Preface

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Among the many young American scientists who were mobilized during World War II to work on the Manhattan Project was Alvin M. Weinberg. His distinguished career is celebrated in this *Festschrift* issue, contributed by his present and former associates. The very broad scope of his interests is reflected in the wide range of topics that are included.

Weinberg received his PhD degree at the University of Chicago in 1939 (at the age of 24) and began work as a mathematical biophysicist. Immediately after Pearl Harbor, he joined Eugene Wigner at the Chicago Metallurgical Laboratory, a code name that concealed the true nature of the activity, design of nuclear reactors to produce plutonium. Weinberg's initial commitment was for a part-time job to last six months. Weinberg helped develop the mathematical formulations for predicting neutron distribution in a chain reactor at a time that important phenomena such as delayed neutrons, xenon poisoning, and fast fission in ^{238}U were either poorly defined or entirely unknown. Considering the primitive state of knowledge, the Met Lab's design of the big Hanford reactors (uranium metal, graphite moderator, water cooled) was a monumental achievement. Weinberg is coholder of the U.S. patents on the original Hanford reactor, the original homogeneous reactor, the first light water reactor, and the first heavy water reactor. Weinberg and Wigner's *The Physical Theory of Neutron Chain Reactors* is the classic work in the field.

Following the war, Weinberg joined the Clinton Laboratories, later renamed the Oak Ridge National Laboratory (ORNL). He early had become interested in the possibility of using water under pressure as both the moderator and coolant of a chain reactor, and he was one of the proponents of this "pressurized-water" reactor system. Hyman Rickover, during his sojourn at the Oak Ridge Reactor School (1946) learned about the pressurized water reactor (PWR) from Weinberg; the result was the nuclear navy. This technology was also translated into the civilian power reactor industry. A forerunner of the PWR was the first really high-powered research reactor, the so-called Materials Testing Reactor (MTR), which, with a neutron flux of 2×10^{14} n/cm$^2 \cdot$s, was for many years the world's most intense neutron source. The water-moderated core of the MTR was designed at ORNL; the reactor was built at the National Reactor Test Station in Idaho.

Weinberg has also been an advocate of the so-called fluid-fuel reactor—one in which the uranium or plutonium fuel, instead of being arranged in a lattice of solid fuel elements, is dissolved in a liquid. Fluid-fuel reactors can be breeders, in which more nuclear fuel is produced (from thorium or ^{238}U) than is consumed. Fluid-fuel reactors eliminate the necessity of refabricating spent solid fuel elements in order to breed. Oak Ridge National Laboratory built fluid-fuel reactors using solutions of uranyl sulfate in water, and using solutions of uranium fluoride in molten mixtures of alkali fluorides. The liquid-metal breeder was ultimately chosen, however, and the development of fluid-fuel technology was abandoned.

Weinberg, as director of ORNL (1955-1973), wrote extensively on some of the difficult problems of public policy posed by the growth of modern science. He coined the phrase "Big Science" to describe the new kind of large-scale scientific enterprise exemplified by ORNL. He invented some other terms that are now part of the language, or at least part of the jargon used by physicists and engineers—"technological fix," "burning the rocks" (breeding based on low-grade sources of uranium and thorium), and "trans-science" (that area of science and public policy where science cannot answer questions precisely enough to satisfy the needs of public decision makers).

Weinberg had an important influence in broadening the missions at ORNL, and indirectly at the other Atomic Energy Commission laboratories. He strongly encouraged biological research on the impacts of radiation, the formation of a solid state physics division, and a fusion program at ORNL, and the application of nuclear power to seawater desalination (now practiced only in the USSR). The study of a "national environmental laboratory," headed by David Rose and Jim Liverman in the late 1960s, culminated eventually in the creation of a large multidisciplinary division (the Energy Division) intended to perform research on both social and technical issues.

He retired from ORNL to found the Institute for Energy Analysis (IEA) at Oak Ridge Associated Universities. Almost immediately he was summoned to become director of the Office of Energy Research and Development of the Federal Energy Agency in the White House. He thus became a participant in the exciting efforts of the Nixon and Ford administrations to mitigate the "energy crisis." This period of his career is described in Henry Linden's paper.

In 1975 he returned to his post as director of the IEA. Since then, Weinberg has been actively involved in the strident debate over nuclear power. Weinberg was one of the first to call attention to the requirement for social and institutional stability imposed by nuclear power. He dubbed the exchange of institutional stability for an inexhaustible energy source a "Faustian bargain," a term that has been widely used, and misused, in the debate. The IEA has been a participant in many important fields of research, reflected in part by some of the contributions to this volume.

Weinberg is currently developing an idea for winding down the nuclear arms race, with Jack Barkenbus (a political scientist at IEA). What they propose is a "defense-protected build-down," which involves the dismantling of some offensive missiles at the same time a ballistic missile defense is deployed. The number of warheads dismantled would be based on the percentage of Soviet missiles that could be knocked out during a large-scale attack. The hope is that the Soviets would reciprocate, reducing their offensive capability also as they deploy a defense.

My personal involvement with Alvin Weinberg began soon after my employment as an engineer at ORNL. He became familiar with my contributions to the fluid-fuel reactor program. He and I played violin and piano sonatas, too. I was always amazed at his detailed knowledge of what hundreds of scientists were doing in the laboratory. His understanding was displayed each year at the State of the Laboratory talks we would hear. More recently I joined the IEA to coordinate the "Second Nuclear Era" study—a study focused on the possibilities of inherently safe reactors. It has been a privilege to work directly with Alvin Weinberg. I should like to thank the many contributors to this *Festschrift* issue for their efforts, and hope that you, the reader, will gain pleasure and knowledge from your reading of it.

PARTIAL LIST OF A. M. WEINBERG'S PUBLICATIONS

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