JORDAN BIMM*

Andean Man & the Astronaut: Race and the 1958 Mount Evans Acclimatization Experiment

ABSTRACT

In 1958, Bruno Balke, a former German Luftwaffe doctor working for the United States Air Force (USAF), led a team of airmen up Colorado's Mount Evans. Could acclimatization to the thin mountain air boost the oxygen efficiency of future astronauts living in artificial low-pressure spacecraft environments? To judge their improvement, Balke, an expert in the nascent field of space medicine, compared their performance not with military test-pilots, but with high-altitude Indigenous people he had studied in the Peruvian Andes. This article expands discussions of race in space history beyond Black scientists, mathematicians, and pilots in the Civil Rights era to this earlier case of the permanent residents of Morococha, Peru, who participated in efforts to define an ideal spacefaring body. More than recovering the story of a nearly forgotten group of astronaut-adjacent test-subjects, this article shows how racial discrimination in space medicine functioned by *inclusion*. Balke studied and even celebrated the bodies of Morococochans, but never considered them potential astronauts. This article begins with Balke's participation in the 1938 Nazi-funded expedition to summit Nanga Parbat in the Himalayas, and his follow-on work acclimatizing Luftwaffe pilots during World War Two. Then it focuses on his USAF work in the 1950s studying miners living and working in Morococha, Peru, and his attempt to replicate their altitude tolerance in American airmen on Mount Evans. Recovering Balke's work places the high-altitude Indigenous person and the mountaineer alongside the familiar figure of the pilot in the genealogy of the early American astronaut.

KEY WORDS: race, space medicine, Bruno Balke, astronauts, altitude physiology, Peru, high-altitude Indigenous people, acclimatization, space exploration, mountaineering

*Postdoctoral Research Fellow, Stevanovich Institute on the Formation of Knowledge, University of Chicago, 5737 South University Avenue, Chicago, IL 60637; jordanbimm@uchicago.edu

The following abbreviations are used: IAB, Institute of Andean Biology; NASA, National Aeronautics and Space Administration; SAM, School of Aviation Medicine (USAF); TUC, time of useful consciousness; USAF, United States Air Force.

Historical Studies in the Natural Sciences, Vol. 51, Number 3, pps. 285–329. ISSN 1939-1811, electronic ISSN 1939-182X. DOI: https://doi.org/10.1525/hsns.2021.51.3.285.

> What our Air Force wants to learn about Andean Man is this: Is there some chemical difference which enables him to live and perform as efficiently as he does in his lofty mountain regions? If so, can we reproduce it artificially, adapting our navigators and future spacemen to life at extremely high altitudes? Air Force scientists hope so . . . [1]

On July 7, 1958, a team of seven men from the United States Air Force's (USAF) School of Aviation Medicine (SAM) made their way up Mount Evans in Colorado to conduct an experiment in the new field of space medicine, an emerging discipline concerned with selecting and protecting future astronauts.[2] The group was led by Bruno Balke, a former German military doctor and mountaineer who had worked for the Luftwaffe in World War Two. His goal was to see if acclimatization to the thin mountain air could boost the oxygen efficiency of humans in artificial low-pressure spacecraft environments.[3] To judge the group's improvement Balke compared their performance not with military test-pilots, but with high-altitude Indigenous people in the Peruvian Andes. Starting in 1954, Balke made three research trips to the mining village of Morococha situated at 14,000 feet, where an agreement between the USAF and Peruvian scientists from the Institute of Andean Biology (IAB) allowed him to study the remarkable altitude tolerance of the local population.[4] Then, on Mount Evans, Balke attempted to replicate this performance-at-altitude in his USAF recruits through a rigorous physical training regimen (see Fig. 1). After six weeks on Mount Evans, Balke planned to select the two best acclimatized men for a ten-day simulated spaceflight, where the ambient cabin pressure would be set to the equivalent of 14,000 feet. Balke's comparative study brought so-called Andean Man into the orbit of the early American astronaut, but tellingly these two categories were always kept separate.

Histories of the astronaut often begin in 1959 with the National Aeronautics and Space Administration's (NASA) selection of seven white, male, military test-pilots for Project Mercury, and then focus on the storied Space Race of the

1. "What Type of Navigator will be Chosen for Space?" *The Navigator* 5, no. 1 (1958): 26.

2. "A Scientist's Ordeal in Make-Believe Space" *LIFE* 45, no. 15 (13 Oct 1958): 49.

3. Bruno Balke, "Experimental Studies on the Conditioning of Man for Space Crews," in *Man in Space: The United States Air Force Program for Developing the Spacecraft Crew*, ed. Lt. Col. Kenneth F. Gantz (New York: Duell, Sloan, and Pearce, 1959), 177.

4. "School of Aviation Medicine, USAF, Semi-annual History Volume 23, 1 July–31 December 1956," Air Force Historical Research Agency, IRIS #0480872.

FIGURE 1. Bruno Balke leads a team of seven USAF airmen on Mount Evans, Colorado, in the summer of 1958. *Source:* National Archives and Records Administration, moving image ID: 342-USAF-26260. Public domain.

1960s.[5] However, the work of preparing humans for spaceflight began a whole decade earlier in 1949 when the USAF established the Department of Space Medicine at SAM in San Antonio, Texas. Likewise, when space historians discuss the topic of race, it has mainly been in the context of the Civil Rights Movement of the 1960s, and the slow integration of African Americans into professional roles at NASA, including the astronaut corps.[6] Shifting space history's focus from NASA's astronaut selection to this earlier moment of USAF astronaut development expands space history's discussion of race to include high-altitude Indigenous people who participated in efforts to define

5. Colin Burgess, *Selecting the Mercury Seven: The Search for America's First Astronauts* (Chichester: Springer, 2011); Matthew Hersch, *Inventing the American Astronaut* (New York: Palgrave MacMillan, 2012).

6. See Margot Lee Shetterly, *Hidden Figures: The American Dream and the Untold Story of the Black Women Who Helped Win the Space Race* (New York: William Morrow & Co., 2016); Lynn Spigel, "Outer Space and Inner Cities: African American Responses to NASA," in *Welcome to the Dreamhouse: Popular Media and Postwar Suburbs* (Durham, NC: Duke University Press, 2001), 141–85; Charles L. Sanders, "The Troubles of 'Astronaut' Edward Dwight: Official Excuses Cloud Routine Assignment of Nation's Only Negro Trained for Role in Space," *Ebony*, June 1965.

an ideal spacefaring body. In addition to recovering a nearly forgotten group of astronaut-adjacent test-subjects, this case also offers an example of how a barrier to spaceflight was constructed in early space medicine around notions of race. Balke's comparative studies explicitly cast Indigenous people in opposition to prospective astronauts. Even though Balke was very interested in the bodies of Morocochan miners, and even believed they were particularly well-suited for space, he never contemplated or suggested including them as potential astronaut candidates. The plan was always to "attempt to train prospective crewmen as closely as possible to the physical standards of these natives."[7] Balke assumed the category of "astronaut" was reserved for white men in excellent physical condition and structured his studies in a way that ensured this outcome.

This episode also offers historians of medicine an example of how racial typologies persisted in biomedical research beyond the so-called postwar "retreat of scientific racism."[8] Vanessa Heggie, a historian of science and medicine, has already shown that high-altitude physiology in Peru was one place where racial categories endured.[9] This subsequent story of space medicine's arrival in the Andes deepens this understanding of race and altitude, and reveals one under-perceived mechanism for how medical exclusion functions: *by inclusion*.[10] Space medicine did not exclude high-altitude Indigenous people from spaceflight by ignoring them; it focused on them intently and even celebrated aspects of their physiology. Rather, it excluded them by constructing two distinct biological types, with only one being considered for space. To ensure that white bodies could still be considered "superior," Balke's studies reinforced and extended older distinctions—a set of binaries including

7. Alberto Hurtado and Robert T. Clark, "Parameters of Human Adaptation to Altitude," in *Physics and Medicine of the Atmosphere and Space*, ed. Otis O. Benson Jr. and Hubertus Strughold (New York: John Wiley & Sons, 1960), 367.

8. Nancy Stepan, *The Idea of Race in Science: Great Britain 1800–1960* (New York: Macmillan, 1982); Elazar Barkan, *The Retreat of Scientific Racism: Changing Concepts of Race in Britain and the United States between the World Wars* (Cambridge: Cambridge University Press, 1991); Jenny Reardon, *Race to the Finish: Identity and Governance in an Age of Genomics* (Princeton, NJ: Princeton University Press, 2004).

9. Vanessa Heggie, "Blood, Race and Indigenous Peoples in Twentieth Century Extreme Physiology," *History and Philosophy of the Life Sciences* 41, no. 26, (2019): 1–20; Vanessa Heggie, *Higher and Colder: A History of Extreme Physiology and Exploration* (Chicago: University of Chicago Press, 2019): 133–43.

10. Steven Epstein, *Inclusion: The Politics of Difference in Medical Research* (Chicago: University of Chicago Press, 2007).

Indigenous and white, highlander and lowlander, adaptation and acclimatization, resident and visitor, colonized and colonizer—into new Cold War categories of non-astronaut and astronaut, with evolution-steeped connotations of past and future.

To understand early astronauts, space historians have traditionally turned to pilots and the field of aviation medicine.[11] Exploring Balke's Mount Evans experiment traces an additional contributing genealogy, one that focuses instead on mountaineers and high-altitude Indigenous people, specifically miners who lived and worked in Morococha, Peru (see Fig. 2).[12] Like mountaineers and the miners at Morococha, astronauts can spend long periods of time living and working in low-pressure environments.[13] When astronauts leave their craft and step onto the surface of another celestial body, they shed their identity as pilots, and take on aspects of the extreme explorer.[14] In late 1958, before NASA decided to limit its inaugural search for astronauts to military test-pilots with degrees in engineering, their initial recruitment call listed "mountain climbing" as one of a handful of dangerous occupations where good candidates might be found.[15] So while space medicine did focus on pilots, mountaineers were also in the mix. Decentering the pilot both highlights and parses the hybridity of the astronaut and adds a critical new vantage point from which to study space medicine's construction of an ideal spacefaring body.

In his history of the 1963 American Mount Everest Expedition, *Science in an Extreme Environment* (2019), historian Philip W. Clements recounts how organizer Norman Dyhrenfurth promoted his team of climbers and scientists as analogous to NASA's Project Mercury astronauts. Balke's work shows an important and instructive precursor of this connection—the "deployment of

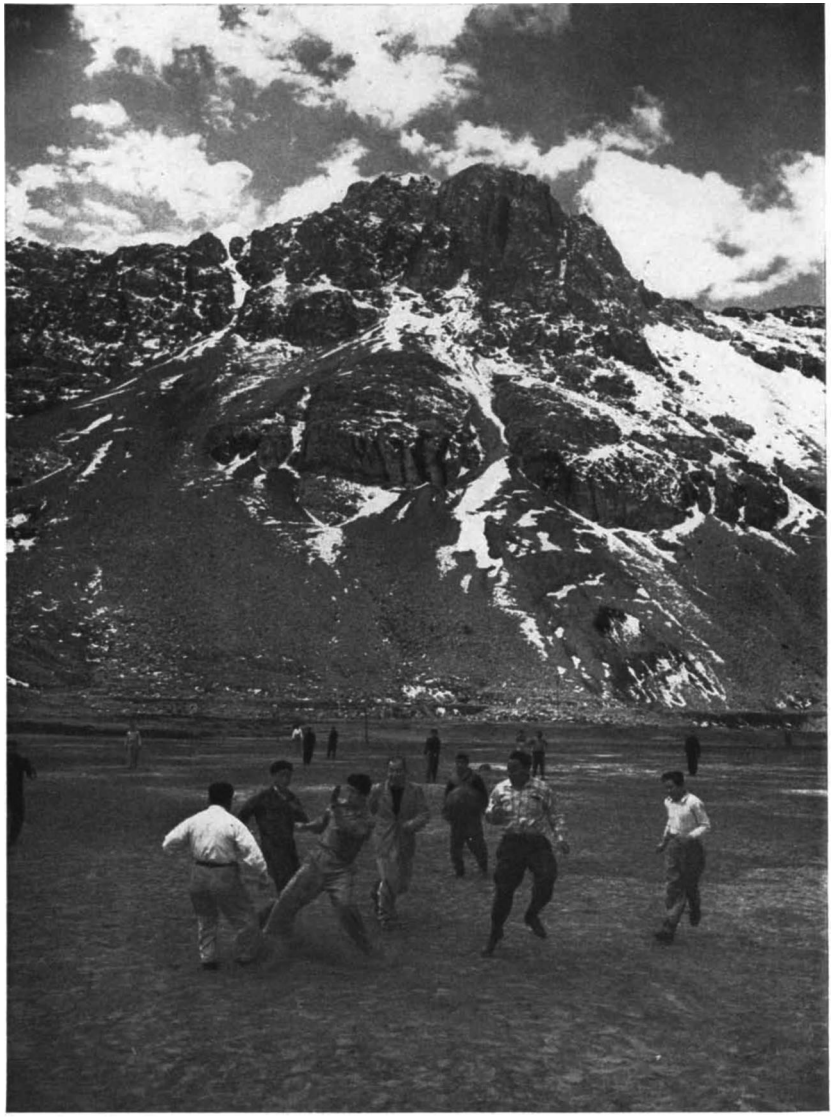
11. Maura Philips Mackowski, *Testing the Limits: Aviation Medicine and the Origins of Manned Space Flight* (College Station: Texas A&M University Press, 2006); Roger Launius, "Heroes in a Vacuum: The Apollo Astronaut as Cultural Icon," in *The Florida Historical Quarterly* 87, no. 2 (2008): 174–209.

