BIOGRAPHICAL MEMOIRS

Bruce D. Hammock

August 13, 1947–January 5, 2026
Elected to the NAS, 1999

A Biographical Memoir by Keith D. Wing, Qing X. Li, Sarjeet S. Gill, and Thomas C. Sparks

Bruce D. Hammock was a standout in the fields of insect physiology, toxicology, environmental monitoring, and human pharmacology and therapeutics. Characterized by an interdisciplinary approach, his work blended biology, biochemistry, chemistry, toxicology, and biotechnology to address some of the most pressing challenges in science and society over five decades of groundbreaking research and innovation. His work bridged fundamental biological and chemistry research with practical applications, influencing disciplines as diverse as agriculture, medicine, and environmental health.[1] Hammock's publication record is truly extraordinary: more than 1,500 refereed journal papers and book chapters, resulting in more than 100,000 citations and a Google Scholar H-index of 147. His lab's ninety patents include twelve for green pesticides, eighteen involving immunochemistry and diagnostics, and sixty-five related to human health.

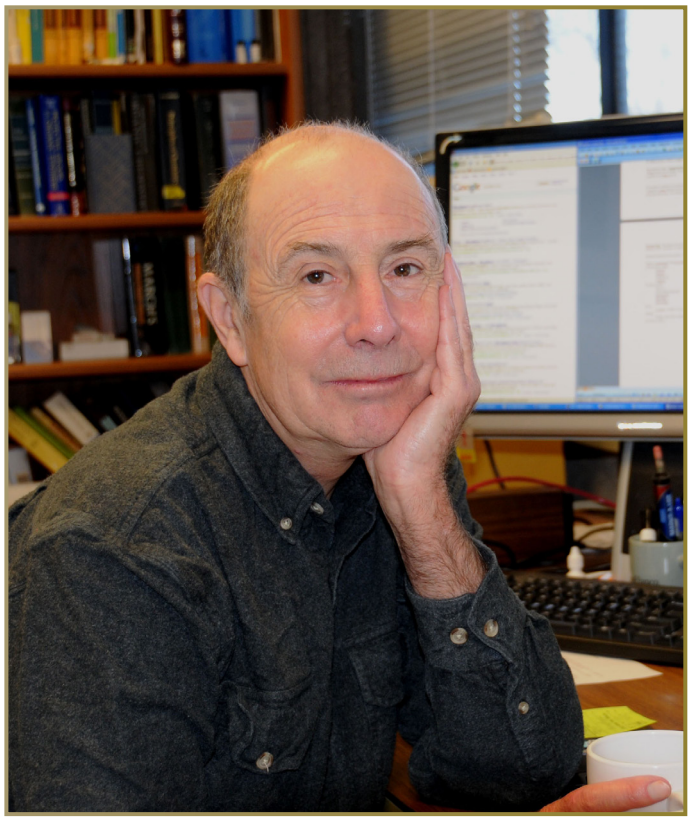

Figure 1 Professor Bruce D. Hammock in his office. *Photo courtesy of the Hammock Family.*

Family, Education, and Academic Career

Born on August 13, 1947, in Little Rock, Arkansas, to a postal worker father, Bruce, and a salesperson mother, Grace Lillian, Bruce D. Hammock developed an early interest in the natural sciences and grew up in a time of rapid scientific advancement and societal change. His early fascination with the natural world and chemistry set the stage for a career that would span multiple fields. In 1965, he enrolled at Louisiana State University (LSU), where he developed a keen interest in the biochemical mechanisms underlying insect behavior and physiology. Two years into his education, he joined the U.S. Army Reserve.

