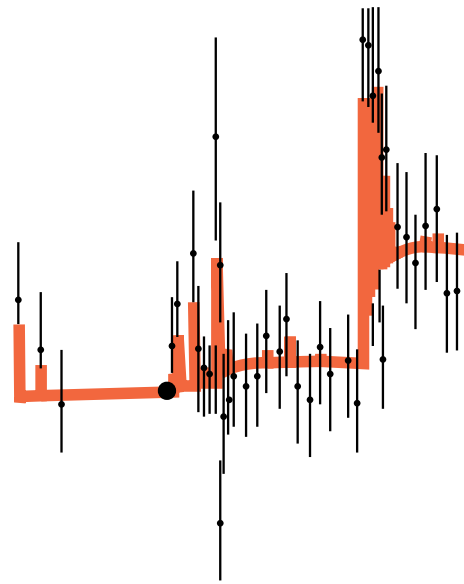
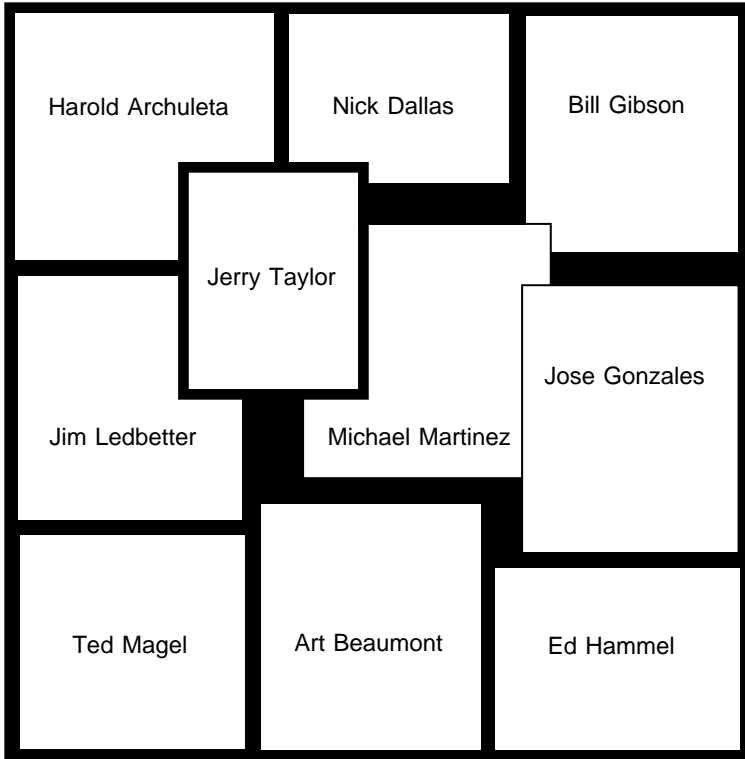


Los Alamos Science

LOS ALAMOS NATIONAL LABORATORY





On the cover are the images of ten men who have worked with plutonium and now carry measurable body burdens of this radioactive element. Some of those individuals were at Los Alamos during the days of the Manhattan Project, and some of them are here today. In this volume on radiation protection and the human radiation experiments, these men share their experiences with plutonium, the stories of their accidents, and their perspectives on the human plutonium injection experiments. We thank them for their generosity. No doubt their stories will help others who come into similar circumstances.

As much as the plutonium injection experiments were flawed from an ethical standpoint, they did provide the bulk of the data that are now used to estimate the seriousness of an accidental intake of plutonium. Those data relate the amount of plutonium excreted in the urine to the amount retained in the body. The graph (above right) shows data points for the amount of plutonium in the urine versus time for one individual. The fit to that data made using the maximum-entropy method is shown in red. Fifty-year committed doses in rem are calculated from the urine results using biokinetic models of the time-dependent distribution of plutonium in the body. Those models are based on data gathered from the plutonium injectees as well as from the tissues of deceased plutonium workers.

Because plutonium is an ongoing responsibility of this Laboratory, the protection of those who handle that dangerous material is also our ongoing responsibility. This volume is dedicated to openness and to the proper handling of our role in plutonium work.

