

Ludwik Hirszfeld: A pioneer of transfusion and immunology during the world wars and beyond

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Abstract

Ludwik Hirszfeld (1884–1954) was a Polish physician, immunologist and microbiologist. Together with Emil von Dungern, he showed that blood groups are heritable traits and established the terminology of the ABO blood group system. He discovered A₁ and A₂ blood groups, and showed for the first time, in a large-scale population study, that blood group frequency differs between populations. During World War I, he volunteered as an army physician. In the interwar period, he helped to create the National Institute of Hygiene in Warsaw and was instrumental in developing transfusion centres in Poland. During World War II, which he barely survived, he co-organized secret medical courses in the Warsaw Ghetto and played a major role in containing the typhus epidemic that ran rampant there since 1941. After the war, he was the first in Poland to put the theory of serological conflict between mother and foetus into clinical practice, saving the lives of almost 200 children by introducing exchange transfusions.

KEYWORDS

blood groups, blood transfusion, Ludwik Hirszfeld

Highlights

- Ludwik Hirszfeld (1884–1954) was a Polish physician, immunologist and microbiologist.
- He made fundamental discoveries and contributions in immunogenetics and immunohematology, including blood group inheritance (together with Emil von Dungern), the nomenclature of the ABO blood group system, and blood group frequency differences between populations (with Hanna Hirszfeld).
- Hirszfeld's commitment to science and humanitarian ideas helped contain typhus and typhoid fever epidemics during the World Wars, and save dozens of children after WWII when he put the theory of foetomaternal serological conflict into clinical practice by introducing exchange transfusions.

THE EARLY YEARS

Ludwik Hirszfeld was born in Warsaw (then part of the Russian Empire) on September 5th, 1884, in a family of assimilated Polish

Jews. When Karl Landsteiner described agglutination of human red blood cells by sera of other individuals [1, 2], Ludwik Hirszfeld was 17 years old, had just graduated from high school in Łódź, and left the town to study medicine in Germany. He graduated from the Friedrich

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Wilhelm University in Berlin and defended his M.D. thesis (a part of Prussian medical education at the time), which described physical aspects of haemagglutination and was published in 1907 [3].

Hirszfeld's first position was as an assistant at the Cancer Research Institute in Heidelberg, Germany. He worked with the head of the Serology department, Dr. Emil von Dungern, and they found that dog sera could be used to identify blood groups, similar to those described by Landsteiner [4]. They also found that canines inherit blood groups, prompting them to hypothesize that human blood groups are heritable too. By examining 348 individuals from 72 families, they showed that blood groups A and B did not occur in the offspring unless they were present in at least one of the parents, fulfilling the Mendelian principles of inheritance [5]. They showed that A and B are dominant, while O is a recessive trait. In addition, they came up with the names A, B and O for these blood groups, which have been used since. Interestingly, they adopted Mendel's nomenclature ("A" for the dominant trait, "a" for the recessive trait), and used "A" for the blood group that occurred more often, and "B" for the less common blood group [4]. It seems that contrary to the popular belief, they never used the letter O as an abbreviation for the word "Ohne," meaning "without" in German [6]. Rather, they used the terminology "weder A, noch B," meaning "neither A, nor B" [7]. As Felix Milgrom recalls, initially Hirszfeld insisted on using the numeral 0 instead of the letter O and he would give his students lower grades in oral examinations if they spoke about blood group O [6, 8]. Before the advent of computers, the letter O and the digit 0 were used interchangeably, which confused transfusion practitioners. Finally, the "Commission Permanent de Standardisation" created by the Hygiene Committee of the League of Nations in April 1928 accepted the nomenclature "proposed by von Dungern and Hirszfeld" (i.e., A, B and O) [6], which is still recommended today [9].

One year later, von Dungern and Hirszfeld showed that agglutination of A red blood cells can be strong or weak, and proposed two subtypes, named A_1 and A_2 [7]. They hypothesized that inheritance of blood groups was under the control of two independent pairs of genes; A and non-A, and B and non-B, presumably located on different chromosomes. Thus, a blood type O individual should be non-A/non-A and non-B/non-B, while a type AB individual could be A/non-A B/non-B. The theory worked quite well except it allowed the possibility that a person with group AB could have an O group child, which was ruled out by later observations. In 1924, a German mathematician Felix Bernstein developed a correction to the theory, proposing three allelic genes: A, B and O, and this explanation holds up to this day [10].

