Andean Biology in Peru

Scientific Styles on the Periphery

*By Marcos Cueto**

TEN THOUSAND YEARS AGO, the inhabitants of the Andes learned to live at an altitude of 10,000 feet above sea level. The first scientific explanation for this phenomenon was provided by French and British researchers, who began investigations in the highlands of Mexico and Peru in the late nineteenth and early twentieth centuries. Most of them believed that the native Indian of these highlands was a physically inferior being, since "normal" physiological functions were impossible at altitudes where oxygen is rarefied. But some Peruvian doctors saw that physiological normality might vary from place to place. In 1927 one of these, Carlos Monge Medrano, organized an expedition to the highlands, where he confirmed the existence of physical and physiological mechanisms that had over the centuries acclimatized the Andean people to the low oxygen pressure of high altitudes. This was the beginning of experimental physiology in Peru. Its history is one in which scientific ideas became intertwined with nationalistic motivations; the story features a small group of researchers who carried out original work in a country whose scientific tradition was peripheral to world centers of knowledge.

The Institute of Andean Biology, created in 1931 at San Marcos University, became the center of this new field in Peru; it has been in continuous operation since its founding. That continuity is uncommon among Latin American scientific communities. However, it should not be equated with uniform development. We can distinguish two different scientific styles in Peruvian physiology, interacting in a relationship both tense and complementary. Monge Medrano, who was engaged in a scientific and cultural crusade for the redemption of the Andean people, personified the first, while Alberto Hurtado, who tried to categorize high-altitude studies under an international academic standard, was the exemplar of the second. Such a combination of excellence, institutional continuity, and variety of scientific styles is rare in less developed countries. I will analyze their emergence during the first years of high-altitude studies in Peru.

EARLY HIGH-ALTITUDE STUDIES

Among the earliest high-altitude studies were those conducted by three French physiologists, Dennis Jourdanet, Paul Bert (a disciple of Claude Bernard), and

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The papers of Alberto Hurtado Abadía and Carlos Monge Medrano are kept in Lima by their respective sons, Gabriela Hurtado de Fort and Carlos Monge Cassinelli. I thank them for access to these sources. An earlier version of this article won the Henry and Ida Schuman Prize.

François-Gilbert Viault. Jourdanet performed his studies in Mexico in 1863, examining the local inhabitants' adaptation to life at high altitudes. He concluded that Mexicans were an anemic race because anoxia (the lack of oxygen in the blood experienced at high altitudes) kept them in a permanently weakened state.[1] Bert, who worked primarily with balloonists undergoing rapid ascension, described basic reactions to decreasing barometric pressure and made important contributions for understanding oxygen deprivation. He suggested that changes in the blood might allow tolerance of high altitudes.

At the end of the century Bert convinced the third French doctor, Viault, to perform physiological studies in the Peruvian highlands. Viault worked in Morococha, an area in the Peruvian highlands 14,900 feet above sea level, in 1889. He was the first to observe the increased number of red blood cells in persons who climb at or inhabit high altitudes, and he believed the increase to be an adaptation of the organism to a low-oxygen environment. The physiological process is known as polycythemia. On his return to Paris, Viault communicated his hematological research to the French Academy of Sciences. This work introduced the idea that compensatory mechanisms to high altitude existed, an idea Peruvian physiologists would later study and expand upon.[2]

Most significant for this article is the study made in 1921, when an expedition of North American and English scientists, led by the prestigious Cambridge physiologist Joseph Barcroft, visited the mining district of Cerro de Pasco, a Peruvian highland community located 14,200 feet above sea level. At the time Barcroft was involved in a debate with the British physiologist John Scott Haldane.[3] Just before World War I Haldane directed an expedition to Pike's Peak, Colorado (14,000 feet). Observations he made there led him to believe that during the acclimatization process the human lung secretes oxygen into the blood at a higher pressure than the pressure in the alveolar air. After determining the oxygen tension in arterial blood by the indirect carbon monoxide method, as modified by himself and a fellow researcher, C. G. Douglas, Haldane suggested that residents of high altitudes had an oxygen pressure in the arterial blood equal to that normally prevailing at sea level. Barcroft, however, developed a new technique, direct arterial puncture, to dispute this conclusion. In a well-known experiment in a glass chamber, conducted in 1919, he subjected himself to decreasing oxygen over a period of six days. He then obtained blood for analysis directly

[1] Jourdanet's main work is Dennis Jourdanet, *Influence de la pression de l'air sur la vie de l'homme* (Paris: Masson, 1875); Bert's is Paul Bert, *La pression barometrique* (Paris: Masson, 1878). Bert's work was not translated into English until 1943; see Paul Bert, *Barometric Pressure: Researches in Experimental Physiology,* ed. and trans. G. Masson, M. A. Hitchcock, and F. A. Hitchcock (Columbus, Ohio: College Book Co., 1943). Jourdanet's views are reminiscent of notions regarding the biological inferiority of the New World in the eighteenth and nineteenth centuries; the classical work on this issue is Antonello Gerbi, *La disputa del Nuevo Mundo: Historia de una polémica, 1750–1900* (Mexico: Fondo de Cultura Económica, 1955). Jourdanet's views were not universal. His point of view was countered by two Mexican physicians; see A. Herrera and D. Vergara Lopez, *La vie sur les hauts plateaux* (Washington, D.C.: Smithsonian Institution/Concours Hodkings, 1895). In addition, around the turn of the century many believed that high altitude was beneficial for certain illnesses, such as tuberculosis.

[2] For an evaluation of Viault's works see Carlos Monge Medrano, "Allocution prononcée à la Faculté de Médécine de Lima pour l'inauguration du voyage de François-Gilbert Viault, précurseur des études d'altitude," *Travaux de l'Institut Français d'Etudes Andines,* 1957–1958, 6:1–4.

[3] For an account of this debate see Kenneth J. Franklin, *Joseph Barcroft, 1872–1947* (Oxford: Blackwell Scientific, 1953), pp. 115–121.

from his artery. His results failed to corroborate Haldane's finding: no evidence of oxygen secretion was found by direct arterial puncture.

Barcroft organized the expedition to the Andes to test the importance of diffusion in the pressure of oxygen in the blood in a natural environment and to expand his earlier findings. For three months he and his associates made numerous observations on the effects of high altitude on the human body. Although most of their studies analyzed the respiratory physiology of members of the party, none of whom were accustomed to high altitude, a few measurements were taken on natives. The expedition's results were reported in 1923 in *Philosophical Transactions of the Royal Society*. They did not coincide with Haldane's findings: instead, Barcroft found that oxygen pressure was considerably lower in inhabitants of high altitudes than in dwellers at sea level. Another important conclusion was that human acclimatization to high altitude was extremely difficult. A few years later Barcroft published a more conclusive opinion on the consequences of acclimatization: "All dwellers at high-altitude are persons of impaired physical and mental powers."[4] His views thus coincided with those of the French physiologists Jourdanet and Bert.

French, British, and American doctors' interest in life at high altitudes had its nationalistic component: such research was supported by their respective governments because it could contribute to the expansion of the economic and political interests of their countries. Bert's physiological studies were expressly directed to resolving the acclimatization problem of the French troops attempting to maintain the Habsburg regime of Maximilian I in Mexico. Barcroft's research was done in Cerro de Pasco, the country's most important mining district, which was exploited by the U.S. Cerro de Pasco Copper Corporation, a company that controlled the extraction of Peruvian copper. His conclusions on physical exertion at high altitudes could be useful for the mining industry; in fact, Cerro de Pasco provided assistance and facilities to the expedition.

