History of Physics
NEWSLETTER
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Mary Jo Nye Awarded 2017 Pais Prize

by Richard Staley
University of Cambridge

Mary Jo Nye

The 2017 Abraham Pais Prize for the History of Physics has been awarded to Mary Jo Nye, who will receive the award in the APS March meeting in New Orleans.

Since the early 1970s, Nye has produced pathbreaking and enduring studies of the physical sciences that are distinguished equally by their attention to the coherence and integrity of the approaches taken by individual scientists, to the evolving boundaries between physics, chemistry and physical chemistry, and to the roles that critical conceptual issues such as atomism and quantum theory have played in reshaping the landscape of knowledge. Most characteristic is that in her treatment of each of these issues, she has shown how scientists' understandings of their disciplines – and the nature of knowledge itself – have been shaped to serve the social environments within which they have worked, thereby illuminating the life of science as one of public service.

In 1972, Nye's first book, *Molecular Reality*, paired a study of Jean Perrin with a treatment of the rise of atomism, exposing the multifaceted work required to offer convincing proofs of a disputed doctrine and exploring how this transformed philosophical commitments. In a series of books and edited volumes published in the 1980s and 90s, her work pioneered in addressing the communal structures and disciplinary lineaments of the physical sciences since 1800, in particular by drawing early attention to the role of the provinces in the development of science in France and by highlighting the creative interdependence of physics and chemistry. In 2003, she edited the authoritative *Cambridge History of Science, Volume 5: Modern Physical and Mathematical Sciences*.

In 2004 and 2011, Nye returned to biography with masterful accounts of the lives of P.M.S. Blackett and Michael Polanyi. Offering nuanced treatments of the diverse ways that these European scientists' work and engagement with politics yielded pragmatic philosophies and sharp epistemological beliefs, across the political spectrum, Nye showed how their views in turn provoked controversy, echoed in the corridors of power, and have offered resources for the social analysis of science.

Mary Jo Nye's intellectual life has been one of service, especially to the University of Oklahoma-Norman and Oregon State University, and to the history of science discipline in the US and internationally. She has had the courage and conviction to address problems (such as big science) well before a sufficient set of other scholars were interested enough in them to turn their collected work into a field

Continues on page 2

In This Issue

Continued from page 1

within the history of physics. She has, again and again, incorporated methodologies (like biographical analysis) which at the time she began using them were mostly considered non-traditional in history of physics. She has never hesitated to draw on concepts in use outside the set taught to young history of physics scholars (such as deconstruction). All these she drew on and applied courageously, with full knowledge of the disciplinary prejudices she would have to confront. And over many decades she unselfishly influenced and nurtured the work and careers of a huge number of younger scholars. She may be the historian of physics working today who best encapsulates the diversity and scope of the science of physics itself.

Nye is a past president of the History of Science Society, Fellow of the American Academy of the Arts and Sciences, and of the American Association for the Advancement of Science, and a Member of the International Academy of the History of Science. Amongst her many honors are the Sarton Medal for lifetime achievement in History of Science and the Dexter Award for Outstanding Achievement in the History of Chemistry. Mary Jo Nye is married to historian Robert A. Nye, and their daughter is Lesley Nye of Pasadena, California. ■

History of Physics NEWSLETTER

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The articles in this issue represent the views of their authors and are not necessarily those of the Forum or APS.

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A Compendium of Striking Manhattan Project Quotes

by B. Cameron Reed
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Left: James Chadwick (1891-1974), discoverer of the neutron. Right: Leo Szilard (1898-1964), who conceived of the idea of a chain reaction. [Wikimedia Commons]

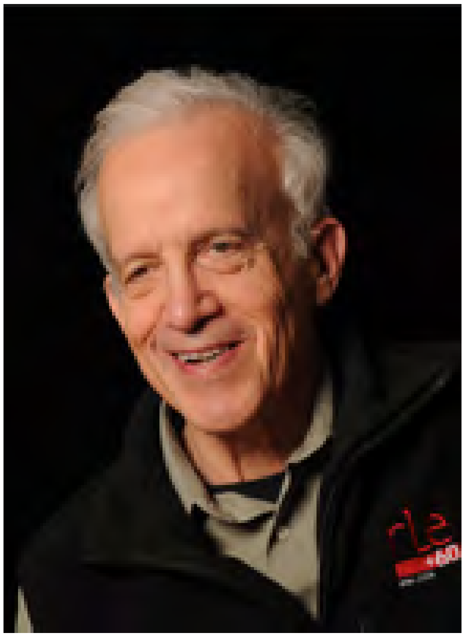
Introduction

For several years now I have been researching the physics and history of the Manhattan Project, the United States Army's World War II effort to develop and deploy the first generation of nuclear weapons. In reviewing literally thousands of documents on the Project, I began to come across so many striking remarks concerning the work and its effects that I began keeping a record of the more notable ones. These quotes cover topics ranging from the physics underlying nuclear weapons to the current world nuclear situation. I find it helpful to use some of them in a class I teach on the history of the Manhattan Project; they help students appreciate that scientists, generals, and public figures are also human beings who reflect on the consequences of their work and actions. In this article I reproduce excerpts from some of the more memorable of these quotes, arranged under a series of topic headings which proceed in roughly chronological order from some of the early discoveries of nuclear physics to the present-day situation: Neutrons,

Continues on page 8

Dan Kleppner Awarded 2017 APS Medal

by Michael Riordan



APS Medal Winner Daniel Kleppner

On September 21, the American Physical Society announced that Daniel Kleppner of MIT will be awarded the 2017 APS Medal for Exceptional Achievement in Research for his "seminal research setting the direction for modern atomic, molecular, and optical physics." He follows in the footsteps of Edward Witten of Princeton, who won the inaugural medal this year for his seminal contributions to quantum field theory.

A graduate student of Norman Ramsey at Harvard, with whom Kleppner worked on the invention of the hydrogen maser, Kleppner's wide-ranging research interests include precision measurements, fundamental constants, Rydberg atoms, cavity quantum electrodynamics, and quantum chaos. With Thomas Greytak and others, he helped pioneer the field of Bose-Einstein condensation, achieving this phenomenon in hydrogen in 1998. "The impact of his lifelong work is so broad and so deep that it's difficult to even summarize the scope of his continuing influence on modern science," said APS President-Elect Laura Greene, chair of the APS Medal nominating committee.

Kleppner served as Chair of the Forum on History of Physics from 2010 to 2011 and currently represents the Forum on the APS Council. He also organized and led the successful effort to establish the Physics Heritage Fund.