The seminal discovery of von Dungern and Hirszfeld marked the beginning of human immunogenetics. When Karl Landsteiner received the Nobel Prize in Physiology and Medicine in 1930 "for his discovery of human blood groups," he stated in his Nobel lecture: "... in the studies of the hereditary transmission of the blood groups, the principal factual results in this field we owe to the work of von Dungern and Hirszfeld" [11, 12].

Four years spent in Heidelberg were considered by Hirszfeld as "the most creative period in my whole life" [4]. But when in 1912 his wife Hanna assumed her new position at a paediatric clinic in Zürich, Ludwik applied for a position at the university there. In 1914, he

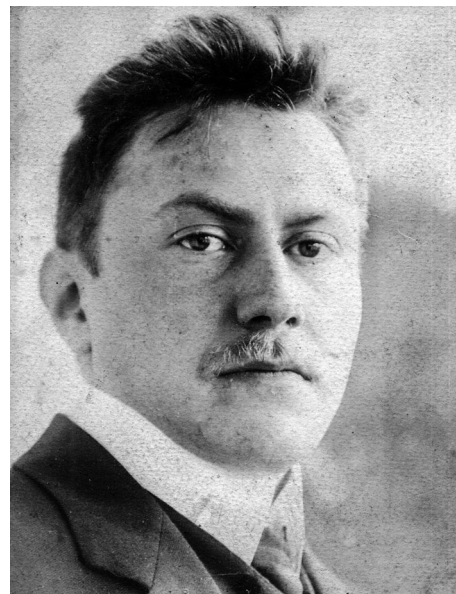


FIGURE 1 Ludwik Hirszfeld during his stay in Switzerland, years 1912–1915 [69]

presented a dissertation summarizing his studies on blood clotting and the complement system and was awarded the title of *Privatdozent* from the University of Zürich, Hygiene Institute [4]. It was there that Hirszfeld started teaching, which became his passion for years to come (Figure 1).

WAR, EPIDEMIC AND SCIENCE

When the war started in August 1914, Ludwik Hirszfeld volunteered to join the Serbian army and travelled to Valjevo, which was on the brink of an epidemiological disaster. Medical corps of the Serbian army all but collapsed and the hospitals were overwhelmed with injured and sick soldiers. Together with Hanna Hirszfeld and Serbian medical personnel, they tried to stop the advance of the typhoid fever epidemic by introducing means of mass disinfection (Figure 2). Eventually, they succeeded, but the death toll was devastating: some 300,000 Serbian civilians and 100,000 soldiers died [13]. Incredibly, amid these dire circumstances, Ludwik Hirszfeld made important findings: he isolated two new strains causing paratyphoid fever A and paratyphoid fever C; one of the strains was later named *Salmonella hirszfeldii* [14]. But the advance of Austro-Hungarian and Bulgarian armies forced the Serbian forces to retreat through the Dinaric Alps to Albania in the winter of 1916, and Hirszfelds joined the withdrawing army [4].

They returned to Zürich, but soon went to the Balkans again, this time as physicians in the "Armées Alliées d'Orient." The armies, sent there by the Allied forces and stationed in Thessaloniki, were supposed to be an armed branch of Entente in the Balkans and included soldiers of many ethnic backgrounds [4]. This encouraged Ludwik Hirszfeld to look at the frequency of blood groups among people from many different countries. Together with Hanna they tested over 8000 individuals from at least 16 different ethnic groups, and



FIGURE 2 Ludwik and Hanna Hirszfeld with colonels of Serbian army (Slatol and Nekić). Valjevo, 1914 [69]

TABLE IV.—Showing the percentage frequency of A and B serological reactions in various national types

