

• SPECIAL ARTICLE ON HEALTH SCIENCES RESEARCH IN PUERTO RICO •

The Department of Physiology of the UPR-School of Medicine: History and Contribution to the Physiological Sciences in Puerto Rico 1950-2010

Nelson Escobales, PhD

In 1949, the creation of the University of Puerto Rico-School of Medicine required the recruitment of a group of faculty with expertise in the physiological sciences. The assembled group established the foundation for the Department of Physiology in the fall of 1950. Since then, the Department has made important contributions to the School of Medicine, the Medical Sciences Campus, and the University of Puerto Rico. These contributions include among others, participation in the educational programs in medicine, dentistry, and the biomedical sciences, the generation of knowledge in science through research in different components of the physiological sciences, and the development of researchers and academicians, many of whom have eventually occupied key positions in the UPR system and the private sector. Through the involvement of key faculty in the development of the MBRS-SCORE and RCMI Programs, the Department has made significant contributions to the infrastructure of the Medical Sciences Campus. Recently, the Department faculty was instrumental in the formation of the Puerto Rico Physiological Society to help promote education and research in the physiological sciences in Puerto Rico. Sixty years after its creation, the Department of Physiology is stronger than ever, and looks to the future with optimism, based on our learned experiences and our capacity to adapt in response to the evolving needs of research and education. [*PR Health Sci J* 2012;31:3-13]

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“Although the policy of trying to plan for the future is admirable, recent events have proven that it possesses the vagaries of a roulette wheel at Las Vegas. It is, of course, easier to look back and see where, when, and how we made our positive achievements and our mistakes, and try on this basis to prepare for future developments.” Selkurt, EE (1).

In his book *On Health in Puerto Rico* (2), Dr. Norman Maldonado, former President of the University of Puerto Rico and Chancellor of the Medical Sciences Campus, presented his personal construct and historical perspective of the developments of health care, medical education and practice, and public health in Puerto Rico. Of particular interest in this book is a brief description of the origins of the Department of Physiology in the 1950s. This was the time when the University of Puerto Rico-School of Medicine (UPR-SOM) opened its doors to the first class, which included Dr. Maldonado as one of its medical students. Sixty years later, “Building the Physiology Department in the 1950s” is the only published account on this subject.

Since its creation, the UPR-SOM Department of Physiology has played a critical role in the development of the physiological sciences in Puerto Rico. It was the first unit created on the island for medical and graduate education, and for biomedical research in this area. Indeed, departments of physiology in private institutions in Puerto Rico (Universidad Central del Caribe and Ponce Medical School) developed many years later (late 1970s) for the sole purpose of medical education. In recent years, however, these schools have also established research and graduate programs in the biomedical sciences that are contributing to further develop the physiological sciences in the island.

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The information that follows provides a description of the development of the UPR-SOM Department of Physiology based on Dr. Maldonado's book, UPR-SOM and Departmental annual reports since 1950, and my experience in the unit since 1977. The description is presented by periods of time that characterized major transitions in the growth and progress of the Department, and for each time period, its directors and faculty with primary appointments, and the most significant accomplishments. To simplify the presentation, some time periods have been rounded-up to indicate full years. For example, Dr. Escobales' tenure is started in 1997, although he was actually appointed in the summer 1996. Similarly, Dr. F. Vargas' tenure is started in January 1980, although he was appointed later in the year. The Vital Statistics section provides a measure of academic productivity (i.e. articles published and grant dollars generated, both of which are estimates based on faculty annual reports, and students trained and degrees awarded) by Departmental faculty since 1950.

The data presented here allow us to conclude that since its creation, the Department of Physiology has contributed significantly to the mission, growth, and development of UPR-SOM. The Department has also played a vital role in developing the physiological sciences in Puerto Rico, and has contributed significantly to the generation of our knowledge in physiology through research. Sixty years after its creation, the Department of Physiology is still evolving and continues to play a pivotal role in medical education and scientific research for the benefit of our society.

The Early Years

Drs. Roger Reinecke, Carmen B. Casas, Ramón Torres-Pinedo : 1950-1973

The origin of the Department of Physiology dates back to 1949, when the UPR-SOM was authorized by law. The first medical class was admitted in 1950. The creation of the Graduate School, however, had to wait until 1960, when the Superior Council of Education of the University of Puerto Rico approved the graduate programs in anatomy, biochemistry and nutrition, medical zoology, microbiology, and physiology. The mission of the basic science departments was to teach medical students, with research as an important, but secondary, goal.

Initially, pharmacology was combined with physiology in the Department of Physiology and Pharmacology. The founding chair of the Department of Physiology and Pharmacology was Dr. Roger M. Reinecke (Figure 1), MD, PhD, University of Minnesota, who chaired the Department from 1950 to 1963. He was probably recruited by Dr. Harold W. Brown, who gathered the initial faculty of the UPR-SOM in 1949 (3). Dr. Reinecke worked on the design and operation of an artificial kidney and thus, was a pioneer in this area. He also evaluated the arteriovenous difference of glucose in the

dog kidney, demonstrating the *in vivo* capacity of the organ for gluconeogenesis. He was responsible for the teaching of neurophysiology, nerve conduction, and action potentials to medical students. In his book *On Health in Puerto Rico* (2), Dr. Maldonado indicates that in his initial years as a medical student (1956), eighty percent of the class failed Dr. Reinecke's first exam. Apparently, his didactic style and exam evaluations caused major difficulties for medical students. However, learning physiology has remained challenging for students everywhere to this day (4-5).



