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# THE NON-CORRELATION OF BIOMETRICS AND EUGENICS: RIVAL FORMS OF LABORATORY WORK IN KARL PEARSON'S CAREER AT UNIVERSITY COLLEGE LONDON, PART 2

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## THE METHODS AND THE TOOLS OF THE EUGENICS LABORATORY

After Weldon's death in 1906, Galton spent the autumn and winter months at the Hoe in Plymouth (where Weldon had spent his summers from 1887 to 1898). In the late autumn of 1906, seven months after Weldon's death, Galton wrote to Pearson: "could you be persuaded to take control of the Eugenics office as a branch of the Biometric Laboratory?"[102] Galton had already approached Pearson some three weeks earlier following Schuster's resignation. Pearson sent a letter the next day and explained to Galton that he felt that his biometric methods were not what Galton wanted for eugenics and that there was room for more than his biometric treatment of sociological problems. He went on to say that "I have great hesitation in taking any initiative at all in the Eugenic Records Office work, because I did not want you to think that I was carrying all things into the biometric vortex!"[103] Pearson took on the directorship reluctantly and wanted to step down after the first year. He realized from the beginning that the sorts of sociological problems that Galton wanted to pursue were not amenable to his biometric methods. He then emphasized that there were marked differences in the way that research was undertaken in the two laboratories. In the Drapers' Biometric Laboratory there were about a dozen workers always engaged in research with one inquiry going on for five or six years and through two or three generations of students; the work, nonetheless, got done and was eventually published. One of Pearson's investigations of school children took five years to collect and two additional years to reduce the data before they could be analysed statistically. Pearson, therefore, thought that this system would be too slow for Galton's interests: it would have been almost impossible to undertake Pearson's biometric style of work without continuity nor could one person alone (in the Eugenics Record Office) attempt such an inquiry.[104] Moreover, Pearson was also of the impression that Galton held the view that there was room for more than biometric treatment of the sociological problems that interested Galton.

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Pearson, who had longed to discuss the plan with Weldon, wrote to his widow, Mrs Florence Joy Weldon, in December to let her know that Galton had asked him

> to take entire charge of the Eugenics Office and I am planning its rearrangement. I do wish I could talk it out with [W.F.] R.[Weldon] now. It seems only yesterday that he left the room with these studbooks and only a day or two earlier that those UC lectures were in progress![105]

Pearson finally suggested to Galton that he wanted

> to make a Eugenics Laboratory a centre for information and inquiry ... it ought to associate some half dozen men ... I think we should do no better than [to appoint David] Heron and Miss [Ethel] Elderton should be made a Francis Galton *Scholar*.... I should suggest a series of Eugenics Laboratory Publications [and I can provide] aid in the Biometric Laboratory.[106]

He also suggested that Amy Barrington should be made a paid computer who could work for three or four days in the office. Pearson subsequently recommended that the Eugenics Laboratory would also need a Brunsviga calculator, books of tables of mathematical statistics, and a slide rule, in addition to various instruments for the collection of inquiry schedules and family pedigrees.[107] Pearson also set up an Advisory Committee consisting of a Commissioner in Lunacy, a Royal Army Medical Corps Professor, an actuary, an anthropologist, a zoologist, a pathologist and an anthropologist.[108]

Once Pearson had agreed to take over on 1 February 1907, Galton wrote to him three days later that the "news about the Eugenics Laboratory is delightful. It is such a great relief to me to know that it rests in such strong hands as your own".[109] After Pearson had been director for one year, he realized, however, that they wanted more help than he could give them. Though Pearson was ready to continue superintending the Eugenics Laboratory, he was quite prepared to surrender the reins whenever Galton felt another man could achieve more in the particular directions desired by Galton. Pearson emphasized that he would not be hurt by any decision that Galton would make and further remarked that "if Eugenics and even Biometry were closed down, I should turn to Astronomy with all my energy and time; I know how badly statistical knowledge is needed of the problems therein!"[110] Galton replied that he "had been, for a long time under the *false idea* that the Eugenics Laboratory would aid the Biometric Laboratory rather than hinder it".[111]

Given the frailty of Galton (who was then 87 years old), it is clear that Pearson would not have stepped down — at least not in Galton's own lifetime. Since Pearson had agreed to stay on and as his biometric methods were of limited use in the Eugenics Laboratory, his only option was to devise a new methodology for problems being investigated in this laboratory.

Pearson had already recognized the limitations of his biometric methods for problems in the Eugenics Laboratory before he became its director. Since he had argued that mental deficiency was not a simple unit character (and Pearson did not classify "mental deficiency" as discrete or dichotomous), his biometric techniques for continuous or for discrete variables would not have been appropriate. Though mental deficiency is often viewed within the constraints of a continuous distribution (and falls at the negative end of a normal distribution), Pearson's product–moment correlation for continuous variables was not necessarily appropriate for determining the heredity of intelligence or mental deficiency. If a measure of correlation is used, it can *only* be used with another variable to determine, say, the relationship between IQ of child and parent, or an individual's IQ and the family income. One could study more elaborate correlations by examining IQ with other tests of aptitude (such as musical or mechanical ability along with family income): if all four variables were used, then it would be necessary to use multiple correlation. If knowledge of the predictive value were sought to determine which of these variables contributed the most to a high IQ, then multiple regression would be used.[112]

Whilst Pearson took over a laboratory that Galton created and took on the directorship *only* as a personal favour to Galton (rather than because he wanted to undertake more work), Pearson derived his methodological approach in this laboratory from Galton's approach to problems of eugenics which, for Galton, involved primarily family pedigrees. Galton's *Hereditary genius* is to a large extent a compilation of family pedigrees of talented families; he wanted this work to continue when he set up the Eugenics Record Office and asked Edgar Schuster to collect family pedigrees for his work on *Noteworthy families*.[113] Galton also emphasized the importance of the actuarial side of heredity for problems of eugenics. He thought that if the average degree of resemblance of kinship could be determined by large numbers, this would indicate that "blood relationships could be dealt with even as actuaries deal with birth and death rates".[114] Hence, Pearson's adoption of family pedigrees and his uses of actuarial methods is an extension of Galton's methods.

Since Pearson's biometric methods were not appropriate for problems of eugenics and as he had not formulated any physiological explanation of heredity for the inheritance of dysgenic or eugenic characters, Galton's methodological approach may have appealed to Pearson who had not actually chosen to run the laboratory. Moreover, the Eugenics Laboratory was already up and running when Pearson became its director and Pearson, who was busy with his other laboratories, would not have had the time to develop completely new methods.

