History and Philosophy of the Life Sciences

Human Genetics in Post-WWII Italy. Blood, genes and platforms

--Manuscript Draft--

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Response to Reviewers:	Reviewer #1: Response: I have mostly revised the introduction and the conclusion. The introduction is now – I hope – clearer in terms of structure of the paper. There is not a long list of literature in this field – Italian Human Genetics, so that most of the literature I cited here, and my aim is to add some nuances to the current narrative. I hope this is now done. As a matter of fact, I didn't assume that Lederberg influenced the whole field of Italian Genetics: he influenced greatly Cavalli's career, and as such, it would be interesting (but it's a matter for another research paper) to look at his influence at large. The influence of a Nobel prize, involved in several science management environments in the US, may have travelled through life science networks, even beyond genetics. Furthermore, It may be possible that his "Nobel aura" – as well as his scientific prestige – was exploited by Italian scientists to gain support in their local context. Terms and procedures I hope are now clearer, and I added several footnotes

	explaining them as well as adding details to names. I also included literature where its need was felt (bivins, Mazumdar, Sapp…) , though debates on human genetics are definitely too wide to be discussed here. Thanks a lot for the careful reading of the paper, I really appreciated your help. Reviewer #2: Response: I Have taken care of all the points indicated. Thank you very much!
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Thanks a lot for the careful reading of the paper.

Reviewer #2: Dear author,

Your article is very interesting and the bibliography is up to date. There are, however, some points that need further attention.

I will highlight below some general observations and some more specific.

Please pay attention to the commas and fullstops which seem to be missing in some points, such as p. 2, line 23 "Historiography has, however, shown that…"

Please avoid too long sentences and too long citations, such as p. 2, lines 36-42. In the same sentence, please cite correctly the " (ibid.) "

You write for Lattes that "…the Fascist racial laws forced him to leave the University of Pavia and take refuge in Argentina." but you don't refer to his nationality beforehand. The reader does not understand the reason why he was prosecuted.

P. 3, line 17: delete the article "the" before the name Arthur Murant.

The section "Blood and genes' ' is not proportional because you devote more space and information to the "blood" part than the "genes" part. I would suggest putting additional information on the "genes" part.

P. 4, line 23: remove the : in the sentence "...Blood Transfusion: Race gave one…" and put either a full stop or the word "where".

At the end of p. 4, please move the whole sentence in brackets to a proper reference.

P. 4, ref. 2 please put the words, not the initials of POW (prisoner of war?)

P. 4, ref. 5 put a fullstop.

In some points you write 'the Landerbergs" while in others "Landerberg", please correct because it is not clear if he is one or many.

You should be consistent with the writing of the dates, on p. 6 there are two different formats on the same paragraph.

When citing letters, please use the format "Cavalli to Laderberg", not "letter from Cavalli to Laderberg".

P. 8 ref. 18, please put the full reference, not only the initials, RA, RF.

P. 9 replace "XIX century" with "19th century" or "nineteenth century".

Pay attention to the verb lead-led-led.

Response: I Have taken care of all the points indicated. Thank you very much!

Human Genetics in Post-WWII Italy. Blood, genes and platforms

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ABSTRACT
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INTRODUCTION

After WWII, Italian life sciences were heavily tainted from the cooperation with the Fascist regime. Recent historiography has shown that the dictature implemented a wide-range technocracy that included human and non-human animals, as well as important crops: by means of advanced genetics, varieties were selected to meet the Regime productive requirements (Pogliano, 1999; Saraiva, 2016). The same technocracy was applied – though with different emphasis – to human species. Eugenics was part of the totalitarian effort deployed by the Fascist Government. On the one side, the dictature endorsed high natality, with pro-family propaganda, encouraging married couples to produce a large number of offspring. On the other hand, the Regime called for a mythical racial purity, trying to prevent interracial mixture in the African colonies and to eradicate Jews from Italian society. Scientists – anthropologists, zoologists, physicians – were heavily involved in the fascist eugenics (Cassata, 2006; Mantovani, 2004): some of them were not only supporters of racial categorization in humans (a very common attitude at the time), but were also outspoken anti-Semites and in favor of racial segregation for the benefit of the "white race" (Cassata, 2008; Gillette, 2002).
After WWII, several of those scientists were still in their academic position and according to Luigi Luca Cavalli-Sforza, Italy was still a "scientific desert" in 1950 (Cavalli-Sforza, 1992, p. 635; Stone & Lurquin, 2005, p. 42). This may have held true (though disputable, see below) with respect to human genetics. Historiography has, however, shown that, despite the severe shortages suffered by science during the Fascist regime, the novelties of Mendelian genetics and of Morgan chromosome theory seeped through Italian life sciences (Capocci & Volpone, 2013; Saraiva, 2016). After 1945, Italian international scientific relationships were not limited to Nazi Germany anymore, and several among the new students had the chance to get in touch with other foreign approaches and colleagues in life sciences. This meant that although Italian genetics had to be rebuilt almost from scratch, severing many ties with its grim past, many researchers were able to connect with the growing tide of the new genetics as it was practiced (mostly) in USA and UK. However, local specificities shaped some of the most important contributions by Italian geneticists.

