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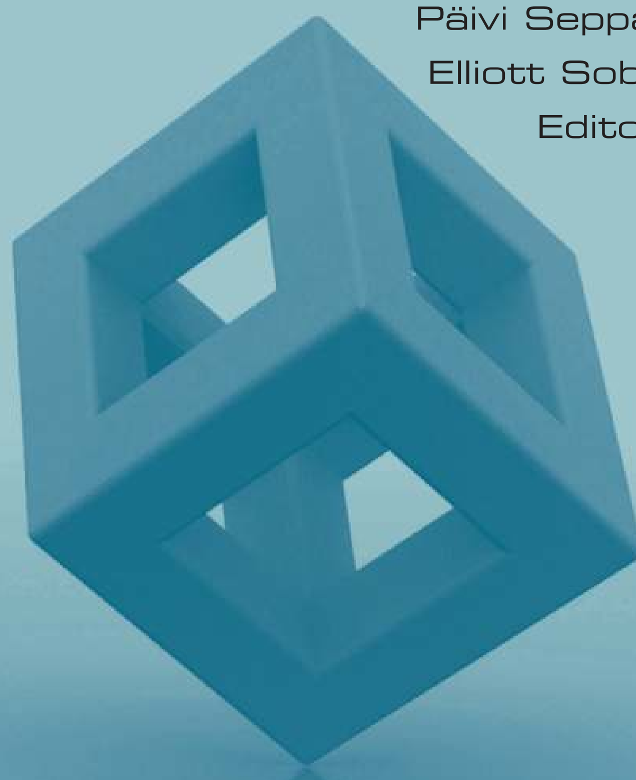
Hannes Leitgeb
Ilkka Niiniluoto
Päivi Seppälä
Elliott Sober
Editors



13 A new look at the history of science. The transnational orientation of the Genetics and Radiobiology Program in Mexico in the 1960s

Ana Barahona *

Abstract. The transnational approach in the history of science is very recent and has been influenced by the effects of globalisation, multiculturalism and the formation of circuits of practices, organizations, objects, goods, knowledge and people, in which scientific developments go beyond nation-state borders, collaborative networks being the units of historical analysis. Recent debates regarding global and local contexts have called attention to circulation networks that explore inter-regional exchanges and transnational circuits that allow quicker cross-border transmission of scientific practices and a faster flow of people, ideas and artefacts. In the case of science studies in Latin America, a great deal of research performed under this approach has indicated that despite their historiographical and epistemological importance, narratives on the national sciences perspective have revealed their analytical limitations. This research has expressed the need to reconstruct transnational stories that account for how the knowledge produced in developing countries forms part of international knowledge as it circulates via international networks of collaboration. A case in point is the cre-

*Department of Evolutionary Biology, School of Sciences, UNAM México 04510, D. F, Mexico. Email: ana.barahona@ciencias.unan.mx.

ation of the first Genetics and Radiobiology Program of the National Commission of Nuclear Energy in Mexico in the 1960s wich was in line with the international trends for the peaceful uses of atomic energy, and with local needs for creating a program to study the effects of radiation in human populations in the country. Alfonso León de Garay's role in the development and establishment of radiobiology and human genetics in Mexico was fundamental.

Keywords: transnational science, circulation of knowledge, genetics and radiobiology, nuclear energy, Alfonso León de Garay.

1 Introduction

The transnational perspective in the history of science is very recent and can be traced to the end of WWII, when there was growing interest for international peace that gave rise to international cooperation programs and organizations that produced important changes on the international political landscape. In the aftermath of WWII, not only were cultural and social processes reconfigured, sea changes occurred in the area of science itself, where the global circulation of scientific instruments, workforce and ideas had come increasingly into focus. Nevertheless, some authors have highlighted the absence of the historian of science in this discussion (Turchetti, Herrán, & Boudia, 2012). They have explained this absence due to "the ways in which the discipline has changed while this approrach has emerged, epistemic univeralism (which understands science as a transcendent, truth-finding activity that, in principle, should not be affected by national, class or ethnic difference), or social interactions that define science as cross-border, transnational activity" (Turchetti et al., 2012, p. 323). According to them, what is needed is that scholars take the role of science in a global dimension seriously.

