

Gene Drive Research in Non-Human Organisms: Recommendations for Responsible Conduct

Committee

James P. Collins

Co-Chair

James P. Collins, PhD, is Virginia M. Ullman Professor of Natural History and the Environment in the School of Life Sciences at Arizona State University (ASU). Dr. Collins's research focuses on the role of host-pathogen interactions in species decline and extinction. His research group uses amphibians, along with viral and fungal pathogens, as models for studying factors that control population dynamics. Dr. Collins's also works on issues related to ecological ethics and the institutional and intellectual factors that have shaped the development of ecology as a discipline. From 1989 to 2002 he was Chair of ASU's Zoology, and then Biology Department, where he used interdisciplinary programs to foster innovation in research, education, and institutional change. He also was a founding director of ASU's Undergraduate Biology Enrichment Program, and served as co-director of ASU's Undergraduate Mentoring in Environmental Biology and Minority Access to Research Careers programs.. Collins's expertise in population dynamics led him to serve as Director of the Population Biology and Physiological Ecology program at the National Science Foundation (NSF) from 1985 to 1986. He also served as NSF's Assistant Director responsible for Biological Sciences, one of seven NSF research directorates. He oversaw a science funding portfolio that spanned molecular biology to global change research, biological infrastructure, and biology education. Dr. Collins is a Fellow of the American Association for the Advancement of Science (AAAS) and the Association for Women in Science (AWIS), and Past President of the American Institute of Biological Sciences (AIBS). He has been a member of numerous review panels for basic research and graduate training programs at NSF. He served as the Chairman of the US National Science and Technology Council's Committee on Science Subcommittee on Biotechnology (2005-2009) and the National Academy of Sciences Committee on Thinking Evolutionarily: Making Biology Education Make Sense (2011). Currently, Dr. Collins is Chair of the National Academy of Science's Board on Life Sciences.

Elizabeth Heitman

Co-Chair

Elizabeth Heitman, PhD, is Associate Professor of Medical Ethics in the Center for Biomedical Ethics and Society, with appointments in the Departments of Medicine and Anesthesiology, at Vanderbilt University Medical Center. She holds additional teaching appointments in the College of Arts and Science through the Center for Medicine, Health, and Society and Department of Religious Studies. Dr. Heitman's work focuses on cultural issues and international aspects of ethics in medicine, biomedical science, and public health. Her research examines international standards of research ethics and education in the responsible conduct of research (RCR) and trainees' awareness of professional and cultural norms. She is co-principal investigator (co-PI) of a 5-year research ethics education grant from the National Institutes of Health's Fogarty International Center, "Formação Colaborativa na Ética em Pesquisa (Collaborative Research Ethics Education." Together with colleagues from the Universidade Eduardo Mondlane in Maputo, Mozambique, she and Troy Moon, MD, from Vanderbilt's Institute for Global Health, are developing curricular materials and courses for Mozambique's growing infrastructure in the ethical review of research with human participants. From 2007 to 2012, Dr. Heitman directed a similar Fogarty-sponsored program with the Hospital Nacional de Niños in San José, Costa Rica. She has been a collaborator on the Fogarty-sponsored Pan American Bioethics Initiative at the University of Miami, and she currently serves as an advisory committee member and consultant on similar programs in the Caribbean (Union Graduate College/Universidad Autonoma de Querétaro/St. George's University) and China (University of Pittsburgh). She was also previously PI of the National Science Foundation grant "Research Integrity in the Education of International Science Trainees." Dr. Heitman leads the research ethics activities of the Design, Biostatistics, and Ethics in Research Core of the Vanderbilt Institute for Clinical and Translational Research (VICTR), and coordinates VICTR's educational programs in the responsible conduct of research (RCR). Dr. Heitman is immediate past Chair of the national CTSA Consortium's former Clinical Research Ethics Key Function Committee, and served on the Committee's Educational Materials Working Group. Dr. Heitman is a member of the National Academy of Sciences (NAS) Board on Life Sciences, and its Standing Committee on Educational Institutes for Teaching Responsible Science. Through the NAS she has been a faculty member in the International Faculty Development Project on Education about Research in the Life Sciences with Dual Use Potential in the Middle East and North Africa (MENA), co-sponsored by the Bibliotheca Alexandrina and The World Academy of Sciences (TWAS). She currently chairs the NAS Committee for the Third MENA Institute for Responsible Science, and recently chaired the NAS Committee on the Elaboration of a National Curriculum in Bioethics and Responsible Conduct of Science for Algeria, advising the Algerian Ministry of Higher Education. Since 2009 she has been a member of the American Association for the Advancement of Science's (AAAS) Science Ethics Initiative with the China Association for Science and Technology, and has contributed to AAAS's work on biosafety/biosecurity education since 2008. Dr. Heitman received her PhD in Religious Studies in 1988 from Rice University's joint program in biomedical ethics with the University of Texas - Houston Medical School.