In this essay, I will look at the development of human genetics in Italy in the two decades after WWII, by looking at the career of two similar scientists – Luigi Luca Cavalli Sforza and Ruggero Ceppellini – that eventually became two world leading researchers in their domains, and recognized as extremely influential in building genetics in Italy after WWII. Though they went on to work in different fields of human genetics, they shared a long tradition in serology and blood research. Their careers will be contextualized in the broader international network in post-WWII human genetics, where the innovation in actors and concepts was

matched by a continuity in the methods and practices. The mix of continuity and innovation allowed Italian scientists to create strong relations within the international genetics community. It also provides an additional explanation for the flourishing of Italian genetics in the 1950-60s, despite the several problems affecting Italian academic environment. The first paragraph will set the scene of blood and genetics research in Italy in the pre-WWII age. I will then reconstruct some of the aspects of Luigi Luca Cavalli Sforza and Ruggero Ceppellini's early careers. The connections with different Anglo-American institutions in their respective fields proved instrumental in the development of their work. However, the connections were made possible by the shared roots in serology. In the conclusion, I will provide a tentative interpretation of the interplay between local and global dimensions, drawing on the concept of "biomedical platform" (Keating & Cambrosio, 2003).

A Serological Tradition

According to the recent book by Jenny Bangham, at the end of the WWII "Blood groups were still the best-understood human genetic traits, and they were certainly the only human characters for which genetic data was so abundant. […] They had served as a model for what human genetics could be – mathematically informed and amenable to being recorded in very large numbers." (Bangham, 2020, pp. 102–103) In this perspective, blood groups were instrumental for "understanding the genetics of complex traits". (*ibid.*)

In Italy, the study of blood groups by means of serological reactions[1] was pioneered by Leone Lattes (1887-1954), an anthropologist, psychiatrist, and forensic scientist. Lattes' studies included the use of blood analysis to establish the connections with individuality, akin to fingerprints, to be used even in court to discuss and eventually solve criminal or paternity cases. His works were widely read and translated – especially his 1922 book on blood individuality in biology, clinics and forensic medicine (Lattes, 1922) – gaining him considerable fame. Lattes' academic career developed in several Italian universities until 1938, when the Fascist racial laws forced him to leave the University of Pavia because of his Jewish descent, and take refuge in Argentina. Lattes returned in Pavia after the war, where he went on working on forensic medicine, including human hereditary features, but died suddenly in 1954 (Di

[1] Serology in blood groups research is based on the reactions (agglutination, precipitation, haemolysis) occurring when serum is mixed with blood red cells. The ABO system, for example, identifies specific groups of antigens present on the surface of red blood cells: in an individual, the serum contains antibodies against the antigens absent in that individual's red blood cells. By exposing red cells to different sera, it is possible to determine which ABO antigens groups are reacting to the ABO antibodies present in the serum. Serological reactions where extremely useful in human genetics research, since several antigens present in blood cells depend on simple Mendelian inheritance. "The blood groups were easily definable as Mendelian unit-characters, with a simple, direct relationship between genotype and phenotype. […] Blood-group serology offered a model system for human genetics." (Mazumdar, 1996, p. 620)

Guglielmo, 1954; Introzzi, 1958). The first comprehensive treatise in Italian – "Serology and Serodiagnostics" (Carlinfanti, 1941) – extensively referred to Lattes' research, and mapped immunological research performed internationally by means of serological reactions. The author of the treatise, Erminio Carlinfanti (1911-1950) was a graduate in medicine at the University of Rome, and after the degree visited several laboratories in UK, France, and Germany, establishing solid scientific relationships[2]. His 1941 work drew on a vast corpus of literature and on his own lab experiments to show the scope of serology as a laboratory tool in biomedicine, ranging from diagnostics, to microbiology, to parasitology, to forensic medicine, and to "seroanthropology", that is, human "peoples" and "races" observed through the lens of blood antigens (mostly, the ABO system) groups[3]. Just before WWII, Carlinfanti became professor in microbiology at the University of Milan, giving courses about vaccines, serum therapies, and serum diagnostics (the lectures eventually formed the bulk of the 1941 treatise). In 1940, Carlinfanti was appointed head of the vaccines and sera division and of the blood transfusion laboratory of the Istituto Sieroterapico Milanese (ISM), a private institute founded in 1894 by Serafino Belfanti and devoted to serological research and commercial production, including a blood bank. In 1946 Carlinfanti published a second expanded edition of his book, changing its name to "Nozioni di Immunologia", again with the imprint of the ISM. In 1947, he went to another Istituto Sieroterapico, in Naples, and was an active member of the World Influenza Centre of the WHO, established in 1948 (Executive Board, 1949). He also operated within the WHO Committee for the standardization of serology in blood grouping, and in this capacity, he was in contact with the Arthur Mourant, the well-known British hematologist whose aim was to produce "a scientific picture of human history" by the worldwide collection of blood samples (Bangham, 2020, p. 135). In his 1941 monograph, Carlinfanti devoted a 3-pages paragraph to "seroanthropology", writing: "Sero-anthropological studies based on numerical differences in O, A and B frequency allow to study the prehistorical and historical migration of peoples and to challenge problems strictly connected with the origin and the evolution of mankind" (Carlinfanti, 1941, p. 290).

As for classical genetics, we must note the creation of the first chair in this field in 1934 at the University of Rome. The appointed lecturer was Giuseppe Montalenti, a 30-years-old embryologist turned geneticist after visiting Chicago and Woods Hole in the US (thanks to Rockefeller Foundation), where he worked with Frank Lillie and attended Sewall Wright's lectures.

