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Ronald A. Fisher and the improvement of humankind

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Abstract

In this paper we argue that the motif underlying Ronald Aylmer Fisher (1890-1962) scientific endeavors was eugenics and the notion of differential fertility. Fisher's contribution to Neo-Darwinian synthesis and the development of several basic concepts of modern statistics, among others, derived from his interest in providing sound grounds to the hypothesis that the reproduction of the 'well-born' ought to be encouraged, while individuals "unfit for civilized society" were to be financially and socially discouraged from bearing children. Fisher believed that all striving notwithstanding, all human societies were doomed to decadence and collapse due to purely biological reasons, being eugenics the only approach likely to prevent such sorry fate. In Fisher's work statistics, evolution theory, genetics and eugenics form one single logical structure, since all of them directly concern a more general problem, i.e., the biological improvement of humankind. Eugenics did not disappear after the end of World War II, but was reframed at least partially as present-day genetics, including clinical genetic counseling.

Keywords: Ronald A. Fisher; neoDarwinian synthesis; Statistics; Genetics; Eugenics

Resumo

Neste trabalho argumentamos que o motivo subjacente aos esforços científicos de Ronald Aylmer Fisher (1890-1962) foi a eugenia e a noção de fertilidade diferencial. A contribuição de Fisher à síntese neodarwiniana e ao desenvolvimento de vários conceitos básicos da estatística moderna, entre outros, derivou de seu interesse em fornecer bases sólidas à hipótese de que a reprodução dos "bem nascidos" deveria ser encorajada, enquanto "indivíduos impróprios para a sociedade civilizada" deviam ser financeira e socialmente desencorajados a ter filhos. Fisher acreditava que apesar de todo esforço, todas as sociedades humanas estavam condenadas à decadência e ao colapso por razões puramente biológicas, sendo a eugenia a única abordagem que provavelmente evitaria esse destino lastimável. No trabalho de Fisher, estatística, a teoria da evolução, a genética e a eugenia formam uma estrutura lógica única, uma vez que todas elas dizem respeito diretamente a um problema mais geral, ou seja, o melhoramento biológico da humanidade. A eugenia não desapareceu após o fim da Segunda Guerra Mundial, mas foi reformulada pelo menos parcialmente com a genética atual, incluindo o aconselhamento genético clínico.

Palavras chave: Ronald A. Fisher; síntese neodarwinista; estatística; genética; eugenia

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Introduction: "the greatest since Darwin"

The contributions of the British scientist Ronald Aylmer Fisher (1890-1962) to several fields, statistics, evolution theory and genetics in particular, resulted in a liberal use of praiseful adjectives to qualify both his person and his work by historians, scientists and other admirers from the second half of the 20th century onwards. In an article published in journal *Biometrics* soon after his death, Fisher is described as the "founder of the modern methods of design and analysis of experiments"[1]. Then, in another paper published in 1992 in journal *Statistical Science,* Fisher is celebrated as the one who made the "major steps that led to the establishment and recognition of statistics as a separate scientific discipline and an inevitable tool in improving natural knowledge"[2]. In 2000 the highly reputed journal *Genetics* made a point of paying homage to Fisher on the occasion of the 70th anniversary of the publication of one of his main works, *The Genetical Theory of Natural Selection.*[3] To finish this small sample of laudatory comments, historian Pauline Mazumdar[4] considers that Fisher "was one of the most important and productive thinkers in statistics" in the 20th century: "Any current textbook is full of his methods; they are used in every field in which data are collected and analyzed, from agriculture to economics."

The scope of Fisher's accomplishments was indeed dramatically broad, ranging from the formulation of key-notions of population genetics to pure statistics to the discovery of the mechanism of genetic inheritance of the Rhesus (Rh) blood group system[5]. Relative to statistics, for instance, in an early paper from 1912 entitled *On an Absolute Criterion for Fitting Frequency Curves*, he introduced the notion of maximum likelihood. He then published *On a Distribution Yielding the Error Functions of Several Well Known Statistics*, in 1924, where he presented the distribution of Karl Pearson's (1857-1936) chi-square and Student's (W.S. Gosset, 1876-1937) in one and the same structure. According to the mathematician Harold Hotelling these contributions alone suffice to qualify Fisher as the greatest statistician of the twentieth century[6]. Along the 1920s, Fisher developed statistical methods adequate for small samples, as well as basic concepts of inferential statistics, such as consistency, efficiency and

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[1] Frank Yates, "Sir Ronald Fisher and the Design of Experiments." *Biometrics* 20, nº 2 (1964): 307-321, 307.

[2] C. Radhakrishna Rao, "R.A. Fisher: The Founder of Modern Statistics." *Statistical Science* 7, nº 1 (1992): 34-48, 34.

[3] Anthony W.F. Edwards, "The Genetical Theory of Natural Selection." *Genetics* 154, nº 4 (2000): 1419-1426 on 1419.

[4] Pauline Mazumdar, *Eugenics, Human Genetics and Human Failings: The Eugenics Society, Its Sources and Its Critics in Britain* (London: Routledge, 2005).

[5] Silvia Waisse, "MBE: Medicina Baseada em Eugenia? Origem da Bioestatística Moderna como Ferramenta ao Serviço da Melhora da Raça," in *Eugenia e História: ciência, educação e regionalidades* (São Paulo: Faculdade de Medicina da USP, Universidade Federal do ABC, CD. G Casa de Soluções e Editora (2013), 17-36, 26.

[6] Millor F Rosário, "120 Anos do Nascimento do Cientista R.A. Fisher (1890-2010)." *Revista Brasileira de Biometria* 2, nº 4 (2009): 659-672, 659.

sufficiency. All in all, Fisher published more than 300 papers and six books, four dealing with statistics and two with genetics[7].