Kleppner is a member of the National Academy of Sciences and was awarded the National Medal of Science (2006), the Wolf Prize in Physics (2005), the APS Lillienfeld Prize (1990) and Davisson-Germer Prize (1985), and many others. ■

April 2016 Meeting Session Reports:
"The New Big Science and the Transformation of Research"

by B. Catherine Westfall
Michigan State University

Thomas Kaiserfeld

The session began with a talk by Catherine Westfall that described a new era in the development of large-scale research as evident in the U.S. national laboratories: the New Big Science. She explained that the change from the Old Big Science to the new began the 1980s when post-WWII emphasis and enthusiasm for basic research waned and interest in industrial participation grew along with the development of stand-alone large-scale materials science accelerators. By the end of the decade the development of the New Big Science was accelerated by efforts to bolster support for the huge (and doomed) high-energy physics accelerator, the Superconducting Supercollider. Early efforts by DOE Director of Energy Research, Alvin Trivelpiece, to reduce intra-laboratory squabbling to help secure the SSC led to a plan that included large projects – including large materials science accelerators – for existing laboratories. When the SSC was cancelled, plans for these accelerators proceeded so that the largest projects in the U.S. national laboratories, by default, were for materials science. The New Big Science that emerged is characterized by greater government accountability that favors practicality and thus greater industrial participation. These traits in turn lead to a highly diverse and sizable user community advantageous to funding prospects, smaller facilities and experiments than the Old Big Science, and a greater propensity for international and multidisciplinary collaboration, especially involving biomedical research.

Crease's talk built upon Westfall's

Continues on page 6

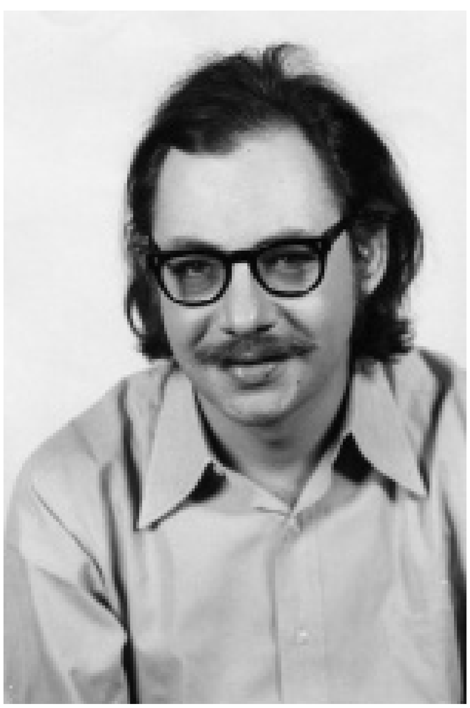
Session Report:
"Sidney Coleman Remembered: Correspondence and Commentary"

by Alan Chodos
American Physical Society

From the early 1960s into the 21st century, Sidney Coleman was an iconic figure in the Cambridge, Massachusetts community of theoretical physics, both at Harvard, where he taught, and at the numerous surrounding institutions of higher learning. Among an evolving galaxy of stars and superstars, Coleman stood out for his precise and piercing intellect, for his wit, and for the idiosyncrasies that gave rise to a seemingly endless supply of stories and anecdotes.

In 2003 Coleman took medical leave from Harvard, and he died, at age 70, in 2006 after a long battle with diabetes and Parkinson's disease. Now his widow, Diana, and historians Aaron Wright at Harvard and David Kaiser at MIT, are engaged in collecting and editing Coleman's correspondence, much of which is preserved in carbon copy; they are also seeking copies of letters, and other memorabilia, that may be in the hands of his friends and correspondents.

Stimulated by this activity, the Forum organized a session at the April Meeting devoted to remembering Coleman. The first speaker was Wright. He was followed by Erick Weinberg of Columbia, who was Coleman's graduate student in the early 1970s, and by Howard Georgi, a longtime faculty colleague of Coleman's at Harvard.



Sidney Coleman

Wright began by reading a message from Diana Coleman, who had been invited but was unfortunately unable to attend. In her message, she said that re-reading letters to and from Coleman impressed on her that "Sidney had the courage to be an original. He did boldly provocative things, epitomized by the purple suit he wore around campus, and his notorious quips, which some students printed on a tee shirt. Of course, a few students were shocked and offended by him, especially the student who complained that Sidney used a four-letter word during a lecture. He 'didn't expect that from a Harvard professor!'

"There are many priceless examples of Sidney's humor in the letters, and of the rebellion that often underlay them – but probably the most revealing is the long correspondence between Sidney and Nino Zichichi, as they fought over Sidney's Erice lectures."

Wright explained that from the late 1960s to the early 1980s, Coleman was a regular participant in the Erice Summer School that took place annually in Sicily; Zichichi was its founder and chief organizer. Coleman's lectures at the school were valued so highly that preprint copies of them, increasingly blurry from having been Xeroxed many times, were passed from generation to generation of graduate students. In 1985 most of them were collected in a classic volume, "Aspects of Symmetry", published by Cambridge University Press.

The correspondence that Wright shared with the audience consisted of a back and forth between Zichichi, also a colorful character, and Coleman, in which the former sought to induce the latter in 1969 to lecture on some recent work by Gabriele Veneziano, which to Coleman was unacceptable. Zichichi attempted flattery, praising Coleman for being able to lecture on anything, but Coleman refused to yield to his blandishments, at one point sending Zichichi a letter whose sole content was the sentence "I will not lecture on Veneziano" repeated a dozen times. Zichichi got the message, and Coleman ended up lecturing instead on "Acausality", the lecture notes for which begin with the instruction to read them last week. (Unfortunately, "Acausality" is one of only two sets of Erice lectures not included in "Aspects of Symmetry.")

Weinberg showed the audience some rare examples of problem sets and final exams that he still had from courses taken with Coleman in the late '60s and early '70s. Coleman often taught the same courses over a number of years, during which time he not only refined the contents but also polished the "spontaneous" jokes that went with them; when delivered, the jokes were punctuated with bouts of laughter from Coleman, because no one thought the jokes funnier than he did.

The problem sets and exams were likewise peppered with apt quotations from the likes of Paracelsus and the Grand Grimoire. In the final lecture for a course in General Relativity, Coleman offered the students the following advice: "You may have enjoyed this course and decided that you want to do your thesis research on General Relativity. DON'T. Einstein spent the last 30 years of his life working on General Relativity and it led to nothing. And he was smarter than you." This illustrates Coleman's rapport with his students, and his style of communication, but it also provides a quaint snapshot of the state of relativity research at the time (1970). Subsequent developments have ensured that no one would give such unequivocal advice today.

Weinberg reminded the audience of Coleman's notable achievements in research in the '60s and '70s, beginning

Continues on page 7

Session Report:
"Pais Prize Session: Some History You Won't Find in Physics Textbooks"

by Allan Franklin
University of Colorado

Pais Prizewinner Allan Franklin (center) with George Smith (right) and Jed Buchwald (left).