12. John B. West, *High Life: A History of High-Altitude Physiology and Medicine* (New York: Springer, 1998); Heggie, *Higher and Colder* (ref. 9).

13. Vanessa Heggie, "Experimental Physiology, Everest and Oxygen: From the ghastly kitchens to the gasping lung," *British Society for the History of Science* 46, no. 1, (2013): 123–47.

14. Bruno Balke, *Human Tolerances* (Oklahoma City: Federal Aviation Agency, 1962); see also Jordan Bimm and Patrick Kilian, "The Well-Tempered Astronaut," in *Nach Feierabend: Der Kalte Krieg*, ed. Silvia Berger Ziauddin, David Eugster, and Christa Wirth (Zurich: Diaphanes, 2017), 85–107.

15. "NASA Project A, Announcement No. 1," NASA Historical Reference Collection, 4.



PERUVIAN MINERS play soccer near Morococha, the altitude of which is near 15,000 feet. At this height (pressure eight pounds per square inch) men who are accustomed to living at sea level (pressure about 14 pounds) are exhausted by climbing a few steps.

FIGURE 2. Beginning in 1954, Morocochan miners participated in USAF-sponsored high-altitude physiology studies to determine physical conditioning methods for future astronauts. *Source:* Gray, "Life at High Altitudes," (ref. 84), 58. Reprinted with permission.

mountaineers and scientists as proxies for astronauts"—that Clements writes about.[16] In the summer of 1958, when Balke and his recruits were training on Mount Evans, NASA was still an idea being debated in congress. It would be nearly a year before the Mercury Seven were selected and celebrated. Even at this early moment Balke saw his Evans Seven as model astronauts.[17] Occurring only months after the Sputnik scare, Balke's pairing of mountains and astronauts was popularized in *LIFE* magazine, *Popular Science*, and in an installment of science fiction pioneer Donald G. Wollheim's young-adult adventure series, *Mike Mars: Astronaut.*[18]

Balke described space medicine's work as a search "for the qualities of the superman."[19] The "superpower" he was most interested in providing astronauts was the ability to remain alert and active in low-pressure, low-oxygen environments where most people would quickly lose consciousness. When humans move significantly higher into the atmosphere, the reduction in air pressure decreases the amount of oxygen reaching the brain. Above 10,000 feet, symptoms known collectively as altitude sickness can become noticeable, including of hyperventilation, light-headedness, headache, confusion, sore joints, nausea, loss of appetite, and weakness. Above 26,000 feet—a region popularly called the Death Zone—the body is slowly dying, and humans risk losing consciousness and succumbing to anoxia. At SAM, Balke learned that engineers designing early spacecraft were planning to utilize thin artificial atmospheres to save on weight.[20] This meant astronauts might have to live in pressure conditions equivalent to 14,000 feet, which made Balke's specialty in mountain science and altitude conditioning a viable countermeasure.

16. Philip W. Clements, *Science in an Extreme Environment: The 1963 American Mount Everest Expedition* (Pittsburgh: The University of Pittsburgh Press, 2018), 50.

17. The title of Balke's report was explicit: "Man in Space: Experimental Studies on Physiological Aspects of Training and Selection for Manned Extraterrestrial Flights," in *Bioastronautics: Advances in Research* (San Antonio, TX: Air University, 1959).

18. "A Scientist's Ordeal" (ref. 2), 49; Donald Wollheim, *Mike Mars: Astronaut* (New York: Doubleday & Company, 1961) 44.

19. Bruno Balke, "Experimental Studies on the Conditioning of Man for Space Crews," in *Man in Space: The United States Air Force Program for Developing the Spacecraft Crew*, ed. Kenneth F. Gantz (New York: Duell, Sloan and Pearce, 1959) 178.

20. "If the normal tolerance of Air Force flying personnel to oxygen deficiency and reduced atmospheric pressure could be raised by an altitude equivalent of even 10,000 feet, the weight and bulk of pressurization equipment required in aircraft operating at 30,000 to 45,000 feet could be sharply reduced, thus increasing their speed and payload." "Selected Research Projects," in *Air University: School of Aviation Medicine* (1957), Air Force Historical Research Agency, IRIS #00918003 (1957), 15.

Balke's story also expands scholarship on the large-scale influx of German scientists to America's military-industrial-academic complex after World War Two as part of "Operation Paperclip" and its follow-on programs.[21] Both popular culture and space history have zeroed in on the charismatic and influential rocket designer Wernher Von Braun and his team of engineers who ended up working for the U.S. Army and later NASA in Huntsville, Alabama.[22] In the separate niche of space medicine, historians have focused on Hubertus Strughold, the former director of the Luftwaffe's Aviation Medicine Research Institute in Berlin, who, despite connections to wartime experiments on concentration camp prisoners, was put in charge of the USAF SAM's Department of Space Medicine in 1949.[23] This article offers a close look at one of the lesser-known Luftwaffe medical experts Strughold recruited to SAM to solve the biological problems of spaceflight, one who brought ideas about race, nation, and the body from German mountaineering to bear on the early astronaut. Balke is also interesting for selecting himself to serve as one of the two subjects in the ten-day-long spaceflight simulation that followed his time on Mount Evans. This created a unique moment: the only time one of the many former Luftwaffe doctors active in early USAF space medicine played the role of an American astronaut in a simulated spaceflight.

This study traces Balke's work on altitude acclimatization between three different mountain sites from 1938 to 1958 to show how ideas about race and altitude were integrated into early space medicine and established a method for perfecting the astronaut body. It begins with Balke's participation in the 1938 Nazi-funded expedition to summit Nanga Parbat, one of the tallest mountains in the Himalayas, and follow-on work acclimatizing Luftwaffe pilots during World War Two, where he first utilized the basic program he would later apply in the context of space medicine. Then it focuses on his work with high-altitude Indigenous people—specifically miners living and working in

21. Annie Jacobson, *Operation Paperclip: The Secret Intelligence Program That Brought Nazi Scientists to America* (New York: Back Bay Books, 2014); Brian E. Crim, *Our Germans: Project Paperclip and the National Security State* (Baltimore: Johns Hopkins University Press, 2018).

22. For histories of Von Braun and the V-2 rocket, see: Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (Cambridge, MA: Harvard University Press, 1995); Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War* (New York: Routledge, 2007). For a broader look at Von Braun's German rocket group in America, see Monique Laney, *German Rocketeers in the Heart of Dixie: Making Sense of the Nazi Past during the Civil Rights Era* (New Haven, CT: Yale University Press, 2015).

23. Mackowski, *Testing the Limits* (ref. 11); Mark Campbell and Viktor Harsch, *Hubertus Strughold: Life and Works in the Fields of Space Medicine* (Neubrandenburg: Rethra Verlag, 2013).

Morococha, Peru—for the USAF, and the resulting association between Andean Man and the astronaut. Finally, a close account of the 1958 Mount Evans experiment and subsequent spaceflight simulation—featuring Balke himself playing one of the two astronauts—leads to a discussion of how "Andean Man" and acclimatized soldiers ended up factoring into debates in the 1960s over cyborgs and the ethics of improving bodies for space.

BRUNO BALKE AND THE 1938 GERMAN EXPEDITION TO NANGA PARBAT

In April, 1938, two decades before the Mount Evans experiment, Balke boarded a freighter in Amsterdam bound for Mumbai. He was part of a large, high-profile German expedition competing to be the first to set foot on a desolate, extreme environment of purely symbolic value. Not the Moon, but the summit of Nanga Parbat, a 26,000-foot peak in the Himalayas then considered on par with Everest.[24] Led by Paul Bauer, the leading figure in German mountaineering, the team's goal was to make an historic first summit of the infamously perilous "Mountain of Destiny."[25] Balke's role as team physician extended beyond simply caring for sick or injured climbers, he was also conducting secret altitude research for the Luftwaffe. Could a few weeks of rigorous activity high in the mountains boost the altitude tolerance of fighter pilots, giving them a tactical advantage in aerial combat? Balke's task was to study changes in the bodies of his teammates over the weeks and months living and working at altitude to see if this was possible.

Balke (pronounced BALL-Kay) was born in 1907 in Braunschweig, Germany, to a sporting family of skiers and mountain climbers. Described as tall, lithe, and eagle-faced, Balke enrolled in Berlin's new Academy of Physical Education with the goal of becoming a teacher or trainer.[26] In 1928, he was admitted into medical school at Berlin. To afford the expensive tuition, he worked nights as a fencing coach, and spent semester breaks as a mountain guide and ski instructor in the Alps.[27] At medical school, Balke met another

24. Harald Hoebusch, *"Mountain of Destiny": Nanga Parbat and Its Path into the German Imagination* (Rochester, NY: Camden House, 2016).

25. Another nickname for Nanga Parbat is simply Killer Mountain.

26. Mary Ann Jackson, "Bruno Balke Welcomes—and Creates—Avalanches," *The Physician and Sportsmedicine* 5, no. 9, (1977): 93–98.

27. Bruno Balke, *Matters of the Heart* (Monterey, CA: Healthy Learning, 2007), 25–26.

student named Ulrich C. Luft, who later had a recurring role shaping his career, first in Germany and later in the United States. Balke received his medical degree in 1936, and in 1937 was hired as a sports physician at the University of Berlin.[28]

After Adolph Hitler seized power in 1933, mountaineering ascended to a prominent place in German society and Nazi ideology. Since the nineteenth century, German mountaineering culture had been steeped in notions of physical, racial, and national superiority, which made it extremely compatible with the Third Reich's ideas and aims. Mountaineering expeditions were presented as quasi-military "proxy battles" between rival European nations where heroic Germans could demonstrate renewed national strength and regain prestige lost in World War One. This culture shaped Balke's ideas about race and perfection through rigorous physical activity.

In early 1938, Luft came to Balke with an enticing but risky proposition: Would Balke join him as part of an expedition attempting to summit Nanga Parbat? It was a very dangerous offer. In 1937, just months before visiting Balke, Luft had been the sole survivor of a disastrous attempt. While camped at 20,000 feet, a massive avalanche crushed the team's tents, suffocating sixteen climbers in their sleep.[29] Luft alone was spared because he had temporarily returned to a lower camp. Back in Germany, the disaster undercut the nationalistic climbing community's narrative of German superiority, and Paul Bauer, head of Nazi mountaineering, was determined to deliver the Himalayan propaganda victory eluding them.[30] Luft's job on the doomed 1937 expedition had been to assist Hans Hartmann, a physiologist with the Luftwaffe's new Aviation Medicine Research Institute in Berlin.[31] Their role was to study how the team acclimatized to altitude, but Hartmann was one of the sixteen climbers killed in the avalanche. All was not lost, however. Luft and a rescue team were able to excavate Hartmann's frozen corpse and locate his notebook filled

28. Ibid., 30.

29. George W. Rodway, "Ulrich C. Luft and the Physiology of Nanga Parbat: The Winds of War," *High Altitude Medicine and Biology* 10, no. 1 (2009): 89–96; Harald Hoebusch, "Ascent into Darkness: German Himalaya Expeditions and the National Socialist Quest for High-Altitude Flight," *The International Journal of the History of Sport* 24, no. 4, (2007): 525.

30. Jonathan Neale, *Tigers of the Snow: How One Fateful Climb Made the Sherpas Mountaineering Legends* (New York: Thomas Dunne Books, 2002), 209.

31. Hubertus Strughold was the director of the Institute from 1935 until the fall of Berlin in 1945. He later became the first director of the USAF SAM's Department of Space Medicine and was crucial in recruiting Balke to America.