In addition to his prestige in the field of statistics, Fisher is considered also one of the main biologists of the twentieth century for his contribution to the so-called Darwinian synthesis or Neo-Darwinism, namely, the basic theoretical paradigm for evolutionary biology[8]. In an interview given to Edge.org, Richard Dawkins (2011) qualified Fisher as the "the greatest biologist of all times since Darwin," because "He [...] provided researchers in biology and medicine with their most important research tools, as well as with the modern version of biology's central theorem." [9]

However, the literature puts Fisher's eugenic ideas aside as mere 'deviations', when not fully pass them over. Yet our analysis indicates that eugenics - the notion of differential fertility, in particular - was the basis for a large part of Fisher's work in several fields of science. As we shall argue, Fisher's contribution to Neo-Darwinian synthesis and the development of several basic concepts of modern statistics, among other topics, derived from his interest in providing sound grounds to the hypothesis that the reproduction of the 'well-born', i.e., the eugenic, namely, individuals carrying hereditary characteristics favorable for civilized society, ought to be encouraged. Reciprocally, individuals unfit for civilized society, i.e. "those who tend to breed decadence"[10] were to be financially and socially discouraged from bearing children. Fisher believed that the high fertility rates exhibited by the "worse stocks"[11] were the main cause of most of the evils that had befallen on human civilization all throughout history. According to him, all striving notwithstanding, all human societies were doomed to decadence and collapse due to purely biological reasons, being eugenics the only approach likely to prevent such sorry fate. As we shall show, in Fisher's work statistics, evolution theory, genetics and eugenics form one single logical structure, since all of them directly concern a more general problem, i.e., the biological improvement of humankind.

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[7] Rao, 47

[8] Massimo & Pigliucci & Gerd B. Müller. "Elements of an Extended Evolutionary Synthesis," in *Evolution: The Extended Synthesis*, ed. M. Pigliucci, & G.B. Müller (Cambridge [MA]: The MIT Press, 2010), p. 3-17, 1.

[9] Interview in *Edge*, available at https://www.edge.org/conversation/who-is-the-greatestbiologist-Of-all-time. Access on 15 June 2016.

[10] Ronald A Fisher, "Some Hopes of a Eugenist." *The Eugenics Review* 5, nº 4 (1914): 309-315, 311.

[11] Ibid.

The beginnings: the gradualism-saltationism debate

By the end of the 1800s, scientists saw themselves immersed in a profound controversy as to the basis of biological variation and its relationship to evolution theory as formulated by Charles Darwin (1809-1882). This debate involved two diametrically opposed positions, evolution through sudden changes – saltationism – or via the operation of natural selection on smaller continuous variations – gradualism[12]. As mentioned above, Fisher is considered one of the main architects of Neo-Darwinian synthesis, which precisely put an end to this controversy and inaugurated a new era in biological thought. To understand Fisher's role better, next we briefly summarize the main lines of the debate.

One of the basic assumptions in Darwin's *The Origin of Species* was that variations affecting species are small and continuous, being the substrate for the action of natural selection, resulting first in the differentiation of varieties within a same species, and finally differentiation into two or more separated species[13]. Darwin believed it was easier to explain the common continuous variability through his theory of natural selection, in turn based on the assumption of endless organic individual variation.

Following the publication of *The Origin of Species* in 1859, Darwin's cousin, Francis Galton (1822-1911) became interested in the possible application of evolution theory to the human species.[14] His main objective was to develop mechanisms to direct human evolution toward what he came to call *eugenics*. For this purpose he conducted studies on human inheritance and applied statistical tools to the analysis of continuous variation in humans. Thus he concluded that the work of natural selection on continuous variations was not efficacious. The reason was that selection of continuous traits could not result in new varieties or species due to a phenomenon that he named *regression to the mean*. According to it the dispersion of a trait across one generation was nullified by its reversion in the following one. This phenomenon explained why children looking very different from their parents could closely resemble their grandparents, and also hindered the occurrence of major transformations within a species. Therefore, in Galton's view, evolution of races and species demanded what he called *sports*, namely, spontaneous appearance of highly different traits preventing the occurrence of regression to the mean, and thus resulting in a new point of organic stability.[15]

By the turn of the century, Galton's statistical work exerted significant influence on three British scientists: the already mentioned mathematician Pearson and biologists W.F.

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[12] Nicholas W. Gillham, "Evolution by Jumps: Francis Galton and William Bateson and the Mechanism of Evolutionary Change." *Genetics* 159, nº 4 (2001): 1383-1392.

[13] Darwin, apud Ernst Mayr, *O Desenvolvimento do Pensamento Biológico: Diversidade, Evolução e Herança*. Ed. UnB, 1998, 599.

[14] Francis Galton, *Hereditary Genius* (London: Macmillan and Company, 1869).

[15] Ibid, "V. Discontinuity in Evolution." *Mind* 3, nº 11 (1894): 362-372, 362-4.

Raphael Weldon (1860-1906) and William Bateson (1861-1926). Galton, Pearson and Weldon founded journal *Biometrika*, devoted to the application of statistics to biological phenomena, following an incident involving Bateson.[16] That fact notwithstanding, Bateson joined Galton in the defense of saltationism, i.e., occurrence of sports as the main mechanism driving evolution. In 1894 he published *Materials for the Study of Variation*, in which he described hundreds of examples he himself had gathered of discontinuous variations in nature and that served as evidence for saltationism and consequent rebuttal of gradualism.[17] Weldon and Pearson, in turn, adopted the opposite view and upheld gradualism as the substrate for the operation of natural selection, and thus the core element of evolution.

The controversy opposing gradualism and saltationism, which lasted many years, attained a new level after the rediscovery of Gregor Mendel's (1822-1884) work. Fitting particularly well with his view of discontinuous variation, Bateson became the main advocate and divulgator of Mendelism in Britain[18]. Mendel's model made the fact of two yellow peas having green offspring entirely plausible and provided the grounds for the discontinuous 'jumps'. Bateson organized study groups, taught courses and conducted research in his own residence until genetics came to find institutional place as an autonomous science. To be sure, it was Bateson who minted the term *genetics*, first used in 1905[19].

