

THEMATIC RESEARCH

A MEXICAN SCIENTIST'S RELATIONS ABROAD

The Case of Arturo Rosenblueth

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Abstract:

This article describes the contributions Mexican physiologist and philosopher of science Arturo Rosenblueth made to scientific production, to reflections on the philosophy of science, and to the training of North American, European, and Latin American researchers in the medical schools of Mexico, La Sorbonne, and Harvard (1918-1945). Also studied is his work at Mexico's National Institute of Cardiology and the Center of Research and Advanced Studies (1945-1970) in the framework of the complex labor conditions experienced by the scientists of his time. Emphasis is placed on Rosenblueth's relations and scientific production with physiologist Walter B. Cannon and mathematician Norbert Wiener, with whom he held new discussions in the fields of neurophysiology and cybernetics. The article is based on archival documents, bibliographical sources of the past and present, and interviews.

Keywords: science, educational policy, higher education, academic training, physiology, cybernetics.

Arturo Rosenblueth, Mexican physiologist and philosopher of science, wrote in 1969, one year before his death:

The cultivation of scientific research in higher teaching institutions has [...] a central role. It elevates the level of teaching aimed at preparing competent professionals and technicians. It provides the intellectual atmosphere necessary for the formation of distinguished teachers. Lastly, it permits the training of other researchers. Scientific research is not learned in texts, nor in monographs, nor in scientific journals; it is learned through the guidance of a researcher, and such learning is more pleasant and easy, the more creative, competent, and humanly comprehensive the researcher (Rosenblueth, 1969:96).

Rosenblueth believed that education is organized in a pyramidal form, with six levels—elementary, secondary, preparatory, professional training, higher education, and research—and that the final levels are key in elevating the educational quality of the entire structure. According to Rosenblueth:

Any program that is undertaken in an attempt to improve a country's educational system must take into account that increasing the base of the pyramid is not sufficient; it is more important still to raise the height. Broadening the base will not raise this height, but any perfection of the research level and higher education will reflect favorably on the entire system. In this field, as in many others, the quality is more important than the quantity (Rosenblueth, 1969: 97-98).

But for this growth to occur, Rosenblueth suggested that it was necessary “to increase the government subsidies destined to scientific research”, taking into consideration “the achievements of already existing institutions” and:

[...] to raise the professional fees of researchers, which at present are insufficient, to increase their number in order to consolidate and strengthen existing departments, to expand our teaching facilities to be able to accept more students than we can properly serve now (Rosenblueth, 1969: 96).

In addition, the first Director of Centro de Investigación y de Estudios Avanzados (“Center of Research and Advanced Studies”) at Instituto Politécnico Nacional (now Cinvestav) proposed two extra conditions for strengthening science: “to create new departments in fields of great importance for Mexico, that are not cultivated or are cultivated only in limited form, such as physical chemistry, metallurgy and petrochemicals”; and to guarantee the conditions for “expert foreigners in the fields we do not have in Mexico” not only to offer “a few conferences” but also to “establish stays in the nation for a few years to carry out research as well as teaching” (Rosenblueth, 1969:99).

This Mexican physiologist and philosopher of science also suggested other ways to strengthen research, such as importing tax-exempt experimental equipment supported by government policy, and decentralizing research facilities by creating specialized institutes and promoting new centers and schools in Mexico’s states.

In 1969, Rosenblueth proposed forming an organization to promote scientific research in Mexico, separate from other educational levels, and assigning scholarships to students “from the city” and “from the provinces”, particularly for teachers. He suggested that a single organization assume responsibility for assigning these scholarships: the newly created Instituto Nacional de la Investigación Científica (“National Institute of Scientific Research”--INIC), which years later would become Consejo Nacional de Ciencia y Tecnología (“National Council of Science and Technology”--CONACYT).

In Rosenblueth’s opinion, it was also necessary to take advantage of scholarship recipients’ knowledge. He proposed that “scholarships should be considered as an investment our country makes”, adding that “funds should be contributed” to create “positions and places of work for former scholarship recipients”; in this way, the “brain drain” of numerous researchers would be avoided and their technical and scientific knowledge utilized.

In this regard, Rosenblueth indicated: “It is fair for me to point out that I was able to study physiology at Harvard Medical School thanks to a two-year fellowship that the Guggenheim Foundation gave me” (Rosenblueth, 1969:102).

Rosenblueth stated on July 5, 1963, at the opening ceremony of Cinvestav that:

Centro de Investigación y de Estudios Avanzados at IPN was created to solve some of these problems: a) To promote and provide installations for the realization of original technological and scientific research; b) To prepare researchers and professors who, disseminated throughout the country, will raise the quality of higher education; and c) To direct and channel studies of applied science that permit improving living conditions and the country’s technical development. The three goals are closely related; if the first is attained, the others will be reached automatically (Cinvestav, s/f).

Many of these proposals seem to have been written in recent years. They have been fundamental in the attainment of Cinvestav’s recognized position as the second most important location in Mexico for research and the training of researchers. Such proposals were derived from the educational and professional experience of the center’s founder, whose stay at the school was linked with social movements and the political ideas from various times of his academic and professional life.

Arturo Rosenblueth was born on October 2, 1900, in Ciudad Guerrero, Chihuahua. He was the son of a Hungarian Jew who sold clothing and a Catholic mother from the United States; Rosenblueth’s mother was also the daughter of a Catholic mother and Jewish father. Arturo was the second of eight siblings, and was influenced by his father’s profound interest in educating his children through formal schooling and the disciplined study of music and language.

Julio Rosenblueth believed that his children should have the tools that would allow them to survive difficult times; he spent time with them every afternoon, teaching them to play various musical instruments.¹ Arturo Rosenblueth grew up to love music, inseparable from his piano.

