

Obituary

Juan Cristián Orrego-Benavente (January 31, 1944 Santiago, Chile - December 12, 2018 San Salvador, El Salvador)¹

Jorge A. Santiago-Blay², Ashlee J. Loewy³, and Michael Goldman⁴

Abstract: A summary of the life of Juan Cristián Orrego-Benavente, a Chilean molecular biologist with intense interests in the practical applications of his craft through which real world humanitarian problems could be solved.

Key Words: Forensics; molecular biology; California Department of Justice; Abuelas de la Plaza de Mayo of Buenos Aires, Argentina; Asociación Pro-Búsqueda of El Salvador; Human Rights Center at the University of California, Berkeley; “disappeared” people; missing people; dictatorships; war.

It is difficult to summarize the life of a colleague dear to us with metrics and other “objective” tools. Often, the contributions of a colleague and friend extend well beyond scores as s/he has helped us grow in ways that far exceed the limits of science. Herein, we tell the story of Dr. Juan Cristián Orrego Benavente⁵, through the remembrances of family, friends, and colleagues. This account is necessarily incomplete, as none of us knew his full life and its impact in its totality. Sadly, numerous collecting trips that Cristián and author JASB planned after his move to El Salvador towards the end of 2014, which would have granted plenty of time to talk as we drove along, did not materialize. Nevertheless, we believe Cristián would have been pleased with this effort gathered from our hearts.

Meeting Dr. Cristián Orrego, early 1990’s and first impressions

We (authors JASB and MG) met Dr. Orrego in the early 1990’s at San Francisco State University (SFSU). Author MG was (and still is) a Professor of Biology at SFSU. At the time, author JASB was serving as a postdoctoral fellow at the University of California at Berkeley as well as a part-time adjunct faculty

¹ Submitted on February 24, 2019. Accepted on February 25, 2019.

² Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia 2-560 USA. Email: blayj@si.edu

³ Forensics Sciences major, The Pennsylvania State University, York, Pennsylvania 17403 USA.

⁴ Department of Biology, 1600 Holloway Avenue, San Francisco State University, San Francisco, California 94132 USA. Email: goldman@sfsu.edu

⁵ Although most of us addressed him as “Cristián”, some colleagues used an Anglicized version of his name, such as Christián, Christian, or Cristian.

member in several colleges in the San Francisco Bay Area⁶. Through one of the many professional development opportunities available then for faculty members in Californian colleges, JASB attended a workshop in molecular biology at SFSU in which MG was a presenter and through that connection soon became acquainted with Dr. Orrego, then serving as the Founding Director of the Conservation Genetics Laboratory (CGL)⁷. JASB, MG, and other colleagues of that time who knew Dr. Orrego remember him as being someone with a distinguished presence, formal, poised, hard working, and willing to help others.

With time, Cristián and JASB became friends and neighbors living on the eastern shore of the San Francisco Bay. Whenever possible, JASB gave him a ride from his home, near the top of a small hill in the city of El Cerrito, Spanish for the “little hill”, to the CGL, then a 45-minute ride with some luck. Leaving very early in the morning, trying to beat the ferocious traffic across the Oakland – San Francisco Bay Bridge, we were often rewarded with the most coveted parking spot, which we used to call “the parking spot of El Presidente”, in front of Hensill Hall, home of SFSU’s Biology Department.

True to mutually shared values, almost every day was a workday. We always woke up ready for the *luta molecular*, Portuguese for molecular struggle. Full of hope and optimism, we would tackle the day’s challenges savoring the unforeseen discoveries displayed in an electrophoresis agarose gel or a polyacrylamide gel, which displayed the results of DNA sequencing⁸. It was during this time that JASB and Dr. Orrego developed an abiding friendship, which lasted throughout the rest of his life. Cristian’s generosity as a trusted mentor and friend is something JASB will always treasure. We are grateful to Cristian’s family, friends, and colleagues who helped to fill in the gaps of his earlier and later life, described in the next sections.

“Mamá, ¿cómo un hombre le hace una guagua a una mujer?”
Mom, how do a man and a woman make a baby?

Early Life (1944-1971)

Cristián was born in Santiago, Chile in January 31, 1944. According to Cristián’s mother, Ms. Carmen Benavente, currently 97 years young (personal communication to JASB, February 6, 2019), as a child he was curious, as shown in the quote above. According to Ms. Benavente, after a detailed biological explanation, the boy said, “*Mamá, ésa es la cosa más linda que he escuchado*”, Mom, that is the most beautiful thing I have heard. At an earlier time, Cristián asked his mom about the origins of humanity, back through the generations leading to the topic of human evolution. Years later his mother gave him a toy

⁶ Colleagues in such teaching positions are colloquially referred to as “road warriors”.

⁷ Currently, the CGL is known as the Genomics/Transcriptomics Analysis Core (GTAC).

⁸ Nowadays, DNA sequencing can be done through robotic technology.

microscope, which delighted him. Little did Cristián know that life and the clamor of many people looking for their beloved “*desaparecidos*” (“disappeared”) would draw him to genetics for the most meaningful part of his professional life.

The family traveled to the United States with the support of a grant from The Rockefeller Foundation and two grants from the John Simon Guggenheim Memorial Foundation. Cristián’s father, Dr. Juan Orrego-Salas, a prominent Chilean composer, 100 years young, had traveled to the USA during the 1940’s and 1950’s, furthering his musical training with Randall Thompson and Aaron Copland. In 1961 funded by the Rockefeller Foundation Dr. Orrego-Salas created the Latin American Music Center (LAMC) at the University of Indiana in Bloomington.

