

# **Radiation and Human Health**

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**Almonte Lectures**

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- Radiation

- History of radiation damage

- International Standards

- Food Irradiation

- Personal exposure

- Recent Results

## First Some Definitions

**$\alpha$  radiation:** Heavy particles  
Short range, high energy, dense damage

**$\beta$  radiation:** electrons; longer range,  
medium energy, less dense damage

**$\gamma$  radiation:** like x-rays, higher energy  
longer range, least dense damage

# **Health Effects of Radiation**

## **External Sources:**

**General, Topical, Radiation Sickness**

## **Internal Sources:**

**Organ-specific  
Thyroid, Bone Marrow, Liver, Others**

# Molecular Effects of Radiation

Most reactions are with water

Producing  $\text{H}_2\text{O}^-$ ,  $\text{H}_2\text{O}^+$ ,  $\text{H}_3\text{O}^+$  and  $\text{OH}$

These oxidizing molecules can  
Change or destroy normal molecules

# Radiation Measurement

Gray: Gy     $1 \text{ Gy} = 1 \text{ Joule/Kg}$   
Amount of radiation

Sievert: Sv (mSv)  
Amount of *effective* radiation  
includes specific biological effects

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# Health Effects

<u>Dose (mSv)</u>	<u>Effect</u>
>5000	Probable death
1000	Possible Radiation Sickness
100	Might cause cancer
30 - 100	Full CT Scan
1.8	Normal annual background dose
0.1	Dose from lung x-ray
0.01	Dose from dental x-ray



## Early Exposures

X-Ray experts

Lost fingers, hands

Many cancers (Marie Curie)

## American Watch-Dial Painters

Much Radium got into their bones

Many died of cancer or other problems

## Problems in Chernobyl

A few workers serious

I-131: ~ 1600 cancers – most cured  
Avoidable with KI pills

## Problems in Fukushima

~ 50 workers seriously affected

Most serious was the social effect of moving citizens away from the area.

## Localized effects

Mostly medical treatments

Platinum needles of radium

$^{131}\text{I}$  thyroid treatment

Focussed  $^{137}\text{Cs}$ ,  $^{60}\text{Co}$

Recent Example:  
Bone cancer treatment  
With Ra223:

~

## Ra-223: a series of alpha emitters

Ra-223	$\alpha$	11.4 d
Rn-219	$\alpha$	4 sec
Po-215	$\alpha$	2 msec
Pb-211	$\beta$	36 min
Bi-211	$\alpha$	2 min
Tl-207	$\beta$	5 min
Pb-207		Stable

Radium goes directly to

Active bone centres – Cancers

$\alpha$  particles have very short range

Normal Dose  $\sim 90 \mu\text{Ci}$  per treatment

My colleague gets  $120 \mu\text{Ci}$  every four weeks

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# Natural Background Radiation

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Source	Dose Rate (mSv/a)
Cosmic Radiation	0.3 - 0.5
Concrete House	0.5 - 1.5
4-hour Jet flight	0.01
Radon (outdoors)	0.2
Medical x-rays	0.3 - 0.4
Human Body ( $^{14}\text{C}$ , $^{40}\text{K}$ )	0.2
<b>Total (Average)</b>	<b>2 - 3 mSv/a</b>