Along this period Bateson, among other scientists, such as Charles Davenport (1866-1944) in the United States, performed countless experiments based on the principles of Mendelian inheritance.[20] In turn, the gradualist biometricians advocated a rival principle first developed by Galton, the so-called *law of ancestral heredity*. According to it, the contribution of ancestral hereditary traits was more relevant the closer the kinship between individuals was and had mathematical formulation, as follows:

> "[...] two parents contribute between them on the average one-half, or (0.5) of the total heritage of the offspring; the four grandparents, one –quarter, or $(0.5)^2$; the eight great-grandparents, one eighth, or $(0,5)^3$, and so on. Thus the sum

[16] Theodore M. Karl Pearson Porter, *The Scientific Life in a Statistical Age*. (Princeton: Princeton University Press, 2010), 268-9.

[17] See William Bateson. *Materials for the Study of Variation: treated with especial regard to discontinuity in the origin of species* (Cambridge: Cambridge University Press, 2012).

[18] Robert Olby. "The Dimensions of Scientific Controversy: The Biometric—Mendelian debate." *The British Journal for the History of Science* 22, nº 3 (1989): 299-320, 304.

[19] Marsha L Richmond, "The 'Domestication' of Heredity: The Familial Organization of Geneticists at Cambridge University, 1895–1910." *Journal of the History of Biology* 39, nº 3 (2006): 565-605, 565.

[20] Between 1900 and 1910, several researchers in the US and Britain concluded that several human traits followed the concepts formulated by Mendel, such as color blindness, ABO blood types, polydactyly, albinism and various diseases; see Garland Allen, "The Eugenics Record Office at Cold Spring Harbor, 1910-1945: An Essay in Institutional History". *Osiris* 2nd series 2 (1986): 225-264, 226.

of ancestral contribution is expressed by the series {(0.5) + $(0.5)^2$ + $(0.5)^3$, &c.}, which, being equal to 1, accounts for the whole heritage"[21]

In an article from 1902, Weldon stated than the example described by Mendel was just a particular case of inheritance. While Galton's theory considered the various levels of influence exerted by all ancestors, from Mendel's perspective only the parental generation accounted for the full inheritance, therefore there was no need to know anything about the more remote ancestors to predict the characteristics of the offspring (Weldon, 1902). Furthermore, Weldon rebutted Bateson's views by showing errors in experimental models developed by the latter, like the one of plants from genus *Lychnis*[22] as well as the Mendelian view of the inheritance of mental deficiency.[23]

Ronald Fisher enters the debate: the synthesis

In 1947, Fisher evoked his impressions on the controversy upon first arriving as an undergraduate student to Cambridge:

> "I first came to Cambridge in 1909, the year which the centenary of Darwin's birth and the jubilee of the publication of *The Origin of Species* were being celebrated. The new school of genetics using Mendel's laws of inheritance was full of activity and confidence, and the shops were full of books good and bad form which one could see how completely many writers of this movement believed that Darwins's position had been discredited"[24].

In 1959, he further elaborated:

> "The early Mendelians could scarcely have misapprehended more thoroughly the bearings of Mendel's discovery, and of their own advances, on the process of evolution. They regarded species as passively awaiting the next favourable mutation, instead of recognizing them as abundantly supplied with

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[21] Galton, 402.

[22] William Bateson & E.R. Saunders. "The Facts of Heredity In the Light of Mendel's Discovery," *Reports to the Evolution Committee of the Royal Society*, 1 (1902): 125-160.

[23] For Davenport and other American naturalists, mental deficiency was inherited through a recessive factor. One of the great proponents of this thesis was the psychologist Henry H. Goddard (1866-1957), whose work influenced several geneticists. In turn, for the biometricians, the mental capacity was a characteristic that varied gradually and its deficiency was a part of the lower tail of the normal distribution curve of the results of three tests: intelligence, memory and maturity. See Cruz, Rodrigo A. "Oito Votos contra Um: O Desenvolvimento da Ciência Eugenista nos Estados Unidos". Dissertação de mestrado, (Pontifícia Universidade Católica de São Paulo, 2012), 45-53.

[24] Joan Fisher Box, *R. A. Fisher, the Life of a Scientist* (New York: John Wiley & Sons, 1978), 23.

> heritable variation, prepared in advance for changes in all directions, and sensitively poised to respond to every kind of selective influence. They confused the discontinuity of particulate trans mission with discontinuity in the genealogy of new species. They thought of Mendelism as having dealt a death blow to selection theory, whereas in reality it had swept the field of all its competitors”[25]

In the beginning of his academic career, Fisher emphasized - in a speech read at a meeting of the Cambridge Eugenics Society - the spectacular discoveries derived from the application of Mendel’s ideas[26]. After stating “prediction is a matter of probability”, he observed that Mendelian theory “can with certainty predict the possible types of children of given parents” and in what proportion. Being the offpsring large enough, “the numbers actually approximate to the ratios required by theory”, while the results of biometric research were less precise, they had a broader scope of application and offered advantages for the treatment of population-based data.

Merely a few years after his arrival in Cambridge, Fisher (1919) published a paper that would prove crucial to the solution of the controversy and that is currently considered to be one of the milestones in the development of evolutionary synthesis.[27] Curiously, this paper was rejected for publication by Punnett and Pearson, as referees for Proceedings of the Royal Society. Later on Fisher attributed this rejection to “a biologist who knew no statistics and a statistician who knew no biology”[28]. The influence and financial support of Leonard Darwin were needed to the paper to be finally published, in 1918, in Transactions of the Royal Society of Edinburgh[29]. It is worth to observe that Punnett succeeded Bateson as professor of genetics in Cambridge by the time Fisher first arrived at the university. Punnett and Fisher founded together the Cambridge University Eugenics Society [30]comments that Fisher wrote “brilliantly original papers which could not be published in England because of opposition from the leading authorities in biometry and genetics.”

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[25] Ronald A Fisher, *The Genetical Theory of Natural Selection*. (Oxford: Oxford University Press, 1930), 16-7.