Juan Cristián stayed in Chile and studied one semester at the School of Agriculture of the Universidad Católica, where he became interested in biochemistry. Then, on arriving in Bloomington, Indiana he enrolled in the Department of Chemistry at Indiana University. His mother remembers his very sober style in furnishing his bedroom, indicating what would become a lifelong style of living in great simplicity, to dedicate his time fully to his work.



Figure 1. Dr. Juan Orrego-Salas (left), Carmen Benavente (center), Juan Cristián Orrego-Benavente (right), and little Juan Matías Orrego-Benavente, Cristián’s brother, in Bloomington Indiana, USA in the early 1960’s.

While studying in the Department of Chemistry at IUB, Orrego met an influential faculty member, Dr. Lawrence K. (Mike) Montgomery. He remembers Orrego, as follows: “Cristián was in the first undergraduate class I taught at Indiana University [in the spring semester of 1962]. He subsequently became the first undergraduate to do work in my research group. He did research with me for three years and was one of the most talented undergraduates to work with me” (Montgomery to JASB, personal communication, February 11, 2019). Cristián completed his Bachelor of Science with a concentration in Chemistry at IUB in 1965. He joined the doctoral program of Biochemistry at Brandeis University, in Waltham, Massachusetts. There, he completed his PhD with a dissertation entitled, *Studies on the RNA Polymerase from Micrococcus luteus* in 1971 with the supervision of Dr. Lawrence Grossman.

“¡¡Te estoy esperando!!” I’m waiting for you!! (Delia Giovanola, abuela of desaparecidos, Huber et al. 2017)

A Mid-Life of Transition (1971 to 1984): Looking for Meaning

These were turbulent times in South American countries. These were also the terrifying days of brutal dictatorial regimes in Chile, El Salvador, and Argentina. Thousands of people disappeared at their hands leaving desperate mothers, grandmothers and family members to wait and worry if they would ever return.

At this time, Cristian had been working in different post-doctoral appointments, including at the Laboratory of Enzymology at the Centre National de la Recherche Scientifique (Gif-Sur-Yvette, France; 1971-1972), the Catholic University of Valparaíso (Chile, 1973-1974), where he served as an Assistant Professor in the Instituto de Química in the area of biochemistry, the Rosenstiel Basic Medical Sciences Research Center of Brandeis University (1974-1978), Harvard University (1977-1981), and the National Institutes of Health (NIH, Bethesda, Maryland, USA; 1982-1984).

During the 1990’s Dr. Orrego returned to Chile. One of his colleagues, at the Pontificia Universidad Católica of Valparaíso, Dr. Sergio Hernán Marshall González, commented, “Cristián was like a brother to me. For instance, he received me when I arrived at Brandeis University in 1969. Our friendship and collaborations grew through the years. We organized courses in Forensic Genetics and others that were extraordinarily successful nationally. Our collaborations extended well beyond my research group at the Instituto de Biología, as they included colleagues in the departments of Chemistry and Biochemical Engineering. Because Cristián was so well regarded and respected at the Instituto, in the early 1990’s he was unanimously voted *Profesor*

Extraordinario de la Universidad (Extraordinary Professor of the University) affiliated to the Instituto de Biología. He kept this honor until his death.”

While these were fruitful professional years, Cristian’s mother knew there was something missing for him. The intersection of extensive professional preparation and practical application which together would address a deeply distressing problem was about to reveal a deeper meaning and purpose in his life.

“*Nunca abandoné la pregunta de las abuelas.*”
I never abandoned the question of the grandmothers.

Later in Life (1984-2018): Finding New Directions and a Greater Meaning in Science and Life (Figure 2)

During 1984, while Orrego worked at NIH, researching the molecular genetics of bacteria, a fundamental realization of ethical identity came to him. At the time, he formed part of the delegation sponsored by the American Association for the Advancement of Science (AAAS) that travelled to Argentina to provide scientific support to the *Comisión de la Verdad*, “*Nunca Más*” (Comission for the Truth, ‘Never Again’) and the non-governmental organization *Abuelas de la Plaza de Mayo* (Grandmothers of the May Square). The *Abuelas* is an Argentinian organization whose mission is finding the whereabouts of children of “disappeared” mothers during the military dictatorship (1977-1983). To Orrego, the pillars of fulfilling professional choices, and many other choices in life, are a combination of the heart (emotional attractiveness), the mind (intellectual interest), and the hands (the capability of being inspired to pursue ethically noble actions).

Perhaps inspired in part by the question of the *Abuelas*, he garnered a research position at the University of California, Berkeley, working with Dr. Allan Wilson, a trail blazer on the use of molecular techniques in the study of human evolution. He served in research positions at UC Berkeley during 1986 to the mid 1990’s and at San Francisco State University.



Figure 2. Dr. Cristián Orrego explaining to an Amazonian child from Pillcopata, Cuzco, Perú how to move Eppendorf tubes on a simplified PCR setup without thermocycler. Photo circa 1985 courtesy of Dr. Jorge Arévalo (Universidad Peruana Cayetano Heredia) and Dr. Martín López (Fairleigh Dickinson University, Vancouver Campus, Canada). Boy's face is masked as we have not located the person depicted in the photo.

