

# **The Evolution of Radiation Protection:**

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From Erythema to  
Risks of heritable damage to  
Risk of cancer to?

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# 1915

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Guidance to Physicians from German  
and British Societies



# Why 1915?

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- Roentgen, Becquerel, Curie
  - Wide-spread application
  - Concern about electrotherapists and other “unqualified” practitioners
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# Guidance

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- Requires "a qualified medical practitioner experienced in x-ray work"
  - X-ray tubes to be enclosed
  - Tests of opacity on commercial shields
  - Don't use the hand to test quality or hardness
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# 1921

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Detailed  
Recommendations from  
the British  
X-Ray and Radium  
Protection Committee



# Why 1921?

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Collidge Hot Cathode X-Ray Tube

Radium commerce

WW I

Battlefield experience and  
military procurement requirements

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# 1925

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Erythema Limit  
ICRU Formed



# Recommendations

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- Codified the 1915 guidance
  - Incorporated radium protection
  - Introduced working conditions
  - Measurements and standards organizations addressed
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# Erythema Limit

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- Mutscheller: 1/100 erythema dose in 30 days
  - Sievert: 1/10 erythema dose in 1 year
  - Threshold concept
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# ICRU

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- Formed by the International Congress of Radiology (ICR)
  - X-Ray Units Committee
  - Physical measurement required
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# 1928

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"Roentgen" Defined  
ICRP Formed



# Why 1928?

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- "Roentgen": Proposed by the "Units" Committee in 1925
  - Adopted by the ICR in 1928
  - "the exposure when the x-ray or gamma-ray field produces 1 e.s.u. of negative charge in 0.00129 gram of air"
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# ICRP

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- ❑ ICR formed the International Advisory Committee on X-Ray and Radium Protection (ICRP)
- ❑ Laurie Taylor was US representative



# 1929

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NCRP Formed



# Why 1929?

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- ❑ ICRP suggested in 1928 that each representative form a national group of advisors
  - ❑ Taylor asked presidents of relevant Medical Societies such as the American Roentgen Ray Society, and representatives of x-ray equipment manufacturers for advice
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## NCRP cont.

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- US Committee on X-Ray and Radium Protection was approved
  - Each society to name a radiologist and a physicist
  - Equipment manufacturers to elect two representatives as members
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# 1933–1934

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NCRP	0.1 R/day
ICRP	0.2 R/day



## Why 1933–1934?

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- Application of the Roentgen to the erythema dose
  - Erythema “dose”  $\sim 600$  R
  - $600$  R divided by  $30$  day divided by  $100 = 0.2$  R/day
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## Why 0.1 for NCRP?

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- Taylor suggested 0.1 R/day based on uncertainty
- Failla endorsed the 0.1 R/day but said radium work would require 5 R/day for the fingers
- Both suggestions accepted



# 1941

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NCRP

0.1  $\mu\text{g}$  Radium  
Body Burden



# Why 1941?

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- ❑ Excessive radium use by the public *via* patent medicines
  - ❑ Radium dial painters exhibit damage
  - ❑ Robley Evans begins radium study in 1932
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# Robley Evans Data

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- 27 cases reviewed
    - 7 cases  $<0.5 \mu\text{g}$  — no effect
    - 20 cases  $1.2 - 23 \mu\text{g}$  — various degrees of injury
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# NCRP Committee

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0.1  $\mu\text{g}$  accepted

“We would feel confident if our wife or daughter were the subject”

NBS Handbook No. 27, 1941

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## Merrill Eisenbud Observation

- 0.1 R/day and 0.1  $\mu\text{g}$  of radium were available before Pearl Harbor, just after the discovery of plutonium and at the start of the Manhattan Project



# 1949–1954

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ICRP and NCRP Introduce a New Set  
of Weekly Dose Limits



## Why 1949–1954?

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- Tripartite conferences (U.S., Canada, U.K.) evaluated all the information gained from the universities and federal labs during the war
  
  - Meetings: 1949 – 1952
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# Tripartite Contributions

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- Effects of dose and dose rate
  - Depth dose
  - RBE, as applied to high-LET radiation
  - Radionuclide metabolism and dosimetry
  - Reference Man
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# Weekly Limits