[26] Ronald A Fisher, "Mendelism and Biometry." Unpublished manuscript, included in *Natural Selection, Heredity, and Eugenics: Including Selected Correspondence of R.A. Fisher with Leonard Darwin and Others*. Ed., introd. J. Bennett (Oxford: Oxford University Press, 1983), 51-56; R. A Fisher, “Some hopes of a eugenist,” *The Eugenics Review*, 5(4), (1914): 309, 53.

[27] Massimo Pigliucci & Gerd B. Müller. "Elements of an Extended Evolutionary Synthesis," in *Evolution: The Extended Synthesis*, ed. M. Pigliucci, & G.B. Müller (Cambridge [MA]: The MIT Press, 2010), 3-17, 1.

[28] Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Cambridge: Harvard University Press, 1995), 288.

[29] Mazumdar, 71-2.

[30] Ronald A. Fisher, "Mendelism and Biometry." Unpublished manuscript, included in *Natural Selection, Heredity, and Eugenics: Including Selected Correspondence of R.A. Fisher with Leonard Darwin and Others,* ed., introd. J. Bennett (Oxford: Oxford University Press, 1983), 51-56; Fisher, R. A. (1914). R. A Fisher, “Some hopes of a eugenist,” *The Eugenics Review*, 5(4), (1914): 309, 15.

Indeed, in *The Correlation between Relatives on the Supposition of Mendelian Inheritance*, Fisher demonstrated on sound mathematical grounds that the inheritance of several traits presenting continuous variation could be explained by the Mendelian model. This led him to conclude, "[...] the statistical properties of any feature determined by a large number of Mendelian factors have been successfully elucidated"[31]. His main argument was that multiple Mendelian factors accounted for the inheritance of traits presenting continuous variation. According to Bennett[32], Fisher showed that *variance* – a term he first introduced in this very paper – could be divided into inheritable and non-inheritable portions. And the inheritable fraction could be analyzed with different functions, as additive genes, dominance and other genic interactions.

In addition, he called the attention to another factor that could further contribute to the continuous variation of traits: perhaps the Mendelian factors contained more than dominant or recessive variations, whence

> "[…] we abandon the strictly Mendelian mode of inheritance in almost its full generality. Since, however, well-authenticated cases of multiple allelomorphism have been brought to light by the Mendelian method of research, this generalized conception of inheritance may well be treated as an extension of the classical Mendelism, which we have so far investigated"[33].

Eugenics as foundation

The controversy notwithstanding, a common substrate unified both currents of British scientists at the beginning of the 20th century: eugenics. As a contemporary witness, Cambridge botanist Robert Lock (1879-1915), a colleague of Bateson and Reginald Punnett (1875-1967) observed, the agreement "between the conclusions on race improvement drawn by the students of Genetics, on the one hand, and by those of Biometry, on the other, is a remarkable one […]"[34].

The seed of synthesis had already been germinating within the British eugenic milieu many years before the aforementioned paper by Fisher. In 1902, for instance, George Udny Yule (1871-1951) suggested that the discontinuity exhibited by the Mendelian factors could be reconciled with the gradual distribution of biometrical measurements upon assuming that several different factors could be involved in the determination of quantitative traits,

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[31] Ronald A. Fisher, "XV. The Correlation between Relatives on the Supposition of Mendelian Inheritance." *Transactions of the Royal Society of Edinburgh* 52, nº 2 (1919): 399-433, 432.

[32] Ibid, "Mendelism and Biometry", 6.

[33] Ibid, "Correlation between Relatives", 415.

[34] Lock apud Olby, 304.

such as the body height.[35] This hypothesis is rather curious, as Yule's goal in this paper was to disqualify Mendelian theory. However, he paved the road for a synthesis upon stating

> "[…] biologists – statistical or otherwise – should recognise that Mendel's Law and the Law of Ancestral Heredity are not necessarily contradictory statements […] are perfectly consistent the one with the other and may quite well form parts of one homogenous theory of heredity"[36] .

To be sure, for many eugenicists the differences between Mendelian theory and biometry did not seem to be insurmountable. For instance, Montague H. Crackanthorpe (1872-1950), president of the Eugenics Education Society, stated in a speech delivered in 1910 that both approaches were equally necessary for the success of eugenics[37]. Also Fisher, at the aforementioned meeting of eugenicists held in Cambridge in 1911, stated that biometrics and genetics were "the two lines of modern research which are of particular interest in Eugenics".[38] As evidence, we might mention the fact that lectures on both Mendelian theory and biometrics were delivered at the Eugenics Education Society along its first year of existence. Then, in the course on "Groundworks of Eugenics" taught at Imperial College in 1913, while Yule lectured on biometrics, Punnett, then professor of genetics at Cambridge, taught Mendelian theory[39]. The latter was relevant to eugenics, according to Punnett, because,

> "It is coming to be more clearly recognized that the eugenic ideal is sharply circumscribed by the facts of heredity and variation and the laws which govern the transmission of qualities in living things. What these facts, what these laws are, I have endeavoured to indicate […] for I feel convinced that if the eugenist is to achieve anything solid, it is upon them he must build."[40]

In the same meeting in 1911, when Fisher was just a 21-year-old undergraduate student in Cambridge, he explicitly manifested his enthusiasm vis-à-vis the possibility of applying Mendelian theory to eugenics:

> "A large number of rare defects among men are now known to be Mendelian dominants; colour blindness, brachydactyly and the form of insanity

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[35] G. Udny Yule, "Mendel's Laws and Their Probable Relations to Intra-racial Heredity," *New Phytologist* 1, nº 10 (1902): 222-238, 235.
[36] Ibid, 236.
[37] Crackanthorpe apud Mazumdar, 62.
[38] Fisher, "Mendelism and Biometry", 52.
[39] Mazumdar, 63.
[40] Ibid, 27.

known as chorea are among these […] These would all be stamped out in one generation by prohibiting affected persons form pairing”.[41]