With time, his professional interests took him to the California Department of Justice (CA DOJ) from October 1999 to October 2011. During his tenure at the CA DOJ, California became the first state of the United States to use DNA evidence to search for disappeared people. According to Dr. Patricia del Carmen Vásquez (personal communication to JASB, February 12, 2019), during 2003, the Jesuit priest, Father Jon de Cortina, who had created together with relatives of the disappeared in El Salvador, the Salvadorian ONG “*Asociación Pro-Búsqueda de Niñas y Niños Desaparecidos*” in 1994, and knew about the work of the *Abuelas*, got in touch with Dr. Orrego through Erick Stover (Director of Human Rights Center in Berkeley, California). Father Cortina sought Cristián's assistance in the identification of children that had “disappeared” during the Salvadorian Civil War (1980-1992). Dr. Orrego, several staff members of the CA DOJ, and other forensic scientists in the USA joined forces to train Salvadorian personnel in the taking of samples for DNA analysis of the relatives of children who had disappeared. Since then, he began to travel to El Salvador in his vacation period. Thereafter, Dr. Orrego joined the Human Rights Center of the School of Law at the University of California in Berkeley in November 2011 and served as a Fellow in Forensic Genetics until his death.

The geneticist of *Asociación Pro-Búsqueda*, Dr. Patricia del Carmen Vásquez became Cristián's second wife on December 7, 2013 (Figure 3). The

work of assisting the living victims of the “disappeared” was larger than originally considered. Orrego thought that the actual number of “disappeared” could have been two to three times larger than originally estimated. One day, during the intense work of trying to find the identity of “disappeared” people, Cristián interviewed someone held in prison who had been responsible for some of the “disappearances”. Later, he wrote to his mom, “*Mamá, he encontrado a una persona que no es un humano.*” (Mother, I have met a person who is not human.) We can only imagine the horrendous impression such an encounter must have caused in Cristián along with the resolve to continue the important work.



Figure 3. Dr. Cristián Orrego and Dr. Patricia del Carmen Vásquez on their wedding day, December 7, 2013. Photo taken by Juan Matías Orrego Benavente, brother of the groom.

“The creation and maintenance of the *Banco de ADN de Pro-Búsqueda* (Pro-Búsqueda DNA Bank) as well as the initiation of the *Registro Poblacional de ADN Forense (REPAF) de El Salvador* (Population Registry of Forensic DNA of El Salvador) both El Salvadorean databases of human DNA sequences were valuable contributions of Cristián. From the moment that he became aware of the effort of relatives of “disappeared” and met Father Jon Cortina, Cristián wanted to form part of the effort, generously gave his knowledge, and encouraged his colleagues to help in the application of science to identify children that “disappeared” during the El Salvador civil war. Given Cristián’s experience at the CA DOJ, he brought excellent quality and ethical standards into his work in El Salvador. Additionally, Cristián brought his profound sense of commitment Pro-Búsqueda DNA Bank.” (Vásquez to Santiago-Blay,

personal communication February 2019). Dr. Orrego's professional activities on behalf of the "disappeared" were highlighted in numerous venues (e.g., Beckwith 1987, Rojas Escobar 2006, Penchaszadech 2011).

After over 50 years of life in the USA, Cristián became a US citizen in July 2014. As a life-long learner, Cristián continued enrolling in professional trainings (e.g., genetics, mitochondrial DNA analysis, kinship analysis, etc.), giving scientific talks, serving as an active member of numerous scientific organizations, advising colleagues with questions about molecular techniques, and participating in numerous other professional activities. Participating with profound gratefulness in a panel sponsored by the Banco Nacional de Datos Genéticos (BNDG) in Buenos Aires, Argentina during the summer of 2017, Cristián reflected on his career choices, echoing many themes familiar to those who knew him (Orrego et al. 2017).

These professional activities continued with intensity until, just as the famous New York Yankees baseball player of the 1920's and 1930's, Lou Gehrig, Cristián got a "bad break". The first symptoms, such as the inability to pronounce an otherwise easily pronounceable word, ensued in the summer 2017. Sometime in October 2017, he was diagnosed with amyotrophic lateral sclerosis, also known as Lou Gehrig's disease, a family of neurological diseases, currently incurable. Although everything that the specialists suggested, such as exercises and a special diet, was followed with the assistance of Patricia, his wife, the presentation of the signs and his symptoms were unrelenting. As the candle of life became dimmer, sometime in the spring of 2018, Cristián lost his voice although he could still read emails. To the inquiry as to whether he wanted JASB to continue to email him, he replied "sí"; his last words to coauthor JASB.

Approximately two weeks before his death, Cristián pointed to the letters of the alphabet on a tablet held by Patricia and "dictated" the farewell that precedes the Acknowledgments (below). It took him two days to complete the seemingly daunting task. Dr. Cristián Orrego died peacefully on December 12, 2018. He is survived by his widow, Dr. Patricia del Carmen Vásquez, Daniel, a son from a previous marriage, his parents, siblings, and numerous colleagues who will always remember him with great love and esteem.