FIGURE 3. Bruno Balke climbs above 18,000 feet on Nanga Parbat. Balke conducted an acclimatization study for the Luftwaffe as part of the 1938 expedition. *Source:* Balke et al., *Nanga Parbat* (ref. 32), 117. Public domain.

with data. It was this Luftwaffe-sponsored study that Luft now asked Balke to join him in completing. Balke jumped at the chance for adventure.

In 1943, Balke, Luft, and five other team members published an account of the 1938 expedition, titled *Nanga Parbat: Berg Der Kameraden* (Mountain of Comrades).[32] The travel narrative is illustrated with one hundred striking black and white photographs. It begins by depicting the team's arrival in India, and their long trek into the Himalayas to base camp. Once at base camp, they participated in an operation with clear military applications: the test-recovery of airdropped supplies on the mountain. After spending two months working their way up to 25,000 feet on Nanga Parbat, Bauer decided to conclude the expedition without reaching the top (see Fig. 3). Exercising caution, he turned back shy of the summit rather than risking another embarrassing disaster. But Luft and Balke succeeded in completing Hartmann's study.[33] Luft concluded,

32. Bruno Balke, Fritz Bechthold, Rolf von Chlingensperg, Alfred Ebermann, Uli Luft, Herbert Ruths, and Lex Thoenes, *Nanga Parbat, Berg der Kameraden: Bericht der deutschen Himalaya-Expedition 1938* (Berlin: Union Deutsche Verlagsgesellschaft Berlin Roth und Co., 1943), 42.

33. Hoebusch, "Ascent into Darkness" (ref. 29), 527. This included taking cardiovascular, respiratory, and hematological measurements of all team members during the expedition, and

"The data we obtained on the mountain at altitudes up to 25,000 feet led to the conclusion that, given enough time at intermediate altitudes, the human body can adapt adequately up to 19,000 or 20,000 feet for a period of many weeks."[34] Luft and Balke suggested that pilots acclimatized in this manner could fly unpressurized fighter planes 3,000 feet higher than their Allied adversaries, and published their encouraging data in two articles that appeared in the military aviation medicine journal *Luftfahrtmedizin*.[35]

BALKE'S WAR

In September 1939, Germany invaded Poland and the Second World War began in earnest. Shortly afterward, Balke joined the Wehrmacht—the German Army—where he served as a field doctor.[36] In the spring of 1940, Balke requested a transfer and was reassigned to the Wehrmacht's elite First Mountain Division, famous for their ability to fight in difficult terrain. He participated in the invasion of France, where he was briefly reunited with Paul Bauer and other members of the Nanga Parbat expedition.[37] In 1941, Balke's unit was part of Operation Barbarossa, the Nazi invasion of Russia. As a doctor near the front, he saw many horrors of war firsthand, treating both gunshot and shrapnel wounds as well as infectious diseases. Balke eventually contracted hepatitis and was ordered back to Berlin to recuperate—an unlucky turn that probably saved his life. While in Berlin, his old friend Luft contacted him with another life-altering offer. Luftwaffe leaders had read their Nanga Parbat studies and wanted a program to acclimatize pilots at a high-altitude mountain station. Luft, who had replaced Hartmann as Strughold's deputy in Berlin, thought Balke perfect for the alpine post.

Early in 1942, Balke reported to the Wehrmacht's Mountain Medical School in St. Johann, a small town on the Austrian side of the Tyrolean Alps. The school had been established to train physicians and officers in the medical

---

determining how their tolerance of acute exposure to extreme altitude in low-pressure chambers had changed before and after they had been acclimatized.

34. Ibid., 527.

35. Ibid., 527. Their articles were titled "Physiologische Beobachtungen am Nanga Parbat 1937/38" [Physiological observations on Nanga Parbat 1937/38] and "Zur Verwendung von Hohenatemgeraten auf Himalajaexpeditionen" [On the use of oxygen apparatus on Himalayan expeditions].

36. Balke, *Matters of the Heart* (ref. 27), 42.

37. Ibid., 43.

problems of fighting in extreme environments. It had two existing laboratories, including one that focused on Balke's forte: "experimental investigations of human capacity and on adaptability to special conditions encountered in mountain regions."[38] His first job was to establish a third off-site high-altitude laboratory for training and conditioning Luftwaffe pilots. A scouting excursion to the central Alps near Grossglocker located a good fit: the Oberwalder Hut constructed by the Austrian Alpine Club at 9,900 feet was quickly converted to accommodate his work.

Here Balke first employed the mix of techniques he later used to study the permanent residents of Morococha in the Andes, and to condition USAF airmen on Mount Evans. Balke summarized the process as performing "tests of maximal functional capacity at the end of rigorous physical training at low elevation, followed by training at altitudes above 3,000 meters (10,000 feet) and testing again after returning to the former lower base level."[39] Specifically, Balke was most interested in expanding two measures of human performance relevant to pilots: work capacity and time of useful consciousness (TUC). Work capacity was the amount of time a person could exert themselves at a given altitude before total exhaustion. TUC was a riskier measurement. As the name suggests, TUC is the amount of time a person can perform meaningful tasks at altitudes where supplementary oxygen would otherwise be necessary to maintain consciousness. For example, an unacclimated person suddenly exposed to the low-pressure environment at 30,000 feet might be able to function for a minute before blacking out from anoxia.[40] In the context of flying (and later spaceflight), work capacity corresponded to "normal" life and work at a survivable higher altitude, whereas TUC tests simulated an emergency situation, like a sudden loss of cabin pressure when pilots or astronaut would have only seconds to initiate life-saving procedures, like donning a full pressure suit, sealing a hatch, or descending to a lower altitude.[41]

38. Ibid., 48.

39. Ibid., 49.

40. TUC varies between people and is slightly higher if the exposure to altitude is gradual rather than sudden. In the vacuum of space, TUC is around 6 to 9 seconds.

41. Valerie A. Olson, "The Ecobiopolitics of Space Biomedicine," *Medical Anthropology* 29, no. 2 (2010): 171–72. Olson has written about how astronauts are environmental subjects defined in relation to normal and emergency conditions (173). See also Valerie Olson, *Into the Extreme: U.S. Environmental Systems and Politics Beyond Earth* (Minneapolis: University of Minnesota Press, 2018).

After acclimatizing Luftwaffe pilots on the mountain, Balke would seal them in a pressure chamber. For work capacity tests, subjects pedaled a cycle ergometer (an early form of stationary bicycle). Balke would adjust the pressure to a predetermined level and see if the pilot could exert himself for longer than before acclimation. For TUC tests, the pilot sat in the chamber and was (either gradually or suddenly) exposed to a critical altitude. He would then attempt to perform some task, like writing a sequence of numbers, for as long as possible until blacking out—hopefully lasting longer than before acclimatizing. Balke recalled that "we learned that a period of two to three weeks at an altitude above 3,000 meters (10,000 feet) resulted in maintaining consciousness at simulated altitudes of 10,000 meters (32,800 feet). For practical applications, fighter pilots were trained under my guidance at the high-altitude station. Upon returning to their bases, they were able to exceed the altitude tolerance of nonacclimatized pilots by about 3,000 feet, a great advantage in battle."[42]

In the aftermath of the war, Balke claims to have been cleared of explicit connections to Nazism by an unnamed French official during the occupation.[43] Like many other German scientists who participated in Operation Paperclip and related programs, Balke later downplayed the military character of his research, casting himself as an archetypical apolitical scientist. In his 2007 autobiography, Balke wrote, "My own sportsmedical work and the work with Uli Luft on the physiological evaluation of the expedition members occupied all of my time and interest; thus I paid no attention to the political upheaval of that time."[44] But his work *was* inherently and obviously political. Figuring out how to achieve high-altitude flight supported the Luftwaffe's goal of attaining air superiority—a crucial element of Hitler's expansionist plans.[45] This early phase of Balke's career in service to the Third Reich is significant for understanding his later interest in improving the bodies of astronauts. It is

42. Balke, *Matters of the Heart* (ref. 27), 50. Balke used his research at the high-altitude station as the basis for a PhD dissertation in physiology titled "Physical Performance Capabilities in High Mountains," which was granted by the University of Leipzig in March 1945, just days before the fall of the Reich. Balke's dissertation can be found in Box 1, Folder 1 of the Bruno Balke Papers (MSS 0468) in the Special Collections and Archives of University of California San Diego.

43. Balke, *Matters of the Heart* (ref. 27), 56. "All accusations against me were dropped. I could go home as a free man."

44. Ibid., 42.

45. Karl Heinz Roth, "Flying Bodies—Enforcing States: German aviation medical research from 1925 to 1975 and the Deutsche Forschungsgemeinschaft," in *Man, Medicine, and the State: The Human Body as an Object of Government Sponsored Medical Research in the 20th Century*, ed. Wolfgang U. Eckart (Stuttgart: Franz Steiner Verlag), 107–27.

important to realize that the first bodies Balke sought to improve for altitude were Luftwaffe fighter pilots, white military men carefully selected based on notions of physical superiority and already deeply associated with a eugenic, nationalist future. This is even more important in the context of his later Cold War work in which he attempted to perfect white bodies for space by using non-white bodies as research subjects.

***

Balke spent the next few years bouncing around the ruins of Europe, working as a masseuse for the Austrian nation hockey team, and as a cobbler. His luck changed in November 1949, when he received a personal visit from Hubertus Strughold. From 1935 to 1945, Strughold had been the director of the Luftwaffe's Aviation Medicine Research Institute in Berlin, which had employed Hartmann and Luft. After the war, Strughold was captured by Americans who then offered him a leadership role at the USAF SAM in San Antonio, Texas, eventually in 1949, putting him in charge of the new forward-looking Department of Space Medicine. Now Strughold was looking to further enhance his new space-minded research staff with a specialist in human performance physiology. Luft, who had followed Strughold to Texas, again recommended Balke. Balke agreed to Strughold's offer without hesitation. In February 1950, Balke boarded a transport ship in Bremerhaven and made port in New York City. He headed south to Texas by train.

Balke arrived at SAM later than most of the German scientists employed there. Now forty-three years old, he was assigned to the newly minted Department of Human Performance and Physiology for a six-month trial, which was eventually followed by an offer of permanent employment. By comparison, most of the other German scientists had already secured long-term contracts, resettled their families, moved into houses, and even owned their own cars—astonishing to Balke, who had just come from poverty-stricken post-war Germany. Determined to impress his new American bosses, Balke immediately began working on new Cold War–era problems: chiefly, jet pilot performance at altitudes in excess of 50,000 feet, a region Strughold had recently reframed as equivalent to space in terms of human survival.[46]

46. Ibid., 64. In 1953, Balke was able to bring the rest of his family over from Germany, and in 1954, his status as a permanent resident was approved by the U.S. Civil Service Commission.

SPACE MEDICINE AND HIGH-ALTITUDE INDIGENOUS PEOPLE

In 1954, Balke flew to Lima, Peru, and then drove up from the coast to Morococha, a small industrial mining town situated at 14,900 feet in the Andes Mountains. He was sent by SAM to perform acclimatization tests on himself, but also to carefully study the local population of permanent residents that labored in silver and copper mines and had for decades been considered uniquely adapted to the high-altitude environment.[47] Just like in the Alps, Balke tested his own work capacity and TUC, but mainly he was there to give these tests to miners who lived and worked permanently at altitude. This section explores the USAF's little-known activity in the Andes, where in the first half of the twentieth century Peruvian scientists steeped in a newfound nationalism created a unique variant of high-altitude physiology called Andean Biology. A USAF contract with the Lima-based Institute of Andean Biology (IAB) allowed Balke to use their laboratory at Morococha to experiment on the permanent residents with the bodies of future American astronauts in mind.

Like the cold acclimatization and radiation experiments USAF scientists performed on Indigenous people in Alaska, Balke's goal was biological appropriation.[48] He attempted to mobilize aspects of Indigenous bodies that seemed militarily advantageous, and then recreate their functional effects in white soldiers—akin to reverse engineering human difference. In the 1950s, Indigenous people in Peru were also studied by American social scientists, and were the subject of a special World Health Organization session in 1966.[49] In *Race to the Finish: Identity and Governance in an Age of Genomics*, science and technology studies scholar Jenny Reardon explains how after the Holocaust scientists attempted to discredit and jettison the now-toxic concept of race. An important episode in this so-called post-war retreat from scientific racism was the 1946–1947 Nuremberg Doctor's Trial, in which twenty-three German medical doctors—including some of Balke's close Luftwaffe associates—were tried for crimes that included lethal altitude experiments on vulnerable subjects

47. "Peru Natives Are High Air Birds," *Madera Mercury*, 25 Dec 1921.