Within this context, he had resource to biometric data to reinforce the fact that the environment has minimal influence on both mental and physical human traits. Quoting from Galton’s *Hereditary Genius*, Fisher affirms that mental traits have normal distribution, besides emphasizing that this book “show[s] how strongly such talents are inherited”.[42]

So persuaded Fisher was of the relevance of eugenics that during his second year at Cambridge he suggested the creation of the Cambridge University Eugenics Society. Some of its members later on become highly relevant figures of the British scientific and intellectual circles, such as the already mentioned Punnett, the economist John Maynard Keynes (1883-1946) and the engineer Horace Darwin (1851-1928), Charles’ son. The Society grew rapidly, to reach 150 members one year after its foundation on 11 May 1911[43]. The main problem to be solved, according to them, was the high fertility rates of the poorer social classes. Thus, for instance, Fisher warned “but at present, there is no doubt that the birth-rate of the most valuable classes is considerably lower than that of the population in general, and conspicuously lower than of the lowest mental and moral class of the population”.[44]

Genetics and eugenics

In 1930, Fisher published *The Genetical Theory of Natural Selection*, which is considered the fundamental work of Neo-Darwinism, by establishing the field of population genetics, today still considered “the theoretical-mathematical backbone of evolutionary biology”[45], in addition to “a milestone in the history of population genetics”[46]. The praises to this book are countless (Edwards, 2000; Haldane, 1931, p. 115; Bennet, 1983, p. v and 36; Clarke, 1990, p. 1447).

The first half of the book has the content one might expect from its title: Fisher successively describes the foundations of Mendelism and Darwinism, discusses the concepts of genetic mutation, intermediate inheritance, speed of evolution, population genetics and sex-linked inheritance. However, the second half of the book is a surprise for the modern

[41] Fisher, “Mendelism and Biometry”, 54.
[42] Ibid, 57.
[43] Box, 27.
[44] Fisher, “Mendelism and Biometry”, 57.
[45] Pigliucci & Müller, 6.
[46] Nicolas Bacaër, *A Short History of Mathematical Population Dynamics*. (Dordrecht: Springer Science & Business Media, 2011), 79.

reader, as it deals with plain eugenics, comprising discussions on the fall of ancient civilizations and differential fertility between social classes. The reason is explicitly given by the author: a part of the contemporary geneticists merely focused on the mechanisms of heredity, and "[they] appear to fear that the purity of their subject, as an abstract science, would be contaminated were it applied to the species to which themselves belong", fully passing over the role of other factors of change, the ones coming from the outer environment in particular[47]. The other, and by far largest part of the geneticists did pay attention to the outer environment, but losing from sight the crucial relevance of inheritance as the ground for the organization of human societies, and consequently the eugenic nature of genetics.[48]

Following Darwinian lines, Fisher asserts that the science of genetics had no value whatsoever when isolated from the environment – after all, it is the environment which selects characteristics advantageous at a given time. Therefore, the advances in the studies on genetics notwithstanding, they led nowhere by themselves. Neo-Darwinian synthesis came precisely to reunite these two aspects.

To account for this, Fisher considers that historical and sociological aspects have paramount importance and he reviews the history of civilization from the perspective of inheritance. The underpinning argument is that the "very different races" that became civilized did not only fail to maintain their national superiority, but also to persist over an average period of time on earth due to the lack of an eugenic policy favoring differential fertility, i.e., selective reproduction of the best human stock[49]. And with this we came to the core of Fisher's concerns: differential fertility, which is the ultimate subject of *The Genetical Theory of Natural Selection*.

Fisher's starting point is that civilized societies possess insurmountable advantages over their non-civilized neighbors, "divided by hereditary enmities and petty jealousies." All civilized societies along history develop an "industrial organization," which allows them to create more efficient military systems, as well as superior knowledge and better information to ground collective action[50]. This – and here the radicality of Fisher's view – does not come from educational, economic or political aspects, but from plain biology[51]. Hence the imperative to address human reproduction.

Within this context, Fisher successively discusses the contemporary introduction of efficient contraceptive methods, which was severely reducing the birth rate of the better components of "civilized nations", i.e. the United States and Western Europe[52] and the effect

[47] Fisher, *Genetical Theory*, 173
[48] Ibid, 74.
[49] Ibid, 176.
[50] Ibid, 175.
[51] Ibid, 176-7.
[52] Ibid, 193.

of family size on fertility – the larger a family, the higher the birth rate of the following generation[53], among other cases. Statistical analysis of these and many other examples showed that the fertility rate had major influence on the reproductive profile of a given population, eventually coming to turn it upside down. The situation was particularly worrisome in Fisher's time, because civilization had enormously affected the human fertility rate to the point that evolution was developing at vertiginous speed, dramatically much faster and strongly than the one expected from wild animals in environments undergoing gradual change. Even more important, such fast evolution accounted for the remarkable changes in the frequency of "appropriate mental attributes", which could thus occur along a few generations[54]. Shortly, for Western civilization to survive, action was needed now.

Resorting to the analogy with the most efficient insect societies, i.e. the ones of bees – a recurrent theme in Fisher's thought appearing in the beginning of his intellectual production, as early as in 1914 – the unit is not the human individual as such, but the human collective. Fisher thus highlights the relationship between the social class to which an individual belongs and the general biological capacity of that individual. To him, someone who fails "in one occupation is free, at the expense of some loss of social class, to find some humbler mode of living in which his talents are sufficient to win the necessary support for himself and his family." In addition, specialization was an advantage, because "The elasticity afforded by the range of occupations [leaves to] the majority of the population a certain margin of safety from absolute destitution"[55].

However, marriages tended to occur between individuals of the same social class, which fact Fisher[56] considers to have paramount biological relevance, since "[…] distinctions of social class are distinctions of relatively permanent biological entities". He characterizes the members of the various social classes as different "varieties of a species" just like the various breeds of cats or dogs[57]. Social classes exhibit a "relatively permanent character", this being a *sine qua non* condition for evolution, as it demands that groups differing in some traits, as e.g., reproduction rates, also be genetically different[58]. Thus he investigated the relationship between income and number of children[59] eventually coming to demonstrate, based on statistical analysis, that the fertility rate varied gradually, rather than abruptly as a function of social class, the gradient increasing from the upper toward the lower social classes[60].