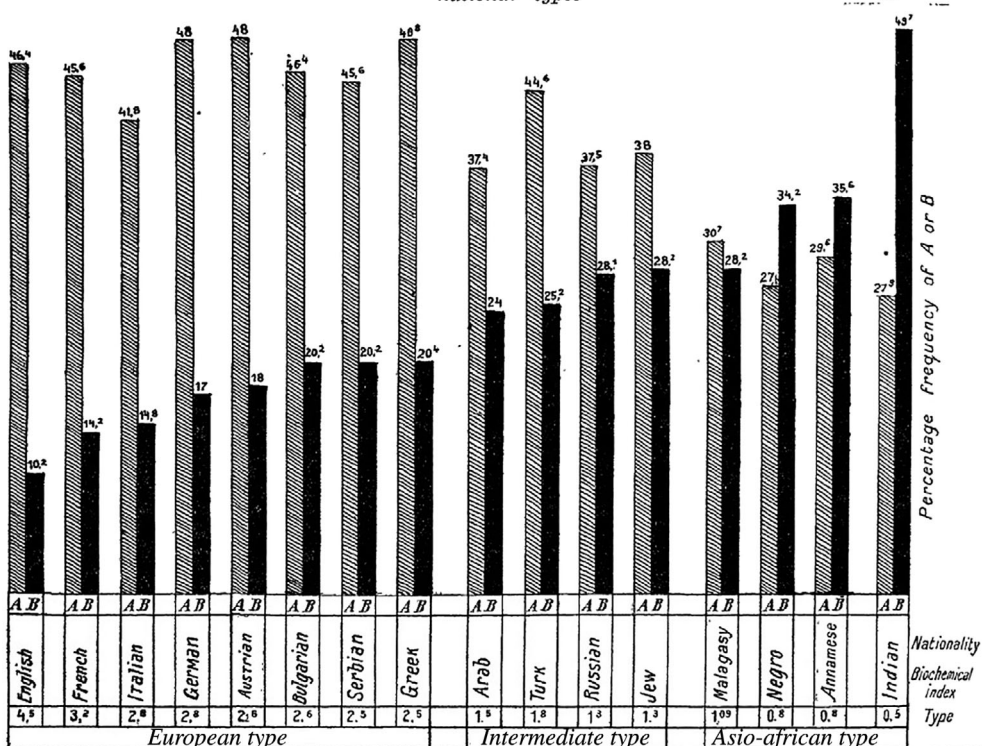


FIGURE 3 Frequency of A and B blood groups among individuals from different ethnic groups [15]. Reprinted with permission

found that the frequency of blood groups differed depending on the ethnic background; group A was more common among people from Western Europe (English 46% A, 10% B), while B was more common among Asians (Indian 27% A, 47% B). Their report was accepted by “The Lancet” and published in 1919, and it was the first paper showing that blood group frequencies differ between populations

(Figure 3) [15]. Interestingly, in the same year, Frigyes Verzár and Oszkár Weszeczky from the University of Debrecen in Hungary performed a similar study among people living around Budapest [16]. Their study included 457 Hungarians, 81 “Gypsies” (now called Roma-Sinti) and 12 Germans. Despite the limited sample size, they obtained similar results: the most common blood group among

Germans was A, while B was predominant among Roma-Sinti. Their findings supported Hirszfeld's notion that the predominant blood group was A in Western Europe and B in Eastern Europe. Furthermore, the dominance of blood group B among Roma-Sinti, who arrived in Europe from the Indian subcontinent during the Middle Ages, suggested that blood groups may remain *racial traits* for hundreds of years, allowing to trace *racial origins* through blood analysis.

Ludwik and Hanna Hirszfeld's discovery introduced serological procedures into anthropology. They proposed that the A and B blood groups originated in geographically distinct locations: A in Europe and B in India. Notably, they used the term "race" when describing ethnic groups, and "blood" as a metaphor for heritage. At the time, these were widely used terms, devoid of any racist connotations that they have acquired later. However, the idea of different kinds of blood was corrupted by followers of the "völkisch" ideology in Germany, which emerged from the "blood and soil" mystic movements of the 18th century [17, 18]. The völkisch ideology started to gain traction in Germany when the Nazi party was rising into power after The Great Depression began in 1929. Studies by the German Society for Blood Group Science evaluated blood groups in several countries and found that blood group A predominated in Germany, while blood group B was more common in Poland (albeit by a small margin), which led them to the conclusion that "racially superior" people lived in Western Europe [19].