In 1969, Hammock earned his bachelor's degree in entomology (with a minor in zoology and chemistry) and then began graduate studies at the University of California, Berkeley (UCB). On August 26, 1972, he married Lassie May Graham, and the following year he earned his Ph.D. in entomology and toxicology under John E. Casida. Also in 1973, as part of his service in the U.S. Army Reserve, he acquired a medical science certificate as a public health medical officer in the U.S. Army Academy of Health Sciences in San Antonio, Texas. He then served in two postdoctoral fellowships, one

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in 1973 at UCB in entomology and toxicology and a second in 1974 in biochemistry with the Rockefeller Foundation at Northwestern University in Evanston, Illinois. In 1975, he joined University of California, Riverside (UCR) as an assistant professor of entomology. He moved to the University of California, Davis (UCD) in 1980 as associate professor of entomology and toxicology and was promoted to full professor in 1983. He was named a distinguished professor in 2003.

Research Hallmarks

Some enduring themes which characterize Hammock's work and career include basic science, often originating from insect biochemistry and physiology, and leading to applications affecting human health. This ability to connect seemingly disparate fields of study would become a defining characteristic of his research. He was also known for his application of cutting-edge biochemical technologies to basic biology and agricultural and pharmaceutical science and a legacy of method innovation and refinement, which resulted in cross-disciplinary and practical applications. Hammock believed science, collaboration, and continual learning are fun and enrich people's lives. He always engaged in positive mentorship combined with rigorous scientific training and standards. He cared for people, led by example, and improved their lives. Through his pioneering research and his cultivation of an interdisciplinary approach to science, Hammock remains an enduring inspiration for scientists worldwide.

Early Contributions to Green Insecticides

Hammock had a deep interest in developing insect-specific, consumer-acceptable alternatives for controlling insect pests of crops and vectors of disease. His early research, initiated during his doctoral studies at UCB (1969–73) focused on the regulation of insect juvenile hormone (JH), the critical insect-specific mediator of metamorphosis and development.[2,3] Note that in the 1970s, 94 percent of insecticides were neurotoxins belonging to three (often environmentally problematic) chemistry classes: organochlorines, carbamates and organophosphates. Based on fundamental understanding of insect JH physiological regulation, he synthesized and studied a series of insect growth regulators (IGRs) that were mimics of JH (juvenoids) aimed at reducing dependence on neurotoxic insecticides. Juvenoids are exceptionally powerful chemical mediators, as the insect is trapped in a larval stage which prevents reproduction. Hammock helped further expand the IGR field through a long-term consultation with the Zoecon Corporation. His influence aided in the discovery of new juvenoids and antagonists, that were both highly effective and environmentally benign.[4] Several of these IGRs continue to be used as green insecticides today.

Hammock demonstrated that the enzymatic degradation of JH is as critical as its biosynthesis in controlling developmental timing.[5,6] He proposed that hydrolytic enzymes such as JH esterase[7,8] (JHE) and epoxide hydrolase (EH) are essential for modulating JH levels in insects. This work not only advanced insect physiology but also highlighted the importance of catabolic pathways in hormone/metabolite regulation.[9-12] This enduring interest led to the concept of using enzyme inhibitors as species-specific pest control agents. More importantly, an outgrowth of Hammock's work was the discovery of soluble EHs (sEH), first in mammals and then in other animals.[13-19] These enzymes ultimately proved to be of great importance in human health (see below), leading to the exploration of non-addictive solutions to managing chronic pain.[20,21]

Transgenic Baculoviruses as Insecticides

While studying the basic physiology of insect metamorphosis, Hammock's research on JHE led him to propose using the enzyme itself as a potential insecticide. His lab cloned the JHE gene and expressed it in a natural baculovirus of caterpillars.[22] This became the first genetically engineered "green" viral insecticide, causing larvae to stop feeding and pupate before they could damage crops. Hammock's lab later developed expertise in insect-specific peptide toxins and expressed a scorpion toxin, which acts as a highly potent insecticide on the insect sodium channel.[23,24] While these were not commercialized, this work demonstrated the viability of engineering biological insecticides.[25,26]

Transition-State Theory and Enzyme Inhibitor Design

Hammock's work dramatically advanced fundamental understanding of enzyme active site mechanisms, leading to integration of transition-state theory into inhibitor design.[27] Using transition state theory, his lab designed enzyme inhibitors exhibiting picomolar potency, unparalleled specificity, and drug-like properties.[28] His team also used transition state inhibitors of sEH as chemical probes and discovered multiple pathways regulated by epoxy-lipids and the sEH that hydrolyzes them. The sEH inhibitors have been shown to be active against multiple human diseases in animal models.