Nicole Achee

Member

Nicole L. Achee, PhD, is a Medical Entomologist (Research Associate Professor) within the Department of Biological Sciences and holds a joint Associate Professor appointment in the Eck Institute for Global Health at the University of Notre Dame. She joined the faculty in 2013, following a 2-year position as Assistant Professor at the Uniformed Services University of the Health Sciences in Bethesda, Maryland. She has a combined 20 years of experience in vector behavior research related to the epidemiology and control of arthropod-borne diseases, including evaluation of vector ecology, habitat management and adult control strategies, disease risk modeling using GIS and remote sensing technologies, and evaluation of chemical actions against mosquito vectors under both laboratory and field conditions. She has worked in the international settings of Belize, Indonesia, Mexico, Nepal, Peru, South Korea, Suriname, Tanzania and Thailand. Achee was the principal investigator of a research program funded by the Bill & Melinda Gates Foundation focused on the development of spatial repellents for use in combination push-pull systems to reduce human-vector contact for dengue prevention. She is currently a Principal Investigator for a multicenter intervention trial to generate evidence of the protective efficacy of spatial repellents for prevention of malaria and dengue human infections for use towards full WHO recommendations. Achee is a Working Group member for the WHO Pesticide Evaluation Scheme (WHOPES), is the Chair of the American Committee of Medical Entomology (ACME) of the American Society for Tropical Medicine and Hygiene (ASTMH), a member of the WHO Global Collaboration for the Development of Pesticides for Public Health partnership (GCDPP), a Vector Control Working Group representative of Roll Back Malaria and served as the lead scientist for the recent publication of the WHO Guidelines for Efficacy Testing of Spatial Repellents. Her latest efforts have been dedicated to co-Directing the Belize Vector and Ecology Center (BVEC) in Belize to serve as a local platform of excellence for research, training and education in public health.

Vicki L. Chandler

Member

Vicki Chandler, PhD, (NAS) is Dean of the College of Natural Sciences at the Minerva Schools at the Keck Graduate Institute of Applied Life Sciences. Dr. Chandler has conducted critical research in the field of plant genetics for three decades and is recognized as one of the foremost geneticists in the world. In 2014, she was appointed to the National Science Board by President Barack Obama for a six-year term. Prior to Minerva, Chandler served as the Chief Program Officer for Science at the Gordon and Betty Moore Foundation. Prior to joining the Foundation, she was a Professor at the University of Oregon and the University of Arizona. She is passionate about helping students develop the skills they need to be successful in their future careers, part of which is directing them to be curious, lifelong learners. Dr. Chandler was a postdoctoral fellow at Stanford University, received a Ph.D. from the University of California San Francisco, and a B.A. from the University of California Berkeley.