MONGE'S EXPEDITION AND MONGE'S DISEASE

Barcroft's negative conclusions led directly to Peruvian involvement in high-altitude studies, for it sparked the opposition of Carlos Monge Medrano, the Peruvian pioneer of the field. Monge had taken clinical courses in Paris and at the London School of Tropical Medicine, from which he received a diploma. Upon returning to Lima in 1913, he initially did research on native infectious diseases. He became interested in high-altitude physiology in 1925, when he observed a patient from the highlands whose diagnostic picture resembled that of Vaquez's disease—also known as polycythemia vera—an entity he was familiar with from his studies in Paris. At about the same time Monge became acquainted with the work Barcroft had published in England. He then conceived the idea of organizing a Peruvian expedition that would refute the conclusions of Barcroft's mission. It is revealing to read Monge's account, offered in an interview in the early 1930s, of his reaction to the Barcroft studies:

[4] Joseph Barcroft *et al.*, "Observations upon the Effects of High Altitude on the Physiological Processes of the Human Body Carried Out in the Peruvian Andes at Cerro de Pasco," *Philosophical Transactions of the Royal Society,* Series B: *Papers of Biological Character,* 1923, *211*:351–480; and Barcroft, *Lessons from High Altitude: The Respiratory Function of the Blood* (Cambridge: Cambridge Univ. Press, 1925), p. 176.

> With amazement I read the thesis that man at high altitudes is physically and mentally deficient compared to other men, to which was added the thesis that discussed the lack of adaptation of low-altitude inhabitants to this environment. My difference of opinion matured a long time. This superficial knowledge of reality was so severely biased that it induced me to come up with a different thesis. . . . This took until 1927, when it was possible to begin the scientific study I had been planning.[5]

The first Peruvian expedition to the Andes was subsidized by the San Marcos Faculty of Medicine and directed by Monge. In April 1927 a group of four doctors and eight students left for Cerro de Pasco. Among them was Alberto Hurtado, a young Peruvian physician who had just graduated from Harvard and who would later become the other important Peruvian figure in high-altitude studies. Some of the Peruvian physiologists' first experiments were performed simply to confirm the observations of earlier scientists such as Barcroft and Haldane. For example, all studied the physical shape of the natives, changes in the chemical composition of their blood, and lung ventilation. The main scientific novelty of this first expedition was the analysis of exercising physiology. Barcroft mentioned the importance of studying the effect of altitude under conditions of continuous and spasmodic exercise, but his own work concentrated on resting physiology.[6]

The objectives of Monge's expedition were to study the effects of the high-altitude environment on the human organism and to analyze the loss of acclimatization to high altitude. This work emphasized the exceptional performance—especially physical performance—of native Indians adapted for centuries to the high-altitude environment. Monge was also responsible for the definition of a new clinical entity, the loss of acclimatization, which he referred to as the "disease of the Andes" or "chronic mountain sickness" and which later became known as Monge's disease. Although the definition was not as clear then as it is nowadays, the diagnostic picture describes a loss of tolerance to high altitude, rather than a degenerative disease, experienced by previously acclimatized highlanders. The principal symptoms of Monge's disease are related to alterations in mental capacity and the nervous system: sufferers are cured when they descend to sea level.[7]

After returning from the expedition, Monge dedicated himself to promoting experimental physiology. He presented his group's results in Lima at the National Academy of Medicine and the seventh Pan American Health Conference. Later he went to Europe. In 1929 the Paris Faculty of Medicine organized an exposition on the disease of the Andes, where Monge was introduced by M.

[5] Carlos Monge, *Sobre un caso de enfermedad de Vaquez* (Lima: Imprenta San Martín, 1925); and "Importantes declaraciones del Doctor Monge," *El Perú,* newspaper clipping, Monge Medrano Papers, Lima, Peru (hereafter **Monge papers**).

[6] The entire volume of the Lima faculty of medicine annals for 1928 was devoted to the results of the first expedition; it contains eight articles about different aspects of Monge's disease and life at high altitude. See Carlos Monge Medrano *et al.*, "La enfermedad de los Andes," *Anales de la Facultad de Medicina,* 1928, *14*:1–314.

[7] The disease was given different names: altitude erythemia, Andes disease, high-altitude disease, chronic soroche. At present two names are used: chronic mountain sickness and Monge's disease. One of the most widely known works on the subject is Carlos Monge Medrano and Carlos Monge Cassinelli, *High-Altitude Diseases: Mechanism and Management* (Springfield, Ill.: Charles C Thomas, 1966), pp. 32–36. For a recent discussion of studies on high altitude see Carlos Monge Cassinelli and Robert M. Winslow, *Hypoxia, Polycythemia, and Chronic Mountain Sickness* (Baltimore: Johns Hopkins Univ. Press, 1987).

Vaquez, who had first identified polycythemia vera. Some days later Vaquez reported to the French Academy of Medicine that he thought the disease Monge described was different from the disease that carried his own name, and he proposed that the former should be called "Monge's disease." Shortly afterward, the dean of the Paris faculty, in the prologue to the French translation of Monge's book on the disease of the Andes, referred to this clinical entity as Monge's disease.[8]

This book, published in 1929, was soon reviewed in fifteen different specialized journals, of which six were French, three English, three German, two Spanish, and one Polish. From Paris, Monge went to Italy, where he gave lectures and published articles in the official journal of the Italian Academy of Medicine.[9] The French translation of the book brought the emerging Peruvian physiology to the forefront of the international medical and scientific community. Monge Medrano, in a letter written years later to his son, compared his trip to Europe as a student and the visits he had made since 1929: "Let me tell you in confidence that I began to travel in the opposite direction: it was I who made them listen."[10]

THE INSTITUTE OF ANDEAN BIOLOGY

When he returned to Lima in 1930, Monge and his associates organized new expeditions to the highlands. Between 1927 and 1932 they made eight trips to ten different zones of the central and southern highlands. Five doctors and nineteen students in their last year of medical school participated.[11] In 1931, during the short reformist rectorship of José Antonio Encinas, the Instituto de Biología y Patología Andina was formally created as part of the Faculty of Medicine of San Marcos University.[12] This was the first institute for scientific research ever established in a Peruvian university.

Carlos Monge Medrano was named director of the Institute of Andean Biology in 1934, a position he held until 1956. Alberto Hurtado occupied the post of research director and later replaced Monge as director. In 1940 the institute was declared an official organ of the Peruvian government, thus becoming a "national institute" that could receive assistance from the state without losing its university funding. Years later, in 1944, it was transferred back to the Faculty of Medi-

[8] G. H. Roger, preface to Carlos Monge Medrano, *Les érythrémies de l'altitude* (Paris: Masson, 1929) (a trans. of Monge's contribution to Monge *et al.*, "Enfermedad" [cit. n. 6], i.e., pp. 76–209). Monge's papers preserve an invitation to the meeting of the Paris Faculty of Medicine in which Vaquez is listed as introducer of Monge Medrano. See also the article written by an assistant to the meeting: Oscar Miro Quesada, "Los Peruanos en el extranjero: El Doctor Monge en la Facultad de Medicina de París," *El Comercio,* 19 June 1929, Monge papers.

