9 The Beginnings of Statistics

9.0 Texts

Theodore M Porter (1986) *The Rise of Statistical Thinking 1820-1900* Princeton University Press

Stigler, Stephen(1986) *The History of Statistics : The Measurement of Uncertainty Before 1900*

Hacking, Ian (1982) *Emergence of Probability; A Philosophical Study of Early Ideas about Probability, Induction, and Decision*

Gerd Gigerenzer, et al *The Empire of Chance : How Probability Changed Science and Everyday Life (Ideas in Context)*;

Hacking, Ian (1990) *The Taming of Chance* Cambridge University Press, Cambridge.

Graunt, John(1662) *Natural and Political observations mentioned in a following Index, and made upon the Bills of Mortality*. London. Reprinted in an edition edited by W.F.Willcox, Baltimore, 1939

Quetelet, Adolphe(1844) Sur l'appréciation des documents statistiques, et en particulier sur l'application des moyens, *Bulletin de la Commission Centrale de la Statistique (of Belgium*), 2:258

Statistics derives from a German term *Statistik* first used by Professor Achenwall in 1749, a science concerned with describing political States. Only later did it become identified with numerical descriptions of states, and then with numerical descriptions of any populations. The English usage statistics is attributed to John Sinclair, 1791-1799 *Statistical Account of Scotland.* A principal reason for the development of statistics during the 19th century was the development of centralized bureaucracies in the European countries at the beginning of the 19th century, their need for estimates of population numbers for planning conscription and taxation, which required regular censuses of the population.

9.1 Early Censuses

The word census derives from the Roman censor, the official in charge of counting Romans and setting tax rates.

From
http://www.dispatchesfromthevanishingworld.com/pastdispatches/mountain/mountain_3.html
The practice of conducting a regular, comprehensive census is a recent development in most of the world, although the Babylonians appear to have been doing it as early as 3800 B.C., and the Romans were inveterate census takers. The periodic assessment of adult male Roman citizens and their property was instituted by the sixth king, Servius Tullius, around 550 B.C. and continued until the Empire fell. In 158 B.C., three hundred and twenty-eight thousand citizens capable of bearing arms were enumerated. At the time of Caesar Augustus, the census was expanded to take in the whole Roman Empire. (One recalls how, in the Gospel of Luke, Joseph and Mary had to go to Bethlehem to be counted among the descendants of David.) Fragments of Chinese censuses in the fourth and fifth centuries of the present era have been found in the Tunhuang caves, in Kansu province; the demographer John Durand has discovered records of or references to hundreds of censuses taken between 2 A.D., when the golden age of the Earlier Han Dynasty was drawing to a close, and 1911, when the last Ching emperor was deposed. The Japanese were keeping track of themselves, with land registers that contained additional household information, by the seventh century, but the practice stopped in the eighth century, when the society became feudal. The inquisition records of the repressive Tokugawa Shogunate (1603-1867), however, are as nearly comprehensive as most modern censuses; in fact, they represent the earliest instance of the gathering of vital statistics for almost a whole population.

Ancient Censuses are mentioned in the Bible, the first at the time of the Exodus, about 1490 B.C.

The Lord spoke to Moses...in these words:"Number the whole community of Israel by families in the father's line, recording the name of every male person aged twenty years and upward fit for military service." So Moses and Aaron...summoned the whole community on the first day of the second month, and they registered their descent.

A second census mentioned was taken about 1000 B.C. at the order of King David.

[David]...instructed Joab and the officers of the army with him to go around all the tribes of Israel, from Dan to Beersheba, and make a record of the people and report the number to him...They covered the whole country and arrived back at Jerusalem after nine months and twenty days. Joab reported to the King the total number of people: the

number of able-bodied men, capable of bearing arms, was eight hundred thousand in Israel and five hundred thousand in Judiah.

During the Roman Empire, censuses were taken from about 550 B.C. One of these Roman censuses is well known:

In those days a decree was issued by the Emperor Augustus for a registration to be made throughout the Roman world. For this purpose everyone made his way to his own town; and so Joseph went up from Judaea from the town of Nazareth in Galilee, to register at the City of David, called Bethlehem.