At this year's April APS meeting in Salt Lake City, the forum sponsored a session on "Some History You Won't Find in Physics Textbooks." The first speaker was Allan Franklin of the University of Colorado, winner of the 2016 Abraham Pais Prize for History of Physics. Franklin's topic was "Physics Textbooks Don't Always Tell the Truth." He noted that there was often a difference between the actual history of physics and that presented in physics textbooks. He remarked that this was not necessarily a bad thing. An inaccurate history may well serve a pedagogic purpose. It may help students to better understand certain concepts. Nevertheless, he stated that physics teachers should be aware of the actual history and that students should learn that the history of physics is not the unbroken string of successes that it appears to be in textbooks.

Franklin discussed two experiments: 1) Robert Millikan's measurement of Planck's constant using the photoelectric effect and 2) the measurement of the average energy of electrons emitted in the beta decay of Radium E (210Bi) by Charles Ellis and William Wooster. Virtually all physics textbooks tell us that Millikan's experiment confirmed and established Einstein's photon theory of light. As discussed later, the Ellis and Wooster experiment was quite important, but it is not often mentioned in physics textbooks. Franklin noted that Millikan, himself, did not believe in the photon theory either before or after his experiment because it conflicted with the well-established facts of interference. Millikan called the idea of a photon "a bold not to say reckless hypothesis." The photon theory predicts that the maximum kinetic energy of the electron emitted in the photoelectric effect is given by KEmax = eVstop = hν – W0, where ν is the frequency of the incoming light and W0 is the work function of the metal. Millikan plotted Vstop against the frequency and obtained a straight line, from which, knowing e, the charge of the electron, he could determine h, Planck's constant. Millikan believed that his result confirmed on Einstein's equation and not the underlying photon theory. Millikan, along with the physics community did not accept the photon theory until the 1930s.

Franklin also discussed the Ellis-Wooster experiment. In the early 20th century most physicists believed that beta decay was a two-body process. Thus the observation of a spectrum of electron energies by Becquerel, by Kaufmann, and by Chadwick posed a problem because the conservation of energy and momentum required a unique energy for the electron. Physicists believed that the emitted electrons were monoenergetic, but lost energy by various processes in leaving the radioactive source. Ellis and Wooster proposed to solve the problem by measuring the average energy of the electrons using a total-absorption calorimeter. If that energy was the maximum decay energy 1 MeV, then the emitted electrons were monoenergetic and that the spread in energy was caused by energy loss in leaving the source. If the average energy was that of the observed spectrum, about 350 keV, then the observed spectrum was the spectrum of the emitted electrons. Ellis and Wooster found that the average energy was approximately 350 keV, establishing the continuous spectrum A few years later Pauli solved the problem by proposing that a third particle with no charge, very small mass, and spin 1/2 was also emitted in beta decay. This particle, later named by Fermi as the neutrino, was soon incorporated in Fermi's successful theory of beta decay. Although the Ellis-Wooster is a very important contribution to physics, it is often neglected by textbooks writers.

George Smith, of Tufts University, discussed "Newton's *Principia*, Myth and Reality." He argued against the received view that Newton developed his law of gravity in order to explain Kepler's laws of planetary motion and that his success in doing so was, for Newton, the principal evidence for his theory. Smith noted that there were, at the time, five other calculations of planetary orbits in addition to that of Kepler;

Continues on page 7

FHP Invited and Contributed Sessions at the 2017 January-April ("Japril") and March Meetings

January 28-31, 2017 Meeting, Washington, D.C.

Saturday, January 28, 10:45 am
Session B10, Roosevelt 2
Transitions in Physics and Related Fields from the Late 19th Century to Today

Sunday, January 29, 1:30 pm
Session K16, Washington 3
Manhattan Project Scientific Legacy (cosponsored by DNP and FPS)

Sunday, January 29, 3:30 pm
Session M7, Delaware A
The Social Legacy of the Manhattan Project
(cosponsored by DNP and FPS)

Monday, January 30, 10:45 am
Session R7, Delaware A
The Manhattan Project: History and Heritage
(cosponsored by DNP and FPS)

Monday, January 30, 1:30 pm
Joint FOEP/FHP contributed session: Physics Outreach and Physics History

Monday, January 30, 3:30 pm
Session U8, Delaware B
History of the Search for Gravitational Waves

March 13-17, 2017 Meeting, New Orleans, LA

Monday, March 13, 8:00 am
The Author in Dialogue: *The Physicist and the Philosopher: Einstein, Bergson, and the Debate that Changed Our Understanding of Time*

Monday, March 13, 2:30 pm
Pais Prize Session

Tuesday, March 14, 8:00 am
60 Years Since BCS and 30 Years Since Woodstock ■

Sunday, January 29, 8:00 pm
APS Meeting Hotel
Play title: Reykjavik
Playwright: Richard Rhodes
Staged Reading:
www.tonictheater.org

A talk-back will be presented after the play reading.

Richard Rhodes, the Pulitzer Prize-winning author of 24 books, has written his first play, and it spins off of his research into the history of nuclear weapons. Mr. Rhodes's Reykjavik is about the historic 1986 meeting between Ronald Reagan and Mikhail Gorbachev in that city.

Reykjavik is a dramatic reconstruction of the two-day summit during which the world leaders almost reached agreement on the total abolition of their countries' nuclear weapons. The play uses the actual transcripts of the Reykjavik meeting as well as the memoirs of both Reagan and Mr. Gorbachev.

Session Report: "The New Big Science and the Transformation of Research"

Continued from page 3

by examining the research ecology of the New Big Science at the NSLS II's precursor, the NSLS. The NSLS, Crease said, can serve as kind of an ecologist's quadrat or square, a tool used to isolate a representative region in which to analyze an ecosystem. Crease then went on to consider the features of the New Big Science as they were present in research at the NSLS. He also discussed the challenges that the New Big Science poses not only for scientists but also for managers and funders. These include greater bureaucracy and pressure for accountability, issues involving insurance and intellectual property, and the difficulty of promoting such facilities in Congress and to a public used to symbolically significant Big Science machines aimed at Big Discoveries. Crease concluded by suggesting that the New Big Science poses problems for historians as well. It may be necessary, he said, to develop new kinds of digital tools to keep track of and image the complex changing patterns of the New Big Science, bringing the tools of computer analysis and visualization to bear on the study of a single, historically rich, immensely complex instrument of the scale of a synchrotron light source.