[9] See Carlos Monge Medrano, "La malattia delle Ande," *Bulletino e Altti della Reale Accademia Medica de Roma,* 1928–1929, *50*:1–8. The book reviews are in the Monge papers.

[10] Carlos Monge Medrano to Carlos Monge Cassinelli, Lima, 31 May 1953, Monge papers.

[11] A brief account of these expeditions appears in Carlos Monge Medrano, "Climato-fisiología andina," *An. Fac. Med.,* 1935, *17*:184–187.

[12] For details on the organization of the Institute of Andean Biology see Carlos Monge Medrano, "Instituto de Biología y Patología Andina: Documentos concernientes a su creación," *An. Fac. Med.,* 1935, *17*:183–184. The name of the institute was shortened to Instituto de Biología Andina and it was known as such in the years after its creation. This institute still exists as a research center of San Marcos University. By the early 1960s another center for high-altitude studies appeared in Peru, the Instituto de Investigaciones de Altura, associated with the then recently created Universidad Peruana Cayetano Heredia. Hurtado, first vice-president and later president of Cayetano Heredia, worked in the Instituto de Investigaciones de Altura.

Figure 1. *Carlos Monge Medrano in 1941. Courtesy of the Carlos Monge Medrano papers.*

cine but retained state support. The concentration of high-altitude studies in one government-funded center eased the professionalization of research, providing stability and continuity, for at the time even the university was ambivalent about research and did not provide solid ground for a scientific career. Professorial salaries at San Marcos's Faculty of Medicine were low because practically all teachers were on a part-time basis and combined teaching and research with private practice.[13]

The institute began with an ambitious program that dealt with the social and biological aspects of life in the highlands. Among the areas of study were the history of high-altitude research, life in the inhabited highlands of Peru, and Andean biochemistry, physiology, and pathology.[14] The first years of the Peruvian high-altitude studies involved two somewhat contradictory impulses. At the practical level, basic studies of Monge's disease emphasized the loss of acclimatization and the characteristics, mainly taxonomic, of life at high altitudes. They investigated the anatomical features of Peruvian Indians and their physical performance in their Andean environment. This work focused on the definition of physical and physiological compensatory mechanisms—for example, the greater chest volume of native Indians, the elevated number of red cells in their blood,

[13] See Robert A. Lambert, "Medical Education in Peru, 1926," Rockefeller Foundation Archive, R.G. 1.1., Series 331 Peru, Box 1, Folder 19, Rockefeller Archive Center, Pocantico Hills, New York.

[14] No effort will be made here to describe in detail the intended subjects of study of the institute at its creation because most of them were not researched until some years later. For a description of the first areas of interest of the institute see Carlos Monge Medrano, "Instituto de Biología y Patología del hombre de los Andes: Materias de estudio," *An. Fac. Med.*, 1935, *17*:179–183.

and their characteristic hyperventilation (the greater quantity of air taken by their lungs).

At a higher level, Carlos Monge Medrano, in particular, truly believed that his studies had established a new scientific specialty: Andean biology. He thought that the error of earlier physiologists had been to study life at high altitudes using life at sea level as a standard for normality, ignoring the reality that thousands of people, animals, and plants were perfectly acclimatized. Monge considered that the study of life at high altitudes required a new biology sensitive to the biological features of the Andean people that were distinct from those of sea-level inhabitants. According to Monge, the Peruvian Indian belonged to a climatic variety of the human race. Furthermore, in a report directed to the government, he postulated the existence of a high-altitude zoology and a high-altitude botany.[15]

Monge observed that heavy muscular work was a natural phenomenon in the high-altitude native population. He considered the Andean people to be the "race with the greatest physical performance in the world," citing the fact that many Andeans, despite their low-oxygen environment, exhibited a vitality and strength greater than that of dwellers at sea level. According to Monge, the permanent oxygen deficiency of the high altitudes compelled the highlanders to develop special qualities similar to those obtained by an athlete through exercise. With a mixture of national pride and scientific propaganda, Monge declared to *Time* magazine, "Where North American aviators ask for oxygen, Peruvians play soccer."[16] Although he never used the term, Monge considered Andean man a sort of superman.

PERUVIAN CULTURE DURING THE 1920s

Monge's scientific defense of the native Indian, which gained him wide attention in nonscientific circles, both within and outside of Peru, was connected with the rise of a Peruvian nationalistic ethos in the 1920s and the early 1930s. During that period Peru experienced an intense process of cultural and political renovation, principally manifested in the appearance of nationalistic currents that reconsidered the place of the native Indian in Peruvian society.[17] These currents reacted against the positivism, characterized by a cosmopolitan outlook, that had emerged in the classrooms of San Marcos University at the turn of the century.

Positivism had played a contradictory role in Peru, since most professors cultivated a rhetoric of the importance of science but did not make research an objective of university life. It differed from other versions of the movement in Latin America, such as those of Brazil or Mexico, where positivists had a greater commitment to research and to nationalism. San Marcos positivists wrote works praising science and European writers but did little to advance experimental studies in their own country. Nevertheless, the limited reappraisal of science generated interest in the study of native illnesses, in local flora and fauna, and in that long-forgotten character of Peruvian history, the Indian. The positivists of

[15] See Carlos Monge Medrano, *Biología andina y de altitud: Aclimatación y mal de montana crónico en las altiplanicies del Perú, México y Estados Unidos* (Lima: Editora Médica Peruana, 1947).

[16] *Ibid.*, p. 24; and *Time*, 23 June 1947.

[17] See the illuminating account of this issue in Carlos Ivan Degregori *et al.*, *Indigenismo, clases sociales y problema nacional* (Lima: Ediciones Celats, 1980).

the early twentieth century had adopted two distinct attitudes toward the Indian. One was a paternalism inspired by colonial legislation, which considered the Indian a minor who required state protection; the other attitude was racism. Peruvian intellectuals at the turn of the century justified class differences and the backwardness of the indigenous population by attributing them to racial factors. Their desperate call for European immigration was often derived from a desire to "improve" the Peruvian "race."[18]

Redefinition of the Indian question came when profound changes were taking place in the Peruvian capital. The population growth Lima had been experiencing since the beginning of the twentieth century was due more to the migration of provincials than to European immigration. Writers, journalists, and professors who moved in from the provinces began to manifest their pride in the national territories outside of the capital. San Marcos University lost some of its aristocratic character when its classrooms began to fill with students from the provinces and with middle-class students from Lima.[19] All of these changes contributed to the rupture of the elitist culture that had dominated Lima at the turn of the century.

In 1919, inspired by recent university reform in Argentina, the students of the humanities held a strike demanding a reorientation of higher education toward national topics. In the early 1920s the first sociological studies of Andean reality were initiated. These criticized both paternalism and racism.[20] *Indigenismo* was the generic Spanish name given in Peru to the reappraisal of Andean life. Its followers pointed out the artificiality of the Peruvian national configuration: Peru was a formally democratic republic where colonial and servile relations persisted in the treatment of the indigenous population. Literature, painting, and the social sciences, cultivated within and outside the university, were the principal vehicles for redefining the Indian question. During the 1920s *indigenismo* had a strong influence on essayists such as José Carlos Mariategui, politicians such as Victor Raul Haya de la Torre, painters such as José Sabogal, anthropologists such as Luis E. Valcarcel, and archaeologists such as Julio C. Tello.[21] Their writings called for the recovery of the Andean world. This line of thought produced a rupture in the country's cultural life, and its influence extended to medical and scientific circles.