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53 Ibid, 195.
54 Ibid, 199.
55 Ibid, 210.
56 Ibid, 211.
57 Ibid, 216.
58 Ibid, 211.
59 Ibid, 215-12; 221.
60 Ibid, 212.

Fisher concludes that the overall fall of the birth rate recorded since the 1870s was not uniformly distributed across the social spectrum, but affected more strongly the upper classes and did not extend proportionally to the lower echelons of the social pyramid. Society exhibited a paradoxical aspect:

> "[...] the socially lower occupations are the more fertile, we must face the paradox that the biologically successful members of our society are to be found principally among its social failures, and equally that classes of persons who are prosperous and socially successful are, on the whole, the biological failures, the unfit of the struggle for existence, doomed more or less speedily, according to their social distinction, to be eradicated from the human stock"[61].

Thus Fisher felt he had statistical proof to rebut the Neo-Malthusian argument that education was the answer. No educational campaign would ever be able to make differential fertility disappear[62]. The only possible approach was to reduce the fertility rate of the lower strata of the population[63] and reorganize governmental investment, and even also charity, according to eugenic values. Global, indiscriminate charity actually delayed the cultural progress of all social classes, as it put the educational system under tension by the injunction to improve the educational levels of individuals "suffering from early disadvantages" (Fisher, 1930, p. 225).

To summarize, the ultimate goal of Fisher in the overwhelmingly celebrated *The Genetical Theory of Natural Selection* was to demonstrate that inheritance of low fertility was genetically linked to a set of traits adequate for civilized society, such as "the desire to do well, fortitude and persistence in overcoming difficulties, the just manliness of a good leader, enterprise and imagination, qualities which seem essential for the progress" (Fisher, 1930, p. 262). However, the socially adequate individuals were "congenitally averse to the consequences of normal reproduction in [the] existing economic conditions". Reciprocally, high fertility was genetically related with traits proper to barbarian societies, like greater physical development and strength[64].

Fisher [65]concludes the book emphasizing that its content "constituted an important public service", were its concepts and suggested actions to be "widely instilled in the education of all," and the economic system readjusted to meet these goals.

Not only Fisher's efforts in the development of statistical tools thus served the purposes of eugenics, but even his work with the Rh blood group system evolved within the

[61] Ibid, 222.
[62] Ibid, 220.
[63] Ibid, 222.
[64] Ibid, 263.
[65] Ibid, 264.

eugenic framework. Indeed, in the early 1930s he pressed the Eugenics Society to create a committee to study the human blood groups for its potential benefits for eugenics[66]. He believed that gene links eventually demonstrated by the study of blood groups would provide highly consistent evidence for the correlation between different characteristics. In 1930 Fisher criticized R. R. Gates, who had said that these differences in human blood "were apparently without selective effect". Fisher observed: "There are good many climatically limited blood diseases, such as malaria and yellow fever, so I would not be too sure of the absence of selection"[67].

In a letter sent in 1932 to Charles Todd, a researcher investigating antigens in bird red blood cells, Fisher manifested enthusiasm with the "greater advance both theoretical and practical in the problems of human genetics than can be expected from any further work along biometrical or genealogical lines"[68]. Consistently, Fisher tried to have the Eugenics Society fund studies on this topic.[69] However, this request was turned down. As a result, in 1933 Fisher established a department of serology at the Galton Laboratory, University College London (UCL), where he conducted his work on human blood types until 1943[70]. In that year he moved to Cambridge as professor of genetics, when he finally came to describe the mechanism of inheritance of the Rh factor[71], according to some scholars, his greatest contribution to medicine[72].

Neither in this case Fisher lost the potential eugenic value of this research from sight. Indeed, in a letter to the immunologist William Boyd (1903-1983) from October 1934, he wrote:

> "I cannot see any escape from the view that the frequencies have been determined by more or less favourable selection in different regions, governed not improbably by the varying incidence of different endemic diseases in which the reaction of the blood may well be of slight but appreciable importance".[73]

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[66] Box, 339.
[67] Fisher, "Mendelism and Biometry", 37.
[68] Box, 339.
[69] In the course of time, Fisher ran into conflict with the board of the Eugenics Society, which led to the cut of funding for *Annals of Eugenics*. Fisher criticized the "lack of permeability to scientific advice" expressed by the Society. In 1937, he left the vice-presidency of the Society and completely disengaged in 1942. See Fisher, "Mendelism and Biometry", 17.
[70] Fisher, "Mendelism and Biometry", 37.
[71] Ibid, "The Rhesus Factor: A Study in Scientific Method." *American Scientist* 35, nº 1 (1947): 95-113.
[72] Cyril Clarke, "Professor Sir Ronald Fisher, FRS." *British Medical Journal* 301, nº 6766 (1990): 1446-1448, 1446.
[73] Fisher, "Mendelism and Biometry", 37.

Then, in an article published in 1936, he criticized the researcher Lancelot Hogben (1895-1975) for prematurely announcing a full lack of correlation between blood types and hereditary deficiencies on the grounds that the samples assessed were too small.[74]

(Eu)genetics?

The intimate relationship between eugenics and genetics was made further explicit by the time Fisher was appointed editor of *Annals of Eugenics*. Founded in October 1926, the journal was published by the Galton Laboratory having Karl Pearson as chief editor. [75] In 1934 the latter retired to be replaced by Fisher, and the Eugenics Society joined in as co-publisher. While under Pearson the editorial mission was announced as "a journal for the scientific study of racial problems", Fisher changed it to "statistical studies in genetics and human inheritance", which thus defined the new scope of eugenics (Figure 1).