Recent debates regarding global and local contexts have called attention to circulation networks that explore inter-regional exchanges and transnational circuits that allow quicker cross-border transmission of scientific practices and a faster flow of people, ideas and artefacts. A great deal of research performed under this approach has indicated that despite their historiographical and epistemological importance, narratives on the national sciences perspective have revealed their analytical limitations. A case in point is the creation of the first Genetics and Radiobiology Program (Programa de Genética y Radiobiología, PGR) of the National Commission of Nuclear Energy (Comisión Nacional de Energía Nuclear, CNEN) in Mexico in the 1960s, which was in line with international trends for peaceful uses of atomic energy, and with local needs for creating a program to study the effects of radiation in human populations in the country. Alfonso León de Garay's role in the development and establishment of radiobiology and genetics in Mexico due to his belonging to international networks was fundamental.

2 A new look at the history of science, the transnatinal perspective

In the case of history of sience focused outside the United States and Europe, there have been two leading models to explain the flow of knowledge, diffusionism and dependency. Many historians, especially those focused on colonial science, referred to and often sought to implement the model proposed by George Basalla in 1967. According to this model, there are three phases in the diffusion of science from the metropolis towards the peripheries; that is, from Europe to non-European countries. These phases are lineal, sequential, progressive, and necessary for the transformation of science in local or peripheral contexts (Basalla, 1967); or have focused on the asymmetrical relationships between centre and periphery that implies the inability of the latter to develop an autonomous system of science and technology (see for example Cardoso & Faletto, 1979). During the 1970s and the 1980s, these patterns framed the development of historical studies seeking to account for the development of science particularly in Latin American countries (Sagasti & Guerrero, 1974; Stepan, 1981; Lafuente & Sala-Catalá, 1989; Chambers, 1987). None of these studies acknowledge on the global or reciprocal connections, or focus on the networks of collaboration that may help explain the construction of knowledge at both the local and the global level.

However, recent historiography of science has focused on how knowledge circulates in widely different contexts. In the last decades of the 20th Century, the historiography of science, imperialism and postcolonialism elaborated upon the dynamic interactions between what have been traditionally called centers and peripheries. For example, recent studies in the history of science in developing countries have confronted the accepted idea about the coexistence of the global circulation of people, practices and techniques, and the symmetries between scientists working in metropolitan centers and those working in less-developed ones, showing that not all science on the so-called periphery should be regarded as peripheral, and criticizing those perspectives that see the diffusion process as unilateral and promoted by metropolitan centers and adapted in the peripheries. Moreover, some historians have proposed the abandoning of the terms center and periphery, inasmuch as they do not reflect the dynamics or circulation of the elites from less-developed countries who made outstanding contributions and participate in international networks (Kreimer, 2010).

Debates regarding global and local contexts have called attention to circulation networks formed by shared interests through which exchange is negotiated and in which the circulation of knowledge, people and practices occurs (van der Vleuten, 2008; Sivasundaram, 2010; Safier, 2010; Birn & Necochea López, 2011; Hofmeyr, 2013; Druglitrø & Kirk, 2014). Sivasundaram, for example, emphasizes that in order for science to be successful it has to travel, “studying networks fit well with global history because networks cross empires, nations, and regions” (Sivasundaram, 2010, p. 158). Secord, for his part, has demonstrated that science can be understood as knowledge in transit, which has to cross national, temporal and disciplinary borders owing to its social nature (Secord, 2004). Even more recently, Finnegan proposed four distinct types of place in which scientists operate: sites, regions, territories, and boundaries or circulation, the latter used to understand the dynamics of knowledge that became universal by circulating (Finnegan, 2008); for Kohler, these categoriesries embrace the material and the social aspects of place, the local and socially constructed character of scientific knowledge (Kohler, 2012). The role played by the creation of networks in the stabilization of scientific facts has focused on how local knowledge becomes universally accepted. Important works that show the techniques by which scientists convinced their peers about their knowledge claims highlight the agency of local actors in the flow of knowledge (to name a few see Latour & Woolgar, 1979; Rudwick, 1984; Collins, 1985; Shapin & Schaffer, 1985; Latour, 1988; Daston & Galison, 1992; Shapin, 1994; Porter, 1995; Golinsky, 1998; Daston & Galison, 2007).