Monge, who was born to a poor Lima family and obtained a chair thanks only to the university reform of 1919, was a close friend of Tello and other *indigenistas* of his time; he lived and reflected this cultural milieu in his work. Although not all the members of the Institute of Andean Biology shared his *indigenismo,* it was this feature that permitted the institute's scientific research in physiology to

[18] The social concerns of Peruvian positivism are discussed in Marcos Cueto, "Intellectual Thought and Aristocracy" (M.A. thesis, Columbia Univ., 1983).

[19] On the changes in the social origins of university students at the beginning of the century see Marcos Cueto, "La Reforma Universitaria de 1919: Universidad y estudiantes a comienzos de siglo" (B.A., Pontificia Universidad Católica del Peru, Lima, 1982).

[20] Some of the most important works that defend the Indians and the Andean world, written by students, professors, and others, are José Antonio Encinas, "Causas de la criminalidad indígena," *Revista Universitaria de San Marcos,* 1919, *14*:192–268; Hildebrando Castro Pozo, *Nuestra comunidad indígena* (Lima: Tipografía "El Lucero," 1924); Luis E. Valcarcel, *Tempestad en los Andes* (Lima: Editorial Minerva, 1927); and José Uriel García, *El nuevo indio* (Cusco: H. G. Rozas, 1930).

[21] The best historiographical account of the social and cultural developments in Peru during the 1920s is Manuel Burga and Alberto Flores Galindo, *Apogeo y crisis de la república aristocrática* (Lima: Ediciones Rickchay, 1980).

attract local support and recognition outside of medical circles. This nationalistic component is decisive for understanding the reception of modern physiology in Peru.

During the late 1940s and 1950s, a conservative mood again came to dominate Peruvian culture and contributed to the decline of *indigenismo,* the main cultural support of Andean biology. As a result, this cultural emphasis in Peruvian physiology began to lessen. The loss of the indigenous focus was expressed, for example, in the change in the specialty's name: in the early 1930s, researchers worked in something vaguely called "Andean biology"; twenty years later, the area was universally known as "high-altitude studies." Further, a more universalistic conception of science emerged after World War II, one that supported the idea that rational thought and scientific truth were the same for every culture. This idea contributed to the increasing tendency of Peruvian physiologists to define the discipline's scientific boundaries in terms of high-altitude biomedical studies.

THE INSTITUTIONALIZATION OF HIGH-ALTITUDE STUDIES IN PERU

Once physiological research in Peru had begun, economic and social considerations appeared to justify high-altitude studies, particularly in the 1940s. This was not surprising, since life at high altitudes was the norm for most of the Peruvian population. The 1940 national census, the census taken closest to the date of the institute's founding, indicated that 51.7 percent of the country's population lived at altitudes between 9,840 and 16,400 feet above sea level.[22] The fascination of nonscientific elites with the studies of Andean biology was due chiefly to the application these studies could have in the highlands in the areas of agriculture, livestock, and mining. Later, interests outside Peru also began to fund the institute's activities.

The institute began to extend its relations and to obtain its first clients outside of the university environment in the late 1930s. Chief among these clients were mining companies, livestock breeders from the central highlands, and the U.S. Air Force. The mining companies were ambivalent about the institute's work. They recognized the importance of the studies on physical performance at high altitudes, since the principal mining camps were located in the highest zones of the central Peruvian highlands. But they feared that the institute would suggest measures to the government that would harm their interests—for example, the reduction of working hours because of the unhealthy conditions in the mines. Nevertheless, the mining companies hired Alberto Hurtado in 1935 as a consultant for the diagnosis and treatment of an occupational illness, pneumoconiosis, an affliction produced when dust from the mines accumulates in the lungs. Another of Hurtado's original contributions that was valuable to the mining companies was the discovery of the acute lung edema produced by rapid ascension to high altitudes.[23]

Studies on animal fertility began to attract attention in 1940, when it was discovered that the sterility manifested in some species transported to high altitudes

[22] See Perú, Ministerio de Hacienda y Comercio, Dirección Nacional de Estadística, *Censo nacional de población y ocupación de 1940,* Vol. I: *Resúmenes generales* (Lima: Imprenta Torres Aguirre, 1944), pp. 11–14.

[23] A description of pneumoconiosis appears in Alberto Hurtado, "Estimación de la incapacidad causada por la neumoconiosis," *An. Fac. Med.,* 1944, *22*:1–20.

was due to a lack of acclimatization. One of Monge's disciples, Mauricio San Martin, began to specialize in this problem, first by studying cats and rabbits moved to Morococha and later by concentrating on the reproduction of wool-producing livestock at high altitudes. Throughout the 1940s the Institute of Andean Biology worked in the Department of Junin, a highland livestock area near Lima, with support from the Rockefeller Foundation, the National Council of the Wool Industry, and the Central Livestock Society.[24] Husbandry techniques based on that research were among the scientific and technological innovations that played an important role in the modernization of and increased productivity in land use in the central Peruvian highlands between 1930 and 1960.[25]

The institute refuted the widely accepted idea that the low fertility rate in sheep at high altitudes, compared with their reproduction at sea level, was due to barrenness in ewes. Each year a large number of ewes were killed under the incorrect assumption that they were infertile. Experiments performed by institute personnel revealed that male infertility was responsible for the usually low reproductive rate of imported sea-level sheep. According to Monge and his associates, semen analysis indicated that altitude-induced anoxia had an elective action against the germinal epithelium of the testicles. In each herd of sheep brought from the coast, about 65 percent of the rams initially manifested serious deficiencies in reproductive capacity and had to go through a process of adaptation to the altitude.[26] At some of the Central Livestock Society's ranches, the institute evaluated selected rams imported to the highlands before the mating season began to determine which specimens were best for reproduction. From the first articles on animal fertility, the Peruvian researchers repeatedly stressed the economic utility of their work.[27]

The need to counter the effects of high altitude on pilots has always been an important factor in high-altitude studies. At the end of World War I, the British Royal Air Force became interested in these effects when it was discovered that 90 percent of plane accidents were due to human errors, some of them caused by inadaptation to high altitude.[28] The U.S. Navy also became interested in this problem and in the early 1930s founded a school of aviation medicine in Florida. This center maintained close ties with the Peruvian physiological school. U.S. agencies were eager to fund the institute because they thought its location one of the best in the world for high-altitude studies. Hurtado eventually received an important grant from the U.S. Aerospace Center, then located at Randolph

[24] See the acknowledgments in Carlos Monge Medrano *et al.*, "Aclimatación del ganado ovino en las grandes alturas: Fertilidad e infertilidad reversible durante la fase adaptativa," *An. Fac. Med.*, 1945, *28*:15–31, on p. 15.

[25] On the increased productivity see Gerardo Rénique, "El desarrollo de una empresa ganadera de los Andes centrales (1910–1960)," *Tierra y Sociedad: Revista del Archivo del Fuero Agrario,* 1978, *1*:39–59.

[26] Monge Medrano *et al.*,, "Aclimatación" (cit. n. 24), p. 30.