# Dose-response Curve

a major guide-post  
in controlling the use of  
radioactivity

Usually Cancers per mSv

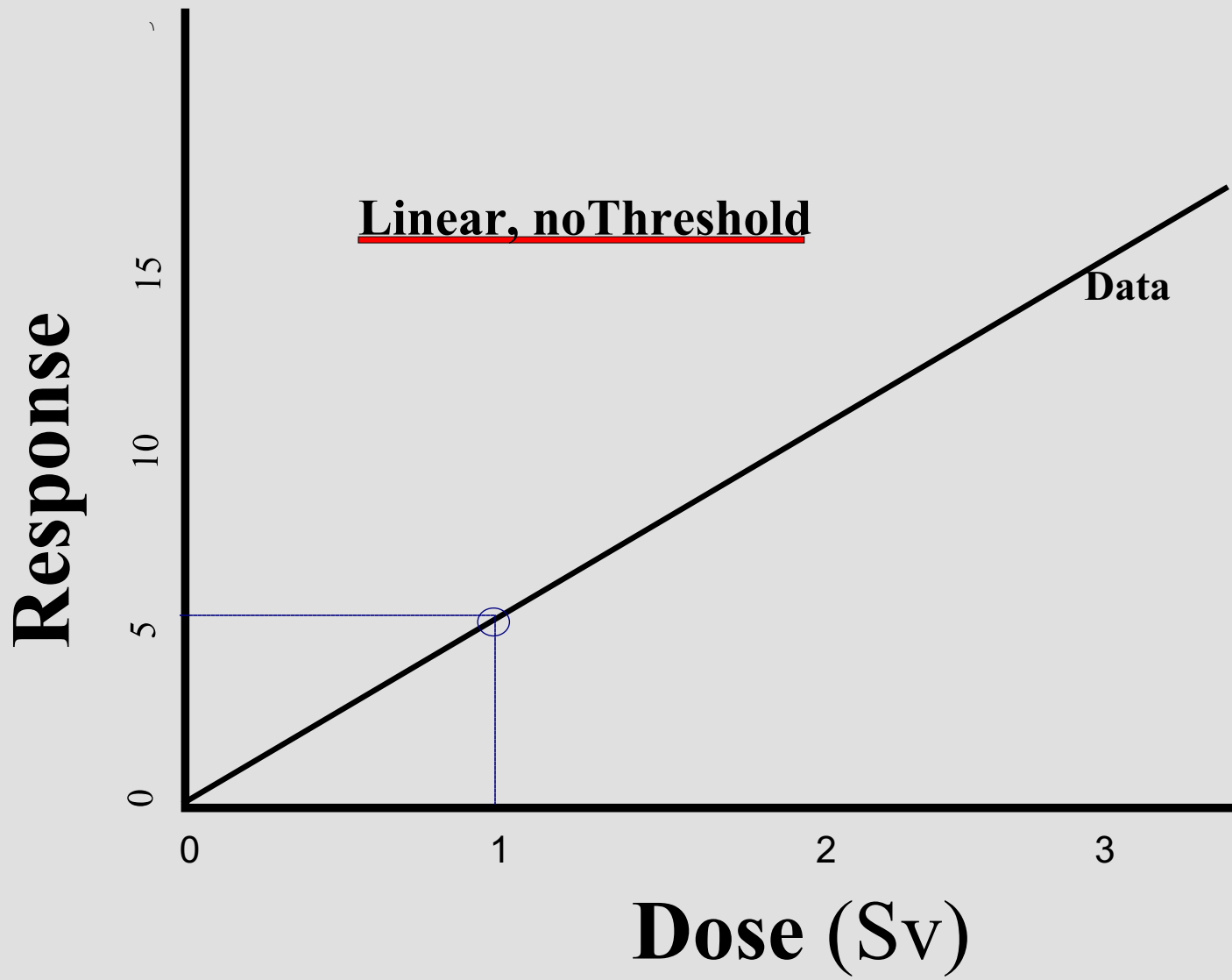
Many important scientists wanted  
to stop nuclear bomb testing.