At age six, Arturo accompanied his older brother Emilio to Mexico City to enroll at Institut Franco-Anglais Sainte Marie, now known as Colegio Franco Inglés, where members of the Marist

order gave religious and formal instruction based substantially on texts in French.² David Alfaro Siqueiros, who studied at the school at about the same time, gave a graphic description in his autobiography of the school's harsh treatment when he was wrongly accused, instead of his brother Jesús, of taking a coin from his father's coin box:

That is the state I was in when Father Toral, with his always tight gray lips and northern French accent, told me: <Viens ici... Le père Sabady (the director) t'appelle... Salaud!... Pourriture!... (filthy swine). Stumbling, I climbed the stairs, followed by Father Toral, and I reached the director's room. There Father Sabady was waiting for me in the center of the room. With a stern expression, he told me: <Come in. Close the door and give me the key.> Then he looked straight at me and with the most severe French I have heard in my life, he told me: <Thief... You have stolen from your father. You are going to end up in jail... And I understand that this is not the first time, that this has been your habit for a long time. I believe there is no remedy for you!> And then making a tremendous gesture, he added: <Open the door and go to the school chapel and ask God and the Virgin to forgive you for your horrible crimes > (Siqueiros, 1987:25).³

At the outbreak of the Mexican Revolution, the school was temporarily closed and the Rosenblueth brothers returned to Monterrey where their father's clothing store, "La Ciudad de Londres", was located. There Arturo finished elementary school and studied music until entering Colegio Civil de Monterrey; this school, like Escuela Nacional Preparatoria, aimed at promoting a positivist education among students during their five-year stays⁴ (Reboloso, 2002:6). It was there that Rosenblueth became interested in science and mathematics, as he stated in the preface of his final monograph, *Mente y cerebro. Una filosofía de la ciencia*, published the year before his death:

My interest in certain problems that I analyze in this monograph began in 1915, when as a preparatory student, I read some of the books that Poincaré dedicated to the scientific method [Poincaré, 1905, 1906, 1908]. In truth, these readings were one of the factors that led me to select scientific research as a fundamental goal of my professional activities (Rosenblueth, 1984:3).⁵

As a result of his reading and the deep love for mathematics that he would develop with extraordinary skill throughout his professional life, young Arthur planned to study mathematics as a profession. His father, however, prohibited him from doing so, to prevent him from becoming "a humble school teacher". Instead, he directed him to study medicine (SPP, 1979:15-17).

At age seventeen, Arturo Rosenblueth returned to Mexico City, this time to request enrollment in Escuela Nacional de Medicina ("National School of Medicine"). The institution was in full academic effervescence. The school's director, Rosendo Amor, and Fernando Ocaranza were promoting substantial changes in the focus for teaching medicine, to replace a discipline based on clinical diagnosis with a discipline sustained by the principles of scientific medicine proposed by Claude Bernard in the late 19th century. Thus Rosenblueth was trained in the glow of lively discussion among his professors, in a school where physiology assumed a central role in the medical discipline (Bernard, 1994).

From the time he enrolled, Arturo was an outstanding student, as proven by his academic grades. In his first two years of college, he was evaluated as "perfectly good" ("PB") in the two courses of Descriptive Anatomy and the two courses of Dissections: Descriptive Anatomy and Topographical Anatomy. He received the same grade in the courses of Microscopic Anatomy; Histology and Embryology; Physiology; Medical Chemistry; Microbiology; Topographical Anatomy; and the first course of Medical Pathology and Pathological Anatomy. In Surgical Pathology his triple evaluation was divided into two "PB" and one "very good" ("MB"); Clinical Preparation with three "MB" Galenical Pharmacy with two "MB" and one "B" ("good"); while in the course of Parasitology and Tropical Diseases, he earned a "pass". Arthur's file includes his request for confirmation of having

received a diploma in the first and third years of medicine, and a medal in the second year (EARS-AGUNAM).

During the last two years of his studies, Arthur's economical situation became very difficult and he was forced to leave school to play the piano in a quartet at "La Europea" café, the "Lady Baltimore" restaurant, and at the movies—the final two years of silent pictures in Mexico. He also worked as an employee at American Book & Printing, now the American Book Store.

A couple of years later, firmly supported by the multiple efforts of Guillermo Parra, the new director of Escuela Nacional de Medicina, Rosenblueth attempted to attain, without success, a scholarship at Universidad Nacional de México or a job related to medicine at a hospital. Parra's efforts were promoted by Felipe Brockenheimer, a professor of surgery at the Medical School of Berlin who obtained a scholarship for Arturo to continue his studies at that university. Rosenblueth later explained the reason he remained in the school only six months: "I had a transitory and unpleasant stay in Berlin, which confirmed my Latin American sentiment, and then I enrolled in the school of Paris" (Benton, 1987:15).⁶

In the company of his friends Raoul Fournier and Leopoldo Salazar Viniegra, and financed by his older brother Emilio, Arturo enrolled as a student of the French medical school of La Sorbonne, where he studied Physiology, Medical Chemistry and Physics, and became familiar with the main precepts of Claude Bernard and his *Introduction à l'étude de la médecine expérimentale* taught by Charles Robert Richet, Nobel prizewinner in medicine in 1913. Arturo studied neurology with Joseph Francois Felix Babinski, who discovered the sign that carries his name, used to differentiate organic from hysterical paralysis. And as a result of his extraordinary skills in experimental work, Arturo worked as an honorary assistant in the physiology class taught by Dr. Eugenio Gley, known for his discoveries about insulin, and his transformation of the basic practices of endocrinology (Fournier, 1971:13-16; Fraiman, 2000: 1-16; De Iceta, 1999:26).

Other Latin American students in France joined the trio of Rosenblueth, Salazar Viniegra and Fournier, who explained:

Our group had grown: Nacho Morones Prieto, Fernando Velásquez, Antonio Riquelme and a Dominican we called Leónidas Tigrillo—a character from Pirandello—who, when we spoke of the "colossus of the north" did not think of the United States but of Mexico—something that pleased us very much and raised our spirits. At the corner of Rue des Ecoles and Rue la Sorbonne the Brasserie Balzar still exists a few steps away from the Montesquieu Hotel. We would go there to eat our *soupe à l'oignon*, raspberry tart, and mug of beer. At midnight other Mexicans would arrive: refugees in Paris following the De la Huerta uprising, simply spongers, or some general who was looking for company and an audience, and would pay the bill. Arturo was always the same: categorical, argumentative, obsessed by his work, passionate about art, thinking about Mexico as a distant goal, and about success as something unreachable (Fournier, 1971:15-16).⁷

In 1927, Arturo returned to Mexico with a degree in Neuropsychiatry and obtained work as a professor's assistant in physiology for Fernando Ocaranza, then the Director of Escuela Nacional de Medicina. The following year, the decision was made to divide the physiology students, and Rosenblueth was named head professor for the subject, with responsibility for 250 students, while Ocaranza taught a group of a similar size. Arturo also worked as a professor of Clinical Preparation and Surgery and as a professor of other subjects (EARS-ADGP-AGUNAM, 1928).

At the same time, Rosenblueth installed an office for seeing neuropsychiatric patients at Rosales street, where his family lived, and he joined the staff at La Castañeda insane asylum where Salazar Viniegra worked. He also served as a professor at Escuela Nacional de Medicina and a few years later, as the director of the same psychiatric hospital (Velasco y Donadieu, 1993: 393).