Admittedly, many beliefs about races as well as mental and physical differences between them that are currently controversial or have long been discarded were part of the zeitgeist in the 1930s. Thus, Hirszfeld's discovery found fertile ground and inadvertently made racial discrimination easier than other anthropological methods (such as craniometry), which had more obvious inconsistencies. So, it may be argued that Hirszfeld's theory of serological races buttressed the racial hierarchy, although it was not his intent to reinforce the idea of "superior" and "inferior" races [19]. In Nazi Germany, this misused theory led to biased research aiming at distinguishing "native Germans" from those who had mixed with other "inferior" races, such as Slavs or Jews. According to the völkisch theories, such mixing of blood between "superior" and "inferior" races would cause deterioration of the "Aryan" race [20]. As a result, fallacies of racial hygiene based on breeding a racial aristocracy from "uncorrupted peasant stock" became a staple among the community, and were endorsed by leading German scientists [19]. Ludwik Hirszfeld distanced himself from such pseudoscientific theories on many occasions, writing for example: "There are societies that would like to use blood groups for the goals that are not scientific, but solely political" [21].

In the landmark book "Les groupes sanguines" (1938), he said (translated from French by Rachel E. Boaz) [19]: "I would like to separate myself from those who link the blood types to the mystique of race. We have created the notion of the serological race analogous to the biological race. A biological race is made up of a group of individuals who share a unique characteristic. The notion of a serological race has nothing to do with that of an anthropological race. Furthermore, the actual distribution of blood types across the globe indicates the mixing of races and provides even more proof that mankind is a mosaic of races. The anthropological races, by contrast, are characterized by a mix of arbitrarily chosen traits" [19, 22].

Strangely enough, the bizarre connections linking Ludwik Hirszfeld with völkisch and racist theories have not died away after World War II, but persisted well into the 21st century. In 2013, a Swiss historian Myriam Spörri wrote in her book (which was also her PhD thesis at the University of Zürich) that "the fields of research Hirszfeld founded were "eugenically charged from the start," and the idea of "pure blood" first expressed by the Hirszfelds held on tenaciously and was never challenged, despite new findings" [23]. This recent reinterpretation of Hirszfeld's legacy shows how careless application of the contemporary worldview to historical analyses may pigeonhole historical figures and lead to absurd conclusions.

BUILDING A NEW WORLD IN INDEPENDENT POLAND

Poland regained independence in November 1918, and the Hirszfelds decided to come back to the newly formed country. Thanks to the support of Ludwik Rajchman who worked at the Ministry of Health, Ludwik Hirszfeld assumed responsibility to create the Institute of Serum Research, which later became the National Institute of Hygiene. He became deputy director, supervising the training of new generations of researchers in the fields of bacteriology, virology, immunology, cancer research and diagnostics [4].

The Institute grew from a small laboratory to a large institution employing several hundred people, keeping Hirszfeld busy with organizational matters, but he still managed to pursue his interest in blood groups. The research initiated by Ludwik Hirszfeld in the Balkans was continued at the National Institute of Hygiene by Jerzy Mokrzycki and Wanda Halber, who showed that the frequency of blood group A differed geographically across Poland, and varied from 32.2% in Lublin Voivodeship (province) to 46% in Kraków voivodeship, while group B frequency varied from 16.9% in Nowogródek Voivodeship (now Belarus) to 23.7% in Kraków Voivodeship [21]. In addition, Róża Amzel surveyed the distribution of the M blood group, which had been discovered at that time [24, 25]. Exploring links between blood groups and infectious diseases, Hirszfeld and his coworkers Amzel and Halber found that individuals with blood group O tested negative in the Wassermann reaction more often than people with other blood types [26].

In addition, he made important contributions to forensic science, which increasingly relied on blood group testing, and often testified as an expert witness in court [27]. Ludwik Hirszfeld also hypothesized on how blood groups may have evolved. He formulated the theory of pleiades, according to which the trait O is the precursor of A and B antigens [28]. Hirszfeld and Amzel showed that red blood cells from A or B individuals contain various amounts of "O substance," which today we would call the H antigen [29]. This led them to the hypothesis that the A and B antigens emerged from the O antigen by gradual mutations [29]. Today we know that this is indeed the case, as the H antigen is the precursor of A and B antigens, and both arise by sequential action of glycosyltransferases [30]. Later, the seminal studies by Morgan and Watkins supported that theory [31], which led

them to decipher the molecular background of the ABO blood group system [32]. At present, over 70 alleles of the ABO gene, which arose from recurrent mutations or intragenic recombination, are known, and their expression often leads to changes in phenotype [33]. It is tempting to speculate that Hirszfeld would have come to the same conclusions had the war never occurred. He summarized his views on the relationship between the ABO blood group antigens in the review written in occupied Poland in 1943 and published in the *Journal of Immunology* in 1947 [34].