[27] See, e.g., Carlos Monge Medrano and Mauricio San Martín, "Infertilidad reversible debido a la acción del viaje maritimo de Magallanes al Callao," *An. Fac. Med.*, 1945, *28*:1–14. Monge Medrano also explored the infertility that many sea-level couples experience during residence in the highlands. The Peruvian historian José de la Riva Aguero called Monge's attention to colonial sources of data on human infertility in the Andes; see Carlos Monge Medrano, *Influencia biológica del altiplano en el individuo, la raza, las sociedades y la historia de América* (Lima: Editorial Minerva, 1940).

[28] For the interest of schools of aviation in research on high altitude see Elmer L. Cavery, "History of the School of Aviation Medicine, Naval Air Station, Pensacola, Florida," *Contac: School of Aviation Medicine,* 1946, *6*:149–152.

Field, San Antonio, Texas, which permitted him to equip the laboratory at Morococha with a treadmill and other modern equipment for clinical and metabolic studies. This relationship between the Institute of Andean Biology and the U.S. Air Force extended to NASA, which used the results of the high-altitude experiments for its space program.

As interest in high-altitude studies developed in the United States, it had profound effects on the Peruvian efforts. That interest was not confined to air and space agencies. In 1935 Ancel Keys, a professor from the Mayo Foundation for Medical Research, organized an ambitious expedition to the Andes of northern Chile. Using such advanced instrumentation as Van Slyke and Haldane apparatuses, the American expedition demonstrated for the first time the great muscular capacity of high-altitude natives, as shown by the small accumulation of lactic acid in their blood after heavy exercise. They also showed that the hemoglobin of animals native to a high altitude had a great affinity for oxygen. One result of this expedition was increasing recognition in the States for Monge. An article by David B. Dill and John H. Talbot in the *American Journal of the Medical Sciences* for 1936 was the first work in a U.S. scientific journal to describe Monge's disease. Soon after, in 1937, Monge published his first article in a U.S. journal, and in 1941 the University of Chicago named him *Doctor honoris causa* (the highest honor of his scientific career).[29] Dill, who had contacted Monge and Hurtado while passing through Lima, would become Monge's assiduous correspondent and himself an authority on high altitude.

The new interest in high-altitude studies in the United States stimulated a close collaboration between U.S. universities and foundations and the Institute of Andean Biology. During the early years of high-altitude studies in Peru, local institutions were the most important sources of income. From 1934 the Rockefeller Foundation equipped the institute's laboratories and, in 1936, began to award scholarships to Peruvian medical students for postgraduate training at U.S. universities. In the late 1940s a great influx of money came from the States. In 1949 six of the nine institute researchers who received scholarships to study abroad had been Rockefeller fellows. Monge and Hurtado were frequently invited by the foundation to visit U.S. laboratories.[30]

By the early 1950s the institute's annual operating budget was $29,400, 31 percent of which came from the Peruvian government and the rest mostly from San Marcos University. Special grants supplemented the operating budget. Besides grants from the Rockefeller Foundation (detailed in the next section), the institute received the following. In 1947 the Peruvian Ministry of Public Health gave the institute $20,000; in 1950 the U.S. National Institutes of Health donated $22,000, and the U.S. Public Health Service provided $621,421, which included

[29] See John H. Talbott and David B. Dill, "Clinical Observations at High Altitudes: Observations on Six Healthy Persons Living at 17,500 Ft. and a Report of One Case of Chronic Mountain Sickness," *American Journal of Medical Sciences,* 1936, *192*:626; and Carlos Monge Medrano, "High Altitude Disease," *Archives of Internal Medicine,* 1937, *59*:32–40. (This last article was preceded by a brief prologue that used the eponym *Monge's disease.*) For a general overview of the expedition see Ancel Keys, "The Physiology of Life at High Altitudes: The International High Altitude Expedition to Chile, 1935," *Scientific Monthly,* 1936, *43*:289–312.

[30] At the Rockefeller Archive Center there are approximately eighteen folders on the topic of Peruvian physiology, the oldest dated 1934 and the most recent 1962: Rockefeller Foundation Archive, R.G. 1.1, 1.2, Series 331 Peru.

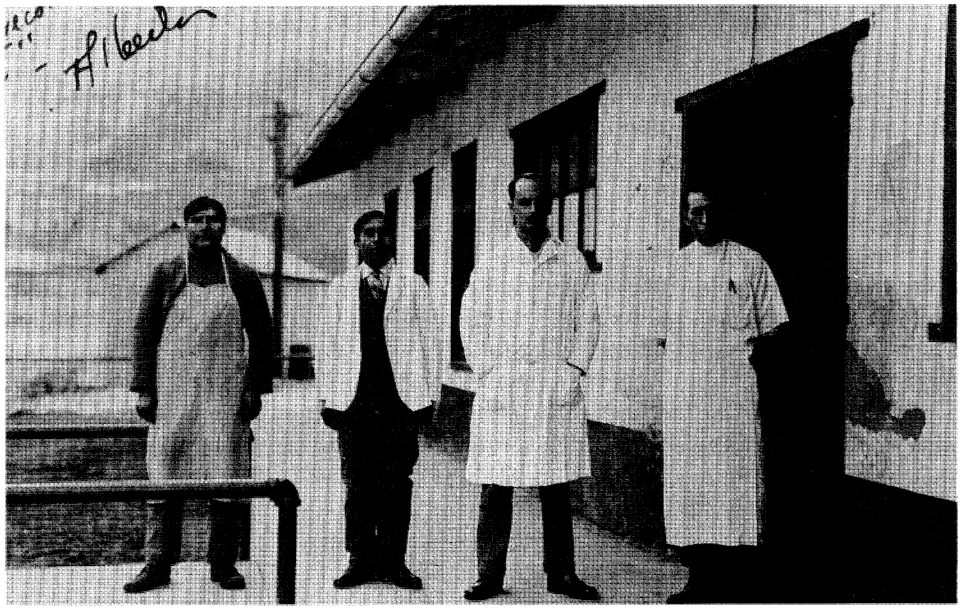

Figure 2. *Expeditions to Morococha, pictured here, began in the late 1920s. Alberto Hurtado is second from the right, in the long-sleeved white coat. Courtesy of the Alberto Hurtado Abadía papers.*

the salaries of four Peruvian researchers; in 1951 the U.S. Air Force donated $196,414 for a three-year period.[31]

Most of the income was used to pay researchers' salaries and the expenses of the institute's four establishments: the locale in Lima, seven miles from the Pacific coast and at sea level; the laboratories in Morococha and Huancayo; and the Volcan Mine Station, located about 16,400 feet above sea level. The institute thus was able to perform laboratory studies with human research subjects at several different altitudes. The institute's staff consisted of nine researchers, each of whom worked in a specialized section. These sections included cardiology, metabolic studies, genetics, hematology, industrial hygienics, and chemistry. The remainder of the staff consisted of fifteen assistants, young doctors and medical students.[32] The activity of these sections in the institute reflected one of the most important effects of high-altitude studies on the emerging Peruvian scientific community: the opening of new specialties. Diverse medical and biological sciences such as biochemistry and endocrinology developed out of the work done at the institute. Thus the Institute of Andean Biology was a decisive influence not only in the rise of modern physiology in Peru but also in the promotion of other new disciplines.[33]

[31] Information about these grants comes from the Monge papers, the Instituto de Biología Andina, *El Estudio,* and Alberto Hurtado to Wade W. Oliver, 22 Aug. 1950, Rockefeller Foundation Archive, R.G. 1.1, Series 331 Peru, Box 2, Folder 14.