"Me despido repleto de fortunas y con la felicidad de vuestro cariño. Si mi Patricia del Carmen tiene razón, nos volveremos a encontrar. Un tierno y prolongado abrazo." - Juan Cristián

I farewell all of you full of fortunes and with the happiness of your affection. If my Patricia del Carmen is right, we will meet again. A tender and prolonged hug. - Juan Cristián

Acknowledgments

Ms. Carmen Benavente (Bloomington, Indiana, USA) and Dr. Patricia del Carmen Vásquez, mother and widow, respectively, of Dr. Orrego, generously offered memories of Dr. Orrego to JASB. Dr. Ellen Prager and another colleague who preferred to remain anonymous, both at the Human Rights Center of the School of Law at the University of California, Berkeley (USA), provided the most up-to-date versions of Dr. Orrego's curriculum vita. Those documents, along with several searches on major databases helped us produce what we hope is a fairly complete

bibliography of Dr. Orrego. Numerous colleagues completed our, at times, incomplete bibliographic information. They include Dr. Miguel Laufer (*Interciencia*, Caracas, Venezuela) and many others who preferred to remain anonymous. Suzanne C. Shaffer (Penn State University, York) read the manuscript and greatly improved it.

Literature Cited

- Anonymous. No date. Delegation from El Salvador visits International Commission on Missing Persons. International Commission on Missing Persons. <https://www.icmp.int/press-releases/delegation-from-el-salvador-visits-international-commission-on-missing-persons-delegacija-iz-el-salvadora-posjetila-medunarodnu-komisiju-za-nestale-osobedelegacion-de-el-salvador-visita-la-comision-in/>
- Beckwith, B. 1987 (January/February). Science for human rights. Using genetic screening and forensic science to find Argentina's disappeared. *Science for the People* 19(1):6-9, 32.
- Bonefof, P. 2017 (October 21). Cancer didn't kill Pablo Neruda, panel finds. Was it murder? *The New York Times* https://www.nytimes.com/2017/10/21/world/americas/pablo-neruda-death-forensic.html?_r=0
- Huber, B. (photography by S. Pabst and R. M. Cromwell). 2017 The Living Disappeared. *The California Sunday Magazine* April 2017:36-49. <https://story.californiasunday.com/the-living-disappeared>
- Orrego Benavente, C., E. Stover, V. Penchaszadeh, and D. Golombek. 2017. *Evento 30 aniversario Banco Nacional de Datos Genéticos [BNDG] - Ciencia e Identidad*. 1h,21",45". <https://www.youtube.com/watch?v=g0j-1AE3w7A>. Retrieved on February 10, 2019.
- Penchaszadeh, V. B. 2011. Genetic identification of children of the disappeared in Argentina. *Journal of the American Medical Women's Association (JAMWA)* 52(1):16-21.
- Rojas Escobar, H. 2006 (June). El Patio 29: "Hay que restablecer la confianza". *Revista Mensaje* 55(549):38-41. http://repositorio.uahurtado.cl/static/pages/docs/2006/n549_38.pdf

A Bibliography of Dr. Cristián Orrego Benavente

- Allen E. R., C. Orrego, H. Wabiko, and E. Freese. 1986. An ethA mutation in *Bacillus subtilis* 168 permits induction of sporulation by ethionine and increases DNA modification of bacteriophage phi 105. *Journal of Bacteriology* 166(1):1-8. <https://doi.org/10.1128/jb.166.1.1-8.1986>
- Beckman K. B., M. F. Smith, and C. Orrego. 1993. Purification of mitochondrial DNA with Wizard™ Minipreps DNA Purification System. *Promega Notes* 43:10-13.
- Blaine, L., M. I. Krichevsky, and C. Orrego. 1991. International Network for multifaceted leishmaniasis research. 69th General Session of the International Association for Dental Research. 20th Annual Session of the American Association for Dental Research, and the 12th Annual Session of the Mexican Division of the IADR. (International Association for Dental Research). April 17-21, 1991. Acapulco, Mexico. *Journal of Dental Research* 70(Special Issue April):503.
- Bryant, J. Sumartin, C. Orrego, J. A. Santiago-Blay, and E. Perez. 1996. Identification via the PCR of lutzomyia sandflies, vectors of human leishmaniasis. 1996 AAAS Annual Meeting and Science Innovation Exposition: The 162nd National Meeting of the American Association for the Advancement of Science. February 8-13, 1996. Baltimore, Maryland, USA. 162:A127.
- Date Chong, M., C. D. Calloway, S. B. Klein, C. Orrego, and M. R. Buoncristiani. 2005. Optimization of a duplex amplification and sequencing strategy for the HV1/HVII regions of human mitochondrial DNA for forensic casework. *Forensic Science International* 154:137-148. <https://doi.org/10.1016/j.forsciint.2004.09.128>. (Author M. Date Chong is sometimes indexed under the last name Chong.)
- Date-Chong M., M. R. Buoncristiani, M. Aceves, and C. Orrego. 2013. An examination of the utility of a nuclear DNA/mitochondrial DNA duplex qPCR assay to assess surface decontamination of hair. *Forensic Science International: Genetics* 7(3):392-396. <https://doi.org/10.1016/j.fsigen.2013.03.003> (Author M. Date Chong is sometimes indexed under the last name Chong.)

