

Invisible Exposures: The *Radium Girls* and the Origins of Accountability for Radiation Protection

Radium - Miracle or Menace?

David J. Allard, MS, CHP, FHPS

ICMGLT Webinar

May 12, 2026



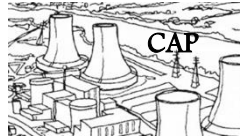
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Chairperson, TMI Unit-2 Community Advisory Panel



Retired Director, of the PA DEP Bureau of Radiation Protection



Past Chairman and Commissioner of the interstate ASLLRWC



Fellow, Past Officer, and Emeritus Member of the HPS



Past Chairperson, Board and (now) Life Member of the CRCPD

Dedication



To Richard (Dick) Toohey who studied
the Radium Dial Painters while at ANL.

November 20, 2023

Richard E. Toohey, September 2, 1945 – November 13, 2023 In Memoriam



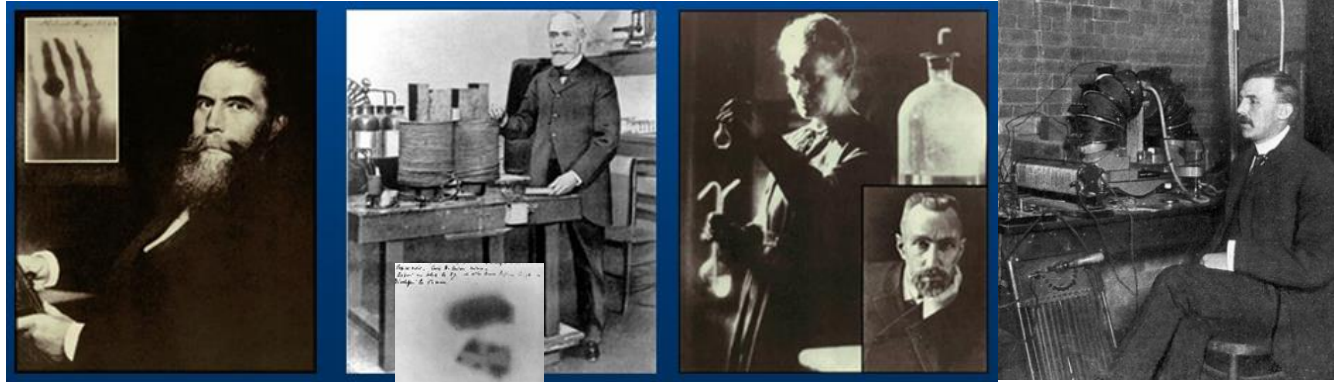
The NCRP family is deeply saddened by the passing of Richard Toohey. Dr. Toohey was a gentle giant in radiation science and a towering personality in life. He was brilliant and humble, kind and compassionate, wise and diligent, innovative and trustworthy, thoughtful and steadfast, and a friend to all of us. His accomplishments are legion from the study of radium dial painters to the Million Person Study. His leadership and mentoring were extensive and lasting, nationally with NCRP and internationally with the International Radiation Protection Association (IRPA).



Evolution of Radiological Sciences

Discovery

X rays, Radioactivity
and Radium c1900



Application

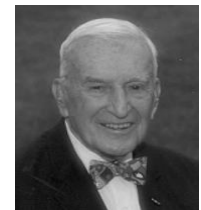
Medicine and Industry



Protection



Workers, public and
environment [ICRP 1928]





Physics & Chemistry

When Z is >82 , elements are unstable...
and **radioactive**.



Periodic Table of the Elements

1 IA 1A		2 IIA 2A												3 IIIA 3A	4 IVA 4A	5 VA 5A	6 VIA 6A	7 VIIA 7A	8 VIIIA 8A	2 He Helium 4.003
1 H Hydrogen 1.008		3 Li Lithium 6.941	4 Be Beryllium 9.012																10 Ne Neon 20.180	
11 Na Sodium 22.990	12 Mg Magnesium 24.305	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 83.798	
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294			
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [209]	86 Rn Radon 222.018			
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]			
			57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967			
			89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]			

Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetal	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide
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U-238 Decay Chain

Uranium-238 Decay Chain

U-238~98% by wt, ~50% of radioactivity
Radionuclide (half-life)