After the fall of the Roman Empire, census taking practically ceased in the western world with the exception of the Domesday inquest which was ordered by William the Conqueror of England in 1086 to assess the population and wealth of the newly-conquered realm.
Again, from
http://www.dispatchesfromthevanishingworld.com/pastdispatches/mountain/mountain_3.html
The first post-Roman censuses in the West were Scandinavian: Sweden in 1539 (but just the taxable part of the population), Iceland in 1703 (a very thorough one, listing entire households). The first federal census in the United States was taken in 1790, and there has been one every ten years since. But until 1850 only heads of households were listed; the rest of the family appeared as numbers in age and sex columns, and Indians-unless they had been assimilated into white society -were not counted until 1860. Recent American censuses have probably undercounted by between one and three per cent. Russia did not conduct a fullscale census until 1897, and there have been only five censuses since. The 1897 census seems to have been conducted rather like one of the Christmas bird counts by the Audubon Society. It was all done in one day, January 28th (the reasoning was that people were most likely to be at home in the dead of winter), by a hundred and fifty thousand census takers, who filled more than thirty million sheets with data. Even visiting foreigners were counted. The 1897 census was a notable improvement, however, over the "revisions" of taxable "souls" (all males not in the nobility), started by Peter the Great. The first of these began in 1719 and dragged on until 1727. The twenty-three million souls counted in the tenth revision, which was completed in 1859, are estimated to have been only thirty-five per cent of the Czar's subjects.

The age of modern vital-record keeping is widely considered to have begun in 1538, when Thomas Cromwell, Henry VIII's vicar-general, ordered the parish clergy to record every christening, wedding, and burial (although the Japanese, whose Buddhist necrologies go back to the thirteenth century, and the Italians, whose baptismal records begin in the early fifteenth century, might not agree). Most of the other European countries were also keeping parish registers by the end of the sixteenth century. The usefulness of these records varies from country to country (one scholar recently ranked the German registers as the "most meticulous," the French ones as "a hodgepodge," and the Spanish ones as even more difficult than the French ones to evaluate), but in general parish registers are the meat and potatoes of European genealogists. Because they are restricted to local congregations, however, they are far from comprehensive; by the end of the seventeenth century they covered, at most, only half the European population. The first civil records were begun in France in 1792, and they are between ninety-five and a hundred percent complete. In the United States, most states did not begin to keep birth and death records until after 1900; American genealogists have had to rely on probate and land records, which have been kept since the beginning of Colonial history.

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9.2 Modern censuses

It is hard to say when the first census of a modern type was carried out. According to the demographer Thomlinson,
"the first known counting of every man, woman, and child occurred in central Europe in 1449, when Nuremburg was enumerated because its leaders feared depletion of a limited food supply under a stage of seige: as is often the case is such circumstances, results of the research were considered state secrets."

Nouvelle France (later Quebec) and Acadie (later Nova Scotia) had 16 enumerations between 1665 and 1754. (... The enumerations were possible and exact because the people were few and frozen-in during mid-Winter when the censuses were taken..) The Spanish had a census in Peru in 1548 and of their North American Possessions in 1576. Virginia had censuses in 1642-5. Ireland was surveyed in 1679 for land, buildings, people, and cattle. New York made a census in 1698, Connecticut in 1756, Massuchussetts in 1764.

It is generally agreed, however, that the first continuing complete count, taken at regular intervals was instituted in Sweden in 1749. Norway and Denmark followed in 1769, while the census in the United States began in 1790.