Jason Delborne

Member

Jason A. Delborne, PhD, is Associate Professor of Science, Policy, and Society in the Department of Forestry and Environmental Resources at North Carolina State University. Delborne joined NC State in August 2013 as part of the Chancellor's Faculty Excellence Program cluster in Genetic Engineering and Society. Delborne's research focuses on highly politicized scientific controversies, such as agricultural biotechnology, nanotechnology, biofuels, and climate change. Drawing upon the highly interdisciplinary field of Science, Technology, and Society (STS), he engages various qualitative research methodologies to ask questions about how policymakers and members of the public interface with controversial science. He also studies models for public engagement with science and technology, and the governance of emerging technologies. One of his current projects compares multiple pathways of development of genetically modified trees by exploring the extent to which responsible innovation is pursued and achieved. Delborne teaches and advises students affiliated with NC State's Genetic Engineering and Society Center, and in particular Ph.D. fellows in the NSF-IGERT funded Ph.D.interdisciplinary minor program focused on transgenic pests. on Genetic Engineering and Society: The Case of Genetic Pest Management. Delborne has published peer-reviewed articles in journals such as Social Studies of Science, Public Understanding of Science, and Science and Public Policy, and he co-edited *Controversies in Science and Technology: From Evolution to Energy* (Mary Ann Liebert, 2010).

Brandon S. Gaut

Member

Brandon S. Gaut is Professor of Ecology and Environmental Biology at the University of California at Irvine (UCI). Dr. Gaut has been a faculty member at UCI since 1998. He served as Chair of the Department from 2006 to 2012 and Interim Dean of the School of Biological Sciences in 2013. Dr. Gaut's research focuses on the balance of forces that contribute to evolutionary change in plant populations, with particular emphasis on evolutionary genetics and comparative genomics of plant systems, including the genetics of domestication. Another dimension of his research is the evolution of transposable elements, sequences of DNA that move from one location in the genome to another, and how they contribute to genome differentiation and interspecific divergence. Dr. Gaut is the recipient of numerous honors, and investigator and teaching awards including UCI Professor of the Year, Outstanding Professor, and Biological Sciences Excellence and Teaching. He is an elected fellow of the American Association for the Advancement of Science, Senior Editor for Molecular Biology and Evolution, and serves on the editorial board of *Genome Biology and Evolution*. Dr. Gaut also served as President for the Society of Molecular Biology and Evolution in 2014. Under the mentorship of Michael T. Clegg (member of the National Academy of Sciences), Dr. Gaut received his PhD in Plant Population Genetics from the University of California, Riverside.

Stephen Higgs

Member

Stephen Higgs, PhD, is the Virginia and Perry Peine Biosecurity Chair, Director of Biosecurity Research Institute (BRI), and Associate Vice President for Research at Kansas State University. The BRI is a secure biosafety level-3 and biosafety level-3 agriculture facility at Pat Roberts Hall. It enables studies on diseases that impact the global food supply, including those affecting humans, livestock and plants as well as food-borne pathogens. Collaborative research, education and training is conducted at the BRI by faculty and staff from multiple departments, federal agencies and industry. Dr. Higgs is responsible for oversight, coordination and expansion of BRI's multidisciplinary research and education programs. He also serves as associate vice president for research, facilitating bio-preparedness research campus-wide. Dr. Higgs' research interests are mosquito-virus-vertebrate interactions, and is an expert in vector biology, arthropod-borne infectious diseases, immune modulation and vaccine evaluation. He is experienced in developing collaborative, multidisciplinary research projects and has organized training in biocontainment facilities for researchers from other universities and other countries. He has published more than 150 peer-reviewed papers and 16 book chapters, and has been a member of numerous national and international research program review panels. He is a fellow of the American Society of Tropical Medicine and Hygiene and the Royal Entomological Society. He also is editor-in-chief of the international journal Vector-Borne and Zoonotic Diseases, and an editorial board member of Health Security (formerly Biosecurity and Bioterrorism). Higgs earned a doctorate in parasitology from Reading University in the United Kingdom and a bachelor of science with honors in zoology from King's College in London. He was involved in training and research at the London School of Hygiene and Tropical Medicine and at the Institute of Virology and Environmental Microbiology, Oxford, in the United Kingdom before coming to the United States in 1991.