The session ended with a talk by Thomas Kaiserfeld that analyzed the development of the European Spallation Source currently being built in Lund in the era of the New Big Science. Kaiserfeld explained how ESS planners have successfully managed to present the project as relevant to different national and international policy makers, to the community of European neutron researchers as well as to different industrial interests. All this has been achieved in a research-policy environment which has been subject to drastic transformations, from calls to engage former researchers from the former eastern bloc in the early 1990s via competition with America and Asian researchers at the turn of the 21st century to intensified demands on business applications. During this process there have also been fierce competition between different potential sites in the U.K., Germany, Spain, Hungary, and Sweden, not once, but twice. The project has in addition been plagued by withdrawals of key actors as well as challenging problems in the field of spallation-source construction. By analyzing the different measures taken and arguments raised by planners, Kaiserfeld explained how the European Spallation Source has survived from the early 1990s until today. ■

Session Report: "Sidney Coleman Remembered: Correspondence and Commentary"

Continued from page 4

with the Coleman-Mandula theorem of 1967 showing that internal and space-time symmetries cannot be combined in a non-trivial way (except for supersymmetry, which they did not consider). In addition, Weinberg mentioned the work that established the equivalence between the sine-Gordon and Thirring models, and his own work with Coleman on "Radiative Corrections as the Origin of Spontaneous Symmetry Breaking", which introduced the key idea of dimensional transmutation. Weinberg also showed a list of the 40 graduate students supervised by Coleman between 1964 and 2001, better than one a year, among whom are many physicists who have gone on to distinguished careers of their own.

Georgi placed Coleman in the context of the Harvard of that era, mentioning his colleagues Shelly Glashow, with whom Coleman had a fruitful collaboration, and Steven Weinberg, as well as younger physicists such as Tom Appelquist, Helen Quinn, Joel Primack and Erick Weinberg, and Georgi himself. Georgi commented on Coleman's role as an oracle, saying that "he often understood the theoretical ideas better than the original authors."

Coleman was famous for working late into the night, and then sleeping past noon. Georgi said that, at one point, due to a revolt of the junior faculty, senior faculty were called upon to teach beginning undergraduate classes, which required Coleman to make the supreme sacrifice of getting up early. But as Weinberg noted, when he could get away with it, Coleman was also capable of showing up for the first 10 am class of the semester, and announcing that henceforth the class would meet at two in the afternoon.

Another aspect of Coleman that Georgi talked about was his passion for science fiction, which complemented his life as a physicist. This had been mentioned as well by Diana Coleman, who said that "the science fiction crowd prided itself on being much freer and wilder. Purple suits were not startling there….[Sidney]'s science fiction friends were a quite different gang, with different traditions."

Georgi, who has posted the written version of his talk about Coleman on the arXiv (http://arxiv.org/pdf/1606.03738.pdf), also alluded to some of Coleman's later important contributions, as did Weinberg. These include a series of articles on the decay of the false vacuum, partially in collaboration with Curtis Callan and Frank DeLucia, in the period 1977-1980, and the article "Why there is nothing rather than something: a theory of the cosmological constant" in 1988. As Weinberg pointed out, the title was a riposte to Leibniz's "Why is there something rather than nothing?" (1714).

The preface to "Aspects of Symmetry" ends with a revealing paragraph, quoted by Weinberg, that is quintessential Coleman, not only for its wit and flair, but for the underlying passion for physics about which he was very serious indeed. It reads: "These lectures span fourteen years, from 1966 to 1979. This was a great time to be a high-energy theorist, the period of the famous triumph of quantum field theory. And what a triumph it was, in the old sense of the word: a glorious victory parade, full of wonderful things brought back from far places, to make the spectator gasp with awe and laugh with joy. I hope some of that awe and joy has been captured here." ■

Session Report: "Pais Prize Session: Some History You Won't Find in Physics Textbooks"

Continued from page 5

those of Boulliau, Horrocks, Streete, Wing, and Mercator. He also remarked that Newton understood quite well that "the planets neither move exactly in ellipses nor revolve twice in the same orbit." Smith identifies Newton's method as finding a robust physical source for each discrepancy between theory and observation, one that had further observational consequences. As Newton stated, "If the sun were at rest and the Planets did not act on one another, the orbits would elliptical." In addition, Kepler's other two laws, the equal areas law, and the relation between planetary orbits and their periods, would also be exact. It was the planetary interaction that provided the robust physical source, and hence it was the observation of the deviations from Kepler's laws, explained by the interaction that provided Newton with the principal evidence for his theory of gravity.

A second myth identified by Smith was, as Euler said, that in order for the discrepancies between calculated and observed motions to be evidence for Newton's theory, Newton was presupposing that all motions refer to what we call inertial frames. Smith argued that on the contrary, Newton assumed that the planetary system was quasi-insular, "i.e. a system in which, if not all, then at least all of the detectable changes of position and motions of its bodies among themselves result entirely from the actions of those bodies on one another." Smith outlined the continuing tests of Newton's counterfactual assumptions. He stated Newton's method of testing counterfactual conclusions as follows: 1) idealized calculated orbits presupposing theory and principal physical sources; 2) comparison with observations; 3) discrepancy with a clear signature; 4) physical source of the discrepancy, still further physical sources that make a difference; 5) New idealized calculation incorporating the new sources and their further implications. The process would then begin again with comparison with observations. He illustrated this with the discovery of Neptune and the advance of the perihelion of Mercury.

Jed Buchwald, of the California Institute of Technology, was the third speaker. He extended the discussion in his talk, "Historical Examples of Politics, Morality, Innovation and Fraud in Physical Science and Technology." His first example was Heinrich Hertz's discovery of electromagnetic radiation.

When Hertz published his account of the discovery he claimed that he was relating the actual sequence of experiments and thoughts that resulted in that discovery. Hertz's notebook, recently found, tells a very different story. It shows that Hertz had considerably altered the true course of events in ways that made his path to discovery seem to be more logical and linear than it was. Buchwald asked whether Hertz's misrepresentation should be considered fraud, an issue that has been in the news recently. In Buchwald's view this was not the case. Hertz did not attempt to mislead his readers to enhance their view of his experimental and logical abilities, nor did he have a financial interest in his account. Rather Hertz's presentation was good pedagogy. Other laboratories soon began to investigate electromagnetic radiation.

Buchwald also discussed the relation between science and technology. He remarked that the cliché, "Science produces, industry consumes," is occasionally correct, but that more often the interaction is more complex. His example was the work of Marconi and Fleming. Buchwald pointed out that Hertz's discovery, using a very broadband device, was useless as a practical means of communication. Marconi's device, which had a narrow bandwidth, was the only possibility. Buchwald argues that the path to a useful Marconi device was quite complex, involving connections to economics, society, and government, even though the science was already known.