Ludwik Hirszfeld was also interested in how ABO blood group incompatibility between mother and foetus may cause damage to the foetus or newborn [35]. It seems that he was the first to propose that serologic incompatibility between mother and foetus may lead to abortion or fetal or neonatal disease. The conclusive evidence for that idea came in the 1950s when it was demonstrated that the Rh blood antigen can cause hemolytic disease of the foetus and newborn [36].

As an internationally recognized blood group scientist, Ludwik Hirszfeld often participated in conferences and congresses. The international meeting of transfusion science, convened in Rome in 1935, was a particularly remarkable event. Ludwik Hirszfeld gave the opening address (translated from French by Hans Erik Heier [17]): “Our science expresses not only the intellectual progress, but also the moral values of a nation. To give blood to a fellow human being is an act of compassion, it is to imagine and suffer the suffering of the other. For this reason, the interest which a nation carries in the problem of organizing blood donors, allow to judge not only the culture and the spirit (of that nation), but its moral strength. It is in our area that a unique organization of anonymous donors was created, offering their blood to the unknown suffering one” [4, 17, 37]. The participants of the meeting decided to meet again in 1937 in Paris, where the International Society of Blood Transfusion (ISBT) was formed [17, 37]. Ludwik Hirszfeld participated in that conference too, as well as in several meetings of the Standardization Committee of the League of Nations.

MEDICINE IN THE WARSAW GHETTO

In September 1939, Ludwik Hirszfeld was supposed to attend the International Microbiology Congress in New York, but changed his mind and remained in Poland. Thus, the Hirszfelds were in Warsaw when the war started: Hanna organized a provisional hospital in the Saska Kępa (a prestigious Warsaw neighbourhood where they built a house), and Ludwik was busy organizing blood transfusions at the Ujazdowski Hospital because the Institute of Blood Transfusion, which was responsible for this task, had been destroyed in one of the first German air raids [4]. Warsaw surrendered on 28 September 1939, and the brutal German occupation began; meanwhile, the Eastern part of Poland was occupied by the Soviets. In one of the first decrees, Germans ordered that all Jews wear yellow armbands with the Star of David, but Hirszfeld ignored this order. However, he was powerless against the other German decree, which stated that the new director of the National Institute of Hygiene would be Dr. Robert

von Kudicke, his former colleague from Heidelberg. In the autumn of 1940, Germans started forming a Ghetto in Warsaw, forcing over 300,000 people to live in the area of 2.9 km², but in the beginning, the Hirszfelds were able to remain in their home at Saska Kępa, where Ludwik wrote his book “General Immunology,” which appeared after the war [38]. For some time, they were able to survive in the “Aryan” (i.e. not Jewish) part of Warsaw, but in February 1941 they were forced to move to the Ghetto. Hirszfeld recalled a meaningful episode: a German sentry at the entrance to the Ghetto inspected the suitcase and found a book written by Hirszfeld in German. Hirszfeld explained that he wrote that book as a scientist employed by the German government. The soldier said “but now you are just a Jew” [4].

In the Ghetto, they found shelter at the rectory of All Saints Church at Grzybowski Square. Ludwik Hirszfeld offered his services as a medical doctor, so the chairman of Jewish Community in the Ghetto, Adam Czerniaków, asked him to introduce measures against typhoid fever, which was the main cause of high mortality in the Ghetto in addition to hunger. He became the chairman of the Health Council and did his best to slow down the epidemic. Despite having very limited access to medications, diagnostic reagents and disinfectants, he managed to improve the health conditions. The great help in this work was provided by his former National Institute of Hygiene assistant, Róża Amzel (later murdered by Nazis), also forced to live in the Ghetto. They secretly vaccinated people against typhoid fever, using the vaccine invented by Prof. Rudolf Weigl and produced at the Weigl's Institute of Studies on Typhus and Viruses in Lwów (Lemberg), then under German occupation as well [39]. Later, the vaccine was produced according to Rudolf Weigl's protocol by Dr. Edmund Wojciechowski at the National Institute of Hygiene and smuggled to the Ghetto [40]. They also managed to design a simple test to detect typhoid fever bacteria in urine using precipitation by a patient's serum [41]. In addition, Ludwik Hirszfeld was teaching bacteriology and serology at secret courses of medicine. Over 500 students attended the courses, of whom fewer than 50 survived the war [40].