48. Matthew Farish, "The Lab and the Land: Overcoming the Arctic in Cold War Alaska," *Isis* 104, no. 1 (2013): 1–29.

49. See *Life at high altitudes: Proceedings of the Special Session held during the Fifth Meeting of the PAHO Advisory Committee on Medical Research 15 June 1966*, PAHO Scientific Publication 140 (Washington, DC: Pan American Health Organization, 1966); *Biomedical Challenges Presented by the American Indian*, PAHO Scientific Publication 165 (Washington, DC: Pan American Health Organization, 1968), 1; Jason Pribilsky, "Developing Selves: Photography, Cold War Science and 'Backward' People in the Peruvian Andes, 1951–1966," *Visual Studies* 30, no. 2, (2015): 132.

considered to be racially inferior and therefore disposable for scientific ends. A major result of the trial was the establishment of the Nuremberg Code, which provides clear rules for scientific experiments involving human subjects. Chief among these is the concept of informed consent, forbidding the use of force to compel a person to participate in an experiment.[50] Supporting Reardon's point that this retreat was largely superficial, Balke provides an interesting case: a former Nazi doctor resuming human experimentation on vulnerable racialized populations seven years after the Doctor's Trial and in the wake of the UNESCO statements on race, for the U.S. military.[51] There is no evidence in any of Balke's contemporaneous reports or in his autobiography—or anywhere else, for that matter—that he practiced informed consent in his studies of miners at Morococha.

This close look at Balke's work at Morococha will show how high-altitude physiology's colonial character constructed two separate models for the relationship between humans and low-pressure milieus: long-term adaptation and short-term acclimatization. Critically, these two models also distinguished between two different racialized subjects: Indigenous inhabitants who had adapted, and white colonial visitors (considered the normal) who wanted to "acclimatize" relatively quickly. This dichotomy already had facilitated the colonization of the Andes, but in the Cold War it became part of a move to colonize an entire *type* of space: low-pressure artificial environments in outer space. Extending his wartime Luftwaffe work, Balke again sought to acclimatize "visitors" to altitude—white USAF personnel—but added an important new benchmark: Could they match the performance of Morocochan miners? In the context of space medicine, this practice implicitly defined the astronaut in opposition to people who had lived at high-altitude their entire lives—specifically, the permanent residents of Morococha. This was a subtle, yet crucial act of exclusion that had an insidious self-reinforcing effect: information generated in these studies became norms for selecting and training future astronauts.[52] The following section provides a brief history of high-altitude physiologists' interest in Andean people, with a focus on research at Morococha.[53]

50. For a history of the Trial and the Code, see Paul Julian Weindling, *Nazi Medicine and the Nuremberg Trials: From Medical War Crimes to Informed Consent* (New York: Palgrave MacMillan, 2004), 287–88.

51. Reardon, *Race to the Finish* (ref. 8), 25–28; Stepan, *The Idea of Race* (ref. 8).

52. Hurtado and Clark, "Parameters of Human Adaptation" (ref. 7).

53. On the topic of high-altitude physiology in Peru, Marcos Cueto and Heggie have each written about the main personalities, Carlos Monge Medrano and Alberto Hurtado, as well as the

ANDEAN BIOLOGY AND ANDEAN MAN

Starting in the late nineteenth century, European physiologists attempting to understand respiration became interested in humans who lived permanently at high altitude in Mexico, Chile, and Peru. In 1863, the French physician Denis Jourdanet journeyed from France to the high plains of Mexico, where he performed the first physiological studies on non-White people living at altitude. He concluded that they were "a race characterized by signs of marked debility."[54] In 1889, his colleague Paul Bert persuaded another French physiologist, Francois-Gilbert Viault, to travel to the Peruvian Andes to conduct tests on local people who labored in high-altitude copper and silver mines. Viault travelled to Morococha—the site of Balke's Cold War visits—where he noted an increase in red blood cells in samples drawn from himself and the residents, which he believed to be an adaptation to the low atmospheric pressure. This was the first suggestion that then-unknown physiological processes could counteract the effects of altitude.[55]

In 1921, Cambridge physiologist Joseph A. Barcroft led an expedition to the Cerro de Pasco mining district located at 14,200 feet in the central Peruvian Andes. After converting an empty railcar into a makeshift laboratory, his group began three months of tests on themselves and the local population. At the time, Barcroft was engaged in a debate with Scottish physiologist and expert on respiration J. S. Haldane over the exact mechanism of acclimatization. In 1914, Haldane had conducted an expedition to Pike's Peak in Colorado, where he concluded that people who live at high altitudes undergo physiological changes that effectively counteract the low pressure and eventually produce functionality equivalent to that at sea level. Barcroft's work in Peru, published in 1923,

---

founding of the IAB in Lima. Additionally, Jorge Lossio has written about the Institute's partnership with the Cerro De Pasco Mining Corporation by focusing on work at the Chulec Hospital. Marcos Cueto, "Andean Biology in Peru: Scientific Styles on the Periphery," *The History of Science Society* 80, no. 4, (1989): 640–58; Heggie, "Blood, Race and Indigenous Peoples" (ref. 9); Jorge Lossio. "Nation Disease and Health: Medical Research in the Peruvian Andes and the Emergence of 'High-Altitude Diseases," in *Beyond Borders: Fresh Perspectives in History of Science*, ed. Josep Simon and Néstor Herran (Newcastle, UK: Cambridge Scholars Publishing, 2008), 269–90.

54. West, *High Life* (ref. 12), 205. According to Cueto, Jourdanet "concluded that Mexicans were an anemic race because anoxia . . . kept them in a permanently weakened state." Cueto, "Andean Biology in Peru" (ref. 53), 641.

55. Ibid., 641.

found the opposite: "All dwellers at high-altitude are persons of impaired physical and mental powers."[56]

These findings, and Barcroft's statement in particular, provoked the ire of Carlos Monge Medrano, a mostly self-taught Peruvian physiologist who also had trained in Paris and London in tropical medicine. Insulted by what he presented to readers as Barcroft's apparent low estimation of Andean people, Monge led his own team from San Marco University in Lima up to Morococha in 1927.[57] Between 1927 and 1932, Monge and groups of Peruvian researchers made eight trips to different settlements in the highlands. Monge's resulting publications trumpeted "the exceptional performance—especially physical performance—of native Indians," and significantly raised his profile among his better-funded North American and European peers.[58] Sustained interest from abroad resulted in the founding of the IAB at the Faculty of Medicine at San Marcos University in Lima in 1931.[59] In 1934, Monge became the director of the Institute.[60]

In contrast to Balke's work in the Himalayas that focused on Germans and virtually ignored the Sherpas facilitating their expedition, Monge vigorously promoted what he saw as the unique strengths of Andean bodies. Monge's strong response to Barcroft, and the subsequent founding of the Institute, were part of a wider nationalist intellectual movement in Peruvian society called *indigenismo*.[61] Started in the 1920s, *indigenismo* sought to recover Andean life and rethink the place of Indigenous people in modern Peruvian society.[62] Taking Barcroft's assessment as an affront to national pride, Monge set out to rehabilitate the standing of Indigenous Peruvians in biology. This was *indigenismo* "extended to medical and scientific circles."[63] Monge's view of

56. Cueto, "Andean Biology in Peru" (ref. 53), 642; West, *High Life* (ref. 12), 205.

57. Cueto notes that Monge made eight trips to ten different destinations between 1927 and 1932. Heggie convincingly argues that Monge misinterpreted and sensationalized Barcroft's findings to bolster his nationalist agenda. Heggie, "Blood, Race and Indigenous Peoples" (ref. 9) 26.

58. Cueto, "Andean Biology in Peru" (ref. 53), 644.

59. Ibid.

60. This activity directly preceded Harvard Fatigue Lab physiologist Ancel Keys's 1935 expedition to the Chilean Andes, a project he framed as having potential benefits for both high-altitude miners and pilots. See Sarah W. Tracy, "The Physiology of Extremes: Ancel Keys and the International High Altitude Expedition of 1935," *Bulletin of the History of Medicine*, 86, no. 4 (2012): 627–60.

61. Pribilsky, "Developing Selves" (ref. 49), 134.

62. Cueto, "Andean Biology in Peru" (ref. 53), 647.

63. Ibid., 647.

biology incorporated this surging nationalistic sentiment. He believed that the high-altitude Andean environment was unique, and that existing medical ideas and practices that took sea-level conditions as normal needed to be adapted.[64] Historian Jorge Lossio notes that Monge stressed the locality of medical knowledge, which ran counter to the dominant trend toward universalistic conceptions of health and pathology. To underscore this power of place, Monge called his new sub-discipline Andean Biology.[65]

For Monge, the reconfiguration of normal and pathological in Andean Biology demanded a reappraisal of its unique human subject, the Indigenous Peruvian, as the hardy and tireless Andean Man. Crucially, whereas Barcroft had only studied resting bodies, Monge shifted the focus to exercise physiology. According to Monge, the low-pressure environment had produced special adaptations in the bodies of Andean people that allowed them to physically outperform visitors from the lowlands by significant margins. When Monge's work was documented in *Time* magazine in 1947, Andean Man was described as "a stocky individual with a broad chest and purplish-ruddy complexion . . . [with] lungs [that] are bigger than normal, with more blood vessels in them. Their blood is in greater volume and contains more oxygen per unit. Their hearts can do 12% more work than the hearts of sea-level men. Their nerve cells are less sensitive to anoxia (oxygen starvation)."[66] He considered Andean Man to belong to a special "climatic variety of the human race," and to be "the race with the greatest physical performance in the world."[67] Far from the insulting picture he took from Barcroft—of people permanently impaired at altitude—Monge held up Andean Man as a kind of superman.[68]

Monge's defense of Andean people still stemmed from a particular paternalistic colonial gaze, now known as Andeanism. Looking at Europe and the Alps, historian Michael S. Reidy has detailed how male climbers crafted a gendered hierarchy of altitudinal zones, with the highest levels comprising a masculine preserve.[69] A similar concept of altitudinal zoning, this time along racial

64. This is a precursor to Olson's concept of "space normal." Olson, "Ecobiopolitics of Space Medicine" (ref. 41), 172.

65. Historian Philip Clements explores the locality of knowledge in high-altitude physiology in *Science in an Extreme Environment* (ref. 16).

66. "Andean Man," *Time* 49, no. 25 (1947): 74.

67. Cueto, "Andean Biology in Peru" (ref. 53), 646.

68. Ibid., 646. Heggie also points out Monge's total lack of interest in "Andean Woman." Heggie, "Blood, Race and Indigenous Peoples" (ref. 9), 15.

69. Michael S. Reidy, "Mountaineering, Masculinity, and the Male Body in Mid-Victorian Britain," *Osiris* 30 (2015): 158–81.

lines, was constructed in Peru, with European-descended *mestizo* inhabiting the lower coastal areas, and Andean people properly residing in the mountains. This was the basis for the idea that Peru is really "two countries in one."[70] Andeanism, inspired by Said's Orientalism, divides humans into categories of we and they and essentializes the resultant other. Andeanism dichotomizes between the urban, coastal, Western *mestizo* and the inland, Indigenous peoples who reside in the Andes. This view portrays Indigenous people as unitary, pure, and timeless. This division is spatial (horizontal *and* vertical) but also temporal. The coast is depicted as the future-oriented present, while life in the mountains harkens back to the pre-colonial Incan past.[71] Lossio points out that this idealized view of the "timeless Andean native" masked the reality that these people had undergone massive social and cultural upheavals since colonization, from Inca, to colonial peasants, to industrial miners.[72] Focusing on Andean Man's resilience against nature allowed Monge to conveniently avoid addressing the hostile social and economic environment of these mining towns. He promoted their physiology, but still viewed the miners as scientific objects in a natural laboratory. This colonial binary of lowland/highland at the root of Andeanism was reproduced in comparative high-altitude physiology and extended by Balke to outer space.

The story of Monge and Andean Man is incomplete without highlighting the essential and deeply troubling role of the Cerro de Pasco Mining Corporation in creating Andean Biology. Cueto and Lossio both argue that by installing modern medical facilities in remote areas and employing large Indigenous populations, industrialized mining was indispensable in the development of Peruvian high-altitude physiology. Without these elements already in place, Monge's work would have been prohibitively difficult. In the early twentieth century, a group of American investors bought up most of the lands and mines in central Peru, launching a major effort to industrialize and scale up

70. Lossio, "Nation Disease and Health" (ref. 53), 282. When this characterization of geographic and cultural division is extended to include the Amazon region, Peru becomes "three lands." See Hermann Rahn, "Soccer or Soroche," *Rochester Review* 17, no. 4 (1956): 15.

