

David Cardús (1922–2003), the physician of the space

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ON JUNE 1, 2003, DAVID CARDÚS, a Catalan physician and scientist who had lived and worked in the United States for almost 50 years, died in Spring, Texas. Trained as a cardiologist, Cardús conducted research in a wide array of medical fields, including the effects of gravitation on human physiology, spinal cord injury rehabilitation, respiratory physiology, aging, and the use of computational and mathematical systems to analyze biological data. Throughout his life, he maintained close ties with Catalonia and Catalan language and culture, working actively to ensure an awareness of both in the United States. The tenth anniversary of his death is a good opportunity to remember him not only as an outstanding physician and scientist, but also as a passionate advocate of the interests of his country.

David Cardús was born in Barcelona on August 6, 1922. He studied at the *Institut Escola*, a public school whose core values were mass literacy and equal access to education. In 1939, following the Spanish Civil War, he moved to France with his father—his mother had died in 1933. In 1942, after his graduation in Arts and Science (Physics, Chemistry and Mathematics) from the University of Montpellier, France, he returned to Barcelona, and he was forced to serve in the army for four years. Afterwards he studied medicine at the University of Barcelona, earning his M.D. degree in 1949. He did his internship at the Clinic Hospital of the University of Barcelona and completed his residency, from 1950 to 1953, at the private Sanatorium of Puig de l'Olena, in Sant Quirze de Safaja, a small village in the mountains, north of Barcelona. During that time, despite the recent availability of antibiotics to treat tuberculosis, mountain air was still considered curative of the disease and was a therapeutic option adopted by those families who could afford it. During his time at the sanatorium, Cardús met Joan Colomines Puig (1922–2011), a laboratory physician who familiarized Cardús with the Dubos and Middlebrook hemagglutination test in the diagnosis

of tuberculosis [1]. The Puig d'Olena sanatorium, which was in operation from 1933 to 1954, was more than a health center; it was a private hospital owned by Maria Plana, a woman who sympathized with Catalanists. Many of the people who had fled to France at the end of the Civil War but returned because the insecure conditions of German-occupied France, made a stop at Puig d'Olena before going to Barcelona. The sanatorium's patient population included intellectuals and artists, such as the painter Antoni Tàpies (1923–2012), the poet Màrius Torres (1910–1942), who died in the sanatorium, and the writer, literary critic, publisher, and editor, both in Catalan and in Spanish, Josep Maria Castellet. The above-mentioned physician Joan Colomines went on to become the author of poetry, plays, and essays, as well as a political activist, first clandestinely, during Franco's years, and later as a member of the Parliament of the Autonomous Government of Catalonia (*Generalitat de Catalunya*).

Political exiles tend to meet to maintain links to their countries and so did the Catalans in the countries that hosted them after the Spanish Civil War (1936–1939). In France, Cardús met Francesca Ribas, the woman he would marry. Her father, Francesc Ribas, had been a *Conseller* (Minister) in the Catalan Government during the Spanish Second Republic (1931–1939), and was the personal physician of the Catalan President, Lluís Companys, who was also an exile in France. (In 1940, Companys was arrested by the Nazi authorities and extradited to Spain, where he was accused by the dictatorship of *militar rebellion*; he was executed in Barcelona on October 15, 1940.) Once David Cardús and Francesca returned to Catalonia, she enrolled at the University of Barcelona, obtaining her M.S. in Pharmacy in 1956 and her Ph.D. in Pharmacy in 1960. That same year, the Cardús family moved to the United States. In Houston, she worked as a Research Associate at Baylor College of Medicine, a position she held from 1970 to 2000.



Fig. 2. Rotating platform used both in spacecraft, to reproduce gravity, and on Earth, to study the effects of greater or lesser gravitational forces on human biological functions.