Recent studies have emphasized the need to write connected transnational narratives based on a reciprocal treatment of global and local contexts (Subrahmanyam, 1997). This transnational approach abandons the nation as a unit of analysis, Eurocentric narratives, cultural-diffusion interpretations, and the rigid opposition of the categories of "center" and "periphery" in order to explain the dynamics of transnational circuits and the global and local circulation of knowledge, people, artefacts and scientific practices. This rich approach problematizes the notion of "international science" and has pending issues such as the precise definition of notions such as circulation, reception, adaptation and creativity. However, this new perspective thoroughly emphasizes the interaction of experts from different countries and the transnational circulation of people, knowledge and practices as an intrinsic part of knowledge production (Birn & Necochea López, 2011). "Exploring the transnational circulation of knowledge thus becomes a key feature in the analysis of how hazardous trades have been reinterpreted, negotiated and relocated in undeveloped and less-developed countries" (Turchetti et al., 2012, p. 328). Many case studies looking through the transnational glasses of the recent historiographical turn have been produced (for Latin American studies see Cañizares, 2000; Cueto, 2006, 2007; Hochman, 2008; Soto Laveaga, 2009; Medina, 2011). It is under this perspective that I analysed the creation of the PGR of the CNEN in the 1960s in Mexico together with the pioneering work of the Mexican physician-turned-geneticist Alfonso León de Garay. In this narrative the term 'transnational' allowed us to understand the formation of the Program based on local needs and the aim of working beyond geographical limitations to thus facilitate the circulation of knowledge, practices and people from and to Mexico.

3 Nuclear physics in México during the Cold War[1]

In the early 1950s, an acceleration in the arms race and atomic tests became apparent as a result of the bombings of Hiroshima and Nagasaki that put an end to the Second World War (WWII). Within this international context, President Dwight D. Eisenhower gave the *Atoms for Peace* speech on December 8th 1953 before the UN General Assembly in which he stated his preference for halting the military and warfaring uses of nuclear energy and offering peaceful nuclear technology to humanity instead (Eisenhower, 1953/2007).[2] Eisenhower suggested the creation of an international organization to regulate the process for creation and use of atomic energy and proposed that countries with nuclear technology projects contribute economical and technical resources to the development of peaceful uses of nuclear energy. In 1957 the International Atomic Energy Agency (IAEA) was created with its headquarters in Vienna.[3] The member countries of the UN were invited to participate by creating their own national institutions to attend relevant meetings and benefit from the knowledge produced and establish control mechanisms. Several of these organisms were created before or concurrently with the formalization of the IAEA in 1957, as was the case for the CNEN. The creation of the IAEA increased funding sources for nuclear scientists and technicians with emphasis on the peaceful uses of radioisotopes in medical genetics and agriculture, among others.

The interest of Mexican scientists and politicians did not begin with the creation of the CNEN. According to Vélez Ocón, Mexican nuclear projects began as a result of the atomic bombings in Japan, when the Mexican government declared nuclear deposits of uranium, thorium and actinium, national reserves in 1945 (Vélez Ocón, 1997). At the end of 1945, General Ávila Camacho's government lobbied enthusiastically for the attendance of a Mexican representative at the atomic tests the United States would hold. This was how Harvard-educated Guggenheim Fellow soil engineer Nabor Carrillo, who was at the time the Scientific Research Coordinator at the National Autonomous University of Mexico (UNAM), and Soil Mechanics Research Section Head of the Commission for Promotion and Coordination of Scientific Research (Comisión Impulsora y Coordinadora de la Invetigación Científica, CICIC), was invited to attend the Bikini Atoll tests as an observer in 1946, along with Colonel Juan Loyo González. Most countries, Mexico included, declared themselves in favor of the peaceful use of atomic energy, and stated that the atomic bomb and other weapons of destruction would bring permanent peace to the world. At a national level, President Ávila Camacho had founded the CICIC in 1942. Its first director, even while he was living

[1] Sections 3 and 4 are a revised and shortened version of Barahona (2015).