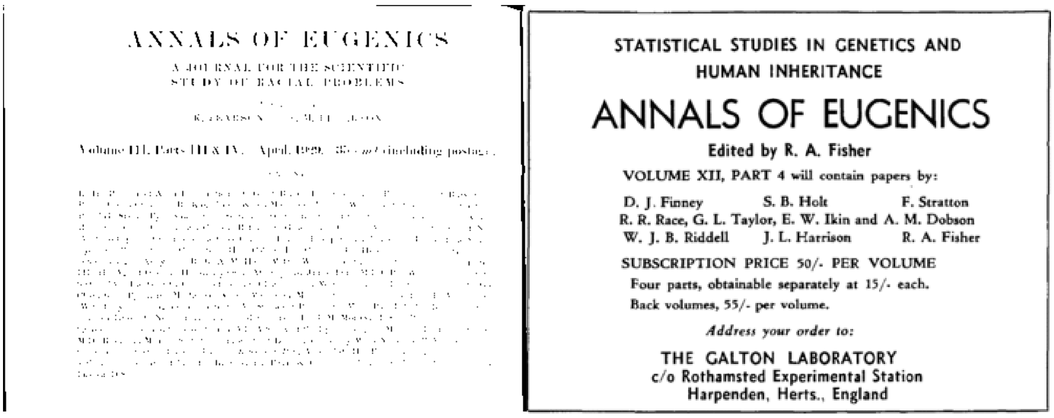

Fig. 1. Cover of *Annals of Eugenics*, left under Pearson's editorship, right under Fisher's editorship

As is known, in the post-war period eugenics became a dirty word in the face of the atrocities perpetrated in its name first in the United Stated (Allen, 1989; Kevles, 1995; Lombardo, 1999; Watson, 2005) and then even more indescribably horrendous in Nazi Germany. In 1954 the journal's name was changed by Lionel Penrose (1898-1972), its chief

[74] Ibid, "Heterogeneity of Linkage Data for Friedreich's Ataxia and the Spontaneous Antigens." *Annals of Eugenics* 7, nº 1 (1936): 17-21, 21.
[75] Weiss, Kenneth M., & Brian W. Lambert. "When the Time Seems Ripe: Eugenics, the Annals, and the Subtle Persistence of Typological Thinking." *Annals of Human Genetics* 75, nº 3 (2011): 334-343, 336-7.

editor, to *Journal of Human Genetics*, remaining as such to this day[76]. This was not a mere politically correct change. Penrose was appointed to the chair of eugenics of UCL succeeding Fisher in 1945. In his inaugural lecture he emphatically tried to detach eugenics from its original racial connotations. He adduced that races simply do not exist in humans. Traits attributed to races are simply more frequent in a given population than in others, and even so they are not present in all the members of a so-called race. In addition, statistical analysis showed that the average differences between the alleged races were much smaller than commonly believed. Shortly, the human species was to be considered as one single race, if one still wanted to speak in these terms. Yet, there were dysgenic individuals within this one single race, and to correct this state of affairs the target of the new eugenics ought to be the "normal" members carrying defective recessive genes[77]. More explicitly, to account for the change in the journal's name, Penrose observed that the research conducted at the Galton Laboratory could no longer be rated eugenic, since it "benefit[s] the human race, because [it] increase[s] the body of scientific knowledge about man's nature".[78]

In regard to the UCL chair, only in 1963 its name changed to Galton Chair of Human Genetics[79]. Also in that year the "The Francis Galton Laboratory of National Eugenics" became "The Galton Laboratory of the Department of Human Genetics & Biometry", currently included in UCL Department of Biology.[80] Starting 1980, the chair of genetics at the Department of Genetics, Evolution and Environment of UCL was given Galton's name despite the protests of the academic community.[81] The Eugenic Society changed its name even later, to become the Galton Institute in 1989, together with a warning that it fully rejects the theoretical and practical basis of "coercive" eugenics: "Galton's idea of 'eugenics' was

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[76] Ibid, 341.

[77] Lionel Penrose, "Phenylketonuria: A Problem in Eugenics." *Lancet* 1, nº 6409 (1949): 949-953.

[78] Penrose, "From Eugenics to Genetics", 10, in Penrose, *The Lionel Penrose Papers*, http://wellcomelibrary.org/collections/digital-collections/makers-of-modern-genetics/digitised-archives/lionel-penrose/digitised-archives/lionel-penrose/; Access on 5 July 2016.

[79] Weiss & Lambert, 341.

[80] *UCL Galton Collection*, https://www.ucl.ac.uk/museums/galton/about/history), access on 14 February 2016.

[81] *UCL*, https://iris.ucl.ac.uk/iris/browse/profile?upi=NWWOO43; *UCL Archives*, http://archives.ucl.ac.uk/DServe/dserve.exe?dsqIni=Dserve.ini&dsqApp=Archive&dsqCmd=Show.tcl &dsqSearch=RefNo==%27GALTON%20LABORATORY%27&dsqDb=Catalog) access on 14 February 2016. In the present time, a movement known as *Why Isn't My Professor Black*? opposes the permanence of honor mentions to Galton at UCL, as well as the attribution of Pearson's name in 1980 to one of the university buildings. During a lecture, upon being questioned by a student, UCL dean Michael Arthur answered: "You're not the first person to make that point to me; my only defence is that I inherited him". On the internal debates at UCL, see "Eugenics at UCL: We Inherited Galton", *Times Higher Education*, https://www.timeshighereducation.com/news/eugenics-at-ucl-we-inherited-galton/2016281.article, which is the source of the just quoted citation, and "Why Isn't My Professor Black?", *UCL Events*, https://blogs.ucl.ac.uk/events/2014/03/21/whyisntmyprofessorblack/. Access on 14 February 2016.

based on concepts and hypotheses that served to create artificial hierarchies and division between peoples of different class, ethnicity and culture."[82]

As to Fisher, after ten years as professor of eugenics at UCL, in 1943 he was appointed to the Alfred Balfour chair of genetics in Cambridge, where he remained until 1956, when he moved to teach at The University of Adelaide in Australia until his death in 1962. In addition, he presided from 1941 to 1943 the Genetical Society founded by Bateson in 1919, which presently is the Genetics Society. All along this time he remained an ardent advocate of eugenics its infamous reputation notwithstanding. In a letter from 1951 he explicitly referred to the ongoing status of eugenics, which he attributed to political rather than to proper scientific reasons: "The coincidence that opponents of Eugenics in this century have been almost always Communists, or fellow travellers, cannot […] be overlooked"[83].