Explanation

↓ Alpha decay
 ↗ Beta decay

Uranium

U-238
 4.5×10^9 y

U-234
 2.5×10^5 y

Protactinium

Pa-234
 1.17 m

Thorium

Th-234
 24.1 d

Th-230
 7.5×10^4 y

Radium

>

Ra-226
 1600 y

Radon

Rn-222
 3.8 d

Polonium

Po-218
 3.1 m

Po-214
 1.6×10^{-4} s

Po-210
 138.4 d

Bismuth

Bi-214
 19.9 m

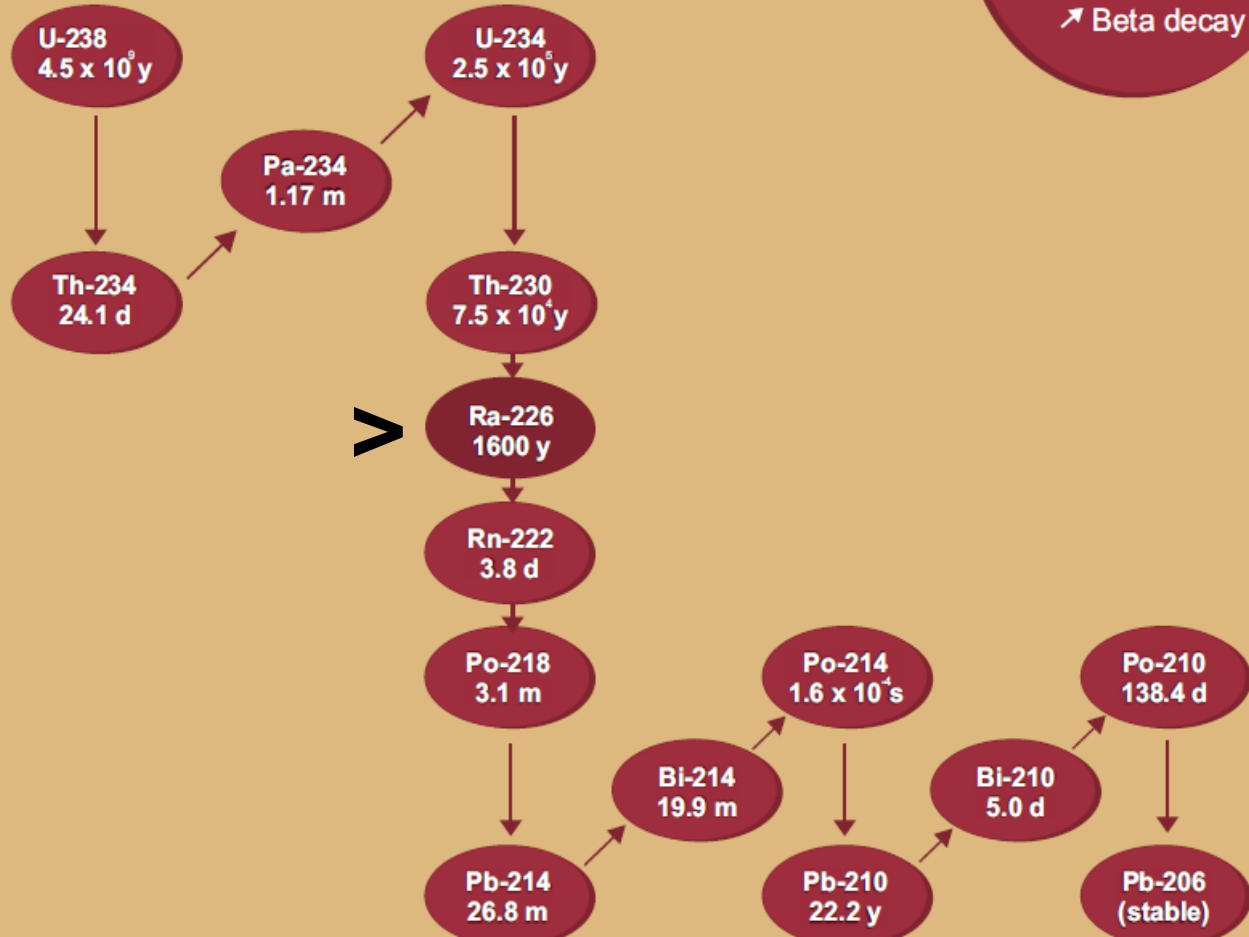
Bi-210
 5.0 d

Lead

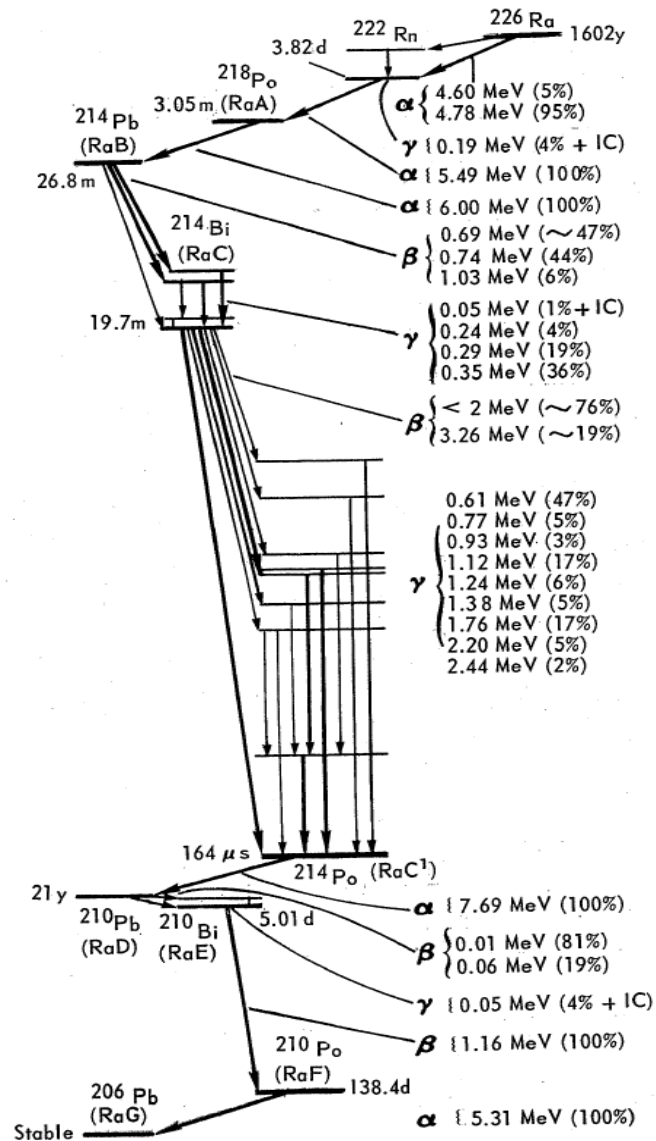
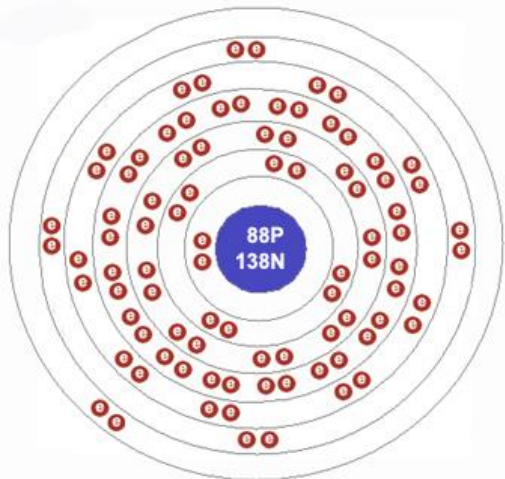
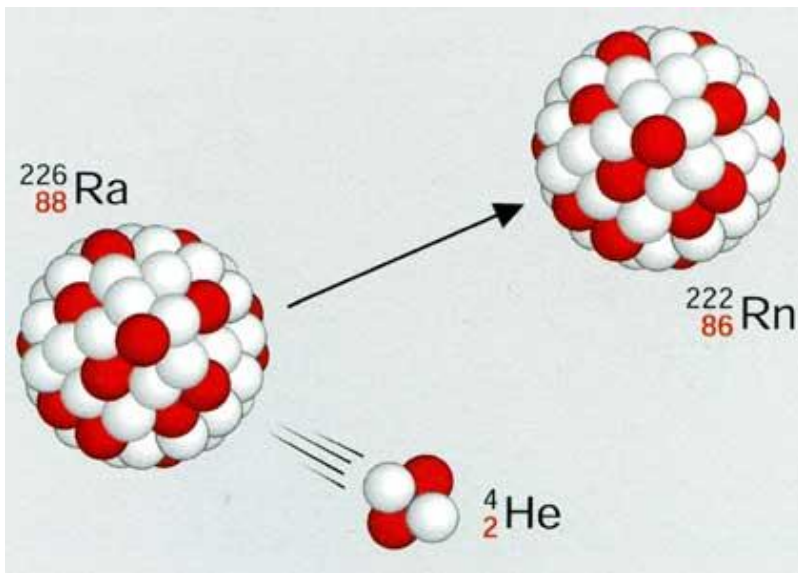
Pb-214
 26.8 m

Pb-210
 22.2 y

Pb-206
 (stable)

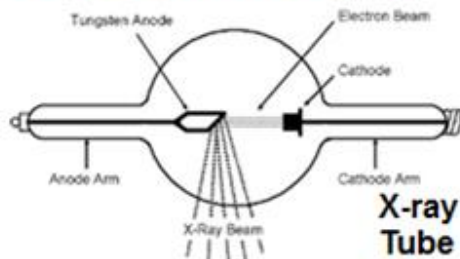
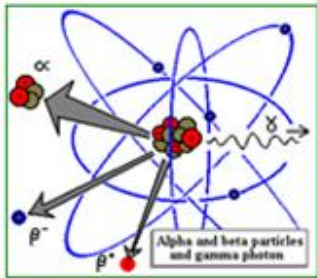


Ra-226 Decay Scheme

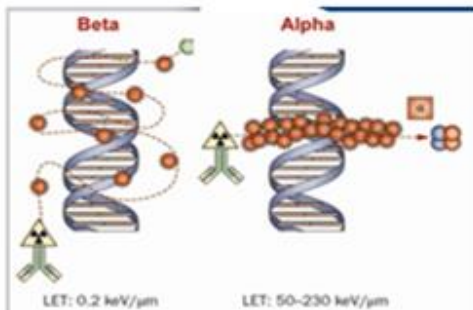
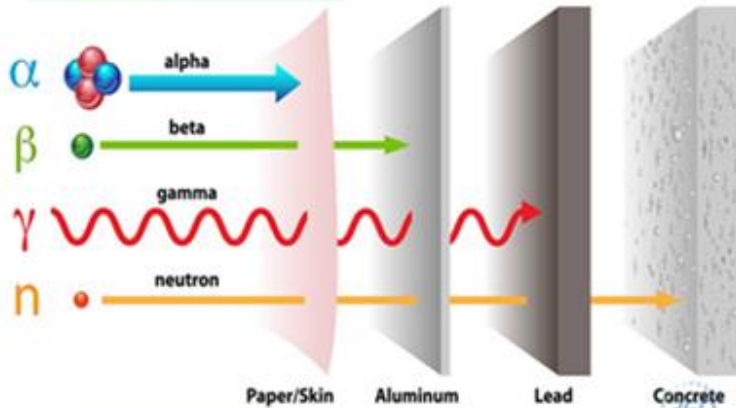
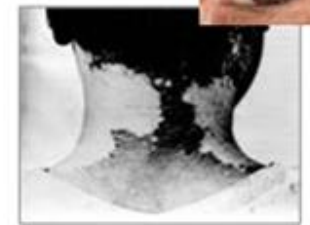


Radiation and Biological Effects

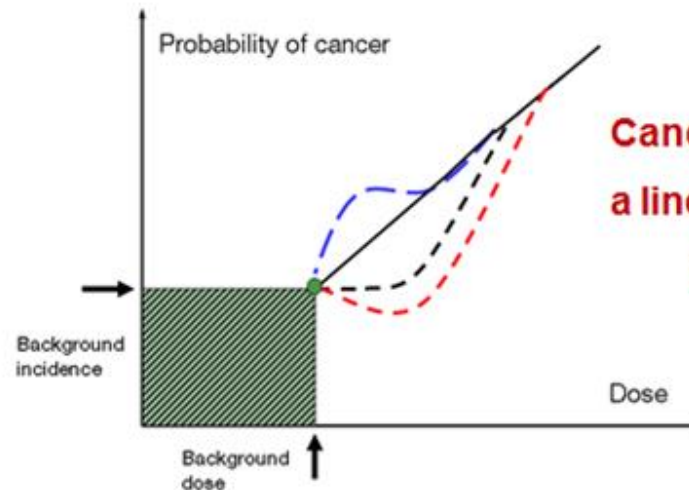
Radiation & Effects =>



Non-stochastic Effects (skin)
Stochastic Effects (cancer)



Dose-Response Relationships



Cancer – we assume a linear no threshold (LNT) model

Energy Deposition & Biological Effects

Radiation Measurement

Wt. & Temp.



Radiation Units

<u>Measure of</u>	<u>Quantity</u>	<u>Unit</u>
Amount of radioactive material	Activity	curie (Ci)
Ionization in air	Exposure	roentgen (R)
Absorbed energy per mass	Absorbed Dose	rad
Absorbed dose weighted by type of radiation	Dose Equivalent	rem
For most types of radiation		$1 R \approx 1 \text{ rad} \approx 1 \text{ rem}$

SI

Bq

C/kg

Gy

Sv

Average Radiation Exposure in US

Note: Radium-226 Decays to Radon-222

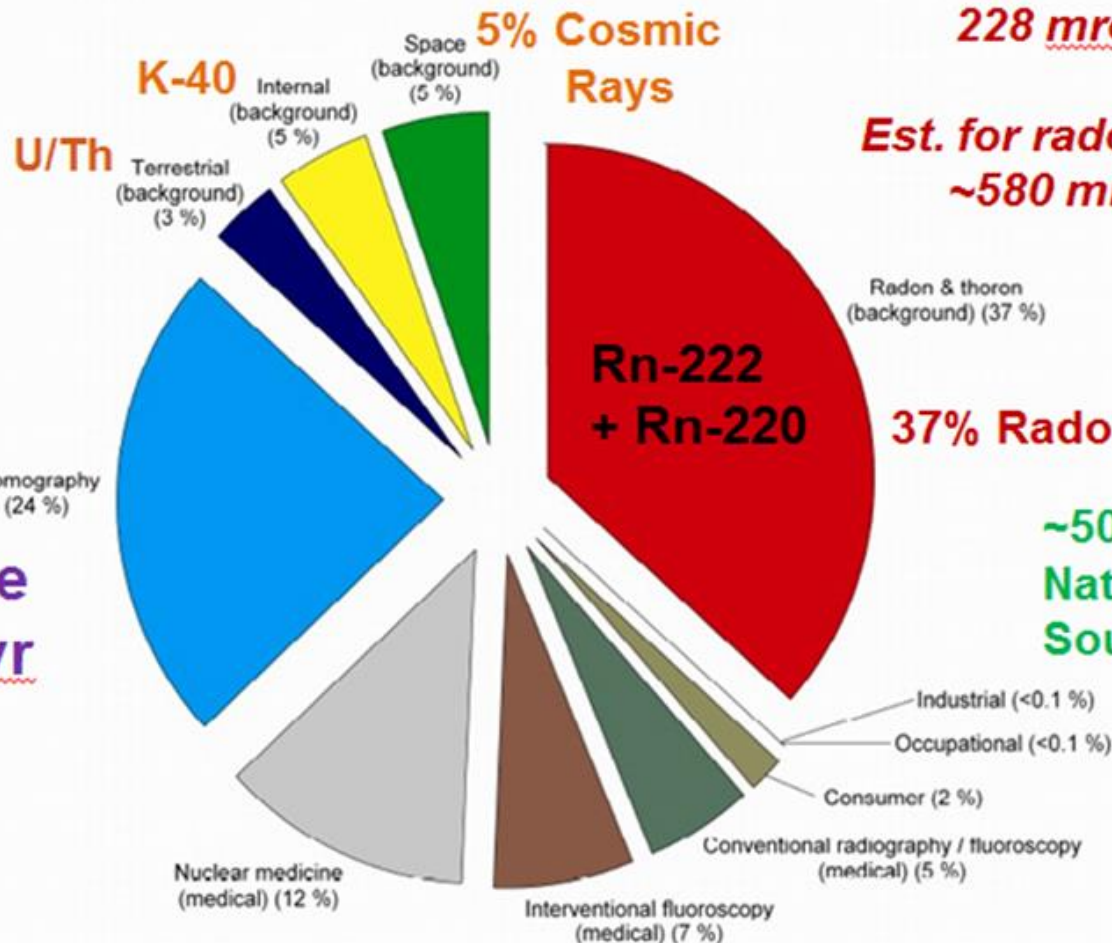
NCRP Rpt. 160



All Exposure Categories
Collective Effective Dose (percent), 2006

NOTE: average radon eff. dose in USA is 228 mrem;

