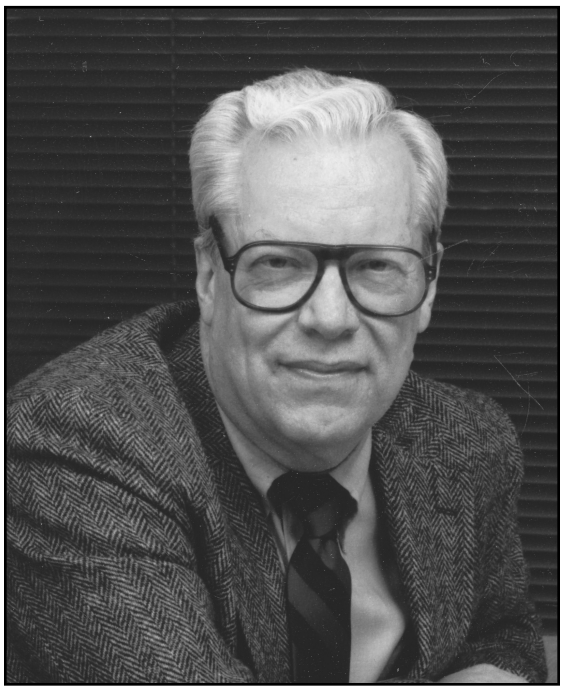
PAUL MEAD DOTY



1 JUNE 1920 · 5 DECEMBER 2011

BORN IN 1920, Paul Mead Doty grew up in the small town of Chicora, Pennsylvania, with no connections to the world of science and science policy.[1] This was a world that he would later come to dominate, based solely on his character, intelligence, and self-effacing charm. Paul was unique because he was a true pioneer in two very different areas: academic science and the application of science to central issues of public policy. In both cases, his highly original contributions produced a rich legacy of ideas, trained scientists, and new institutions that continue to have a highly beneficial impact around the globe.

The number of prominent scientists who trained in Paul's laboratory is astounding. After conducting World War II-related research and receiving a Ph.D. from Columbia University, Paul began his independent research career as a physical chemist at the Polytechnic Institute of Brooklyn, studying solutions of synthetic polymers and making many practical and theoretical contributions to the then-new technique of light scattering.[2, 3] Inspired by Max Perutz during a year spent at Cambridge University as a Rockefeller research fellow (1946–7), he began to focus on biological macromolecules, bringing unique skills and insights to the new field of molecular biology.[4, 5, 6, 7] Paul was recruited to Harvard as an Associate Professor at age 30, remaining there until his death at 91. In total, he supervised the research of 66 undergraduate and graduate students, of whom 44 became professors. In addition, 36 of 85 post-doctoral fellows became faculty in academia. Thus, Paul produced 80 professors, doing enormously more than his part to populate the next generation of science faculty. Many of these individuals became leaders in their fields, and at least 11 would be elected to membership in the National Academy of Sciences.

The productivity of the Doty laboratory at Harvard reached its height in the decade following the early 1950s, benefitting from a major influx of outstanding graduate students and post-doctoral fellows, many of the latter from abroad. There were a large number of contributions to the fundamental structural understanding of the three main macromolecules of life—DNA, RNA, and proteins—including detailed studies of how the two strands of the DNA double helix, the molecular basis for our genes, separate when the molecule is heated, or *denatured*.[8, 9] However, one set of discoveries stands out from all of the rest, being equivalent to the breakthroughs that earn a Nobel Prize. This was the then-shocking discovery of the process of DNA *renaturation*. In a now-classic 1960 paper with Marmur, Eigner, and Schildkraut (a post-doctoral fellow and two graduate students, respectively), Doty reported conditions that allow the separated

strands of the DNA double helix to rapidly re-find each other through highly specific base-pair matching.[10] This observation of specific DNA:DNA pairing was quickly extended to RNA:RNA and DNA:RNA pairing as well.[11, 12, 13] Known as *nucleic acid hybridization*, this process has formed the basis for DNA cloning and the biotechnology revolution, as well as for other tools that have increased our current understanding of the complex biochemical mechanisms that make life possible.