Buchwald's final example was the conflict between Herman Helmholtz and Friedrich Zollner on the virtues of free investigation, unconstituted by ideologies or religious beliefs. This was Helmholtz's view, one opposed by Zollner. Zollner accused Helmholtz of propagating unGermanic science, primarily because Helmholtz had translated William Thomson's, later Lord Kelvin, *Treatise on Natural Philosophy*. Zollner's opposition to academic freedom dismayed Helmholtz who advocated the free pursuit of scientific research as a model for intellectual freedom and for a tolerant and moral society. Helmholtz's view was abandoned in Germany in the 1930s as typified by tearing down a statue honoring Hertz, because of his Jewish ancestry. ■

George Smith

A Compendium of Striking Manhattan Project Quotes

Continued from page 2

Nuclear Energy, and Fission; On the Possibility of Atomic Bombs; The Manhattan Engineer District, General Groves, Robert Oppenheimer, Los Alamos, and Trinity; Politics, Hiroshima, and Nagasaki; and Afterward. References to original sources are given for all quotes. I would certainly appreciate hearing from readers regarding further entries.

A note on source notation: A few entries have citations of the form Mxxxx-y, image zzzz. This refers to National Archives and Records Administration microfilm file Mxxxx, reel y, image zzzz on the DVD of the file supplied to this author by the NARA.

Neutrons, Nuclear Energy, and Fission

"I am afraid neutrons will not be of any use to any one." [James Chadwick quoted in the February 29, 1932, edition of the New York Times; Kuhn (1932)]

" ... [T]he neutron is practically the theme song of this whole project." [Smyth report, sect. 1.18, Smyth (1945)]

" ... [A]nyone who looked for a source of power in the transformation of the atoms was talking moonshine." [Ernest Rutherford on prospect of harnessing nuclear energy; London Times, September 12, 1933]

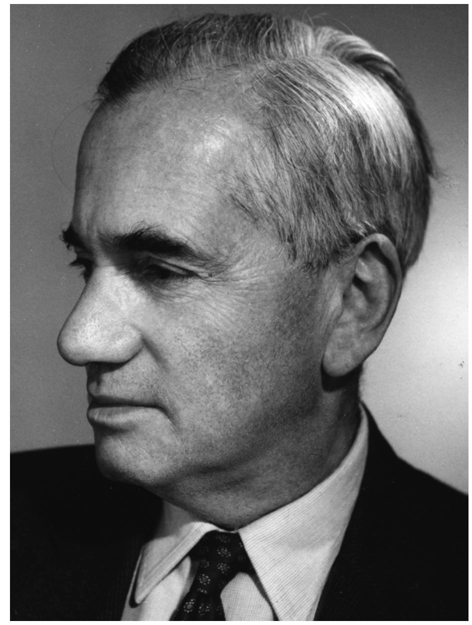
" ... [I]t suddenly occurred to me that if we could find an element which is split by neutrons and which would emit two neutrons when it absorbed one neutron, such an element, if assembled in sufficiently large mass, could sustain a nuclear chain reaction, liberate energy on an industrial scale, and construct atomic bombs." [Leo Szilard reminiscence of conceiving chain reaction ca. September 1933, quoted in Feld et al. (1972) p. 530]

"When heavy nuclei are bombarded by neutrons, it is conceivable that the nucleus breaks up into several large fragments, which would of course be isotopes of known elements but would not be neighbors of the irradiated element." [Ida Noddack on possibility of uranium fission; I. Noddack, "Über das Element 93," *Zeitschrift fur Angewandte Chemie* **47**(37), 653-655 (1934). An English translation prepared by H. G. Graetzer is available at http://www.chemteam.info/Chem-History/Noddack-1934.html]

"Suppose someone gave you a quantity of pure 235 isotope of uranium – what would happen?" [Otto Frisch to Rudolf Peierls, early 1940, as related in Peierls (1985) pp. 154-155]

"I remember the spring of 1941 to this day. I realized then that a nuclear bomb was not only possible — it was inevitable. ... And I had then to start taking sleeping pills. It was the only remedy, I've never stopped since then. It's 28 years, and I don't think I've missed a single night in all those 28 years." [James Chadwick, oral history interview, April 20, 1969; https://publishing.aip.org/history-programs/niels-bohr-library/oral-histories/3974-4]

"Disintegration of Uranium by



Left: Genia (1908-1986) and Rudolf (1907-1995) Peierls in New York, 1943. Photograph by Francis Simon, courtesy AIP Emilio Segre Visual Archives. Right: Otto Frisch (1904-1979). [Lotte Meitner-Graf, London, courtesy AIP Emilio Segre Visual Archives]

Neutrons: a New Type of Nuclear Reaction." [Title of paper announcing discovery of fission; L. Meitner and O. R. Frisch; Nature 143(3615) 239-240, February 11, 1939]

On the Possibility of Atomic Bombs

"That night there was very little doubt in my mind that the world was headed for grief." [Leo Szilard recollection of observing secondary neutrons from fission, March 1939; Weart & Szilard (1978) p. 55]

"Some recent work by E. Fermi and L. Szilard ... leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future." [Albert Einstein to President Roosevelt, August 2, 1939; http://hypertextbook.com/eworld/einstein.shtml]

"At that point we stared at each other and realized that an atomic bomb might after all be possible." [Otto Frisch and Rudolf Peierls, early 1940; Frisch (1979) p. 126]

"As a weapon, the super-bomb would be practically irresistible. There is no material or structure that could be expected to resist the force of the explosion." [Frisch-Peierls Memorandum, March 1940. Reprinted in Serber (1992) pp. 80-88]

"A fission bomb of superlatively destructive power will result from bringing quickly together a sufficient mass of element U235. This seems to be as sure as any untried prediction based upon theory and experiment can be." [Arthur Compton, National Academy of Sciences Uranium Committee report, Nov. 6, 1941; M1392-1, image 0491]

"The stuff will apparently be more powerful than we thought, the amount necessary appears to be less, the possibilities of actual production appear more certain." [Vannevar Bush to President Roosevelt, March 9, 1942; M1392-1, image 1007]

" ... I think the whole thing should be pushed not only in regard to development, but also with due regard to time. Time is very much of the essence. ..." [President Roosevelt to Vannevar Bush, March 11, 1942; M1392-1, image 0785]

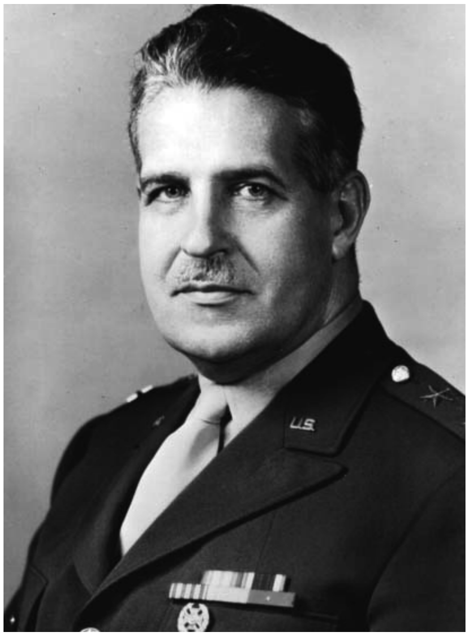
"This is going to do it. Now it will become self-sustaining. The trace will climb and continue to climb; it will not level off." [Enrico Fermi to Arthur Compton on the occasion of initiating the first self-sustaining chain reaction, December 2, 1942; Wattenberg (1993) p. 50]

