

International Workshop Assessing the Security Implications of Genome Editing Technology

11-13 October, 2017
Herrenhausen Palace • Hanover, Germany

The workshop organizing committee is comprised of 10 international scholars with expertise on genome editing, security implications of biotechnology, science and technology policy, and public engagement in science. The organizing committee is assisted by 6 expert staff from the partnering global academies of sciences.

ORGANIZING COMMITTEE

Volker ter Meulen, MD (Chair), studied medicine in Münster, Innsbruck (Austria), Kiel and Göttingen, received a training in virology at the University of Philadelphia, USA, and in pediatrics at the University Hospital of Göttingen. In 1975 he became Chairman at the Institute of Virology and Immunobiology, University of Würzburg. His major research investigations have been directed towards the study of the etiology and pathogenesis of persistent virus infections with particular emphasis of the central nervous system. He was twice Dean of the Faculty of Medicine at the University of Würzburg and due to the recognition of his research achievements and his experiences to head a Medical Faculty successfully, Dr. ter Meulen has served as a member of many national and international committees giving scientific advice to policy makers and society. From 2003 – 2010, Dr. ter Meulen was President of the German Academy of Sciences Leopoldina. From 2007 – 2010, he served as president of the European Academies of Science Advisory Council (EASAC). Since 2013, Dr. ter Meulen is Co-Chair of IAP: the InterAcademy Partnership, the Global Network of Science and Medical Academies.

Baerbel Friedrich, PhD, is the Scientific Director of the Alfred Krupp Institute of Advanced Studies in Greifswald, Germany. Her main research interests include synthesis, structure and function of hydrogenase enzymes, protein-catalyzed assembly of metal co-factors, biological hydrogen production, and the functional genome research of lithoautotrophic bacteria. She was a Full Professor in Microbiology at the Humboldt-University, Berlin, Germany (1994 - 2013) and a Full Professor in Microbiology at the Free University, Berlin, Germany (1985 - 1994). She received her doctorate in microbiology from the University of Göttingen, Germany and was a postdoctoral fellow at the Massachusetts Institute of Technology in the United States. Her recent awards are the Leopoldina Medal of Merit (2016), the Arthur Burkhardt Prize (2013), and the Order of Merit (Verdienstkreuz am Bande) of the Federal Republic of Germany (2013). She is a member of the German National Academy of Sciences Leopoldina and the Berlin-Brandenburg Academy of Sciences, Germany, and a corresponding member of the Academy of Science in Göttingen, Germany, and the North Rhine-Westphalia Academy of Science.

Fred Gould, PhD, is a University Distinguished Professor of Entomology and codirector of the Genetic Engineering and Society Center at North Carolina State University. He studies the ecology and genetics of insect pests to improve food production and human and environmental health. Dr. Gould's research on the application of evolutionary biology and ecological genetics to sustainable insect-pest management has influenced management of insect pests of crops on a global scale and promises to do the same for arthropod vectors of human disease. He has been a leader in shaping the science-based regulatory framework for the deployment of *Bt* crops in the United States and globally. His research and major contributions have earned him numerous national and international awards, including the

Alexander von Humboldt Award in 2004, which is presented annually to the person judged to have made the most important contribution to American agriculture during the previous 5 years. In 2011, he was elected to the U.S. National Academy of Sciences (NAS). Dr. Gould has served on several NAS–National Research Council committees studying effects of the commercialization of genetically engineered crops. He currently serves on the National Academies of Sciences, Engineering, and Medicine’s Board on Agriculture and Natural Resources. He is a fellow of the Entomological Society of America and of the American Association for the Advancement of Science. Dr. Gould is the author or a coauthor of more than 180 refereed publications. He received his BS in biology from Queens College and a PhD in ecology and evolutionary biology from the State University of New York at Stony Brook.