Family pedigrees were used in most of the articles in the *Annals of eugenics* and in a number of the public lectures (given by those who worked in the Eugenics Laboratory), whilst actuarial death rates were used fairly regularly as well. As ancillary measures to the family pedigrees and actuarial death rates, some of Pearson's biometric methods were used in the Eugenics Laboratory. As I discussed earlier, Pearson would have chosen the appropriate statistical methods based on the corresponding "scale of measurement" appropriate for the variable being measured. Hence, there was no one particular Pearsonian statistical method that was favoured over another. Donald Mackenzie has, however, argued that Pearson's tetrachoric correlation and related developments were seen as being part of "the distinctive approach of the biometric school [and] were widely applied to empirical data, primarily in the eugenic field".[115] Moreover, the "tetrachoric was [regarded as] a social institution as it was needed for the school's eugenic work" and was used in "the typical manner of 'biometric eugenics' to argue for the importance of the hereditary factor in tuberculosis".[116] The tetrachoric correlation can, however, only be used when certain criteria have been met: the technique requires that both X and Y variables are continuous (which can then be made dichotomous), that they follow a normal distribution, and that they are linearly related. A number of the variables that Pearson would have examined when he wanted to determine various statistical relationships would *not* have met these criteria. Mackenzie also gave little consideration to Pearson's hereditarian studies at the turn of the century when his attention was directed towards the application of Mendelian distributions to the chi-square goodness of fit test. Moreover, Pearson considered it "inappropriate to use the tetrachoric correlation for Mendel or for any situation in which the variables were not continuous and assumed an underlying normal distribution".[117] Pearson and Heron further argued that

> in the usual case, however, of Mendelian practice, what we need is not the values of a correlation, but an investigation of whether observation is a reasonable fit to theory, i.e. we must use the ordinary [chi-square] "Goodness of Fit".[118]

The following four correlational methods were used in the Eugenics Laboratory when examining either continuous variables (such as stature, weight, time) or discrete variables (such as father's occupation) or a combination of the two: (1) Pearson's product–moment correlation coefficient was used for two continuous variables, (2) the point–biserial correlation coefficient was used when one variable was dichotomous and the other was continuous, (3) the tetrachoric correlation coefficient, which assumes an underlying continuous distribution, was used when both variables were dichotomous (i.e., when stature is measured in inches or centimetres it is continuous, but a dichotomy can be created by classifying subjects into 'short' or 'tall' groups), and (4) the phi-coefficient was used in situations where a true dichotomy exists (e.g., 'vaccinated' and 'not-vaccinated'). As a measure of association, the chi-square test of independence for contingency tables was used for discrete variables that could be classified in two or more categories. The chi-square goodness of fit test was used for the first time in 1933.[119] In addition to these methods, such quantitative methods as 'sorting-cards' were also used.[120] The Galton research workers used, when necessary, instruments and rooms belonging to the Drapers' Biometric Laboratory.[121] Provisions were thus made for the biometricians to assist in giving training in these statistical methods to research workers dealing with special eugenic problems.

### *The Work in the Galton Eugenics Laboratory*

Pearson instituted a regular course of lectures on the "science of eugenics" on 23 February 1908. Four years later he introduced the *Eugenics Laboratory lecture* *series* (to publish these lectures from 1912 to 1921). From the beginning, the work in the Laboratory involved "a great deal of heavy tabling and calculating" for constructing the family pedigrees and calculating actuarial death rates. Basic descriptive statistical methods (such as the mean, standard deviation and the coefficient of variation) were also calculated from time to time. Pearson outlined these aims of the Galton Eugenics Laboratory in a letter to *The Times*:

> (i) research in all that tends mentally or physically to the improvement of the races, (ii) the spread of the knowledge thus gained by publication and public lectures, and (iii) the accumulation of material learning on problems of racial fitness.[122]

In his first report to University College on the work in the Galton Eugenics Laboratory, Pearson described the routine work undertaken in the laboratory; this involved the continual collection of family histories which were to be published in a *Thesaurus* of family pedigrees of pathological, physical and mental characters.[123] This thesaurus, which would become known later as the *Treasury of family inheritance*, was published in three volumes (with approximately seven parts to a volume) beginning in March 1909 and ending in 1930. Though the idea of the *Treasury* was not Galton's, it "met with his full sympathy".[124] One of the first tasks that was undertaken in the Eugenics Laboratory was a very extensive collection of pedigrees which also required draughtsmen for the engraving. Less than six weeks after the Laboratory had been established, he wrote to Major Greenwood that the

> idea of a *Thesaurus* I suggested is not only needed for medical men but for all theorists of heredity so that we should get together a classical work. We have now nearly 400 albino pedigrees. Some of them quite short, others long trees with 100 to 200 individuals and on average 10 pedigrees go to a plate.[125]

By then, David Heron, who had been reappointed Research Fellow for the year, had given a lecture on Heredity (followed up by a discussion on the work of the Eugenics Laboratory) before the newly formed Eugenics Education Society of which Galton was the Honorary President.[126] Ethel Elderton decided to remain on the Laboratory Staff even though she was offered an important secretarial post in one of the Schools of the University. Amy Barrington, who held a teaching appointment at Bedford College for two days a week, finished her work on the "Inheritance of vision and the influence of environment on eyesight".[127] Miss K. Ryley had prepared nearly thirty pages of pedigrees in more than a hundred families.

### *Family Pedigrees*

Pearson and his co-workers in the Eugenics Laboratory constructed family pedigrees across four or five generations consisting of as many as four hundred ascendants and collaterals.[128] To form an "effective" pedigree, it was necessary to make "inquiries in all parts of the country, possibly abroad, and to journey about seeing

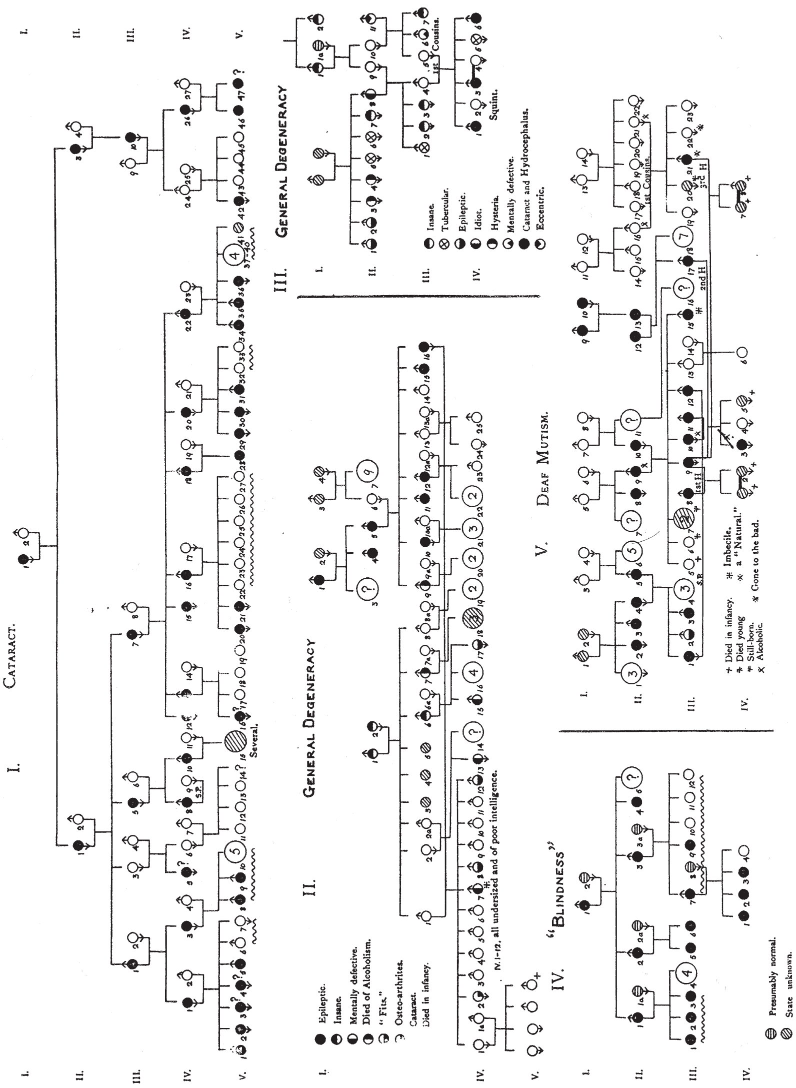


FIG. 5. Pearson's pedigree for cataracts and general degeneracy, as used in his 1910 Presidential Address to the Social and Political Education League (KP:UCL, 199/1).