As if this were not enough, Paul had an equally important influence in the world of policy.[14] Beginning with his attendance at the first Pugwash Conferences on Science and World Affairs in Nova Scotia in 1957, he became a central figure in the successful efforts of a small team of Soviet and U.S. scientists to diffuse Cold War tensions between the two superpowers, aimed at preventing a nuclear war. This led to the formation of the so-called "Doty group," as well as to dozens of trips to Russia.[15] It also led to Paul's service on the President's Science Advisory Committee (1961–4), the Arms Control Advisory Committee to the President (1977–81), and the National Academy of Sciences' Committee on International Security and Arms Control (1981–99).

In 1973, Paul founded the Harvard Center for Science and International Affairs and served as its first director. This center, and the journal *International Security* that he likewise began, started a critical new effort to engage outstanding scientists in analytical studies of international security and arms control. Now known as the Belfer Center and much copied by degree programs established at other universities, the Center remains the world's leading academic institute for research and training on the intersections between science and international affairs. Among its more than 500 alumni (and thus Paul's disciples) are many current leaders, including President Obama's Science Advisor (John Holdren), his Deputy Secretary and then Secretary of Defense (Ashton Carter), and his Science Advisor to the Secretary of State (E. William Colglazier).

Some comments on Paul's personality are relevant here. His leadership training began in high school, when his poorly prepared teacher recruited him to take over teaching the chemistry class—even though Paul was one of its students. As an undergraduate in the Chemistry Department at Penn State, he became the president of the Student Council. He had enormous charm, constantly finding humor in life's many foibles, including laughing at himself quite often. Perhaps it was this characteristic that endeared him to the many leading Soviet scientists who became his friends. Paul was also extremely wise, being skilled in finding a productive path forward despite many obstacles. As just one example, he was fond of recounting his machinations that got

the young Jim Watson (later a Nobel laureate) a position at Harvard, overcoming a great deal of faculty resistance. Later, he and Jim became close friends, and together, they managed to get molecular biology off to a great start at Harvard. But most of all, Paul was incessantly trying to make a better world through science, with zero sense of ego or ulterior motive. This selflessness was one of Paul's most endearing qualities, and it was widely recognized.

I am one of many examples of Paul's influence. I began research in his laboratory in 1958, when I was a Harvard College undergraduate working with my tutor, Jacques Fresco (one of Paul's post-doctoral fellows).[16] In the end, I would remain with Paul for 7 years, earning my Ph.D. degree with him in 1965. He played a major role in teaching me how to write, through his extensive and skillful edits on the very inadequate first draft that I submitted to him as a Ph.D. thesis.[17] Along the way, I became permanently stamped by Paul's strong desire to fix things. And like him, I soon became overcommitted with way too many problems to solve. This streak of volunteerism eventually took me out of the laboratory and into full-time science policy; in 1993, I became the president of the National Academy of Sciences, where I would serve for 12 years. Then, in 2009, I was suddenly drafted as one of President Obama's first three Science Envoys—assigned in this position to Indonesia and Pakistan. The Science Envoy position continues, with a total of 13 scientists now having served in such a position. John Holdren, Obama's science advisor since 2008, was one of Paul's students at the Belfer Center. Thus, I strongly suspect that the idea of establishing science envoys was inspired by Paul—who had played such a huge role as a "science envoy" to the Soviet Union at the height of Cold War tensions.

Paul Mead Doty was a completely honest, idealistic American from a small town in Pennsylvania—and he has left us a giant legacy. Others have reviewed these accomplishments in more detail than is possible in this brief space.[18, 19, 20] But I can think of no better way to end this brief memoir to him than by quoting from John Holdren's tribute in 2000, delivered at Paul's 80th birthday celebration:

> Here is a man who has had a lifetime of accomplishment as a scientist-statesman, educator, policy-advisor, and institution builder at the intersection of science and international affairs—a career so full that it is hard to imagine how he found the time to do any science per se. You in this audience have already offered your judgments about his science. His monuments, from the other part of his career that it was my responsibility to cover tonight, include in my judgment: 1) the creation of the leading academic center of

> research and training on science and international affairs in the world; 2) the success of Cold War channels of communication between U.S. and Soviet scientists that almost certainly were more important in averting catastrophe than any but a few will ever fully appreciate; and 3) in substantial measure, the ABM [Anti-Ballistic Missile] Treaty itself, without which I really do think we would probably all by now be dead.