Arturo Rosenblueth did not support himself for long with these two clinical positions, however, due to his disagreement with the neuropsychiatric clinical practices of the time. Backed by his

friend, Fournier, he began to work with Dr. José Zozaya at Instituto de Higiene, where along with Teófilo Ortiz Ramírez he developed a physiological research study on the mechanisms of breathing (Fournier, 1971:13-16; García Ramos, 1981; Benton, 1987).

During that era, scientists in the United States were seeking to expand their lines of research toward Latin America, and certain American foundations dedicated to supporting new scientists turned their attention to nations south of the border. The beneficiaries of this policy included José Joaquín Izquierdo, first Rosenblueth's professor and then his co-worker at Escuela Nacional de Medicina. In 1925, with the help of the Rockefeller Foundation, Izquierdo spent time in the laboratory of W. B. Cannon at Harvard Medical School, in Sir J. Barcroft's Laboratory of Physiology at Cambridge University in England, and in the Department of Physiology at the University of Cologne in Germany, with H. E. Hering (Castañeda, 2005).

In 1929, the John Simon Guggenheim Memorial Foundation opened its fellowship program to Latin America. After reviewing close to fifty applications from young people in various disciplines in several states of Mexico, the Foundation officially announced the selection of the first two Latin American recipients. One was the mathematician, Alfonso Nápoles Gándara, who would work with Dirk J. Struick at Massachusetts Institute of Technology (MIT) and attain recognition for his innovations in teaching mathematics as well as for having founded the Mathematics Department at the Faculty of Philosophical Sciences in 1939. The other fellowship recipient was the young neuropsychiatrist Arturo Rosenblueth Stearns, who was supported by Ocaranza and Zozaya in applying for work with Walter B. Cannon, the head of the Physiology Department of Harvard Medical School and the most well-know US physiologist at that time.

In the fall of 1930, Rosenblueth entered the physiology laboratory at Harvard and began to work intensely, with a high level of scientific productivity and enormous initiative and skill to learn and perform experimental research. A detailed review of his work shows that his scientific production at Harvard Medical School was immense, not only in terms of the number of published articles—eleven as a Guggenheim fellow, and eighty as a member of the school's Physiology Laboratories—but also in the way these studies were produced.

Besides his fourteen publications as sole author, Rosenblueth produced thirteen with Dr. Walter B. Cannon (including a monograph) as well as "Behavior, Purpose and Teleology" with Norbert Wiener and Julian Bigelow, recognized as the first article of cybernetic science.⁸ Rosenblueth also signed studies with thirty-six different collaborators, and was the primary author of thirty-five papers out of a total of 59.

Although most of the studies were produced by Rosenblueth with researchers assigned to the physiology department laboratories of Harvard Medical School, he also produced, between 1932 and 1936, seven articles with scientists from the departments of anatomy, neuropathology and fatigue, as well as the department of bacteriology and immunology of the same school; three of these scientists were supported by the National Research Council.

Rosenblueth was recognized as an excellent educator of innumerable physiologists, although criticism of his lack of patience was never lacking.⁹ He signed eighteen publications with thirteen scholarship recipients from prestigious institutions and societies, including the American Physiological Society, the Rockefeller Foundation, the John Simon Guggenheim Memorial Foundation, Harvard University's national scholars, the Belgian-American Educational Foundation, the Peiping Union Medical College of China and Chile's Universidad Católica. In addition, Arturo Rosenblueth appears as an author from Harvard University in various international journals.

Cannon was recognized for his special interest in promoting scientific research in various countries of Latin America, Europe, China, and the Soviet Union, and his laboratory received students and visitors from around the globe. Rosenblueth was responsible for training many of these students and worked jointly with others to develop experimental research in the laboratory. His publications include twenty that were developed with ten researchers from other nations.

The most well-known and polemical of these coauthors may be the Belgian Zenon M. Bacq. Although the two scholars published only one joint article (1934), they maintained a lengthy discussion on the “theory of sympathins”. Bacq’s disagreement with the theory did not limit the two men’s longstanding personal relationship.

The European researchers who published with Rosenblueth were René Gayet, the director of the laboratory of physiopathology at Collège de France, and Jean Antoine Reboul (two articles in 1939 and one in 1940); the Hungarian Kalman Lissàk (two articles in 1939 and one in 1940) and Finnish Per Olof Therman (1940). Rosenblueth is still recognized as an outstanding physiologist in China¹⁰, based on a text written in 1935 with researcher A.C. Liu.

It is worthwhile to look more closely at Rosenblueth’s coauthors in Latin America during his stay at Harvard Medical School. The first is Teodoro Schlossberg, an Argentine scholarship recipient of the Harvard Association who published his first research work in the United States with Rosenblueth in 1931: “The sensitization of vascular response to ‘sympathin’ by cocaine and the quantitation of ‘sympathin’ in terms of adrenin”, an article on sympathin, the substance “similar to adrenaline” that would interest him for the rest of his life.

In 1936, Rosenblueth published an article with the Mexico’s Teófilo Ortiz Ramírez, a Guggenheim fellow. He had worked with Rosenblueth for years at Instituto de Higiene de México and in 1945 would contribute to the creation of the physiology department at Instituto Nacional de Cardiología.

In 1937, a scholarship recipient at Chile’s Universidad Católica, Joaquín V. Luco, published for the first time with Rosenblueth, followed by two more occasions in 1939. That same year, two studies were published with Argentine Alfredo Lanari. Both of these Latin American researchers collaborated with Arturo Rosenblueth, Kalman Lissàk and Fiorindo Simeone in constructing the theory of nerve transmission that would be sustained by Cannon and Rosenblueth (Wolfe, *et al.*, 2000:416-419).¹¹

Another Mexican, Efrén del Pozo, coauthored five articles with Rosenblueth in 1942 and 1943. He enjoyed a tense but fruitful relationship with Rosenblueth in Mexico and in 1957 would spearhead, in the company of other outstanding physiologists, the foundation of Sociedad Mexicana de Ciencias Fisiológicas. A student first of José Joaquín Izquierdo and then of Cannon as a Guggenheim fellow (1940-1943), Efrén worked in later years at Escuela Nacional de Ciencias Biológicas and Instituto de Enfermedades Tropicales, and participated in founding Instituto de Estudios Médicos y Biológicos at UNAM (currently Instituto de Investigaciones Biomédicas). This controversial scholar also filled the position of Secretary General at Universidad Nacional Autónoma de México in 1958, during the times of Nabor Carrillo (Aréchiga, 1988:79-107; Castañeda, 2005:76-79).