[2] As Creager and Santesmases have shown, 'even before President Eisenhower's initiative, biology, agriculture, and medicine served to represent the peaceful face of atomic energy', but it was only after WWII that medical practices and biological knowledge changed drastically (Creager & Santesmases, 2006).

[3] Among the Mexican delegation that attended the Conference were Manuel Sandoval Vallarta, Nabor Carrillo and Carlos Graef. We will see the connection with the PGR below.

in the United States, was Dr. Manuel Sandoval Vallarta, the Mexican MIT-educated Guggenheim Fellow physicist. He had collaborated with MIT from 1923 to 1946, and traveled to Mexico several times to promote nuclear energy studies. In about 1943, the CICIC established the first radioactivity research laboratory, which had been promoted by Sandoval Vallarta with the main objective of developing radiochemistry. This was because one of his chief scientific concerns was acid rain. The head of the soils mechanics laboratory at the time was his colleague and friend, Nabor Carrillo (Bulbulian & Rivero-Espejel, 2012).

From this moment on, interest in the study of atomic energy grew in Mexico, and so the nuclear research program was set up. Dr. Carrillo, who was Rector of the UNAM at the time, visited the American company High Voltage Engineering Corporation in Cambridge, Massachusetts, thanks to Dr. William Buechner's invitation to attend the facilities and familiarize himself with the equipment. This allowed the UNAM to install a Van de Graaff accelerator with federal support in the 1950s (Domínguez-Martínez, 2012). The immediate effect of this was, on the one hand, the development of research, including the commencement of various projects and the training of technicians on radioisotope techniques, and on the other, an increase in and consolidation of institutional relationships and collaborations between Mexican and foreign scientists. Chief among these collaborations was that of Mexican Harvard-educated and Guggenheim Fellow physicist Dr. Carlos Graef –Sandoval's former student-, who was interested in cosmic radiation and relativity, with Harlow Shapley, the high-profile promoter of the United States National Academy of Sciences and director of the Harvard College Observatory.

The creation of the CNEN was created in 1956 and highlighted the efficiency of nuclear energy as an energy source, besides considering it a more economical source than oil, coal or hydropower. Since its inception, the Mexican nuclear program has had civilian and not military purposes, so the word 'atomic' was excluded because of its implications for war and the arms race. Instead, the word 'nuclear' was included, due to its peaceful connotations – energy and non-energy applications, as well as studies in nuclear science that included agronomy and genetics among others (Vélez Ocón, 1997). President Adolfo Ruiz Cortines appointed the lawyer and ex-President of the Supreme Court José María Ortiz Tirado as chairman of the Commission, and Doctors Nabor Carrillo and Manuel Sandoval Vallarta as members. The Advisory Board would be comprised of Doctors Alberto Barajas Celis, Fernando Alba Andrade and Carlos Graef Fernández, José Mireles Malpica (M.Sc.) and the engineers Eduardo Díaz Losada and Jorge Suárez Díaz.

The CNEN was founded upon two general fields of interest: energy and non-energy applications; and nuclear science studies. It was created with a complement of nine programs: nuclear physics, education and training, seminars, reactors, radioisotopes, industrial afflictions from radiation, agronomy, genetics and radiological protection. Thanks to the efforts of Sandoval Vallarta, Nabor Carrillo and Carlos Graef, who prompted the study of nuclear physics in Mexico, land and resources were obtained to develop a nuclear center. In 1964, construction began on the 'Nabor Carrillo' Nuclear

Center as part of the CNEN in the town of Salazar, State of Mexico, and both a Triga Mark III reactor and a Tandem Van de Graaff positive ion accelerator were acquired; these facilities would house all the CNEN's programs and laboratories that were scattered throughout the city, and give support to other institutions such as the UNAM and the National Polytechnic Institute (Instituto Politécnico Nacional, IPN).