- Dean, D. H., J. C. Orrego, K. W. Hutchinson, and H. O. Halvorson. 1976. New temperate bacteriophage for *Bacillus subtilis*, rho 11. *Journal of Virology* 20(2):509-519. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC355018/>
- De Geofroy, I., R. Patterson, C. Orrego, and R. K. Zebell. 1996. Phylogeny and biogeography of the high-elevation species of *Polemonium* (Polemoniaceae). *American Journal of Botany* 83(6 Supplement):149-150.
- DiLonardo, A. M., P. Darlu, M. Baur, C. Orrego, and M.-C. King. 1984. Human genetics and human rights. Identifying the families of kidnapped children. *The American Journal of Forensic Medicine and Pathology* 5(4):339-347. <https://doi.org/10.1097/0000433-198412000-00011>
- Freese, E., E. B. Freese, E. R. Allen, Z. Olempska-Beer, C. Orrego, A. Varma, and H. Wabiko. 1985. Metabolic initiation of spore development. pp. 194-202. In, Hoch, J. A. and P. Stelow (Editors). *Molecular Biology of Microbial Differentiation*. Proceedings of the Ninth International Spores Conference. Asilomar, California, USA. September 3-6, 1984. American Society for Microbiology. Washington, District of Columbia, USA. 280 pp.
- Gottfried M., C. Orrego, A. Keynan, and H. O. Halvorson. 1979. Specific inhibition of outgrowth of *Bacillus subtilis* spores by novobiocin. *Journal of Bacteriology* 138(2):314-319. <https://jb.asm.org/content/jb/138/2/314.full.pdf>
- Hamilton, L. A., R. Patterson, R. K. Zebell, and C. Orrego. 1996. Testing morphological phylogenies of *Linanthus* sect. *Dianthoides* (Polemoniaceae) using matK sequence data. *American Journal of Botany* 83(6 Supplement):160-161.
- Halvorson, H. O., K. W. Hutchinson, and C. Orrego. 1977. Bacterial Endospores. In, *McGraw-Hill Encyclopedia of Science and Technology: An International Reference Work in Fifteen Volumes Including an Index*. Fourth Edition. McGraw-Hill. New York, NY, USA. 15 volumes.
- Harris E., M. López, J. Arévalo, J. Bellatin, A. Belli, J. Morán, and C. Orrego. 1993. Short courses on DNA detection and amplification for public health in central and South America: The democratization of molecular biology. *Biochemical and Molecular Biology Education* 21(1):16-22. [https://doi.org/10.1016/0307-4412\(93\)90004-J](https://doi.org/10.1016/0307-4412(93)90004-J).
- Heath, S., S. Pak, V. Henriquez, S. H. Marshall, and C. Orrego. 1999. Denaturant gel electrophoresis for monitoring of genetic diversity in *Piscirickettsia salmonis*, the causative agent of epizootic outbreaks in farmed salmonids in Chile. 99th General Meeting of the American Society for Microbiology. May 30-June 3, 1999. Chicago, Illinois, USA. *Abstracts of the General Meeting of the American Society for Microbiology* 99:466-467.
- Heath, S., S. Pak, S. Marshall, and C. Orrego. 1999. Genetic monitoring by denaturant gel electrophoresis of *Piscirickettsia salmonis*, a bacterial disease of farmed salmonids. *Mutation Analysis BioRad Tech Note* 2451. Three unenumerated pages. http://www.bio-rad.com/webroot/web/pdf/lsr/literature/Bulletin_2451C.pdf
- Heath, S., S. Pak, S. Marshall, E. M. Prager, and C. Orrego. 2000. Monitoring *Piscirickettsia salmonis* by denaturant gel electrophoresis and competitive PCR. *Diseases of Aquatic Organisms* 41:19-29. <https://doi.org/10.3354/dao041019>
- Herrera, S., S. Pak, J. Marti, G. Modi, J. E. Perez, and C. Orrego. 1999. DNA tags from the blood meal to identify animal host(s) employed by sand flies of the genus *Lutzomyia*, vectors of human leishmaniasis. 99th General Meeting of the American Society for Microbiology. May 30-June 3, 1999. Chicago, Illinois, USA. *Abstracts of the General Meeting of the American Society for Microbiology* 99:232-233.
- Hollibaugh, J. T., P. S. Wong, N. Bano, S. K. Pak, E. M. Prager, and C. Orrego. 2001. Stratification of microbial assemblages in Mono Lake, California, and response to a mixing event. *Hydrobiologia* 466(1):45-60. <https://doi.org/10.1023/A:1014505131859>
- Irwin, J. and C. Orrego. 1998. DGGE analysis for non-invasive studies of primate diet: a prototype for at-distance diet analyses of natural populations. *Mutation Analysis BioRad Tech Note* 2328. 2 unenumerated pp. http://www.bio-rad.com/webroot/web/pdf/lsr/literature/Bulletin_2328B.pdf
- King, J. and C. Orrego. 1982. Biotechnology. In, *McGraw-Hill Encyclopedia of Science and Technology: An International Reference Work in Fifteen Volumes Including an Index*. Fifth Edition. McGraw-Hill. New York, NY, USA. 15 volumes.