[2] There is scant biographical information about Carlinfanti. Apart from a few obituaries (Maurizi, 1951; Puntoni, 1950; Zironi, 1950), the main source is the Archivio Storico dell'Università degli Studi di Milano (ASUM), Fascicoli Docenti, "Carlinfanti Erminio".

[3] An account of the history of seroanthropology in the twentieth century – including an analysis of Lattes' career – is provided by Pogliano (2005, in chp.3).

Montalenti's lecture notes eventually turned into a book, "Elementi di Genetica", published in 1939 soon after his appointment in Bologna (where agricultural genetics was flourishing)[4]. As Fabio De Sio (2006) noted, in the same year the first Italian journal devoted to the discipline – *Scientia genetica* – was founded, and the first Italian academic center for genetic research was created in Pavia. Both were the result of Carlo Jucci's effort in establishing genetics as part of the research core in life sciences. In Pavia was also created one of the first three chairs in genetics after WWII (before the war, the only chair was created in Naples for Montalenti). Jucci helped Adriano Buzzati-Traverso, a bright young colleague, to introduce in Pavia the biophysical approach to life sciences he learned in USA and Germany – the roots of molecular biology, including not only the theory but also the methods and practices, such as the study of drosophila as a model organism. The International Congress of Genetics in Stockholm in 1948 was the chance to introduce the new Italian generation of researchers in the international genetic community, and allowed the "young" scientists to dispute the authority of the old school over Italian genetics (Cassata, 2014).

New genetics, old sera

In those years, at the ISM in Milan we find two scientists at work: Luigi Luca Cavalli-Sforza and Ruggero Ceppellini, respectively on bacteria and blood groups. The latter was a physician – born in 1917 – with a degree in Pavia (1944) and an interest in serology and genetics.[5] Cavalli-Sforza arrived at ISM from Pavia, where he studied medicine and became familiar with research approaches that where exotic to the Italian academy.[6] In Pavia, he was one of the students raised by Adriano Buzzati-Traverso, a biologist who had already spent some years abroad in Germany and the US, meeting the molecular-physical approach to life sciences and the new research models and methods. In Milan, under Carlinfanti and in cooperation with geneticist Niccolò Visconti di Modrone[7], Cavalli-Sforza managed to continue the work

[4] Montalenti eventually became a dominating figure in Italian genetics, being part of the management of the Naples Zoological Station and directing the Genetics department at the University of Rome (De Sio, 2006).

[5] During WWII, Ceppellini fought in North Africa and was detained several months as a prisoner of war in Palestine where he worked with the geneticist Chaim Sheba, who sparked his interest in medical genetics (Bodmer, 1989). Detailed information about Ceppellini's career can be found in Archivio Storico Università degli Studi di Milano (ASUM), Fascicolo Studente, nr 2404, "Ceppellini, Ruggero", and Fascicolo Docente by the same name.

[6] More details on Cavalli-Sforza life and career are found in Stone and Lurquin (2005), Cavalli-Sforza (2008), Edwards (2021), Pogliano (1998).

[7] From an ancient and wealthy family of Milanese origin, and first cousin to the famous director Luchino Visconti, Niccolò Visconti di Modrone in the late 1940-50s worked mostly on phage genetics, spending a lot of time in the USA. Later, he left research to direct a pharmaceutical company, the Pierrel, very active in

on bacterial mutagenesis begun in Pavia, a hot topic in those years and mostly pursued in the United States. As Carlo Jucci stated in 1948 at the Stockholm Congress: "The most striking advance we were confronted with – when after the war scientific relations were resumed and we had at last notice of what had been done in the U.S. of America in the field of genetics in those bloody years – was, I think, the genetics of microrganisms, *lato sensu*, including fungi, bacteria and viruses. These organisms […] had entered at last the field of genetics" (Jucci, 1949, p. 286). Although during the war years Jucci was disconnected from the British and American genetics, he managed to catch up quite quickly. Jucci, Buzzati-Traverso and Cavalli-Sforza all presented papers at the Stockholm congress, respectively on silkworm, drosophila and *E.coli*. When the Stockholm congress took place, Cavalli was already in UK at the John Innes Horticultural Institute, in Norwich, thanks to a short-term fellowship awarded by the Italian National Research Council (CNR).

However, in 1946, Cavalli already had made acquaintance with the leading British hematologist Robert Race in Milan, when the ISM contributed to the organization of the Third National Congress on Blood Transfusion, and Race gave one of the four keynote lectures[8]. In the biography of her father, Joan Fisher Box (1978, p. 409) wrote that it was Race to introduce Cavalli's name to sir Ronald Fisher, soon after the congress in Milan. Two years later, at the Stockholm congress, Fisher offered an assistant post in Cambridge to Cavalli, to work on bacterial mutations. In Fisher's lab, Cavalli refined his work about so-called bacterial sexuality[9], collaborating remotely with Joshua Lederberg, who discovered the phenomenon together with Edward L. Tatum in 1946[10]. Cavalli also perfected his mastering of biological statistics. In 1950 Cavalli returned to Italy, at the ISM, and took a part-time unpaid appointment as lecturer in genetics at the University of Parma, thanks to the zoologist Bruno Schreiber. In his early years in Parma, Cavalli fruitfully applied the serological tools refined at the ISM to the evolution of birds (genus *Columba*), with Bruno Schreiber and the young student Danilo Mainardi (Sforza et al., 1954). While in Parma, he was contacted by the Rockefeller Foundation (RF) and received a grant that finally brought him in Madison to work with Joshua and Esther Zimmer Lederberg[11], in the summer of 1954. It is not surprising that the Rockefeller Foundation was keen to help Cavalli: Buzzati-Traverso was close to the RF, and the genetics cluster between Milan and Pavia was gaining international attention. Jeffries Wyman, a prominent

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the development and production of antimicrobial drugs (Zeller, 2011; Capocci, 2013).