Alexander Kagansky, PhD, is a Chancellor’s Fellow at the MRC Human Genetics Unit, Institute of Genetics and Molecular Medicine, School of Molecular, Genetic and Population Health Sciences, College of Medicine and Veterinary Medicine, University of Edinburgh, and leads the research at the Synthetic Epigenetics Lab, Chromosomes and Gene Expression Section of the IGMM. In 2005 – 2012 Dr. Kagansky worked at the Wellcome Trust Centre for Cell Biology, University of Edinburgh, as a postdoctoral research associate (Robin Allshire lab, until 2010) and then as senior research associate (Bill Earnshaw lab). Research in his lab is aimed at the understanding of the molecular basis of the epigenetic transitions of the mammalian genomes, and at finding ways to control these transitions, which will be crucial for the future of molecular medicine. In his studies he combines genetics, synthetic biology, biochemistry and proteomics. He received his Ph.D. in Molecular Biology in 2004 after spending 3 years in National Institutes of Health in the United States. In 1998 he received his MS in Biophysics from St.Petersburg State Polytechnical University in Russia. Apart from the research in the lab, Dr. Kagansky is regularly organizing public engagement of science activities for different target group: artists, primary school kids, and general public, in different parts of the world, which result in new collaborations between scientists and artists. In 1991 he was a first Russian delegate to the European Youth Parliament. He is also a member of Young Academy of Scotland and Mason Institute for Medicine, Life Sciences and the Law.

Robin Lovell-Badge, Ph.D., is a Senior Group Leader at The Francis Crick Institute. Dr. Lovell-Badge has had long-standing interests in the biology of stem cells, in how genes work in the context of embryo development, and how decisions of cell fate are made. Major themes of his current work include sex determination, development of the nervous system and pituitary, and the biology of stem cells within the early embryo. He is also very active in both public engagement and policy work, notably around stem cells, genetics, human embryo and animal research, and in ways science is regulated and disseminated. He is a co-opted member of the HFEA’s Scientific and Clinical Advances Advisory Committee and a member of their panel looking at the science and safety of ways to avoid mitochondrial diseases. He was a member of the UK Academy of Medical Science’s committees on “Interspecies human embryos”, “Animals Containing Human Material” and a Joint Academies committee on “Human Enhancement and the future of work”. He is also a member of the steering committee of the Hinxton Group, of the Royal Society’s Public Engagement Committee and of the UK Science Media Centre’s Advisory Board. He was elected a member of EMBO in 1993, a fellow of the Academy of Medical Sciences in 1999, and a fellow of The Royal Society in 2001. He has received the Louis Jeantet Prize for Medicine in 1995, the Amory Prize, awarded by the American Academy of Arts and Sciences, in 1996, the Feldberg Foundation Prize in 2008, and the Waddington Medal of the British Society for Developmental Biology in 2010. He is also a distinguished visiting professor at the University of Hong Kong (2009-2015) and the president of the Institute of Animal Technologists. Dr. Lovell-Badge obtained his B.B.Sc. in zoology at the University College London in 1975 and his Ph.D. in embryology at the University College London in 1978.

Peter Mills, Ph.D. is Assistant Director at the Nuffield Council on Bioethics, an independent body that examines and reports on ethical issues in biology and medicine. His work relates to a wide range of issues at the intersection of science, ethics and public policy, and has included major reports on emerging biotechnologies (December 2012) and the linking and re-use of data in biomedical research and health care (February 2015). He is currently working on the ethics of genome editing. From 2007 to 2010 Peter was Head of Human Genetics and Bioethics at the Department of Health, leading a team that provided the secretariat for the Human Genetics Commission, the UK Government's independent advisory body on developments in human genetics and their implications for individuals and society. As well as the HGC secretariat, Peter was also responsible for other bioethics-related work on behalf of the UK government, for example as a UK delegate to the UNESCO Intergovernmental Bioethics Committee (IGBC) and the Council of Europe Steering Group on Bioethics (CDBI). Before moving to the Department of Health, Peter led a number of high-profile policy initiatives at the Human Fertilisation and Embryology Authority, concentrating on ethical, legal, social and personal implications of developments in assisted conception and human embryo research. These included the development of groundbreaking policies on preimplantation genetic diagnosis, sex selection, preimplantation tissue typing ('saviour siblings'), and sperm, egg and embryo donation. Peter returned to the HFEA briefly in 2010-11 to a portmanteau role involving, among other things, oversight of statutory information access regimes and corporate projects, such as Equality Act compliance. Before joining the HFEA, Peter had a brief career in publishing. In the more distant past, he read PPE at Trinity College, Oxford, and received a Ph.D. in philosophy from the University of Warwick.