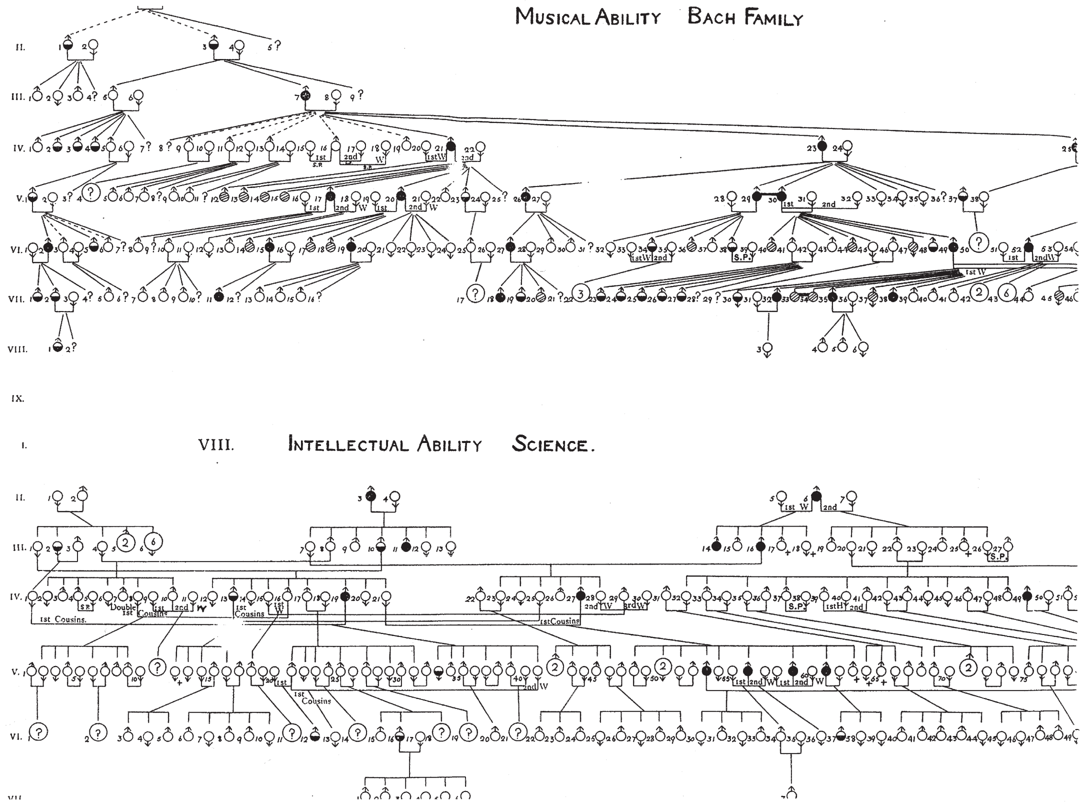


FIG. 6. Pearson's pedigree for musical ability in the Bach family, as used in his 1910 Presidential Address to the Social and Political Education League (KP:UCL, 199/1).

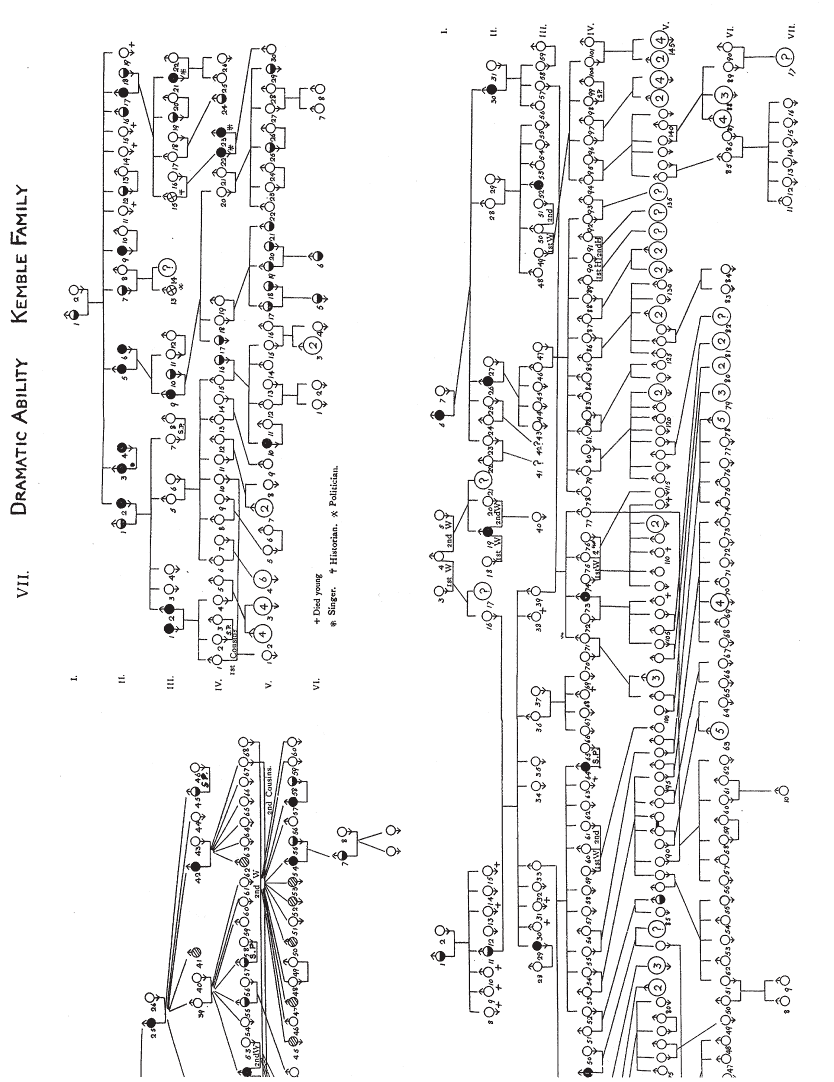


FIG. 7. Pearson's pedigree for dramatic ability in the Kemble family, as used in his 1910 Presidential Address to the Social and Political Education League (KP:UCL, 199/1).

innumerable people and often in strange environments".[129]

The groupings consisted of the father and mother ("with reference to their family group numbers"), their offspring, the wife or husband of each child with their family group members, and the family group number which gave the offspring of each marriage in the first family group. They also included the birthdays of the parents in every family group, to distinguish couples with the same names.[130] In Pearson's Presidential Address on "Nature and nurture: The problems of the future", delivered on 28 April 1910 to the Social and Political Education League, he devised pedigrees for cataracts and general degeneracy (see Figure 5), musical ability in the Bach Family (Figure 6) plus dramatic ability in the Kemble Family (Figure 7).[131] Pauline Mazumdar has described the pedigree as

> a network of relationships, demonstrating inheritance of defect in terms of the biological connections within a social class. The hereditary transmission of the defects which are the characteristics of this class it made obvious at a glance.... The pedigrees [were] not arranged like diagrams of Mendelian inheritance, with two parents and two filial generations. They [were] more like huge kinship networks, spreading often across several fold-out pages.[132]

Pearson was interested in looking at the inheritance of "mental disease" which he regarded as "only one of the ills of humanity with which we have to deal in the course of our eugenic researches; it [was] from the national standpoint one of utmost gravity, and at the same time, unfortunately, one upon which it is hardest to obtain accurate information".[133]

When looking for patterns of mental disease or of feeble mindedness, Pearson found a number of anomalies in the families for whom he had devised pedigrees across five generations. Thus it seemed that there was not only one form of insanity but "there was a fringe of other types of failures". Of the attempts made to fit insanity and feeble-mindedness into the Mendelian theory, Pearson thought that they "failed hopelessly for they overlooked essentially the fact that insanity and feeble-mindedness are far from being simple-unit characters".[134] Moreover, he did not agree with those "geneticists who believe[d] that feeble-mindedness was a simple Mendelian unit character recessive of normal mentality!"[135] There seemed to be no clear-cut boundary between mental defect and normality: the states of mental efficiency and inefficiency were not a single unit gene, but were instead thought to be "continuous".[136]

The immense biological complexity of problems of the nature and nurture of degeneracy required

> not verbal disquisition, but an intensive study of heredity in man of differential death rates, differential fertility, selective death rates, to say nothing of immigration and emigration, and of the correlation of all of these social and antisocial qualities of the several reproductive groups in the community.[137]

After having established the various family pedigrees, the next step involved measuring relationships using either the product–moment correlation coefficient, the biserial correlation and the tetrachoric coefficient for such biological measures as length and weight, or vaccination and recovery in the case of smallpox.