Est. for radon in PA ~580 mrem



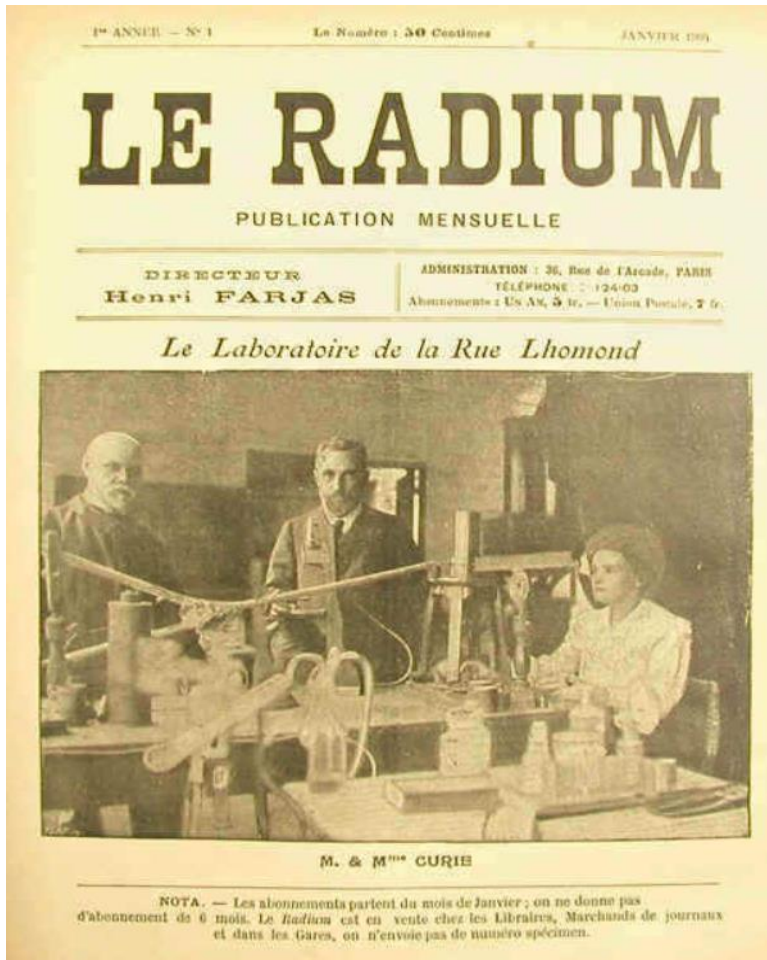
Average dose ~620 mrem/yr

~50% from Medical Sources

~50% from Natural Sources

Discovery of Po and Ra in 1898

M Curie coined the term:
'radio-active'



Vanity Fair 'Spy' Series - 1904

Book - Radium City

Radium City: A History of America's First Nuclear Industry

By Joel O. Lubenau and Edward R. Landa

About the Book

In 1921, Marie Curie, recipient of Nobel Prizes in physics and chemistry and co-discoverer of radium, visited the U.S. to receive a gift of one gram of radium from the women of America. Costing \$100,000, the gift was presented to her by President Harding at the White House. A Pittsburgh enterprise, Standard Chemical Company, founded by James J. and Joseph M. Flannery, produced the radium. After receiving the gift, Marie Curie travelled to western Pennsylvania to see the company's and radium production and refining plants.

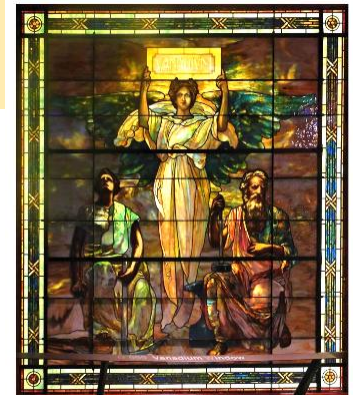
“Radium City” is the story of how the two brothers, undertakers-turned-industrialists, founded the first and largest American company to produce radium and the company's legacies.

<https://www.heinzhistorycenter.org/research/publications/>

<https://www.heinzhistorycenter.org/wp-content/uploads/2022/08/Radium-City.pdf>

**RADIUM
CITY**
**A HISTORY OF
AMERICA'S FIRST
NUCLEAR INDUSTRY**

JOEL O. LUBENAU
&
EDWARD R. LANDA




M Curie in Philadelphia May 1921



The College of Physicians of Philadelphia
BIRTHPLACE OF AMERICAN MEDICINE®

THE MÜTTER MUSEUM
of The College of Physicians of Philadelphia

Centennial of Marie Curie's Visit to The Philadelphia College of Physicians



The College of Physicians
of Philadelphia

A Special Meeting will be held on Monday
Evening, May 23, 1921, at 8.30

MADAME MARIE CURIE, OF PARIS
will present to the College a Quartz Piezo Electric Apparatus, designed and
used by her in her earlier research work for measuring
the radio-activity of radium.

DR. ROBERT ABBE, OF NEW YORK
will present Mementoes of Lord Lister and Louis Pasteur, with a Custodian-
ship Case for Their Permanent Preservation.

PROFESSOR ARTHUR W. GOODSPEED,
PROFESSOR JOHN G. CLARK
AND PRESIDENT M. CAREY THOMAS, OF BRYN MAWR, will speak.

*As the capacity of Mitchell Hall is limited, admission will only be by
presentation of this card.*



MARIE CURIE
COLLEGE CENTENNIAL

May 23, 2021

THE MÜTTER MUSEUM
of The College of Physicians of Philadelphia



<https://www.youtube.com/watch?v=QqfD9dYNnFM>

Cancer Treatment c1935

X-RAY

RADIUM

SURGERY

THE THREE RECOGNIZED TREATMENTS FOR CANCER

CONSULT YOUR DOCTOR OR HEALTH BUREAU

WPA FEDERAL ART PROJECT

The majority of cancers
-in early stages- can be
successfully and completely
removed or destroyed by
Surgery, X-rays or Radium

SPREAD the encouraging findings about cancer: Too many people can see only the dark side of cancer.

There is a widespread and mistaken belief that cancer is incurable and that nothing can be done to stop its destructive progress. Such belief leads people, who have reason to suspect its presence, to delay having an examination—until it is too late.

Another reason why cancer often gains headway is because in its first stages it is usually painless and therefore disregarded.

Wounds that refuse to heal—warts, moles, scars and birthmarks that change in size or color or become scaly—abnormal lumps or strange growths under the skin in the breast and elsewhere—unnatural discharges—all call for immediate action.

Jagged or broken teeth should be smoothed off or removed. Continued irritation of the tongue or any other part of the body is often the beginning of cancer. When any one of the first signs of cancer is discovered, there is no time to lose. If an early discovery is made, the probabilities are that surgery, X-rays, or radium can effect complete recovery.


Cancer is neither contagious nor hereditary, although the history of the disease shows that certain types of individuals and certain families are more susceptible to cancer than others.

Some forms of cancer are obscure and can be detected only by a physician who has had long experience with the disease, but many of the ordinary first symptoms would almost surely be discovered in a thorough periodic health examination.

Tell people that cancer in its first stages can usually be entirely removed or totally destroyed. Help to save lives.

METROPOLITAN LIFE
INSURANCE COMPANY

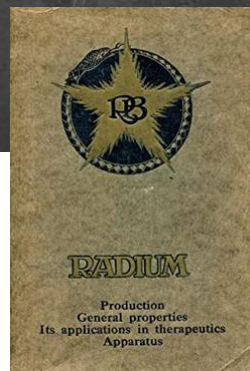
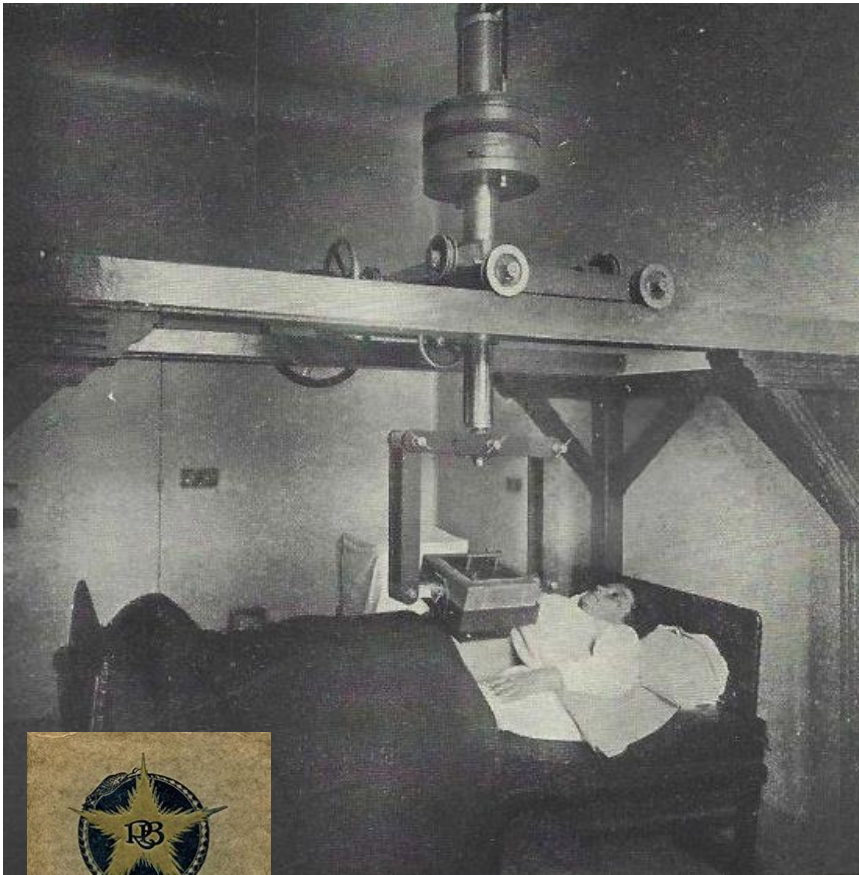
FREDERICK H. ECKER,
PRESIDENT