It is through the CNEN that nuclear physics and genetics and radiobiology were connected in Mexico with the foundation of the PGR, opening new contexts for the development of genetics and radiobiology.

4 The Genetics and Radiobiology Program and the pioneering work of Alfonso León de Garay

After having spent two years in the Galton Laboratory at University College London, under the supervision of British medical geneticist Lionel Penrose, the Mexican physician Alfonso León de Garay founded the PGR under the CNEN. As we shall see, de Garay was part of an international network in human genetics in which the circulation of researchers, knowledge and practices enabled the assimilation and modification of genetic practices in Mexico in the early 1960s. It was in these years, when global trends in human genetics were reshaping the field of biomedicine in the aftermath of WWII, and when growing international interest in understanding the effects of radiation on human beings led to the formation of institutions and a proliferation of multi-centered clinical trials and inter-laboratory studies (Cambrosio, Keatins, & Bourret, 2006).

Alfonso León de Garay (1920-2002) studied medicine in the 1940s at the Autonomous University of Puebla, and served for many years as a neurologist. In 1957, he decided to study population genetics with Lionel Penrose, the Head of the Galton Laboratory. Thanks to an agreement between the IAEA and some European universities, de Garay obtained a grant and went to London. The relationships he established in Europe were extremely influential on the PGR he founded upon his return to Mexico in 1960, and had a profound and lasting importance in his later career and on his thinking (Barahona, 2009).

When de Garay was in England, he attended the 1957 general assembly of the IAEA as a companion to the English representatives, and there he met the Mexican delegation composed of José María Ortiz Tirado, Nabor Carrillo and Manuel Sandoval Vallarta, and the Secretary General of the CNEN, Mr. Salvador Carmona. They urged him to complete his studies and return to Mexico in order to found a program where he could begin studies into the effects of radiation on health (Barahona, 2009).

As a result of this meeting, and due to the support of the Mexican delegation, de Garay went on to study the mutagenic effect of radiation, in line with projects that were being developed in other parts of the world. In 1957, with the support of both

Ortiz Tirado and Dr. Alexander Hollaender, head of the Division of Biology at the Oak Ridge (Tennessee) National Laboratory of the US Atomic Energy Commission, de Garay was able to go to Oak Ridge and become well-grounded in the field of radiobiology (Villalobos-Pietrini, Guzmán, & Levine, 2005). His return to Mexico was hastened because the CNEN insisted on the immediate set-up of a laboratory, due to international pressures that Mexico should develop its own research in genetics and radiobiology.

The PGR was established in 1960 in order to 'contribute to the conservation of health, physical and mental improvement, and sickness prevention, through the investigation of the factors which intervene (favorably or unfavorably) in the biological inheritance of the population' (de Garay, 1960).

De Garay's agenda was two-fold. On the one hand, he intended to open up spaces for the development of genetics and radiobiology in Mexico, and on the other, to promote the PGR on the international stage. This interplay between de Garay, the PGR, the CNEN and the IAEA fostered the circulation of ideas and practices beyond transnational borders. To achieve this agenda, de Garay's objectives were the study of the effects of radiation on human health, and the study of diverse specific aspects of the heredity process, from the molecular level up to population genetics.

The PGR consisted at first of a small staff composed of six researchers, including de Garay as director, Rodolfo Félix Estrada, chief of the *Drosophila* section, and María Cristina Cortina Durán, María Teresa Zenzes Eisembach, Víctor Manuel Salceda Sacanelles, and Claudina Berlanga Siller, who obtained their B.A. degrees in biology in 1960, as well as a technician, a secretary, and a service assistant. By the end of the 1960s, the number of sections increased to include, for example, human genetics and molecular genetics sections (de Garay, 1970; Barahona, Pinar, & Ayala, 2003).