[8] Race was ranked among the two foreign "illustrious guests", together with Arnault Tzanck from Paris (Formentano et al., 1946). The text of the talk delivered by Race is available in his personal papers (Wellcome Archive, PP/SAR/C/11, https://wellcomecollection.org/works/pr9y5r86).

[9] An autobiographical account of this research is provided in Cavalli (1992).

[10] About the invention of "sexuality" in bacteria, see Bivins (2000).

[11] About Lederberg and Zimmer, see Sapp (2021) and Schindler (2021).

molecular biologist and the first US scientific attaché in Paris, visited Italy in 1954 and spent a couple of days in Milan (his visit included the ISM) and Pavia, meeting Cavalli and other colleagues in different disciplines. In his very detailed diary, Wyman wrote: "Evidently the Genetics group there is very strong and, in combination with the group in Milan, makes this region the outstanding genetics center of the country and one of the best places in Europe" (RG 59 UD 2472. France, Paris Embassy, Diary of the Scientific Attaches, 1952-1954, Box 1-2, "Trip to Italy", p.860).[12]

While the Rockefeller Foundation financially supported Cavalli's work on bacteria, his mind was already turning to humans. In Parma, he had met the 25 years old student Antonio Moroni, a Catholic priest who suggested him to look at the archives of consanguineous marriage licenses accorded by the Church. By means of those records – virtually present in every parish of the country – it would have been possible to perform *a posteriori* controlled reproduction experiments in humans, just like *in vitro* experiments with bacteria. Cavalli's research was going to overcome the major issues in human genetics, traditionally "limited in scope and importance by the awkward nature of its subject material, unsuited to experimental manipulation, difficult to observe, and complex"[13], because of small numbers and long intergenerational time (Montalenti, 1950). The statistical training was thus highly useful to Cavalli: it virtually made all the species treatable in the same fashion, provided that a large enough data set was collected. As contemporary literature repeatedly pointed out, the emergence of the field was heavily influenced by the interest in the biological effects of nuclear radiation, including mutagenesis (Cassata, 2013; Rasmussen, 1997). The grand work envisioned by Cavalli aimed at establishing a baseline rate for mutation in humans, using blood groups as the preceding generation of geneticists used visible characters in drosophila.[14]

A large grant (20.000$ per 5 years, annually renewed until late 1970s) by the USA Atomic Energy Commission (AEC, contract number AT(04-3)-326) paid for Cavalli's new research program on "Mutation Rates and Mutational Loads in Man", based at the Institute of Genetics of the University of Pavia. According to the Chief of the Biology Branch of the Division of Biology and Medicine of the AEC, Max R. Zelle, Cavalli's proposal "was approved […] with enthusiasm" by the Research Committee, though they noted that the blood-related part of the study – estimating mutational rates in maternal and fetal blood types – was rather heroic, although eventually feasible. Less problematic was the study of

[12] This document has been shared as a courtesy by Audra J. Wolfe, who discusses the source in Wolfe (2018).

[13] The quote is from the presentation of the grant in aid of Ceppellini by the Rockefeller Foundation, 1961. Rockefeller Archive Center (RAC), RF, 1.2, series 751, box 4, folder 46.

[14] According to Pauline Mazumdar "The blood-grouping laboratory was the fly-room of the human species" (1996, p.620).

consanguinity by means of the Church records and their statistical analysis (Letter from Zelle to Adriano Buzzati-Traverso, 22.09.1958)[15]. It was, according to a letter from Adriano Buzzati-Traverso (to Mario di Domizio, 7.11.1958) the first grant provided from the AEC to a non-US laboratory. The grant allowed for the creation of a large jigsaw puzzle of research projects, with a broad scope and involving researchers from different Italian and international institutions, including the Vatican archives, the EURATOM and the National Statistics Institute (ISTAT) as well as several universities (LIGB, 1967) . Tools included a state-of-the-art IBM computer (and later an Italian-made Olivetti machine) to manage the huge number of records obtained from the Catholic Church as well as to perform statistical analysis of the data, and the serological analysis on blood samples performed at the ISM, as well as consuming fieldwork to collect samples in several communities. The novelty of the approach could hardly be overestimated: in 1963, Cavalli's was the only research program explicitly referred to within the Presidential Report "Some New Technologies and Their Promise for the Life Sciences"[16], as an example on how computer analysis could be useful in tackle epidemiological problems requiring large sets of data (p.6). Thanks to this research project, Cavalli-Sforza managed to become an important node in the international network of human and microbial genetics alike. Visiting researcher included Motoo Kimura (the celebrated proponent of the neutral theory of evolution) and Anthony W. F. Edwards, a former R.A. Fisher's student with whom Cavalli-Sforza pioneered statistical methods in the reconstruction of human phylogenesis. In the same years, Cavalli-Sforza managed to bring on his collaboration with Joshua and Esther Zimmer Lederberg, even having them as guest researchers in Italy. Their bond was quite strong, as shown by the hundreds of letters they exchanged over the years and collected among the Joshua Lederberg Papers. Cavalli-Sforza reached out to Lederberg on many occasions, even involving him as a consultant in public-private enterprise between the Italian pharmaceutical company Lepetit (directed by his former colleague and co-author Niccolò Visconti di Modrone) and the Institute of Genetics at the University of Pavia[17]. However, their cooperation moved beyond bacterial genetics, and Lederberg invited Cavalli-Sforza to

[15] Archivio Adriano Buzzati-Traverso (ABT), box 35, folder 121. The archive is located at Sapienza Università di Roma, Unit of History of Medicine.