In his "Nature and nurture" paper, Pearson deduced that the effects of environment were small. He began by measuring relationship between siblings for a series of physical characteristics such as stature, eye-colour, cephalic index; the correlation coefficients for these variables ranged from 0.43 to 0.65. Pearson then addressed problems of nurture and attempted to find correlations between "economic conditions of home and keenness of vision of offspring", "employment of mother and weight of son/daughter", or "wages of father and weight of child". (For these variables, he used partial correlations, biserial correlations and the product moment correlation coefficients.) He deduced that the effects of environment were negligible as the results produced very low correlations ranging from 0.00 to 0.11. Pearson's interpretation of his data seems to be one instance where he placed too much emphasis on the results of his statistical methods. There are a number of reasons why his data could have produced low correlations: the results may have been statistical artefacts due to the construction of the variables or of the range of the scales used (especially for so-called 'nature' variables); there may also have been 'outliers' in the data set, or the sample may not have been as representative as Pearson would have wanted. Though he would

> not dogmatically assert that the environment matters not at all ... [it was] quite safe to say that the influence of environment is not one-fifth that of heredity.... There is no real comparison between nature and nurture; it is essentially the man who makes the environment, and not the environment which makes the man.[138]

The Eugenics Society, founded a year after Pearson established the Eugenics Laboratory, also adopted the family pedigree as its methodology. Mazumdar has argued that the

> earliest method adopted was the pedigree. It was the Eugenics Society's preferred tool for both investigation and propaganda, in Britain as it was generally throughout Europe and America in the years before the First World War.... The British group did not use it in the way it was used in America, to claim that a trait was inherited as a Mendelian unit character. Instead they saw a pedigree as a straightforward demonstration that like engendered like, with no specific theory of inheritance implied.[139]

Though she argues convincingly that the pedigree was the methodology of the Eugenics Society and has addressed Pearson's work on pedigrees in the *Treasury*, when considering the methods used in the Eugenics Laboratory she argues that

> Pearson used his department mainly for the collection and statistical analysis of data on inheritance. The statistical tool which was most typical of the biometric style was the calculation of the correlation coefficient.[140]

Thus her emphasis on Pearson's correlation coefficient rather than his very extensive use of family pedigrees is unjustified.

Two years after the Eugenics Laboratory was established and after the collection of more than five hundred pedigrees, Pearson issued the first volume of the *Treasury of human inheritance* in March 1910. This was to have "provided students of eugenics and of sociology, medical men and others with an organ where their investigations could be published".[141] This work demanded the development "of special methods of forming, drawing and engraving pedigrees, and of briefly describing the character of individuals".[142] Pearson had hoped to issue the first part in 1909, but as the laboratory "had to break new ground, form new channels of information, [and] devise new methods of representation, these difficulties must largely excuse the delay in publications".[143] The first volume of the *Treasury*, which was issued in six parts, contained the following types of pedigrees:

Parts I and II: Diabetes, tuberculosis, polydactylism, deaf-mutism, insanity and legal ability;
Part III: Hermaphroditism, angioneurotic oedema, insanity and commercial ability;
Part IV: Hare-lip, cleft plate, congenital cataract;
Parts V and VI: Haemophilia only.

Pearson had received a considerable amount of help from the medical profession. His family pedigrees were, in fact, his first successful attempt to engage the medical profession in some sort of quantitative work. The collection of family pedigrees enabled these doctors to move away from concentrating on individual pathological cases or 'types' and to see, instead, a wide range of pathological variation in the disease (or condition) of the doctor's speciality.[144]

### *Actuarial Death Rates*

On 16 June 1910, William Palin Elderton informed Pearson that he had sent out a series of letters to various actuaries in London.[145] He wrote to the actuaries as he understood that they had "libraries at their chief offices containing books and papers dealing with the subject connected with Life Insurance statistics and Medical matters"; he thus enclosed a list of publications

> issued by the Eugenics Laboratory. I may call your special attention to the *Treasury of Human Inheritance* which deals amongst other things with actual pedigrees of families suffering from various illnesses and I hope your company will become a subscriber to this publication.[146]

By the end of that year Elderton and Sidney Perry published the results of their work on actuarial death rates, and they were among the first in the Eugenics Laboratory to use them.[147] In the foreword of their article, Pearson stressed that this work indicated the "extreme importance of collecting data as to the treatment of the tuberculosis in a form capable of actuarial reduction".[148]

Elderton and Perry compared the mortality among tuberculosis patients (1) after treatment, with that of the general population, and (2) after sanatorium treatment, with the mortality of patients before that treatment was used.[149] They explained that mortality in these situations could be compared accurately even from only "a few years [of] observations" as it was possible to determine how many people were "exposed at various ages to risks of death — or had the chance of dying — in each year under consideration".[150] From the numbers "exposed to risk", they then worked out the number of deaths that would have occurred if the mortality had been the same as that of the general population. The method they used was derived from the actuarial method of death-rates used by insurance offices which "determine whether the sum paid in claims by an insurance office in a year or series of years exceeds or falls short of the amount that the office would have expected to pay if the mortality had been the same as that assumed in the valuation of the liabilities of the office".[151] They found that the mortality of tuberculous patients who underwent treatment was much greater than that of the general population: when the disease was at an incipient state, the mortality was about "four times as heavy" whereas the mortality of the apparently cured cases was "twice as heavy as that of the general population".[152] By 1912, Elderton began to work as an actuarialist for the Star Assurance Society (though he continued to see Pearson quite regularly).[153] A couple of years later, Elderton and Richard Flippard published a book on the construction of mortality and sickness tables intended for those who used actuarial methods in their work.[154]

At the end of the 1920s, Mary Noel Karn undertook the second most extensive use of actuarial death rates in her work in the Eugenics Laboratory, which was published in 1931. The method she used to determine the influence of the death rates from some particular disease on duration of life was derived partly from the work of Daniel Bernoulli (1700–82) in 1760.[155] Bernoulli's method of obtaining a measure of the influence of special diseases on the duration of life involved a comparison of two life-tables; he compared Edmond Halley's life-table with a hypothetical life-table showing the number of survivors there would have been at each age.[156] Bernoulli was especially interested in the mathematical theory of obtaining life-table populations freed from the mortality of a particular disease.[157]

Karn wanted to measure the effect of the death-rates from cancer and other diseases on the expectation of life as was given in the English life-tables. Her aim was to find out if there had been an increase in the mean duration of life once these diseases were eliminated as causes of death.[158] The material was taken from the Registrar-General's records of deaths "year by year for certain age groups, and from the ten-yearly census populations".[159] The method of obtaining the various death-rates was the same for all the diseases considered: the average number of deaths per 100,000 for given ages for 5 years grouped around the census years 1891, 1901, 1911 and 1921. These death rates were then applied to the life-table population appropriate to that period.