The magnitude of Arturo Rosenblueth’s work at Harvard Medical School can also be appreciated through the trajectories of the scientists who worked with him. He published an article in 1932 with Philip Bard, who would serve as the vice president (1957-1959) and president of John Hopkins University (1959-1961). Rosenblueth co-authored five papers with Robert S. Morison, first the director of Medical and Natural Sciences at the Rockefeller Foundation, and then the head of the Biology Division at Cornell. He also worked with George H. Acheson, a friend from his first year at Harvard Medical School and later the head of the pharmacology department of the medical school at the University of Cincinnati, in Ohio¹² (Rockefeller Foundation, 1961, Zottoli, 2001).

Rosenblueth also wrote with Alexander Forbes (1933 and 1935) and Davis Hallowell (1935 and 1936), both considered, along with the Mexican physiologist, the most outstanding collaborators of Walter B. Cannon (Beecher and Altschule, 1977 and Wolfe, *et.al.* 2000). Not taken into account here are Rosenblueth’s unpublished papers and his teaching work at Harvard Medical School, where he guided students in bibliographical reviews, experimentation and laboratory work, as well as exercises directed to publication. It is also of interest to note that of his total production, 76

articles were published in the *American Journal of Physiology* and thirteen in other journals (nine US journals, two French journals, and two from Mexico).

In addition to his enormous scientific productivity, Rosenblueth was in charge of acquiring equipment and inputs for experimental work. In certain cases he was also responsible for finding professors to teach subjects at the medical school. He organized periodical work sessions with the researchers assigned to his laboratory and followed up on the progress of each collaborator's experimental work, conferences, and articles. Rosenblueth was interested in operating new teaching strategies that would allow students to develop their scientific skills fully (WBCA, IC 1930-38, 1935).

From the moment of his arrival at the Harvard Medical School physiology laboratory in the fall of 1930, Rosenblueth returned to the research begun by Cannon and Bacq on the substance they called "sympathin" and described as "adrenaline-like". According to the experiments carried out in 1921 by Cannon and Uridil and in 1922 by Cannon and Griffith, sympathin provoked a stimulating and inhibiting response.

According to the hypotheses that Cannon and Rosenblueth constructed between 1931 and 1933 and which they would sustain for the rest of their lives, sympathin was defined as: "adrenaline modified in one or two directions in ways at the effectors where it is liberated; one of these changes results in a substance (sympathin E) which exerts an excitatory action, the other leads to the production of an inhibitory substance (sympathin I)" (Rosenblueth, 1950: 4).¹³

According to Cannon and Rosenblueth, sympathin had inhibiting effects in some cases (sympathin I) and stimulating effects in others (sympathin E). They called this assumption the "Theory of sympathins", which sustained that nerve transmission did not have an electrical nature, as suggested by John Eccles and his collaborators, but was of a chemical nature. Zenon M. Bacq was firmly opposed to this theory, as expressed in the exchange of letters between the Belgian physiologist and his teacher, Walter B. Cannon. May 11, 1933, was the date of publication in the *American Journal of Physiology* of "Studies on conditions of activity in endocrine organs. XXIX. Sympathin E and Sympathin I", the first of several documents with such ideas by Cannon and Rosenblueth—ideas supported by experimental work on various animals, but never proven. The theory of the two sympathins was a controversial proposal that enormously encouraged scientific research to prove as well as to criticize the theory. It gave rise to ample discussion in the most important physiology journals of the times and at diverse academic encounters centered on the topic.

In 1937, supported by Dr. Richard M. Pierce of the Rockefeller Foundation, Cannon and Rosenblueth published their theory of nerve transmission in the first monograph that they wrote together: *Autonomic Neuro-Effector Systems*. Some authors attribute this research work to Cannon's candidacy for the Nobel Prize in Physiology or Medicine in 1935, 1936 and 1937, nominated by Hamilton first, then by Minot, Smith and Sachs, and on the third occasion, by Burwell and Houssay. However, other voices claim that Cannon did not receive the Nobel Prize precisely because of the work completed with Arturo Rosenblueth and particularly because of the complexity of the theory of sympathins (nobelprize.org, 2008a; Beecher and Altschule, 1997; Valenstein, 2005).¹⁴

It should be pointed out that when Otto Loewi and Henry Dale received the Nobel Prize in 1936, they mentioned the discoveries of Cannon and Rosenblueth in their respective readings. John Eccles continued to sustain a discussion with both of them. Decades later, Eccles assumed some of their proposals and demonstrated that nerve transmission has a physical as well as chemical nature—a discovery that earned him the Nobel Prize in 1963 (Loewi, 2008; Dale, 2008; nobelprize.org, 2008b).¹⁵

Besides his laboratory work, Arturo Rosenblueth organized monthly meetings with some of his collaborators to discuss the scientific method; scientists from various disciplines, from both Harvard and MIT joined the group. The meetings were held in the dining room of Vanderbilt Hall, which still houses students at Harvard Medical School. An outstanding member was Walter B.

Cannon, in his younger years the head of a similar discussion group known as “the witch club”. Another assiduous member of this “club of the philosophy of science” was the prestigious mathematician, Norbert Wiener; in the introduction to his book, *Cybernetics*,¹⁶ published in 1948, Wiener would describe the nature of the discussions held each month in Vanderbilt Hall, describing them as the place his ideas on cybernetics gestated:

In those days, Dr. Rosenblueth [...] conducted a monthly series of discussion meetings on scientific method. The participants were mostly young scientists at the Harvard Medical School, and we would gather for dinner about a round table in Vanderbilt Hall. The conversation was lively and unrestrained. It was not a place where it was either encouraged or made possible for anyone to stand on his dignity. After the meal, someone—either one of our group or an invited guest—would read a paper on some scientific topic, generally one in which questions of methodology were the first consideration, or at least a leading consideration. The speaker had to run the gauntlet of an acute criticism, good-natured but unsparing. It was a perfect catharsis for half-baked ideas, insufficient self-criticism, exaggerated self-confidence, and pomposity. Those who could not stand the gaff would not return, but among the former habitués of these meetings there is more than one of us who feels that they were an important and permanent contribution to our scientific unfolding (Wiener, 1985:13).

Those meetings, a reflection of Rosenblueth’s severity in discussions and his passion for the scientific method, were the birthplace of a friendship and joint reflection on science that would last until Norbert Wiener’s death in 1964.

Within the framework of World War II, the United States encouraged projects directed to the detection of enemy ships, submarines, and aircraft. Norbert Wiener was asked to research the downing of fighter planes. Wiener participated as mathematician, Julian Bigelow as engineer, and Arturo Rosenblueth was invited to represent the perspective of neurophysiology. The aim was to build “a model of the machines’ behavior” similar to that of animals, “from the perspective of intentionality”. The three scientists:

[...] examined the characteristics of the intentional behavior, indicating the conceptual differences between it and unintentional behavior. In their opinion, behavior is not hazard but often has a purpose; i.e., intentionality. [In their argument] the notion of feedback that Rosenblueth began to work on with his teacher, Walter. B. Cannon, in the 1930s on researching the problem of homeostasis [a central concept] permits the comprehension of multiple problems, such as the integration of movements, or the organism’s relation with its surroundings (Rudomín and Guzik, 2005, ix-x).