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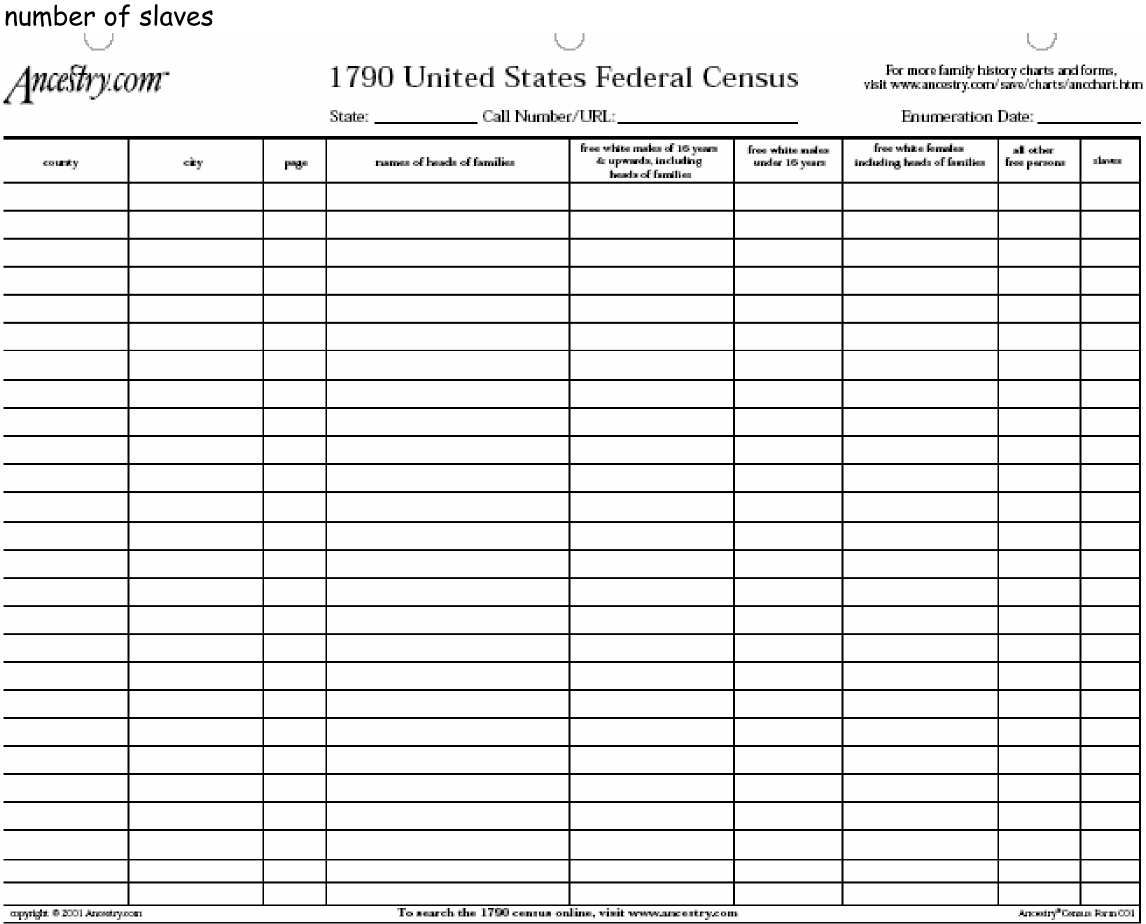
9.3 1790 U.S. Census

2 August 1790

Total Population: 3,929,214

1790 census records exist for Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont and Virginia (Virginia schedules were reconstructed from State enumerations)

head of household
number of free white males ages 16 and older
number of free white males under the age of 16
number of free white females
number of all other free persons
number of slaves



Ancestry.com

1790 United States Federal Census

For more family history charts and forms, visit www.ancestry.com/save/charts/ancchart.htm

State: ____________ Call Number/URL: ____________________ Enumeration Date: ____________

county	city	page	names of heads of families	free white males of 16 years & upwards, including heads of families	free white males under 16 years	free white females including heads of families	all other free persons	slaves

To search the 1790 census online, visit www.ancestry.com
Ancestry® Census Form C01