Indira Nath, MD, is Raja Ramanna Fellow and Emeritus Professor, National Institute of Pathology (ICMR), Safdarjung Hospital Campus, New Delhi, India. She received an MBBS from the All India Institute of Medical Sciences (AIIMS), New Delhi, and later served on the Faculty of AIIMS, making pioneering contributions to immunology research by her seminal work on cellular immune responses in human leprosy and a search for markers for viability of the leprosy bacillus which is not cultivable. She has also mentored many MBiotech, MD, and Ph.D. students and made contributions to education, medical and science policies, and women scientists' issues. She was a member of the Scientific Advisory Committee to Cabinet, Foreign Secretary INSA (1995–1997), council member (1992–1994 and 1998–2006) and vice president (2001–2003) of the Indian Academy of Sciences, Bangalore, and chairperson, Women Scientists Programme, DST (2003). She was conferred numerous awards, notably: Padmashri (1999), Chevalier Ordre National du Merite, France (2003), Silver Banner, Tuscany, Italy (2003), L'Oreal UNESCO Award for Women in Science (Asia Pacific) (2002), SS Bhatnagar Award (1983), and the Basanti Devi Amir Chand Award by ICMR (1994). She was elected fellow of the Indian National Science Academy, Delhi; National Academy of Sciences (India), Allahabad (1988); Indian Academy of Sciences, Bangalore (1990); National Academy of Medical Sciences (India) (1992); Royal College of Pathology (1992); and the Academy of Sciences for the Developing World (TWAS) (1995). She was conferred a DSc (hc) 2002, by Pierre and Marie Curie University, Paris, France.

Pilar N. Ossorio, J.D., Ph.D., is Professor of Law and Bioethics at the University of Wisconsin, Madison (UW), where she is on the faculties of the Law School and the Department of Medical History and Bioethics at the Medical School. In 2011, she became the inaugural Ethics Scholar-in-Residence at the Morgridge Institute for Research, the private, nonprofit research institute that is part of the Wisconsin Institutes of Discovery. She also serves as the co-director of UW's Law and Neuroscience Program, as a faculty member in the UW Masters in Biotechnology Studies program, and as Program Faculty in the Graduate Program in Population Health. Prior to taking her position at UW, she was Director of the Genetics Section of the Institute for Ethics at the American Medical Association, and taught as adjunct

faculty at the University of Chicago Law School. Dr. Ossorio received her Ph.D. in Microbiology and Immunology in 1990 from Stanford University. She went on to complete a post-doctoral fellowship in cell biology at Yale University School of Medicine. Throughout the 1990's, Dr. Ossorio also worked as a consultant for the federal program on the Ethical, Legal, and Social Implications (ELSI) of the Human Genome Project, and in 1994 she took a full time position with the Department of Energy's ELSI program. In 1993 she served on the Ethics Working Group for President Clinton's Health Care Reform Task Force. She received her JD from the University of California at Berkeley School of Law in 1997. While at Berkeley, she was elected to the legal honor society Order of the Coif and received several awards for outstanding legal scholarship.

David Relman, MD, is the Thomas C. and Joan M. Merigan Professor in the Departments of Medicine, and of Microbiology and Immunology at Stanford University, and Chief of Infectious Diseases at the Veterans Affairs Palo Alto Health Care System in Palo Alto, California. He is also Co-Director of the Center for International Security and Cooperation and Senior Fellow at the Freeman Spogli Institute for International Studies at Stanford University. Dr. Relman's research focus is the human indigenous microbiota, and in particular, the nature and mechanisms of variation in patterns of microbial diversity and function, key features of microbial community assembly, and the basis for community stability and resilience. During the past few decades, he has also spearheaded the development of new strategies for identifying previously-unrecognized microbial agents of disease. These efforts have revealed novel pathogens and commensals. Dr. Relman has served as an advisor to a number of agencies and departments within the U.S. Government on matters pertaining to emerging infectious diseases, human-microbe interactions, biotechnology, and biosecurity. He currently serves as Chair of the Forum on Microbial Threats at the Institute of Medicine, and is Immediate Past-President of the Infectious Diseases Society of America. Dr. Relman received an S.B. (Biology) from MIT, M.D. from Harvard Medical School, completed his clinical and research postdoctoral training at Massachusetts General Hospital and at Stanford University, and joined the faculty at Stanford in 1994. He received an NIH Pioneer Award in 2006, an NIH Transformative Research Award in 2011, and was elected a member of the Institute of Medicine in 2011.