The Program consisted of six sections: tissue culture (where cytology and genetic analysis were practiced), photography (microphotography and autoradiography), biochemistry (biochemistry and radiochemistry), education (preparation of educational materials and training of personnel), *Drosophila* labs (conventional experimentation and computing of mutations, including irradiated stocks), and statistics and social work (population genetics and family studies).

The three main lines of research conducted in the years after its foundation that were in line with international projects while responding to the national context were, first, cytogenetic studies of certain abnormalities; second, the study of the effects of radiation on hereditary material, and third, the study of population genetics in *Drosophila* and in Mexican indigenous groups.

4.1 Cytogenetic studies of chromosome abnormalities

The 1960s was a decade of intensive work in the area of human genetics; it was transformed into an enticing frontier for medical research, and the production of technological knowledge from the study of chromosomes held a great deal of hope for progress in the study of human heredity. The technical analysis of the karyotypes and practices that accompanied it became popular worldwide as it allowed human chromosomes to be analyzed and visualized.[4]

De Garay had come into contact with these techniques in England. Upon his return, he brought the first human chromosome preparations that have been studied in the Galton laboratory and donated by Penrose. These studies also led to the standardization of laboratory tissue culture methods, and in general, those practices enabling visualization of chromosomes. To do so, the PGR was assisted by Dr. David A. Hungerford, the American scientist and co-discoverer of the chromosomal abnormalities in cancer cells who worked at the Institute for Cancer Research in Philadelphia, United States. He came to Mexico in 1963 to work on the protocols for the tissue culture from peripheral blood technique that he and his colleagues had developed in the United States, which was originally designed for the study of chromosomes in patients with cancer and in laboratory animals with radiation-induced leukemia. As a result of this collaboration, Hungerford agreed to receive in Philadelphia, PGR technicians Tayde García and Pilar Quijano to specialize in tissue culture and other cytological techniques that had been standardized at Hungerford's laboratory, who upon their return were incorporated to the cytogenetic section of the PGR.

As part of his personal agenda and in response to national needs, de Garay encouraged young people to learn cytogenetic techniques that were being standardized in other laboratories, always with the support of the IAEA through the CNEN. Maria Cristina Cortinas de Nava went to the Hospital des Enfants Malades to learn techniques of human cytogenetics with the French geneticist Jean de Grouchy's group in France (De Grouchy, Cortinas de Nava, & Bilski-Pasquier, 1965); and Maria Teresa Zenses Eisenbach left for Texas University to work with Chinese geneticist T. C. Hsu the techniques for human and animal cytogenetics.

4.2 The study of the effects of radiation on the hereditary material

After WWII, the international call from institutions such as the IAEA, to study the effects of radiation on humans, led to the establishment of local programs, such as the PGR, where de Garay introduced the study on the effects of radiation in the hereditary

[4] Another research group was being formed in the 1960s at the Mexican Institute of Social Security. See Barahona (2009, 2015).

material. According to de Garay, the increasing uses of nuclear energy in electricity production and medical applications, agriculture and industry, forced him 'to increase research and concentrate scientific, technical and legal efforts intended to prevent any damage that may arise from nuclear development' (de Garay, 1962). After that, new prospects for the peaceful application of nuclear energy and research in general opened up gradually within the PGR.

The *Drosophila* section studied the mutagenic effects of diverse radiation-emitting sources by using tracer isotopes. As part of the staff training, annual courses about radioisotopes and nuclear instrumentation were organized in order to obtain and analyze these mutants. These were offered in the Radioisotope Laboratory at the Physics Department of the School of Sciences of the UNAM in close collaboration with the CNEN, by himself and Augusto Moreno y Moreno, whom he had met at the IAEA meeting in Vienna in 1957. The first course was held from March-July in 1960. These courses works were compulsory for the personnel who worked in the Program (Olvera & Guzmán, 2001). By 1962 de Garay and collaborators had obtained 57 *Drosophila* mutants that were used for research and educational purposes.