Gregory Kaebnick

Member

Gregory E. Kaebnick is a research scholar at The Hastings Center and editor of the Hastings Center Report. He is interested in questions about the values at stake in developing and using biotechnologies, and particularly in questions about the value given to nature and human nature. Dr. Kaebnick is the author of *Humans in Nature: The World As We Find It and the World As We Create It* (Oxford 2014), lead editor of *Synthetic Biology and Morality: Artificial Life and the Bounds of Nature* (MIT 2013), and editor of *The Ideal of Nature: Debates about Biotechnology and the Environment* (Johns Hopkins 2011). He is the principal investigator on "Values in Impact Assessment," a research project funded by the National Science Foundation that explores the use of cost-benefit analysis and risk assessment for applications of synthetic biology. He served as a co-investigator on two research projects on synthetic biology funded by the Alfred P. Sloan Foundation and as principal investigator of a project funded by the National Endowment for the Humanities on appeals to nature in debates about biotechnology. He received his Ph.D. (1998) in philosophy from the University of Minnesota and his B.A. (1986) in religion from Swarthmore College.

Ann Kingiri

Member

Ann Kingiri, PhD, is a Senior Research Fellow at African Centre for Technology Studies (ACTS), a knowledge think tank based in Nairobi, Kenya. She is also a visiting researcher at the Development Policy and Practice (DPP) unit, Department of Engineering and Innovation, Open University, UK. Dr. Kingiri's technical expertise ranges across Science, Technology and Innovation (STI) policy analysis and advocacy; environmental policy analysis; biotechnology regulation; climate change; agriculture and food security; inclusive and sustainable development; gender research and analysis; and qualitative research methods. She is particularly interested in understanding these research areas from a Science Technology and Innovation (STI) perspective in relation to inclusive and sustainable development. She is currently pursuing policy-oriented research in agriculture and bioenergy, including climate change and gender as cross cutting themes. As a Senior Research Fellow at ACTS, Dr. Kingiri is responsible for the leadership of research to support the Science and Technology policy oriented capacity building, policy outreach and advocacy. She has been providing results oriented research and scientific leadership across the different programs and projects being implemented by ACTS as well as STI mentorship. Before joining ACTS in 2011, she worked with the Ministry of Agriculture as an agricultural officer, with Kenya Plant Health Inspectorate Service (KEPHIS) as a phytosanitary and biosafety/biosecurity expert. While at KEPHIS, she was extensively involved in development of biotechnology and biosafety regulatory policies in Kenya. Dr. Kingiri has ample experience in networking and advocacy in a multicultural setting involving diverse development and policy actors in the public and private sector. Her previous involvement as a research fellow in the Research into Use (RIU) program implemented in both Africa and Asia exposed her to the institutional and organisational orientation of agricultural entrepreneurship including the role of the private sector in stimulating innovation. Dr. Kingiri holds a PhD in Development Policy and Practice from Open University, UK. Additionally, she holds a Master's degree in Biosafety in Plant Biotechnology from Marche Polytechnic University, Ancona, Italy; an MSc degree in Plant Pathology from the University of Nairobi; and a BSc degree in Agriculture from the University of Nairobi.

Wayne Landis

Member

Wayne Landis, PhD, is Professor and Director of the Institute of Environmental Toxicology at Western Washington University. Dr. Landis's current area of research is ecological risk assessment at large spatial and temporal scales. Dr. Landis's research contributions also include creation of the Action at a Distance Hypothesis for landscape toxicology, the application of complex systems theory to risk assessment, and development of the Relative Risk Model for multiple stressor and regional-scale risk assessment and specialized methods for calculating risk due to invasive species and emergent diseases. He also has patents and papers on the use of enzymes and organisms for the degradation of chemical weapons. Dr. Landis has authored over 130 peer-reviewed publications and government technical reports, made over 300 scientific presentations, edited four books, and wrote the textbook, *Introduction to Environmental Toxicology*, now in its fourth edition. He has consulted for industry, non-governmental organizations as well as federal (U.S. and Canada), state, provincial, and local governments. Dr. Landis serves on the editorial boards of the journals *Human and Ecological Risk Assessment* and *Integrated Environmental Assessment and Management*, and is the ecological risk area editor for *Risk Analysis*. He is a member of the Society of Environmental Toxicology and Chemistry (SETAC) and served on the SETAC Board of Directors from 2000-2003. In 2007 he was named a Fellow of the Society for Risk Analysis. He was recently named to the Science Panel for the Puget Sound Partnership, a state agency that focuses on the restoration of Puget Sound. Dr. Landis received his PhD in Zoology (Indiana University), MA in Biology (Indiana University), and his BA in Biology (Wake Forest University).