Dietram A. Scheufele, Ph.D., is the John E. Ross Professor in Science Communication and Vilas Distinguished Achievement Professor at the University of Wisconsin–Madison and in the Morgridge Institute for Research. He is also an Honorary Professor of Communication at the Technische Universität Dresden, Germany. Dr. Scheufele has co-chaired the U.S. National Academies of Sciences, Engineering, and Medicine's Roundtable on Public Interfaces of the Life Sciences and the National Conference of Lawyers and Scientists, a joint committee of the American Association for the Advancement of Science and the American Bar Association. He is a fellow of the American Association for the Advancement of Science, the International Communication Association, and the Wisconsin Academy of Sciences, Arts, and Letters, and a member of the German National Academy of Science and Engineering. He currently serves on the National Academies of Sciences, Engineering, and Medicine's Division on Earth and Life Studies (DELS) Advisory Committee. In the past, Dr. Scheufele has been a tenured faculty member at Cornell University, a Shorenstein fellow at Harvard University, and a visiting scholar at the Annenberg Public Policy Center of the University of Pennsylvania. His consulting experience includes work for the Public Broadcasting System, the World Health Organization, and the World Bank.

Ernst-Ludwig Winnacker, Ph.D., is Professor-Emeritus at the Ludwig-Maximilians University of Munich. He studied chemistry at the Swiss Federal Institute of Technology (ETH Zurich) where he obtained his Ph.D. in 1968. After postdoctoral work at the University of California in Berkeley and the Karolinska

Institute in Stockholm from 1968 to 1972, he became assistant and then DFG Visiting Professor at the Institute for Genetics, University of Cologne. In 1977 he was appointed associate professor at the Institute of Biochemistry at the Ludwig Maximilians University of Munich, where he was made full professor in 1980. From 1984 to 1997, he was director of the Laboratory of Molecular Biology at the University of Munich Gene Center. He served as president of the German Research Foundation (DFG) from 1998 to 2006. From 2003 to 2004 he also chaired the European Heads of Research Councils (EUROHORCs). He served as first secretary general of the European Research Council (ERC) from 2007 to 2009, and as secretary general of the Human Frontier Science Program from 2009 to 2015. Professor Winnacker is a member of the U.S. National Academy of Medicine, and of the German Academy of Sciences Leopoldina. His main fields of research are virus-cell interaction, the mechanisms of gene expression in higher cells, and prion diseases.

EXPERT STAFF

Robin Fears, Ph.D., D.Sc., is Director of Biosciences Programme at the European Academies Sciences Advisory Council. Dr. Fears trained as a biochemist and has 29 years of experience in the pharmaceutical industry in the UK in R&D. The first 20 years were focused on cardiovascular disease and neurosciences, from discovery through to marketed product. The final 9 years of this industry experience was occupied in setting up and leading a policy group for R&D in Europe. While in industry, he served on committees advising UK and EU trade associations, UK government, Research Councils, university groups and the European Commission and he was Honorary Senior Fellow at the School of Public Policy, University College London. Since leaving the UK pharmaceutical sector, Dr. Fears has worked as advisor to various bodies including academies, universities, businesses and parliamentary groups on issues relating to biomedical science and innovation within the European policy environment. He has provided biosciences support to EASAC since 2002.