Immunoassays

Concurrently, Hammock was the primary driver of the application of immunoassays and immunosensors to measure environmental contaminants. His pioneering 1978 paper on environmental immunoassay effectively created the field. This study focused on the pyrethroid insecticide S-bioallethrin and demonstrated the advantages and opportunities afforded by immunoassays for environmental

Figure 2 The Hammock family, October 2016. *Photo courtesy of the Hammock Family.*

contaminants.[29] His work on the high selectivity of these assays for compounds of environmental concern has inspired generations of scientists. Further, Hammock's 1980 paper[30] introduced enzyme-linked immunosorbent assays (ELISAs) for rapid, sensitive detection of agrochemicals.[31-34] These assays revolutionized regulatory science by enabling high-throughput, low-cost screening of pesticide residues in food and water—a methodology still widely used today and which serves as an excellent complement to physicochemical methods such as chromatography-tandem mass spectrometry.[35] This dual focus on both developing safer pesticides and improving detection methods underscored Hammock's holistic approach to environmental health. His work in environmental toxicology will also continue to inform policies and technologies aimed at reducing human exposure to xenobiotics, especially Superfund chemicals.[36-38] When Hammock was elected to the U.S. National Academy of Sciences in 1999, he was cited for his pioneering work using immunochemistry to analyze and monitor human exposure to environmental chemicals.

His pioneering research helped launch the agricultural and environmental diagnostic industry that manufactures and supplies antibody-based reagents and assays globally. Environmental analysis traditionally relied on laborious workup procedures and sophisticated, expensive equipment. Such protocols did not support rapid data generation in the field, nor the proper regulation of agricultural chemicals in developing countries. Hammock's leadership in the use of fast, economic, easy-to-use immunoassays to measure pesticide residues and small molecule pollutants significantly advanced pesticide monitoring. Indeed, his laboratory gained the reputation of being "the innovation hub of environmental immunochemical technology."[39]

The Hammock lab published more than 600 articles involving the immune-analysis and monitoring of greater than 300 contaminants, pesticides, proteins, and natural toxins in various matrices. Throughout his career, Hammock has invented and adapted many new immunoassay technologies to the environmental field, including nanobodies (such as single domain recombinant antibodies), novel optical and physical formats, and smartphone-interfaced lab-on-a-chip biosensor devices. In 2014, his team published the first nanobody-based assay for environmental analysis of pollutants[40] and subsequently led the field in this area.[41]

SEH Inhibitors, Drug Discovery and Metabolomics

In the course of studying epoxide catabolism of JH/juvenoids,[42] his team discovered sEH inhibitors (sEHi's), and realized they could also influence the metabolism of lipid epoxides in mammals.[43-45] Lipid epoxides in the eicosinoid and other polyunsaturated fatty acid pathways are signaling molecules that play a key, widespread anti-inflammatory role.[46] This discovery marked a major shift in Hammock's career, as he began to explore the therapeutic potential of sEHi's in greater depth.[47,48]

This effort launched a fifty-year research trajectory, culminating in a drug candidate, currently in human trials, that relieves chronic pain without the risk of addiction.[49] Hammock's research has demonstrated that these compounds exert potent anti-inflammatory,[50,51] analgesic,[52] and antihypertensive,[53,54] effects in preclinical models. In animal studies, sEHi's have been shown to reduce inflammation and pain in models of arthritis, diabetes, and neuropathy without the side effects typically associated with traditional nonsteroidal anti-inflammatory drugs (NSAIDs).[55,56] These findings have sparked considerable interest in the pharmaceutical industry, and several sEHi's are currently in clinical trials for the treatment of conditions such as chronic pain, hypertension,[57] and fibrotic diseases. Hammock's contributions have not only advanced our understanding of the role of lipid signaling in health and disease but have also provided promising new approaches for addressing the opioid crisis. Furthermore, his work has improved the treatment of inflammation,[58] cancer,[59,60] cardiovascular disease,[61,62] and obesity,[63] and even enhanced cancer immunotherapy.[64] In the coming decades, the principles established by Hammock's research will continue to influence scientific progress. As research advances in precision medicine, inflammation regulation, and chronic disease management, his sEHi contributions will remain foundational to developing next-generation therapeutics.[65-67]