In 1941, at the beginning of his time in the Ghetto, Ludwik Hirszfeld and Róża Amzel came across an individual with Hodgkin's disease whose blood group was difficult to determine. The red blood cells did not agglutinate with any of the test sera and the patient's serum contained strong anti-O (anti-H in today's nomenclature) agglutinins. It seems that it was the rare Bombay phenotype, described by Bhende et al. 11 years later, and caused by the lack of H epitope, which is the precursor of A and B antigens. After the war, Ludwik Hirszfeld described his observation in a Polish journal [42]. When Bhende et al. published his results in *The Lancet* [43], Hirszfeld wrote a letter to the editor explaining that he had found a similar case during his time in the Ghetto [44]. It is tempting to speculate that the Bombay phenotype might have well been named Warsaw if history had taken a different turn.

Meanwhile, the situation in the Ghetto was on the verge of collapse. Overcrowding (the population density was over 140,000 people per km²), inadequate food rations (less than 400 kcal per person per day) and an almost complete lack of healthcare were taking a crushing human toll. The monthly death rate was between 3000 and 5000. A

vivid account of living conditions in the Ghetto was provided by Hirszfeld in "The story of One Life" [4]. As the population of the Ghetto dwindled, the Germans shrank the borders, forcing people to move to an even smaller area. In line with this, the Germans ordered to close hospitals and laboratories. The last laboratory organized by Hirszfeld was located at Żelazna street, but it was never opened, as on July 22nd, 1942, Germans started "Grossaktion Warschau," which was the code name for deportation and mass murder of all Jews from the Warsaw Ghetto. The Jews were rounded up by Waffen SS forces, terrorized and brought to Umschlagplatz station square (today Stawki Street in the Wola neighbourhood), whence they were sent in overcrowded Holocaust trains to Treblinka extermination camp (about 100 km northeast from Warsaw). Before September 1942, over 300,000 Jews from the Warsaw Ghetto were deported to Treblinka. Over 800,000 Jews were murdered there, and fewer than 70 survived [45].

Ludwik and Hanna Hirszfeld managed to escape from the Ghetto between March and June 1942. The extremely risky and costly escape was organized by Konstanty Potocki, an apothecary who ran a pharmacy outside the Ghetto [40]. Their counterfeit documents were provided by Dr. Feliks Przesmycki, a former associate at the National Institute of Hygiene. At first, they were hiding in Warsaw, but soon moved to Kielce voivodeship, where they found shelter in the village Kamienna posing as fugitives from Warsaw. Their only daughter Maria died in the neighbouring village of Kocina and was buried at a small cemetery under the false name of Maria Halecka. After her passing, they moved to Tłuszcz in the Mazowsze region where they were hiding until the Germans withdrew [4].

PULLING THE MICROSCOPE OUT OF THE RUBBLE

When the Soviet army entered Poland, the Hirszfelds moved to Lublin, a city in Eastern Poland, where both helped to establish a new university (now Maria Curie-Skłodowska University). They did not want to return to Warsaw, which was razed to the ground, so they accepted the invitation to organize a new university in Wrocław, the former German city of Breslau, which after the Potsdam Conference was handed over to Poland. Ludwik Hirszfeld helped to organize the Faculty of Medicine at the University of Wrocław, and became its first dean. He gave the first lecture at the newly opened School of Medicine, and created the Department of Medical Microbiology. Thanks to the Rockefeller Foundation, he and Hanna travelled to the United States in 1946 and visited top American medical schools and laboratories. Hirszfeld was impressed with the progress of blood group research; he met Dr. Alexander Wiener and Dr. Philip Levine and discussed with them their studies on the haemolytic disease of the newborn caused by Rh incompatibility [46].

He returned to Poland realizing that science had advanced considerably, and the 6 years he lost to war was a time he could never reclaim. Nevertheless, he continued his research on blood groups. The Rh antigen, the main player in haemolytic disease of the foetus and newborn (HDFN), had already been discovered [47], but there was no prophylaxis, so Hirszfeld, together with obstetrician prof. Kazimierz Jabłoński, introduced exchange transfusion as a treatment for HDFN. This therapy saved the lives of almost 200 children [48, 49].