[16] The report is available at the CIA website: https://www.cia.gov/readingroom/document/cia-rdp66r00546r000200100002-1 (last accessed 12/10/2021).

[17] The project, called "International Institute for Scientific Research" (shortened as Interist) was managed by Magni and Cavalli: they involved Lederberg as a consultant with a quite large amount of money and almost no duties. The annual fee was 4000 USD (Lederberg annual salary in Stanford amounted to 16000 USD, as stated in Alway to Lederberg, 21.07.1958; The Joshua Lederberg Papers (JLP), box 73, folder 3, available at https://profiles.nlm.nih.gov/101584906X17905) plus expenses if travelling to Italy was deemed necessary (Magni to Lederberg, 23.12.1959; JLP, box 11, folder 81, available at https://profiles.nlm.nih.gov/101584906X11855).

Stanford to lecture on human evolution, a temporary appointment that eventually turned into a career. Bringing Cavalli-Sforza to Stanford was indeed a long endeavor, starting already in mid-1958. The process overlapped with Lederberg's own move to California, the Nobel Prize, and with Cavalli's struggle to find a permanent academic position within the Italian university. Despite Cavalli's research unit in Pavia was bubbling with international activity, he was struggling to secure a national career. And while Cavalli tried to explain to Joshua Lederberg the rather whimsical Italian recruitment system and the complex network of alliances needed (Cavalli to Lederberg, 19.12.1959)[18], Lederberg was busy creating a new program in medical genetics in Stanford. A memorandum circulated in April 1959[19] described the enterprise to potential financial backers. The new program was pivoted around three professors: Lederberg, to cover bacterial genetics; a "professor X" for "transplantation genetics"; an "instructor Y" for "Human Genetics". The memorandum echoed what Lederberg wrote to Robert I (the dean of the Stanford School of Medicine) on May 16th, 1958, in a typescript titled "Notes on the areas of genetic research that have some relevance to medicine"[20], that sketched the three domains of "Human genetics", "Experimental mammalian genetics" (including organ transplant), and "Microorganisms". In between the two documents (on December 3rd, 1958), Lederberg wrote in a letter to his new dean – before the "hasty departure for Stockholm" to attend the Nobel ceremony: "I am still working on Cavalli as far as the Professorship in Human Genetics in (*sic*) concerned, but I would be wary of mentioning his name until we came to a firm conclusion"[21]. Furthermore, foreign policy was to be taken into account. As said, AEC had just awarded Cavalli his research grant in late 1958, and Lederberg warned Alway that "some agencies are not very happy about our raiding European Institutions" (*ibid.*). This is fully understandable, since in the 1950s the strategy of US administration emphasized the aids to other countries in scientific education and research, framed within the Cold War propaganda. Genetics was especially relevant to the cause, since the Lysenko case[22] made the discipline one of the harshest

[18] JLP, box 9, folder 129, available at https://profiles.nlm.nih.gov/101584906X5555.
[19] JLP, box 11, folder 98, available at https://profiles.nlm.nih.gov/101584906X10510.
[20] JLP, box 73, folder 3, available at https://profiles.nlm.nih.gov/101584906X17890.
[21] JLP, box 5, folder 22, available at https://profiles.nlm.nih.gov/101584906X18429.
[22] Trofim Denysovyč Lysenko was the Soviet agronomist that built his career on the hypothesis that organisms could inherited acquired characters, so that Mendelian genetics and the Darwinian theory of evolution should be refuted. "Lysenkoism" was supposedly based on agricultural experiments, and it promised to create new plant varieties to be exploited to increase crop output in USSR. Lysenko was strongly supported by Stalin, so that in 1938 the agronomist became the President of the V.I. Lenin Academy of Agricultural Sciences, a position he held until 1956. Under his domination, several geneticists were executed or sent to labor camps for supporting "bourgeois genetics". Lysenkoism was part of the

battlegrounds between the "Free World" and the Soviets (Wolfe, 2018). In 1957 the Sputnik utterly escalated the scientific rivalry, and in front of such a scientific check the US scientific diplomacy threaded on treacherous ground when dealing with the European allies and the possible prospect of a "brain drain". In 1959, while he was "working on Cavalli", Lederberg had an interview made with Italian magazine "Tempo Medico". Created by the Lepetit pharmaceutical company, and directed by Visconti di Modrone, the magazine targeted Italian GPs, lavishly illustrated, with a top-notch educational content and innovative communication strategies. The conversation with Ceppellini, Cavalli and Visconti took place in the editorial office of the magazine after Lederberg visited Naples and Pavia: he explained the science that led to his Nobel Prize, and possible directions for future research. On a different tone, in the last lines Lederberg offered his opinion about biological research in Italy: "Dulbecco, Luria, Pontecorvo, are top rated scientists that greatly honored Italian biology, but they now work abroad. There are still valuable students in Italy: do not lose them, brain export is always a bad deal" (Ceppellini, 1959)[23]. According to Ceppellini, the sentence about 'brain export' circulated in Italian newspapers and was appreciated by those "campaining (*sic*) for the necessity of improuving (*sic*) scientific education in Italy"[24]. Yet, the national competition for a chair in genetics held in 1959 – both Cavalli and Ceppellini applied – revealed that the academic environment was still dominated by the parochial interests of the so-called "barons", so that "only Luca has good chances of being elected"[25]. Finally, Cavalli was given a chair in genetics in 1960 and this gave him the possibility to develop further his research program, while his mentor Adriano Buzzati-Traverso was busy implementing his plan for a new molecular biology institution: the International Laboratory of Genetics and Biophysics - ILGB, opened in Naples in 1962. The Institute of Genetics in Pavia – though geographically separated, was a section of the newly founded institution. Cavalli was also part of the governing board of the ILGB, and he obviously shared with Buzzati-Traverso a will to overcome the limitations of Italian academic system, especially its hierarchical structure, its complex and obscure recruitment process, and the rigid disciplinary sectarianism. These problems were exacerbated by the