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- 300 mR — blood forming organs  
lens, gonads
  - 600 mR — skin
  - 300 - 600 mR — other organs
  - 1,500 mR — extremities (x rays)
  - 1/10 these values for minors
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# NCRP Report 17 (1954)

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- Permissible Dose " ---the dose of ionizing radiation that, in the light of present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his lifetime"



# 1957–1958

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ICRP and NCRP  
Introduce New  
Age-Related Limits



# Why 1957–1958?

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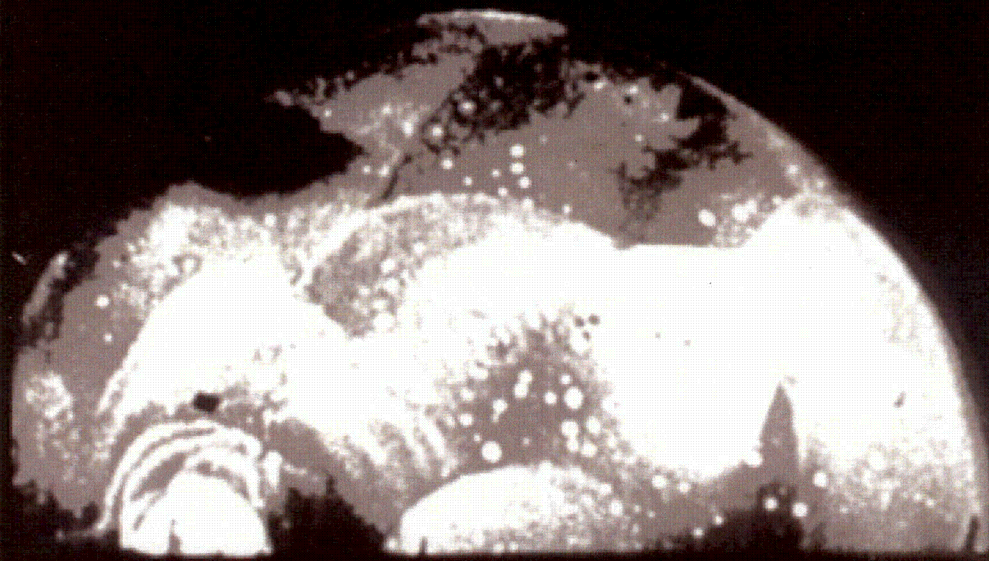
- Weapons testing fallout
  - Bravo Weapons Test
  - Vocal scientists
  - Public concern
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**LIFE**

COLOR PICTURES OF HYDROGEN TEST

DAVE BECK, FORMER BOSS OF GOONS,  
EMERGES AS LABOR'S NEW STRONG MAN



THE AWESOME FIREBALL

20 CENTS

APRIL 19, 1954



# Eisenbud on Lucky Dragon

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# Results of Public Concern

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- National Academy of Science  
Biological Effects of Atomic Radiation  
(BEAR) Committee
  - UK Medical Research Council (MRC)  
Committee
  - United Nations Scientific Committee  
on the Effects of Atomic Radiation  
(UNSCEAR)
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# BEAR Recommendations

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- Worker Limits
    - 50 R to age 30
    - 50 R more to age 40
  
  - Population Limit
    - 10 R to age 30 — all exposure minus background
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# MRC Recommendations

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- Worker Limits
    - 50 R to age 30
    - 200 R lifetime
  
  - Population Limit
    - 2 x natural background
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# Hereditary Effects!

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- Genetically significant dose (GSD)
  - Leukemia known — not quantifiable
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## 1957–1958 Limits

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- 5 x (age – 18) rem/year,  
3 rem/13 weeks — head, trunk, active  
blood forming organs, lens, and gonads
  - 10 x (age – 18) rem/year,  
6 rem/13 weeks for skin
  - 75 rem/year, 25 rem/13 weeks for the  
extremities
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## 1957–1958 Limits Cont.

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- 15 rem for internal organs
  - Population limit — 5 rem/30 years  
(170 mrem/year)
  - Small groups — 0.5 rem/year
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