Lynn M. Riddiford

Member

Lynn Riddiford, PhD, (NAS) is a Senior Fellow at the Howard Hughes Medical Institute and Professor of Biology Emeritus at the University of Washington. Her research focuses on the hormonal control of insect growth, molting, and metamorphosis, particularly the roles of ecdysone and juvenile hormone. She is also interested in the hormonal basis of metamorphic and reproductive behaviors. Dr. Riddiford pioneered in vitro approaches for studying the molecular mechanism of the major insect developmental hormones. Her basic studies on hormone action has aided in the development of hormone mimics for insect control. Dr. Riddiford is a member of the National Academy of Sciences, a Fellow of the American Academy of Arts and Sciences, AAAS, and the Entomological Society of America, and an Honorary Fellow of the Royal Entomological Society in England. She received the first Recognition Award in Insect Physiology, Biochemistry, and Toxicology from the Entomological Society of America in 1997, the G. J. Mendel Honorary Medal for Merit in the Biological Sciences from the Academy of Sciences of the Czech Republic in 1998, and the Vollum Award from Reed College in 2011. She was President of the American Society of Zoologists in 1991-92, the Councils of the International Congress of Entomology from 2000 to 2004, and the Federation of International Comparative Endocrinological Societies from 2001 to 2005. In addition, she has served on review and advisory panels for the National Science Foundation, the National Institutes of Health, the U.S. Department of Agriculture, the Scientific Advisory Board of the Whitney Marine Laboratory, and the Board of Directors of the Entomological Foundation, and the Governing Council of the International Center for Insect Physiology and Ecology, Nairobi, Kenya.

Joyce Tait

Member

Joyce Tait, PhD, is Director of the Innogen Institute, and a professor at the University of Edinburgh. She has an interdisciplinary background in natural and social sciences, covering agrochemical, pharmaceutical and life science industry sectors, focusing on: strategic planning for innovation; governance, risk management and regulation; and stakeholder attitudes and influences. Relevant life science areas include synthetic biology, genetic databases, GM crops, biofuels, pharmaceuticals, stem cell therapies and translational medicine. She is a Fellow of the Royal Society of Edinburgh and also of the Society for Risk Analysis. Current and recent appointments include: John Innes Centre Science and Impact Advisory Board; UK Department for Business Innovation and Skills (BIS) Synthetic Biology Leadership Council (Chair of Governance Subgroup); UK Department of Health Emerging Science and Bioethics Advisory Committee; Board of Directors, Roslin Foundation; Scottish Science Advisory Council; Scientific and Technical Council of the International Risk Governance Council, Geneva. Dr. Tait received her BSc from Glasgow University and her PhD from the University of Cambridge.

Lisa A. Taneyhill

Member

Dr. Lisa Taneyhill is an Associate Professor in the Department of Animal and Avian Sciences at the University of Maryland, College Park. Dr. Taneyhill's lab explores the molecular basis of neural crest cell development in the chicken embryo to provide insight into the formation of the vertebrate embryo. The lab uses advanced molecular, cellular, and biochemical techniques to elucidate how neural crest cells form, migrate, differentiate, and associate with other cell types to generate a variety of different tissues, including the peripheral nervous system, craniofacial skeleton, and portions of the heart. Understanding how neural crest cells are created and communicate with other cells has been the focus of grants Dr. Taneyhill has continuously received since 2007. Her initial contributions to the field of Developmental Biology began with the identification and characterization of specific genes that mediate the neural crest cell epithelial-to-mesenchymal transition (EMT). Since then, her research has advanced the field of Developmental Biology by describing the function, and dynamic modulation of, cellular junctions during EMT, and the essential role of cell adhesion proteins in neural crest cells later as these cells associate with different cells to form new tissues. Dr. Taneyhill earned her Masters and Ph.D. degrees in Molecular Biology from Princeton University and completed Postdoctoral training in Development Biology at the California Institute of Technology. Dr. Taneyhill has served as the principal organizer for the regional Society for Developmental Biology annual meeting and has authored 18 refereed scientific papers and 6 book chapters and reviews.

