preliminary meetings with Iraqi military officials (arranged by Lebanese arms dealer Sarkis Soghanalian). But it wasn't until 1987 that Bull struck a deal with the Iraqis to modify some of their howitzers, to help them develop several longer range versions, and to work on the much discussed Iraqi "supergun."

Adams speculates about what Saddam Hussein intended to do with such an unwieldy weapon, which could probably not have been fired more frequently than three times a day. He leaves open the possibility that Iraq did in fact plan to use the gun for Bull's original purpose, launching satellites. Leaving aside the question of the supergun's ultimate purpose, Adams provides the fullest account yet of Bull's contribution to Iraq's military capabilities, both through direct contracts with Iraq and through South African and Austrian arms manufacturers' sales of his howitzer design.

As for the lessons to be drawn from Bull's checkered career, Adams suggests in his concluding chapter that "Bull and his inventions are merely symbols of a greater problem: the failure of the international community to halt the spread of weapons throughout the world, and the seemingly endless cycle of proliferation that is a hallmark of the arms business."

Adams describes the strengths and weaknesses of current efforts to curb the spread of nuclear, chemical, biological, and conventional arms, and offers a few pointed observations about ways to improve them. The one thing missing from Adams's analysis—and it would make the strongest link with the rest of the book—is an analysis of how to deal with individuals like Bull who decide to sell their design and manufacturing knowledge to the highest bidder. A fuller presentation of Adams's views on this issue would have been a welcome addition to the book's concluding section.

Finally, the biggest mystery of the book—who killed Bull—is not definitively solved. It is clear that Bull was gunned down by a professional assassin outside his Brussels apartment in March 1990, for reasons connected with his ongoing activities as an arms merchant and scientific mercenary. Adams provides a reasoned analysis of the strengths and weaknesses of a half dozen theories about who was behind Bull's assassination. He ends up leaning toward the now popular view that he was hit by Israeli intelligence, in part to stop the Iraqi supergun project, and in part to serve "as a warning to all the other dealers operating in the underground arms bazaar that trading with Israel's enemies is a dangerous business." ■

William D. Hartung is the director of the Arms Transfer Control Project of the World Policy Institute in New York City. He is working on a book about the future of U.S. arms transfer policy.

A life in science

A Different Sort of Time: The Life of Jerrold Zacharias, Scientist, Engineer, Educator
by Jack S. Goldstein
M.I.T. Press, 1992
373 pages; $35.00

BERNARD T. FELD

Jerrold Zacharias was the ideal scientist-administrator. He understood, as well as anyone he supervised, the scientific and technical content of the work. And he did not hesitate to intervene directly when he perceived a way of accelerating progress. At the same time, he gave individual scientists maximum leeway for developing their skills and ideas.

Zacharias grew up in Jacksonville, Florida. From his earliest teens, he was interested in things technical: cameras, automobile engines, and amateur radio transmission and receiving. He studied engineering in high school (physics was not yet taught in public schools) and he attended Columbia University in New York, where he majored in mathematics and minored in physics (no major was available). After graduation, he did his doctoral research at the solid state laboratory of Professor Shirley Quimby, Columbia's foremost solid state physics researcher.

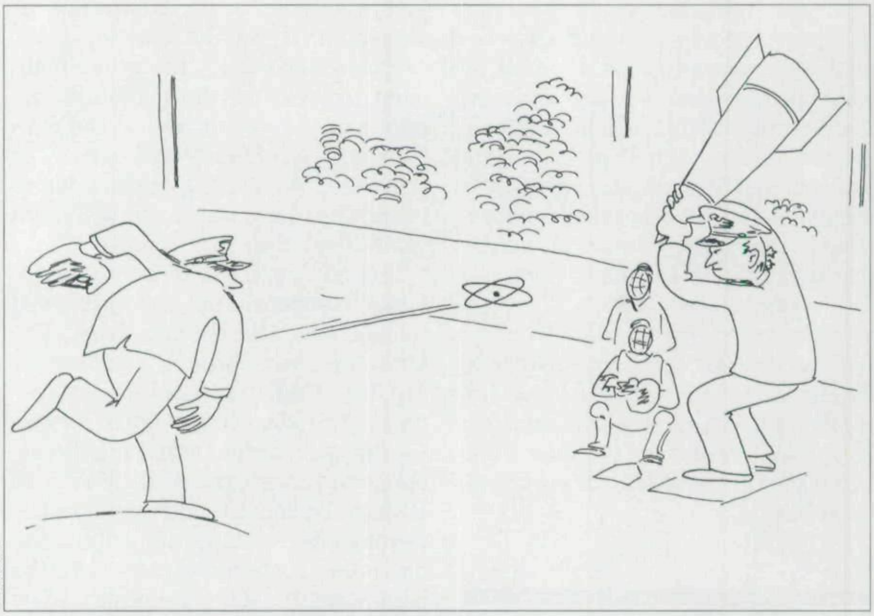
After graduation he taught at Hunter College and spent his spare time doing research in Professor I. I. Rabi's atomic beam laboratory at Columbia. It was an exciting time; among other things, the group managed to measure the magnetic moments of the proton and of the deutron (nucleus of heavy hydrogen). For this research and the exploration of its ramifications, Rabi eventually won the Nobel Prize.