CANADIAN
HEAD OFFICE
OTTAWA

SERVING CANADA SINCE 1872

Early Reference Books on Radium



^ Radium Bomb

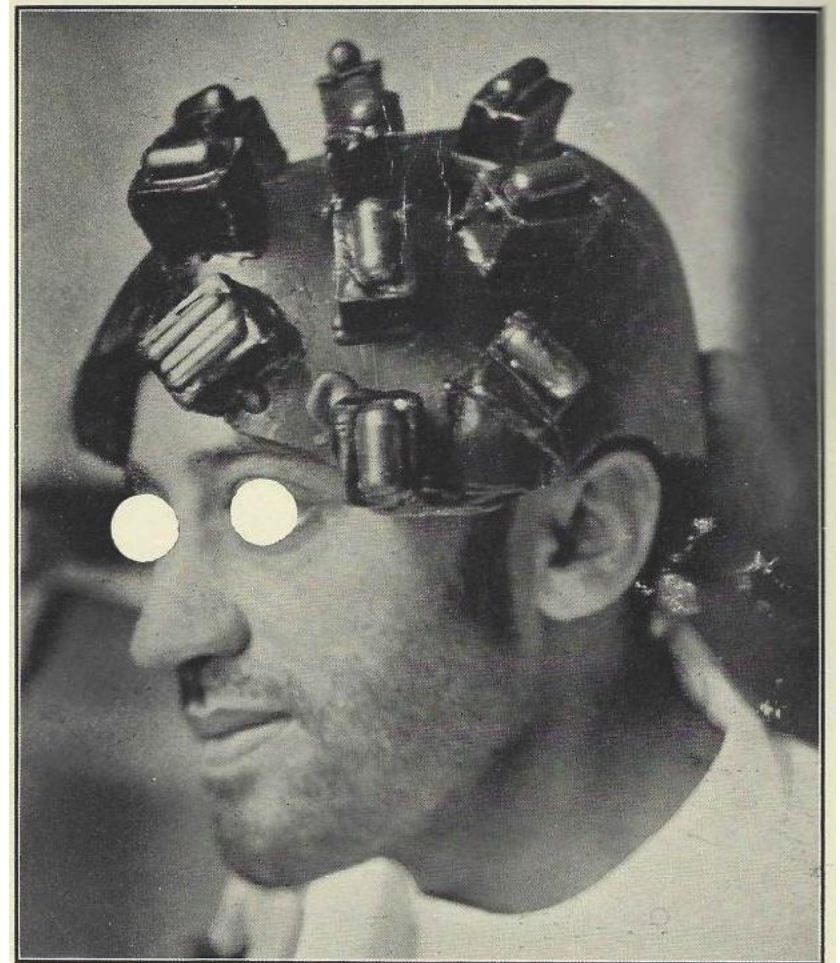


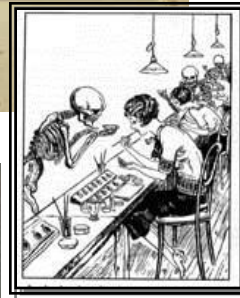
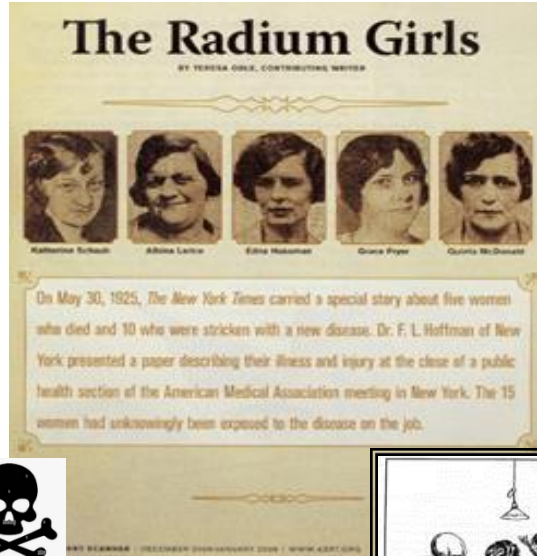
Fig. 119. — Surface applicator for treatment of a cerebral tumour.

US Radium (NJ) & Luminous Paint

NJ Radium Girls >



**Hammer
1902**



von Sochocky

1915



US Radium (NJ)



US Radium Paint Application Building, 2nd floor, 1998
Insert: Dial Painters in same room, 1922



US Radium Corporation site in Orange, NJ, 1998

**US EPA
Superfund
Site, ~\$40M**

Figure 19. Dr. Sabir Arnold von Sochocky

Radium Dial Painters in NJ

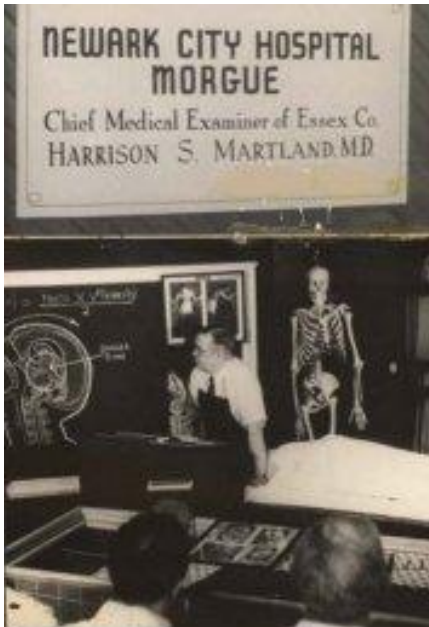
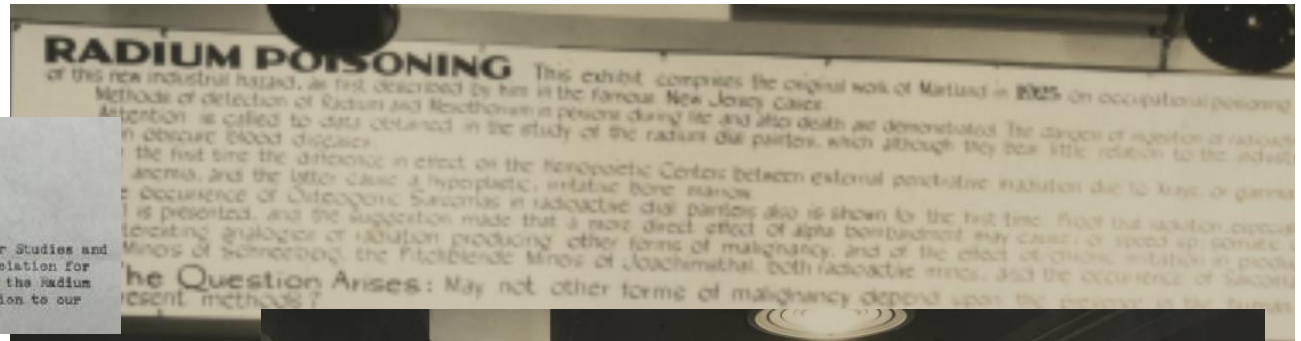
Dr. Harrison S. Martland

OAK RIDGE INSTITUTE OF NUCLEAR STUDIES
INCORPORATED
P. O. BOX 117
OAK RIDGE, TENNESSEE
April 29, 1949

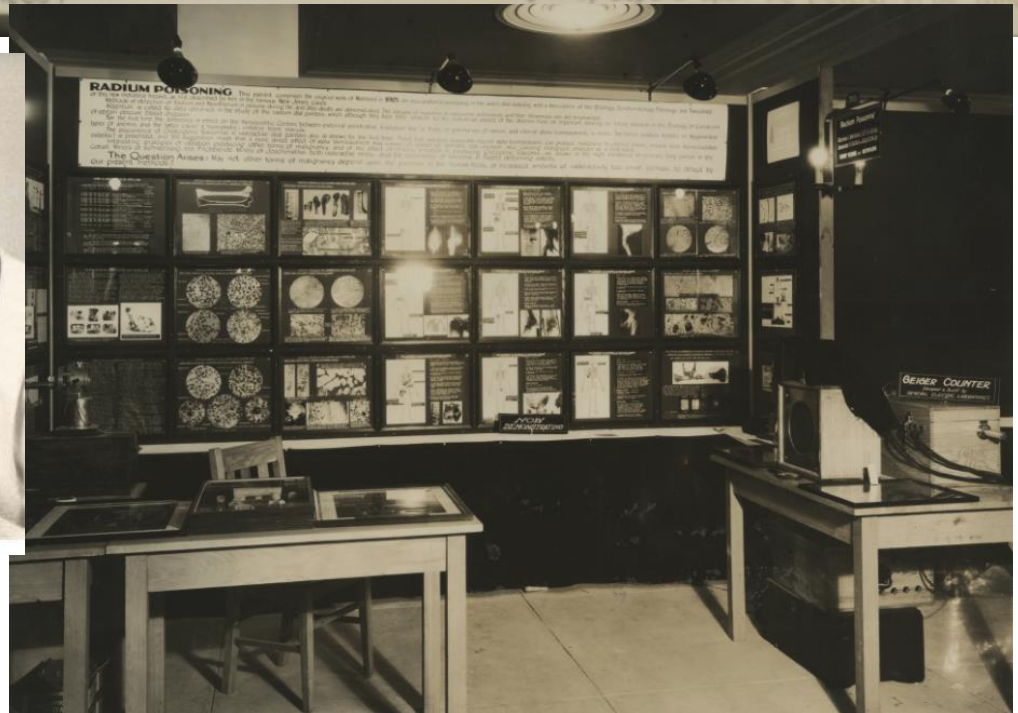
Dr. Harrison S. Martland
Chief Medical Examiner
Essex County, New Jersey

Dear Dr. Martland:

On behalf of the Oak Ridge Institute of Nuclear Studies and this Museum, I want to express our thanks and appreciation for the very fine historical and documentary records of the Radium Dial Workers. This constitutes an invaluable addition to our medical exhibits.



Harrison S. Martland, MD, ca. 1940



Radium Industry in IL

Radium Girls in Ottawa, IL (c1935)



Photographed by Duane and Tracy Marsteller, July 10, 2022

<https://www.hmdb.org/m.asp?m=202329>

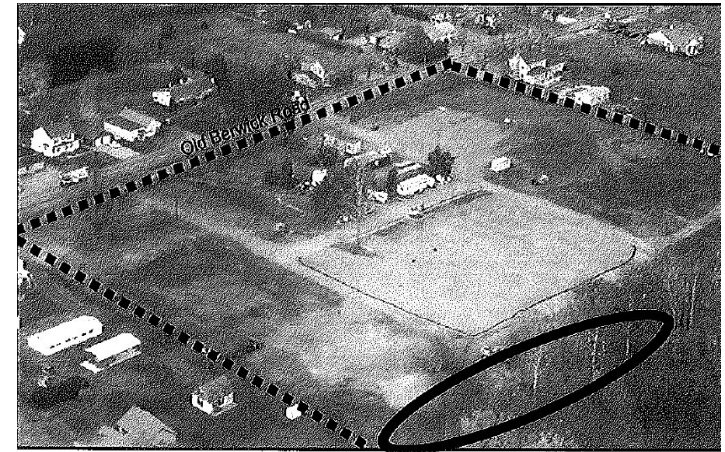
Major EPA Superfund Rad Cleanup

US Radium / SLC Site in Bloomsburg, PA



c2001 ^

c2002 >



2015/16 "waste dumps" ^

Silo Waste Forms



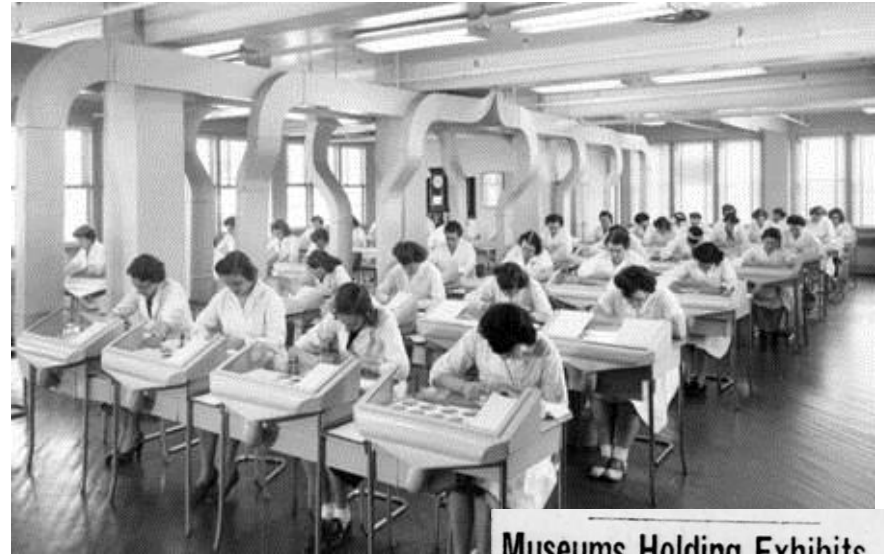
Onsite: Ra-226, H-3, Cs-137, Sr-90, Am-241