[32] Budget information appears in "Presupuesto del Instituto de Biología y Patología Andina para 1952 aprobado por la Facultad de Medicina," Monge papers. The number of people working at the institute has been deduced from "Planilla de haberes del personal del Instituto de Biología Andina del año de 1955," *ibid.*

[33] E.g., physicians found useful the work on anoxia, one of the main subjects of high-altitude

TWO PERSONALITY STYLES

Peruvian physiology was directed by two men: Carlos Monge Medrano and Alberto Hurtado, each representing a distinct personality type and a different scientific work method. Eventually they disagreed on the meaning and dimensions of the field they investigated, but their differences led to creative tension at the Institute of Andean Biology.

Monge Medrano, sixteen years older than Hurtado, received most of his training from the Lima Faculty of Medicine between 1904 and 1910. This institution awarded his doctorate, although he also had the diploma from the London School of Tropical Medicine, received in 1912. Monge was self-taught in modern physiology. His critics claimed that his scientific work contained brilliant ideas but little in the way of empirical data. A local promoter of physiology as well as a pioneering researcher, he had a special talent for being in contact with and winning support from the most varied circles. A familiar Peruvian anecdote has it that Monge was the head doctor for Mariscal Benavides, president of Peru from 1933 to 1939, and at the same time attended Victor Raul Haya de la Torre, the Aprista leader who lived in hiding because he was persecuted by Benavides.[34]

Hurtado, by contrast, was educated primarily abroad. He graduated from Harvard University in 1924 and worked under the direction of Francis Peabody at the Thorndike Memorial Laboratory of Boston City Hospital in 1924 and 1925. Between 1931 and 1934 he specialized in physiology at the University of Rochester, New York, where he worked at the Strong Memorial Hospital with William S. McCann.[35]

Hurtado was responsible for the development of a more experimental style of physiology than that initially favored by Monge. He introduced applied statistics to medical research in Peru, publishing a pamphlet on the subject in 1945. He also introduced scientific novelties: insulin, the measurement of gases in the blood, arterial puncture, and the determination of corpuscular constants in hematological research. His work was characterized by scientific rigor, a concern for exact measurements, and precision in the conclusions. Hurtado and his associates concentrated on precise and detailed description of the mechanisms of acclimatization to a rarefied atmosphere, which produced changes not only in the physical shape of the human body, but also in its chemical composition and organic functions.[36]

At the institute, Hurtado promoted specialization and academic ties with U.S. foundations and universities. He was strongly identified with the standards and methods of U.S. medical research. In 1937 he stated to Robert A. Lambert, a Rockefeller Foundation official: "I think that the day is not far when American

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studies, because it was an alteration also common to respiratory, circulatory, and hematological diseases that occur at sea level. See Alberto Hurtado, "La investigación médica en las grandes alturas," *Mar del Sur,* 1952, *7*:26–33.

[34] For this anecdote see David B. Dill, "Carlos Monge M.: Pioneer in Environmental Physiology," *Physiologist,* 1973, *16*:103–109.

[35] See the curriculum vitae preserved in the Hurtado papers.

[36] For an evaluation of Hurtado's original contributions to the medical and biological sciences see Roger Guerra-García, "Alberto Hurtado: Obra médico-científica," *Acta Médica Peruana,* 1972, *3*:253–254; and Tulio Velasquez, "Alberto Hurtado: Investigador," *Homenaje a la memoria del Dr. Alberto Hurtado Abadía* (Lima: Universidad Peruana Cayetano Heredia, 1984), pp. 17–22. The pamphlet on statistics was published as an article in the faculty annals; see Alberto Hurtado, "Métodos estadísticos," *An. Fac. Med.,* 1945, *28*:125–306.

medicine will have a decisive influence in our teaching and research. I will do my best to contribute to this end."[37]

Monge and Hurtado occupied strategic positions at the university that allowed them to recruit young researchers from among the medical students. Monge directed the chair of clinical medicine. Third- and fourth-year students were required to do internships under his direction in Pavilions 3 and 4 of the Hospital Arzobispo Loayza, then Lima's most important health center. Hurtado held the chair of pathological physiology and directed Pavilions 1 and 2, where last-year students had their internships. The Lima laboratory of the Institute of Andean Biology was housed in a wing of the Loayza Hospital and functioned in association with Hurtado's chair. According to the testimony of those who were students during the period, an aura of prestige and a spirit of teamwork existed among institute members. This prestige was based on Monge's reputation and Hurtado's discipline.[38]

Monge never abandoned the professional practice of medicine, and although dedicated to physiological research, he was always considered a clinician. He directed medical careers outside of the physiological field and worked on non-physiological subjects himself. According to his secretary, Monge did not have a regular schedule and carried out a variety of activities every day. Hurtado, by contrast, was always a professional researcher specializing exclusively in high-altitude research. His apprentices were trained to follow a disciplined work routine that included experiments that began every other day at 5:30 A.M. at the laboratory.[39]

Obviously, Monge and Hurtado were two distinct scientific personalities. Thus it is not surprising that although they were the most prolific authors in Andean biology they cosigned only one article during their time together at the institute. This fact can be further explained by their different interests within the field of physiology. Monge had always concentrated on the ecological and human dimensions of high-altitude research. His strongest ties were to the Huancayo Laboratory, an establishment donated to the Institute of Andean Biology in 1940 by a senator from the region. Huancayo was a city situated at an altitude of about 10,500 feet in the western range of the Andes some 300 miles southeast of Lima, with a population in 1940 of 26,729 inhabitants. It was located in the middle of a rich livestock and agricultural zone where Andean people had lived since pre-Hispanic times. Its altitude was not high enough for it to be useful to, for example, the doctors at the U.S. School of Aviation.

Hurtado and his associates worked independently at the Morococha Laboratory, which was constructed in 1947 on a lot donated by the Cerro de Pasco

[37] Alberto Hurtado to Robert A. Lambert, 4 Jan. 1937, Rockefeller Foundation Archive, R.G. 1.1, Series 331 Peru, Box 1, Folder 6.

[38] All those I interviewed—members of the Institute of Andean Biology from San Marcos University or of the Instituto de Investigaciones de Altura from the Universidad Peruana Cayetano Heredia who were apprentices of Hurtado and Monge Medrano in the 1950s and 1960s—agreed on the atmosphere at the institute: Dr. Roger Guerra-García, interview with Marcos Cueto, Lima, 12 Nov. 1986; Dr. Carlos Monge Cassinelli, interview with Marcos Cueto, Lima, 15 Jan. 1987; Dr. Emilio Picón, interview with Marcos Cueto, Lima, 24 Mar. 1987.

[39] Carlos Monge Medrano's secretary mentioned the lack of schedule in his scientific work: Dr. Juana Maria Solano, interview with Marcos Cueto, Lima, 21 Apr. 1987. The discipline that Hurtado encouraged among his students is remembered by one of his collaborators in later years: Carlos Monge Cassinelli to Alberto Hurtado, 6 Apr. 1970, Alberto Hurtado Abadía Papers, Lima (hereafter **Hurtado papers**).

Copper Corporation. Morococha, 90 miles due west of Lima, was located at an altitude of 14,900 feet and in 1947 had a rural and urban population of 8,078. It was a mining zone of very recent human settlement. Morococha had the distinction of being the highest laboratory in the world.