71. Rahn, "Soccer or Soroche" (ref. 70), 15. One example of this depiction is given by Hermann Rahn, an American physiologist who worked at Morococha in 1956 as part of a Rockefeller-funded fellowship: "The Spanish settled primarily along the Pacific Coast and Lima has become the cultural and business center, while on the east side of the mountains remain the vast and nearly untapped resources of the Amazon. In between lies the lofty Andean home of the ancient Inca empire. Even today their descendants prefer the high altitudes and provide one of nature's fascinating experiments—acclimatization of man to low oxygen pressure." Ibid., 15.

72. Lossio, "Nation Disease and Health" (ref. 53), 272.

extraction under the banner of the Cerro de Pasco Mining Corporation. By the end of World War Two, the U.S.-based company was the largest single employer in Peru.[73] Lossio notes how American managers sought to employ a large, exclusively Indigenous workforce. This involved instigating "the migration of thousands of native workers from moderate to high altitudes, and the establishment of modern hospital facilities there." These modern hospital facilities included laboratories and equipment, but most crucially patients, who researchers from Monge's Institute would use as experimental subjects.[74]

Lossio also outlines the company's long history of exploitative labor practices. They used questionable tactics to convince Indigenous people to relocate to mining towns—everything from predatory lending, to willfully destroying the farmlands around existing villages. At the mines, life and work was racially divided, with white American managers and engineers overseeing teams of Indigenous workers. Lossio notes that the company exclusively recruited Andean workers because of a "conviction of the unique capacity of the Andeans to resist the effects of high-altitude," but also because they were a population that could be exploited.[75] Work in the mines was often perilous, and the company's checkered safety record was first protested by activist Dora Mayer in her 1913 condemnation *The Conduct of the Cerro de Pasco Mining Company*, which highlighted the widespread use of child labor, institutionalized neglect for worker safety, high number of worker deaths, and poor living conditions.[76] Lossio describes these miners and their families as a "captive population" and a "population out of place," lacking the resources to escape the coercive circuits of the company town. Lossio includes this chilling description of the tight hold the Pasco Corporation had on its all-Indigenous workforce: "the physician of the company delivers the children; afterward they attend the school of the company; are employed by the company; and are buried by the undertaker of the company."[77] The Morococha miners were a vulnerable population, and

73. Ibid., 272.

74. Lossio points out that although Monge and his student Hurtado were at times critical of the corporation's treatment of the Indigenous workers, they still accepted work and resources presented by the company. Lossio goes so far as to suggest that the company used the presence of the physicians and token improvements to soften its reputation for brutality.

75. Lossio, "Nation Disease and Health" (ref. 53), 273.

76. Dora Mayer, *The Conduct of the Cerro de Pasco Mining Company* (Lima: Association Pro-Indigena, 1913).

77. Lossio, "Nation Disease and Health" (ref. 53), 274. See also Epstein, *Inclusion* (ref. 10), 41.

this uneven power dynamic influenced their participation in experimental medical research.

IAB & SAM

Soon after the founding of the IAB in 1931, outside funding began to arrive from American universities and foundations. In 1934, the Rockefeller Foundation began a long-standing relationship with the Institute, donating equipment for laboratories, and paying for Peruvian medical students to study at American universities. One student who had previously gone this route in the 1920s was Alberto Hurtado, who along with Monge, is the other major figure in Peruvian high-altitude physiology. A generation younger than Monge, Hurtado was a Harvard-trained medical doctor who had done Rockefeller-funded research at the University of Rochester. Although the two disagreed on the essential uniqueness of Andean Biology, Hurtado worked alongside Monge at the Institute as research director and formed the most lucrative relationships with American funding bodies, including the USAF.

In 1947, Monge and Hurtado used their connections with the Rockefeller Foundation and the Cerro de Pasco Mining Corporation to establish a special high-altitude laboratory at Morococha, which had been a site of previous expeditions going back to Viault in 1889. The Pasco Corporation donated a plot of land, and a Rockefeller grant provided funds for equipment and staff salaries. Hurtado saw these partnerships as essential for science to thrive on the "periphery": "We are the sons of Rockefeller . . . They gave us the possibility of equipment, training—everything."[78]

Morococha's selling point for locating the new laboratory was the local population of miners; the stone and glass building even ominously overlooked a row of their houses (see Fig. 4).[79] Monge and Hurtado advertised the facilities to American experts in a 1947 letter published in the *Journal of the American Medical Association* as "the highest laboratory in the world." "Morococha, where the laboratory is being built," they wrote, "is a mining town with a permanent population of about 4,000 inhabitants, most of whom are of the Indian race . . . [This] will allow investigations concerning the effects

78. Cueto, "Andean Biology in Peru" (ref. 53), 654.

79. A photo in Rahn's article depicts this close proximity between researchers and workers—literally meters apart—showing the laboratory looming over a row of housing. Rahn, "Soccer or Soroche" (ref. 70), 15.

FIGURE 4. The IAB laboratory at Morococha (foreground) overlooks a row of worker homes. *Source:* John T. Reeves and Robert F. Grover, "Pulmonary Circulation and Hypoxia Insights by Peruvian scientists into the pathogenesis of human chronic hypoxic pulmonary hypertension," *Journal of Applied Physiology* 98 (2005): 386. Reprinted with permission.

of a low pressure environment on human beings and animals born and raised under such a condition and on newcomers."[80]

A journalist for *Popular Mechanics* described the experience of a "lowland" visitor arriving at the Institute's high-altitude laboratory:

> At Morococha, after 90 tortuous miles, even rugged men unaccustomed to the rarified air in the mining town, pant from the exertion of getting out of the car at the 14,900-foot altitude, flop weakly into a chair and complain of light-headedness. Often their demoralization is made complete by the sight, through the lab's big windows of Peruvian miners racing around outside in a vigorous game of soccer.[81]

80. Monge and Hurtado made every effort to sell the unique facilities to American researchers: "Incidentally, it may be mentioned that Lima, and in consequence Morococha, are only twenty hours air travel distance from New York." They also reassuringly stress the town's colonial structure, mentioning that "there are also a considerable number of white persons." See "Correspondence: Institute of Andean Biology for Study of High Altitude Physiology," *Journal of the American Medical Association* 135, no. 6, (1947): 375.

81. Richard Dempewolff, "Science Climbs the Mountain Peaks," *Popular Mechanics* (Feb 1962): 151–52, 220. Soccer is often referenced to soften the image of hard labor in these towns. Rahn, "Soccer or Soroche" (ref. 70).

Paul A. Campbell, director of research at SAM and one of Balke's American overseers, had a similar recollection: "Here I had stood gasping for breath, watching a new generation of children born at that altitude, play a most vigorous game of touch football."[82] Unsteady newcomers were often greeted with aspirin, orange juice, and advisement not to smoke.

In 1953, the USAF's SAM took Monge and Hurtado up on their offer, granting Hurtado an ongoing research contract (AF-18[600]-174) to conduct high-altitude studies on Andean miners.[83] Part of this agreement involved the USAF installing two state-of-the-art low-pressure chambers, one at the Institute in Lima and one at the laboratory at Morococha. Balke's trip in 1954 was to check on their progress and to conduct his own study of the local population.

ANDEAN MAN AND THE ASTRONAUT

Balke made the first of three research trips to Morococha in the spring of 1954. According to his report, "Experimental Studies on the Conditioning of Man for Space Crews," he spent six weeks there, each day hiking from the Institute's laboratory up to 17,000 feet in an effort to hasten the acclimatization process. Balke's interest in the miners at Morococha took the same two experimental tracks as in the Alps: work capacity and TUC. Here, Balke was interested in how long the Morocochan miners could function at altitudes between 25,000 and 40,000 feet, and whether he could condition and train himself to match or exceed their abilities. Nowhere in the technical or secondary literature is the informed, ethical consent of the Morocochan test subjects discussed or even mentioned. Indicative of Balke's low regard, his research team never

82. Paul Campbell, *Earthman, Spaceman, Universal Man?* (New York: Pageant Press, 1965), 136.

83. "Biographies and Abstracts: Physics and Medicine of the Upper Atmosphere II, 1958," See entry for "Alberto Hurtado": "Most of the work carried out is related to the study of the Indian native resident in the Andean region, at an altitude of 14,900 feet. Since 1953, has a contract with the School of Aviation Medicine, USAF, Randolph Field, Texas, for high altitude research." Hurtado's research project was #AF-18[600]-174, as reported in "School of Aviation Medicine, United States Air Force, Randolph Air Force Base, Texas: Semiannual Historical Report, 23" (1 July 1956 to December 1956), on 19. See T. Velasquez, "Correlation Between Altitude and Consciousness Time in High Altitude Natives (Morococha)," Report (unpublished) to the School of Aviation Medicine, USAF, Randolph Air Force Base, Texas, March 1956; C. Merino, "The Plasma Erythropoietic Factor in the Polycythemia of High Altitudes," Report 56–103, School of Aviation Medicine, USAF, Randolph Air Force Base, Texas, November 1956.

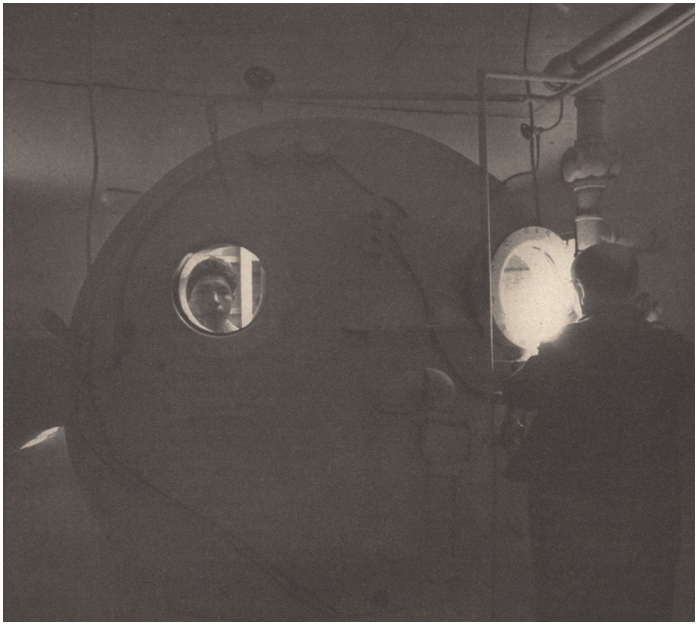


FIGURE 5. A miner employed by the Cerro de Pasco Mining Corporation sits inside the low-pressure chamber in the IAB laboratory at Morococha in 1955. *Source:* Gray, "Life at High Altitudes" (ref. 84), 62. (Scan courtesy of the Linda Hall Library). Reprinted with permission.

described the miners as individuals nor recorded their biographies or even their names.