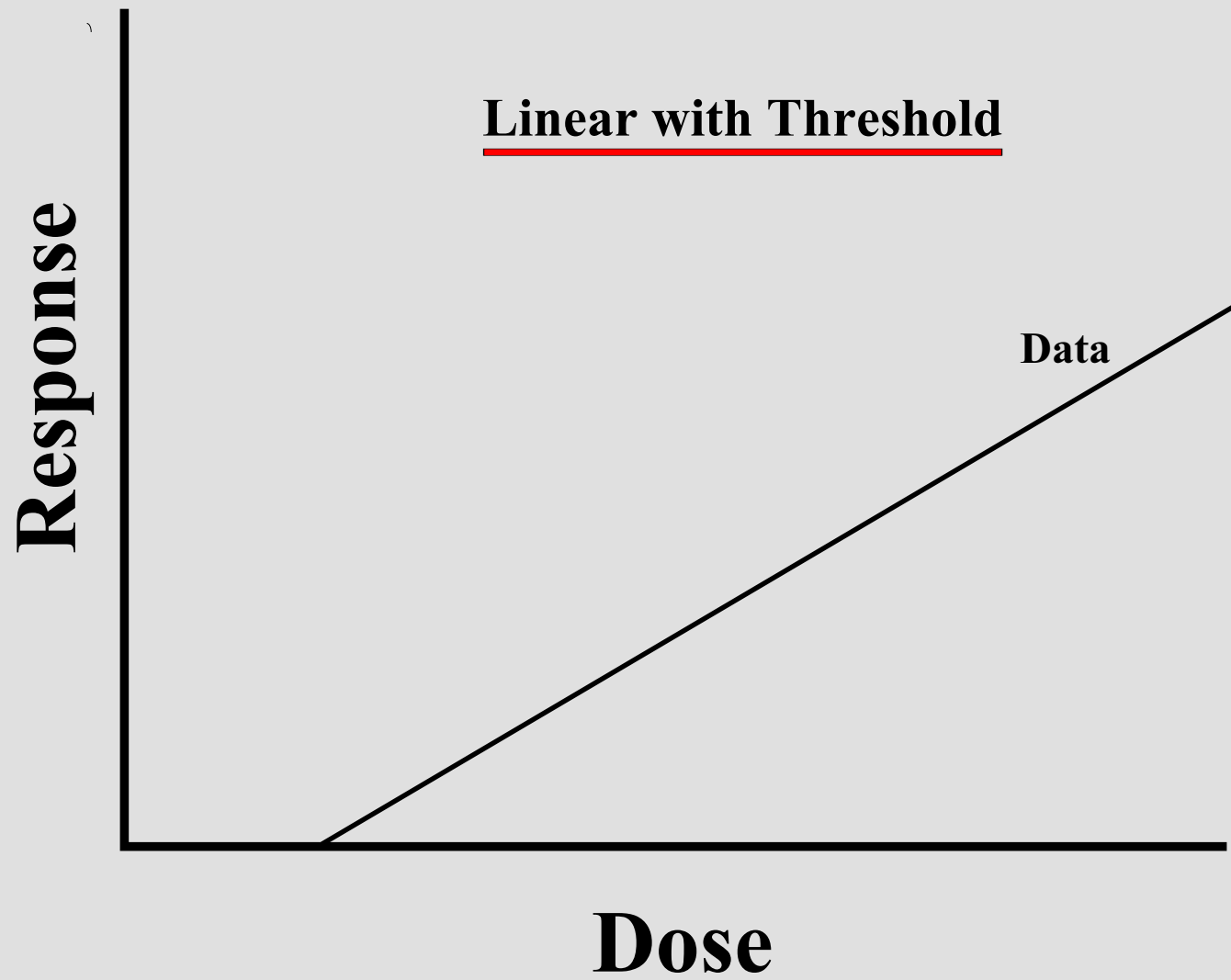
Viktor Weisskopf *et al*

**“No level of radiation is safe”**

Therefore, use a straight line  
down to Zero

ICRP 1956



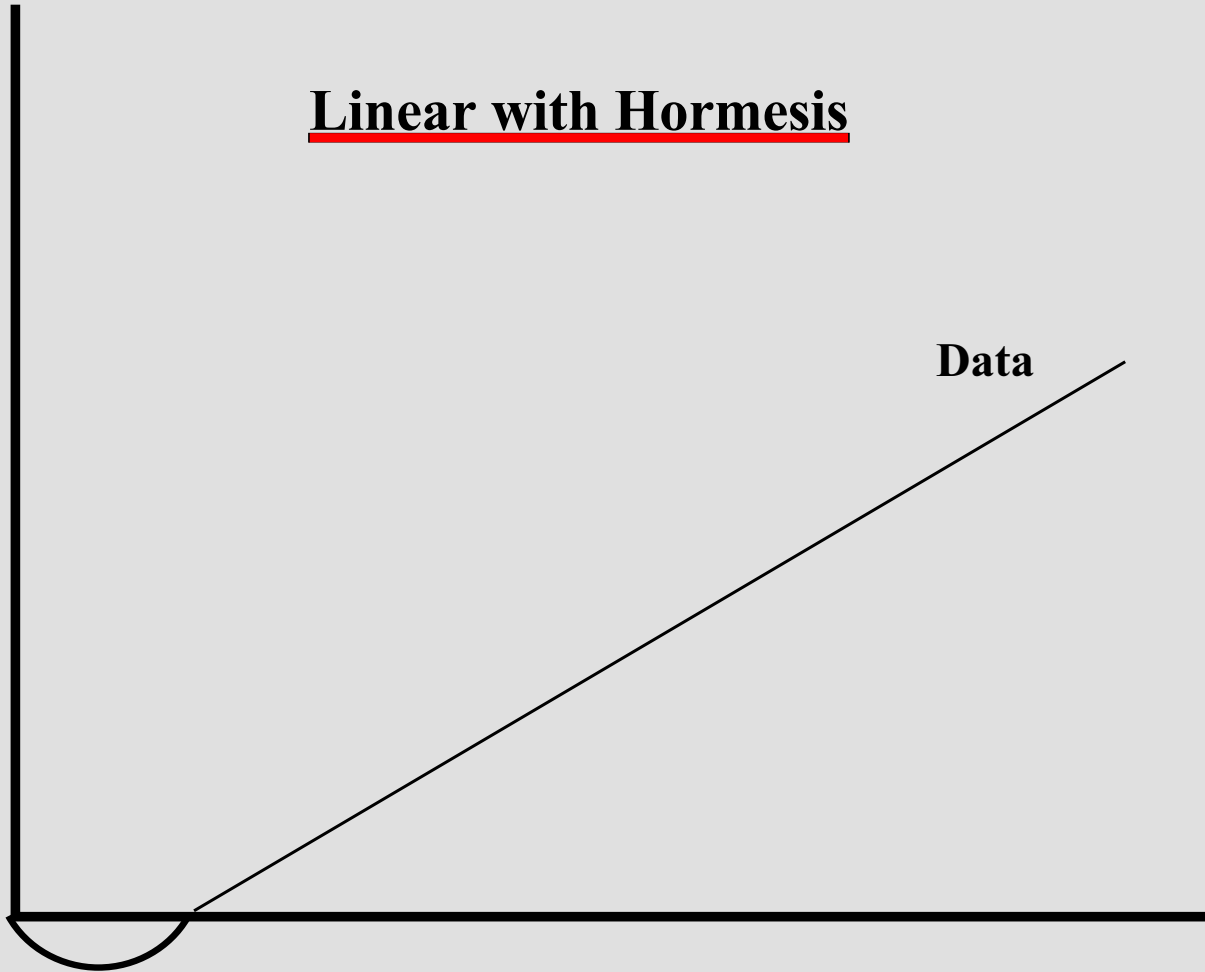


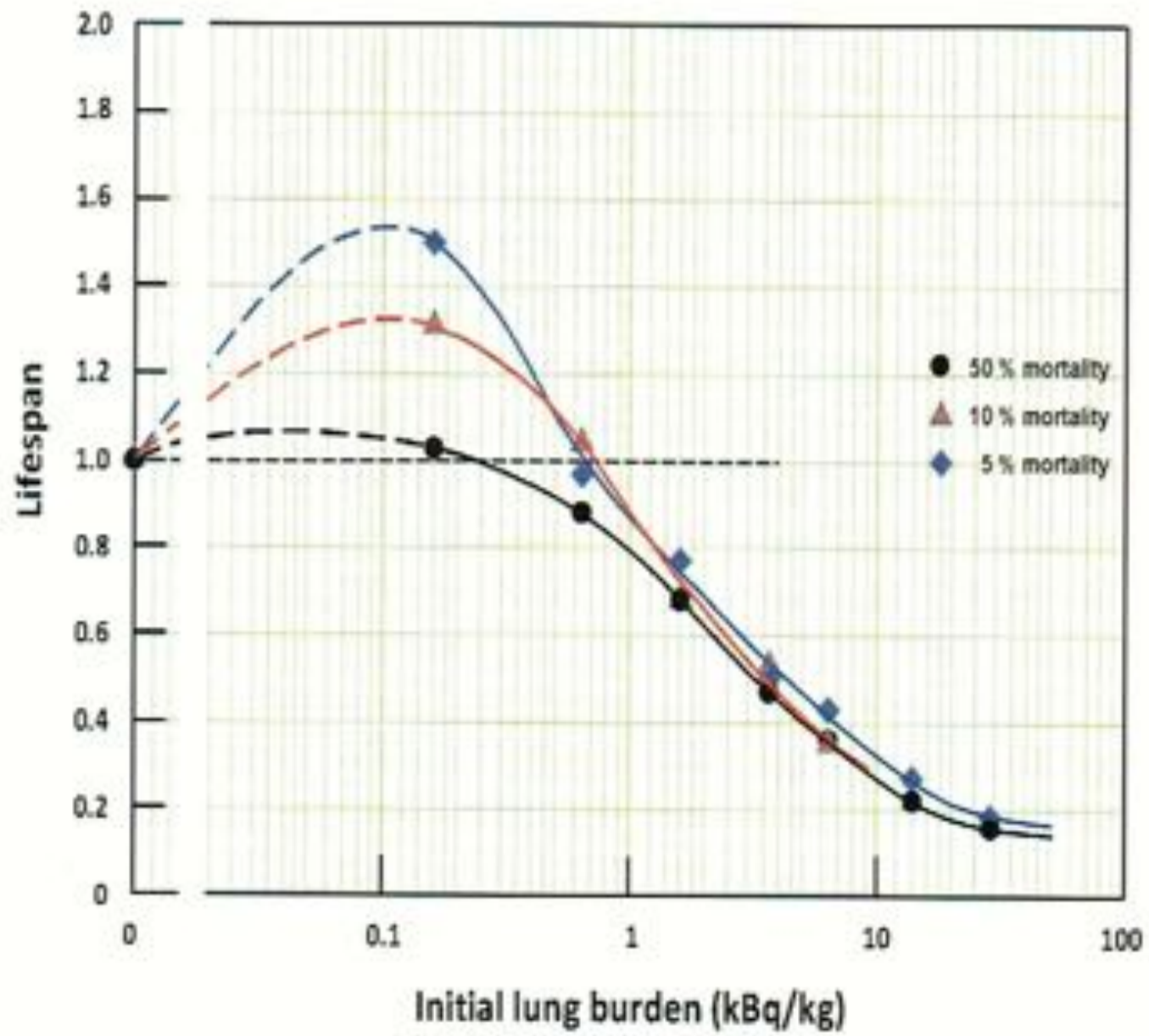
**Response**

**Linear with Hormesis**

**Data**

**Dose**





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# Food Irradiation

Usually  $\gamma$  rays or X-rays

- Improves shelf-life
- Kills harmful bacteria that spoil food
- Kills insects that are poisonous to us
  
- Does not reverse current damage
- Done only when legal

# Food Irradiation in Canada

Permitted by Law:

Onions, Potatoes, Wheat,  
Wheat Flour, Dried spices;  
Mangoes, Poultry, Shrimp, Ground Beef

What is Actually Done in Canada ???

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## **In the beginning: 1947**

B.Sc., B.Ed. - No job

Go to Industry, see what comes up!

**Port Hope**  
Home of Radium

I had never heard of Port Hope  
or of Radium

# My First Job! in Port Hope, Ontario

## Purifying Radium

darkened beakers, glowing powders  
burned fingers, inhaling radium  
Our film badges were black every day

In charge of the Vault  
Gilbert Labine's Diamonds



Radium Burn

DRW Fingerprints

MIT – 1950

Prof. Robley Evans

Radon in my Breath!

About 25 times the maximum allowed

MIT Medical School

Strontium-90 in Urine





Energy:            Low    High    Stable

So they must measure Yttrium

BUT

Y(OH)<sub>3</sub> adsorbs on the glass and is lost!

Solution:

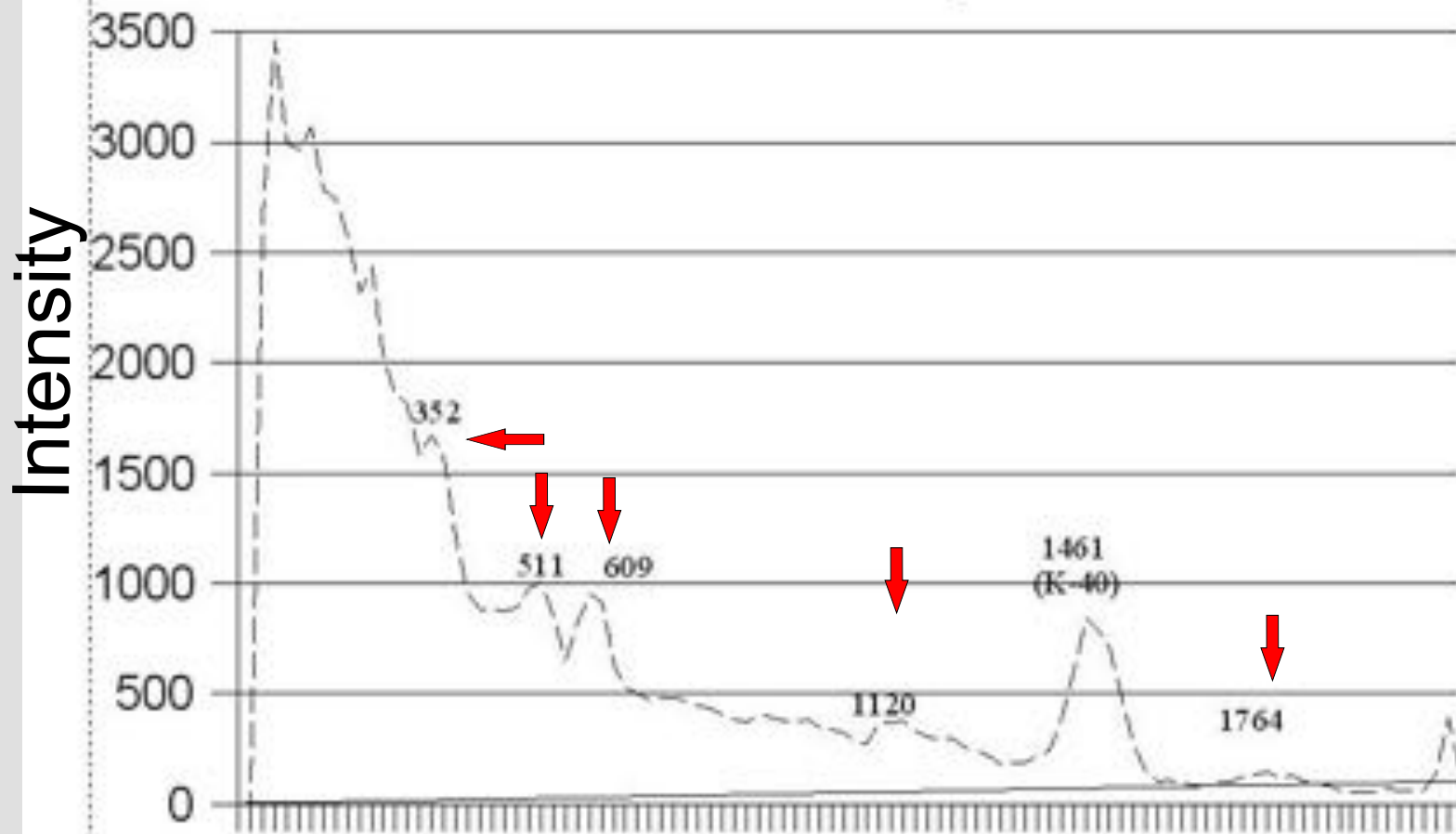
Add an acid

**Concentrated Hydrochloric Acid!!**

**Very volatile on being warmed!!!**

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# DRW Gamma Spectrum



Gamma ray energy (keV)

# DRW Radiation Exposure Data

DRW:2014 1300 Bq body burden 35 ng Ra

Ra gamma spectrum:

$^{226}\text{Ra}$   $\alpha$  4.8 MeV

$^{222}\text{Rn}$  6.5

$^{218}\text{Po}$  6.0

$^{214}\text{Po}$  7.7 Sum = 25 MeV

$^{214}\text{Pb}$   $\beta$  0.25 MeV

$^{215}\text{Bi}$  0.64 Sum = 0.89 MeV

Total 25.9 MeV

$1300 \times 25.9 = 33,670 \rightarrow 33.7 \times 10^3 \text{ MeV/sec}$  distributed throughout the bones

# DRW Radiation History

Health Canada National Dose Registry

Not including the Port Hope or MIT radiation

34.80 mSv

$\alpha$  radiation not included

Since then, no effects

Biological Half Life

About 120 years

(Physical half life 1620 years)

**Thank You**