Editor

Necia Grant Cooper

Art Director

Gloria Sharp

Science Writers

Debra A. Daugherty

Roger Eckhardt

Gerald Friedman

Jay A. Schecker

Production

Kay P. Coddens

Technical Illustration

Annmarie Dyson

Eric Vigil

Ward Zaelke

Drawings

David R. Delano

Photography

John A. Flower

Computer Art

Anita Flores

Donald Montoya

Design Assistance

Zizi Kolshorn

Historical Consultant

Roger A. Meade

Photo Services

CIC-9 Photography

Printing

Guadalupe D. Archuleta

Circulation

Kay P. Coddens

Address Mail to:

Los Alamos Science

Mail Stop M708

Los Alamos National Laboratory

Los Alamos, NM 87545

lascience@lanl.gov

Radiation Protection and the Human Radiation Experiments

Los Alamos
NATIONAL LABORATORY

Comments from the Director ii
Siegfried S. Hecker

I. Radiation, Cancer, and Risk—Three Primers

Ionizing Radiation—It's Everywhere! 1 *There are a variety of myths and misconceptions about the ionizing radiation that surrounds and penetrates us all. Dispel a few of these by taking a leisurely tour of radiation and its properties, of the natural and man-made sources of ionizing radiation, and of the way doses are calculated. End your tour by estimating your own annual dose.*
Roger Eckhardt

Radiation, Cell Cycle, and Cancer 50 *By damaging DNA and inducing genetic mutations, ionizing radiation can potentially initiate a cell on the road to cancer. We review what is currently known about regulation of cellular reproduction, DNA damage and repair, cellular defense mechanisms, and the specific "cancer-causing" genes that are susceptible to ionizing radiation.*
Richard J. Reynolds and Jay A. Schecker

Radiation and Risk: A Hard Look at the Data 90 *This rapid survey of the data on radiation effects in humans shows that high radiation doses increase the risk of cancer, whereas the effects of low doses are very difficult to detect. The hypothetical risks at low doses, which are estimated from the atomic-bomb survivors, are compared to the low-dose data so that the reader can assess the present level of uncertainty.*
Mario E. Schillaci

A Brief History of Radiation Protection Standards 116
*William C. Inkret, John C. Taschner,
and Charles B. Meinhold*

II. On the Front Lines—A Roundtable with Los Alamos Plutonium Workers Past and Present 124

The Participants

Setting the Stage in Chicago

Working with Plutonium

The Early Years—1944-1946 in D Building

Middle Years—1952-1978 at DP Site

Modern Times—1980 to the Present at TA-55

Accidents with Plutonium

Follow-up Studies, Expert Opinions, and Future Prospects

Opinions about the Plutonium Injection Experiments

As part of the openness initiative, ten individuals who have worked with plutonium during various periods in the Laboratory's history were asked to share their experiences including their accidental intakes. Their frankness, their courage, and their pride in their accomplishments are an example for all of us. The history and prognosis of people who have had plutonium exposures is discussed by the Laboratory's leading epidemiologist.

Plutonium Metal: The First Gram 162
Ed Hammel

In 1944, two participants in the roundtable above made the first plutonium sample large enough to be analyzed for its physical properties.

The Future of Plutonium Technology 168
Dana Christensen

Activities at TA-55, the Laboratory's plutonium facility, are more challenging than ever even though the cold war is over.

III. The Human Radiation Experiments

Introduction to the Human Studies Project 174

William C. Inkret

The Los Alamos Human Studies Project Team was appointed to search for and release to the public all documents relating to human radiation experiments.

The Human Plutonium Injection Experiments 176

William Moss and Roger Eckhardt

Wright Haskell Langham 1911-1972

Louis H. Hempelmann 1914-1993

During World War II and into 1947, scientists working in the Manhattan Project had 18 people injected with plutonium. Why were these experiments performed? How dangerous were they to the people who were injected with plutonium? Was consent obtained? How was the information used? How is it being used today?

Radium: The Benchmark for Internal Alpha Emitters 224

A True Measure of Plutonium Exposure: The Human Tissue Analysis Program at Los Alamos 234

James F. McInroy

Authorization and Collection of Tissue

The charge of “body-snatching” is here refuted by the leader of the tissue analysis program. The author also explains how the distribution of plutonium in deceased plutonium workers has supplemented the data from the human injection experiments and improved the estimation of risks from plutonium intakes.

The Cecil Kelley Criticality Accident:

The Origin of the Los Alamos Human Tissue Analysis Program 250

The Karen Silkwood Story: What We Know at Los Alamos 252

Tracer Studies at Los Alamos and the Birth of Nuclear Medicine 256

*George L. Voelz and Donald Petersen
as told to Debra A. Daugherty*

Child Volunteers: One Dad Tells the Story 266

Donald Petersen

Between 1950 and 1967, radioactive tracers were used in biological and medical human experiments at Los Alamos. About 130 people volunteered in these experiments. Read about the experiments themselves, the volunteers, and their doses.

Los Alamos Radiation Detectors for Biology and Medicine 274

Ethics: “Ethical Harm” and the Plutonium Injection Experiments 280

Michael S. Yesley

The Final Report of President Clinton’s Advisory Committee on Human Radiation Experiments is reviewed herein with an emphasis on ethics and informed consent.

Art and Photo Credits 282