Between 1953 and 1954, Cardús was in Paris, on a scholarship awarded to him by the French Government that allowed him to specialize in cardiology at the Bucicot Hospital and La Pieté Hospital. There, he published his first scientific article (see Bibliography at the end). He then returned to Barcelona to become certified in cardiology, at the University of Barcelona. In 1957, with a scholarship from the British Council, he moved to Manchester, UK, where he worked at the Royal Infirmary of the University of Manchester. From 1957 to 1960 he was a Research Associate in the Department of Physiology of the Lovelace Foundation for Medical Education and Research (currently, the Lovelace Respiratory Research Institute) in Albuquerque, New Mexico, USA. During the 1950s, the Lovelace Foundation had expanded the scope of its research and was the USA's premier center for research in aviation and space medicine, in the context of which its researchers had developed a protocol to test candidates for their fitness for space missions.

In 1960, Cardús settled in Houston, Texas, to work as a Research Associate at The Institute for Rehabilitation and Research (TIRR). He remained at the Institute until his retirement. During his tenure there he held various high-level positions, including Director of Research, Director of the Work Tolerance Laboratory, Director of the Cardiopulmonary and Vital Studies Laboratory, and Director of the Biomathematics Division. The TIRR is a teaching hospital of Baylor College of Medicine and the University of Texas Medical School at Houston, a leader in medical rehabilitation and research. Its roots go back to the Southwestern Poliomyelitis Respiratory

Center, set up in the early 1950s, when poliomyelitis was a devastating disease in the United States. With the introduction of the polio vaccine, the incidence of the disease decreased dramatically and the expertise and know-how of the center were subsequently applied to the rehabilitation of handicapped patients suffering from other disabling diseases and injuries.

In 1966, Cardús obtained a Ph.D. in mathematics at the University of Michigan-Ann Arbor. He had a great interest in mathematics and sought to establish a connection between the life sciences and mathematics. He emphasized the importance of quantitative measures in medicine and biology and the need to apply mathematical models to the study of cardiac function. Later, he became interested in computer science and its application to the life sciences. Cardús realized that physiological data, such as temperature, pulse, and respiration rate, if expressed as discrete data points, could be processed in a computer almost instantaneously. If the data could be entered into a computer in real time, biological functions and any related changes could be studied as they were happening. Cardús even set up a system that, at his office in Houston, allowed him to record and analyze in real time data from a person performing exercises in Barcelona. The results could then be transmitted and visually displayed in Barcelona [4]. It is clear from his bibliography that his interest in these methods stems from as far back as the late 1960s. By 1970, he and his collaborator Lawrence Newton had published a paper describing the development of a computer technique that allowed the transmissions and long-dis-

tance analysis of three analog signals: instantaneous air-flow, O_2 , and CO_2 .

In addition to his research and his clinical practice, Cardús pursued an academic career, not only at Baylor College of Medicine, where he had several appointments including Professor of Rehabilitation, of Physiology, and of Biomathematics, but also at Rice University, Houston, Texas, where he taught both mathematics and statistics. In 1970, he served as vice-chairman in the organization of a Gordon Conference on biomathematics. (The Gordon Research Conferences are prestigious scientific meetings with a long tradition; they were initiated in the 1920s to promote the exchange of ideas and knowledge at the research frontiers of the biological, chemical, and physical sciences.)

Both Cardús and Joan Oró—a Catalan biochemist who also settled in Houston [see *CONTRIB SCI* 2:579-594]—tend to be associated mainly with the work they did for the US National Aeronautics and Space Administration (NASA). However, the collaboration with NASA was only part of their research. Cardús studied the effects of weightlessness on the anatomy and physiology of astronauts. His early studies showed that a loss of gravity, such as experienced by astronauts in outer space, would compromise bone growth, muscle tone, fluid distribution, cardiovascular function, and other biological factors. Cardús searched for a method to counteract these effects, by simulating gravity inside the space vehicles. He invented the artificial gravity simulator (AGS), which consists of a short-radius rotating platform capable of producing a centrifugal effect on astronauts' bodies that replicates the gravitational effect humans experience on the Earth's surface (Fig. 1). That rotating platform has been used both in spacecraft, to reproduce gravity, and on Earth, to study the effects of greater or lesser gravitational forces on human biological functions.