Figure 1. Original members of the Department of Physiology. Seated from left to right: Drs. Roger Reinecke, Agustín Fernández, and Carmen B. Casas. Standing: Dr. Andrew Maretsky, Dr. Conrado Asenjo and Dr. Jesús Santos-Martínez. Drs. Maretsky and Asenjo were actually members of the Department of Biochemistry. The group was the MS Thesis Committee of Mr. Fernandez, 1964.

The faculty of the Department in those early years (1950-1952) included Carmen B. Casas, PhD, University of Minnesota, who studied cardiovascular physiology, and David B. Tyler, a PhD in Pharmacology, who investigated naturally occurring inhibitors and lysins in tissues. Also on the faculty were Richard R. Bobb and Ralph J. Lum, Assistant Professors of Physiology and Pharmacology, respectively. In 1953, Dr. Bobb left the institution and was replaced by Dr. Franklin E. South, who studied the effect of inert gases on tissue metabolism. Dr. South left the institution in 1954.

The first reference to separate Departments of Physiology and Pharmacology is found in the annual reports of the UPR-SOM for 1954-1955 (Medical Sciences Campus, Library). The Department of Physiology was chaired by Dr. Reinecke, and Dr. Tyler was appointed head of the Pharmacology Department. There is no specific reference in the reports to the administrative decisions that lead to the departmental split. It is possible that the creation of separate departments resulted from a recommendation by an Evaluating Commission of the Association of American Medical Colleges, who regularly

visited the UPR-SOM in those early years. The faculty of Physiology at that time was composed of only Dr. Reinecke and Dr. Casas.

In 1956, Jesús Santos-Martínez, PhD, Purdue University, and a member of the UPR School of Pharmacy faculty, joined the Department of Physiology. He later completed postdoctoral studies with Ewald E. Selkurt at Indiana University. Dr. Selkurt, a well-known renal physiologist, held a Visiting Professorship in the UPR-SOM Department of Physiology in 1968, and became the 49th President of the American Physiological Society in 1976. Dr. Santos-Martínez is the only surviving faculty from those early years.

By the end of 1958, the research program continued to develop with the inclusion of Pura Suarez-Roldán, MD and Lloyd A. Le Zotte, PhD as Research Associates. In addition, student training was initiated through the involvement of several medical and dental students in the research projects of Drs. Reinecke, Casas, and Santos-Martínez. Two of these students were Dr. Ibrahim Pérez (1958) and Dr. José M. Saldaña (1962).

Funding for research during those early years (\$164,815 from 1950-1960) was provided by the National Institutes of Health, the National Cancer Institute, the pharmaceutical industry, and the Puerto Rico Heart Association. The faculty published five manuscripts and gave thirteen presentations at national meetings.

In 1963, Ian F.S. Mackay, MD, Royal College of Surgeons in Ireland, and PhD, University of Manchester in England, joined the Department. Dr. MacKay was an active, NIH funded, investigator who worked on the physiology of circulation. He was also recognized as an excellent illustrator and painter. Dr. Mackay was previously (1957) a Visiting Professor in the Department through a faculty exchange program with the University College of the West Indies in Jamaica. Dr. Reinecke and Dr. Casas also participated in this exchange program. Dr. Reinecke recruited Alejita Firpi, MS, Duke University, as a faculty member. Professor Firpi who had been Reinecke's research assistant since 1952, eventually taught physiology to dental students.

In 1963, Dr. Reinecke resigned his chairman position, and Dr. Casas became the first Chairwoman of the Department. She recruited Eugene Crichlow, PhD, a neurophysiologist from the University of Washington, and Pura Suárez Roldán, MD, University of Puerto Rico, who completed her PhD at Ohio State University. Dr. Suárez Roldán conducted research in cardiovascular physiology. Dr. Casas also recruited two physiology doctoral students: Mr. Orlando Rendón, MS, and Agustín Fernández, MS. Both Rendón and Fernández completed their PhD degrees in the Department (see Table 1). Dr. Casas directed the Department until 1966, when Ramón Torres-Pinedo, MD, University of Madrid, was appointed Chairman. At the time, Dr. Torres-Pinedo was a pediatrician

Table 1. Graduate Students Completing Degrees 1960-2011.

Student	MS	PhD
Agustín Fernández Quintana	1964	1968
Pieter van Loon	1968	1977
Brunilda Pacheco Adam	1971	
Orlando R. Rendón		1972
Aurora P. Llopart	1977	1981
Emma Fernández Repollet	1977	1979
Celso A. Rivera	1978	
Ana L. Figueroa	1979	
Fanny Blandino	1978	
Carmen Rodríguez-Sargent		1981
Rubén García García	1982	1988
Nelson Escobales		1982
Guido E. Santacana		1982
Amelia Rivera		1982
Lillian Lizardi	1982	1989
Ilva I. Sanabria	1983	
Lydia Hernández Rodríguez	1983	
Luis A. Capo Díaz	1983	
Mildred Morales	1984	
Delia M. Camacho		1986
Priscila Sanabria		1987
Carmen A. Juarbe	1986	
Legier V. Rojas		1987
María de Lourdes Philippi	1989	
Alicia Rivera Rodríguez	1989	
Marisela Bonilla	1990	
María Teresa Miranda		1990
Mildred Morales		1990
Miriam E. Rios Motta	1990	
Lisa Phyllis Rubero	1990	
Sara Ortíz Vega	1991	
María M. Pesquera	1992	
Orlando González	1992	2001
Maribel de Jesus	1993	
Grisel Ortíz Rivera	1996	
José A. Ramos	1996	
María M. Rivera Correa		1998
Marcos Vivoni	1999	
José J. Reyes Tomasini	2001	
Rhina M. Jiménez López	2001	
Jocelyn Montalvo	2002	
Marcelo Febo		2002
Anita Rivera Brown		2004
Carmen Aracelis Padró		2004
Lillian Cruz Orengo		2005
Johnny D. Figueroa Montiel		2006
Kandy T. Velázquez	2006	
Nildris Cruz Díaz	2007	
Karina Acevedo Torres		2009
Anabel Puig		2010
José García Colon		2010
Natasha Lugo Escobar		2011
Raissa Menéndez		2011
Ana E. Rodríguez Zayas		2011
Luz C. Arocho Martínez		2011
José M. Santiago Santana		2011
Laurivette Mosquera		2011