Early Radium Industry

US Radium in PA (c1955) >



Ra Appl. Co. (CA), c1928
Radon Breath Analysis



- Watch & Clock Faces
- Aircraft Gauges
- Industrial Radiography
- Static Eliminators
- Misc. of Devices

Museums Holding Exhibits To Explain Uses of Radium

As part of an educational campaign being conducted by 13 leading institutions of the state, the Erie Public Museum, Allegheny College and the Carnegie Museum here are exhibiting carnotite ore containing radium, instruments for the use of radium and pictures explaining its derivation. The exhibit is part of an effort to explain to the public the value and use of radium in therapeutic and illuminative uses.

Ra Mus. Exhibit (PA), 1922 ^

Radium Studies at MIT and ANL

ANL/ER-3

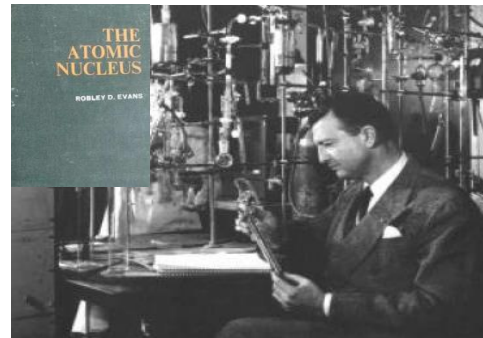
Radium in Humans

A Review of U.S. Studies

R.E. Rowland
Argonne National Laboratory

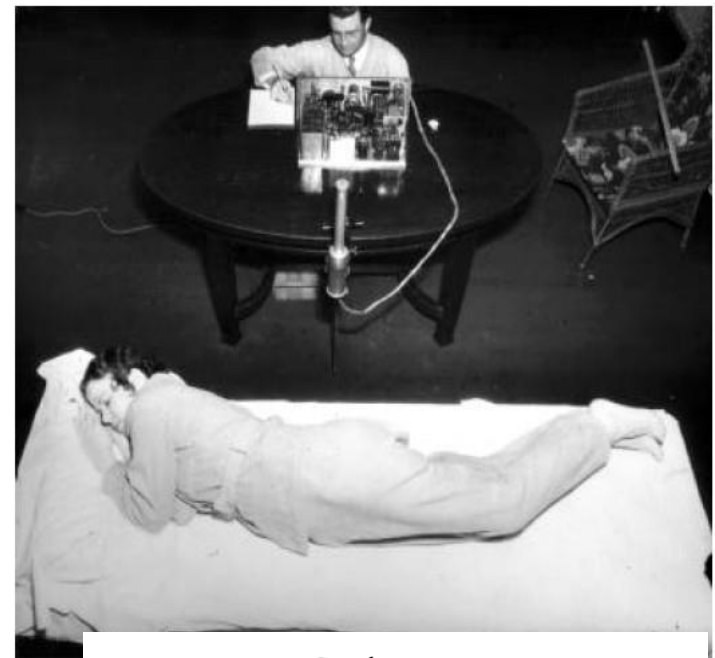


The photograph above shows the breathalyzer test used by Evans to measure the amount of radon being exhaled per second. That amount turned out to be about 50 per cent of the total radon produced per second and thus reflected about 50 per cent of the total radium body burden.



In Vivo Measurements of Radium

The technique by which Evans measured the *in vivo* radium body burden required two measurements, one involving the rate at which radon is expired in the breath and another involving the intensity of gamma rays emitted from the body. Together, these two measurements provided all the information that was needed to determine the amount of radium in a patient's body.



Volume XXIII

October, 1933

Number 10

Radium Poisoning A Review of Present Knowledge

ROBLEY D. EVANS, PH.D.

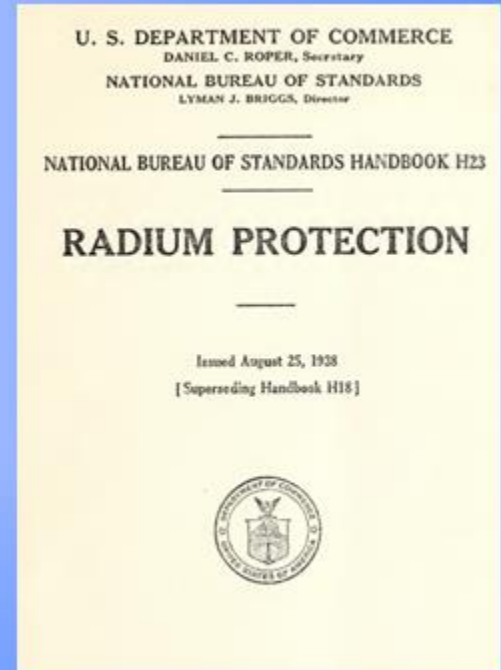
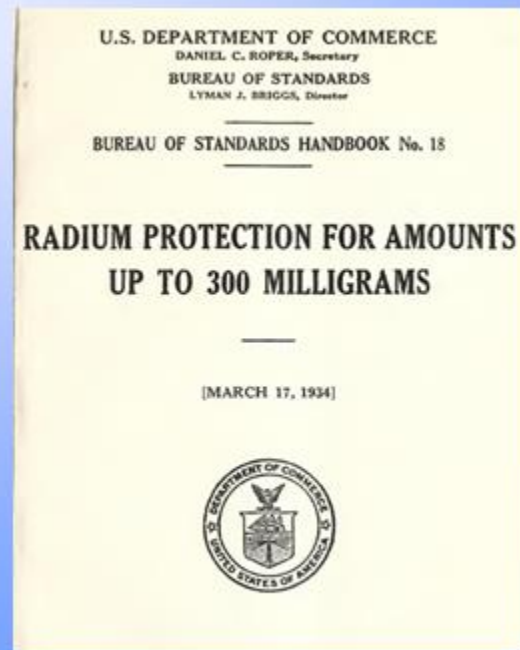
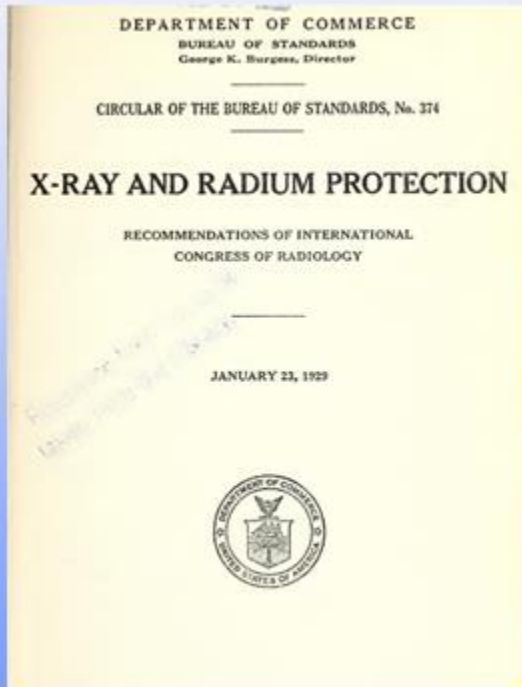
National Research Fellow, Physics Department, University of California,
Berkeley, Calif.



<https://publications.anl.gov/anlpubs/1994/11/16311.pdf>

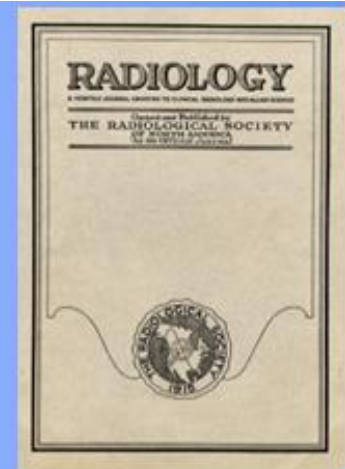
Evolution of Radiation Standards

Focus on external hazards from Ra-226, and thresholds to prevent such effects.



Internal Radiation Exposure

Ra-226, no limits for internal intake.



JANUARY 23, 1929

ABSTRACT

The X-ray and radium protection proposals that were adopted by the Second International Congress of Radiology are given in their final form. The section of the 1928 National Electrical Code, dealing with X-ray and high-frequency apparatus is also given. The first set of recommendations are effective until the next congress in 1931.

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X-RAY AND RADIUM PROTECTION

3

I. RECOMMENDATIONS ADOPTED BY THE SECOND INTERNATIONAL CONGRESS OF RADIOLOGY, JULY, 1928

1. The dangers of overexposure to X rays and radium can be avoided by the provision of adequate protection and suitable working conditions. It is the duty of those in charge of X-ray and radium departments to ensure such conditions for their personnel. The known effects to be guarded against are: (a) Injuries to the superficial tissues, (b) derangements of internal organs and changes in the blood.

Radiation Protection (RP) in USA

History of Radiation Protection standards and regulation in the U.S.