"Fermi was as cool as a cucumber – much more so than his associates who were excited or a bit scared." [Crawford Greenewalt, witness to startup of CP-1 reactor; quoted in Kelly (2007) pp. 86-87]

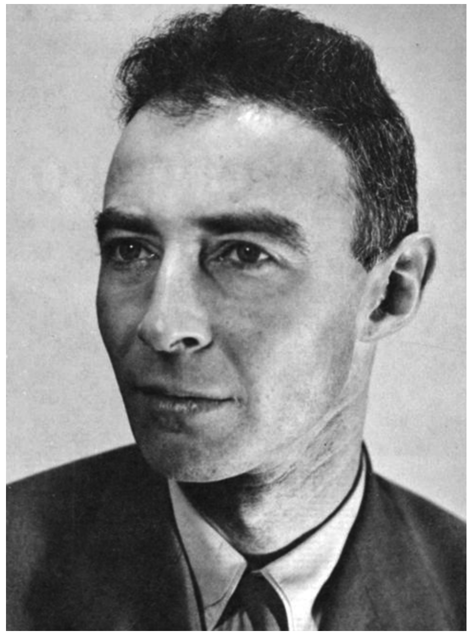
Vannevar Bush (1890-1974), Director of the Office of Scientific Research and Development. [AIP Emilio Segre Visual Archives]

The Manhattan Engineer District, General Groves, Robert Oppenheimer, Los Alamos, and Trinity

"It bore no relation to the industrial or social life of our country; it was a separate state, with its own airplanes and its own factories and its thousands



Manhattan Engineer District Commander General Leslie R. Groves (1896-1970). [Wikimedia Commons]



Robert Oppenheimer (1904-1967), Director of the Los Alamos Scientific Laboratory, ca.1944. [Wikimedia Commons]

of secrets. It had a peculiar sovereignty, one that could bring about the end, peacefully or violently, of all other sovereignties." [Herbert Marks on the Manhattan Engineer District; quoted in Lang (1959) p. 80]

"The object of the project is to produce a *practical military* weapon in the form of a bomb in which the energy is released by a fast neutron chain reaction in one or more of the materials known to show nuclear fission." [Robert Serber in T*he Los Alamos Primer*; Serber (1992) p. 3]

"I fear we are in the soup." [Vannevar Bush to Harvey Bundy (an aide to Henry Stimson) upon learning of Groves' appointment to the Manhattan District; quoted in Norris (2002) p. 178]

" ... [N]o one with whom I talked showed any great enthusiasm about Oppenheimer as a possible director of the project." [General Groves; Groves (1983) p. 61]

"He couldn't run a hamburger stand." [Attributed to an unnamed friend of Oppenheimer by Luis Alvarez; Alvarez (1987) p. 78]

"The story of Robert Oppenheimer is as timely as today's news and as timeless as a Greek tragedy." [Senator Jeff Bigaman (D-NM), in Kelly (2006) p. 11]

"I think it was a real stroke of genius on the part of General Groves, who is not generally considered to be a genius, to have appointed him ..." [I. I. Rabi on appointment of Oppenheimer, interview in *The Day After Trinity*, John Else in association with KTEH-TV(1980), in minute 28]

"In all my life I have never known a personality more complex than Robert Oppenheimer." [Abraham Pais on Robert Oppenheimer; Pais & Crease (2006) p. 139]

"Rome wasn't built in a day, but then, DuPont didn't have that job." [Walter Simon, DuPont plant operations manager at Hanford Engineer Works; Thayer (1996) p. 35]

"The choice was to junk the whole discovery of the chain reaction that produced plutonium, and all of the investment in time and effort of the Hanford plant, unless somebody could come up with a way of assembling the plutonium material into a weapon that would explode." [John Manley on the plutonium spontaneous fission crisis that led to the development of the implosion bomb; Hoddeson et al. (1993) p. 242]

" ... [A]t that time there was not a single experimental result that gave good reason to believe that a plutonium bomb could be made at all." [David Hawkins on the status of the plutonium bomb project as of mid-1944; Hawkins (1947) p. 143]

"It just goes to show the incompressibility of water." [Robert Oppenheimer to McAllister Hull upon occasion of General Groves being sprayed on the backside by a jet of water; Hull & Bianco (2005) pp. 56-57]

" ... [A]n immense project that was underway – a project looking to the development of a new explosive of almost unbelievable destructive power." [Henry Stimson to President Truman, April 12, 1945; Norris (2002) p. 375]

"Now I'm scared." [Kenneth Greisen to I. I. Rabi, seconds before the *Trinity* detonation. Moments earlier, Rabi had asked Greisen "Aren't you nervous" as they lay on the ground. Los Alamos Historical Society (2002), p. 51]

"We knew the world would not be the same. A few people laughed, a few people cried, most people were silent. I remembered the line from the Hindu scripture, the *Bhagavad-Gita*. Vishnu is trying to persuade the Prince that he should do his duty and to impress him takes on his multi-armed form and says, "Now I am become Death, the destroyer of worlds. I suppose we all thought that, one way or another." [Robert Oppenheimer on the Trinity test; interview in *The Decision to Drop the Bomb*, http://www.atomicarchive.com/Movies/Movie8.shtml]

"Now we are all sons of bitches." [Kenneth Bainbridge to Robert Oppenheimer after Trinity test; Bainbridge in Wilson (1975) p. 230.]

"Suddenly, there was an enormous flash of light, the brightest light I have ever seen or that I think anyone has ever seen. It blasted; it pounced; it bored its way right through you. It was a vision which was seen with more than the eye. It was seen to last forever. You would wish it would stop; although it lasted about two seconds. Finally it was over, diminishing, and we looked toward the place where the bomb had been; there was an enormous ball of fire which grew and grew and it rolled as it grew; it went up into the air, in yellow flashes and into scarlet and green. It looked menacing. It seemed to come toward one. A new thing had just been born; a new control; a new understanding of man, which man had acquired over nature." [I. I. Rabi description of Trinity test; Serber (1992) p. xvii, quoted from Rabi (1970) p. 138]

"The shot was truly awe-inspiring. Most experiences in life can be comprehended by prior experiences but the atom bomb did not fit into any preconception possessed by anybody. The most startling feature was the intense light." [Norris Bradbury on Trinity test; Los Alamos Historical Society (2002) p. 53]

"I am sure that at the end of the world – in the last milli-second of the earth's existence – the last man will see what we saw." [George Kistiakowsky quoted in Laurence (1946) p. 11]