in the UPR-SOM Department of Medicine and University Hospital. He held the position of Departmental Chairman until 1973.

Dr. Torres Pinedo was an active researcher in gastrointestinal disorders of children. He published an average of three papers every year, reflecting his commitment to research. Dr. Torres Pinedo helped recruit Antonio Bonnet, PhD, and Francisco Alvarado, PhD, both from the University of Madrid. Dr. Bonnet worked in muscle physiology and Dr. Alvarado was



Dr. Ramón Torres-Pinedo

an active and established investigator in the area of membrane transport. Previous to their appointments in Physiology, Drs. Bonnet and Alvarado were researchers at the Institute of Neurobiology. Dr. Torres Pinedo also recruited Sixto García Castiñeiras, MD, University of Madrid, as an Instructor in the Department. He became a PhD student training under Dr. Alvarado. In 1974, Dr. García-Castiñeiras transferred to the Department of Biochemistry, where he completed the Ph.D. degree. He remains a faculty member at the UPR-SOM.

A notable recruit of Dr. Torres-Pinedo was James Keene, PhD, University of Michigan. Dr. Keene had a pleasing personality and offered exciting lectures on the complex topic of neurophysiology. He developed what was probably the most advanced laboratory for brain research in Puerto Rico at that time. In 1974, he received a grant (\$11,000) from Digital Equipment Co. to acquire a PDP-11 computer, which was the heart of his laboratory. The computer, used in the analysis of brain cell activity, was so bulky that it occupied much of his laboratory space. Dr. Keene maintained an active, NIH-funded research program, and helped train many graduate students throughout the years.

In 1971, Dr. Santos-Martínez left the department to join the faculty of the School of Dentistry owing to strong disagreements with Dr. Torres-Pinedo. Faculty that retired during that time period were Drs. Crichlow, Suárez Roldán, Fernández, Rendón, MacKay, and Casas.

By the end of 1973, the Department of Physiology was organized around 10 faculty positions. Research Funds (Annual Direct Costs: ADC) from 1960 to 1973 totaled \$397,801 and 80 manuscripts were published by the faculty. The first graduate students to complete Degrees in the Department were Agustín Fernández, MS 1964, PhD 1968 and Pieter van Loon, MS 1968 (see Table 1). Two additional students completed degrees (1 MS and 1 PhD) for a total of four graduates during this time period. In summary, Drs. Reinecke, Casas, and Torres-Pinedo played crucial roles in building the framework of the Department in those early years.

Development

Dr. Manuel Martínez-Maldonado, 1973-1979

In 1973, Dr. Manuel Martínez-Maldonado, Chief of Medical Services at the Veterans Hospital in San Juan, was appointed Acting Director of the Department of Physiology. Dr. Martínez-Maldonado was an active and established investigator in the area of renal physiology, where he made important contributions. His research program was funded by the Veterans Administration Center and the NIH. Dr. Martínez-Maldonado served on several Editorial Boards of prestigious journals and was a Scientific Reviewer for the National Science Foundation.



Dr. Manuel Martínez-Maldonado

Dr. Martínez-Maldonado contributed to the further development of the Department and its graduate program. He recruited a group of recently graduated scientists: Susan C. Opava, PhD, University of Michigan, who studied renal physiology and played a key role in the development of the Research Centers in Minority Institutions (RCMI) Program on the Medical Sciences Campus; Louis Kent Stitzer PhD, University of Michigan, who conducted research on endocrinology; Pieter van Loon, PhD, who completed his doctoral studies in cardiovascular physiology in the Department, and Mario Altamirano, MD, University of Chile, who studied gastrointestinal physiology.

Another recruit of Dr. Martínez-Maldonado was Jaime Bernstein, a PhD in Pharmacology from the University of Toronto. He contributed research in the area of ethanol metabolism in the liver and trained various physiology students, including Dr. Guido E. Santacana and the author. Dr. Bernstein, considered by his peers as a bright and eloquent individual, was involved in controversies with both faculty and medical students, and was highly critical of the UPR-SOM's policies on curricular reform and of medical student performance, based on both internal and external evaluations.

Conchita Zuazaga, PhD, University of Minnesota, was granted an Instructor Ad Honorem position in the Department while she conducted post-doctoral studies on membrane excitability at the Institute of Neurobiology. During this period, and with the availability of new research laboratories and faculty, the graduate program of the Department strengthened. Indeed, by the end of 1979, twenty students were registered in the Department's graduate program.