In 1955, *Scientific American* sent George W. Gray to report on the altitude physiology work being conducted at Morococha. In the resulting article he describes encountering one of these unnamed test subjects: "At the end of our laboratory tour we entered a small room in which a man was seated. He was small of stature, copper-coloured, with jet-black hair and deep-set eyes. He got up hastily and bowed. 'This is a man from Morococha,' the scientist explained, 'a native who has lived here all his life . . . '" (see Fig. 5).[84] In 1962, *Popular Mechanics* described the work of the miners in the IAB pressure chamber: "In the stone and glass station at Morococha, these mountain men sit for long periods in a huge spherical altitude chamber, where atmospheric pressures are raised and reduced while scientists study a battery of instruments to observe

84. George W. Gray, "Life at High Altitudes," *Scientific American* 193, no. 6 (1955) 58–72.

reactions."[85] Neither article interviews or gives the names of these workers doing double-duty as test-subjects. Nor do they make any mention of informed consent, or even specifics of how these men came to be in the pressure chambers in the first place. Gray even dismissively refers to them as "human material."[86]

In his autobiography, Balke claims that his efforts to acclimatize himself at Morococha succeeded. Eventually, he says, he could match the work capacity of the miners. "It turned out that no difference existed in terms of maximal working capacity on the treadmill between myself and the most efficient miners."[87] He also claims to have exceeded their TUC: "a group of native residents reached an average critical altitude of 31,000 feet. The author . . . was still conscious at 33,000 feet."[88] Balke concluded that the miners' physiology showed unique and intriguing efficiencies, but that his body could be trained and conditioned to go beyond. "Even the native Indians who live and work at altitudes between 13,000 and 16,000 feet, and who work and play harder at those altitudes than most people in lower countrysides, do not attain the same maximal performance as do well-conditioned subjects at sea level."[89] However, further experiments on miners performed by Balke and T. Velasquez, a researcher from the IAB, set an even higher bar for white acclimatized bodies: "a TUC of one and one half minutes for natives exposed to a simulated altitude of 40,000 feet."[90]

Balke's work in Peru forged a lasting although little-known connection between Andean Man and the astronaut, but consistent boundary work, including distinct medical categories, kept the two idealized figures separate. As Hurtado noted in a 1958 report, "Most of the prerequisites [for astronauts] are met by high-altitude natives; therefore, it would seem feasible to attempt to train prospective crewmen as closely as possible to the physical standards of these natives."[91] In his 1959 book *New Dimensions of Flight*, American author Lewis Zarem noted, "For the past several years, the attention of the Air Force School of Aviation Medicine has been focused on the *Andean Man*, who lives

85. Dempewolff, "Science Climbs" (ref. 81), 152.
86. Gray, "Life at High Altitudes" (ref. 84), 65, 61.
87. Balke, *Matters of the Heart* (ref. 27), 65.
88. Balke, "Experimental Studies" (ref. 3), 182.
89. Ibid., 181.
90. Ibid., 182.
91. Hurtado and Clark, "Parameters of Human Adaptation" (ref. 7), 367.

in the tiny Peruvian mining village of Morococha, 14,900 feet high, in the Andes Mountains northeast of Lima, Peru."[92] Also in 1959, author Harry Edward Neal wrote, "A tribe of South American Indians, living closer to outer space than any other people, may help the first human space traveler to survive."[93] Hans Clamann, SAM's German expert on atmospheres, told reporters in 1954, "The Incas of Peru work without difficulty in the mines of the Andes at that altitude . . . and maybe America's space men of tomorrow can too."[94] In 1958, an article in *LIFE* magazine summarized Balke's research simply as "copying high-altitude Indians."[95] That issue's editor lauded Balke's space research in grand, epochal terms: "scientists of the present are reaching out into our future by learning how to live like the men of tomorrow."[96] These references convey a temporal dichotomy rooted in Andeanism: the astronaut represents the future of humanity, and Andean Man is cast as an interesting yet totally separate model from the past not to be included in "the men of tomorrow." Morocochan miners were marked as other through the instrumental use of their bodies as a benchmark for normalized white subjects. For example, Balke wrote, "Man, when temporarily acclimatized to more extreme altitudes, behaves more like a native Peruvian Indian."[97] Here, most blatantly, Man is presented as distinct from "native Peruvian Indian." Presenting "Andean Man" as a foil for the astronaut was an act of discrimination accomplished not through exclusion, but through *inclusion* in space medicine studies that implicitly cast the astronaut as white.

EXPANDING DISCUSSIONS ABOUT RACE IN SPACE HISTORY

Discussions of race in space history have focused primarily on the experiences of Black scientists, engineers, mathematicians, and pilots during the American Civil Rights Movement.[98] Analyses of these important cases have described systems of structural and institutional racism in the military, NASA, and wider

92. Lewis Zarem, *New Dimensions of Flight* (Boston: Dutton, 1959), 184.

93. Harry Edward Neal, *Disease Detectives: Your Career in Medical Research* (New York: Julius Messner, 1959), 9.

94. "Air Force Gets New 'Space Ship'," *The Victoria Advocate*, 8 Aug 1954. "Without difficulty" masks the challenging social and economic conditions.

95. "A Scientist's Ordeal" (ref. 2), 53.

96. Ibid., 2.

97. Balke, "Experimental Studies" (ref. 3), 181.

98. Shetterly, *Hidden Figures* (ref. 6); Spigel, "Outer Space and Inner Cities" (ref. 6).

American society during the Space Race of the 1960s. The story of the Morococha miners studied by USAF space medicine experts in the 1950s offers new avenues for discussions of race in space history focused on knowledge-making practices in science and medicine, rather than in a bracketed-off society. First, it widens the scope of race to include groups beyond African Americans.[99] Secondly, it shifts the focus from a national context to transnational networks connecting Germany, the United States, and Peru. Most importantly, though, it offers an example of how discrimination and exclusion from space can operate through inclusion in space medicine studies. Balke's studies included white and non-white subjects, but the comparative set up between two distinct racial typologies performed critical boundary work preemptively excluding high-altitude Indigenous people from consideration for spaceflight. Rather than a Civil Rights story, this is an example of exclusion couched in scientific interest and the construction of medical subjectivities defined by reductive distinctions and assumptions about who belongs in the future. Through this, Balke not only reinforced existing racial hierarchies, he updated existing racial typologies in altitude physiology for the Cold War, extending them to new categories of astronaut and non-astronaut.

This episode from space history further links discussions of race and indigeneity in altitude physiology highlighted by Heggie to other complementary studies in the wider history of twentieth-century biomedical research by Jenny Reardon, Kim TallBear, Joanna Radin, and others focused on blood sampling, DNA analysis, identity, and genomics.[100] As Radin and Dent and Riccardo have shown, Cold War–era life scientists took renewed interest in the bodies of Indigenous people in South America to understand the past, but also to ensure the future.[101] They saw Indigenous bodies as both "portals to the past" and as crucial for securing

99. This limited engagement with the possibilities of the topic of race is similar to how discussions of gender in space history have focused only on ostensibly heterosexual women.

100. Jenny Reardon and Kim TallBear, "'Your DNA Is Our History': Genomics, Anthropology, and the Construction of Whiteness as Property," *Current Anthropology* 53, no. S5 (2012): S233–S245.; Kim TallBear, "Narratives of Ice and Indigeneity in the Genographic Project," *Journal of Law Medicine & Ethics* 35, no. 3 (2007): 412–24.

101. Joanna Radin, *Life on Ice: A History of New Uses for Cold Blood* (Chicago: University of Chicago Press, 2017); Rosanna Dent and Ricardo Ventura Santos, "'An Unusual and Fast Disappearing Opportunity': Infectious Disease, Indigenous Populations, and New Biomedical Knowledge in Amazonia, 1960–1970," *Perspectives on Science* 25, no. 5 (2017): 585–605.

human survival in the long term.[102] Balke's studies of Morocochan miners shows how this type of interest manifested in the context of spaceflight. Balke was not interested in Morocochans as portals to the past—he made no effort to understand their cultural or evolutionary history—but he was interested in them as resources helpful in solving the future-dealing question of human survival in space.

But Balke's exclusion-via-inclusion did reinforce the racist notion that Indigenous people are older or closer to primitive humans, which was extra potent in the futuristic contexts of spaceflight. When Balke arrived in Morococha in 1954, he stepped into a long-running debate over altitude, race, and environmental determinism, which had been brewing since the late nineteenth century. Heggie offers an in-depth account, but in summary, when applied to physiology, the doctrine of environmental determinism held that bodies are indelibly shaped by environmental and climactic factors, including temperature and pressure.[103] European proponents used this theory to justify colonial mistreatment; "the 'noble savage' remained unchangeably shaped by his environment, while temperate man had evolved into his civilised status."[104] As Heggie notes, this conjured a place-based racial hierarchy with white bodies considered superior and advanced and Indigenous bodies thought to be inferior and "closer to, and therefore more representative of, primitive human populations and shared ancient ancestors."[105] Interestingly, Monge's defense and promotion of Andean Man was also deeply environmentally deterministic—he believed the low-pressure environment shaped bodies, behaviors, and even culture in the Andes—the difference being that he vehemently rejected previous conclusions that this resulted in inferiority. Instead, he argued Andean Man was absolutely *superior* to any newcomers from the lowlands. No matter how fit or well acclimatized, no lowlander could replicate their performance. This was their home turf, so to speak. This claim highlighted a troubling contradiction and anxiety among European alpinists like Balke: If white bodies really did belong at the top of a race hierarchy, how to explain the superior performance of non-white bodies in harsh climates? Heggie notes that one solution was rhetorical: simply label this advantage *merely* biological—"molded by the heights," as Gray essentialized in *Scientific American*—which is

102. Radin, *Life on Ice* (ref. 101); Dent and Santos, "Unusual and Fast Disappearing Opportunity" (ref. 101).

103. Heggie, "Blood, Race and Indigenous People" (ref. 9).

104. Ibid., 12.

105. Ibid.

why Balke only studied physiology in the Andes, never considering the culture, tools, oral traditions, or practices of the Morocochans to be of any significance. But for Balke and others, this nagging contradiction took on a new dimension in the Cold War: How could humans he considered to be older and inferior also be templates for perfecting bodies of the future?

Balke offered a solution that put him at odds with Monge's assertions of Andean superiority. Balke believed physically fit white bodies had a latent capacity to outperform Andean Man in the Andean arena, they just needed the right combination of aggressive training and conditioning. He was no doubt familiar with Monge's nationalistic boast about Andean Man printed in *TIME* magazine: "Where North American aviators ask for oxygen, Peruvians play soccer."[106] Writing in his autobiography, Balke recalled dismissing the conclusions of Peruvian physiologists. "According to Dr. Hurtado, the performance capacity of the Andean natives was supposedly much superior to that of any newcomer from the lowlands, and thus they were perhaps ideally suited for eventual extraterrestrial work."[107] But, Balke continued, "from my experience in the Himalayan mountains I knew that ordinary men coming from sea level can adjust to the demands of very high altitude in a relatively short time. Therefore, I was interested in comparing my performance level after a few weeks of training at altitudes up to 6,000 meters (20,000 feet) with the functional capacity of the natives."[108]

The way Balke presented it, this was not simply a data-gathering effort, it was a physical competition between biologically distinct races for ultimate physical superiority in low-pressure environments. Balke wanted to show his sea-level European body could beat any environmentally bestowed advantages of the Morocochan miners. Not only would this resolve the thorny question of why Indigenous people appeared to outperform supposedly superior Europeans at altitude—both in the Andes and in the Himalaya—it would also preempt any objection that so-called primitive bodies might actually be the most compatible with futuristic milieus. Viewed this way, Balke's interest in altitude physiology and Indigenous people was an example of race science lingering into, and reconfigured for, the Cold War. His approach was inherently antagonistic and invested in reserving space for white, masculine, European bodies. This is only one example of how discussions of race in space history can be expanded beyond Civil Rights narratives.

106. Quoted in Cueto, "Andean Biology in Peru" (ref. 53), 646.
107. Balke, *Matters of the Heart* (ref. 27), 65.
108. Ibid.

FIGURE 6. The SAM mobile laboratory (left) and pressure chamber (right) parked near the summit. *Source:* Balke, "Man In Space" (ref. 17), 143. Public domain.

THE MOUNT EVANS ACCLIMATIZATION EXPERIMENT

In July 1958, Balke and six other USAF personnel flew from San Antonio to Denver, and then drove one hour west to the small mining town of Idaho Springs, Colorado. Here they turned up the winding Mount Evans Scenic By-way—"the highest paved road in America"—which since 1930 has provided access to an area near the summit. Behind them, a five-ton military truck towed a trailer-laboratory. Hitched to the back was a mobile pressure chamber—their make-believe spaceship. Looking somewhat like a railroad tank car, the chamber would allow them to "ascend" from Mount Evans's 14,620 feet to much higher simulated altitudes, equivalent to the stratosphere or space. At the high terminus of the Scenic By-way stood a modest collection of buildings—part of the Inter-University High Altitude Laboratories—which included a small cosmic ray observatory and two wooden A-frame huts. The large gravel parking lot next to the observatory and directly under the rocky, boulder-strewn summit is where Balke eventually parked their pressure chamber spaceship (see Fig. 6).

Balke's plan was to gradually acclimatize himself and the team on the drive up, beginning at Echo Lake (10,000 feet) and then at Hoosier Pass (11,500 feet), before finally arriving at the summit laboratories some weeks later. At each stage, Balke led the men in a rigorous daily physical fitness program. Then he would evaluate the effectiveness of their acclimatization through various gradual and rapid decompression tests in the mobile pressure chamber. After six weeks on the mountain, the team would return to SAM, and Balke would select two members to be sealed inside the mobile pressure chamber for ten days as a spaceflight simulation. Just like in the Alps and in the Andes, Balke was hoping to see improvements in their work capacity and TUC, as well as a few other measures like tolerance to the bends and carbon dioxide accumulation. "The results," Balke noted, "can be basically applied to the eventual procedures of training and selecting crews for extraterrestrial flights."[109] This section provides the first close recounting of the Mount Evans experiment, which has not yet been covered in the history of altitude physiology or space history.

