intelligence, Galton devised the first scientific methods for measuring mental faculties, and thereby founded psychometrics. He also introduced the use of questionnaires and surveys for collecting data, thus paving the way for modern market research and opinion polls. Galton was also a very innovative designer and builder of a plethora of scientific measuring instruments to support his research. For example, in an effort to measure the range of frequencies that could be heard by various animals and for testing differential hearing abilities in humans, Galton invented the so-called dog whistle in 1876.

He saw "bell curves" wherever he went and was principally responsible for the transformation of the normal distribution (he coined the word "normal") from being a "law of error" used mainly in astronomy to a "law of nature" applicable to almost every facet of commerce, industry and everyday life. With his gadget, the quincunx, he demonstrated and to some extent proved the tendency towards "normality" in nature. Together with Quetelet, Edgeworth and Pearson, he brought mathematical statistics into the realm of the social sciences and invented the concept of statistical correlation. He insisted that variety is ever present, but that there is often order in what may seem chaos and sometimes there is at least some structure in the seemingly unpredictability of random events. In the late 1860s, Galton conceived of a measure to quantify variation: the standard deviation. In the 1870s and 1880s, he was a pioneer in the use of the normal distribution to fit histograms of actual tabulated data. Galton devoted many years of study to the use of "composite portraiture". This concept entails combining photographs of different subjects through repeated limited exposure to produce a single blended image. Galton perfected the technical details of the method by repeated trial and error over many years, using apparatus of his own design. He was especially interested in the use of these composites to test if there was a recognisable criminal type revealed by them, but his experiments in this direction proved that, within the range of data available to him, no such type revealed itself. The portraits of criminals tended to blend away into normality. This research, together with his work on fingerprints, eventually led to the development of pattern recognition techniques such as the bar code identifications used in warehouses and supermarkets today.

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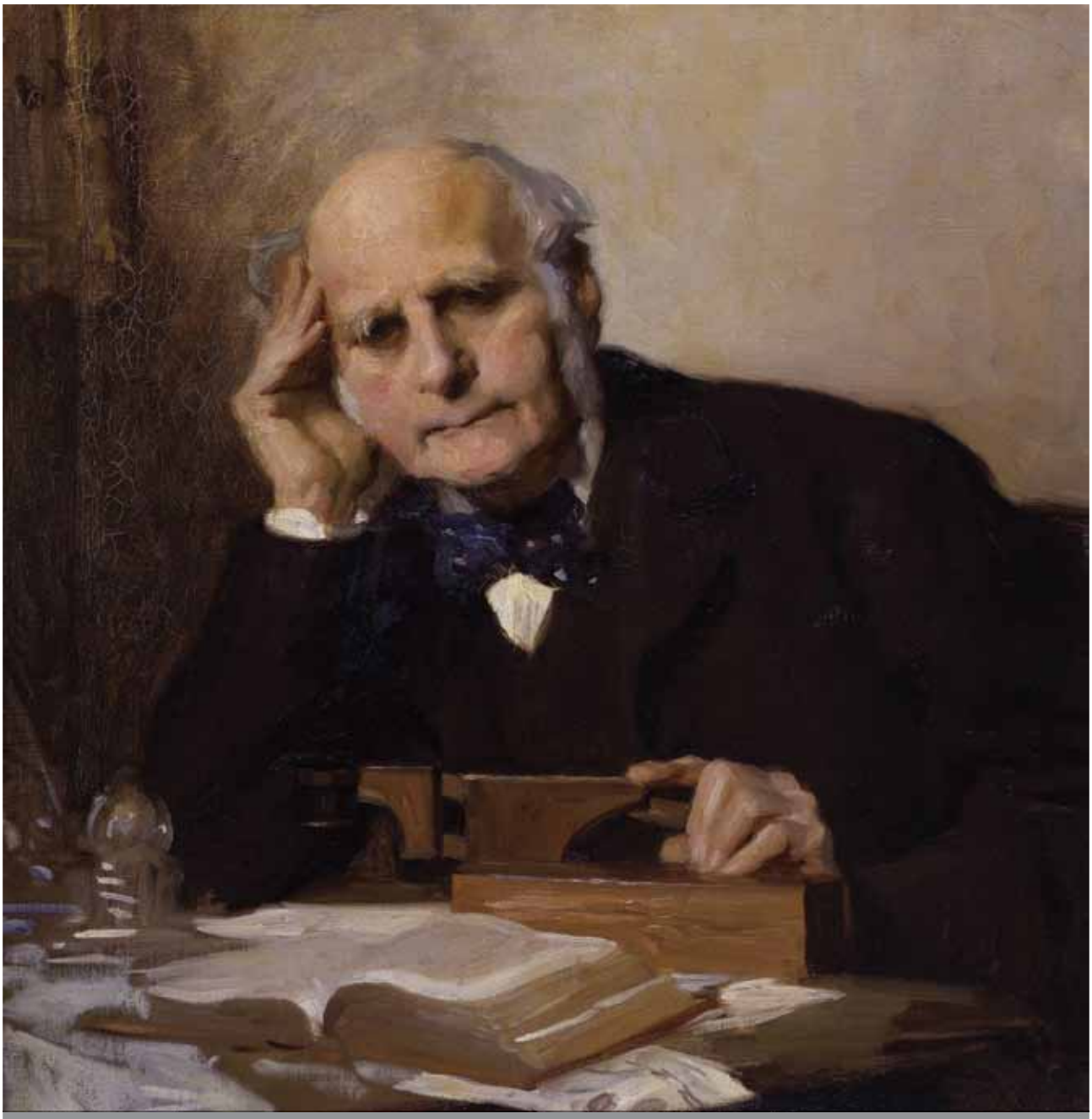

Sir Francis Galton by Charles Wellington Furse.

In his will, Galton bequeathed the then enormous sum of £45 000 for the establishment of a Chair in Eugenics at the University College London. Karl Pearson, his life-long friend, protégé, co-worker, biographer and co-founder of the highly influential journal *Biometrika* (1901), was the first professor incumbent and Ronald Fisher was the second. The Chair was later renamed the Galton Chair in Genetics, and is still in existence today.

Galton was a truly multitalented scientist. He was a polymath, anthropologist, eugenicist, explorer, geographer, inventor, innovator, meteorologist, protogeneticist, psychometrician and statistician. He made significant contributions to all of these disciplines. He will be remembered and revered for these contributions. The well-known and prestigious medical journal, *The Lancet*, published a special article in 2011 entitled "The legacies of Francis Galton" to commemorate the centenary of his death. Similarly, the University College in London mounted two exhibitions as part of the Legacies of Galton: *Centenary Programme at UCL*. Galton published over 340 papers and books during his long life. He was knighted in 1909 at the age of 87.

Sir Francis Galton, Fellow of the Royal Society (FRS), died on 17 January 1911 in Haslemere of unspecified causes and was buried in Claverdon, England.

Adapted primarily from *Against the gods: The remarkable story of risk* by PL Bernstein; *The wind makes dust* by Ben Maclennan; *The life, letters and labours of Francis Galton* by Karl Pearson, http://galton.org, http://www-history.mcs.st-and.ac.uk and http://en.wikipedia.org, as well as many more easily accessible websites.