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effort to expand Soviet influence in science, so that in several Western European countries a debate about Soviet genetics ensued, fostered by scientists involved with local Marxist and Communist parties. A recent and comprehensive reconstruction of Lysenkoism is provided by the collection of essays edited by William deJong-Lambert and Nikolay Krementsov (2017).

[23] Although the article wasn't signed, before its publication Ceppellini sent Lederberg the final text of the interview. In the accompanying letter, Ceppellini wrote: "I hope to have interpreted faithfully what you have said and also what you haven't said" (Ceppellini to Lederberg, 10.8.1959; JLP, box 9, folder 130, available at https://profiles.nlm.nih.gov/101584906X4929).

[24] Ceppellini to Lederberg, 5.11.1959 (JLP, box 9, folder 130, available at https://profiles.nlm.nih.gov/101584906X4933).

[25] *Ibid*.

peculiar nature of the "new" biology, demanding interdisciplinary skills crossing several boundaries.

Eventually, Lederberg courtship was successful: in 1970 Cavalli left Italy for a position at Stanford. In Italy, Buzzati-Traverso effort collapsed. In the spring 1969, Buzzati-Traverso left the ILGB because of a strong political protest that heavily targeted his connections with the USA. The turmoil emphasized some sort of American cultural colonialism over European science (Capocci, 2011; Cassata, 2013), underlining the role of genetics in creating a capitalistic narrative about human species. Cavalli-Sforza was deeply affected by the protest, unable to understand any of their motives and having always considered science as a neutral territory. Furthermore, Italian science was deeply touched from the dwindling support of American Institutions to Europe. Starting in 1964, the US government changed its policy because of national budget problems, and cut in half the money for grants to be used abroad (McElheny, 1964). In 1967, the CIA involvement in European culture – including funding to scientific societies and large philanthropic foundations – was brought to light (Wolfe, 2018) and financial support dwindled further. Italian budget for international scientific cooperation stalled, and the foreign funding for R&D was halved between 1967 and 1970 (Capocci, 2011). Furthermore, Cavalli-Sforza's research on human evolutionary genetics rapidly expanded its geography, focusing on Pygmies peoples in Africa[26] and eventually tracing the path for the much-discussed – and eventually aborted – Human Genetic Diversity Project (Gannett & Griesemer, 2004). However, he managed to establish an important school for human genetics in Italy, and his authority in his home country was unabated by his departure (Capocci, 2006; Capocci & Volpone, 2013).

More blood from UK to Italy

Cavalli's early career, though special, was far from not unique. We have used it as a magnifier for specific factors, whose influence can be found in the career of other prominent researchers in the field. Ceppellini's career followed a similar trajectory: a degree in medicine during the war (in Milan), the influence of serology and blood research at the ISM and in UK, the American financial help to establish his career. Ceppellini was in fact the offspring of Carlinfanti at the University of Milan and then at the ISM – where serology and blood research were part of the core business of the institute – with international connections that were an important legacy of Carlinfanti (he left the ISM in 1947 to go to Naples). In 1948, Ceppellini and Cavalli translated (for the imprint of the ISM) the introductory handbook about Rh blood groups published by the British Medical Research Council (Mollison et al., 1948). Ceppellini's work soon yielded brilliant results: he cooperated with Mourant in Milan in 1949,

[26] Cold-war colonialism is obviously part of this story, but it is beyond the scope of this paper. Further research would be needed in order to understand to what extent Cavalli-Sforza's research was integral to the "Cold War network" envisaged by Susan Lindee (2014).