In the process of developing the sEHi's as pharmacological agents and studying their efficacy in mammalian models and the fate of key long chain lipid signaling lipids, Hammock dramatically advanced the field of metabolomics.[68,69] His 2007 paper[70] has become a cornerstone resource, fundamentally reshaping how researchers approach the study of metabolic processes. This highly cited work provided a comprehensive and accessible overview of mass spectrometry-based techniques, effectively democratizing the field and empowering scientists from diverse backgrounds to incorporate metabolomic approaches into their research, helping to pioneer the application of accelerator mass spectrometry to biological science. By providing a robust and accessible framework for metabolomics research, he enabled scientists across a wide range of disciplines to incorporate metabolomic approaches into their studies. This has led to significant advancements in our understanding of cellular metabolism in health and disease, drug metabolism and toxicity, environmental toxicology, and personalized medicine.

Hammock also played a key role in shaping the metabolomics field through his leadership and mentorship. As the director of the NIH Biotechnology Training Program and the NIEHS Superfund Research Program at UC Davis, he trained a new generation of metabolomics researchers, equipping them with the skills and knowledge to tackle the challenges of the future. His former students and postdocs have gone on to establish successful careers in academia, industry, and government, further amplifying his impact on the field.

Translational Science and the Private Sector

Hammock founded three companies that have benefited society. The first, Arete Therapeutics, was founded in 2003 to advance the commercialization of sEHis for reducing cardiovascular diseases and neuropathic pain in animals and humans. EicOsis, established in 2011, built on this earlier effort to include other neurodegenerative diseases. The third, Synthia (2015), aimed to assist students in better understanding technology transfer.

These companies have included several Hammock lab members, which has led all to develop experience and leadership skills in drug discovery, optimization, fundraising, regulation and FDA collaboration, and other critical commercialization skills. EC5026 from his laboratory is now in Phase II clinic trials.

Mentorship, Pedagogical Legacy and Collaborative Influence

Over the course of his career, Hammock trained more than 400 students, postdoctoral researchers, and visiting scientists, many of whom have gone on to become leaders in their respective fields. His laboratory was known for its collaborative and interdisciplinary approach, bringing together researchers from diverse backgrounds to tackle complex scientific problems. His emphasis on teamwork and innovation fostered a culture of creativity and excellence, enabling groundbreaking discoveries that might not have been possible in a more traditional research setting.

Hammock was also a phenomenal leader and mentor. As a distinguished professor at UC Davis, he served as a valued mentor and advisor to students and faculty across multiple departments. A defining characteristic of Hammock's pedagogical approach is that "science should be fun."[71] He directed the nation's first NIEHS Superfund Program (1987–2025). He also directed the NIH Biotechnology Training Program (1986–2000) and the NIEHS Combined Analytical Laboratory at UC Davis for more than fifteen years,[72] while maintaining an NIH-supported mass spectrometry laboratory for over three decades. These programs not only facilitated cutting-edge research but also instilled a commitment to translating scientific discoveries into tangible solutions for real-world challenges in environmental health and toxicology. Hammock was a founding member of the UC Davis Medical School Comprehensive Cancer Center in 1991. He also was one of the founding board members of the Medical Center's Center for Pain Relief.

Within his lab, Hammock cultivated a dynamic and collaborative environment emphasizing both critical thinking and rigorous science and the skills needed for interdisciplinary research. Hammock alumni have been directly involved in the discovery and development of at least five entirely new classes of insect control chemistries now in the marketplace and representing about 10 percent of the 2018 total global insecticide sales and 15 to 20 percent of the total global sales for newer, more environmentally friendly products. Three of these chemistries have won the U.S. Environmental Protection Agency's Presidential Green Chemistry Award.

