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Foreword

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Foreword. Forty years of conversations in tropospheric chemistry and public health: the legacies of Harvey E. Jeffries and Richard M. Kamens at the University of North Carolina at Chapel Hill

Jeffrey R. Arnold[A] *and Jian Zhen Yu*[B,C]

[A]US Army Corps of Engineers, Institute for Water Resources, and University of Washington, College of the Environment, Joint Institute for the Study of the Atmosphere and Ocean, 3737 Brooklyn Avenue NE, JM Wallace Hall, Seattle, WA 98105-6715, USA. Email: jeffrey.r.arnold@usace.army.mil

[B]*Environmental Chemistry* Editorial Board member.

[C]Hong Kong University of Science & Technology, Department of Chemistry and Division of Environment, Clear Water Bay, Kowloon, Hong Kong, China. Email: jian.yu@ust.hk

This issue of *Environmental Chemistry* is dedicated to two eminent scholar-scientists who continue to make deep and lasting contributions to our understanding of the chemistry and physics of the lower troposphere. Harvey E. Jeffries and Richard M. Kamens have worked for more than 40 years, together and along their separate lines of research, directly and with their long threads of successful graduate students, post docs and visiting scientists, to identify and characterise important questions in oxidant and aerosol chemistry and physics. And, importantly, they worked to make the answers they provided to those questions applicable to actual problems in air pollution and public health policy. This is an uncommon combination.

Harvey and Rich (no one calls them anything else for long) each began his work in graduate school in Chapel Hill at the University of North Carolina's School of Public Health in the late 1960s with Lyman Ripperton ('Rip' to everyone, immediately). Before coming to Chapel Hill, Harvey received a B.Sc. in Chemistry from Florida Presbyterian College (now Eckerd College) in 1964 and Rich received a B.A. in Chemistry from the State University of New York–Buffalo in 1965. Rich spent 2 years as a Peace Corps Volunteer in Thailand and taught junior high school students in Monticello, New York, and Seattle, Washington, before starting his graduate studies in University of North Carolina (UNC). Harvey received his M.Sc. in Public Health in 1967, followed by Ph.D. in atmospheric chemistry in 1971. Rich received his M.Sc. in Public Health in 1971. When they retired in 2011 they retired as full professors of the Department of Environmental Sciences and Engineering – they had both done nearly all of their lives' work in the same department and school where they began. This is also, and increasingly, an uncommon combination.

In the time between 1971 and 2011, Harvey and Rich did exemplary work in oxidant and aerosol chemistry and physics, beginning just as these areas of research became so fertile and influential in other parts of environmental chemistry. The science of urban-area ozone formation, propagation, transport and destruction advanced remarkably in the first years of the 1970s as the United States Environmental Protection Agency (US EPA) was created and new legislation and funding helped support operation of what became its national laboratory in

Professor Harvey E. Jeffries

Professor Richard M. Kamens

Research Triangle Park, NC, only 10 miles (~16 km) from where Harvey and Rich were working at UNC. The chemistry of urban-area ozone in the lower troposphere was poorly understood before the 1970s, although the general human and ecosystem health effects of exposure to ozone and other chemical constituents of smog had been established. The UNC School of Public Health and the nearby US EPA national laboratory for air pollution, together with researchers at the Research Triangle Institute (now officially RTI) became an internationally known leading centre for improving that chemical understanding and for linking it to those health effects.

The key to Harvey and Rich's early and continuing successes in grantsmanship, in chemical insight, in publications, and in new analytical and numerical ideas has been the experimental outdoor smog chamber facility established at UNC in 1972 (H. E. Jeffries and R. M. Kamens, forthcoming paper). Professor Ripperton attracted initial funding from US EPA to build and operate the large (312-m^3) dual-sided outdoor chamber, but soon left UNC for RTI. Harvey, Rich and Don Fox, who had come to UNC for a post-doctoral fellowship on the atmospheric chemistry of nitrogen oxides with Rip, undertook the task to design and build the chamber from scratch. Harvey and Rich quickly increased the analytical and computer capacity of the chamber facility and, over the years of continuous funding from US EPA, NSF, US Department of Energy (DOE) and other sources, added substantial new experimental infrastructure to the original 'smog chamber site' and in their laboratories in the School of Public Health buildings in Chapel Hill.