and their research uncovered a new allele at the locus E (Mourant, 1949; Ceppellini et al., 1950). In 1954, Ceppellini started a collaboration with Leslie C. Dunn[27] at the newly founded Institute for the Study of Human Variation at Columbia University, thanks to a Rockefeller fellowship. In the 1950s, Ceppellini became one of the leading experts in blood group research with dozens of publications that revolved around the genetics of blood antigens, and gradually expanded his research to the study of linkage in inheritance, trying to overcome the "beanbag" approach to genetics (Falk, 2003). He also investigated a classical case study: the genetics of haemoglobinopathies and the protection against malaria, in cooperation with other Italian human and medical geneticists: Ida Bianco, Ezio Silvestroni and Marcello Siniscalco (Bianco et al., 1954; Carcassi et al., 1957)[28]. Ceppellini, like Cavalli, was allowed to establish his own institute by US grants. The Rockefeller Foundation helped him when he was nominated as untenured professor in Turin in 1958, with a symbolic salary and no laboratory, and provided a grant-in-aid of 10.000USD (ref. nr. GA BMR 59 31, renewed again in 1960) to meet the needs of a newly created department in medical genetics[29], complementing the funding of a local charity association of blood donors (Ceppellini to Maier, 15.10.1958. RA, RF 1.2, series 751, box 4, folder 46). In 1961, after Ceppellini became full professor, a more substantial grant was provided (60.000USD over 5 years). In the discussion of the proposal two key factors were explicitly noted: Ceppellini's prominence as an "international recognized authority" in blood group research; and his stubborn insistence to remain "at home in the hope of developing the field there", even if "emigration would have greatly facilitated his own work, and although there were no career possibilities in human genetics in Italy at the time"[30]. Along the RF support, Ceppellini also received an even larger grant by the National Institutes of Health, focused on the research on human leukocyte antigens and histocompatibility[31]. In this endeavor, Ceppellini and his institute in Turin were part of an international network that eventually discovered the genetic

[27] Leslie Clarence Dunn was a prominent mouse and human geneticist. Together with Theodosious Dobzhansky, Dunn founded and directed the Institute for the Study of human Variation at Columbia, and was an outspoken opponent of eugenics and racism. He visited Italy several times, since he conducted in 1953-1955 a large genetic analysis of the Jewish Community in Rome (Gormley, 2009).

[28] Ida Bianco and Ezio Silvestroni, physicians, pioneered genetic counselling in Italy against thalassemia (Canali & Corbellini, 2006). Marcello Siniscalco grew up as a student of Giuseppe Montalenti, later working in Leiden and the USA. A founder of the Human Genome Organization, he established a human genetics laboratory in Sardinia, before spending his final years in the USA (Capocci, 2014b).

[29] RAC, RF 1.2, series 751, box 4, folder 46.

[30] *Ibid.*

[31] These antigens are exposed on the surface of white cells and determine the tissue compatibility between two individuals. Consider the transplant between a donor and a recipient: The more the white cell antigens differ in the two individuals, the stronger the immune reaction of the recipient will be against the donated organ.

systems controlling immune reactions in humans (the so-called HLA system), and ultimately led to the implementation of tissue typing for organ transplantation (Capocci, 2014a). Ceppellini was in the "great HLA adventure" (Dausset, 1998)[32] the only trained geneticist other than Cavalli-Sforza's colleague in Stanford (and of Fisherian ancestry), Walter Bodmer (now Sir)[33]. In this large network, including several laboratories in Europe and US, new methods of cooperation were established – such as weeks long wet workshops, with experiments taking place during the meetings in order to evaluate and standardize sera and techniques, and discussing the genetic and clinical meaning of the results (Terasaki, 1990). The "Histocompatibility Workshops" started in 1964 and drew on the considerable experience some of their members (including Ceppellini) had in serological techniques and haematology (several of them worked in blood banks and transfusion services). The community that gathered around the newly discovered leukocyte antigens (observed in humans in 1958) reasoned about "grouping" the sera for histocompatibility, just like it had been done in the past with red blood cell antigens, looking for relatively simple systems similar to blood groups. Since the early meetings, the need to standardize the nomenclature arose, in order to avoid scientific chaos. The discovery and understanding of the genetic systems behind the serologically-detected diversity (eventually achieved at the Third Histocompatibility Workshop in Turin, organized by Ceppellini) was a key to standardization or – as one of the participants put it, "tissue typing was no longer an art but had become part of the science of genetics" (Amos, 1990, p. 82). In fact, the discovery of the complexities in the histocompatibility system in humans marked the change in the name of an entire discipline: Immunogenetics. Until the 1960s this was the study of genetics (i.e., inheritance, like in blood groups) by means of immunological tools (that is, serological techniques); after, it became the study of the genetic basis of immune system. The importance of this shift can hardly be overstated, since it was a leap into the complexity of human genetics, allowing for a true understanding of human diversity. It's no wonder that HLA will be soon incorporated in the anthropological studies led by Cavalli, showing some continuity – but not a complete overlap – between physical anthropology, serology and post-WWII human genetics (Gannett & Griesemer, 2004). So on one side, it may be possible to agree with Jonathan Marks (2012) in seeing a wide gap between ABO blood grouping (what he calls 'racial serology') and later human genetics. On the other hand, there is a clear lineage – in methods, standards, practices – at work.

[32] The importance of the discovery of HLA was recognized by the 1980 Nobel prize to the French hematologist Jean Dausset.

[33] Walter Bodmer is among the most important post-WWII human geneticists, and he acted as well as a leading British scientific organizer. He co-authored with Cavalli-Sforza an influential comprehensive treatise on human evolution (Cavalli-Sforza & Bodmer, 1971).