As a product of this work, Rosenblueth, Wiener and Bigelow published “Behavior, purpose and teleology” in the January, 1943, edition of *Philosophy of Science*, considered by many authors to be the primary text of cybernetic science.

In May of 1942, Cannon apologized for his inability to attend a meeting at the Josiah Macy Jr. Foundation to discuss cerebral inhibition. He recommended that Dr. Arturo Rosenblueth take his place by presenting the results of his work with Wiener and Bigelow, before the work was published.

The attendees included neuropsychiatrist Warren McCulloch and psychologist Lawrence Kubie, who were interested in constructing engineering devices that would respond to a model of human behavior; anthropologist Margaret Mead, psychologist Gregory Bateson, and sociologist Lawrence K. Frank, who were working on the relations between people and the environment. The participants listened with enthusiasm to the ideas of feedback and circular causality that Rosenblueth expressed. They considered their own projects, and promised to continue working on the topic at the end of World War II, with financing from the Macy Foundation. Meetings were in fact held from 1946 to 1953, and over time became the basis for the “Cybernetic Group”.¹⁷

Rosenblueth's intense, complex, and rich work at Harvard Medical School was never supported, however, by stable working conditions. His salary came from the tutoring budget, implying his classification as a non-permanent worker and a low income. He was thus forced to work at other universities, such as Cambridge, where he was an instructor in Biochemical Science (WBCA, IC 1939-44, 1943).

The search for an established position that would allow him to continue his research in physiology in the United States was very important for Rosenblueth, as well as for his teacher. We can read, for example, that in 1933, Dr. William C. Rose asked Cannon to recommend candidates for a position in the physiology department at the University of Illinois in Urbana. In response, Cannon supplied the names of four people. The last name he mentioned was Arturo Rosenblueth:

Still another person you might wish to consider is Dr. Arturo Rosenblueth. Dr. came to this department about three years ago as the holder of a Guggenheim Fellowship from Mexico. His mother was an American. He received his medical education in France and later studied in Germany. He speaks Spanish, French, and English with fluency and exactness. Since coming here he has shown extraordinary capacity for investigative work. A review of the volumes of the American Journal of Physiology during the past two or three years will show you how productive he has been. I regard him as unusually capable person. This year he is serving as Research Assistant and also as a tutor in the Biochemical Sciences in Cambridge. He has married a Radcliffe graduate and has the intention of continuing his scientific career in the United States. Of all four persons I have mentioned Dr. Rosenblueth has the best mental and technical equipment for research. He has presented before our colloquium the results of his researches and has done it extraordinarily well (WBCA, RA to WBC OR 1930-35, 1933).¹⁸

In response to this letter, Dr. Rose made the following observations:

As far as I can judge, the training and experience of Dr. Griffith would best meet our needs. Inasmuch as Dr. Burge will continue in the department, at least for a time, the new head should be somewhat older than Dr. Gregersen and Dr. Ring. Perhaps you can tell me whether Dr. Rosenblueth is a more mature individual. Also is he of Hebrew origin. Other things being equal we would prefer a gentile for the position. I shall appreciate it if you would kindly give me additional information concerning your estimate of Drs. Griffith and Rosenblueth which would you prefer for a position in your own laboratory? (WBCA, RA to WBC OR 1930-35, 1933).¹⁹

In response to this query, Cannon described Griffith and without alluding to Rose's mention of Rosenblueth's Jewish roots, he reiterates that "he has married a very charming American girl, Miss Thompson of Portland, Oregon, who graduated from Reed College and who at the time of her marriage was a graduate student at Radcliffe College." He also mentioned Rosenblueth's previous and current work, insisting on his intellectual abilities, indicating that even without the administrative experience of Griffith, Rosenblueth could be an ideal candidate for the position (WBCA, RA to WBC OR 1930-35, 1933).

Rose answered that for a month or more he would be unable to hire anyone, since the state legislature had not approved the university's budget, and that the reorganization of the physiology department would begin the following year.

The historical archives at Harvard Medical School contain other letters proposing Rosenblueth for the position of physiology professor at Cornell and at the Physiology Division of the National Health Institute in Washington, but Cannon was not successful in either case.

In April of 1934, Rosenblueth wrote to his teacher that during his last trip to Mexico, the Department of Public Health had offered him work as a researcher and physiology teacher in a laboratory that was well-equipped in spite of having a poor library. His salary would be fourteen thousand pesos a month, or four thousand dollars a year. The amount was similar to what he

earned in Harvard, “but [Rosenblueth added that] the cost of living in Mexico is a least one-third of what it is here [in Boston] and so the salary is proportionally higher” (WBCA, IC 1930-38). According to Benton (1987), this letter worried Cannon; supported by Hans Sinsson, he placed Rosenblueth in the highest category for tutors at Harvard Medical School.

Cannon’s biographers—Wolfe, Barger and Benison (2000)—criticize his anti-Semitic tone in the letters of recommendation he wrote for Jewish scientists, including those that refer to Rosenblueth. The position reflects a common practice in US higher education during the war years. Jews, like Rosenblueth, were hired for temporary positions and at times were prohibited from accepting additional employment (Graham, 1979 and Tenenbaum, 2003).

Adverse attitudes toward Mexicans in US universities prevail even today. The transcription of an interview with Dr. George W. Thorn in the early 1990s (1991-1993) in the framework of a series of interviews to safeguard the history of Harvard Medical School, refers to Rosenblueth as “that Mexican”. Dr. Thorn mentions him along with the Belgian physiologist Zennon Bacq, mentioning that Cannon always had the custom of hiring Mexicans (Thorn, 1993).

In spite of these circumstances, Rosenblueth’s work was rigorous and intense at all times. In 1941, when Cannon was requested to name a “skeleton crew” of researchers to confront the limitations of the wartime economy, Cannon selected Rosenblueth over Hallowell Davis, another major collaborator (Benton, 1987: 41).

In the early 1940s, Cannon began to plan his retirement as the head of the Physiology Department of the most important Bostonian university. According to various authors, his aim was for Arturo Rosenblueth to succeed him in the position.