- Koenig, A., P. O' Donnell, E. Stover, and C. Orrego Benavente. 2012. *Beyond Reasonable Doubt: Using Scientific Evidence to Advance Prosecutions at the International Criminal Court*. 23-24 October 2012. Workshop Report. Human Rights Center. School of Law, University of California, Berkeley. 26 pp. https://www.law.berkeley.edu/files/HRC/HRC_Beyond_Reasonable_Doubt_FINAL.pdf
- Larson, R. J., C. Orrego, and R. W. Julian. 1995. *Genetic analysis of yearclass formation in shortbelly rockfish, *Sebastes jordani**. Report to California Sea Grant. La Jolla, California, USA. [This document appears to be a grant progress report that was submitted to California Sea Grant. A master's thesis with the same title was subsequently completed with the following bibliographic information: Julian, R. W. 1996. *Genetic analysis of year class formation in shortbelly rockfish (*Sebastes jordani*)*. Department of Biology, San Francisco State University, San Francisco, California, USA. 90 pp. A link to the title pages and abstract follows: https://eos.ucs.uri.edu/EOSWebOPAC/OPAC/Common/Pages/GetDoc.aspx?ClientID=EOSM_AIN&MediaCode=9482]
- Lessa, E. P., M. F. Smith, and C. Orrego. 1992. A cool hot start for PCR amplifications. *Ancient DNA Newsletter* (London, England, UK) 1:40-42.
- Lopez, M., R. M. Inga, M. A. Cangalya, J. Echevarria, A. Llanos-Cuentas, C. Orrego, and J. Arevalo. 1993. Diagnosis of *Leishmania* using the Polymerase Chain Reaction: a simplified procedure for field work *The American Journal of Tropical Medicine and Hygiene* 49(3):348-356. <https://doi.org/10.4269/ajtmh.1993.49.348>
- Lopez, M., C. Orrego, M. A. Cangalya, R. M. Inga, and J. L. Arevalo. 1990. Detection of *Leishmania braziliensis* from minimally processed human biopsies via the Polymerase Chain Reaction, PCR. 90th Annual Meeting of the American Society for Microbiology. May 13-17, 1990. Anaheim, California, USA. *Abstracts of the Annual Meeting of the American Society for Microbiology* 90:114.
- Marshall, S., S. Heath, V. Henriquez, and C. Orrego. 1988. Minimally invasive detection of *Piscirickettsia salmonis* in cultivated salmonids via the PCR. *Applied and Environmental Microbiology* 64(8):3066-3069.
- Matoq, M. D., F. X. Villablanca, C. Orrego, and J. A. Randall. 1995. A mtDNA study of museum specimens reveals low historic genetic diversity in the endangered Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*). In, *Unity in Diversity*. Strauss, M. S. (Editor). 1995 AAAS Annual Meeting and Science Innovation Exposition. The 161st National Meeting of the American Association for the Advancement of Science. February 16-21, 1995. Atlanta, Georgia, USA. Abstracts 122. Pagination varies.
- Murray, A. E., J. T. Hollibaugh, and C. Orrego. 1996. Phylogenetic compositions of bacterioplankton from two California estuaries compared by denaturing gradient gel electrophoresis of 16S rDNA fragments. *Applied and Environmental Microbiology* 62(7):2676-2680. <https://aem.asm.org/content/aem/62/7/2676.full.pdf>
- Orrego, C. 1971. *Studies on the RNA Polymerase from *Micrococcus luteus**. Brandeis University. Department of Biochemistry. Waltham, Massachusetts, USA. 201 pp. Note: In Orrego's dissertation, his name is spelled "Christián". https://search.library.brandeis.edu/prime-explore/fulldisplay?docid=BRAND_ALMA21230702250001921&context=L&vid=BRAND&search_scope=EVERYTHING&tab=everything&lang=en_US
- Orrego, C. 1981. Evaluation of microbial technologies involved in fuel production, agriculture and forestry. Science and Technology Series No. 36. The World Bank. Washington, District of Columbia, USA.
- Orrego, C. 1982. *Chemicals, animal feed and fertilizer production from solar energy conversion by algae. A survey of research and development opportunities relevant to Portugal*. Internal Document. Center for Policy Alternatives. Massachusetts Institute of Technology (CPA/MIT). Cambridge, Massachusetts, USA.
- Orrego, C. 1982. *Biotechnology. Discussion of an option for Portugal*. Internal Document. Center for Policy Alternatives. Massachusetts Institute of Technology (CPA/MIT). Cambridge, Massachusetts, USA.