9. 4 Questions Asked in the 1890 Census

- street name and house number in cities
- name, age, sex and race of each individual in the household
- relationship of each individual to head of household
- whether single, married, widowed, or divorced
- if married within the census year
- if a mother, number of children and number of those children still living
- Civil War veteran (Union or Confederate) or widow
- profession, occupation, or trade
- number of months unemployed during the census year
- place of birth (state, territory, or country)
- father's place of birth
- mother's place of birth
- number of years resided in the United States, if foreign born
- whether or not a naturalized citizen
- number of months at school within the preceding year
- whether able to read and write
- whether able to speak English
- language spoken, if not able to speak English
- name and duration of acute or chronic disease
- name of defect if defective in mind, sight, hearing, or speech or crippled, maimed, or deformed
- whether prisoner, convict, homeless child, or pauper
- whether home was owned or rented; and if mortgaged
- if head of family is a farmer, is the farm rented, or owned
- if farm is owned, then free or mortgage, plus post office addre

9.5 Statistical Bureaucracies

An occasional census by a conquerer or new king or colonialising power happens and it is over. But a regular census requires a continuing bureaucracy, and sustained sytematic record keeping. These bureacracies began to form in Europe around 1800.

From Sir John Sinclair, *A statistical account of Scotland*:

Edinburgh, 1 January 1798 Many people were at first surprised at my using the words, Statistics and Statistical. ..In the course of a very extensive tour, through the northern parts of Europe, which I happened to take in 1786, I found that in Germany they were engaged in a species of political inquiry to which they had given the name of Statistics. By statistical is meant in Germany an inquiry for the purpose of ascertaining the political strength of a country , or questions concerning matters of state; whereas the idea I annexed to the term is an inquiry into the state of a country, for the purpose of ascertaining the quantum of happiness enjoyed by its inhabitants and the means of it future improvement.'

According to Hacking(1982), Leibniz was the godfather of Prussian official statistics. In 1685, before there was a Prussian State, he formulated the idea of a central statistical office which would record deaths, baptisms, and marriages, and so be able to estimate the population, and therefore the power of the state. In 1700 he urged the case of Prince Frederick of Prussia to be king of a united Brandenburg and Prussia, opposed by some on the grounds that Prussia provided only a small fraction of the population of the new state. Leibniz (using the Prussian registry of births begun in 1983) argued that Prussian had 22,680 compared to 65,400 for the entire region, and so was vital to the new state. Leibniz multiplied by 30 to get the population of the new state.

However, Prussian enumerations in the new state did not begin until Friedrich-Wilhelm I (1713-1740). Workmen in various categories, buildings, lands, roads were counted ; the numbers were used for taxation and conscription and to measure the power of the state. The population list was declared a State Secret in 1733. Friedrich loved saving things, and built up the army and the finances of the state without actually wanting to spend either. He especially treasured his regiment of six-footers, and was always on the lookout for impressively tall recruits. His son Frederick the Great (1740-1786) had a different attitude. They aint no-one calling Friedrich the great enumerator!

A Prussian Statistical Office was finally established in 1805 on the following decree of Friedrich Wilhelm III :

A bureau shall be established to collect and integrate statistical tables from the different departments and offices, the special directories, and from the Silesian finance ministry. His majesty decrees that this bureau shall be administered by councillor Krug, with direct responsibility to Minister of State Stein.

And unlike the secretive counts of the eighteenth centuries, the nineteenth century statistical offices published everything.

Germany had special statistical needs due to the customs union of 1833. Excise taxes for trade between states in the union were apportioned according to populations in the different states, which were assessed every three years.

Most European states had central statistical offices by 1820.
These offices had no interest in probability or random sampling, only in complete accurate enumerations. The London Statistical Society took as its motto *Aliis exterendum*, to be threshed out by others. To some extent, that motto was advanced because the early statists had pronounced opinions about necessary reforms, which they intended to advance with the persuasive mysterious scientific power of numbers, suitably interpreted.