Hammock actively sought partnerships with worldwide researchers from diverse disciplines, fostering a vibrant network of over 3,500 collaborators. His willingness to share novel chemistry, ideas, data, and expertise has accelerated the pace of discovery and innovation in numerous fields. He maintained collaboration with some of his students during his entire career.[73,74]

Hammock also helped shape scientific agendas and policies through his service on various advisory boards and committees. His insights and expertise have been sought by government agencies, industry leaders, and academic institutions.

Recognitions, Honors and Awards

Over the course of his career, Hammock received numerous accolades for his contributions to science and society. He

Figure 3 Several Hammock lab alumni, August 25, 2018, at the University of California, Davis for his seventieth birthday celebration. *Photo courtesy of the Hammock Family.*

was a member of the National Academy of Sciences (1999) and the National Academy of Inventors (2015). His work has been recognized with awards such as the Frasch Foundation Award in Agricultural Chemistry grant for 1982–87, the International Award in Pesticide Chemistry of the American Chemical Society (ACS) (1992), the Kenneth A. Spencer Award of the ACS (1993), the Alexander von Humboldt Award in Agriculture (1995), the Entomological Society of America's Recognition Award in Insect Physiology, Biochemistry, and Toxicology (1998), the UC Davis Medal (2000), UCD Academic Senate's Faculty Research Lecturer Award (2001), the UCD Distinguished Teaching Award (2008), the Bernard B. Brodie Award in Drug Metabolism and Disposition from the American Society for Pharmacology and Experimental Therapeutics (2014), and UCD Lifetime Achievement Award (2020). He also was honored with the USDA Agricultural Research Service's Sterling B. Hendricks Memorial Lectureship (1999) and the William E. M. Lands Lectureship in Biochemistry and Nutrition (2013) and was named a Fellow of the Entomological Society of America (2010). These honors reflect the breadth and depth of his impact, as well as the high regard in which he was held by his peers.

Legacy

Hammock was always able to see connections between seemingly unrelated fields. His work on insect physiology led to discoveries in human health, demonstrating the power of interdisciplinary research. By bridging entomology, biochemistry, and medicine, Hammock showed how insights from one area of science can lead to breakthroughs in another. Hammock's research established a synergistic loop between basic and applied science. This broad-minded approach enabled him to tackle complex science problems while dramatically improving biochemical methodologies in each field he pursued.

Hammock's journey embodies the spirit of scientific exploration and the power of interdisciplinary collaboration. His research has advanced our understanding of biochemistry and toxicology, led to the development of new pest control strategies and therapeutic agents, and inspired countless researchers to pursue careers in science. He also had an informal, friendly style while encouraging scientific rigor and social responsibility. Hammock's lab parties, water balloon fights outside the UCD entomology building, local hikes, and creek inner tube trips were legendary, and his students, postdocs, and collaborators formed a friendly, tightknit group and continue to enjoy each other's company and discourse.

His story is not just one of scientific discoveries but of a life dedicated to making a difference. He worked tirelessly till his passing, and his impact will be felt for generations to come. His legacy extends beyond his individual accomplishments. His influence can be seen in the success of his former students and colleagues, who are now leading research programs and making very significant contributions to their respective fields. His career serves as an inspiration to scientists of all disciplines, demonstrating the transformative power of interdisciplinary research, dedicated mentorship, and a relentless pursuit of scientific excellence.[75] Barry Sharpless remarked "He was always flat out, working as hard as he could. It is hard to imagine the world without him. Bruce was a true force of nature to all his friends and one of the most creative scientists I have ever known."

He is survived by his wife, three children (Thomas, Bruce, and Frances), and two grandchildren (Max and Lelia Ioana). Hammock enjoyed outdoor activities, including white water kayaking, hiking, and climbing; this occasionally led to unwelcome injuries that he characteristically brushed off.

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