The medical physiology course, part of the integrated curriculum of those days, was challenging not only for first year medical students, but also for graduate students who were required to take it as the basic physiology course. The

course was both intense and comprehensive, but examinations were difficult, in terms of their construction and the inherent complexity of the subject. Not surprisingly, failure rates were high and, with an open policy to discuss the results of exams and its questions with the class, major debates and arguments between students and faculty ensued. The negative atmosphere created in those harsh sessions became the theme of discussions for curriculum committees and faculty meetings, and in the opinion of the author, contributed for many years to the adversarial environment among the School Administration, faculty, and the Department of Physiology.

Several efforts were made to recruit a full-time Departmental Chairman, but without success. In 1979, Dr. Martínez-Maldonado resigned from his position as Acting Chairman of the Department. Despite these problems, six graduate students completed degrees (5 MS and 2 PhD) from 1973 to 1979 (Table 1), research funds (ADC) totaled \$911,931, and 97 manuscripts were published.

Dr. Fernando F. Vargas, 1980-1986

Following Dr. Martínez-Maldonado's resignation, the Dean of Medicine Pedro J. Santiago-Borrero, appointed Dr. Jaime Bernstein as Acting Chairman. This appointment, however, was short lived (a few months), and he was succeeded by Dr. Lloyd A. Le Zotte, then Associate Dean of Biomedical Sciences. Dr. Le Zotte maintained the Acting Chairman position for several months.



Dr. Fernando F. Vargas

During this time period (1979-1980), Alberto Hugo Sillau, PhD, Colorado State University, and Conchita Zuazaga, were recruited as faculty members. Dr. Sillau conducted research on mitochondrial and capillary distribution in skeletal muscle, and trained many students.

Dr. Zuazaga was a neurophysiologist who maintained her research laboratory at the Institute of Neurobiology. Dr. Le Zotte also chaired the search committee that selected Dr. Fernando F. Vargas for the position of Chairman of Physiology in 1980. Dr. Vargas was a DDS from the University of Concepcion in Chile, and a PhD from the University of Minnesota. He was an established investigator who studied capillary transport and rheology. Dr. Vargas played a critical role in developing the Minority Biomedical Research Support (MBRS) Program at the Medical Sciences Campus. He recruited Alberto Politoff, MD, University of Chile, who performed research in neuroscience; Ian Hentall, PhD, MIT, with NIH-supported research in neurophysiology; and the author, a graduate of the Department (1982), with postdoctoral training in membrane transport from Harvard Medical School.

A notable recruit of Dr. Vargas in 1983 was Dr. Richard P. Durbin, a well-known and outstanding biophysicist, who contributed significantly to the field of ion transport by gastric mucosa. Dr. Durbin was a leader in the area of proton transport mechanisms. Unfortunately, he had an untimely death soon after joining the department. Dr. Reinecke retired from service in 1980, and Dr. Politoff resigned in 1985.

An important event during this time period was Dr. Opava being transferred, over her strong objections, to the Department of Pharmacology. This action aggravated many faculty issues that characterized the period. The state of affairs led to the termination of Dr. Vargas's administrative appointment in 1986, and contributed to a negative recruitment and training environment for graduate students.

By the end of this period, research funds (ADC) totaled \$640,552, 23 manuscripts were published, and 12 graduate students completed degrees (6 MS and 6 PhD).

Dr. Manuel Martínez-Maldonado, 1986-1988

In 1986, Dr. Manuel Martínez-Maldonado was reappointed as Acting Chairman by Dean Nydia de Jesus and, as a result, Dr. Opava was transferred back to the Department. This time period was characterized by faculty issues that played a key role in defining the administration of the Department. In 1988, Dr. Martínez-Maldonado resigned his position as Acting Chairman. By the end of 1988, research funds (ADC) totaled \$926,118, 20 manuscripts were published, and four students completed degrees (1 MS and 3 PhD).

Dr. Susan C. Opava, 1989-1994

The resignation of Dr. Martínez-Maldonado was followed by the appointment of Dr. Opava as Chairwoman. Dr. Opava was also serving as the Director of the RCMI Program, which she helped develop. She maintained an active federally funded research program in renal function and hypertension, and trained many students. She helped recruit Annabell Segarra, PhD, New York University, who is a researcher



Dr. Susan C. Opava

in neuroendocrinology, and Robert Furilla, PhD, University of British Columbia, with studied the regulation of respiration. Dr. Furilla played a major role in promoting the use of computer technology in physiological teaching and research. He obtained NSF support to study the regulation of ventilation and trained various students. Other recruits by Dr. Opava were Kenneth Gruber, PhD, New York University, who studied membrane transport and hypertension, and Jorge Valenzuela-Rendon, MD, University of Mississippi, who studied cardiovascular physiology. Both Dr. Gruber and Valenzuela, however, resigned their positions a few years after arriving. Additional faculty

members who resigned their positions during this time period were Drs. Vargas, Bonnet, and Keene in 1989 and Dr. Hentall in 1991.

Dr. Opava also strengthened the Department's collaboration with the Institute of Neurobiology in Old San Juan. This contributed to increasing the amount of Departmental research funds in that time period to \$3,158,201. A total of 14 manuscripts were published and 12 graduate students earned degrees (9 MS and 3 PhD, see Table 1).

Dr. Louis K. Stitzer - John G.H. Cant, 1994-1996

In 1994, Dr. Opava resigned as Chair to accept an administrative position at California Polytechnic State University, and Dr. Louis K. Stitzer was appointed Interim Chairman (1994-1995) by Dean Nilda Candelario. A search committee was appointed to recruit a new Departmental Chair. Following an administration change in the Deanship, new Dean Angel Roman Franco appointed Dr. John G.H. Cant, then Chair of the Department of Anatomy, as Acting Chairman of the Department of Physiology (1995). This action was taken to work with several curricular and faculty issues affecting the medical physiology program. Dr. Cant's appointment generated some controversy because it was perceived by the faculty as an effort to merge Anatomy and Physiology; a process that was also taking place in many schools on the mainland. The idea, however, never materialized.