Very quickly, the work in Harvey and Rich's laboratories using the smog chambers and other experimental tools at UNC came to centre on creating, characterising, testing and explaining the chemical conditions and pathways of the hundreds of complex interactions of nitrogen oxides with various volatile organic compounds to create ozone and other oxidants. In doing this, Harvey and Rich established and nurtured close and very productive relationships with researchers in the US EPA national laboratory in Research Triangle Park, NC. This included work with Paul Altshuller, Bill Lonneman, Joe Bufalini, Bruce Gay, Bob Stevens, Len Stockburger and others in analytical chemistry; and with Basil Dimitriades, Marcia Dodge, Jerry Gipson, Robin Dennis and others on numerical representations of chemical mechanisms and air quality model applications. The support of and collaboration with Dr Marcia Dodge over more than two decades was crucial to the successes of the chamber work. Harvey developed excellent working relationships with key decision makers in the Office of Air Quality Planning and Standards (the policy and regulatory arm of EPA Research Triangle Park), including Edwin Myers, Tommy Helms, David Sanders, Ellen Baldridge and John Seitz; in part this was because he could easily be persuaded to come out to EPA to a meeting or to just talk. Ideas and insights were shared; instruments were developed together and used for methods inter-comparisons; and a professional camaraderie developed that continues between the two institutions to this day.

In the mid-1980s, Rich's work expanded, with the aid of EPA colleagues Joellen Lewtas and Larry Claxton at the Health Effects Research Laboratory, and Ron Bradow at the Mobile Source Emissions Research Branch of EPA Research Triangle Park, to address wood-smoke, gas- and particle-phase toxicity. Harvey's work at approximately the same time moved to include new methods to test and explain the numerical predictions of ozone and other oxidants in the real-world applications for urban areas having some of the most difficult air pollution problems in the US. Harvey's methods included the very earliest instances of 'instrumenting' numerical code so that the model results could be queried to reveal how they processed the reactions, some of which had been analytically described first by Harvey or Rich. In another uncommon combination, the two different types of work Harvey and Rich moved into in the 1980s and 1990s have come together again in the very latest developments from their laboratories: new techniques packaged into instrumentation for understanding how the toxicity of particles created in ambient pollution conditions changes with those conditions and time.

All this work in analytical and environmental chemistry was done in UNC's School of Public Health, and Harvey and Rich have always understood that the special location of their department there has been crucially important to the meaning and importance of their work, funded for the most part by public money. When either Harvey or Rich was in a doctoral candidate's final defence, they asked nearly every student 'the Morris Shiffman question', named in honour of a long-serving professor of Environmental Sciences and Engineering at UNC: 'Yes, but what does your work mean for public health?' This was part of their recognition that all of their work developing, testing, and explaining mechanisms of atmospheric chemistry was done as environmental chemistry for public health.

Harvey and Rich's work in all these areas of atmospheric chemistry and physics can be measured easily in the conventional ways: 27 masters and 30 doctoral students produced; 170 peer-reviewed articles, book chapters and reviews published; creating and leading multiple graduate and undergraduate courses and teaching in very many more with faculty throughout the university and around the world; serving on national and international project and program review committees; and – the key to being able to do all that – keeping two university research groups fully funded and productive for nearly 40 years. Harvey is recognised as one of the best scientific minds by colleagues working in the national effort to abate ozone air pollution in

Jeffrey R. Arnold (Ph.D. UNC DESE, 1997) is Senior Scientist for the US Army Corps of Engineers and co-directs the Corps' climate change programs. Jeff worked closely with Harvey and Rich for more than 10 years at the UNC Ambient Air Research Facility and in the UNC numerical modelling laboratories where his ideas about how to do atmospheric science and apply science for public health benefit were deeply shaped and nurtured in conversations with Harvey and Rich.

