THEATER: HISTORY OF SCIENCE

A Friendship's Fission

Did Nazi Germany fail to make an atomic bomb because of bungling and ineptitude as many believe? Or, as German nuclear scientists insisted after World War II, was the effort deliberately sabotaged from within? On these questions, historians would love to cross-examine Werner Heisenberg, Nobel laureate and a leading figure of German nuclear research who died in 1976 without having satisfied anyone's curiosity. And what was Heisenberg up to when he made a mysterious visit to Nazi-occupied Denmark to consult his mentor Niels Bohr at the height of the war? The debate over these events burns hot even today. It supplies the dramatic fuel for Michael Frayn's stunning play *Copenhagen*, now opening in New York while continuing a successful two-year run in London. The New York previews were accompanied by a remarkable day-long symposium at the City University of New York that brought together scientists, historians, and the play's creators (*2*).

Copenhagen
by Michael Frayn
Opening at the Royale Theatre, New York, 11 April 2000. Continuing at the Duchess Theatre, London (*1*).

Creating Copenhagen
A Symposium
Presented by the Graduate Center of the City University of New York and the Ensemble Theater/Alfred P. Sloan Foundation Science & Technology Project, 27 March 2000.

During the 1920s, Bohr (from his institute in Denmark) and his colleagues in Munich and Göttingen laid siege to the crumbling order of classical physics and crafted a new quantum world to explain the atom and its nucleus. Their world view, the Copenhagen interpretation, sought to make sense of the strangeness of quantum theory; Heisenberg's work was one of its pillars. Before the war, Bohr and Heisenberg were close friends, perhaps nearly as close as father and son. Yet when the Nazi armies overran Europe, they were split apart. Bohr desperately tried to keep his institute going under German occupation while Heisenberg stayed in Germany to run his country's nuclear research program.

In September 1941, Heisenberg made a peculiar visit to Bohr that left the Danish physicist outraged and ended their friendship. No direct record exists of what passed between the two men, and afterward they gave conflicting versions. Did Heisenberg disclose to Bohr a Nazi nuclear effort? Was Heisenberg trying to enlist Bohr's support in derailing the Allied nuclear weapon when it seemed that the Nazi program was going nowhere? Powerful arguments one way or the other fill books, including those by historian David Cassidy (*3*) and journalist Thomas Powers (*4*). Even the rich historical goldmine provided by the Farm Hall transcripts of secretly recorded conversations among the captured German scientists has failed to nail down the answers.

A prewar excursion. Niels and Margrethe Bohr riding a motorcycle, circa 1930.

Michael Frayn steps courageously into this void, summoning the spirits of Bohr, his wife Margrethe, and Heisenberg into the theatrical equivalent of a three-particle collision. *Copenhagen* is not a nice chat in a Danish sitting room, but rather a boxing match in two acts, fought among haunted souls trying to reclaim the past. The cast of the New York production is stellar: Heisenberg, played by Michael Cumpsty, alternates between hearty, false good humor and a brittle self-doubt as he repeatedly offends his hosts by forgetting his position as representative of the occupying Nazis. Blair Brown as Margrethe is a relentless foil to Heisenberg's squirrelly courtship of Bohr. Philip Bosco is captivating as Bohr, grieving for his son killed in a boating accident and angry with his lost almost-son Heisenberg.

Contained within Peter Davison's spare stage design of lit circle, chairs, and a single entrance, Bohr and Heisenberg clash and reminesce, while Margrethe serves as chorus and conscience. To emphasize the dreamlike nature of the play, part of the audience sits on stage—the observers participating in what is observed. Director Michael Blakemore weaves a tight choreography as the characters confront, rebound, and reflect on dire unanswered riddles. "Does it matter now, my love, now that we're all three of us dead and gone?" asks Bohr of his wife. "Some questions remain long after their owners have died," she replies.

In a nod to Bohr's habit of compulsively revising his scientific manuscripts, Frayn has the spectral threesome "redraft" the visit three times. Each version takes a slightly different path to the climactic point at which the relationship of Bohr and Heisenberg explodes. Each draft begins with Heisenberg's walk toward Bohr's front door: "I crunch over the familiar gravel and tug at the familiar bell-pull." Each time we learn a little more of the foundations of their friendship and of the science that they created together.

In his Heisenberg, Frayn has fashioned neither a cartoon crypto-Nazi nor a quietly heroic internal saboteur of the German bomb. Instead, drawing on the Farm Hall papers, the playwright gives Heisenberg full knowledge that atomic weapons were possible but has him assuming—without calculating—that the critical mass of nuclear material needed for a bomb was immense, too large to be feasible. "Why didn't you do the calculation?" asks Bohr. To which Heisenberg responds "Because I wasn't trying to build a bomb." Indeed it appears that Heisenberg was concentrating on reactors for power and not bombs. But what if Heisenberg had done the calculation, would he have proceeded to weapons? We can't know. And so around the drafts and redrafts go. Ultimately, each version ends with the ghosts realizing that the purpose and meaning of Heisenberg's visit must stay cloaked in uncertainty.

Drama is necessarily a distilling of essences, a telling of truth without the detailed evidence. Thus, much credit is due the organizers of the accompanying symposium "Creating Copenhagen." Though the play stands robustly on its own, the symposium's three sessions provided additional valuable perspectives on the history and science, as well as an evening discussion with the playwright and the director.

The session on physics supplied a quartet of brief tutorials on the science behind *Copenhagen*. Fay Ajzenberg-Selove's account of nuclear fission laid the foundation for everything in the play having to do with isotopes, reactors, and bombs. The basics of quantum mechanics and the

CREDIT: UHLENBECK COLLECTION/COURTESY AMERICAN INSTITUTE OF PHYSICS EMILIO SEGRÈ VISUAL ARCHIVES

Copenhagen interpretation were discussed by Eugen Merzbacher, whose textbook on the subject is familiar to generations of physicists. Brian Greene gave an entertaining talk on non-Copenhagen schools of thought such as the bizarre many-worlds interpretation, and Anton Zeilinger reviewed recent experimental work on the foundations of quantum theory.