9.6 Early threshing

With all these new statistics being collected and published, people will start drawing conclusions from them. Of course, the early censuses were collected with firm purposes of taxation and conscription.
But what about analyses based on data collected for different purposes.
The usual first named analyst is John Graunt (but it must be that people have always used the censuses and population data for unofficial conclusions.)
John Graunt analysed the Bills of Mortality, begun in the plague year 1603; they list the number of children christened each week, and classify deaths according to disease and gender. Graunt produces the first *survival* curve:

Age in years	0	6	16	26	36	46	56	66	76
Number of Survivors To that age	100	64	40	25	16	10	6	3	1

Some Conclusions from the "Bills of Mortality" (p. 9-15)

That about one third of all that were quick die under five years old, and about thirty six per Centum under six.

That some diseases, and Casualties keep a constant proportion, whereas some others are very irregular.

That not one Woman in an hundred dies in Child-bed, nor one of two hundred in her Labour.

There hath been in London within this age four times of great mortality, viz. Anno 1592, 1603, 1625, and 1638, whereof that of 1603 was the greatest.

Annis 1603, and 1625, about a fifth part of the whole died, and eight times more than were born.

That a fourth part more die of the Plague than are set down.

The Plague Anno 1603 lasted eight years, that in 1636 twelve years, but that in 1625 continued but one single year.

That Purples, small-Pox, and other malignant Diseases fore-run the Plague.

That as about l/5 part of the whole people died in the great Plague-years, so two other fifths fled.

That Plagues always come in with King's Reigns is most false.

That Autumn, or the Fall is the most unhealthfull season.

That in London there have been twelve burials for eleven Christnings.

That in the Country there have been contrary-wise, sixty-three Christnings for fifty-two Burials.

A supposition, that the people in, and about London, are a fifteenth part of the people of all England, and Wales.

That there are about six millions, and a half of people in England, and Wales.

That the people in the Country double by Procreation but in two hundred and eighty years, and in London in about seventy, as hereafter will be shown; the reason whereof is, that many of the breeders leave the Country, and that the breeders of London come from all parts of the
Country, such persons breeding in the Country almost onely, as were born there, but in London multitudes of others.

That about 6000 per Annum come up to London out of the Country.

That in London about three die yearly out of eleven Families.

That in London are more impediments of breeding than in the Country.

That there are fourteen Males for thirteen Females in London, and in the Country but fifteen Males for fourteen Females.

There being fourteen Males to thirteen Females, and Males being prolifique fourty years, and Females but twenty five, it follows that in effect there be 560 males to 325 Females.

The said inequality is reduced by the latter marriage of the males, and their imployment in wars, Sea-voiage, and Colonies.

Physicians have two Women Patients to one Man, and yet more Men die than Women.

There come yearly to dwell at London about 6000 Strangers out of the Country, which swells the Burials about 200 per Annum.

That every Wedding one with another produces four Children.

London not so healthfull now as heretofore.

The Diseases, and Casualties this year being 1632

Affrighted	1
Abortive and Stilborn	445
Aged	628
Ague	43
Apoplex, and Meagrom	17
Bloody flux	348
Bruised and Ulcers	28
Burst, and Rupture	9
Cancer, and Wolf	10
Canker	1
Childbed	171
Chrisomes, and Infants	2268
Colick, Stone, Strangury	55
Consumption	1756
Cut of Stone	5
Dead in the Street	6
Dropsie	267
Drowned	34
Executed and Prest to Death	18
Falling Sickness	7
Fever	1108
Fistula	13
Flocks, and Small Pox	531
French Pox	12
Gangrene	5
Gout	4

Bit with a mad dog	1
Grief	11
Jaundies	43
Jawfain	8
Impostume	74
Kil'd by several accidents	46
King's Evil	38
Lethargie	2
Made away themselves	15
Measles	80
Murthered	17
Palsie	25
Plague	8
Planet	13
Pleursie and Splees	86
Purples	38
Quinsie	7
Rising of the Lights	98
Scurvey	9
Suddenly	62
Surfet	86
Teeth	470
Thursh and Sore Mouth	40
Tympany	13
Tissick	34
Vomiting	1
Worms	27
Overlaid and starved	7

9.7 Adolphe Quetelet

Quetelet who was the first great interpreter, applying the methods of the new inferencial and probabilistic thinking in astronomy to the flood of statistical data emerging from the new statistical offices.