When she wanted to determine the proportion of cancer deaths to all deaths in

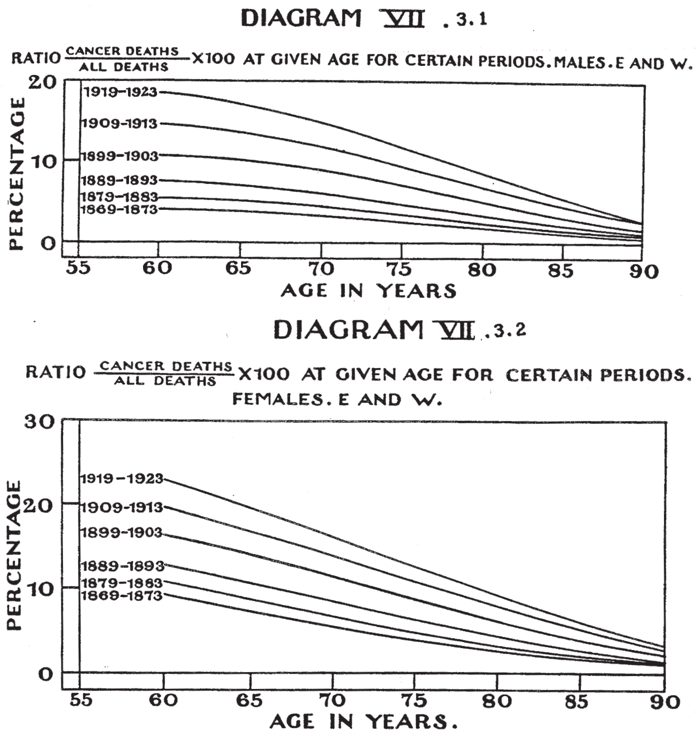


FIG. 8. Mary Noel Karn's 1931 diagrams of deaths from cancer in England and Wales of males (above) and females (below) in the period 1869–1923 (from *Annals of eugenics*, iv (1931)).

different types of districts she used the ratio: (cancer deaths)/(all deaths) at given age groups for London and Rural Areas. The ratio: (cancer deaths)/(all deaths) × 100 was used to determine the death rates for given periods in various age groups (Figure 8).[160]

Two years later, Karn followed up this paper with a short ten-page paper in *Biometrika*. In the previous paper she discussed d'Alembert's formula, which gave 'instantaneous values' for calculating life tables for a population from which cancer and tuberculosis were supposed to be eliminated as causes of death, in order to estimate the effect of these diseases in shortening the duration of life.[161] In this paper she discussed the work of William Farr and Louis I. Dublin. Farr used the quinquennial age-groups where the number of deaths in age-groups X to X + 5 was divided by the population of that age group which gave the probability *p* of "living one year in the middle of the period".[162] (Thus Farr's method was only applicable after 5 years, whereas Dublin had worked out formula values at yearly intervals.) She concluded that for

> rapidity of calculation, combined with accuracy, the formula giving yearly values has some advantages over that giving instantaneous values. In either case the

> results are arbitrary to some extent, as the original figures are usually obtainable only in quinquennial age-groups.[163]

The work on family pedigrees and actuarial death rates developed for problems in the Eugenics Laboratory were to remain the principal methodology used during Pearson's directorship in this laboratory.

Once the Galton Eugenics Laboratory had been set up in 1907, Pearson established the following journals: *Eugenics Laboratory lecture memoirs*, reprints of lectures given in the Eugenics Laboratory from 1909 to 1912; *Studies in national deterioration*, which involved studies of lunacy, alcoholism and tuberculosis (1909–12), work carried out at the request of Government officials; *Treasury of human inheritance*, the thesaurus of family pedigrees (1909–22), intended primarily for the medical profession and actuaries; and the *Annals of eugenics* (now the *Annals of human genetics*), which published mainly reprints of public lectures (founded in 1928 and edited by Pearson until 1933). These journals thus did not publish research papers in the manner of the organs of the Biometric Laboratory. Pearson was clearly addressing a variety of audiences and, like T. H. Huxley, he was a master of dealing with different audiences and his very diverse writings depended on the interests of those audiences.[164]

On 16 April 1925, Pearson wrote to the American biometrician, Raymond Pearl (1879–1940), to let him know that he and his co-workers in the Eugenics Laboratory had

> settled to issue a new journal to be entitled: *The Annals of Eugenics, a journal for the scientific study of Racial Problems....* The journal will, of course, be run on biometric lines and it will have no "development of theory" papers and be confined to man or experimental work on animals bearing on man.[165]

The *Annals of eugenics* was different from *Biometrika* as the *Annals* "concentrate[d] on man", whereas *Biometrika* was "the measurement of life" and thus was concerned with *all* living organisms.[166] Pearson wanted to know if Pearl would contribute a paper to the first issue; Pearl responded "yes as soon as he possibly could, but it would not be in time for the first volume".[167] The publications from the Eugenics Laboratory were primarily "in-house" journals. The *Annals of eugenics* had a small group of co-workers who contributed regularly to the journal. Those who contributed most regularly from 1928 to 1933 included: Ethel Elderton, Mary Noel Karn, Margaret Moul, Percy Stocks, and Geoffrey Morant. Occasionally, papers came from other parts of London such as the work from H. J. Martin, an epidemiologist at the London School of Hygiene and Tropical Medicine.[168]

As the *Annals* were quite often re-prints of public lectures, they were aimed at a far more general audience than served by *Biometrika*. The articles were, on average, 210 pages long and usually divided into three parts (to be published in three different issues). Ethel Elderton (who wrote several articles in the first volume), Mary Noel Karn, Margaret Moul and Percy Stocks each produced *at least* one 300-page article which involved the use of pedigrees. Morant, however, was more closely aligned to the Biometric Laboratory as he was interested in craniometry: his main contribution was a 180-page article on "Studies on Palaeolithic Man". He felt that this article would have been appropriate for the *Annals of eugenics* since

> the most direct approach to the wider problems of the ancestry of man of racial heredity and development is to be made, at present, by studying the ever increasing number of pre-historic remains which have been preserved.[169]

Though there was very little overlap between *Biometrika* and *Annals of eugenics,* a biometrician such as Geoffrey Morant wrote papers on craniometry for the eugenicists and Mary Noel Karn wrote a short paper for the biometricians on actuarial death rates. This seems to have been the extent of the overlap between the two laboratories during Pearson's editorship. When the eugenicists used biometrical techniques in their articles, such individuals as David Heron, Ethel Elderton and Amy Barrington would have assisted with the calculations. The exchange of the articles served to inform the respective laboratories of their work.

Of the number of articles that Pearson wrote for these journals, he published eleven in the *Annals of eugenics*, eleven in the *Eugenics Laboratory lecture series*, five in *Studies in national deterioration* and two for the *Treasury of human inheritance*: these 29 papers represented 0.04% of his total publications. In addition to these articles, Pearson published an additional 20 articles on matters relating to eugenics in such journals as the *Journal of the Royal Sanitary Institute*, the *British medical journal* and *Questions of the day and fray*. Thus, the total number of Pearson's articles on eugenics include 49 papers which represent 0.09% of his total number of publications. Nonetheless, this 0.09% not only has remained the most controversial of Pearson's writings, but it has assumed greater prominence in the historiography of Pearsonian statistics than have his other scientific contributions.