In the ensuing years, and to be competitive on a worldwide scale, the PGR included the Aquatic Invertebrate Radiobiology section and the Molecular Genetics Laboratory in 1965 and 1966. The idea was to work, respectively, on protective compounds against radiation effects in the flatworm *Planaria*, and to investigate the genetic mechanisms operating in microorganisms, as well as the radiation effects and consequences of radioprotective substances at the molecular level. In parallel, de Garay encouraged Magadalena Carrillo Santín to go to the Atomic Energy Institute at Sao Paulo, Brazil, to study radiochemistry in 1965, and he invited the then-Director of the Oak Ridge National Laboratory of the US, Alexander Hollaender, whom he had met in 1957 at Oak Ridge, to see the facilities and to work on future collaborations in 1966.

4.3 Population genetics studies

Although population genetics had been developed in the first decades of the 20th Century, it was in the post-war years that serological studies of the distribution of blood groups were developed with the intention of measuring the intra-specific variability in human populations. This was possible thanks to the introduction of new techniques such as gel electrophoresis and paper chromatography, which were quickly built to track immune reactions, mainly thanks to the work of Harry Harris at the Galton Laboratory (and whom de Garay had met in England) with human isoenzymes.

In Mexico, human population studies started in the 1940s with the work of physician Mario Salazar Mallén and his students at the General Hospital on the detection of hemoglobin abnormalities in rural communities. Between 1944 and 1949 he published several papers on the blood agglutinogens of the Mexicans, and blood type surveys of urban and indigenous populations (Salazar-Mallén, 1949; Barahona, 2009). This work was followed by Adolfo Karl at the IPN, who studied the distribution of abnormal hemoglobin in a Mazatecan group of the Papaloapan basin using the horizontal electrophoresis technique (Karl, 1957). At that time, the Mexican populations were investigated for ethnographic, anthropological or economic purposes, but rarely from the genetic point of view, so these studies were important in the Mexican local context.

These studies, although aligned with the work of other laboratories in other parts of the world, did not impact Mexican genetics, until other groups such as those of de Garay and Mexican physician Rubén Lisker began to use molecular tracers and more up-to-date electrophoresis techniques to measure the genetic variability of Mexican indigenous populations.[5]

To start these kinds of investigations at the PGR, de Garay invited the physician and biologist Hans Kalmus, the prewar refugee from Czechoslovakia, whom he had met in the Galton Laboratory, to design the study of population genetics of *Drosophila* and Mexican indigenous populations.

Kalmus' first visit thanks to the support of the IAEA was in 1962, but only for a three-month period; these visits became more common and longer in the ensuing years. Under his supervisión, gathering expeditions were made to Chiapas and Oaxaca to collect data on *Drosophila*. Similarly, thanks to this collaboration they began the study of population genetics in indigenous populations using tracer genes of Tzeltal and Tzotzil groups in Chiapas and Mixtec groups near the coast of Oaxaca. Later on, the Lacandon populations in Chiapas and the Otomí group in Hidalgo were investigated. The results of these studies showed that in some communities, the frequencies of certain genetic characteristics increased by prolonged isolation in a small geographical area (de Garay, 1963; Barahona, 2009).

Finger and palm prints were also taken, and tests were performed for phenylthiocarbamide tasting, enzyme deficiencies in the school population, color blindness and the chemical composition of earwax (Kalmus, de Garay, Rodarte, & Cobo, 1964). In order to obtain blood samples and analyze them later in the laboratory, several gathering expeditions were necessary owing to the geographical conditions of the regions studied and the intervention of other Mexican institutions such as the National Indigenist Institute and the Summer Institute of Linguistics.

In order to strengthen this line of research, de Garay arranged for Víctor Salceda to be a visiting scholar at the Rockefeller University in New York, at the laboratory of the Russian-born American geneticist and evolutionist Theodosius Dobzhansky to study genetic load in irradiated populations. This occurred from 1965 to 1967, and enabled the PGR to collaborate with Dobzhansky, who visited Mexico in 1974 at the invitation of de Garay.