From Stigler, Stephen M. "Adolphe Quetelet." Encyclopedia of Statistical Sciences. New York:

Adolphe Quetelet (1796-1874)

Adolphe Quetelet was one of the most influential social statisticians of the nineteenth century. His applications of statistical reasoning to social phenomena profoundly influenced the course of European social science.

Quetelet was born in Ghent, Belgium on February 22, 1796. He received a doctorate of science in 1819 from the University of Ghent. He taught mathematics in Brussels after 1819 and founded and directed the Royal Observatory. Quetelet had studied astronomy and probability for three months in Paris in 1824. He learned astronomy from Arago and Bouvard and the theory of probability from Joseph Fourier and Pierre Laplace; there is some question whether he actually studied with them in person. Here he learned how to run the observatory. Quetelet gave special attention to the meteorological functions of his observatory.

One science was not enough, however, for Quetelet. Starting around 1830, he became heavily involved in statistics and sociology. Quetelet was convinced that probability influenced the course of human affairs more so than earlier generations had and more so than his contemporaries did. Astronomers had used the law of error to gain accurate measurement of phenomena in the physical world. Quetelet believed the law of error could be applied human beings. If the phenomena analyzed were part of huma n nature, Quetelet believed that it was possible to determine the average physical and intellectual features of a population. Through gathering the "facts of life," the behavior of individuals could be assessed against how an "average man"; would normally behave. He believed it possible to identify the underlying regularities for both normal and abnormal behavior. "Average man" could be known from graphically arraying the facts of life as bell shaped curves.

Quetelet had come to be known as the champion of a new science, dedicated to mapping the normal physical and moral characteristics. Quetelet called it social mechanics. He published a detailed account of the new science in 1835 which he titled *A T reatise on Man, and the Development of His Faculties*. This was a lengthy account of the influence of probability over human affairs.

Quetelet thought more of "average" physical and mental qualities as real properties of particular people or races awaiting discovery and not just abstract concepts. Quetelet helped give cognitive strength to ideas of racial differences in ni neteenth century European thought. His conception of "average man" is the central value about which measurements of a human trait are grouped according to the normal curve. The "average man" began as a simple way of summarizing some characteristic of a population, but in some of Quetelet’s later work, "average man" is presented as an ideal type, as if nature were shooting at the "average man" as a target and deviations from this target were errors. Cournot and ot hers criticized the concept. An individual average in all dimensions might not even be biologically feasible, they argued.

In 1846 he published a book on probability and social science that demonstrated as diverse a collection of human measurements as the heights of French conscripts and the chest circumferences of Scottish soldiers could be taken as approximately normally distributed. The use of the normal curve in areas so far from astronomy and geodesy had a powerful influence on Francis Galton and may have influenced James Clark Maxwell in his formulating the kinetic theory of gases.

Quetelet believed that if the investigator took care to ensure that they had obtained accurate measurements of individuals belonging to a particular race or nationality, it would be possible to determine any unknown physical or intellectual aspect of t he population under investigation.

Quetelet was the first to use the normal curve other than as an error law. His studies of the numerical consistency of crimes stimulated discussion of free will versus social determinism. He collected and analyzed statistics on crime, mortality, etc. for the government and devised improvements in census taking.

The Quetelet index is the internationally used measure of obesity. The Quetelet index is:

$QI = \text{weight in kilograms} / (\text{height in meters})^2$

If $QI > 30$ then the person is officially obese.

Quetelet organized the first international statistics conference in 1853. He was instrumental in the forming of the Statistical Society of London, the International Statistics Congresses, and the Statistical Section of the British Association for the Advancement of Science. He was the first foreign member of the American Statistical Association. The historian of science George Sarton called him the "patriarch of statistics."

9.8 Hacking(1990) on Quetelet :

His 1844 monograph went far in four quick steps.

Step 1: 'Let us suppose that I measure the height of some individual several times, with great care.' The measurements won't be identical. If the causes of error work equally towards measuring high and low, there will be a distribution with values clustering around the average height. There will also be a dispersion measured by probable error.