Paul E. Turner

Member

Dr. Paul Turner received his Ph.D. in 1995 from the Center for Microbial Ecology, at Michigan State University. He did postdoctoral work at the National Institutes of Health, University of Valencia in Spain, and University of Maryland, College Park. Dr. Turner is currently Professor and Departmental Chair of Ecology and Evolutionary Biology at Yale University, and a faculty member in the Microbiology Graduate Program at Yale School of Medicine. Dr. Turner was elected Councilor for Division R (Evolutionary and Genomic Microbiology) of the American Society for Microbiology, and Councilor for the American Genetic Association, and currently serves on the Biological Sciences Advisory Committee of the National Science Foundation. Dr. Turner was elected chair of several international meetings, including the 2013 Gordon Research Conference on Microbial Population Biology, and the 2018 Jacques Monod Conference on Viral Emergence. He has authored nearly 100 scholarly journal articles, reviews and book chapters, and has served as Associate Editor for journals such as *Evolution*, and *Evolution, Medicine and Public Health*. Dr. Turner also served on the National Academy of Sciences committee on Biological Confinement of Genetically Engineered Organisms. Dr. Turner's work involves basic research in microbial evolution and the evolution of infectious diseases, often harnessing laboratory populations of viruses as model systems to study mechanisms of evolutionary change. He also conducts applied research on novel approaches to treat infectious diseases of humans and other organisms. Dr. Turner heads a research group with diverse interests; current members are using microbes to address questions relating to the evolution of genetic exchange (sex), host-parasite interactions, pathogen emergence, virus biogeography, the ecology and evolution of infectious disease, and development of novel antimicrobials. His research program is highly inter-disciplinary, employing techniques from microbiology, population genetics, genomics, molecular biology and mathematical modeling. Dr. Turner's lab website is: <http://www.yale.edu/turner/>

David E. Winickoff

Member

David E. Winickoff, JD, is Associate Professor of Bioethics at University of California, Berkeley in the College of Natural Resources where has been located since 2004. Currently, he is serving as a Senior Policy Analyst and Secretary of the Working Party on Bio-, Nano- and Converging Technology at the Organization for Economic Cooperation and Development (OECD) in Paris. Broadly speaking, his work attempts to help solve difficult ethical, legal and social problems at the interface of science, technology and society, especially related to the environment and human health. He draws questions and methods from the fields of science and technology studies (STS), ethics, and the law. In particular, he analyzes the role of science and experts within environmental law and governance across local and global scales; the practices and regulation of emerging technologies like genetic modification, human genomics, and geoengineering; and the ethics and politics of manipulating nature and natural systems using advanced life science. He has over forty publications in academic journals and other outlets. His articles have appeared in *Science*, *New England Journal of Medicine*, *Nature Climate Change* and the *Yale Journal of International Law*, among others. Winickoff served as a Working Group member on a Royal Academy project on geoengineering, and sits on a number of bioethics advisory boards around the United States. At Berkeley, he directs the Program in Science and Technology Studies. He holds degrees from Yale, Cambridge, and Harvard Law School and was a fellow for two years at the Harvard Kennedy School.

Keegan Sawyer

Staff Officer

Dr. Keegan Sawyer a Program Officer on the Board on Life Sciences at the US National Academy of Sciences (NAS). Her work addresses a wide range of research, education, and science policy questions across the broad spectrum of life science disciplines. She has special interest in ecosystem health, the interplay of environmental conditions and human health, and public engagement in science. Dr. Sawyer is the Director of the NAS Roundtable on Public Interfaces of the Life Sciences and Co-lead of the NAS Standing Committee on Emerging Science for Environmental Health Decisions. She is committed to fostering discussions about research infrastructure, collaborative environments, and public engagement in science to support a healthier people and planet. Dr. Sawyer holds a B.S. in environmental biology from University of California Davis and an M.S. and Ph.D. in environmental sciences and engineering from the University of North Carolina Gillings School of Public Health.