But the real world intervened—Hitler overran Europe and threatened to take over the British Isles. The United States, through a project at M.I.T.'s "Radiation Laboratory," developed a radar technology to combat German submarines that were threatening to cut off the U.S. lifeline to Britain. Zacharias contributed to the development of important submarine detecting systems. Afterward, the lab's "scientific stars" concentrated on technical issues related to winning the war with Japan. Most of them were enlisted into various aspects of the Manhattan Project. Zacharias moved to Los Alamos where the atomic bomb was being designed.

The project soon revolved around the possibility of developing an atomic bomb in time to avoid the necessity of an island-by-island march across the Pacific, eventually culminating in an invasion of Japan. Such a march, if carried out, would have involved many casualties (although, in retrospect, it is generally believed that a naval blockade of the Japanese islands would have produced a Japanese surrender, probably requiring more time but producing fewer casualties on both sides).

Dropping the atomic bomb on Hiroshima led rapidly to the Japanese surrender and the end of the war. The Nagasaki bomb was superfluous, only providing a public demonstration that the vast expenditure for the Plutonium Project had not been for nothing.

For Zacharias, myself, and the others at Los Alamos, the time had come to consider how (in the immortal words of General Groves) to "go back to your future lives." I was faced with a choice between two offers—an assistant professorship at Purdue University and an instructorship with Zacharias at M.I.T.'s newly-established Laboratory for Nuclear Science and Engineering. I chose M.I.T. and found Zacharias to be a superb leader. After getting the lab under control, his interest slowly turned to



L. BROWN

science teaching. His initial interest in teaching college physics changed when he realized that the greatest problems arose because of the very poor quality of science teaching in high school and grade school. Typically, he set about remedying these defects by organizing programs for teaching modern science to graduate and high school teachers. He was also attracted to the challenge of teaching science in the underdeveloped world, and arranged for courses training science teachers in Africa.

Summer studies were among Zacharias's favorite methods of gathering the right people to deal with specific problems and issues. It was an obvious way to attract academics, and Zacharias developed the technique to a fine art. If he wanted a colleague to participate in a summer study, that colleague would find it almost impossible to turn him down.

In all of his efforts, Zacharias had the unfailing cooperation and support of his wife Leona, who was also interested in biology its and teaching. Together they raised their small family and pursued their mutual interests with enthusiasm. Toward the end of his life, Zacharias suffered from cardiac problems, and died on December 10, 1977, while undergoing triple bypass coronary artery surgery.

Goldstein's book gives an excellent summary of the life and accomplishments of a man about whom it would be appropriate to use the old cliché: "They broke the mold after they made him." I highly recommend it. ■

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War games

Prisoner's Dilemma
by William Poundstone
Doubleday, 1992
290 pages; $22.50

LINDA GAINES

This book is a pastiche. It combines three elements: the life of John von Neumann, his development of game theory, and the application of game theory to the Cold War. Von Neumann (1903-1957) was a pioneer of the electronic digital computer, a Manhattan Project participant, and a brilliant mathematician. One of his major contributions—game theory—explores conflict situations in which opponents must make simultaneous choices in a way that optimize their payoffs.

Von Neumann was from a well-off Jewish family in Budapest, and his extraordinary abilities were recognized early. Fleeing the persecution of intellectuals and Jews in Hungary and then in Germany, von Neumann came to the United States, where, at age 30, he became a professor at Princeton University's new Institute for Advanced Study. His early contributions to mathematics were impressive, as were his later complex and crucial calculations for the Manhattan Project and then for the H-bomb.

Von Neumann genuinely feared that war with the Soviet Union would follow World War II, and he was reported to have advocated a "preventive war" against the Soviet Union before the Soviets could develop atomic weapons. He was a consultant for the RAND Corporation, the think tank that encouraged thinking about the unthinkable, and he provided important government and corporate counsel. It was at RAND that von Neumann studied and expanded the "prisoner's dilemma."

The dilemma is this: Two prisoners in solitary confinement are each offered a deal. If one testifies against the other, or "defects," he/she goes free or wins and the other gets a stiff prison sentence ("sucker payoff"). If both testify, they get intermediate sentences. If neither testifies (they "cooperate"), they receive light sentences. The dilemma occurs because each prisoner does better if he/she alone chooses to defect rather than to cooperate. But the punishment for two defections is more severe than for cooperation.

In connecting game theory to East-West relations and the bomb, the author invokes interesting people and events and provides some tantalizing hints about how this reasoning might have been used at high levels. In one possible "game," the players were the Allied and the Axis powers; the actions both sides could choose were building or not building the bomb (defecting or cooperating).

How good an analogy is the prisoner's dilemma game for the development and deployment of the bomb? How might it have been used by national security advisers? These questions are not answered. An Allied failure to develop the bomb could have resulted in losing World War II (sucker payoff). But the Allies could have lost even if nobody built the bomb, so the payoff matrix was not typical for the game. In the second and perhaps more standard application of the game, the players were the United States and the Soviet Union, and defection meant dropping the bomb.

The arms race offers another appli-