Conclusion - Serology as a biomedical platform

The history of genetics (and often, biomedicine in general) in Italy has been described as a network of academics trying to innovate a medieval structure and a cultural backwardness (Pogliano, 1999; Capocci & Corbellini, 2002; Stone & Lurquin, 2005; Capocci, 2006; Cassata, 2013), or as an archipelago of unconnected islands, where the efforts of American philanthropy were not enough to build bridges among the isolated landmasses (Gemelli, 1999). These narratives hold true, but they only picture a portion of the disciplinary development after WWII. This paper is no different, for it gives only one among many possible perspectives on the progress in this field, by using Cavalli-Sforza and Ceppellini's early career as a primer to introduce other factors. The first one, often overlooked, is the British influence. Cavalli's "blooming" was strongly influenced by his two years spell in Cambridge, which gave him the the chance to familiarize with the Fisherian analysis of gene frequencies and its meaning, while the blood research tradition (i.e. Race and Mourant) affected both Cavalli and Ceppellini, although in different ways. The second factor at work was the serological tradition that was quite active in Italy and epitomized in our narrative by Carlinfanti and the ISM. Serology was in fact providing the tools for advancing genetic research in human diversity. Until WWI, blood groups observed by serology were mostly medical objects, connected with the emergence of blood transfusions and their increased necessity during the war. Before WWII, they started to become a proxy for race, ancestry, and other population concepts (Gannett & Griesemer, 2004). As per Bangham (2014), after WWII there was an international effort towards "purification of race science" and "blood-group genetics exemplified a modern, 'scientific' and 'objective' method for studying human diversity". Britain was at the heart of this mutation of human genetics and attracted several talented scientists. Italians made no exception, especially before the full deployment of American philanthropy in the 1950s.

Blood group research and its serological tool-kit established itself as an international network, possibly configuring the emergence of a distinct "biomedical platform" characterized by the "constitution and circulation of protocols, instruments, and substances between laboratories and the establishment of conventions that allow them to be used in the generation of biomedical facts" (Keating & Cambrosio, 2003, p. 3). Immunological tools provided by serology were taught and exchanged, with sera, blood samples and scientists alike travelling (Lindee, 2014), establishing international standards: "specific combinations of techniques, instruments, reagents, skills, constituent entities (morphologies, cell-surface markers, genes), spaces of representations, diagnostic, prognostic, and therapeutic indications, and related etiologic accounts." (id., p.4)

In this perspective, the emergence of "modern" human genetics in Italy may be seen not only as a "exaptation" of molecular biology

and the physical approach to life sciences, as imported from the USA. The American influence is probably better understood in terms of institutional support, factoring in the Cold War scenario and the several forms – liminal to the scientific enterprise – taken by the expansion of American power in the West. At the same time, local traditions were mobilized by human genetics in Italy: the involvement of the venerable malaria community (with its own concepts and issues), the availability of Catholic parish records, and the existence of an internationally connected serology and blood group research, have been key factors in the development and innovation of the discipline (along with the support of American institutions and the British intellectual influence). Further research (and archival resources[34]) is needed in order to detail how serology and blood group research – especially in Italy – affected other correlated and already established disciplines like physical anthropology, or organ transplantation practices (influenced by Cavalli and Ceppellini's work, respectively). Serology, in this respect, appears to mirror the sociological hierarchy described by Keating and Cambrosio (2003, chp. 10), in which a platform – with its practices and standards – make networks (*senso* Latour) possible. Sera apt at 15the immuno-recognition of blood groups (at the beginning) and other antigens relevant to the clarification of human genetics played the "actor-network" role within several distinct, though related, communities.

In 1940s-50s, some Italian scientists were part of the establishment of this biomedical platform at international level, made of methods, concepts, technologies and institutions (both as a source of funding and as regulatory-standardizing agencies): Apart from local hindrances (the resistance of academic 'medieval' practices, for example), it is probably the existence of this international-based platform that secured the persistence of the newly established scientific lineages (the ones originated by Cavalli and Ceppellini, but also by other scholars such as Bianco and Silvestroni, or Montalenti[35]). The hypothesis that such a platform was at work may help in solving the riddle of the apparent contradiction of a backward academic system that produced top-level scientific innovation and put at good use the aids coming from abroad. If such an interpretation is correct, it would also show the potential power of the serological platform. This hypothesis would also highlight a constituent difference between a centralized scientific development – such as high energy physics based on massive scale research facilities, to which Italian physicists hooked after WWII and upon which they based their post-

[34] Archives are currently missing or are unavailable for research, such as Cavalli's personal papers or his correspondence with sir Walter Bodmer: the latter's archive in Oxford is available, but the folders pertaining to Cavalli are still embargoed. Sadly, COVID19 pandemic further hindered research for the present paper.

[35] See Capocci & De Sio ((Capocci, 2006; De Sio, 2006; De Sio & Capocci, 2008)

WWII resilience[36] – and a network of scientists, whose objects and practices can be easily moved around along with ideas and concepts.

This interpretation is still tentative, though. Further research is needed in order to understand the role that single scientists with large authority (e.g. Joshua Lederberg) may have played in supporting Italian scientists and how, in turn, Italian scientists exploited the association with such authorities. The analysis of Joshua Lederberg's papers may provide insights in how such influential researchers may have a reach well beyond their own discipline, by interacting with institutions and individuals alike, resulting in the strengthening or the weakening of research networks and affecting local contexts.

What is however certain, is that the emergence of a few researchers in the 1940s-50s shaped the subsequent development in several biomedical areas related to human genetics, and the younger researchers involved in those fields greatly enjoyed the international authority gained by those few mentors that put Italy on the world map of human genetics.

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[36] This is the subject of several letters by Buzzati-Traverso to several Italian physicists: the biologist expressed great admiration for the way in which the physics community cooperated in Italy and participated to the creation of European scientific facilities (Cassata, 2013). On the other side, other scientists (Ceppellini among them) believed that the academic system could be reformed and even revolutionized, from the inside, without the creation of separate institutions (see letters written by Ceppellini to representatives of the Rockefeller Foundations, RAC, RF 1.2, series 751, box 4, folder 46).

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