In addition, Cardús applied his research to health problems common in the normal population. He considered human physical activity at three scales: (i) the capability of performing certain functions, (ii) the optimization of these functions depending on the individual's general health, and (iii) the adaptability of the individual to environmental changes. Based on these considerations, he used a short-radius centrifuge to study cardiovascular disorders in patients suffering from paralysis caused by spinal injury [3].

The scope of Cardús' medical interests went beyond the strictly scientific to include social aspects, to which he devoted significant efforts. He believed in medical progress based on the prevention of a disease rather than on its eradication after it had become established in the body. He found a contradiction in references by health managers to a "health system" given that what actually interested them was disease, not health. Similarly, he found the term "Health Center" a misnomer, and "Medical Center" closer to the true aim of

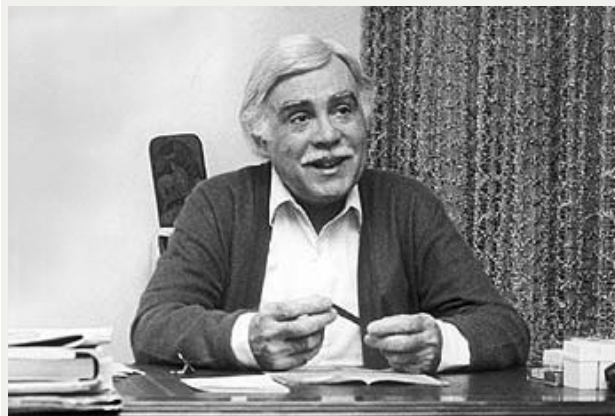
these institutions, since their focus was diagnosis and treatment rather than disease prevention [3].

The scientific output of David Cardús has been analyzed thoroughly by Jacint Corbella, in an article published in the journal of the Royal Academy of Medicine of Catalonia [2]. Corbella examined the production of Cardús, in terms of scientific articles indexed in Medline, regarding their distribution over time, the coauthors, and the topics of research. The 54 articles thus identified were published between 1965 and 1997, with the most productive year being 1967 (8 articles indexed). Wesley G. McTaggart and Carles Vallbona, Cardús' colleagues at Baylor College, were his most frequent coauthors. Vallbona was also a Catalan physician and was already working at Baylor College when Cardús arrived [6]. The subjects of Cardús research, as reflected in his publications, can be summarized as follows: the physiopathology of the blad-

Not in print

The achievements of great scientists are recorded in the articles and books they published throughout their careers. But this is not the case for many of their ideas and thoughts, unless they also published their memoirs or essays.

Despite having spent more than half of his life abroad, David Cardús maintained his ties to his homeland, Catalonia, as well as his love of its language and culture. During one of his stays in Barcelona, in 1995, he talked about language during a radio interview. In that interview he mentioned that a friend of his has sent him the *Dictionary of Catalan Language*, which had just been published by the Institute for Catalan Studies, in Barcelona. Cardús said that he appreciated that gift very much and would make good use of it; besides, he added, he always thought of his friend Ricard each time he used the *Dictionary*. It is a shame that, today, with the publication of dictionaries on line, this kind of personal connection has been lost. **R. Guerrero**



David Cardús (1922–2003), cardiologist.



Fig. 2. Francesca Ribas, Cardús widow, and Salvador Alegret and Ricard Guerrero in the Institute for Catalan Studies in 2005.

der; the effects of bedrest on various physiological functions; cardiac physiopathology and respiratory functions in people suffering from injuries of the central nervous system and the effects on respiratory functions; physical exercise and rehabilitation; spinal cord injury with respect to rehabilitation; public health; mathematics as applied to medicine; the simulation of changing gravity; and books on various topics, in which Cardús was either coauthor or an editor [2].