### *The Galton Chair of Eugenics*

From the shared loss "of an irreplaceable friend and colleague ... which touched them both with nearly equal sorrow", Pearson and Galton were to develop a warm and intimate friendship. Some eighteen months after Weldon's death, on 16 October 1908, Galton wrote to Pearson, "I value friendship more and more the older I grow and am delighted to feel that I possess yours".[170] With Galton's advancing age, he became concerned with the future of the Eugenics Laboratory. On 20 October, Galton made his will and "bequeathed all the residue of [his] estate ... unto the University of London for the establishment and endowment of a Professorship at the said University to be known as 'The Galton Professorship of Eugenics'".[171]

Several months later, Galton was discussing with Pearson men who might be appropriate for the Galton Chair of Eugenics. Pearson let Galton know that he was "wholly unwilling to give up the superintendence of the Biometric Laboratory [he] had founded and confine [his] work to Eugenics Research".[172] Galton, however, thought that Pearson would have been "the most suitable man for the first Galton

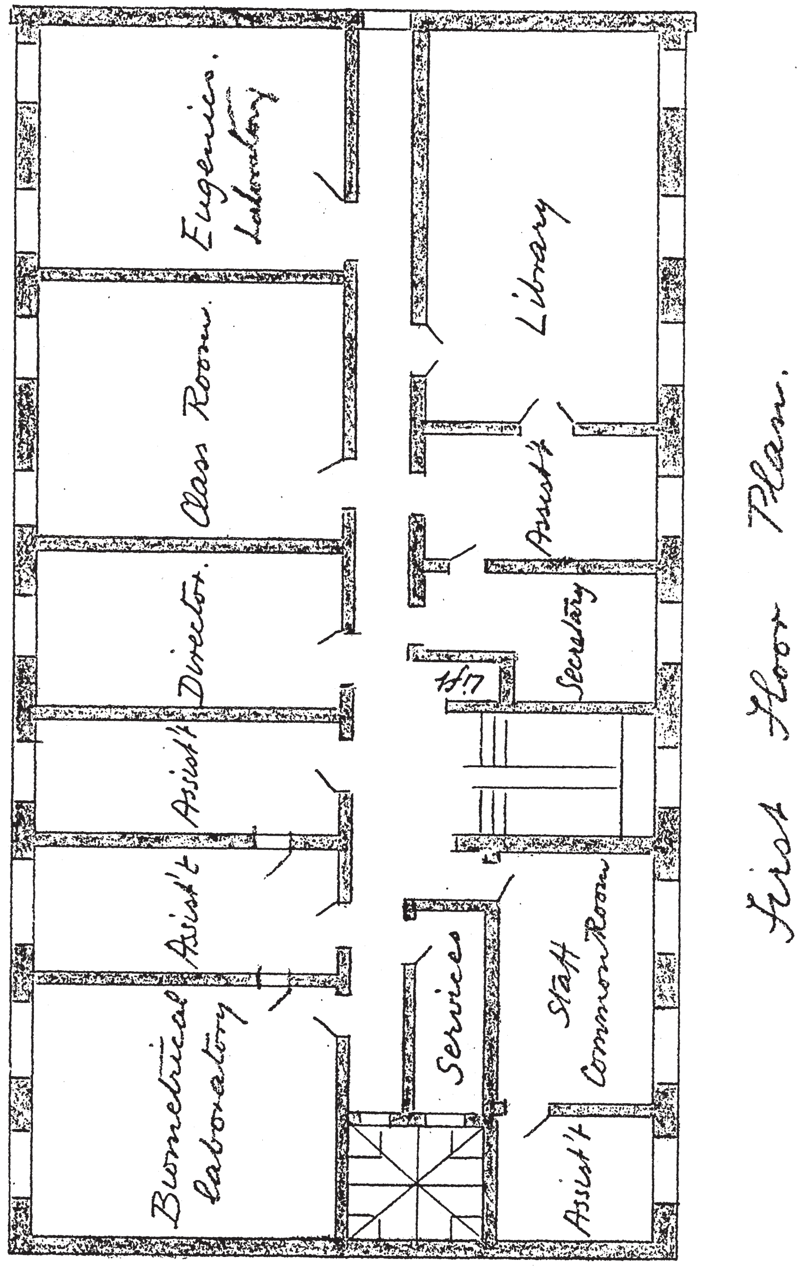


Fig. 9. Pearson's first floor plan for the building to house the Biometric and Eugenics Laboratories.

Professor".[173] He then decided to add a codicil to his will, in May 1909, stating that he "desired that the first Professor of the post shall be offered to Professor Karl Pearson and on such conditions as will give him the liberty to continue his Biometric Laboratory".[174]

In 1909, Galton's health began to deteriorate and towards the end of 1910, he had become physically frail though still mentally active. On 17 January 1911, at the age of 89, he died of heart failure. It was only after Galton's death that Pearson learned of the codicil. In the summer of 1911, Pearson relinquished the Goldsmid Chair of Applied Mathematics after 27 years of tenure to take up the Galton Chair. Upon Pearson's retirement, a new Chair was created from his work in Graphics in the Department of Physics, a new Department of Structural Engineering (later Civil Engineering) was also created, and a Readership was set up in Astronomy. The Department of Applied Mathematics merged with Pure Mathematics and two professors divided the work between them.[175] The Chair of Applied Mathematics went to one of his first students, Louis Napoleon George Filon, whose specialities, like Pearson's, were elasticity and statistics. One of Pearson's friends from King's College, Cambridge, Micaiah J. M. Hill, had been appointed to the Chair of Pure Mathematics in 1884 (and he held this post until 1922). The two laboratories, which would continue to receive separate funding, then became incorporated into the Department of Applied Statistics. The essential aim in combining both laboratories was to enable Pearson to give up his undergraduate teaching of applied mathematics and to devote himself "solely to what had for many years been the main element of [his] research: the advancement of the modern theory of statistics".[176]

When Galton left £30,000 to UCL, he realized that his funds were inadequate for "the complete carrying out of his scheme".[177] In his will he specified that

> his laboratory might, if possible, be associated with the Drapers' Company Biometric Laboratory of the University of London, for he realised that if Eugenics was to become a real branch of knowledge its facts must be submitted to measurement and number for without such a basis it could not assume the status and dignity of a science.[178]

Galton had hoped that the university would provide "adequate housing to the laboratory that was to bear his name".[179] Adequate funding had been raised between 1908 and 1914 and contracts for the fittings had been made.[180]

Galton made it a condition that the University should not spend his endowment on a building, but provide for the necessary accommodations of the Drapers' Company Biometric Laboratory and the Galton Eugenics Laboratory. Pearson had learned from the Provost that the College had arranged to give his building a site and Sir Herbert Bartlett had offered to provide him with a building for his laboratories.[181] A building site had been found in a space occupied by some trees next to the North Wing (now the Slade School); the department of physiology occupied the top floor, the department of chemistry occupied the basement and the Slade Exhibition occupied the first floor and the ground floor in the North Wing.[182] Thus, owing to the

FIG. 10. The Bartlett Building near completion in the summer of 1914.

generosity of Sir Herbert Bartlett, a "fine building for the housing of the Drapers' Biometric Laboratory and the Galton Eugenics Laboratory was completed in 1914".[183] The building contained a public lecture theatre, a museum, a library, machine rooms, instrument rooms, experiment rooms and private rooms for research workers.[184]