Despite Dr. Cant's administrative experience, the state of affairs in the Department did not improve. In the opinion of the author, the most important factor responsible for maintaining the "status quo" was the reluctance of the faculty to support the necessary reforms. The state of apathy was due, in part, to the high turnover of Departmental Chairs, which resulted in a lack of effective supervision and direction. The time period was characterized, therefore, by Departmental instability, low productivity, poor course evaluations, and many faculty vacancies. The prevalent conditions of the Department also affected the graduate program to the point that few applications were received and the number of enrolled students decreased. The situation was so critical, that together with a group of our faculty (Drs. Sillau and Furilla) and Dr. Guido Santacana (Ponce School of Medicine), the author organized a course in comparative physiology that was offered to advanced biology students at the main UPR's campus in Rio Piedras. The course, which was offered voluntarily for various years, was an attempt to improve the department's image and recruit students to the graduate program.

Another critical area that was severely affected was the medical physiology course. The course, which defines to a great extent the teaching mission of the Department, was heavily lecture-based (>150 hrs) with a 30% failing rate. As a result, medical student evaluations of the course were very poor, forcing the Dean to meet regularly with the faculty to discuss the challenging situation. The coordination of the course was also a challenging task due to the refusal of some faculty members to contribute to

its overall administration, and to the management of its subareas (i.e. endocrine physiology) as separate courses. As a result, Dr. Cant resigned as Acting Chairman of Physiology in 1996.

Three faculty positions were vacant and only four out of seven faculty members were engaged in active research. Nevertheless, by the end of the time period (1994-1996) research funds totaled \$833,493, 26 manuscripts were published, and two graduate students completed MS degrees in Physiology.

Dr. Nelson Escobales, 1997-present

By 1996, all attempts to recruit an external Chairperson failed and with the resignation of Dr. Cant, Dean Roman Franco requested the author's help in directing the Department. The Departmental state of affairs was plagued with issues that required urgent solutions. Without previous administrative experience, the author accepted the Dean's petition to help improve the Department's operation. Three areas required immediate attention: 1), faculty recruitment for research, 2), the medical physiology course, and 3), curricular revision and promotion of the graduate program.



Dr. Nelson Escobales

The first recruitment of this period was Guido Santacana, PhD, University of Puerto Rico. Dr. Santacana's responsibilities included among others, the necessary update, restructuring, and coordination of the medical physiology course. With faculty collaboration, the number of contact hours was reduced by 50% and active learning experiences, with strong clinical correlations, were incorporated. Also, external evaluations were included, and recruits from the clinical faculty brought into the course. Today, the medical physiology course is rated as one of the best in the UPR-SOM, as gauged by student evaluations. Indeed, in the 2008 Medical School Graduation Questionnaire of the AAMC, our course was rated as Excellent or Good by 95.4% of the students. This result compares favorably with the 83.3% average rating of similar courses on the mainland. These results were significant because the improved ratings in the course occurred despite the requirements and standards remaining unaltered. It is also important to note that the medical physiology course was the first in the Basic Sciences Division of the UPR-SOM to be restructured in order to incorporate modern educational approaches. In addition to his contribution in medical education, Dr. Santacana contributed to research and student training in the area of airway smooth muscle physiology. In 2007, he was appointed Associate Dean for Academic Affairs of the School of Medicine, a position he holds.

Another faculty member recruited during this time period was Dr. María J. Crespo, who conducts research in cardiovascular pharmacology and physiology. Dr. Crespo

completed doctoral studies under the guidance of Dr. Walmor de Mello in the Department of Pharmacology at UPR-SOM and received postdoctoral training in the author's laboratory. She initially joined the faculty of the Pharmacology Department, but later transferred to the Department of Physiology. She has contributed significantly to the Departmental missions in teaching and research, including the coordination of courses, such as medical physiology (2007-2008). Dr. Crespo also has been coordinating the research program for medical students since 1997. Another member that joined the Department was Jorge Miranda, PhD, University of Florida, who had formal training in molecular biology and neurobiology. Dr. Miranda's research is in spinal cord injury focusing at potential repair mechanisms. He has trained several students from our unit and has contributed to the development of our graduate program. Dr. Miranda coordinated the medical physiology course (2009-2010), and is currently the Associate Dean for Biomedical Sciences of the UPR-SOM.

With the resignation and retirement of faculty during this period, (Drs. Sillau in 2000, Furilla in 2001, and Stitzer in 2004, and J. Bernstein in 2006), new faculty was recruited: Carlos Torres, PhD, University of Texas Medical Branch, studies molecular genetics and aging, Carlos Jiménez, PhD, University of New Mexico, investigates the neurophysiology of addiction, and Sabzali Javadov, MD-PhD, from the Russian Academy of Medical Science, studies cardiovascular physiology, and is the first faculty member in our Department to receive a full-time assignment for research. Walter Silva, PhD, New York University, studies the physiology of glial cells. Dr. Silva served as Associate Dean of Biomedical Sciences (2001-2010) and is the Director of the MBRS-SCORE Program (2003-present). He also holds the position of Associate Vice-President for Research and Technology in the UPR system (2010-present). Also in the department's faculty is Dr. A. Segarra, who has contributed significantly to the department through research in the area of neuroendocrinology and reproduction. She maintains an NIH-supported research laboratory and has trained many graduate students. Dr. Segarra also coordinated the medical physiology course (2011). Dr. C. Zuazaga retired in December, 2010.