Katherine Bowman, Ph.D., is a Senior Program Officer on the Board on Life Sciences (BLS) at the U.S. National Academies of Sciences, Engineering, and Medicine. She manages programs across a range of life sciences topics, with an emphasis on potential biosecurity implications of developments in science and technology and infrastructure needs in the life sciences. Dr. Bowman has served as the Project Director many reports including *Human Genome Editing: Science, Ethics, and Governance*, *Convergence: Facilitating Transdisciplinary Integration of the Life Sciences*. She also has collaborated on several science and technology reviews conducted in partnership with international science organizations to inform the Biological Weapons Convention and the Chemical Weapons Convention review conferences. Prior to BLS, she served as a Program Officer with the Board on International Scientific Organizations, where she directed programs with international scientific unions on biology, chemistry, and radio sciences. Dr. Bowman received her B.A. in Biology from Amherst College and her Ph.D. in Biomedical Engineering from Johns Hopkins University.

Jo Husbands, Ph.D., is a Scholar with the U.S. National National Academies of Sciences, Engineering, and Medicine, where her work focuses on issues related to science, technology, and security. With the Board on Life Sciences, she concentrates on (1) education and outreach in the broader context of responsible science and (2) the implications of continuing advances in the life sciences for efforts to mitigate the risks of misuse. She also represents the Academies on the Biosecurity Working Group of the InterAcademy Partnership (IAP). From 1991-2005 she was Director of the Academies' Committee on International Security and Arms Control and its Working Group on Biological Weapons Control. From

2001-2012 Dr. Husbands was an adjunct professor in the Security Studies Program at Georgetown University. She is a Fellow of the International Union of Pure and Applied Chemistry and an inaugural member of the Advisory Board on Education and Outreach of the Organization for the Prohibition of Chemical Weapons. She holds a Ph.D. in Political Science from the University of Minnesota and a Masters in International Public Policy (International Economics) from the Johns Hopkins University School of Advanced International Studies.

Peter McGrath, Ph.D., is Coordinator at the InterAcademy Partnership (IAP), the global network of academies of science and medicine. Dr. Peter McGrath obtained his BSc (honours) in Agricultural Zoology from the University of Glasgow, UK, and followed this with a PhD from the University of Leeds, UK, in 1989. His 10-year research career focused on the insect transmission of plant viruses and included postdoctoral positions at the Scottish Crop Research Institute (now the James Hutton Institute) as well as Purdue University and the University of Arizona in the United States. Returning to the UK in 1997, he established his own business as a freelance journalist focusing on agricultural, environmental and scientific issues. He moved to The World Academy of Sciences (TWAS) in 2003 where he worked first as a writer/editor and then coordinating the implementation of TWAS core programmes, including South South fellowships and other exchange schemes, research grants and various prizes, as well as the activities of the Organization for Women in Science for the Developing World (OWSD). He has been coordinator at IAP (for IAP for Science and IAP for Health) since 2013, while retaining his duties linked the TWAS science policy/science diplomacy programme.

Keegan Sawyer, Ph.D., is a Senior Program Officer at the US National Academies of Sciences, Engineering, and Medicine's Board on Life Sciences. Her work addresses a wide range of research, policy, and communication questions across the broad spectrum of life science disciplines. She has special interest in the interplay of environmental conditions and human health, ecosystem health, and public engagement in science. Dr. Sawyer is co-lead of the National Academies' Standing Committee on Emerging Science for Environmental Health Decisions. She recently served as the Project Director for the Roundtable on Public Interfaces of the Life Sciences and Project Director of the Committee on Gene Drives Research in Non-Human Organisms: Recommendations for Responsible Conduct. 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.

Audrey Thévenon, Ph.D., is a Program Officer with the Board on Life Sciences at the U.S. National Academies of Sciences, Engineering, and Medicine. Since joining the National Academies, Dr. Thévenon has been involved in activities to support government sponsors programs to counter biological threats, to inform about the potential risks and benefits of gain-of-function research and supported a study on gene drive research in non-human organisms. She is currently leading a Pakistan fellowship initiative around the One-Health concept and the organization of an international conference on Responsible Science. Prior to arriving at the National Academies, Dr. Thévenon worked on malaria vaccine development and placental pharmacology projects at the University of Hawaii and 2 PEPFAR-funded HIV-Malaria projects in collaboration with Nigeria and Kenya at the Uniformed Services University of the Health Sciences. Dr. Thévenon holds a M.S. in Cellular and Molecular Biology with a focus on human reproduction from the Université de Rennes 1 in France, and a M.S. and Ph.D. in Tropical Medicine and Immunology from Georgetown University.