Step 2: Quetelet compared this situation with repeated observations of a single astronomical quantity, made over four years at the Greenwich Observatory .There we have mean, probable error, and the whole Gaussian analysis. This established practice is exactly analogous, he said, to measuring the height of one man over and over again.

Step 3: 'In the preceding examples, we knew, despite the fluctuation in figures, that there really did exist a number for which we were looking, be it the height of an individual or the right polar ascension.' What if we don't know whether there was one real quantity being measured? Given a lot of measurements of heights, are these the measurements of the same individual ? Or are they the measurements of different individuals ? If and only if they are sufficiently like the distribution of figures derived from measurements on a single individual. That suggests a way to tell whether a collection of statistics is derived from a single homogeneous population defined by a real quantity, or several distinct but mixed populations.

Step 4: at this exact point there occurred one of the fundamental transitions in thought, which was to determine the entire future of statistics. Up to here the monograph considered quantities that exist in nature. Here we pass from a real physical unknown, the height of one person, to a postulated reality, an objective property of a population at a time, its mean height or longevity or whatever. This postulated true unknown value of the mean was thought of not as an arithmetical abstract of real heights, but as itself a number that objectively describes the population. What could legitimate this move? We shall say that it objectively describes the population if the distribution of heights or whatever is what it would be if a single individual were being measured inaccurately. In step 3 we looked at a bunch of measurements and asked if there was one man. Now we use the same technique when we know we are talking about different men, and if there is a satisfactory Normal curve, we say that there is one true value, a property not of a person but of a collective.

Quetelet...
did find one unlikely source for an example: in 1817 the Edinburgh Medical Journal had published the height and chest measurements of over 5,000 soldiers in eleven Scottish regiments. What Quetelet read was a classification of soldiers by regiment, by height, and by chest circumference in inches.' He ignored heights, combined the girth distributions for different regiments,... and obtained a distribution for 5,738 chests, with maxima at 1,073 soldiers at 39 inches and 1079 at 40 inches.

He concluded that this was just as if you measured a single Scot with a chest almost 40 inches in circumference. In metric terms the probable error was about 33.34 millimetres. As he put it next year in a popular work, if 'a person little practised in measuring the human body' were repeatedly to measure one typical soldier, '5,738 measurements made on one individual would certainly not group themselves with more regularity. ..than the 5,738 measurements made on the Scotch soldiers; and if the two series were given to us without their being particularly designated, we should be much embarrassed to state which series was taken from 5,738 different soldiers, and which was obtained from one individual with less skill and ruder means of appreciation'.

Such was the rhetoric with which Quetelet gave us the mean and the bell-shaped curve as fundamental indices of the human condition. The law of errors applies as a matter of fact to this human attribute, chest circumference, or so Quetelet alleged. And to almost all others:
Quetelet had immediately applied his distribution to heights of French conscripts. It did not quite fit, which he blamed on fraud, i.e. draft-dodging by feigning shortness. Much later Quetelet took his doctrine to be positively proven during the American Civil War, by data from 25,878 volunteers.

Nowadays our first question is: how well do Quetelet's data fit the curve of error? There was no standard test of goodness of fit. Poisson's fiducial limits weren't part of Quetelet's repertoire. He took a theoretical binomial curve for results of tossing a coin 1,000 times, divided it into segments, and compared it with corresponding segments of the curve for Scottish chests. He found them sufficiently similar .

Within weeks (it seems) the floodgates had been opened. Every sort of physical attribute of humans and then of all the animal and vegetable kingdom was investigated and plotted as if according to the law of error. Next came the moral attributes, for example, the ability to write poetry. One might have expected that Quetelet, an astronomer by profession, would have taken the Gaussian 'error of observation' approach to his bell-shaped curve. It is significant that he took instead the binomial route. It enabled him to understand, or to think that he understood, why natural phenomena should be Normally distributed. For how was one to understand the amazing (alleged) fact that human traits are Normally distributed ?