Dr. Juan García Ramos translated into Spanish a letter Cannon wrote at the time he was beginning to think about his successor; the letter describes the work of the Mexican physiologist:

During the forty years I have served in the Physiology Department, I have known no other researcher who can compare to Dr. Rosenblueth in imagination, critical judgment, and in artistic feeling for the scrupulously supervised manipulation and registration of physiological processes. He has learned to write articles with notable exactitude of expression. In addition, Dr. Rosenblueth does the work with exceptional precision and economy of time. The result has been an entire series of excellent physiological discoveries that have been presented, with severe Laconism, in an important number of publications, without parallel in any laboratory in the country.

I am attaching a list of Dr. Rosenblueth’s publications during the eleven years he has been connected with the Department. You will notice that most have been the product of collaboration with other researchers. As a general rule, he has been the director of the research. If you would like more information about his qualities as a physiologist, I would suggest you consult with one of his collaborators, such as Morison, Rioch, Dempsey, Acheson and Simeone. Morison, Dempsey and Acheson are here (García Ramos, 1981:152).

In the same letter, Cannon indicated that another of Rosenblueth’s attributes was having worked with Latin American visitors, establishing important links between North American universities and those “south of the Rio Grande”. Cannon adds, “I do not believe that the Committee will consider Dr. Rosenblueth as my successor, primarily because of his foreign status and lack of administrative experience.” Yet Cannon suggests that he be retained in the laboratory: “His departure, in my opinion, would weaken the Department to a greater degree than the departure of any other department member. I hope he can be offered a permanent position” (WBCA, RA to WBC OR 1940-42, 1940).

Rosenblueth’s position in the laboratory, however, was complex as well as unstable. Besides numerous collaborators and friends, he had adversaries. Thus with the support of Cannon, Wiener, Moe and McCulloch, he began working to obtain employment that would allow him to continue his scientific research; his efforts intensified when he was notified that his contract would soon end

(WBCA, RA to WBC OR 1940-42 and NWP, Box 4). Out of various proposals, two created a dilemma. On one hand, Dr. Ignacio Chávez invited him to direct the Physiology Laboratory at Mexico's Instituto Nacional de Cardiología, soon to be opened. On the other, his friend Warren McCulloch invited him to work with him at the University of Illinois in Chicago, to continue studying the nervous system and machines in an attempt to define the scientific problem they share.

Pressured on one hand by the university's request to renounce his Mexican citizenship and become a US citizen, and on the other by a newspaper article published in Mexico that announced his appointment as the head of the nation's most important physiology laboratory, Arturo Rosenblueth accepted Chávez' offer and returned to his native country in the company of his wife, first having obtained approval from Instituto Nacional de Cardiología to invite both Cannon and Wiener to carry out joint research once the new institution opened. Rosenblueth left Harvard, but his return to Mexico opened the doors for North American researchers and foundations like the Rockefeller, Guggenheim and Grass foundations to broaden their proposals for scientific development in neuroscience in Mexico (Benton, 1987 and Cueto, 1990).

Several letters that Rosenblueth exchanged with Cannon and Wiener reveal the complex situation during his early years at Instituto Nacional de Cardiología, where he had to build a laboratory and undertake the difficult task of hiring and training technical personnel and researchers to work with him. Over time, however, his doubts dissipated as he came to hold an outstanding place in Mexican scientific development.

Supported by the Rockefeller Foundation and Dr. Ignacio Chávez, Rosenblueth worked for six weeks in his laboratory at Instituto Nacional de Cardiología with Walter B. Cannon. At the end of that period, Cannon was forced to return home because of the aggressiveness of the cancer that would soon take his life, in October, 1945.

On the request of Cornelia James, the wife of his dear teacher, Rosenblueth concluded Cannon's final monograph, *The supersensitivity of denervated structures. A Law of Denervation*. He published the article in 1949 with the support of the McMillan Company, and received credit for its authorship along with Cannon.²⁰ As a result of this work, the fifteenth issue of *Archivos del Instituto Nacional de Cardiología* (1945) published "Sensibilización de las neuronas espinales por denervación parcial" and "Los reflejos espinales extensores cruzado e ipsilateral", by Cannon, Rosenblueth and Juan García Ramos.

Shortly thereafter, financed by the Rockefeller Foundation, Norbert Wiener made working visits to Instituto Nacional de Cardiología while the Instituto sent Rosenblueth to work in the United States. The results of these encounters have been reviewed by numerous researchers and students around the world: "The role of models in science" (1945), "The mathematical formulation of the problem of conduction of impulses in a network of connected excitable elements, specifically in cardiac muscle" (1946), and articles coauthored with Walter Pitts and Juan García Ramos, "An account of the spike potential of axons" (1948) and "A statistical analysis of synaptic excitation" (1949).²¹ While at Instituto Nacional de Cardiología, Wiener wrote his most well-known work, which he dedicated to Rosenblueth: *Cibernética: o el control de la comunicación en animales y máquinas*.

Besides working with various North American researchers at Instituto Nacional de Cardiología, Rosenblueth continued to serve as an educator and collaborator of Mexican and Latin American scholarship recipients in physiology, including Joaquín V. Luco, Ricardo Mileli, Jesús Alanís, Rafael Rubio, Carlos Rodríguez, Guillermo Pilar, and Ramón Álvarez-Buylla, supported by institutions such as the Rockefeller Foundation, the United Cerebral Palsy Foundation, the Life Insurance Medical Research Fund, and Fundación Gildemeister in Chile. The results of the research were published in *Archivos del Instituto de Cardiología de México*, as well as in prestigious publications like *American Journal of Physiology*, *Archives Internationales de Physiologie et de Biochimie*, *Journal of Cellular and Comparative Physiology*, *Acta Physiológica Latinoamericana*, and *Gaceta Médica de México*.

As sole author, Rosenblueth published in *American Heart Journal*, *Circulation* and *Principia Cardiología* and the McMillan firm edited his last physiological monograph: *The Transmission of Nerve Impulses at Neuro-Effector Junctions and Peripheral Synapses* (1950)

Dr. Rosenblueth assumed a lofty position in Mexican and world science upon becoming a member of El Colegio Nacional (October 6, 1947), and receiving the National Prize in Science in 1964, in addition to many other distinctions. He was also known for encouraging the organization of Sociedad Mexicana de Ciencias Fisiológicas (1957), Instituto Nacional de Ortopedia, Instituto Nacional de Investigación Científica (now CONACYT), and other important groups for Mexico's scientific development.

In 1960, Rosenblueth was invited to create Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (now Cinvestav), which opened in 1963; the center's original design is still recognized for its underlying visionary, innovative nature. In this project, Rosenblueth crystallized his experience in scientific research and researcher training, and most particularly, the knowledge he gained by working with Walter B. Cannon and Norbert Wiener, major researchers of their times.