Review Article

U.S. radiation protection regulation, recommendations, and standards ● C. G. Jones

7

A REVIEW OF THE HISTORY OF U.S. RADIATION PROTECTION REGULATIONS, RECOMMENDATIONS, AND STANDARDS

Cynthia G. Jones*

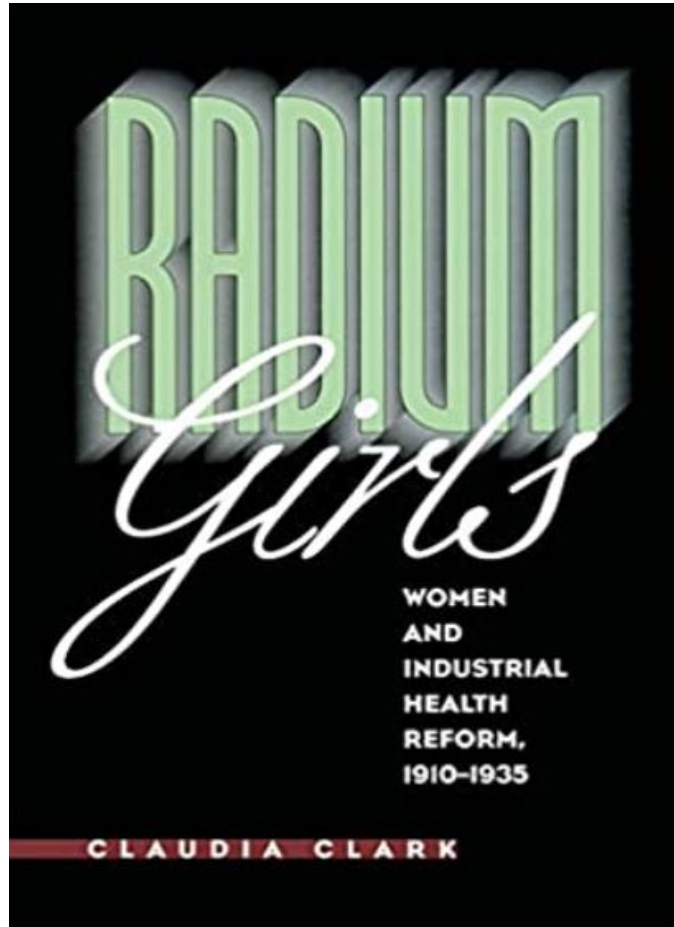
Abstract—Shortly after the discovery of x rays by Wilhelm Konrad Roentgen in 1895, and the isolation of the element radium by Pierre and Marie Curie three years later, the fascination with and potential for an array of uses of ionizing radiation in medicine, science, and technology was born. As with any new technology, there was a need to balance both the beneficial and potential detrimental effects of uses of these new technologies for the advancement of humankind. In the early days, radiation hazards were not well understood. Over the decades increasing concerns in the scientific community and lay population demanded that standardized guidance and recommendations be developed for the use of ionizing radiation. Today, U.S. radiation protection standards and recommendations to protect the occupational worker, members of the general public, and the environment are numerous and complex. This review summarizes the history of the development and application of radiation protection standards and regulations to assure the safe use of radiation and radioactive materials. The evolution and roles of international and national scientific recommending and regulatory organizations that shape U.S. radiation protection policy are described and discussed.

Health Phys. 88(6):697–716; 2005

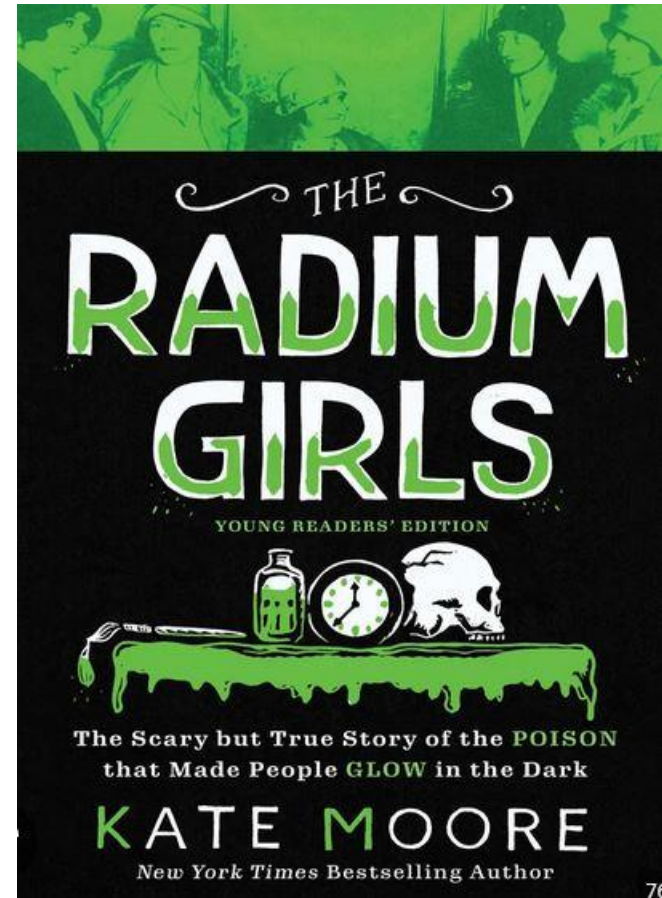
Table 1. Selection of relevant radiation protection guidance and regulations from 1957 to present.

Year	Federal Agency	Document
1957	Atomic Energy Commission (AEC)	Basic Standards for Radiation Protection (10 CFR Part 20)
1960	Federal Radiation Council (FRC)	Presidential Federal Guidance on Occupational and Population Radiation Exposures
1961	FRC	Federal Guidance on Limiting Certain Internal Radiation Exposures
1964	FRC	Federal Protective Action Guides for I-131
1965	FRC	Federal Protective Action Guides for Sr-89, Sr-90, and Cs-137
1967	FRC	Presidential Guidance for the Control of Radiation Hazards in Uranium Mining
1969	FRC	Federal Guidance on Radon Exposures in Uranium Mines
1971	Occupational Health & Safety Administration (OSHA)	OSHA Ionizing Radiation Protection Standards (29 CFR Part 1910.96) (U.S. Department of Labor 1970)
1973	Food & Drug Administration (FDA)	Performance Standards for Ionizing Radiation Emitting Products (21 CFR Part 1020)
1976	U.S. Environmental Protection Agency (U.S. EPA)	U.S. EPA Interim Drinking Water Standards for Radionuclides (40 CFR Part 141)
1976	U.S. EPA	Radiation Protection Guidance for Diagnostic X-Rays (Federal Guidance Report No. 9)
1977	U.S. EPA	Environmental Protection Standards for Nuclear Power Operations (40 CFR Part 190)
1978	U.S. EPA	Presidential Federal Guidance on Diagnostic X-Ray Exposures
1981	U.S. Nuclear Regulatory Commission (U.S. NRC)	Requirements for Disposal of High-Level Radioactive Waste in Geologic Repositories (10 CFR Part 60)
1982	U.S. NRC	Requirements for Land Disposal of Low-Level Radioactive Waste (10 CFR Part 61)
1982	U.S. EPA	Advisory for Protective Action Guides for Radioactive Contamination in Food
1984	U.S. EPA	The Radioactivity Concentration Guides (Federal Guidance Report No. 10)
1985	U.S. EPA	Air Emission Standards for Radionuclides (40 CFR Part 61)
1991	U.S. NRC	Basic Standards for Protection Against Radiation—Final Rule (10 CFR Part 20)
1987	U.S. EPA	Presidential Federal Guidance on Limiting Occupational Radiation Exposures
1988	U.S. EPA	Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion (Federal Guidance Report No. 11)
1989	U.S. EPA	National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61)
1991	U.S. EPA	Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (U.S. EPA-400-R-92-001)
1993	U.S. Department of Energy (U.S. DOE)	Occupational Radiation Protection—Final Rule (10 CFR Part 835)
1993	U.S. EPA	External Exposure to Radionuclides in Air, Water, and Soil (Federal Guidance Report No. 12)
1999	U.S. EPA	Cancer Risk Coefficients for Environmental Exposure to Radionuclides (Federal Guidance Report No. 13)
2001	U.S. EPA	Public Health and Environmental Radiation Standard for Yucca Mt., NV (Energy Policy Act of 1992)
2001	U.S. NRC	Disposal of High-Level Waste in Geologic Repositories (10 CFR Part 60)

“Radium Girls” Books

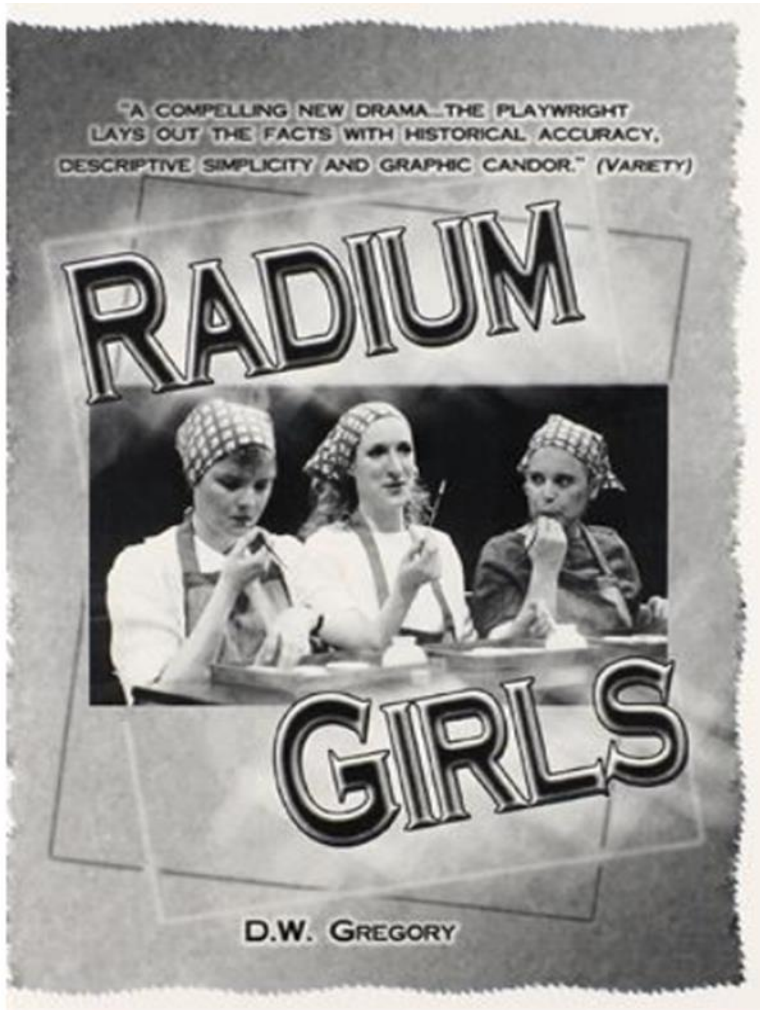


1997



2017

“Radium Girls” Play by D.W. Gregory



Radium Girls written
by **D.W. Gregory** May 2000



D.W. Gregory is best known for RADIUM GIRLS, her most produced play, with nearly 3,000 productions throughout the U.S. and abroad. She is currently developing a musical version with composer Steven M. Alper and lyricist Sarah Knapp.