In summary, as a result of the recruitment process initiated in 1997, all faculty positions remained occupied and new research laboratories have opened to provide new opportunities for graduate student training. Indeed, the Graduate Program in Physiology has increased to a current enrollment of 21 students (20 PhD/1 MS). Finally, the medical physiology course and the graduate program in Physiology have been revised and revitalized. From 1997 to 2010, the research funds received by the faculty of the Department amounted to \$13,142,309, and 183 manuscripts have been published. Research support was provided, among others, by NIH-NIGMS, NSF, SNRP and the Pharmaceutical Industry. Fifteen students completed degrees in Physiology (6

MS and 10 PhD) during this time period, and six additional students completed PhD degrees this year (2011).



Figure 2. The Puerto Rico Physiological Society (PRPS) honors Dr. Jesús Santos-Martínez with the Distinguished Service Award. From left to right: Dr. Norman Maldonado; Dr. Nelson Escobales, President of PRPS; Dr. Jesús Santos-Martínez; Dr. Martin Frank, Executive Director of the American Physiological Society; and Dr. Guido E. Santacana.

Joint Appointments

Although the Department of Physiology derived its strength throughout the years from its primary faculty, other faculty members with joint appointments have made important contributions to education and research in the Department. Among these have been Drs. Richard Orkand (deceased), Damien Kuffler, and Jonathan Blagburn of the Institute of Neurobiology. More recently, Pablo I. Altieri MD, from the Department of Medicine and Walter Frontera Roura, MD-PhD, from the Department of Physical Medicine and Rehabilitation, joined the faculty as joint appointees. Both Drs. Altieri and Frontera Roura maintain strong collaborations with the Department in the areas of cardiovascular physiology and exercise physiology, respectively.

Vital Statistics

Time Distribution of Faculty Academic Load

For 2009-2010, the faculty of the Department of Physiology invested 42%, 27%, 15%, and 16% of its time and effort in teaching, research, service, and administration, respectively. Therefore, the Department contributed to all areas of the academic load. The Department load includes a significant component of administration, which reduces the research productivity of the faculty. Indeed, 40% of our members have institutional administrative responsibilities, which is a higher load than that of any other department in the Basic Sciences. In the absence of new recruits for research, the administrative load is a burden that must be reduced to improve scholarly productivity of the Department as a whole.

Impact of the Department: Leadership and Administration

Since its creation, the Department of Physiology has contributed significantly to the institution and society. This is evidenced by the training of health professionals in Medicine, Dental Medicine, and Health Related Professions. The Department also has contributed to the institution and society through the training of scientists and professionals who have occupied important administrative positions. Table 2 shows physiology graduates who have occupied key administrative positions at the UPR system and private institutions. The point is illustrated by Dr. Emma Fernández-Repollet, a physiology graduate who held the position of Vice-President for Research and Technology in the UPR system from 2003–2009. Dr. Fernández-Repollet also has been directing the RCMI Program of the Medical Sciences Campus since 1994.

Table 2. Physiology graduates who have occupied administrative positions

Name	Position	Institution
Priscila Sanabria	Chairwoman-Physiology	UCC
Emma Fernández-Repollet	Former Vice-President for Res. & Tech.	UPR
Guido E. Santacana	Associate Dean of Academic Affairs, SOM	MSC
Delia M. Camacho	Former of Dean Academic Affairs	MSC
Ruben García	Former Assistant Dean of Academic Affairs	MSC
Nelson Escobales	Chairman-Physiology Department, SOM	MSC

Abbreviations: UCC, Universidad Central del Caribe; MSC, Medical Sciences Campus; SOM, School of Medicine

Table 3 shows the contribution of the physiology faculty to the operation of the UPR-SOM and the Medical Sciences Campus, as of 2010. It is of interest to note that two of the most important research programs on campus, MBRS and RCMI, were developed by physiology faculty (Drs. F. Vargas and S. Opava, respectively). This represents a significant contribution by Physiology faculty because these programs have been critical in developing the institutional research infrastructure since the mid-1980s.

Table 3. Contribution of Physiology Faculty to the School of Medicine (SOM), Medical Sciences Campus (MSC) and the University of Puerto Rico (UPR).

Name	Position	Unit
Maria J. Crespo	Coordinator, Medicine Research Program	SOM
Annabell C. Segarra	Director, Radiation Safety Committee	MSC
Jorge D. Miranda	Associate Dean of Biomedical Sciences	SOM
Nelson Escobales	Chairman, Physiology Department	SOM
Guido E. Santacana	Associate Dean Academic Affairs	SOM
Susan C. Opava	Developed RCMI Program	MSC
Fernando Vargas	Developed MBRS Program	MSC
Walter I. Silva	Former Assoc. Dean of Biomedical Sciences, Associate Vice-President of Res. & Tech.	SOM UPR

Graduate Degrees Awarded by the Department 1960-2010

Figure 3 shows the number of graduates from the Physiology Department since 1960. Fifty-eight degrees have been awarded from 1960-2010. Six additional degrees (PhDs) were awarded in 2011. From 1960 to the end of the 1990s, the majority of degrees awarded (27/44) were Master’s degrees. Since 2000, however, more PhD degrees have been awarded (15/20). Forty-five percent of our graduates serve in academia, 12% in post-doctoral positions mainly in the US, 8% in industry, and 7% in research related professions. Of the remaining graduates, 14% have continued with medicine or dentistry and a similar percentage are working in other professions. Therefore, our program has impacted a wide range of careers, leading with academia, science, and technology.