Historians and witnesses to history took the stage next, and here things took a sharper turn. Two men who actually knew Heisenberg, the physicists Hans Bethe and John Wheeler, recounted their experiences and understanding of what went on. Bethe felt the evidence from Farm Hall clearly showed that Heisenberg never worked on bombs and that Bohr misunderstood Heisenberg's overture in 1941. Wheeler told an emotional tale of his bittersweet encounters with Heisenberg.

Before the fallout. Heisenberg (left) and Bohr eating and talking at a Bohr Institute conference in Copenhagen, 1934.

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David Cassidy, author of the seminal biography of Heisenberg, took issue with Frayn's compression of history. In addition to his Copenhagen trip, Heisenberg made many other visits to occupied countries, so why concentrate on this one? Cassidy further suggested that there is no evidence Heisenberg ever expressed any moral reservations about his nuclear research during the war, but only after. Although the methods and tools of the dramatist are very different from those of the historian, Cassidy seemed to insist on a documentary approach instead of the work of imagination that Frayn did write. Through Margrethe, the play continually reminds us which side Heisenberg was on.

Gerald Holton dropped the symposium's biggest surprise when he disclosed that Bohr had actually written a private letter to Heisenberg taking strong exception to Heisenberg's widely publicized version of their September 1941 meeting. The letter was never mailed and was discovered only after Bohr's death. A long groan rose from the audience when Holton said that the Bohr family won't make the letter public until 2012 and, therefore, he couldn't say anything more about it.

In the symposium's sold-out evening session, the playwright and the director discussed the play's genesis, aims, and production. Frayn said that his primary intent was not to create a moral debate but instead to show the difficulty of knowing what is in another person's mind. "The epistemological issues are logically prior to the moral ones," he asserted. Frayn also countered Cassidy's critique by observing that there is a limit to what you can pack into a play, which must necessarily focus on a single action. So, Frayn has the one visit to Copenhagen stand for all of the situations Heisenberg was in during the war. Michael Blakemore, who directed both the London staging and the New York production, spoke whimsically about the theatrical aspects of the play as an experiment in itself. "First you have the actors orbit around the nucleus of a good text, then you sell tickets to a lot of photons," he said. "Occasionally there are some fast neutrons who want to blow it apart—those are the critics."

"Creating Copenhagen" was the inaugural event in the second year of the "First Light Festival" co-produced by the Ensemble Studio Theatre and the Alfred P. Sloan Foundation. It is to be followed by several new plays about science and technology, and the foundation has also funded filmmakers' efforts to create feature films and a dramatic television series about these subjects. Rather than continue to complain that fictional media, and Hollywood in particular, portrays them in a bad light, scientists need to recognize that the documentary form is not the only way to communicate to the world what they do—an artistic path exists too. Scientists should welcome such thoughtful intrusions as *Copenhagen* into their midst with open arms.

—DAVID VOSS

References and Notes

1. M. Frayn, *Copenhagen* (Methuen, London, 1998).
2. Additional information is available at http://inside.gc.cuny.edu/orup/copenhagen; www.ensemblestudiotheatre.org/; and www.sloan.org/programs/edu_public.htm
3. D. C. Cassidy, *Uncertainty: The Life and Science of Werner Heisenberg* (Freeman, New York, 1992).
4. T. Powers, *Heisenberg's War: The Secret History of the German Bomb* (Knopf, New York, 1993).

BROWSINGS

Memory, Brain, and Belief. *Daniel L. Schacter and Elaine Scarry, Eds.* Harvard University Press, Cambridge, MA, 2000. 359 pp. $39.95, £24.95. ISBN 0-674-00061-7.

Contributors from cognitive psychology, neuroscience, medicine, and literature discuss the complex relations between memory and belief. Among the phenomena they examine are the effects of current beliefs on memories of previous experiences, the nonconscious influences of experiences on beliefs, and the development of detailed recollections of events that never occurred.

The Sanitary City. Urban Infrastructure in America from Colonial Times to the Present. *Martin V. Melosi.* Johns Hopkins University Press, Baltimore, MD, 2000. 592 pp. $59.95, £46.50. ISBN 0-8018-6152-7. Creating the North American Landscape.

Modern urban life is sustained by reliable water supply, wastewater, and garbage-disposal systems. Melosi combines findings from popular accounts, scholarly histories, and legislative studies to trace the historical development of these systems in U.S. cities. He discusses the effects of changing technologies, expanding populations, growing awareness of public health, and shifting social beliefs.

Sexing the Body. Gender Politics and the Construction of Sexuality. *Anne Fausto-Sterling.* Basic Books (Perseus), New York, 2000. 487 pp. $35, $C52.95. ISBN 0-465-07713-7.

How are sex and gender connected? How is sexual identity determined? Biologist and feminist cultural critic Fausto-Sterling addresses such questions through her examination of research, medical practice, and case histories. She argues that the answers are too complex to allow neat categorizations of female and male.

Tropical Forest Ecology. A View from Barro Colorado Island. *Egbert Giles Leigh, Jr.* Oxford University Press, New York, 1999. 261 pp. $85, £55. ISBN 0-19-509602-9. Paper, $39, £27.50. ISBN 0-19-509603-7.

Focusing on the climate, structure, and productivity of this well-studied Panamanian rainforest, Leigh discusses three critical issues: why tropical forests are green despite their abundant herbivores, why such forests are so diverse, and the importance of mutualistic interactions in the forests' ecology.

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