In 1979, Cardús and his wife, Francesca, founded the American Institute of Catalan Studies (AICS), with the goal of raising awareness among Americans of the historical, cultural, artistic, and economics aspects of Catalonia that distinguish it as a nation. AICS promotes scientific, literary, and educational studies related to Catalonia; translates and publishes Catalan literary works; and organizes artistic and popular events such as concerts, demonstrations of *castellers* (human towers), and the annual celebrations of Sant Jordi's Day (April 23) and the National Day of Catalonia (September 11). It also publishes the bulletin *Catalonia*. In 1999, Cardús promoted the federation of all the Catalan entities in the United States.

An active member in many professional associations, Cardús served as an officer in several of them. He was presi-

dent of the International Society for Gravitational Physiology, member of the Board of Directors of the Society for Mathematical Biology, chairman of the board of the Institute for Hispanic Culture in Houston, founding member and president of the Spanish Professionals in America, and member of the editorial boards of several scientific journals. Both Baylor College of Medicine and the Autonomous University of Barcelona made him Doctor *honoris causa*. The Autonomous Government of Catalonia awarded him the Sant Jordi Cross and the Narcís Monturiol Medal, and the Spanish Government the "Encomienda de la Orden de Isabel la Católica".

In July 2005, Francesca Ribas, Cardús widow, donated a collection of books from her husband's library to the Institute for Catalan Studies (Fig. 2). It consists of more than 1000 books on biology, medicine, physics, and mathematics. The books will be classified and kept at the science library of the Autonomous University of Barcelona, the institution that recognized Cardús achievements with an honorary doctorate in 1994.

Cardús belonged to a generation of Catalan scientists who emigrated to other countries to search for what they could not find in Spain, which was recovering from a civil war and was isolated internationally. Most of the country's best researchers and those that might have been their mentors had either gone into exile or died during the war. In Houston, there were other Catalan researchers, not only physicians but also, for example, the aforementioned biochemist Joan Oró, who after teaching at Baylor College of Medicine became Full Professor of Biochemistry at Houston University; Carles Vallbona, Distinguished Service Professor of Community Medicine at Baylor College of Medicine; and Lluís Delclós, Margaret and Ben Love Professor in Clinical Cancer Care at M.D Anderson Cancer Center in Houston, Texas.

While all of these men were well integrated in their host country, they maintained their ties to Catalonia. because, as Pasteur said, even if science does not have homeland, scientist do. Cardús' spirit still hovers over the AICS—currently presided by her daughter, Helena Cardus—which continues to promote Catalan culture in the United States. ■

References

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- Corbella, J (2004) The scientific work by Dr. David Cardús. (Barcelona 1922–Houston 2003). *Rev Reial Acad Med Catalunya* 19:71-76 (In Catalan)
- Guerrero R (2006) David Cardús: space's physician. *Catalunya Recerca* 4:14-15 (In Catalan)
- Newton DE (2007) Latinos in science, maths and professions, A to Z of Latino Americans. Facts on File, New York
- Oleski W (1998, updated 2004) Cardús, David. Hispanic-American Scientists. American Profiles. Facts On File, New York <http://www.fofweb.com/History/MainPrintPage.asp?iPin=HisAmSci2&DataType=AmericanHistory&WinType=Free> (accessed, November 2013)
- Ugalde A, Homedes N (2003) The diaspora of the Catalans to the United States throughout the 20th century: the migratory process and the contribution of Catalan scientists in the field of health. *Gimbernat* 39:237-257 (In Catalan)

David Cardús' Curriculum Vitae and Bibliography

Note: This CV and list of publications is based on the list that one of us (R. Guerrero) received from Prof. David Cardús in 1997.