"I am about the only guy who actually looked at the damn thing - the first *Trinity* test. Everybody else had dark glasses, and the people at six miles couldn't see it because they were all told to lie on the floor. I'm probably the only guy who saw it with the human eye." [Richard Feynman, who viewed the Trinity test through an ultraviolet-light-absorbing truck windshield; Badash et al. (1980) p. 131]

"The light from the explosion was seen clearly at Albuquerque, Santa Fe, Silver City, El Paso, and other points generally to about 180 miles away. The sound was heard … generally to about 100 miles. Only a few windows were broken, although one was some 125 miles away. ... A crater from which all vegetation had vanished, with a diameter of 1,200 feet … In the center was a shallow bowl 130 feet in diameter and 6 feet in depth … The steel from the tower was evaporated … I no longer consider the Pentagon a safe shelter from such a bomb … Radioactive material in small quantities was located as much as 120 miles away … My liaison officer at the Alamogordo Air Base, sixty miles away [reported] a blinding flash of light that lighted the entire northwestern sky". [Excerpts from General Groves' report to Henry Stimson on Trinity test, July 18, 1945. The memo is reprinted in Groves (1983) pp. 433-440]

"Even though the purpose was grim and terrifying, it was one of the greatest physics experiments of all time." [Emilio Segrè on the *Trinity* test; Segrè (1970) p. 145]

"The war is over." [General Thomas Farrell to General Groves after the *Trinity* test. Groves claims that his response was "Yes, after we drop two bombs on Japan." Groves (1983) p. 298]

"Anyway we think we have found the way to cause a disintegration of the atom. An experiment in the New Mexican desert was startling - to put it mildly. Thirteen pounds of the explosive caused the complete disintegration of a steel tower 60 feet high, created a crater 6 feet deep and 1,200 feet in diameter, knocked over a steel tower 1/2 mile away and knocked men down 10,000 yards away. The explosion was visible for more than 200 miles and audible for 40 miles and more. [President Truman diary entry, July 25, 1945; Ferrell (1996) p. 31]

"July 1945 at Alamogordo is the hinge of the century. Nothing after would ever be the same." [Joseph Kanon in Kelly (2007) p. 146]

"Believe Japs will fold up before Russia comes in. I am sure they will when Manhattan appears over their homeland. I shall inform Stalin about it at an opportune time." [President Truman diary entry, July 18, 1945; Ferrell (1996) p. 30]

The Trinity explosion, July 16, 1945. [The Los Alamos National Laboratory Archives]

Politics, Hiroshima, and Nagasaki

"Within four months we shall in all probability have completed the most terrible weapon ever known in human history, one bomb of which could destroy a whole city." [Henry Stimson memo to President Truman, April 25, 1945; http://www.doug-long.com/stim425.htm; Sherwin (1987) pp. 291-292]

"The Secretary expressed the view ... that this project should not be considered simply in terms of military weapons, but as a new relationship of man to the universe. ... While the advances in the field to date had been fostered by the needs of war, it was important to realize that the implications of the project went far beyond the needs of the present war. It must be controlled if possible to make it an assurance of future peace rather than a menace to civilization." [Interim Committee minutes, May 31, 1945; http://www.nuclearfiles.org/menu/key-issues/nuclear-weapons/history/pre-cold-war/interim-committee/index.htm]

"After much discussion concerning various types of targets and the effects to be produced, the Secretary expressed the conclusion, on which there was general agreement, that we could not give the Japanese any warning; that we could not concentrate on a civilian area; but that we should seek to make a profound psychological impression on as many of the inhabitants as possible. At the suggestion of Dr. Conant the Secretary agreed that the most desirable target would be a vital war plant employing a large number of workers and closely surrounded by worker's houses." [Interim Committee minutes, May 31, 1945. Underlining as in original. http://www.nuclearfiles.org/menu/key-issues/nuclear-weapons/

history/pre-cold-war/interim-committee/index.htm]

"The things we are working on are so terrible that no amount of protesting or fiddling with politics will save our souls." Edward Teller in a letter to Leo Szilard, July 2, 1945; Weart & Szilard (1978) p. 208.]

"I had set as the governing factor that the targets chosen should be places the bombing of which would most adversely affect the will of the Japanese people to continue the war." [Groves (1983) p. 267]

"Thus, we cannot hope to avoid a nuclear armament race either by keeping secret from the competing nations the basic scientific facts of nuclear power or by cornering the raw materials required for such a race. ... From this point of view, a demonstration of the new weapon might best be made, before the eyes of representatives of all the United Nations, on the desert or a barren island." [Excerpts from Frank Report, June 1945. Available at http://www.atomicarchive.com/Docs/ManhattanProject/FranckReport.shtml; see also http://blog.nuclearsecrecy.com/2012/01/11/weekly-document-9-the-uncensored-franck-report-1945-1946/. Reprinted in Smith (1965) pp. 560-575]

"This weapon is to be used against Japan between now and August 10th. I have told the Sec. of War, Mr. Stimson, to use it so that military objectives and soldiers and sailors are the target and not women and children. ... It seems to be the most terrible thing ever discovered, but it can be made the most useful." [President Truman diary entry, July 25, 1945; Ferrell (1996) p. 31]

"Colonel, are we splitting atoms today?" [*Enola Gay* tail gunner Robert Caron to Colonel Paul Tibbets, en route to Hiroshima; quoted in Rhodes (1986) p. 707]

"My God, what have we done?" [*Enola Gay* co-pilot Robert Lewis journal entry after dropping bomb. Weintraub (1995) p. 424; http://en.wikipedia.org/wiki/Robert_A._Lewis. In Laurence (1946) p. 221 this is quoted as simply "My God."]

"Results clearcut, successful in all respects. Visible effects greater than New Mexico tests. Conditions normal in airplane following delivery. Target at Hiroshima attacked visually. One-tenth cloud at 052315Z. No fighters and no flak." [Commander William Parsons cable to Groves after Hiroshima drop; Groves (1983) p. 322]

"Apparently it went with a tremendous bang." [General Groves to Oppenheimer, telephone conversation, August 6, 1945. http://blog.nuclearsecrecy.com/2012/04/04/weekly-document-the-hiroshima-phone-call-1945/]

"I walked past Hiroshima station … and saw people with their bowels and brains coming out. … I saw an old lady carrying a suckling infant in her arms. … I just cannot put into words the horror I felt …" [17-year old at Hiroshima, quoted in Lifton (1969) p. 50]

"Thank God for the Atom Bomb" [Title of essay by Paul Fussell; Fussell (1988)]

"Finally Oppenheimer was able to quiet the howling crowd and he began to speak, hardly in low key. It was too early to determine what the results of the bombing might have been, but he was sure that the Japanese didn't like it. More cheering. He was proud, and he showed it, of what we had accomplished. Even more cheering. And his only regret was that we hadn't developed the bomb in time to have used it against the Germans. This practically raised the roof." [Los Alamos physicist Sam Cohen describing Oppenheimer address following Hiroshima mission; Cohen (1983) pp. 21-22]