Jian Zhen Yu (Ph.D. UNC DESE, 1996) is a Professor in the Department of Chemistry and Division of Environment at the Hong Kong University of Science & Technology. She has been an editor of Environmental Chemistry *since 2010. Jian did her Ph.D. work, under the supervision of Harvey, on product characterisation from atmospheric photooxidation of isoprene and alkylbenzenes in the UNC outdoor smog chamber. She spent 2 years as a postdoctoral fellow in Professor John Seinfeld's group at Caltech after completing her Ph.D. studies. Her current research interests in aerosol chemistry are deeply influenced by Rich's teaching of the gas-particle interaction course and conversations with Harvey and Rich throughout her UNC years and beyond.*

the US. He was a member (1995–97) of the US EPA's Subcommittee for the Implementation of New Standards for Ozone, PM and Regional Haze. For his outstanding contributions in this Subcommittee, he was given the Exceptional Leadership Award by the US EPA as Chair of the Science and Technical Workgroup. Harvey is also a founding member (1998–2004) of the Reactivity Research Working Group, an industry–government–academic group that was devoted to advancing the science of photochemical reactivity and its role in ozone reduction. He has been a major contributor to the science-related discussions in meetings of this working group. At the state level, Harvey has been advising the States of North Carolina, Texas and California in developing effective air quality improvement policies. Harvey has also advised and sometimes defended stakeholder groups of regulated parties when the issues are very complex yet simplistic, often costly and likely wrong regulations were being proposed. He invested approximately half of his professional activities between 2000 and 2012 working on effective control polices for ozone in Houston, Texas, with mixed funding sources.

Each of the conventional measures of their work can be profitably unpacked to show in detail how Harvey and Rich have been able to have that much success for this long. Unpacking those details and showing their connections would doubtless be instructive for any new assistant professors of environmental chemistry. Here, we will use one measure, their work with their graduate students, to describe Harvey and Rich's uncommon combination of talents for setting and solving academic (in the most generous sense of the word) problems and then seeing those solutions through to real-world air pollution applications.

One of the first uncommon combinations in being trained by Harvey and Rich is their active encouragement for all students to work at least partly as both experimentalists and modellers, because both their laboratories pursued physical and numerical problems. Most students naturally choose one path or the other to suit their interests and abilities; few people are equally adept at packing their own chromatograph columns and finding that last bug in witheringly long strings of C++ code. But Harvey and Rich are convinced that understanding what it takes to 'get a number' from a complex atmospheric or atmospheric and biological exposure chamber experiment is as great an advantage to a modeller as learning how molecules and molecule-fragments are represented and combined numerically is to an experimentalist. This close interplay of numerical and physical experimenting is so widespread now as to be taken mostly for granted; numerical modelling of chemical and physical mechanisms has become a shared foundation among experimentalists in most areas of environmental chemistry and especially so in atmospheric chemistry. But when Harvey and Rich began doing it, it was new and somewhat risky.

Harvey and Rich teach a great deal of numerical and experimental tropospheric science and engineering – their take-home exams are legendary – but their uncommon combination with that teaching has been coaching students in decision-making. They teach techniques and theory, yes; but they coach students to innovate and to develop and apply judgment that goes beyond their teaching. Coaching is not telling students what to do but rather suggesting the things that are possible to start with and laying out a map of decisions to be made by the students themselves. In this way, Harvey and Rich get their students to start seeing interesting questions for themselves, charting paths to possible answers, and learning how decisions about problems along those paths help or hinder the work. Their coaching creates a professional self-awareness – learning how you do something and thinking about that while you are doing it – that is crucial to successful careers in science, but which is rarely incubated as well as they have done it in their groups. They did this, too, in an uncommon way because Harvey and Rich are both very self-aware but hardly ever self-conscious. That means students can approach and engage with them in a conversation about the science and the broader applications of the work for public health policy.