- Orrego, C. 1983. New cooperative effort planned for Latin American biotechnology. *Nature Biotechnology* 1:413. <https://doi.org/10.1038/nbt0783-413>
- Orrego, C. 1983. Hemispheric cooperation in microbiology. *American Society for Microbiology News* 49:74.
- Orrego, C. 1983. Interciencia Symposium "Biotechnology in the Americas: Prospects for Developing Countries". *Interciencia. Revista de Ciencia y Tecnología de las Américas* 8(6)420-422.
- Orrego, C. 1984. Underutilized funding opportunities for research in the biomedical sciences in Latin America. pp. 73-76. In, Sayer, W. D. (Editor). *Biotechnology in the Americas: Prospects for Developing Countries*: Proceedings of a Symposium held in San José, Costa Rica 3-6 May 1983. Interciencia Association. Washington, District of Columbia, USA. 79 pp.
- Orrego, C. 1984. First scientific conference on the environment in Chile. *Interciencia. Revista de Ciencia y Tecnología de las Américas* 9:407-409.
- Orrego, C. 1984. DNA and the Disappeared. *New Scientist* 104(1430 November 15):14-15.
- Orrego, C. 1986. Interciencia Symposium. Biotechnology in the Americas II: Applications to tropical agriculture. *Interciencia. Revista de Ciencia y Tecnología de las Américas* 11:192-193.
- Orrego, C. 1987. *Opciones para un Programa Regional de Biotecnología*. Informe para el Departamento de Asuntos Científicos y Tecnológicos de la Organización de Estados Americanos [OAS]. [Washington, District of Columbia, USA.]
- Orrego, C. 1989. *Excellence Under Adversity: The Life Sciences and Biotechnology in Latin America and the Role of Scientific Societies in Their Development*. A report prepared on behalf of Interciencia Association[.] The American Association for the Advancement of Science[, and] The American Society for Microbiology. Under a grant from the National Science Foundation. Interciencia Association. Washington, District of Columbia, USA. 64 pp.
- Orrego, C. 1991. *Gene Technologies in Clinical Diagnostics: Recruitment of the Biotechnology Industry to Paho's Mission*. A report to the Office of Research Coordination. Pan American Health Organization. Washington, District of Columbia, USA.
- Orrego, C. 1991. *Recovery of Amplifiable DNA from Human Teeth: An Unusually Simple Extraction Procedure for Forensic Analysis*. A Progress Report to the AAAS Science and Human Rights Program. Washington, District of Columbia, USA.
- Orrego, C. 1995. Biotechnology in the Western Hemisphere: a brief overview by someone skeptical about trends. *Revista de Ciencia y Tecnología de las Américas* (Caracas, Venezuela) 20(3):126-129.
- Orrego, C. 1990. Chapter 54. Organizing a laboratory for PCR work. pp. 447-454. In, Innis, M. A., D. H. Gelfand, J. J. Sninsky, and T. J. White. *PCR Protocols: A Guide to Methods and Applications*. Academic Press. London, England, UK. 482 pp. https://books.google.com/books?hl=en&lr=&id=Z5jwZ2rbVe8C&oi=fnd&pg=PA447&dq=%22cristian+orrego%22&ots=LAJ_Nk2McB&sig=hueTABrvQND8bPnTXdtEiqJq4#v=onepage&q=%22cristian%20orrego%22&f=false
- Orrego, C. 2002. 3.2.9. Forensic DNA analysis of human remains. The learning process and expectations on productivity. pp. 95-98. In, Human remains management. *The Missing. The Right to Know. The Missing: Action to resolve the problem of people unaccounted for as a result of armed conflict or internal violence and to assist their families*. Ecogia ICRC Training Center - Geneva – Switzerland. Final report and outcome International Committee of the Red Cross (Geneva, Switzerland, 7th–12th July 2002). 190 pp. https://www.icrc.org/en/doc/assets/files/other/icrc_themissing_102002_en_3.pdf
- Orrego, C. 2011. Remembering George Carmody. South & South of the Border. *The CACNews* [California Association of Criminalists] Fourth Quarter:9.
- Orrego, C. and F. Agudelo-Silva. 1993. Genetic variation in the parasitoid wasp *Trichogramma* (Hymenoptera: Trichogrammatidae) revealed by DNA amplification of a section of the nuclear ribosomal repeat. *The Florida Entomologist* 76(3):519-524. <https://doi.org/10.2307/3495653>
- Orrego C., M. Arnaud, and H. O. Halvorson. 1977. Location and DNase resistance of the chromosome released during outgrowth of spore of *Bacillus subtilis*. *Abstracts of the Annual Meeting of the American Society for Microbiology* 77:147.