Curriculum vitae

Professor of Physical Medicine Rehabilitation, Baylor College of Medicine, Houston, TX
Adjunct Professor of Mathematical Sciences and Statistics, Rice University, Houston, TX

Education

1942: Bachelor of Arts and Sciences (Physics, Chemistry and Mathematics), University of Montpellier, France
1949: M.D. Degree Magna Cum Laude, University of Barcelona Medical School, Barcelona, Catalonia
1949-1950: (Internship) Clinic Hospital of the University of Barcelona
1950-1953: (Residency) Sanatori Puig d'Olena (Respiratory Diseases), Sant Quirze de Safaja, Barcelona
1956: (Certification) Postgraduate School of Cardiology, Diploma in Cardiology, University of Barcelona
1953-1954: Postgraduate Department of Cardiology of Hôpital Boucicaut and Hôpital de la Pitié, Paris, France
(Fellow, French Government)
1954-1956: Postgraduate School of Cardiology, University of Barcelona
1957: Department of Cardiology, Manchester Royal Infirmary, University of Manchester, England (Fellow, British Council)
1966: Summer Institute in Mathematics for Life Scientists, University of Michigan, Ann Arbor (National Institute of Health Trainee), Michigan, USA

Major areas of interest

Cardiology · gravitational physiology · preventive medicine · rehabilitation · aging

Major research interests

Exercise physiology (applications to space research, health and aging)
Rehabilitation medicine (applications to cardiac rehabilitation, bladder dynamics and body composition in extensive paralysis)
Application of computers and mathematical models to medicine
Application of benefit-cost theory to rehabilitation medicine

Honors and awards

University of Barcelona Medical School, M.D. Degree Magna Cum Laude, 1949
Fellowship of the French Government, 1953-1954
Fellowship of the British Council, 1957
Fellowship of the Institute of International Education, 1957-1960
Society Sigma Xi (Rice University Chapter), 1963
National Institutes of Health Trainee, 1966
American Urological Association 1st Prize for Exhibit on Clinical Research, 1967
American Congress of Rehabilitative Medicine, Gold Award for Scientific Exhibit, "Micturition Following Spinal Cord Injury", 1967
Institut d'Estudis Catalans, August Pi-Sunyer Prize of Physiology for paper "A New Method for Respiratory Measurements in Man", 1968
5th International Congress of Physical Medicine, 1st Prize for Scientific Exhibit, "Micturition Following Spinal Cord Injury", 1968
Vice-Chairman, Gordon Conference on Biomathematics, 1970
Gold Medal for Demonstration on "Use of Computers and Telecommunications in Rehabilitation Medicine", 6th International Congress of Physical Medicine, 1972
Member, Societat Catalana de Biologia, 1972
Charter Member, Society for Mathematical Biology

American Medical Association, Physician's Recognition Award in Continuing Medical Education, 1974-1977
 Member, Instituto de Cultura Hispánica de Madrid
 Elisabeth and Sidney Licht Award for Excellence in Scientific Writing, The American Congress of Physical Medicine and Rehabilitation, 1980
 Commendation of Isabel La Católica, awarded by H.M. King Juan Carlos de España, 1980
 Medal Narcís Monturiol, awarded by the Generalitat de Catalunya (Autonomous Government of Catalonia) for his contributions in rehabilitation and space biomedical research, 1985
 Catalunya Enfora Award, presented by the Institute of Iberoamerican Cooperation, 1987
 Creu de Sant Jordi (St. George's Cross), awarded by the Generalitat de Catalunya, 1992
 Honorary Doctor's Degree (Doctor Honoris Causa), Autonomous University of Barcelona, Spain, 1993
 Joan d'Alòs Award. Centre Cardiovascular Sant Jordi, Barcelona, Spain, 1996

Professional experience and background

Research Associate, Department of Physiology, University of Barcelona, 1954-1955
 Research Associate, Department of Physiology, The Lovelace Foundation, Albuquerque, New Mexico, 1957-1960
 Research Associate in Physiological Studies, Texas Institute for Rehabilitation and Research (TIRR), 1960–
 Director, Work Tolerance Laboratory, TIRR, 1960–
 Active Medical Staff, TIRR, 1960–
 Director of Research, TIRR, 1962-1966
 President Active Medical Staff, TIRR, 1967-1968
 Chairman, Information Sciences Committee, TIRR, 1968-1978
 Director, Cardiopulmonary and Vital Studies Laboratory, TIRR, 1969-1978
 Director, Biomathematics Division, TIRR, 1970–