One of Hurtado's main concerns was to overcome Peru's lack of technological resources for scientific research. To this end, he signed agreements with the most important U.S. foundations to obtain equipment and material for high-altitude research. The institute received many sizable donations; the executor of most of these was Hurtado, who always maintained excellent relations with the Rockefeller Foundation, the U.S. National Institutes of Health, and the U.S. Air Force. Beginning in 1934, the Rockefeller Foundation provided support to the Institute of Andean Biology through its Medical Science and Natural Science divisions. By 1951 these grants totaled slightly more than $100,000.[40] Monge obtained some money from foreign countries, but he was not as successful with the U.S. foundations as Hurtado.

The relationship between Hurtado and the Rockefeller Foundation began in the early 1930s. Half of his postdoctoral studies at Rochester were supported with a foundation grant. Shortly before returning to Peru, Hurtado faced a problem similar to that of any scientist from the Third World who is educated abroad: How should he apply his skills as a researcher in his own country? Hurtado was aware that in a scientifically underdeveloped country like Peru his learning could be underutilized in a private medical practice or if he undertook the heavy teaching load required of scientists at San Marcos University. To avoid this, he asked the Rockefeller Foundation to equip a laboratory for high-altitude studies in Peru, with sophisticated instruments and two assistants. He was awarded $4,000 and began a successful career as a scientist in Peru.[41]

By the early 1950s ten of the institute researchers had studied abroad on Rockefeller fellowships, and approximately three fourths of the money from foundation grants was used to purchase research equipment. One of the most important Rockefeller grants was given to Hurtado in 1949. It provided $50,000 for equipping the Morococha Laboratory and was amended to allow $2,000 a year to be used as a salary for Hurtado.[42] Around 1953, Hurtado escorted a Rockefeller Foundation official through the Lima laboratory and pointed out that the majority of its contents were donated by the foundation. After the visit Hurtado exclaimed: "You can see how we are the sons of Rockefeller. . . . They gave us the possibility of equipment, training—everything." In 1951 another officer from the foundation had remarked, after reviewing Hurtado's file: "I could not avoid the impression that Hurtado is a skilled and rather persistent asker."[43] This skill helped Hurtado to obtain equipment as good as that used by the Harvard Fatigue Laboratory, a research center working in areas related to those that concerned

[40] Interoffice Correspondence, 20 Apr. 1951, Rockefeller Foundation Archive, R.G. 1.1, Series 331 Peru, Box 2, Folder 15.

[41] Research Aid Grant, 26 Apr. 1934, *ibid.*, Box 1, Folder 8.

[42] Flora M. Rhind (Rockefeller Foundation) to Pedro Dulanto (president of San Marcos University), New York, 7 Apr. 1949, published in Instituto Nacional de Biología Andina, *El estudio de la biología de las grandes alturas en las regiones andinas del Perú* (Lima: Facultad de Medicina, 1949), p. 34.

[43] Trustees' Confidential Report, 1 Oct. 1954, Rockefeller Foundation Archive, R.G. 1.1, Series 331 Peru, Box 1, Folder 8; and Interoffice Correspondence, 20 Apr. 1951, *ibid.*, Box 2, Folder 15.

Table 1. Rockefeller Foundation Grants to Peruvian Physiology, 1934–1955

Year	Amount in U.S. dollars	Principal investigator	Purpose
1934	4,000	A. Hurtado	Research equipment for physiology laboratory, University of San Marcos
1939	4,560	A. Hurtado	Research equipment, Department of Pathological Physiology, University of San Marcos
1939	1,000	A. Hurtado	Travel expenses to the U.S.
1939	2,300	A. Rotta	Research equipment, Institute of Andean Biology
1941	4,100	C. Merino; A. Hurtado	Research equipment, Department of Pathological Physiology, University of San Marcos
1941	1,500	C. Monge Medrano	Travel expenses to the U.S.
1942	7,500	Not available	Research equipment, Institute of Andean Biology
1943	9,775	C. Monge Medrano	Research equipment, Huancayo Laboratory, Institute of Andean Biology
1946	2,000	C. Monge Medrano	Travel expenses to the U.S.
1947	4,000	C. Monge Medrano	Research equipment, Institute of Andean Biology
1949	50,000	A. Hurtado	Research equipment, Morococha Laboratory, Institute of Andean Biology
1953	575	A. Hurtado	Travel expenses to the U.S.
1955	90,000	A. Hurtado	Department of Pathological Physiology, University of San Marcos

SOURCE: Rockefeller Foundation Archive, R.G. 1.1, 1.2. Series 331, Rockefeller Archive Center.

the Peruvians.[44] Table 1 shows the grants received by Peruvian physiologists from the Rockefeller Foundation—grants that continued until the late 1960s.

Although Hurtado never explicitly defined his attitude on scientific research, his writings give us a glimpse of a specialist convinced that science was a universal activity, valid for all locales, and dedicated to diffusing the standards of the international scientific journals among Peruvians. Monge made his position on science explicit in two articles, which can be summed up as follows. First, he believed that scientific knowledge was relative. He insisted until the early 1950s that there was a biological knowledge specific to the Andes, different from textbook biology based on sea-level experimentation. Second, he was not much concerned with the acquisition of expensive or sophisticated technology for research. He believed that research in a poor country should be concentrated in areas of study suggested by some natural characteristic, like the high-altitude areas in Peru. The Andes were an excellent natural laboratory for physiological experimentation; furthermore, they afforded Peruvian scientists unique opportunities, because very few countries had extensive populations located at more than 9,800 feet above sea level.[45]

[44] Lambert's interviews, 26 May 1941, *ibid.*, Box 1, Folder 7.

[45] Carlos Monge Medrano also offered some insights into the history of science, quoting from George Sarton's works; see the opening speech of the 1951 academic year, in *La universidad y la*

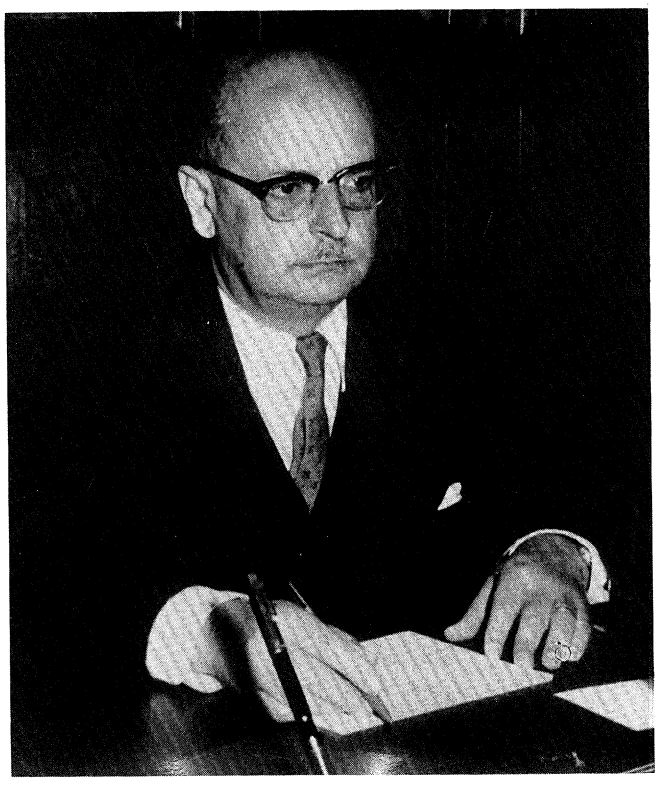

Figure 3. *Alberto Hurtado. Courtesy of the Hurtado papers.*

Hurtado did not dispute the unusual physical capacity of the Andean native. After performing a comparative experiment on physical exertion in sea-level residents and highlanders, he concluded that the native of Morococha could "work longer hours and do so with less oxygen consumption in relation to his body weight. . . . his body functioned more efficiently."[46] Rather, Monge and Hurtado differed over more theoretical matters. For example, Hurtado did not believe that an Andean biology existed as an independent area of scientific knowledge. He also disputed Monge's claim that the Andean people constituted a climatic-physiological race: "Diverse considerations incline us to the unitarian concept of human physiology and to consider that its diverse modifications, dependent on the environment or on customs temporary or permanent, do not justify the criteria of diverse varieties of physiology, especially when they are considered as racial characteristics."[47]