Grant Dollars Awarded to the Unit

Figure 4 illustrates the amount of funds reported by the Department since the 1950s (total of \$20,175,220). There is an increasing tendency in the funds received by our unit and for FY 2010 alone, \$1,345,892 were generated in annual direct costs.

The funds reported in this article do not include the contribution of Departmental faculty to institutional grant support [i.e. MBRS Program (Vargas), RCMI (Opava), Center for Molecular, Developmental and Behavioral Neuroscience-RCM (Zuazaga); Resource Center for Science and Engineering-UPR (Zuazaga), Medical Sciences Campus Research Development-RCM (Zuazaga), and SCORE Program-RCM (Silva)]. The involvement of our faculty in the development of these programs has generated over \$100 million in grant support for the UPR since the mid-1980s. Thus, the contribution of the Department to the institution throughout the years has been significant not only in terms of its academic mission, but also in the generation of funds supporting the infrastructure necessary for the current, highly competitive enterprise of research.

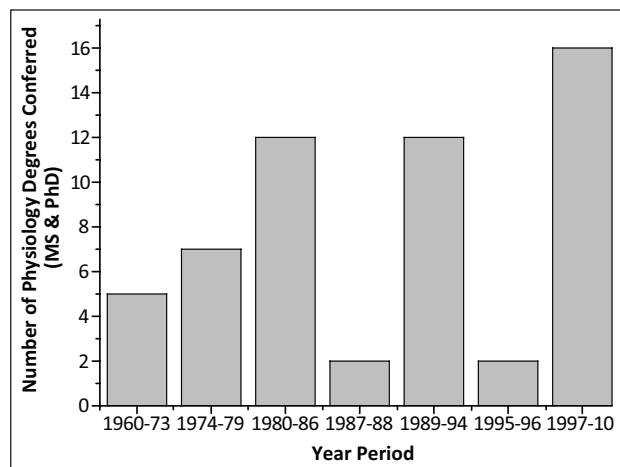


Figure 3. Physiology degrees conferred, 1960-2010. Source: School of Medicine and department records.

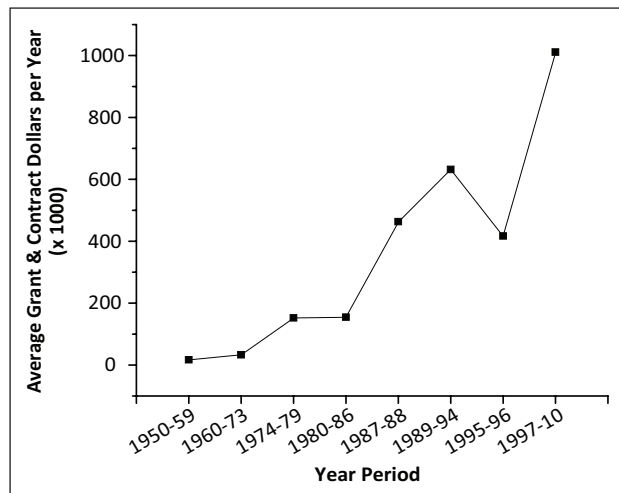


Figure 4. Trend in funds received (grant dollars/year) since 1950. Source: School of Medicine and departmental annual reports.

Scholarly Productivity by the Faculty

Figure 5 shows the scholarly productivity of the Physiology faculty. From 1997 to 2010 the Departmental faculty has published an average of 15 manuscripts per year. The publication rate for this time-period yields an average of 2 manuscripts per faculty, per year. When the whole period from 1950 to 2010 is considered, however, the publication rate averages 1 manuscript per faculty per year. This publication rate could be considered low, but must be analyzed in the context of the mission of the UPR-SOM, which traditionally has set research as a secondary goal. Also, for many years, the research environment lacked the necessary conditions for high productivity. Although significant progress has been made to improve the research environment in the past decade, room for improvement remains.

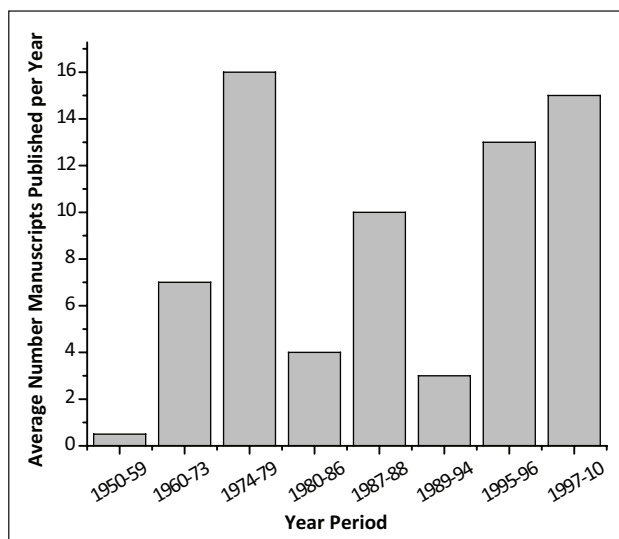
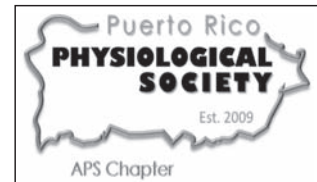


Figure 5. Scholarly productivity of the Physiology Faculty. Source: School of Medicine and departmental annual reports.