Academic appointments

Professor, Department of Rehabilitation, Baylor College of Medicine, 1969–
 Professor, Department of Physiology, Baylor College of Medicine, 1973–
 Adjunct Professor of Mathematical Sciences, Rice University, 1970-1988
 Adjunct Professor of Statistics, Rice University, 1989–
 Director, Biomathematics Program, Baylor College of Medicine, 1966-1968
 Graduate Executive Committee, Baylor College of Medicine, 1968-1969
 Chairman, Biomathematics Committee, School of Graduate Studies, Baylor College of Medicine, 1968-1969
 Visiting Professor of Physiology, Fac. of Medicine, Universidad Autónoma de Barcelona, 1970

Consultant positions

Scientific Advisory Council, Common Research Computer Facility, Texas Medical Center, Houston, 1965-1966
 Rehabilitation Subcommittee, Texas Heart Association, 1967-1969
 U.S. Public Health Service, Division of Health Facilities, Planning and Construction Service, 1967
 Mathematical Association of America, 1968
 Veterans Administration Hospital, Houston, Texas, 1969–
 Community Medicine, Harris County Hospital District, 1974–
 Pan American Health Organization, 1977–

Professional organizations and positions held

American College of Chest Physicians, 1960–
 New York Academy of Sciences, 1962–
 Harris County Medical Society, 9th District Medical Society, 1963–
 Texas Medical Association, 1963–
 American Congress of Physical Medicine and Rehabilitation, 1964–
 American Physiological Society, 1964–
 Federation of American Societies for Experimental Biology, 1964–

Houston Academy of Medicine, Texas Medical Center Library, Scientific Advisory Committee, 1964–
 American Association for the Advancement of Science, 1965–
 American College of Cardiology, 1965–
 Institute of Hispanic Culture of Houston, 1966– (President, 1967; Chairman of the Board of Directors, 1968–
 1969, and 1971-1976)
 American Heart Association, Texas, Affiliate, 1967–
 Biomedical Engineering Society, 1970–
 Automedica Advisory Editorial Committee, 1970–
 American Association of University Professors, 1971–
 American College of Sports Medicine, 1971–
 Society for Mathematical Biology, 1972– (Board of Directors, 1982)
 Methods of Information in Medicine, Editorial Board, 1977–
 Founding member and first president of the American Institute for Catalan Studies (AICS), 1980–
Catalan Review, Editorial Board, 1980–
 Cuadernos de ALDEEU, Editorial Board, 1983–
 Founding Member and president of the Spanish Professionals in America, Inc. (Asociación de Licenciados y Doc-
 tores Españoles en Estados Unidos, ALDEEU), 1984-1985
 American College of Preventive Medicine, 1989–
 Aerospace Medical Association, 1989–
 American Society for Gravitational and Space Biology, 1990–
 International Society for Gravitational Physiology (ISGP), President, 1993
 Journal of Gravitational Physiology (ISGP), Editorial Board, 1994–