Balke's team consisted of five enlisted men: Technical Sargent Joe Rawdon, Master Sargent Samuel G. Karst, Staff Sargent Frankie Hennigan, Staff Sargent Herbert Glenn, and Airman Ronald Holden. The sixth member was another medical doctor, James A. Green. All were drawn from SAM's Department of Biophysics, and at least some had previously served as biomedical test subjects in pressure chamber experiments.[110] Balke described his "all-volunteer" recruits, who ranged in age from 20 to 41 (Balke was nearing his 51st birthday), as "not different from the 'normal man' in the Air Force but for being well conditioned by extensive physical and altitude training."[111] To this end, preparations had gotten underway five weeks earlier at SAM. Each day, Balke and the team ran three to five miles in the desert around Randolph Air Force Base.[112] Balke noted that except for himself none of the men had experience with mountains.[113] Their first stop was at Echo Lake, a small pristine body of water

109. Balke, "Experimental Studies" (ref. 3), 122.

110. "Spacemen of Future Shown," *Sunday Telegram*, 31 Aug 1958.

111. Balke, "Experimental Studies" (ref. 3), 126.

112. Ibid., 71.

113. The study was initiated by the SAM's Department of Space Medicine, and results were first published in their annual *Bioastronautics* report detailing work completed in 1958.

ringed by fir trees at 10,000 feet.[114] They would start their acclimatization process here, and then gradually work their way up to the Inter-University High Altitude Laboratory buildings located near the summit over the next few weeks.

Surrounded by the picturesque spruce-and-pine subalpine forest, they resumed running to speed their acclimatization. Film footage shot by a USAF camera team dispatched to Echo Lake shows Balke leading the men, clad in t-shirts and gym shorts, as they jog through tree-lined paths and piggy-back and wheelbarrow race through meadows. Their first use of the mobile pressure chamber on the mountain, an ascent to see if minimal acclimatization would prevent the bends, was performed at Echo Lake. The stabbing pain the men reported in their joints, and then endured for 50 minutes, led Balke to conclude it would not.[115]

Once acclimatized to this intermediate altitude, the group moved higher, to an area called Hoosier Pass at 11,500 feet, where Balke recalled several team members had difficulty breathing and complained of the typical signs of altitude sickness: headache, nausea, and loss of appetite. Here they began a series of increasingly demanding hikes—which also involved plenty of boulder climbing—zig-zagging up and down the mountainside to further the acclimatization process. "Climbing those danged rocks got to be a real job at 12,000 feet of altitude," recalled Technical Sargent Joe Rawdon, one of the enlisted airmen, speaking to a reporter afterward. "You got tired of climbing, then you got tired of trying to gulp a decent lungful of air, then you just got tired of the whole thing. But you keep going."[116] Starting with a four-hour hike on the first day, this portion of the program culminated on July 20 with a nine-hour trek, which stood out to Staff Sargent Herbert Glenn, another one of the enlisted airmen, as one of the most challenging moments. "We had breakfast at 7 a.m., then started climbing rocks. After two and a half hours of this, we took a five minute rest. Then we went at it again for four hours straight.

114. Mount Evans was selected because it was the highest point in the United States accessible by highway.

115. Balke, "Experimental Studies" (ref. 3), 124. Breathing pressurized oxygen, the men were taken to a simulated altitude of 38,000 feet, and then ordered to perform "five deep kneebends" at regular intervals. Balke notes, "the pains did not reach an intolerable level" (124).

116. "Spacemen of Future Shown," *Sunday Telegram*, 31 Aug 1958.

Lunch lasted a half-hour, and then we went back to the rocks. We didn't rest again until we quit at 4 p.m. Like I said—rough."[117]

On August 1, the team moved up to their final destination, the Inter-University High Altitude Laboratory buildings located near the summit at 14,260 feet. This was where they spent the next two weeks, alternating between hiking around the summit and the most extreme tests yet in their mobile pressure chamber. Ever the taskmaster, Balke put the men to work straight away, leading them on an afternoon hike down to a place called Lake Abyss located below them in a narrow box canyon at 12,000 feet.[118] It was here that Green, the team's junior doctor, slipped from a boulder and badly fractured his left ankle and left arm. Balke, the former Wehrmacht Mountain Division field doctor, sprang into action. "First, of course, I had to immobilize the injured leg, which was accomplished by using branches of shrubs as splints," he recalled. "Then I hastily climbed to Summit House to phone the Air Force Base in Denver . . . there was only one way to save him, and that was by helicopter!"[119] The twilight pararescue of Green from Mount Evans is an interesting precursor to space medicine as practice rather than research. It resembles present-day analog research programs simulating the treatment of injuries astronauts might sustain while exploring the surface of the Moon or Mars.[120] In his research report, Balke blamed Green's accident for the omission of certain "biochemical tests," and later complained bitterly in his autobiography that while the helicopter rescue team received a special citation, "there were no letters of appreciation for the ground rescue team."[121]

Now reduced to six, the team appears much more serious in film reel footage shot around the summit (see Fig. 7).[122] Traversing the desolate, boulder-strewn landscape single-file while wearing dark bomber jackets with USAF flight helmets and model A-13 oxygen masks obscuring their faces, they could be mistaken for astronauts exploring another planet, a connection Balke encouraged in the

117. "Space Age Research on Mt. Evans, Colorado," *Medical Technicians Bulletin* 9, no. 5 (1958): 185–90, 188.

118. Balke, *Matters of the Heart* (ref. 27), 79–80.

119. Ibid., 188.

120. See Matthieu Komorowski and Sarah Fleming, "Intubation after rapid sequence induction performed by non-medical personnel during space exploration missions: A simulation pilot study in a Mars analogue environment," *Aerospace Medicine and Human Performance* 4, no. 19 (2019).

121. Balke, "Experimental Studies" (ref. 3), 128; Balke, *Matters of the Heart* (ref. 27), 81.

122. Balke is instantly recognizable in these films and photographs as the only one wearing German-style bundhosen and knee socks.

FIGURE 7. Balke (left) and his team of USAF airmen near the summit of Mount Evans in summer 1958. *Source:* National Archives and Records Administration, moving image ID: 342-USAF-26260. Public domain.

press. "Perhaps it's far away, but we're preparing now for the day when we'll need men for an orbiting station, or for an exploration of Mars."[123]

After acclimatizing to the summit area, Balke and the enlisted men began their most demanding set of tests in the pressure chamber. First, Balke tested their altitude tolerance, which he defined as "[t]he highest level of simulated altitude at which [unprotected] subjects became unconscious."[124] Control tests conducted back at SAM, where chamber pressure was lowered gradually until subjects became unconscious, had already established the team's unacclimated average at 24,000 feet. After acclimatizing on Mount Evans, Balke reported the group's tolerance had increased to 30,000 feet, higher than the summit of Mount Everest, and well into what is colloquially known as the Death Zone.[125] The week of August 18, Balke moved on to TUC tests, where exposure to high-altitude would be immediate, rather than gradual. Balke noted that after acclimatization "all subjects suddenly exposed to the oxygen

123. "Tests on Mount Evans Anticipate Space Age," *St. Louis Globe-Democrat*, 31 Jul 1958.
124. Balke, "Experimental Studies" (ref. 3), 125.
125. Ibid., 125.

FIGURE 8. On Mount Evans, Balke observes a USAF subject inside the portable pressure chamber. *Source:* National Archives and Records Administration, moving image ID: 342-USAF-26260. Public domain.

pressure equivalent of 25,000 feet stayed alert for a period of 30 minutes."[126] He also noted that two subjects, himself and Karst, volunteered to be suddenly exposed to the equivalent of 30,000 feet in altitude, where a normal human would lose consciousness in two to three minutes. Karst was able to maintain consciousness for five minutes, and Balke remained conscious for 30 minutes, despite hypoxia turning his lips and fingernails blue.[127] Another kind of test, called ceiling tests, took subjects to their highest simulated altitudes. For these tests Balke and the airmen breathed pressurized oxygen thought a mask but wore no other protective garments. First, the chamber's simulated altitude was set to the equivalent of 44,000 feet, and then stepped up in 2,000 foot increments every five minutes. Balke reports that all test subjects were able to work a complex coordinator apparatus—a light board with stick and foot pedal controls similar to an aircraft—at a peak simulated altitude of 55,000 feet for more than 30 minutes (see Fig. 8).[128]

126. Ibid., 125.
127. "Space Age Research on Mt. Evans, Colorado" (ref. 117), 189.
128. Balke, "Experimental Studies" (ref. 3), 126.

At the conclusion of the six-week-long mountain phase (referred to in reports as Mt. Evans I), Balke told reporters their work could be a preview of future astronaut training and flight preparations. "Naturally [the astronaut] will be trained in pressure breathing, and he should be acclimated to about 14,000 feet for optimal protection against lack of oxygen and bends." He went on to explain how present-day jet and rocket plane pilots could benefit, too. "Say a pilot has to go to great altitude on Monday. You have him spend the weekend relaxing on top of Mount Evans. Monday, he gets into a car and puts on an oxygen mask to keep from getting full of nitrogen again. In an hour he's in Denver, at the base, ready to take off with great tolerance for altitude."[129]

Next came the second phase of the experiment (Mt. Evans II), the simulated spaceflight where two of the acclimatized men would live sealed inside the mobile pressure chamber for ten days. The ambient atmosphere would be set to 14,000 feet, the same as Morococha, the summit of Mount Evans, and the expected interiors of future spacecraft. Could these model astronauts live and work relatively comfortably in this oxygen-frugal environment? Could they remain alert and able to respond quickly and effectively to emergency situations, like a rapid decompression? The crew would also attempt to replicate other hazards of sealed artificial environments, including the bends and carbon dioxide accumulation.[130] When it came time to select the crew, Balke chose himself and Karst as the best acclimatized and therefore most analogous to future astronauts. Balke's self-selection marks the only time a former Luftwaffe scientist played the role of American astronaut in a space simulation.

On Friday September 12, 1958, at 8:55 am, next to the main research building at SAM, Balke and Karst were sealed inside their mock spaceship. A team of doctors and technicians playing mission control would continuously monitor them around the clock from just outside the chamber. Inside, the usable space measured only five feet by ten feet. Furnishings consisted of one iron folding chair and one narrow cot. The rest of the space was filled with equipment for adjusting the pressure inside the chamber, as well as instruments to record their physiological reactions. The crew was supplied with tinned food, water, and a selection of juices. During the day, they were put on a demanding 12-hour schedule. At night, their time was divided into two- or three-hour shifts, which

129. "Tests on Mount Evans" (ref. 123).
130. Balke, "Experimental Studies" (ref. 3), 123.

allowed one of them to sleep on the cot while the other monitored the cabin's environmental conditions. According to Balke's report,

> The physical work in the chamber consisted of the following activities: periodic checks of the chamber environment with the corrective actions; changing the chemical absorbents for carbon dioxide and cleaning the chamber—including wiping the condensed water from the chamber walls; neuromuscular coordination tests; simple calculation tests in which speed was essential [the Kraepelin math test] . . . ; practice of donning a pressure suit and helmet in the shortest possible time; collecting physiologic data; and occasional [stationary] bicycle riding."[131]

Both Balke and Karst struggled to live in this confined, sealed environment. Both complained of headaches, nausea, overheating due to heat and humidity, loss of appetite, and foul odors emanating from their urine and feces containers. This combination of stressors resulted in Balke and Karst sleeping only in fits and starts and skipping meals. Still, they maintained a good rapport, and never came close to aborting their mission. On the first day, the ambient pressure was supposed to be set to 14,000 feet (Balke reported revising this plan on-the-fly, lowering the pressure to the equivalent of only 11,000 feet instead due to their initial discomfort). On the sixth day, the pair set the pressure to 16,000 feet for twelve hours, and then the next day to 17,000 feet. On the ninth day, the pair carried out their duties at a simulated altitude of 20,000 feet for eight hours—uncomfortable, but by their account still effective.