Arturo Rosenblueth died on September 20, 1970, months after seeing his final monograph in print: *Mente y cerebro: Una filosofía de la ciencia*, published by Siglo XXI in Mexico and by MIT in the United States. On January 7, 1974, Mexico paid tribute to one of its most distinguished citizens and on presidential decree interred his remains in Rotonda de los Hombres Ilustres at a ceremony attended by his widow Virginia Rosenblueth, with the strains of Beethoven in the background. José Adem offers the following description:

Arturo Rosenblueth was an extraordinary man of science of international prestige, a great philosopher whose work is just beginning to be known, a productive teacher who forged in our country an important school of physiology, and a brave promoter of scientific activity, who was able to influence in a substantial manner our structures of teaching and research (Adem, 1995:28).

Notes

¹ Interview with Roberto Casas, Alfonsina Casas and Gabriela Medina on May 30, 2003 (Tequisquiapan, Querétaro).

² Interview 1. Padre D. V., February 17, 2003 (Colegio Franco Inglés).

³ The annotations and typographical marks are by Siqueiros.

⁴ We must remember that during the early decades of the century, there was no secondary education.

⁵ Brackets by author. The titles in Spanish of Poincaré's work, reviewed by Rosenblueth, are *El valor de la ciencia*, *La ciencia y la hipótesis*, and *Ciencia y método*.

⁶ Translated into Spanish from the English text by Louisa Barclay Benton, who quotes Arturo Rosenblueth (Nov. 1957), "Palabras sobre Don Leopoldo Salazar Viniegra", *Semana Médica de México*: 183.

⁷ Marks and italics by author. Almost forty years later, *Brasserie Balzar* still exists at *49 rue des Ecoles*, 5e.

⁸ In Spanish, "Comportamiento, propósito y teleología", published in *Philosophy of Science*, January, 1943.

⁹ On the first position, see Juan García Ramos, 1971, and on the second, Louisa Barclay Benton, 1987.

¹⁰ Informal conversation with science historian Maruxa Armijo in September, 2007, when she returned to Mexico after speaking at a congress on the History of Science in China.

¹¹ In 1950, Luco and Rosenblueth published a paper written in the Physiology Laboratory at Instituto Nacional de Cardiología de México, in *Journal of Cellular and Comparative Physiology*.

¹² With Morison he published one paper in 1934, two in 1936, and two more in 1937; with Acheson he published in 1936, 1937, 1941 and 1943.

¹³ Translation into Spanish by the author of this article.

¹⁴ Cannon received five more nominations for the most important prize in physiological or medical research, from Went (1939), Christian, Cutler and Forbes (1940), De Aleida Prado, de Moura Campos, Favero, Gualberto and Locchi (1941), Loewi (1942 and 1945) and Bond (1945) (nobelprize.org, 2008a).

¹⁵ The Nobel Prize in Physiology or Medicine in 1963 was awarded to Eccles, Hodgkin and Huxley "for their discoveries of the ionic mechanisms in the excitation and inhibition of the peripheral and central portions of the nerve cell membrane" (translated into Spanish by the author of this paper).

¹⁶ The complete title is *Cibernética: o el control de la comunicación en animales y máquinas*.

¹⁷ For the origins and development of the cybernetic group, see Heims (1993).

¹⁸ Translation into Spanish by this author.

¹⁹ Translation into Spanish by this author.

²⁰ For information on the publication of this and other monographs by Rosenblueth, see Pablo Rudomín and Ruth Guzik, "Introduction" to the monographs of Rosenblueth, volume VI of *Obras de Arturo Rosenblueth*, published by El Colegio Nacional (currently being edited).

²¹ Some additional data on these articles can be consulted in Pablo Rudomín and Ruth Guzik (2005). The first was published in *Philosophy of Science*, the second in *Archivos del Instituto de Cardiología de México*, and the last two in *Journal of Cellular and Comparative Physiology*.

Bibliographical References

- Adem, José (1995). "Arturo Rosenblueth. El hombre", en *Arturo Rosenblueth. Obra científica*, México: El Colegio Nacional, vol. I, pp. 21-28.
- Aréchiga Uriástegui, Hugo (1988). "Contribuciones mexicanas a la fisiología", en Cuauhtémoc Valdez (coord.) y Guillermo Soberón, Jesús Kumate y José Laguna (comps.), Apartado III. "Fisiología", de *La salud en México: Testimonios 1988. Especialidades médicas en México. Pasado, presente y futuro*, tomo IV, vol. I, edición conmemorativa del 40 aniversario de la Organización Mundial de la Salud y Décimo de la Declaración de Alma-Ata, México: SS/ INSP/ El Colegio Nacional/ FCE.
- Bacq, Zenon M. and Arturo Rosenblueth (1934). "The action of calcium and potassium ions on the nictitating membrane. The adrenal medullae and non-pregnant uterus of the cat", *American Journal of Physiology*, number 108: 46-49.
- Beecher, Henry Knowles and Mark D. Altschule (1977). *Medicine at Harvard: The first 300 years*, New Hampshire: The University Press of New England and Hanover.
- Benton, Louisa Barclay (1957). "Palabras sobre don Leopoldo Salazar Viniegra", *Semana Médica de México*: 183.
- Benton, Louisa Barclay (1987). *Arturo Rosenblueth: success or failure? A consideration of the forces which lie behind "success" and "failure" in science through the biography of a Mexican neurophysiologist*, thesis at Harvard University.
- Bernard, Claude (1994). *Introducción al estudio de la medicina experimental*, col. Problemas Científicos y Filosóficos núm. 21, (introducción y traducción de José Joaquín Izquierdo, "Historia crítica de la vida y de los trabajos de Claude Bernard", 1942). México: UNAM- Coordinación de Humanidades y Facultad de Medicina.
- Cannon, Walter B. and Arturo Rosenblueth (1937). *Autonomic Neuro-effector Systems*, New York: McMillan.
- Castañeda López, Gabriela (2005), "José Joaquín Izquierdo en la creación del Departamento de Fisiología de la Facultad de Medicina", *Revista de la Facultad de Medicina* (México) UNAM, vol. 48, núm. 2, marzo-abril, pp. 76-79.
- Cinvestav (s/f) "40 años de física en el Cinvestav", available at: www.fis.cinvestav.mx/40.ps/arturorosenblueth&hL=e. (consulted: March 25, 2002).
- Cueto, Marcos (1990). "The Rockefeller Foundation. Medical policy and scientific research in Latin America: The case of Physiology", *Social Studies of Science*, vol. 20, number 2, May, pp. 229-254.
- Dale, Henry (2008) "Nobel lecture", available at: http://nobelprize.org/nobel_prizes/medicine/laureates/1936/dale-lecture.html (consulted: April 10, 2008).
- De Iceta, Mariano (reseñador) (1999). "Un intento de aproximación entre neurociencia y el psicoanálisis a propósito de la emoción (II): Conclusiones", *Neuro-Psychoanalysis: An interdisciplinary Journal of Psychoanalysis and the neurosciences*, vol. I, núm. 1, pp. 3-7.
- Diario Médico.com, "1913. El Nobel del año. Charles Robert Richet". La medicina del siglo XX", available at: www.diariomedico.com/medicinasiglo/nobel1913.html (consulted: May 28, 2004).
- Fournier, Raoul (1971). "Los años juveniles de Arturo Rosenblueth", *Revista de la Universidad de México* (México), vol. XXV, núm. 5, enero, pp. 13-16.
- Fraiman, Héctor D. (2000). "Precursores de la neurología Argentina y el mundo del siglo XIX", *Revista Neurológica Argentina*, vol. 25, núm. 1, pp. 1-16.
- García Ramos, Juan (ed) (1971). *Libro homenaje a Arturo Rosenblueth*, México: Cinvestav-IPN.
- García Ramos, Juan (1981). "Arturo Rosenblueth" en *Tres científicos mexicanos*, México: SEP-Setentas/Diana.
- Graham Synnot, Marcia (1979). *The half opened door. Discrimination and admissions at Harvard, Yale and Princeton, 1900-1970*, WestPoint: Greenwood Press.
- Heims, Steve Joshua (1993), *Constructing a Social Science for Postwar America. The cybernetics group. 1946-1953*, 2^a ed, Cambridge: The MIT Press.