Grants awarded for the following research projects

The Effects of Bedrest on Various Parameters of Physiological Function. Co-Principal Investigator. NAS-9 1461
 (1963-1965)
 Micturition Studies in Spinal Cord Injury. Co-Investigator. PSH NB-3751-(1965-1968)
 General Clinical Research Center for Chronic Illness. Chairman of the Clinical Research Center Advisory Com-
 mittee. DHEW FR-00219 (1963-1970)
 BUCM Computational Research Center Program. Director of Mathematics and Statistics Program. FR-00259
 (1965-1968)
 A Work Tolerance Evaluation Research and Training Unit for a Cardiac Rehabilitation Program. Principal Investi-
 gator. DHEW 13-P-55235/6 (1969-1974)
 Body Composition Determinations on Paralytic Persons. Principal Investigator. DHEW RD-1871-M-66
 (1969-1974)
 National Research and Demonstration Center for Heart and Vessel Disease Demonstration Project. Establishing
 an Outpost in the Community for Screening and Rehabilitation in Ischemic Heart Disease. Principal Investi-
 gator. DHEW HL-17269 (1974-1975)
 Rehabilitation Research and Training Center no. 4. Principal Investigator in the following projects. DHEW 16-D-
 5681/6 (1969-1980)
 Total Creatinine in Patients with Extensive Muscular Paralysis Estimated by Radioisotopic Tracer Methods (R-22
 1969-1973)
 Exercise and Lipids Profile in Ischemic Heart Disease (R-139.1972-77) Quantitation of ST-segment Changes in
 Exercise ECG Using Computer Techniques (R-159.197447S)
 Quantitation of ST-segment Changes in Exercise ECG Using Computer Techniques (R-159.1974-75)
 Cardiac Rehabilitation Program for Patients with Myocardial Ischemia and Arterial Hypertension [R-179 (PR-7)
 1977-1980]
 Evaluation of Physiological Responses and Diagnostic Criteria for the Application of Exercise Stress Testing with-
 in the Biomedical Space Program. Principal Investigator. NAS 9-14661 (1975-1977)
 Cost-Benefits in Vocational Rehabilitation Project. Director and Principal Investigator. DHEW 12-P-59636
 (1971-1981)

Cost-Benefits in Spinal Cord Injury. Project Director and PI. NIHR C-008005862 (1982-1983)
 Research and Training Center for the Rehabilitation of Persons with Spinal Cord Dysfunction. Project: Development of a Stress Testing Procedure and a Re-conditioning Exercise Program for Patients with paraplegia (R-4). NIHR-G-08005862 (1983-1987)
 Development of a Reconditioning Exercise Program for Patients with Paraplegia. Principal Investigator. NIHR-G-008300044 (1983-1987)
 Research Center for Spinal Cord Injury Census Project: Cardiorespiratory Function in Spinal Cord Injury, Follow-up and Aging Effects. Principal Investigator. NIHR H-133B80020 (1988-1992)
 +Gz 100% Gradient Centrifugation During Sleep and Exercise. Its Utility in Counteracting Physiological Microgravity Effects. Principal Investigator. NAGW-1691 (1989-1992)
 -Gz and +Gz experimentation with the AGS. Principal Investigator. NASA (Subcontract USRA 9910-29-103) (1992-1994)
 Nutritional Status of Persons with Spinal Cord Injury: Relationship to Community Integration. Co-Principal Investigator. NIDRR (Grant No. H133B40011-95 (1993-1999)
 Artificial Gravity as a Countermeasure of Cardiovascular Deconditioning in Simulated Microgravity. Principal Investigator. NASA/TMC (1995-1996)

Student doctoral theses

Couch, James R. Jr. "The development of the electrophysiology of the embryonic and fetal heart." Baylor College of Medicine
 Smith, Laura K. "Passive motion as a stimulus to ventilation in man." Baylor College of Medicine
 Lehman, Jim R. "Quantitative aspects of the inter-conversion of androgens in rat testis and ovary." Baylor College of Medicine
 Batiz-Solorzano, Sergio (1979) "On decisions with multiple objectives: Review and classification of prescriptive methodologies, a group value function problem, and applications of a measure of information to a class of multi-attribute." Rice University
 Hammons, Charles B (1979) "On subjective data in the multicriteria decision problem." Rice University
 Chan, Shou Chao (1979) "Benefit-cost analysis in rehabilitation programs." Rice University
 Littell, Elizabeth H (1980) "Neural regulation of blood flow in on-working muscles." Baylor College of Medicine
 Domingo, Enric (1982) "Utility of the electric impedance technique in the study of the cardiovascular system." Universitat Autònoma de Barcelona