Even as Pearson drew up the floor plans for the building in December 1912, the Biometric and Eugenics Laboratories occupied different physical spaces and were, in fact, on opposite ends of the second floor. The Biometric Laboratory was located on the north side of the building and the Eugenics Laboratory was on the south side (see Figure 9).[185] In the early summer of 1914, the new laboratory building was complete and preparations were under way for the occupation and the fitting up of the public museum and the anthropometric laboratory.[186] Figure 10 shows the Bartlett Building near completion in the summer of 1914. It was hoped that the building would be occupied by October 1915.[187] These developments and further biometric work were shattered by the onset of the First War. The new Laboratory building was taken over by the Government as a military hospital to be used as an annexe to Queen Alexandra Hospital.[188] All contracts were subsequently rescinded.[189]

These changes made it difficult for Pearson to undertake pure research with his highly trained staff. Their position at the beginning of the war was "an extremely difficult one". Pearson felt it was

> essential for the future to retain if possible a highly trained staff, but the funds at [his] disposal neither enabled [them] to compete with the high salaries offered to competent statisticians, nor, if they had been, would it have appeared justifiable to keep members of the staff who were urgently needed for national work of importance.[190]

Pearson thought that "the only reasonable solution of the difficulty [was] the voluntary employment of the Laboratory as a whole on war work".[191] He discussed the matter with his staff in the first week of August 1914, and his staff agreed to dispense with the best part of their holidays and to devote their time to war work.[192] Very early in the war, several members of his staff took on special war duties "for which their training in computing largely fitted them".[193] Many of Pearson's older students and past assistants of the Department were employed in one form or another of statistical work, often of a very confidential character, either for the War Office or for the various new Ministries.[194] Biometric studies could only be carried on

> in brief intervals of rest taken from the computation of machine gun-sights for use against low flying airplanes, from the construction of gun charts and high angle range tables for protection against aircraft, or from other problems of war-like urgency.[195]

Though Pearson carried on with biometric work during the war, he pursued very little work on astronomy during this time. By 1917 he had resigned from the Royal Astronomical Society following a row he had with Lord Rayleigh on matters of measurement. Pearson and his co-workers took on special war duties for the duration of the war. They produced statistical charts for the Board of Trade's Labour Department as well as for its Census Production. Pearson was also involved with elaborate calculations of anti-aircraft guns and bomb trajectories "both through air and air and water". Pearson had also "received requests for trained statisticians and computers from nearly all the chief Government offices and [after] America [had] joined the war even from America".[196]

### *The Opening of the Bartlett Building*

By June 1919, Pearson was in possession of his building and plans were under way for the opening in October 1920. New specifications were made which had shown that the estimates had increased by 300%: Pearson's staff "[stood] before the alternatives of occupying a single floor or postponing occupation entirely".[197] The laboratory had thus been

> crippled in its equipment ... [and] in its funds ... the staff that had been absorbed into national work during the past five years could not be re-established in the old scale. The war had swept out of existence institutions as well as men.[198]

The official opening of the Bartlett Building was on 4 June 1920. In preparation, Pearson wrote to Mrs Weldon on 27 May that

> after Francis Galton himself, the man I could have wished to be here for 4 June would be your husband. He would have understood where none others will. Failing him I should like his widow above everybody. The list is a list not ruled by my wishes, but the rule of the authorities that "all close relatives and all subscribers to the equipment fund of 1911 are to be invited". Do come, of course, my wife will be there.[199]

There was to be a delay of eighteen months before the building would be ready. On 4 December 1922, eight years later than Pearson had originally hoped, the work had been completed and the building was occupied.

This is the point at which all of Pearson's laboratories were juxtaposed together architecturally, but without an underlying continuous methodology. The work undertaken by Pearson and his assistants would continue to remain different in all of the laboratories as well as in the museum. The buildings which contained all of his laboratories with all of their diverse practices, were not a reflection of a monolithic approach to research, but probably had more to do with Pearson's status at UCL and with his high-level institutional power that enabled him to acquire the building space.

There were three floors in the building and the first and second floors were the "working floors". The ground floor was the "public floor", as it contained a large museum which illustrated heredity, statistical processes and social problems. The museum comprised not only a collection of statistical models and measuring apparatus, but also an exhibition of early man and his artefacts of the past 200,000 years. He had also set up a convenient lecture theatre with adjacent diagram and committee rooms, a room for the exhibition of Galton relics and apparatus, an anthropometric laboratory, and a publication room.

The first floor had a library, a class room and staff common room; there were four private dining rooms which included the director's room with rooms for the secretary and the librarian. The second floor had a photographic studio with dark rooms, a large room for biometric workers in craniometry, a workshop, a room for experimental work and two spacious rooms, of which one was for the archives (which stored observations, pedigrees and schedules). There was another room for the instruments integrators, analysers and curve plotters for the use of draughtsmen; additionally there were a class-teaching room and three further private rooms for the staff and research workers. A site had been reserved for extensions which were to include animal breeding experiments. In the basement were cloak and service rooms, plus large stores for the craniological and osteometric collections of the laboratory.[200]

The Animal House and the Anthropometric Laboratory, which opened in 1924, were chiefly made possible by gifts from Dr C. H. Usher of Aberdeen and Ethel M. Elderton, respectively.[201] The Animal House which contained "dogs and very considerable numbers of mice" had been set up for the purpose of testing natural selection on certain physical characters.[202] The salary of the medical officer of the

Anthropometric Laboratory was paid by the London County Hospital; Pearson also had an anthropologist on the staff at a salary of £350.[203]

Pearson continued to attract students from many parts of the world throughout the rest of his tenure. In 1915 he instituted a degree course in statistics at UCL — the first of its kind in Britain.[204] By 1922 he had established two types of classes for British post-graduates: one consisted of teachers in education who sought a higher degree as a means of advancing their position, and the second involved persons sent by Government departments or commercial firms to obtain an adequate statistical training. (Guinness Brewery had, for example, sent William Sealy Gosset ["Student"] to UCL for two years, and the Department of Scientific and Industrial Research also sent some of their co-workers.) Pearson found "the work here with 12 to 14 post-graduate students mentally much more fatiguing than the teaching in the old days of 80 to 100 students of undergraduate standing".[205]

In 1922 the University Reader in Medical Statistics, Dr Major Greenwood, was transferred from the Lister Institute to the Biometric Laboratory to give "courses on vital statistics and the history of epidemiology".[206] By 1925 most of Pearson's students were post-graduates; there were also "a number of junior students working for the B.Sc. or M.Sc. in statistics". Some of his students wished "to obtain professional posts in which statistics would be of service (including Civil Service candidates)".[207] Ethel Elderton became Assistant Professor in the Galton Eugenics Laboratory in 1925; Percy Stocks was the Medical Officer whilst Mary Noel Karn and J. Oscar Irwin became assistants.

With the increasing costs of maintaining the laboratories and of publication, Pearson wrote to Sir Edwin Deller, Principal of the University of London, in the spring of 1924 seeking advice on funding. Deller suggested to Pearson that he write to the Rockefeller Foundation outlining a budget proposal for his laboratories. Pearson accordingly wrote to Edwin Embree, the Secretary to the Rockefeller Foundation, that he

> cannot and does not pay the Staff adequately. We are always impecunious in our publishing funds. We have no funds for carrying on the museum, nor proper maintenance funds for library or animal house or field investigations of any kind.[208]

Though there is no record of any response from Embree, a number of Pearson's former American students (Henry Ruger, Gaius E. Harmon and Raymond Pearl) wrote to the Foundation on his behalf.[209] Harmon said that

> American statistical science owes a great debt to Professor Pearson, for many of our statisticians have studied with him and thus obtained inspiration and knowledge of his methods in a most direct manner. [Moreover,] more of the post graduate workers at the Biometric laboratory come from America than any other country save England.[210]

Embree replied to Harmon that one of the laboratories to which the Foundation would "would certainly give careful attention is that of Professor Pearson". Two of their considerations were "Pearson's age (who was then 69 years old) ... and what [would] become of the institution after his death".[211] The Rockefeller Foundation did not, however, begin to provide grants for University College London until 1934 (a year after Pearson's retirement).