- Loewi, Otto (2008) "Nobel lecture", available at: http://nobelprize.org/nobel_prizes/medicine/laureates/1936/loewi-lecture.html (consulted: May 10, 2008).
- nobelprize.org. (2008a), "The nomination database for the Nobel Prize in Physiology or Medicine, 1900-1951", available at: <http://nobelprize.org/nomination/medicine/nomination.php> (consulted: May 10, 2008).
- nobelprize.org (2008b). "Premio Nobel en fisiología o medicina otorgado a Sir John Carrew Eccles, Alan Lloyd Hodgkin y Andrew Fielding Huxley en 1963", available at: http://nobelprize.org/nobel_prizes/lists/1963.html (consulted: May 10, 2008).
- Ortiz Ramírez, Teófilo and Arturo Rosenblueth (1936). "The crossed respiratory impulses of the phrenic", *American Journal of Physiology*, number 117, pp. 495-513.
- Reboloso Gallardo, Roberto (2002). "Orígenes de la ciencia en Nuevo León". *Revista Ciencia, Universidad Autónoma de Nuevo León*, vol. v, núm. 1, enero-marzo.
- Rockefeller Foundation (1961). *The Rockefeller Foundation. Annual Report, 1961*, New York: The Rockefeller Foundation.
- Rosenblueth, Arturo (1950). *The Transmission of Nerve Impulses at Neuro-Effector Junctions and Peripheral Synapses*, New York and London: The Technology Press of MIT and John Wiley & Sons, Inc, and Chapman & Hall.
- Rosenblueth, Arturo (1969). "La investigación científica y la tecnología", *Pensamiento político II*, núm. 7, pp. 307-317, en Rosenblueth, Arturo (2005). "La investigación científica y la tecnología", *Obra filosófica*, t. 8, México: El Colegio Nacional, pp. 93-104.
- Rosenblueth, Arturo (1984). *Mente y cerebro. Una filosofía de la ciencia*. col. Filosofía, 7ª ed., México: Siglo XXI.
- Rosenblueth, Arturo; Norbert Wiener and Julian Bigelow (1943). "Behavior, purpose and teleology", *Philosophy of Science*, vol. 10, number 1, pp.18-24.
- Rudomín, Pablo y Ruth Guzik (2005). "Introducción a la obra filosófica de Arturo Rosenblueth", en *Obra filosófica*, vol. 8, México: El Colegio Nacional.
- SPP (1979). "Diálogo con la señora Virginia Thompson de Rosenblueth", *Comunidad informática*, México: Secretaría de Programación y Presupuesto/ Dirección General del Sistema Nacional de Información, núm. 2, diciembre, pp. 15-17.
- Siqueiros, David Alfaro (1987). *Me llamaban Coronelazo (memorias)*, col. Testimonios, 3ª ed., México: Grijalbo.
- Schlossberg, Teodoro and Arturo Rosenblueth (1931). "The sensitization of vascular response to 'sympathin' by cocaine and the quantitation of 'sympathin' in terms of adrenin" *American Journal of Physiology*, number 97, pp. 365-374.
- Tenenbaum, Shelly (2003). "The vicissitudes of tolerance. Jewish faculty and students at Clark University", *Massachusetts Historical Review*, vol. 5, available at: www.historycooperative.org/journals/mhr/5/tenenbaum.html (consulted: May 10, 2008).
- Thorn, George W. (1993). *George Widmer Thorn: Transcriptions of interviews sponsored by the Oral History Committee*, Harvard Medical School.
- Valenstein, Elliot. S. (2005). *The war of the soups and the sparks: The discovery of neurotransmitters and the dispute over how nerves communicate*. New York: Columbia University Press.
- Velasco Suárez, Manuel y Francisco Rubio Donnadiu (1993). "La neurología", en: Hugo Aréchiga y Juan Somolinos (comps). *Contribuciones mexicanas al conocimiento médico*. Edición conmemorativa del Quincuagésimo aniversario de la Secretaría de Salud. México: Academia Nacional de Medicina/Academia de la Investigación Científica/FCE, pp. 393-420.
- Wiener, Norbert (1985). *Cibernética: o el control de la comunicación en animales y máquinas*, Barcelona: Tusquets.
- Wolfe, Elin L.; A. Clifford Barger and Saul Benison (2000). *Walter B. Cannon, science and society*, Cambridge, Massachusetts and London: The Boston Medical Library in the Francis A. Countway Library of Medicine.
- Zottoli, Steven J. (2001). "The origins of the Grass Foundation", *Biology Bulletin*, number 201, October, pp. 218-226.

Archives

- Archivo General, Universidad Nacional Autónoma de México (EARS-AGUNAM), located at Instituto de Investigaciones sobre la Universidad y la Educación, UNAM.
- Archivo General, Universidad Nacional Autónoma de México (EARS-ADGP-AGUNAM). Dirección de Personal, UNAM.
- Walter B. Cannon Archive (WBCA). Francis A. Countway Library of Medicine. Rare Books and Special Collections.

Norbert Wiener Papers. MC22 (NWP). Institute Archives and Special Collection, MIT Libraries, Cambridge, Massachusetts.

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