It is worth to observe that not only Fisher, but also other relevant scientists still advocated in favor of eugenics in the second half of the twentieth century. Accompanying the global trend, in 1954 journal *Eugenical News*, published in the United States, changed its name first to *Eugenics Quarterly* and then to *Social Biology* in 1961. It was precisely in the latter that Sheldon Reed (1910-2003) published an article in 1974 in which he told the history of *genetic counseling*, a field he had contributed to develop and which name he had minted himself. Director of the Dight Institute for Human Genetics, University Minnesota, from 1947 to 1977, and president of the American Society of Human Genetics, in 1955, in this article Reed explicitly states that: "Genetic counseling would have been rejected, in all probability, if it had been presented as a technique of eugenics"[84]. Yet he traces the history of genetic counseling back to Galton's early studies on inheritance and to leave no doubts, he asserts that the discipline directly resulted from the eugenic movement originated in Galton[85]. Not only that, but Reed goes on to declare: "There is no question but that the basic concept of eugenics was, and is, valid; it was the misguided attempts at implementation which led to disaster", this due to the fact that "the chickens were counted before they were hatched", because "The eugenics movement failed because it was so easily perverted in its youth, long before it had sufficient scientific underpinnings to permit it to stand alone or to resist seduction"[86].

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[82] *Galton Institute*, http://www.galtoninstitute.org.uk/history/eugenic-past/, access on 14 February 2016.

[83] Daniel Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Cambridge: Harvard University Press, 1995), 398.

[84] Sheldon C. Reed, "A Short History of Genetic Counseling." *Social Biology* 21, nº 4 (1974): 332-339, 335.

[85] Ibid, 333.

[86] Ibid, 333.

Final remarks

The immense contributions of British naturalists and biologists from the late nineteenth and early twentieth centuries to contemporary science are undeniable. Much of the current research in medicine and biology - in addition to other fields such as economics, geography, shortly "every field in which data are collected and analyzed"[87] - use statistics as originally developed by Galton, Pearson and Fisher as basic tool. In turn Neo-Darwinian synthesis serves as framework of thought for the whole field of studies related to inheritance, variation and adaptation to the environment.[88]

The eugenic foundations of this project, evident in all the authors involved from Galton to Reed through Pearson, Bateson, Punnett, Fisher, Davenport and countless others, became veiled after the atrocities committed in the US in the 1920s and 30s, and more especially in Nazi Germany. This intentional veiling is explicit in the case of Penrose. However, a large part of the underlying premises remained, as Reed's work illustrates, as is also the case of the work on biotypological classification conducted by William H. Sheldon (1898-1977) with freshmen at Ivy League universities, including members of the present-day socio-political establishment of the US.[89]

As concerns the history of science, our study contributes to the idea that science does not develop in an impartial and disinterested way, unrelated to the cultural, social, religious and political influences that surround individuals and institutions in definite times and places. Against the assumption of a 'neutral', 'aseptic' science, we showed how Fisher's intellectual makeup was impregnated with the themes, ideals and prejudices of the time, eventually to the point of influencing the choice of data to be analyzed and taken into account or not to corroborate hypotheses by statistical means. As one example, while in 1914 he qualified the data on fertility by class of Nordic populations as "a notable exception"[90], to fully omit this information in *The Genetical Theory* from 1930, a fact denounced by Haldane[91].

One episode that demonstrates the strength of Fisher's convictions is the publication of *The Race Concept* by UNESCO in 1952. It contains ethical guidelines to orient scientific practice in the second half of the twentieth century. In this regard, it explicitly states that "tests have shown essential similarity in mental characters among all human groups" and "The scientific material available to us at present does not justify the conclusion that inherited genetic differences are a major factor in producing the differences between the

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[87] Mazumdar, 98

[88] Pigliucci & Müller, 1.

[89] Patricia Vertinsky, "Physique as Destiny: William H. Sheldon, Barbara Honeyman and the Struggle of Hegemony in the Science of Somatotyping," *Canadian Bulletin of Medical History* 24, no. 2 (2007): 291-316.

[90] Ronald A. Fisher, "Some Hopes of a Eugenist." *The Eugenics Review* 5, nº 4 (1914): 309-315, 313.

[91] J.B.S. Haldane, "Review of The Genetical Theory of Natural Selection. (R.A. Fisher)," *Mathematical Gazette*. 15 (1930): 474-5.

cultures and cultural achievements of different peoples or groups"[92]. A consequence of the massacres committed during World War II, the document was written by leading personalities in the fields of genetics and evolution of the period – some of whom had called themselves eugenists before the war, such as Haldane, then professor at the Department of Biometrics at UCL. Also a "fundamental objection" of Fisher, then professor of genetics at Cambridge, is quoted in the document, moreover qualified as destroying "the very spirit of the whole document." The reason is that he still believed that human beings differ profoundly "in their innate capacity for intellectual and emotional development" and thus infers that "the practical international problem is that of learning to share the resources of this planet amicably with personals of materially different nature." In this sense, for Fisher, the problem was veiled by well-intentioned efforts to "minimize the real differences that exist"[93]

Finally, attention must be drawn to the fact that the innumerable contemporary publications in celebration of Fisher have completely silenced the eugenic aspect of his work. This leads us to conclude this paper with a question: without the duly historiographical criticism, how will we able to detect the new faces of eugenics behind the haze of contemporary scientific authority?

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[92] Unesco. *The Race Concept: Results of an Inquiry*. UNESCO, 1952, 99.
[93] Ibid.