[5] In 1960, another research group headed by Mexican physician Rubén Lisker at the Nutrition Diseases Hospital (later the Salvador Zubirán National Institute of Nutrition) was working on the genetic characterization of Mexican indigenous populations. See Barahona (2009).

The IAEA provided Salceda with a scholarship to go to New York, and he joined Dobzhansky's laboratory in November 1965 to do research on the genetic load of irradiated *Drosophila* flies. When Salceda went back to Mexico in 1967, he tried to initiate collections of *D. pseudoobscura* in natural populations under Dobzhansky's advice, in order to study the geographical distribution of the chromosomal inversions that characterize this species. Because of Dobzhansky's illness and because de Garay's group was involved in the organization of the Olympic Games held in Mexico in 1968, this project did't take off at the time (Barahona & Ayala, 2005b, 2005a).

The context and the conditions in which this research was performed, the commencement of international collaborations, and the role of de Garay and his group in the circulation of knowledge were key pieces in the development and establishment of genetics in Mexico and its positioning at an international level.

5 Conclusions

As Turchetti and colleagues have said,

> in recent years historians of science have focused on the production of scientific knowledge in its social milieu, shedding new light on such key determinants as (among others) the transmission of new paradigms through the training of new generations, the orienation of belief in trading zones, the functioning of laboratories and the circulation of knowledge....They also have challenged narratives built around the celebration of scientific discoveries by presenti the production of knowledge as a complex and dynamic process in which the meaning of new scientific theories are negotiated by a number of different actors (Turchetti et al., 2012).

In this work, the idea of circulation allowed us to understand in greater detail how it is that knowledge and scientific practices have travelled across geographical and temporal spaces, crossing nations and passing through borders. This paper attempted to show how the PGR was created from a simultaneous dialog between the local context responding to national needs and concerns, and a transnational approach owing to its need for international networks through which scientific resources were mobilized in order to enter into a transnational material culture. From the start, de Garay was as committed to the construction of shared languages and practices as he was to networks of collaboration in order to guarantee the necessary conditions for establishing genetics in Mexico. This study also allowed us to place Mexican science within a global context in which interconnected narratives describe the interplay between global trends and national contexts.

I have tried to show how the creation of the CNEN in its local and international contexts, influenced the foundation of the PGR. The training of Alfonso León de Garay at the Galton Laboratory of University College in London was crucial to the establishment of the PGR. The members of the program were important pieces in the movement of knowledge across borders due to their standing as experts, which was thanks to the moral and epistemic authority they had acquired by studying abroad, and through their personal relationships. I tried to show how his subsequent membership of international networks facilitated the flow of knowledge and the circulation of scientific practices and people, which included the training of young geneticists in foreign academic institutions, thus enabling spaces to be opened for the development of genetics in Mexico. This historical reconstruction tried to show the relations between different actors in different countries and at different times, and the scientific programs and institutions that were created in the 1950s and 1960s in Mexico.

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Author biography. Ana Barahona studied biology and graduate studies at the National Autonomous University of Mexico (UNAM). She is Full Time Professor in the Department of Evolutionary Biology of the School of Sciences at the UNAM. She did posdoctoral studies at the University of California, Irvine, with Francisco J. Ayala, and has done research stays at Harvard University with Professor Everett Mendelsohn and Janet Browne, at the American Philosophical Society, at the Max Planck Institute for the History of Science, and at the Florida State University. Pioneer in the science and technology studies (STS) since 1980, she founded the area of Social Studies of Science and Technology in the School of Sciences. She was President (2009-2011) of the *International Society for the History, Philosophy and Social Studies of Biology*, member of the International Committee of the *Scientific Society Sigma Xi* (2003-2005), and Council Member of the Division of History of Science and Technology of the International Union of History and Philosophy of Science (DHST/IUHPS, 2009-2013). She has been recently acknowledged as a Corresponding Member of the International Academy for the History of Science.