New Initiatives

The Puerto Rico Physiological Society (PRPS)

The Department of Physiology has been instrumental in the creation of the Puerto Rico Physiological Society. The PRPS is a non-profit organization created in 2009 under the auspices of the American Physiological Society (APS), with the intent of bringing together researchers, graduate and undergraduate students, as well as faculty involved in the physiological sciences in Puerto Rico. Its membership is diverse, with representation from all medical schools in PR, and several colleges and high schools. An important component of its mission is to promote physiological sciences on the island for scientific and educational purposes. Therefore, the Society is expected to contribute to the mission of the Department by developing the physiological sciences in Puerto Rico.



Puerto Rico Physiological Society logo.

With financial support from Pfizer Pharmaceuticals, in 2010, the Society conducted outreach activities in three high schools on the island. The schools visited were Manuela Toro Morice in Caguas, and Lino Padrón and Brígida Alvarez in Vega Baja. The PRPS impacted a total of 150 students with this initiative, which also integrated high school teachers. These activities were conducted by faculty and graduate students from the Physiology Department, and involved discussions and basic experiences in physiology for advanced science students. From the standpoint of the Department and the PRPS, this initiative is important because it contributes to science education and creates awareness of the field among potential scientists. It also provides graduate students with an opportunity to experience the teacher-student relationship, under supervision, and helps attract high quality students to the activities of our organizations.

On February 4, 2011, the PRPS and the UPR-SOM Department of Physiology sponsored the First Congress on Physiological Sciences in Puerto Rico (6). The activity was an excellent forum that helped advance education, research, and training in physiology. It also provided an ideal opportunity for networking among physiologists, faculty, and students in Puerto Rico. An important element of this activity was the recognition of Dr. Jesús Santos-Martínez with a Distinguished Service Award (Figure 2) for his outstanding career as an educator in the physiological sciences. Dr. Martin Frank, Executive Director of the American Physiological Society, participated in the ceremony.

Conclusion

Since its creation in the 1950s, the Department of Physiology (Figure 6) has contributed significantly to the mission, growth and development of the UPR-SOM. The Department has contributed to the generation of knowledge through research, in cardiovascular, respiratory, neural, endocrinological, renal,

gastrointestinal, muscular, cellular, and molecular physiology, and the physiology of aging. It has also contributed to the research infrastructure of the Medical Sciences Campus through the involvement of key faculty in the establishment of the MBRS and the RCMI Programs. More importantly, the Department has played a vital role in the development of the physiological sciences in Puerto Rico, through the training of researchers and academicians who have occupied key positions at the UPR and in private institutions. The creation of the Puerto Rico Physiological Society will support the Department's missions in education and research, and will foster the development of the physiological sciences on the island. It is expected that these contributions will continue unabated in the years to come ahead, as the Department meets the important challenges of the future.

Sixty years after its creation, the Department of Physiology of the UPR-SOM is stronger than ever and looks to the future with optimism based on its learned experiences and capability to adapt and change, in response to the evolving needs of research and education.

Resumen

La creación de la Escuela de Medicina de la Universidad de Puerto Rico en 1949 requirió una facultad con experiencia en ciencias fisiológicas. El grupo reclutado, estableció las

bases del Departamento de Fisiología en el otoño de 1950. Desde entonces el departamento ha realizado contribuciones significativas a la Escuela de Medicina, el Recinto de Ciencias Médicas, y la Universidad de Puerto Rico. Estas contribuciones incluyen entre otras, la participación en los programas educativos de medicina, odontología y las ciencias biomédicas, la generación de conocimiento en los diferentes componentes de las ciencias fisiológicas, y la formación de investigadores y académicos que han ocupado posiciones claves en el sistema de la Universidad de Puerto Rico y en el sector privado. El departamento también ha contribuido a la infraestructura del Recinto de Ciencias Médicas a través de la participación de facultad clave en la creación de programas institucionales como lo son el MBRS-SCORE y el RCMI. Recientemente, la facultad del departamento fue crítica para la formación de la Sociedad de Fisiología de Puerto Rico, fundada para promover la educación y la investigación en las ciencias fisiológicas en Puerto Rico. Sesenta años después, el departamento está fortalecido y mira al futuro con un optimismo basado en las experiencias aprendidas y nuestra capacidad para adaptarnos a las necesidades en el campo de la investigación y la educación.

Acknowledgments

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Figure 6. Department of Physiology 2010. From left to right - Standing: Miriam Castro, Sharon Fonseca, Iris Salgado, Jacqueline Andino, Gladys Santiago, Tania Ramos, Rebeca Núñez, Iris D. Rivera, Amarilis Torres, Joyce Velez, María Carolina Velázquez, Dr. Carlos Jiménez, María Vélez, Dr. Annabell C. Segarra, Bermery Santos, Dr. Jorge D. Miranda, Raissa Menéndez, Dr. Nelson Escobales, Giselle Barreto, Dr. Sabzali Javadov, Yaria Arroyo, Nildris Cruz, Dr. Carlos Torres, Dr. María J. Crespo, Dr. Walter I. Silva, Dr. Guido E. Santacana. Kneeling: Iván Vázquez, José Quidgley, Francisco Arrencibia, José M. Santiago, Odrick Rosas, Namyrt Martínez, Rafael Vázquez, Rebeca Parodi, Adlín Rodríguez.

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