Their goal with this coaching, if you asked them – and one of the authors did ask in trying to figure out how they did what they did – was to get us even as students to think for ourselves and to trust that we could do that effectively. Harvey once told us before one candidate's oral exam that his objective for the final dissertation defence was to see whether the candidate could talk to the faculty members as they talk to themselves. This explained a great deal, and we still use it as the objective when on dissertation committees.

In a very practical and essential way, for Harvey and Rich, science – in the laboratory, in the literature, in the classroom – is a conversation, and their long productive lives in science are the products of the continuing conversations they create with each student. They are real conversations, too, with reciprocating contributions from each party, and with the edits, revisions, deletions and restatements that characterise all conversations. Everyone who wrote anything for Harvey or Rich never wrote it one time; we have all had the helpful if sometimes bracing experience of writing the same exam question, dissertations chapter, article section or project report summary for them more than once (or twice). And everyone who wrote anything for them has had at least one thing each time made sharper or stronger or funnier – in short, better – by something Harvey or Rich has said in that conversation. Conversations like these sessions of editing and revisions take enormous amounts of time, and Harvey and Rich gave their time generously to these conversations because they saw that doing so helped their students and helped them.

Harvey and Rich's constant enthusiasm for problems in tropospheric chemistry, and for finding the paths to answers to those problems, and for applying those answers to real-world public health policy issues, left a deep and continuing effect on their best students' thinking and careers. And, in turn, the innovation and creativity of their best students partly reshaped the thinking and work that Harvey and Rich themselves did. That reciprocity of creativity and encouragement is, of course, how graduate professional training is supposed to work. But Harvey and Rich have a genuine openness of mind and a willingness to learn while teaching that marks them both as exceptional mentors to scientists who continue the search for problems, solutions and applications. No one is ever happier to be shown they are wrong with the better measurements or sharper insights from their students than Harvey and Rich are because it gives them new things to think about. And their thinking about new things continues, in their many uncommon combinations, in their very many conversations in science. For his continuous demonstrated excellence in teaching, research and service to the broader public health community, Harvey received the Bernard G. Greenberg Alumni Endowment Award in 2003, an award given annually by the UNC School of Public Health to an outstanding full-time faculty member.

A nice selection of some of those conversations appears in the 11 articles in this special issue, which are the result of contributions from scientists who have worked with Harvey and Rich, have had their own work deeply influenced by them, have been trained by them or have now followed them at UNC. Taken together, this array of specially contributed papers from some of the world's leading scientists in atmospheric oxidant chemistry report results from across a wide span of work that neatly traverses much of the diversity in the conversations in the more than 40 years of work by Harvey and Rich.

So, for instance, some of the results reported here are from experiments with reactants and products in smog chambers and other reaction chambers: Aschmann et al.,[1] Beardsley et al.[2] and Zhou et al.,[3] for example, are three cases where three different types of reactants are exposed in three different types of chambers for elucidating in fine detail several differently important gas- or particle-phase reaction pathways. Other results reported here are from experiments designed to evaluate one or more chemical mechanism representations of multiple pathways using either field data, as in Derwent and Murrells,[4] or using smog chamber or laboratory data for aerosol and gas-phase interactions as with Parikh et al.,[5] Kirkland et al.,[6] Jaoui et al.[7] and Zhang et al.[8] Donahue et al.[9] have written an interesting summary of one cohesive interpretation of aerosol formation in the changing mix of interim and final gas- and particle-phase products which can be a basis for other rich interpretations of chemical formation. Couzo et al.[10] provide a geospatial analysis of high ozone formation in a very specific urban setting, Houston, TX, and report the consequence of understanding real-world applications with the combination of numerical model results, field studies and chamber and bench-level analytical experiments. And Faxon and Allen[11] describe the importance of including chlorine chemistry with the more frequently used and studied oxidants like OH.

These papers are a very fine tribute to the scholarly products, the teaching of students and the dedication to environmental chemistry in the service of public health that have uncommonly combined in the long careers and lasting legacies of Harvey Jeffries and Rich Kamens.

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