Ongoing Radium Studies

Volume 150, Issue 5s
1 November 1998



< Previous Article Next Article >

RESEARCH ARTICLE | NOVEMBER 01 1998

Studies of U.S. Radium Dial Workers: An Epidemiological Classic

Shirley A. Fry

Radiat Res (1998) 150 (5s): S21-S29.

<https://doi.org/10.2307/3579805>

Share

Tools

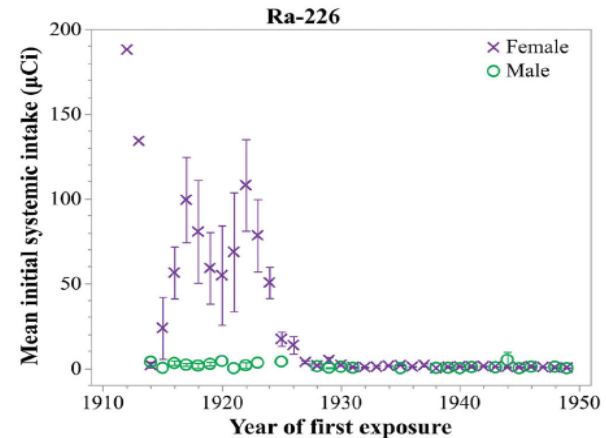
The tragic history of the exposure during the second and third decades of this century in the United States of radium dial workers, patients and members of the public to ionizing radiation from internally deposited isotopes of radium is well documented. Recognition of abnormal health outcomes among female dial workers and determination of a causal association between these outcomes among the workers and their exposure to radium leading to the development of protection standards is a classic example of an epidemiological process whereby knowledge and understanding of "the distribution and determinants of disease" evolve. Health effects studies involving U.S. female dial workers began in the early 1920s and continued into the present decade. These studies are discussed in the context of the epidemiological process whereby cause-effect relationships may be postulated, evaluated and refined to the benefit of workers and the general public.

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Radium dial workers: back to the future

By Nicole E. Martinez, et al.



ABSTRACT

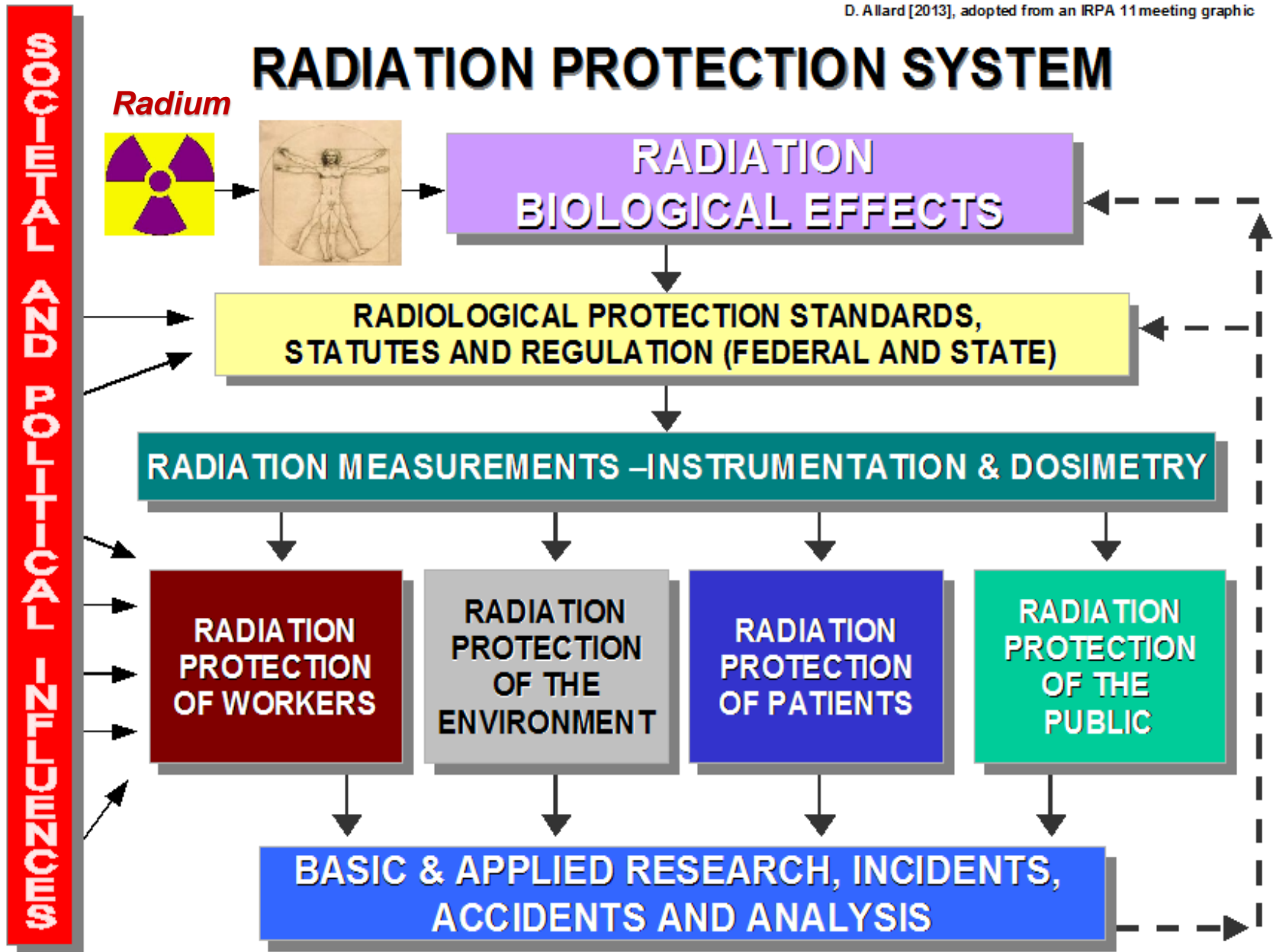
Purpose: This paper reviews the history of the radium dial workers in the United States, summarizes the scientific progress made since the last evaluation in the early 1990s, and discusses current progress in updating the epidemiologic cohort and applying new dosimetric models for radiation risk assessment.

Background: The discoveries of radiation and radioactivity led quickly to medical and commercial applications at the turn of the 20th century, including the development of radioluminescent paint, made by combining radium with phosphorescent material and adhesive. Workers involved with the painting of dials and instruments included painters, handlers, ancillary workers, and chemists who fabricated the paint. Dial painters were primarily women and, prior to the mid to late 1920s, would use their lips to give the brush a fine point, resulting in high intakes of radium. The tragic experience of the dial painters had a significant impact on industrial safety standards, including protection measures taken during the Manhattan Project. The dial workers study has formed the basis for radiation protection standards for intakes of radionuclides by workers and the public.

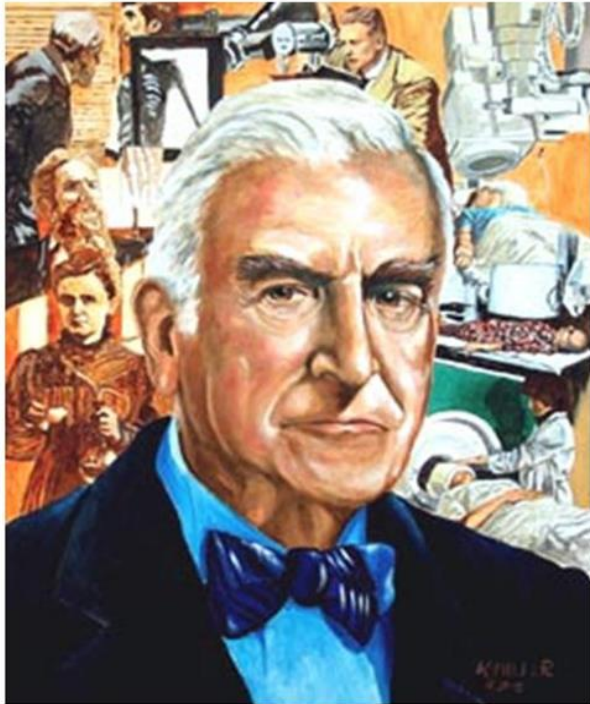


Link to 2021 article above: <https://doi.org/10.1080/09553002.2021.1917785>

RADIATION PROTECTION SYSTEM



➤ NCRP - Lauriston S. Taylor



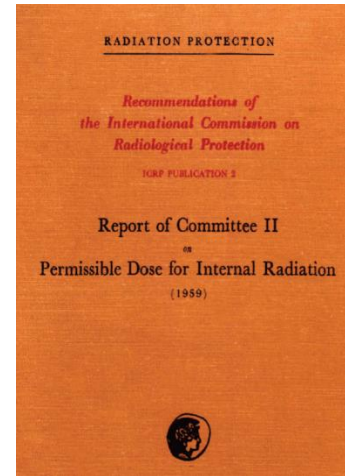
Taylor painting by Ken Miller

“Radiation protection is not only a matter of science. It is a problem of philosophy, and morality, and the utmost wisdom.”

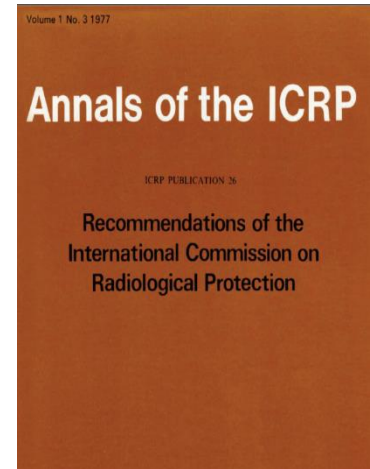
(L.S. Taylor, 1956)

ICRP RP Recommendations

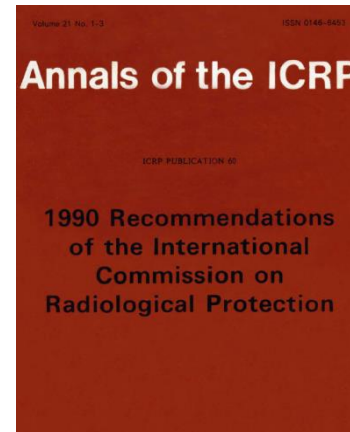
- **Justification**
 - **Optimization [ALARA]**
 - **Limitation**
- > **Existing Conditions**
- > **Planned Scenarios**
- > **Emergencies**



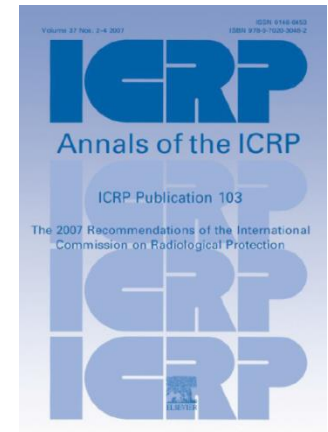
ICRP 2



ICRP 26/30



ICRP 60



ICRP 103

Radiation Protection in USA

Radiation Control in PA



**DEP: X rays,
Accelerators,
Radon, and
Radioactive
Materials &
Emerg. Prep.**

▶ RP Regulations, Limits & Standards

- Public** 100 mrem/yr; 500 mrem/yr; 3 mrem/yr from a NPP
25 mrem/yr any one source, LLRW disposal, and clean-ups
4 mrem/yr [drinking water], 5 pCi/L Ra-226 plus Ra-228
4 pCi/L 'action level' for radon in home, business & school
- Patients** very few dose limits; e.g., 300 mrad per view with mammography
- Worker** 5,000 mrem/yr whole body
15,000 mrem/yr lens of eye
50,000 mrem/yr skin / extremity / organ
- Worker's embryo / fetus** 500 mrem; and less than
50 mrem/month (none for patient's fetus)
- Emergency Workers** 5,000 to 25,000 mrem (can allow >25,000 mrem, if planned for life saving or securing critical property.)