Elected 1970

BRUCE ALBERTS
Chancellor's Leadership Chair in Biochemistry
and Biophysics for Science and Education
University of California, San Francisco

ENDNOTES

1. Chemical Heritage Foundation Oral History. *Paul M. Doty: Transcript of an Interview Conducted by Raymond C. Ferguson at Harvard University on 17 November 1986*; 54 pages. Accessed from http://www.chemheritage.org/discover/collections/oral-histories/details/doty-paul-m.aspx

2. Doty, P. M., B. H. Zimm, and H. Mark. "An Investigation of the Determination of Molecular Weights of High Polymers by Light Scattering." *J. Chem. Phys.* 13 (1945): 159–66.

3. Oster, G., P. M. Doty, and B. H. Zimm. "Light Scattering Studies of Tobacco Mosaic Virus." *J. Am. Chem. Soc.* 69 (1947): 1193–97.

4. Doty, P. M., and B. H. Bunce. "The Molecular Weight and Shape of Desoxypentose Nucleic Acid." *J. Am. Chem. Soc.* 74 (1952): 5029–34.

5. Doty, P., A. Holtzer, J. H. Bradbury, and E. Blout. "Polypeptides. II. The Configuration of Polymers of gamma-benzyl-L-glutamate in Solution." *J. Am Chem. Soc.* 76 (1954): 4493–94.

6. Boedtker, H., and P. M. Doty. "The Native and Denatured States of Soluble Collagen." *J. Am. Chem. Soc.* 78 (1956): 4267–80.

7. Doty, P. M. "The Properties of Biological Macromolecules in Solution." *Proc. Natl. Acad. Sci.* 42 (1956): 791–800.

8. Rice, S. A., and P. Doty. "The Thermal Denaturation of Deoxypentose Nucleic Acid." *J. Am. Chem. Soc.* 79 (1957): 3937–46.

9. Marmur, J., and P. Doty. "Heterogeneity in Deoxyribonucleic Acids. I. Dependence on Composition of the Configurational Stability." *Nature* 183 (1959): 1427–29.

10. Doty, P., J. Marmur, J. Eigner, and C. L. Schildkraut. "Strand Separation and Specific Recombination in Deoxyribonucleic Acid: Physical Chemical Studies." *Proc. Nat. Acad. Sci.* 46 (1960): 461–76.

11. Hall, B. D., and S. Spiegelman. "Sequence Complementarity of T2 DNA and T2-specific RNA." *Proc. Natl. Acad. Sci.* 47 (1961): 137–46.

12. Doty, P., C. L. Schildkraut, and J. Marmur. "The Formation of Hybrid DNA Molecules and Their Use in Studies of DNA Homologies." *J. Mol. Biol.* 3 (1961): 595–617.

13. Eigner, J., and P. Doty. "The Native, Denatured and Renatured States of Deoxyribonucleic Acids." *J. Mol. Biol.* 12 (1965): 549–80.

14. Doty, P. "The Community of Science and the Search for Peace." *Science* 173 (1971): 998–1002.

15. Evangelista, M. *Unarmed Forces: The Transnational Movement to End the Cold War*. Ithaca: Cornell University Press, 1999.

16. Fresco, J. R., B. M. Alberts, and P. Doty. "Some Molecular Details of the Secondary Structure of Ribonucleic Acid." *Nature* 188 (1960): 98–101.

17. Alberts, B. M., and P. Doty. "Characterization of a Naturally Occurring, Cross-Linked Fraction of DNA. I. Nature of the Cross-Linkage." *J. Mol. Biol.* 32 (1968): 379–403.

18. Gratzer, W. B. "Paul Mead Doty (1920–2011)." *Current Biology* 22 (2012): R39–41.

19. Meselson, M. "Paul Mead Doty (1920–2011)." *Science* 335 (2012): 181.

20. Garwin, R. L., and E. P. Geiduschek. "Paul Mead Doty, 1920–2011." *Biographical Memoirs of the National Academy of Sciences* 2013. Accessed from http://www.nasonline.org/member-directory/deceased-members/56236.html