Hurtado and Monge also differed substantially in their views of the origin and reversibility of the compensatory mechanisms to high altitude exhibited by the Andean people. Hurtado thought that most of these mechanisms could be acquired or lost since they originated fundamentally from the environment. Monge,

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ciencia (Lima: Editora Médica Peruana, 1951); and "La investigación científica en la enseñanza médica," *An. Fac. Med.*, 1956, *34*:760–771.

[46] Alberto Hurtado, "Hombre y ambiente: El hombre en las grandes alturas habitadas," *An. Fac. Med.*, 1955, *33*:9–16, on p. 14.

[47] Alberto Hurtado, "Estado actual de las investigaciones sobre aclimatación a la altura," *Anuario de la Academia Nacional de Medicina de Lima, 1952–1953* (Lima: Editorial de San Marcos, 1953), pp. 34–38, on p. 37. See also Hurtado, "Hombre y ambiente."

on the contrary, believed that they had a genetic origin; for proof he pointed to the fact that the Andean people conserved some of the taxonomic characteristics acquired at high altitudes even when living on the coast.[48] This difference reflected an important debate in modern biology—environment versus inheritance—transferred to the preoccupation with explaining life in the Andes.

Hurtado's more internationalist scientific outlook played a contradictory role within the Institute of Andean Biology. On the one hand, his ability to obtain funds from abroad assured the continuation of the effort of institution building. On the other hand, it is very probable that this outside fund-raising compelled Peruvians to produce grant proposals that emphasized the priorities of the foreign scientists who reviewed the applications to U.S. foundations. Did this concern for "imported" scientific problems extinguish local creativity? I believe that it was not affected during the period under study. But according to some contemporary high-altitude physiologists, Peruvian creativity did suffer during the 1960s.

In spite of their differences, Monge recognized that Hurtado was the person most capable of directing the institute after his retirement, as a letter from May 1949 reveals: "Yesterday I had a long conversation with Hurtado and by mutual agreement we are defining [the institute's] general features. . . . Evidently, Hurtado is the only man who can direct the Institute when, for natural reasons, I am no longer able to do so. . . . the only thing that should concern us is that the work continue."[49] Monge probably endorsed Hurtado because he recognized that although he himself may have had doubts about them, the future of physiology in Peru lay in U.S. funding, in quantification, and in sophisticated technology, of which Hurtado was the leader within the institute. Monge's attitude was similar to that of many parents, illiterate in informatics, who encourage their children to study computer science. In fact, Monge told one of his sons who was interested in research to work under Hurtado.

In the mid 1940s Monge became less and less involved with the active direction of the institute and began to hold university administrative posts, such as dean of medicine and acting rector of San Marcos. Although he never stopped publishing in physiology, his enthusiasm turned to anthropology. This interest in the social sciences had a certain logic, given his ecological perspective on the problems of high altitude. Monge Medrano undertook a survey of colonial and nineteenth-century records of instances of acclimatization to high altitude and chronic mountain disease. In 1948 Johns Hopkins University published his historical account analyzing how the Peruvian indigenous society had, since pre-Hispanic times, confronted the high-altitude environment.[50] Two years later, Monge was named director of the Instituto Indigenista Peruano, where, with the aid of Cornell anthropologists, he carried out a widely publicized pilot project for modernizing the rural area of Vicos, a valley located in the northern highlands.[51]

[48] Hurtado, "Estado actual," pp. 36–37; and Carlos Monge Medrano, "Hombre y ambiente: El concepto de aclimatación," *An. Fac. Med.*, 1955, *33*:1–8. Monge's view on the Andean people was neo-Lamarckist, in that he believed that characteristics acquired by an individual can be inherited.

[49] Monge Medrano to Monge Cassinelli, Lima, 4 May 1949, Monge papers.

[50] Carlos Monge Medrano, *Acclimatization in the Andes: Historical Confirmations of "Climatic Aggression" in the Development of Andean Man* (Baltimore: Johns Hopkins Univ. Press, 1948).

[51] See Carlos Monge Medrano and Mario C. Vazquez, "El proceso de aculturación de vicos," *Perú Indígena,* 1963, *10*:9–15; and Henry F. Dobyns and Mario C. Vazquez, "The Cornell Peru Project:

CONCLUSION

Peruvian high-altitude physiology played an unusually active role, compared to most other Latin American disciplines of the time, in the international scientific community. In the last few years scientific communities in Latin American countries have been known as peripherals. This term refers to their marginality to the frontier of knowledge; it connotes a small number of practitioners, a lack of resources, and, often, slight relevance to local needs.[52]

These features of peripherality did not characterize Peruvian physiology owing to several factors. First, qualified scientists with leadership qualities were on-site. Second, high-altitude studies were, in the late 1920s, a totally new area of research. Thus the Peruvian researchers were in at the beginning of the growing subspecialty and in a position to share world leadership. Third, North American researchers had to replicate the effects of high altitude in expensive and sophisticated pressure chambers, but the Peruvians could exploit the natural laboratory that was the Andes, without resorting to high technology. Fourth, the research specialty accorded with national interests—as well as with nationalist pride—and was thus funded and institutionalized in the Institute of Andean Biology. Fifth, the specialty coincided with the interests of richer nations, so that the Peruvians could attract more funds from abroad. The congruence of these factors allowed the creation of a "central" scientific institution in a backward country.

The case of Andean biology suggests that the term *periphery* should be scrutinized by Latin American historians of science. It is useful for characterizing the low rate of contributions of Latin American science to international knowledge according to modern indicators such as the Science Citation Index. But it is imprudent to apply the concept unthinkingly to whole scientific establishments, so that scholars are blinded to the contributions made by less developed countries. The term fails to capture the richness and complexity of the reception and recreation of Western science in non-core Western cultures, and it may cause first-rate research groups in countries with low scientific profiles to be overlooked.

During 1928–1950 the Institute of Andean Biology faced a task fundamental for scientific practitioners in any less developed country: to do original research that was both locally important and significant to specialists working at the international level on the frontier of knowledge. Maintaining research of this nature continues to be a challenge in Peru and in Latin America.

Bibliography and Personnel," Cornell Peru Project Pamphlet No. 2, Department of Anthropology, Cornell Univ., 1964.

[52] For a recent discussion of this subject in relation to a Latin American country see Elena Diaz, Yolanda Texera, and Hebe Vessuri, *La ciencia periférica: Ciencia y sociedad en Venezuela* (Caracas: Monte Avila Editores, 1983).