Note: always keeping doses 'as-low-as-reasonably-achievable' [ALARA]

Future of Radiation Protection

The EO 14300, Section 5(b) Regarding the LNT Model and ALARA...

Look for NRC proposed regs in late June 2026!

Federal Register / Vol. 90, No. 102 / Thursday, May 29, 2025 / Presidential Documents

22587

Executive Order 14300 of May 23, 2025

Sec. 5. *Reforming and Modernizing the NRC's Regulations.* The NRC, working with its DOGE Team, the Office of Management and Budget, and other executive departments and agencies as appropriate, shall undertake a review and wholesale revision of its regulations and guidance documents, and issue notice(s) of proposed rulemaking effecting this revision within 9 months of the date of this order. The NRC shall issue final rules and guidance to conclude this revision process within 18 months of the date of this order. In conducting this wholesale revision, the NRC shall be guided by the policies set forth in section 2 of this order and shall in particular:

Future of Radiation Protection

The EO 14300, Section 5(b) Regarding the LNT Model and ALARA...

Look for NRC proposed regs in late June 2026!

Federal Register / Vol. 90, No. 102 / Thursday, May 29, 2025 / Presidential Documents

22587

Executive Order 14300 of May 23, 2025

Sec. 5. *Reforming and Modernizing the NRC's Regulations.* The NRC, working with its DOE Team, the Office of Management and Budget, and other

(b) Adopt science-based radiation limits. In particular, the NRC shall reconsider reliance on the linear no-threshold (LNT) model for radiation exposure and the “as low as reasonably achievable” standard, which is predicated on LNT. Those models are flawed, as discussed in section 1 of this order. In reconsidering those limits, the NRC shall specifically consider adopting determinate radiation limits, and in doing so shall consult with the Department of Defense (DOD), the Department of Energy (DOE), and the Environmental Protection Agency.

Medical Radiation Therapy Today

Radiation Therapy (close)



< Ir-192 HDR Brachytherapy

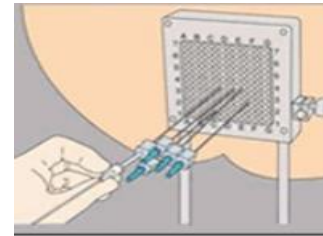
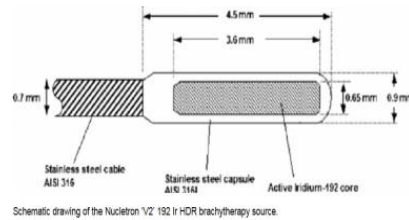
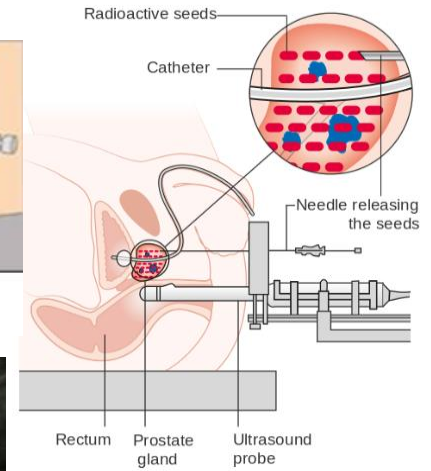
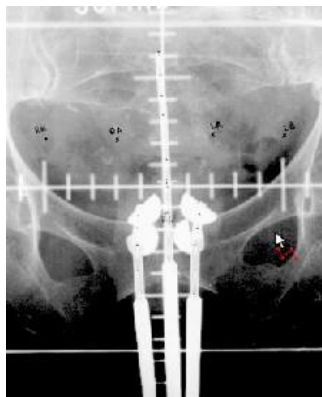


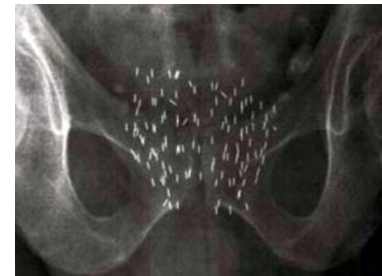
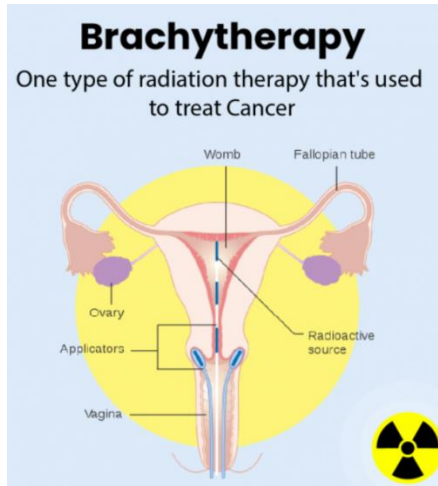
Figure 4: Implanting the seeds
A grid helps guide the needles



I-125 or Pd-103 seeds



Cs-137 LDR Brachytherapy (LDRB) c1975



LRDB

Ophthalmic RT for uveal melanoma >



Medical Radiation Therapy Today

Radiation Therapy



< Photon
& electron

Proton >

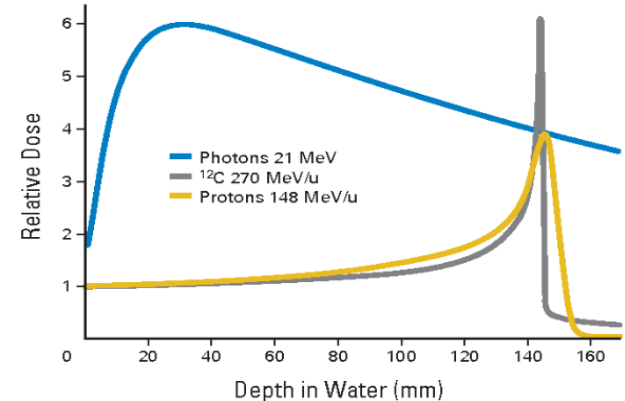


^ Superficial X-ray
radiation therapy

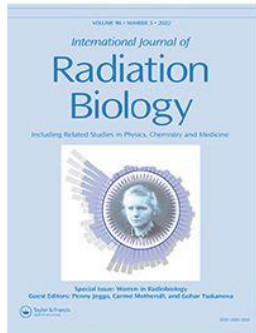


Hitachi, Ltd. announced that its heavy ion beam therapy system has started treatment at Osaka Heavy Ion Therapy Center as of October 16. This marks the first operation of Hitachi's first heavy ion therapy system.

< Future – Heavy Ion?



The Legacy of M Curie and Radium



International Journal of Radiation Biology

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/irab20>

The enduring legacy of Marie Curie: impacts of radium in 21st century radiological and medical sciences

Rebecca Abergel, John Aris, Wesley E. Bolch, Shaheen A. Dewji, Ashley Golden, David A. Hooper, Dmitri Margot, Carly G. Menker, Tatjana Paunesku, Dörthe Schaeue & Gayle E. Woloschak

To cite this article: Rebecca Abergel, John Aris, Wesley E. Bolch, Shaheen A. Dewji, Ashley Golden, David A. Hooper, Dmitri Margot, Carly G. Menker, Tatjana Paunesku, Dörthe Schaeue & Gayle E. Woloschak (2022) The enduring legacy of Marie Curie: impacts of radium in 21st century radiological and medical sciences, *International Journal of Radiation Biology*, 98:3, 267-275, DOI: [10.1080/09553002.2022.2027542](https://doi.org/10.1080/09553002.2022.2027542)

To link to this article: <https://doi.org/10.1080/09553002.2022.2027542>

Conclusion

The discovery, production, and use of radium impacted the health of many workers and members of the public before its ill effects were fully understood.

However, radium and other radioactive materials have also been used safely for decades to treat and cure cancer in medicine. They are used in research and industry, as well as being of significant value to society!

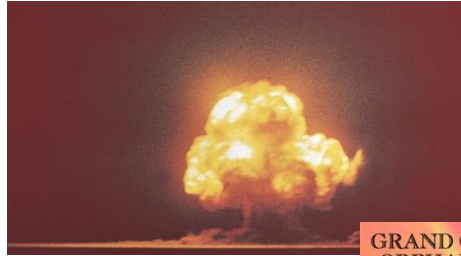
Is radium a miracle or menace?

Both are true, but in my view, the 'miracle' side outweighs the 'menace' aspects.

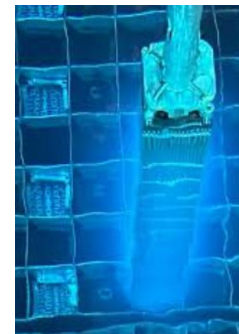
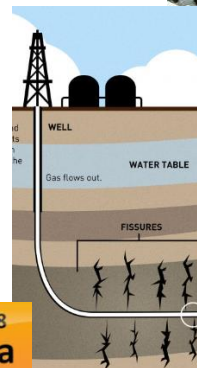
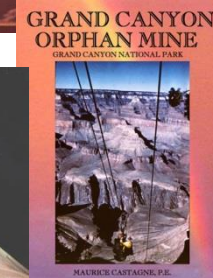


Other Radiation Transgenerational Issues

- Nuclear Weapons
- Atomic Veterans
- Radioactive Fallout
- Uranium Mines
- Health Effects
- Legacy Site Cleanups
- Nuclear Power Plants
- Spent Nuclear Fuel
- Low-level Rad. Waste
- NPP Accidents
- Emergency Response
- Radioactive Wastes
- Radium from 'fracking'



Areas of the Continental United States Crossed by More Than One Nuclear Cloud from Aboveground Detonations.



Thank you!

Questions?



David J. Allard, MS, CHP, FHPS
Medical Health Physicist

Email: allradcon@comcast.net