- Orrego, C., M. Arnaud, and H. O. Halvorson. 1978. *Bacillus subtilis* 168 genetic transformation mediated by outgrowing spores: necessity for cell contact. *Journal of Bacteriology* 143(3): 973-981. https://books.google.com/books?hl=en&lr=&id=Z5jwZ2rbVe8C&oi=fnd&pg=PA416&dq=%22cristian+orrego%22&ots=IAJ_Nk2McB&sig=Gc0WrCyoLL_i8M4FnRz5rMFwwIM#v=onepage&q=%22cristian%20orrego%22&f=false
- Orrego, C. and E. Eisenstadt. 1987. An inducible pathway is required for UV mutagenesis in *Salmonella typhimurium* LT-2. 86th Annual Meeting of the American Society for Microbiology. Washington, D. C. USA. March 23-28, 1986. *Abstracts of the Annual Meeting of the American Society for Microbiology* 86:147.
- Orrego, C. and E. Eisenstadt. 1987. An inducible pathway is required for mutagenesis in *Salmonella typhimurium* LT2. *Journal of Bacteriology* 169(6):2885-2888. <https://doi.org/10.1128/jb.169.6.2885-2888.1987>
- Orrego, C. and M. S. Fox. 1983. A screening procedure for the efficient recognition of *Escherichia coli* K-12 mutants. *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis* 109(2):169-182. [https://doi.org/10.1016/0027-5107\(83\)90044-1](https://doi.org/10.1016/0027-5107(83)90044-1)
- Orrego, C. and M. S. Fox. 1985. On mutation resulting from nitrosoguanidine induced DNA damage in *Escherichia coli* K12 ada'. *Mutation Research* 146:185-189. [https://doi.org/10.1016/0167-8817\(85\)90009-4](https://doi.org/10.1016/0167-8817(85)90009-4)
- Orrego, C., P. Kerjan, M. C. Manca de Nadra, and J. Szulmajster. 1973. Ribonucleic acid polymerase in a thermosensitive sporulation mutant (ts-4) of *Bacillus subtilis*. *Journal of Bacteriology* 116:636-647. <https://jb.asm.org/content/116/2/636>
- Orrego, C. and K. W. Hutchinson. 1975. 2 modes of chromosome release during germination of *Bacillus subtilis* spores. *Abstracts of the Annual Meeting of the American Society for Microbiology* 75:96.
- Orrego, C., P. Kerjan, M. C. Manca de Nadra, and J. Szulmajster. 1973. RNA polymerase in a thermos sensitive sporulation mutant TS-4 of *Bacillus subtilis*. *Journal of Bacteriology* 116(2):636-647.
- Orrego, C. and M. C. King. 1990. Chapter 50. Determination of familial relationships. pp. 416-428. In, Innis, M. A., D. H. Gelfand, J. J. Sninsky, and T. J. White. *PCR Protocols: A Guide to Methods and Applications*. Academic Press. London, England, UK. 482 pp. https://books.google.com/books?hl=en&lr=&id=Z5jwZ2rbVe8C&oi=fnd&pg=PA416&dq=%22cristian+orrego%22&ots=IAJ_Nk2McB&sig=Gc0WrCyoLL_i8M4FnRz5rMFwwIM#v=onepage&q=%22cristian%20orrego%22&f=false
- Orrego, C., A. C. Wilson, and M.-C. King. 1988. Identification of maternally-related individuals by amplification and direct sequencing of a highly polymorphic noncoding region of mitochondrial DNA. 39th Annual Meeting of the American Society of Human Genetics. October 12-15, 1988. New Orleans, Louisiana, USA. *American Journal of Human Genetics* 43(3 Supplement):A219.
- Prager, E. M., C. Orrego, and R. D. Sage. 1998. Genetic variation and phylogeography of central Asian and other house mice, including a major new mitochondrial lineage in Yemen. *Genetics* 150(2):835-861. <http://www.genetics.org/content/150/2/835.short>
- Rensen, G. J., M. R. Buoncristiani, and C. Orrego. 2002. Assessment of DNA retention on plastic surfaces of commercially available microcentrifuge tubes. In, *Proceedings of the Thirteenth International Symposium of Human Identification*. Phoenix, Arizona, USA. https://www.promega.ro/~media/files/resources/conference%20proceedings/ishi%2013/poster%20abstracts/73_buoncristiani.pdf
- Ribble, D. O and C. Orrego. 1990. Storage of tissues in silica gel for DNA extraction. *Fingerprint News* 2:4.
- Schaechter, M. and C. Orrego. 1996 Editorial. *Microbiologia* 12:7-8.
- Skarmeta, A. M., V. Henriquez, M. Zahr, C. Orrego, and S. H. Marshall. Isolation of a virulent *Piscirickettsia salmonis* from the brain of a naturally infected coho salmon. 2000. *Bulletin of the European Association of Fish Pathologists* 20:261-264. <https://www.semanticscholar.org/paper/Isolation-of-a-virulent-Piscirickettsia-salmonis-of-Skarmeta-Henr%3ADquez/96a2729a2381f31714812dcf439cb45e3f82838f>

- Smith C. M., Z. Arany, C. Orrego, and E. Eisenstadt. 1991. DNA damage-inducible loci in *Salmonella typhimurium*. *Journal of Bacteriology* 173(11): 3587-3590. <https://doi.org/10.1128/jb.173.11.3587-3590.1991>
- Smith C. M., Z. Arany, C. Orrego, and E. Eisenstadt. 1992. Mutations in *topA* interfere with the inducible expression of DNA damage response loci in *Salmonella typhimurium*. *Environmental and Molecular Mutagenesis* 19(3): 185-194. <https://doi.org/10.1002/em.2850190302>.
- Snow C. C., L. Levine, L. Lukash, L. G. Tedeschi, C. Orrego, and E. Stover. 1984. The investigation of the human remains of the 'disappeared' in Argentina. *The American Journal of Forensic Medicine and Pathology* 5(4):297-299. <https://doi.org/10.1097/00000433-198412000-00003>
- Tan, A.-M. and C. Orrego. 1992. DNA stabilization and amplification from museum collections of extracts originally intended for allozyme analysis. *Molecular Ecology* 1(3):195-197. <https://doi.org/10.1111/j.1365-294X.1992.tb00176.x>
- Timken M. D., K. L. Swango, and C. Orrego. 2005. A duplex real-time qPCR assay for the quantification of human nuclear and mitochondrial DNA in forensic samples: implications for quantifying DNA in degraded samples. *Journal of Forensic Sciences* 50(5):1044-1060. <https://doi.org/10.1520/JFS2004423>.
- Timken M. D., K. L. Swango, C. Orrego, M. D. Chong, and M. R. Buoncristiani. 2005. Quantitation of DNA for forensic DNA typing by qPCR (quantitative PCR): singleplex and multiple modes for nuclear and mitochondrial genomes, and the Y chromosome. Document No.: 210302. *National Criminal Justice Reference Service (NCJRS)*. 89 pp. <https://www.ncjrs.gov/pdffiles1/nij/grants/210302.pdf>
- Toulouse, R. J. A., C. Orrego, M. S. F. Cambridge, F. Cortes, P. Escalza, J. M. Rodriguez-Higuera, J. M. G Sevilla, G. L. Erexson, J. L. Wilmer, A. D. Kligerman, and L. E. Dillehay. 1983. *uvrA* and *ssbA* genes of *Escherichia coli*. *Mutation Research* 109(2):309-310.