In making his seventh and last appeal to the Worshipful Court of Drapers for continuation of the grant "that it has made to the Drapers' Biometric Laboratory for the space of nearly thirty years", Pearson wrote that

> my object during the past forty years has been to build up a Laboratory unique of its kind, a place where a novel calculus should be applied to problems concerning living forms. This purpose involved the development of a new form of mathematical analysis.... I am writing these pages fully aware that this may form my last Report on the work done here to the Court of the Drapers' Company, and I do so with the full sense of all that Company has done for thirty years to enable me to carry out the aim of my scientific life, the realisation of my dream of forty years ago.[212]

Pearson continued to receive funding from the Drapers' Company until his retirement in 1933.

After Pearson's retirement, UCL created eventually three separate chairs out of his Department of Applied Statistics. In the late spring of 1933, Pearson learnt that R. A. Fisher would be given the Chair of Eugenics.[213] By the beginning of 1934, Pearson's son, Egon, had been made Reader in Statistics.[214] In 1936, Florence Joy Weldon left the residue of her estate for the Weldon Chair of Biometry at UCL, and J. B. S. Haldane became the first to occupy it.[215] Whilst all three of Pearson's successors continued to use his biometrical methods in their statistical work, Fisher and Egon went on to create new statistical methods for different sorts of problems that arose in their work. The division of Pearson's labour makes clear that he took on board more work than any one person could do alone, and the recognition by UCL that Pearson was indeed doing different types of work underscored this feature of his long and productive career.

## CONCLUSIONS

The work undertaken by Pearson and his assistants in the Biometric Laboratory was indeed very different from that in his Eugenics Laboratory. More than that, there was only a very small and practically negligible correlation in the methods of the Biometric and Eugenics Laboratories (when the Eugenics Laboratory borrowed eight biometric methods) as ancillary measures to the principal methodology of family pedigrees and actuarial death rates.[216] More importantly, there was, in every other respect, a complete lack of correlation in the laboratories on all points, including the principal methods, finances, personnel, architectural juxtaposition and the methodological style of the journals. These differences thus challenge the widely held assumption that Pearson's statistical techniques for analysing biological variation were driven by his eugenic concerns. Much of the historiography in which Pearson is traditionally placed has thus distorted the full range of his intellectual enterprises, by arguing that his work in the Biometric Laboratory originated from his interests in eugenics.[217]

Whereas Donald Mackenzie and other historians have treated Pearson's laboratories as a monolithic and unified entity, I have treated his work as specific to the laboratories and as being contingency related. I have also de-emphasized his work in eugenics, as this was forced upon him by institutional factors and by his loyalty to Galton without there being a shared ideology between them. In fact, in contradiction to Mackenzie very little of Pearson's career can be explained by social class interest. It has more to do with institutional factors and people he met and worked with. In many respects, Pearson was never fully in control of his career and thus he could not keep it neatly unified (for example, he could not refuse Galton, and the war interrupted the work in all of his laboratories). Not only did such influences govern Pearson's career, but his work also took on a completely different direction when he met Weldon in 1892, and the direction also changed as a result of the influence of other people with whom he worked.[218]

The historiographical tendency to link Galton's statistical innovations to Pearson's work in the Biometric Laboratory is unjustified because it overlooks the totality and the complexity of Pearsonian statistics. Virtually all of the work on curve-fitting and goodness of fit testing in the Biometric Laboratory was due to the influence of Weldon. Moreover, it was Pearson's recognition of the asymmetry in biological data that provided the linchpin to the construction of his mathematical statistics. Pearson's work on curve-fitting and finding a goodness of fit test represents the most striking departure from the Galtonian tradition of statistics. In a Galtonian system much statistical information would be lost by normalizing asymmetrical distributions, whereas in a Pearsonian system, all information would be used. In Nature Galton saw error and thus to the end of his life he normalized *all* statistical and biological data to accommodate his views. Pearson saw variation in Nature, and his family of distributions reflected the asymmetry of this variation. Hence these divergent views represented a very crucial difference in their statistical approach.

Pearson's work cannot be generalized as a neat unified structure of thought. Moreover, this work cannot be regarded simply as the mental and textual development of "great" statistical ideas: the physical and social spaces of laboratory and field work matter at least as much to understanding the development of Pearson's researches. In chronological terms, it has also been shown that it is not appropriate to consider, as have some historians, that the important work of Pearson's career began in 1895 or in 1900; rather, the manifest continuation from the early 1890s through to the 1920s is strong evidence against any such episodic or 'watershed'-based narratives of Pearsonian biometrics or eugenics. Future studies must acknowledge that Pearson's work is not a unified whole and must also look at his work in the spatial contexts of the laboratories, where it is clear there were diverse, even rival agendas in co-existence.

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104. Pearson, *op. cit.* (ref. 103).
105. Karl Pearson, letter to Mrs Weldon, 22 December 1906 (KP:UCL, 266/8).
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107. Pearson, *op. cit*. (ref. 37), 306.
108. Pearson retained Schuster's services when he appointed him as the zoologist on this committee.
109. Francis Galton, letter to Karl Pearson, 4 February 1907 (FG:UCL).
110. Karl Pearson, letter to Francis Galton, 2 January 1908 (FG:UCL). Also in Pearson, *op. cit.* (ref. 15), 333.
111. Francis Galton, letter to Karl Pearson, 4 February, 1907 (FG:UCL).
112. R. A. Fisher and Sewall Wright both developed later statistical methods which were based on Pearsonian correlations to determine the hereditability of certain traits.
113. In 1913 the Principal of the University of London, Edwin Dellar, bought 719 copies of Galton's *Noteworthy families* from John Murray who had first published the book. Dellar gave most of the copies to Pearson. Dellar wanted the book published "out of regard for Sir Francis Galton, who was an old friend of my father's and my own. We regard the book as a creditable one to ourselves, and are quite content to go on selling copies at present". Edwin Dellar, letter to John Murray, 30 May 1913, enclosed with Pearson's copy of "Resolutions adopted by the Senate on 19 February 1913" (KP:UCL, 242).
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216. These methods include the standard deviation, the coefficient of variation, product–moment correlation, phi-coefficient, teterachoric correlation, the chi-square test of association for contingency tables, and the chi-square goodness of fit test.
217. Yet it is not only Pearson whose interests in eugenics have been overemphasized to the neglect of

his many other activities. There are other biometricians and biologists who have received similar treatment, including one of Pearson's successors, R. A. Fisher, and the American biologist and biometrician Charles Davenport (who spent some time in Pearson's Biometric Laboratory).

218. As I have argued in Magnello, *op. cit.* (ref. 8, 1996), the impetus and much of the development of Pearsonian statistics owe more to Weldon than to any other person, and certainly Pearson himself acknowledged Weldon's contributions throughout his life. Also see Magnello, *op. cit.* (ref. 8, in preparation), where I show how Weldon's relationship was a factor critical in Pearson's change of careers from an elastician to biometrician and that all of Pearson's use of mathematics in his statistical work is due to his Cambridge training.