"Sixteen hours ago an American airplane dropped one bomb on Hiroshima, an important Japanese Army base. That bomb had more power than 20,000 tons of T.N.T. ... It is an atomic bomb. It is a harnessing of the basic power of the universe. The force from which the sun draws its power has been loosed against those who brought war to the Far East." [Excerpt from President Truman press release, August 6, 1945; Ferrell (1996) p. 48]

"Bombed Nagasaki 090158Z visually. No opposition. Results technically successful. Visible effects about equal to Hiroshima. Proceeding to Okinawa. Fuel problem." [*Bockscar* Radio Operator Abe Spitzer strike report on Nagasaki mission; Sweeney, Antonucci & Antonucci (1997) p. 220]

"The next bomb of the implosion type had been scheduled to be ready for delivery on the target on the first good weather after 24 August 1945. We have gained 4 days in manufacture and expect to ship from New Mexico on 12 or 13 August the final components. Providing there are no unforeseen difficulties in manufacture, in transportation to the theatre or after arrival in the theatre, the bomb should be ready for delivery on the first suitable weather after 17 or 18 August." [Groves memo to General George C. Marshall, August 10, 1945; M1109-3, image 0653]

"The President, who usually comes to cabinet not later than 2:05, came in about 2:25 saying he was sorry to be late … Truman said he had given orders to stop atomic bombing. He said the thought of wiping out another 100,000 people was too horrible. He didn't like the idea of killing, as he said, 'all those kids.' " [Secretary of Commerce Henry Wallace diary entry, August 10, 1945; Blum (1973) pp. 473-4]

"Hiroshima saved lives, lots of them, lots of Japanese and many Americans. If there were a nuclear war today, it would be a destruction of both countries, so in that sense it cannot be repeated. But I think the realization that it cannot and must not be repeated was very much facilitated by Hiroshima. If we hadn't had these two atomic bombings, people would not have realized what a terrible thing this is." [Hans Bethe in Palevsky (2000), p. 70]

"At Los Alamos during World War II there was no moral issue with respect to working on the atom bomb. … The whole fate of the civilized world depended upon our succeeding before the Germans! … It is an open question as to whether the world is better or worse for our having made the atom bomb. … After Otto Hahn's and Fritz Strassmann's discovery it became evident that sooner or later some country would make an atom bomb. If an atom bomb had not been made and detonated in World War II, the world would be unprepared to cope with the tremendous threat of nuclear warfare. … warfare is no longer a rational means of settling differences between nations." [Joseph Hirschfelder in Badash et al. (1980) pp. 68-70]

"The peoples of this world must unite or they will perish. This war, that has ravaged so much of the earth, has written these words. This atomic bomb has spelled them out for all men to understand. Other men have spoken them, in other times, of other wars, of other weapons. They have not prevailed. There are some, misled by a false sense of human history, who hold that they will not prevail today. It is not for us to believe that. By our works we are committed to a world united, before this common peril, in law, and in humanity." [Robert Oppenheimer remarks on receiving Certificate of Appreciation from Secretary of War Henry Stimson, October 16, 1945; Pais & Crease (2006) p. 48]

"But when you come right down to it the reason we did this job is because it was an organic necessity. If you are a scientist you cannot stop such a thing. If you are a scientist you believe that it is good to find out how the world works; that it is good to find out what the realities are; that it is good to turn over to mankind at large the greatest possible power to control the world and to deal with it according to its lights and values." [Robert Oppenheimer to Association of Los Alamos Scientists, November 2, 1945; Pais & Crease (2006) p. 51]

"In an enterprise such as the building of the atomic bomb the difference between ideas, hopes, suggestions and theoretical calculations, and solid numbers based on measurement, is paramount. All the committees, the politicking and the plans would have come to naught if a few unpredictable nuclear cross-sections had been different from what they are by a factor of two." [Emilio Segrè quoted in Rhodes (1986) p. 8]

Afterward

"Give it back to the Indians." [Robert Oppenheimer's suggestion for the postwar fate of Los Alamos; Teller (2001), p. 219]

"That was the day I gave up hope, but that was not the day for me to say so publicly." [Robert Oppenheimer on appointment of Bernard Baruch as United States representative to the United Nations Atomic Energy Commission; Pais & Crease (2006) p. 151]

"So for him to have alerted the world that we were going to make a hydrogen bomb at a time when we didn't even know how to make one was one of the worst things he could have done." [I. I. Rabi reaction to President Truman's order to Atomic Energy Commission to continue work on "super" bomb; interview by Jeremy Bernstein, *The New Yorker*, October 2, 1975, p. 78]

"Necessarily such a weapon goes far beyond any military objective and enters the range of very great natural catastrophes. By its very nature it cannot be confined to a military objective but becomes a weapon which in practical effect is almost one of genocide." [Enrico Fermi and I. I. Rabi minority statement to Atomic Energy Commission General Advisory Committee report on prospect of development of "super" bomb, October 1949; GAC (1949)]

" ... I feel I would like to see the vital interests of this country in hands which I understand better and therefore trust more." [Edward Teller testimony regarding Robert Oppenheimer at Oppenheimer's 1954 security hearing; Goodchild (2004) p. 244]

" ... [T]here is no indication in the entire record that Dr. Oppenheimer has ever divulged any secret information." [Henry Smyth in his dissenting report on Oppenheimer security hearing; quoted in Goodchild (1980) p. 265; see also http://www.atomicarchive.com/Docs/Oppenheimer/OppyAEC6.shtml]

"But I also think that it was a damn good thing that the bomb was developed, that it was recognized as something important and new, and that it would have an effect on the course of history. In that world, in that war, it was the only thing to do. I only regret that it was not done two years earlier. I would have saved a million or more lives." [Robert Oppenheimer, New York Times Magazine, August 1, 1965, p. 8]

"I think it is just possible, Mr. President, that it has taken some charity and some courage for you to make this award today." [Oppenheimer to President Lyndon Johnson upon being given the Fermi Award, December 2, 1963; Bird & Sherwin (2005) p. 574]

"The world has changed, but the current arsenal carries the baggage of the cold war. There is the baggage of significant numbers in reserve. There is the baggage of a nuclear stockpile beyond our needs. What is it we're really trying to deter? Our current arsenal does not address the threats of the 21st century." [General James E. Cartwright, former Vice-Chairman of the Joint Chiefs of Staff and Commander of the United States Nuclear Forces, May 2012; http://www.nytimes.com/2012/05/16/world/cartwright-key-retired-general-backs-large-us-nuclear-reduction.html?_r=1] ■

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