A large part of Ludwik Hirszfeld's interest in forensic medicine was paternity testing. Blood grouping has been used to that end since



FIGURE 4 Ludwik Hirszfeld with students. Wrocław, around 1950 [69]

the 1920s [50, 51], but the results were underwhelming because ABO was the only blood group system known at the time. The discovery of blood group systems MN in 1927, and Rh in 1940 significantly improved the reliability of testing. Ludwik Hirszfeld together with Prof. Hugo Steinhaus and Dr. Józef Łukaszewicz prepared a table of probability to guide paternity exclusion [52].

The post-war years were very busy for the Hirszfelds, but like after WWI, it was mainly with administrative efforts. While Hanna Hirszfeld organized a professional paediatric clinic in Wrocław, Ludwik and his coworkers at the Department of Medical Microbiology tried to improve the poor public health in the post-War Poland. Together with his close associate Felix Milgrom, he organized widely publicized diagnostics of sexually transmitted diseases, which ran rampant at the time. He was still an active teacher (Figure 4) [40]. In 1953, Hirszfeld founded the scientific journal *Archivum Immunologiae et Therapiae Experimentalis* and became its first editor-in-chief [53].

Meanwhile, the political situation in Poland was going from bad to worse, as the Communist party tightened the iron grip on the Polish people and the scientific community. The pseudoscientific follies of a Soviet biologist Trofim Lysenko, who argued that acquired traits could be inherited and genes do not exist, became the obligatory school of thought in biology [54]. “Followers of Mendelism-Morganism,” as the scientists who refused to accept Łysenko theory were called, risked losing their jobs (and many of them did). Since most of Hirszfeld’s works concerned genetics, he was often accused of “yielding to old superstitions” [40]. His studies on the frequency of ABO blood groups also sparked controversies with visiting Soviet scientists who considered it “an insult to the Russian nation” because the frequency of B blood group was quite high among Russians, similarly to people of Asian background [15, 55]. Both Hirszfelds resisted the pressure from the officials and never joined the Communist party, which was unusual at the time, especially among high-profile scientists, but that independence came at a cost. Ludwik Hirszfeld’s efforts to transform the Department of Microbiology into an institute of the Polish Academy of Sciences had long been thwarted. Finally, a few months before his death, the Institute of Immunology and Experimental Therapy in Wrocław was created. He became its first director.

He died on March 7th, 1954 and was buried at the St. Laurentis cemetery in Wrocław. Several thousand people attended the funeral. The obituary appeared in *The Lancet* [56]. One of the auditoriums at the Medical University of Wrocław, as well as a major square in Wrocław, bear the name of Ludwik Hirszfeld. The Polish Post issued a stamp with Ludwik Hirszfeld in 2009 [57]. Ludwik Hirszfeld co-authored 395 papers, half of them devoted to blood group science and blood transfusion. He received honorary degrees from the University of Prague (1950) and Zürich (1951). He is considered one of the pioneers of blood group research [8, 57–59]; several books [40, 60, 61], as well as articles in scientific journals have been written about him [62, 63]. His students wrote articles devoted to him [64–67]. His closest associate and friend, Felix Milgrom, wrote two articles, one in the *Vox Sanguinis* series “Milestones in Blood Transfusion and Immunohematology” about his fundamental discoveries [68] and one in Hirszfeld-founded *Archivum of*

Immunologiae and Therapiae Experimentalis, which tells about his interactions with Ludwik Hirszfeld [55]. Milgrom wrote in the former: “Hirszfeld belongs to the extinct group of scientists who created the fields of immunohematology and immunogenetics. He has had a profound influence on blood group science and transfusion medicine.” Sadly, many of his associates involved in blood group science and immunology, including Felix Milgrom, Adam Bekierkunst and Władysław Mański were forced to leave the country after his death.

Ludwik Hirszfeld has been remembered by his students not only as a great scholar but also as a dedicated teacher. He epitomized his favourite aphorism “He who wants to ignite others must burn himself.” Hirszfeld did burn with scientific passion and passed his enthusiasm along to his students.

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CONFLICT OF INTEREST

None declared.

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