The most dramatic tests involved simulating an emergency scenario in space: What if a micrometeoroid pierced their spacecraft's hull? The craft's atmosphere would begin to vent into space through the puncture, causing pressure to steadily fall to dangerously low and eventually fatal levels. In this situation, the crew would have only precious minutes or seconds (depending on the size of the hole and pressure of the atmosphere) to don protective spacesuits and avoid asphyxiating. Acclimatization to altitude could provide astronauts with extra time to work to save themselves before passing out. How fast could Balke and Karst perform this function in the simulator? Balke set the pressure to assume a normal atmosphere of 15,000 feet in altitude for the spacecraft, but then set the chamber to automatically decompress at a rate of 4,000 to 5,000 feet per minute. This was a high-stakes, beat-the-clock

131. Ibid., 133.

situation. First the crew attached their oxygen masks, then began the laborious process of struggling into their bulky pressure suits in the tight space. In the end, it took Balke and Karst eight minutes to suit up, and they remained at this simulated altitude of 50,000 feet for 40 minutes.[132]

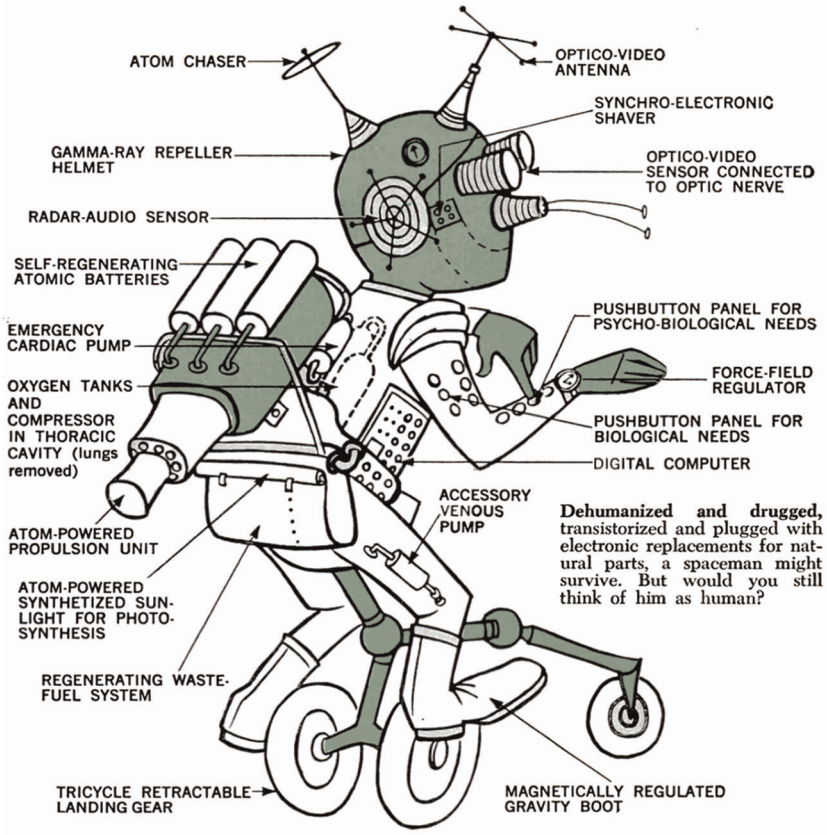
When Balke and Karst finally emerged from their ten-day spaceflight simulation, reporters described the pair as pale and wan—they had each lost eight pounds. Once outside, they had blood taken to compare with pre-simulation samples, and then they each hopped on a treadmill to perform a work capacity test lasting around twenty minutes. Only then could the gaunt and scruffy pair enjoy their first hot showers in over a week and head home for a good night's sleep.

Following the simulation, Balke made the case for acclimatizing future astronauts: "the human organism has a great capacity to adapt to 'superhuman' requirements of biologic nature."[133] He argued it was essential to ensure human reliability in spaceflight. "'Normal' man cannot be expected to perform too well under 'abnormal' conditions . . . only the best conditioned individual will have a chance to perform adequately in the long run."[134] He concluded that "the first space flyer must be capable of the most exacting human performance, must have the highest degree of tolerance to stress, and must have a demonstrated endurance to prolonged marginal conditions."[135]

Later that year, at a symposium organized by SAM and attended by then-Senate majority leader Lyndon Johnson and Wernher Von Braun, Hurtado spoke about Balke's recent work on Mount Evans and their on-going experimentation with Indigenous Peruvian miners. "During the past two years Balke has attempted to build the body reserves of previously untrained personnel to approach that of the high-altitude native."[136] Hurtado noted that Balke and another Peruvian researcher, T. Velasquez, were continuing to compare high-altitude Indigenous people with acclimatized airmen. "It would seem then," he concluded, "that studies on the altitude natives will continue to furnish guide lines for further research toward physical selection and training of crewmen for high performance vehicles in the future."[137]

132. Ibid., 138.
133. Ibid., 139.
134. Ibid., 165.
135. Balke, "Conditioning for Space Crews" (ref. 19), 177.
136. Hurtado, "Parameters of Human Adaptation" (ref. 7), 367.
137. Ibid., 368.

Must Tomorrow's Man Look Like This?



Dehumanized and drugged, transistorized and plugged with electronic replacements for natural parts, a spaceman might survive. But would you still think of him as human?

By Toby Freedman, M.D., and Gerald S. Lindner, M.D.

No electronic plug-ins needed, say these two doctors. Man's own capacity for adaptation, with help from science, can fit him for new ways of life

THE design of vehicles is one of the oldest and noblest arts of mankind. Look at a model of a prehistoric Polynesian canoe. It's as hydrodynamically elegant and functionally beautiful as the X-15. The wheel, the ski, the kayak, the sports car—pure

From a speech at annual meeting of American Rocket Society. The authors are researchers with North American Aviation. 77

FIGURE 9. "Must Tomorrow's Man Look Like This?" Balke's acclimatized astronaut was repackaged in the 1960s as "Optiman," a natural and ethical alternative to the troubling technological cyborg depicted here. *Source:* Freedman and Lindner, "Must Tomorrow's Man Look Like This?" (ref. 141), 77. Reprinted with permission.

CONCLUSION

Balke's Air Force acclimatization program was not adopted by NASA for training Project Mercury astronauts. Alan Shepard and John Glenn did not "spend the weekend relaxing on top of Mount Evans," before jetting to The Cape.[138] Balke never worked directly for NASA; he left the Air Force in 1960 to become chief of the Federal Aviation Agency's Biodynamics Branch and later a professor of physiology and physical fitness at the University of Wisconsin.[139] But neither did the connection Balke forged between acclimatized astronauts and high-altitude Indigenous people disappear into thin air when plans for human spaceflight shifted from the military to NASA. In the 1960s, during the height of NASA's Space Race, the figure of a naturally acclimatized astronaut reappeared in high-profile debates over whether humans should have their bodies fundamentally altered for spaceflight. At issue was the new concept of the cyborg (short for "cybernetic organism"), which was introduced by mathematician and computer scientist Manfred E. Clynes and psychopharmacologist Nathan S. Kline at a space medicine conference in 1960.[140] They initially envisioned using drugs to make astronauts impervious to the hazards of space, but the cyborg quickly became emblematic of technological augmentation, "a creature who accomplishes his space mission at the cost of trading most of his physiological systems for electronic ones."[141] Critics, including Strughold, worried the result would no longer be human and looked for other options, asking, "must tomorrow's man look like this? (see Fig. 9)".[142]

In 1962, USAF space medicine expert Toby Freedman introduced Americans to Optiman, a natural alternative to the cyborg based on exactly the type

138. However, they did breathe pure oxygen for two hours before liftoff to rid their bodies of nitrogen and prevent "the airman's equivalent of the deep-sea diver's bends." Loyd S. Swenson Jr., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington, DC: NASA, 1966). 225–26, 351.

139. Balke, *Human Tolerances* (ref. 14); Balke, *Matters of the Heart* (ref. 27), 83, 90.

140. Manfred E. Clynes and Nathan S. Kline. "Cyborgs and Space," *Astronautics* 5, no. 9 (1960): 26–27, 74–76.

141. Thomas B. Allen, "The Quest for Optiman," *The Quest: A Report on Extraterrestrial Life* (Philadelphia: Chilton Company, 1965), 230; Toby Freedman and Gerald S. Lindner, "Must Tomorrow's Man Look Like This?" *Popular Science* (Nov 1963): 77–80, 188–89.

142. Hannah Arendt, "Man's Conquest of Space," *The American Scholar* 32, no. 4 (1963): 527–40; Allen, "The Quest for Optiman" (ref. 141), 230.

of work Balke had been doing four years earlier.[143] In a series of lectures and press interviews, Freedman presented Optiman (short for optimized man) as a person fine-tuned for survival in space but also free from those dehumanizing technological organs and appendages. This would be accomplished by an amped-up version of Balke's exclusion-by-inclusion conditioning model. Optiman would embody a compilation of extreme human capabilities drawn from different types of people all over the world. According to Freedman, Optiman "would be a man whose outward appearance is quite normal, but who has been adapted to the oxygen requirements of a Himalaya Sherpa, the heat resistance of a walker-on-coals, who needs less food than a hermit, has the strength of Sonny Liston, and runs the mile in three minutes flat, while solving problems in tensor analysis in his head."[144] In a 1964 interview published in *LIFE* magazine, Freedman also included "[t]he Eskimo and the Bedouin . . . [who] both live at temperatures well outside the range of survival for most of us . . . [and people] in the Andes and the Himalayas, [who] live active lives at 12–14,000 feet, where oxygen is 60 per cent of our usual requirements . . . "[145] Freedman's vision was of a human improved for space but without violating the integrity of the body with technology. Freedman points out that "Optiman would presumably not be a mosaic of spare parts and odd pieces of machinery, a Loop unto himself. Rather, he would be pure *man*."[146]

Preserved in Optiman (and reflected in its name) is humanity. So is whiteness. Freedman is not explicit about this, but he implied that Optiman is white and that most if not all of the contributing bodies are not. He describes Optiman as "a man whose outward appearance is quite normal," which to many American readers in the 1960s would read as white (and there was no mention of Optiwoman). He goes on to explain that this white man has been optimized so that his body replicates the physical abilities of a number of nonwhite figures: the Himalayan porter, the firewalker, and Sonny Liston, a Black

143. "Meet Mr. Optiman," *The Times Record* (20 Nov 1962), 10.

144. Ibid., 231. The inclusion of the figure of the Sherpa instead of miners from Morococha seems to be a convenient conflation to conjure the most widely known Indigenous mountain dwellers with which readers would already be familiar. Heggie (2019) points out that Sherpas were not included in altitude acclimatization studies during this time period, but science fiction author Richard K. Morgan depicts both Andean and Tibetan Mars colonists in his 2018 novel *Thin Air*. Heggie, "Blood, Race, and Indigenous Peoples" (ref. 9).

145. Albert Rosenfeld, "The Last Barrier is Man Himself," *LIFE* (2 Oct 1964), 122.

146. Ibid., 231.

heavyweight champion boxer, as well as permanent residents of the Arctic and Andes. Just like Balke's experiments, non-white bodies are included as biological resources or data-bearing benchmarks for optimizing a white, male body symbolic of the future of humanity or "tomorrow's man." The example of Freedman's deployment of Optiman in the debate over the cyborg shows how Balke's approach to acclimatization resonated and endured in space medicine. Even in the hands of a different scientist, the exclusion by inclusion model still reproduces colonial power imbalances and racial hierarchies. In much the same way that historian of science Peter Galison problematizes the cyborg by revisiting its military origin in World War Two anti-aircraft gunnery, the story of Balke's efforts to acclimatize USAF airmen for space casts Optiman in a complicated new light.[147] Optiman was presented to readers in the 1960s as an ethical alternative to the cyborg, but Balke's work reveals an entirely different set of ethical concerns, not dehumanizing technology, but colonialism, race science, biological appropriation, and white supremacy.

Balke's quest to utilize non-white bodies from Morococha, Peru, to perfect a white male astronaut body in America adds a crucial new dimension to discussions of race in both the history of altitude physiology and space history. It provides an example from outside the realm of genetics of how Cold War–era scientists studied Indigenous people with ideas about the future of humanity in mind. It also shows how groups of people can be excluded from roles in space by *inclusion* in space medicine studies. Finally, recovering this nearly forgotten episode adds a revealing contributing genealogy to the origin of the American astronaut that places the mountaineer and the high-altitude Indigenous person alongside the familiar military test-pilot.

ACKNOLWEDGEMENTS

Thank you to Vanessa Heggie and Philip Clements, who provided extremely helpful suggestions as reviewers of this manuscript. Thanks also goes to Janet Vertesi and David Reinecke—the other members of the Princeton Social Studies of Space Research Unit—for reading and commenting on multiple drafts of this article, and

147. Peter Galison. "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21, no. 1 (1994): 228–66.

also to Edward Jones-Imhotep, Matthew Farish, and Asif Siddiqi, who inspired and supported this project right from the start. My gratitude also extends to Patrick Kilian, with whom I have written elsewhere about Bruno Balke, for our many useful discussions in developing this work. Additionally, Benjamin Gross and the Linda Hall Library provided a high-resolution scan of Figure 6, for which I am very appreciative. I would like to acknowledge the support of the Social Sciences and Humanities Research Council of Canada, and the History of Science Society's NASA Fellowship.