Post-doctorate fellows in Dr. Cardús' programs

Ernest Pevney. Medical School of Komenius, University of Bratislava, Czechoslovakia
 Luis I. Vera. School of Medicine, University of Zaragoza, Spain
 Ramón Segura. School of Medicine, University of Sevilla, Spain
 Eduardo Larrousse. School of Medicine, University of Zaragoza, Spain
 Francisco Fuentes. School of Medicine, University of Valencia, Spain
 Alfred Johnston. Department of Electronics, Rice University, Houston, Texas
 Joe Murdock. Mathematical Sciences, Rice University, Houston, Texas
 Jacobo Rosenthal. School of Medicine, Universidad Central de Venezuela, Venezuela
 Domingo Hernández. Departamento de Rehabilitación, Ministerio de Sanidad y Asistencia Social, Caracas, Venezuela
 Ramachandra Srinivasan. Electrical Sciences Department, California Institute of Technology, California
 Andrés Pie. Department of Physiology, University of Zaragoza, Spain
 Enric Domingo. School of Medicine, Universitat Autònoma de Barcelona, Spain
 Norman Fuentes. Departamento de Rehabilitación, Caja Costarricense del Seguro Social, Costa Rica.
 Branco Lovic. Institute Niska Banja, University of Nis, Yugoslavia
 Philippe Vidal. École Nationale Supérieure d'Ingénieurs de Constructions Aéronautiques (ENSICA), Toulouse, France
 Laurent Bonsergeant. École Nationale Supérieure d'Ingénieurs de Constructions Aéronautiques (ENSICA), Toulouse, France

Publications

1954-1964

- Lian C, Vilenski J, Cardús D (1954) Les syncopes des constipés (Syncope accidents in patients with constipation). *L'Hôpital, Revue Mensuelle de Clinique et Thérapeutique* 42:7-10
- Gilbert-Queraltó J, Cardús D (1955) Exploración de la función ventilatoria en el cardiópata (Study of the ventilatory function in the cardiac patient). *Rev Port Med Mil* 3:356
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- Llauradó JG, Cardús D (1955) El fotómetro de llama en la valoración de la aldosterona, halocortisoles, DOCA y sustancias aldosterosímiles (The flame photometer in the evaluation of aldosterone, halocortisoles, DOCA and aldosterone-like substances). *Med Clin* 25:151-157
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- Cardús D, Luft UC, Spencer WA, Hoff HE (1962) Considerations on appraisal of physical fitness. *Arch Phys Med Rehabil* 43:222-227
- Cardús D, Vallbona C (1962) Acerca de la teoría de la información (On the theory of Information). *Insula* 192:10
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- Vallbona C, Spencer WA, Cardús D, Dale J (1963) Control of orthostatic hypotension of quadriplegic patients with pressure suit. *Arch Phys Med Rehabil* 44:7-18
- Cardús D, Luft UC, Beck B (1963) Measurements of total circulating hemoglobin with the carbon monoxide re-breathing method. *J Lab Clin Med* 61:944-952
- Cardús D, Quesada EM, Scott PB (1963) Use of an electromagnetic flowmeter for urine flow measurements. *J Appl Physiol* 18:845-847
- Cardús D, Hoff HE (1963) Pulmonary ventilation response to the metabolic action of 2,4-dinitrophenol. *Arch Int Pharmacodyn* 144:563-570
- Cardús D, Quesada EM, Scott FB (1963) Studies on the dynamics of the bladder. *J Urol* 90:425-433
- Luft UC, Cardús D, Lim TPK, Anderson EC, Howarth JL (1963) Physical performance in relation to body size and composition. *Ann NY Acad Sci* 110:795-808
- Cardús D (1963) A study of the frequency of the heart in the early phase of recovery following muscular exercise. *Proceedings 5th IBM Medical Symposium, Endicott, NY*
- Scott FB, Quesada EM, Cardús D (1964) Studies of the dynamics of micturition: observations on healthy men. *J Urol* 92:455-463

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