.... The Scottish chests could become part of a story about statistical stability. How was one to understand statistical stability in a Laplacian universe, a universe in which an adequately informed mind would be able to compute each and every future event, from one complete momentary account of the state of affairs in the universe? Laplace had said that probability is in part the result of our knowledge, in part, of our ignorance.

But there was a more structured response than that, couched in terms of minute causes that led to the production of an event. The response seems incoherent to many of us today, but it did not wear its difficulties on its face. I shall present the response in a very schematic way, using a sequence of five steps:
the coin;
the binomial distribution for repeated coin-tossing;
errors of measure-
ment;
suicide and crime;
chests
. The following five paragraphs are intended to present not ideas that I think are coherent, but ideas that were by many people found sufficiently satisfying.

1 A coin falls either heads or tails. Which way it falls is determined by the initial conditions of tossing, and by Newtonian mechanics. There is a very large number of variables within the initial conditions. These can be thought of as a large number of possible 'causes', some of which favour heads, and others of which favour tails. On any given toss, the causes that pertain at that toss will determine the outcome of that toss. The probability of getting heads can be pictured as the ratio of favourable causes, to the total number of causes. Our ignorance of the underlying minute causes forces us to talk of probability, and to use observation to determine the ratio of favourable to total causes.

2 In repeated tossing we obtain the binomial distribution whose limit has the form of the curve of errors. We can 'explain' the statistical stability of a coin, and the fact that most often in a sequence of tosses the relative frequency is the same as the probability, by our story of chances for a single toss, plus a mathematical deduction. Quetelet said he had found that the chest curve for soldiers was binomial, and thereby carried with it, in his mind, the idea of a large number of independent trials. This assimilation of the chests to coin-tossing meant that each chest is the product of a large number of minute independent causes.

3 When we are trying to measure the position of an object, or the degree of intensity of light, we are by no means tossing a coin. But the errors made in each measurement are themselves the product of minute causes acting on the instrument, the observer, the signal passing from object to instrument and the like. This helps us understand why the error curve and the binomial distribution have the same shape. Such 'reasoning' was part of the work of Gauss or his illustrious predecessors. It was a way for the reflective but less gifted to understand something conceptually embarrassmg.

4 We turn to the statistical stability of the moral sciences. Here too we can have the picture of lots of minute and varying causes determining an individual human action. The causes vary from person to person, some people being inclined to murder and some not at all. How can statistical stability result in such a situation ? Poisson knew the answer when there is a probability distribution or law of 'causes'. But just what are the myriad minute causes that determine our decisions for good or ill? To answer, ...

Medicine already had a vast categorization of causes under the several heads of predisposing, occasioning, indirect or general. They were causes of illness. Suicide was the perfect bridge between medicine and crime. On the one hand, we had the conclusion of the syllogism with the two premises, 'suicide is a kind of madness' , and 'madness is a disease' .Suicide was, albeit briefly , held to be a disease, and hence subject to the panoply of medical causes. Yet suicide was the most heinous crime of all, the most mortal of sins. So we could think of something like that list of causes applying to other vicious acts.

Guerry's late work was particularly obliging. Recall his crossclassification of 21,322 murders into 97 principal motives and 4,478 subsidiary motives. A fine array of little independent causes! Thus it was by Poisson that the mathematics of Bernoullian statistical stability was transferred to crime, but it was by medicine that the underlying metaphysics of probability, namely the picture of minute causes, was assimilated.

5 Finally we pass to Quetelet's inspired conjecture that human attributes, mental and physical, are distributed just like the law of errors. We are far removed from (1), the toss of a single coin. Yet the rhetoric of (1)-(4) turns Quetelet's proposal, which ought to have been unintelligible,into a startling empirical fact. Doubtless some causes determine the chest circumference of each soldier. The size of the parents has something to do with it but plainly there are many other factors. We 'know' that a multitude of interacting independent causes tends in a large number of cases produce a Gaussian curve. The mathematics of probability and the metaphysics of underlying cause were cobbled together by loose argument to bring an 'understanding' of the statistical stability of all phenomena.