

33rd Annual Conference of Canadian Nuclear Society
Saskatoon, Saskatchewan
Western-Focus Seminar
2012 June 10-13

**What is the appropriate
radiation level for evacuations?**

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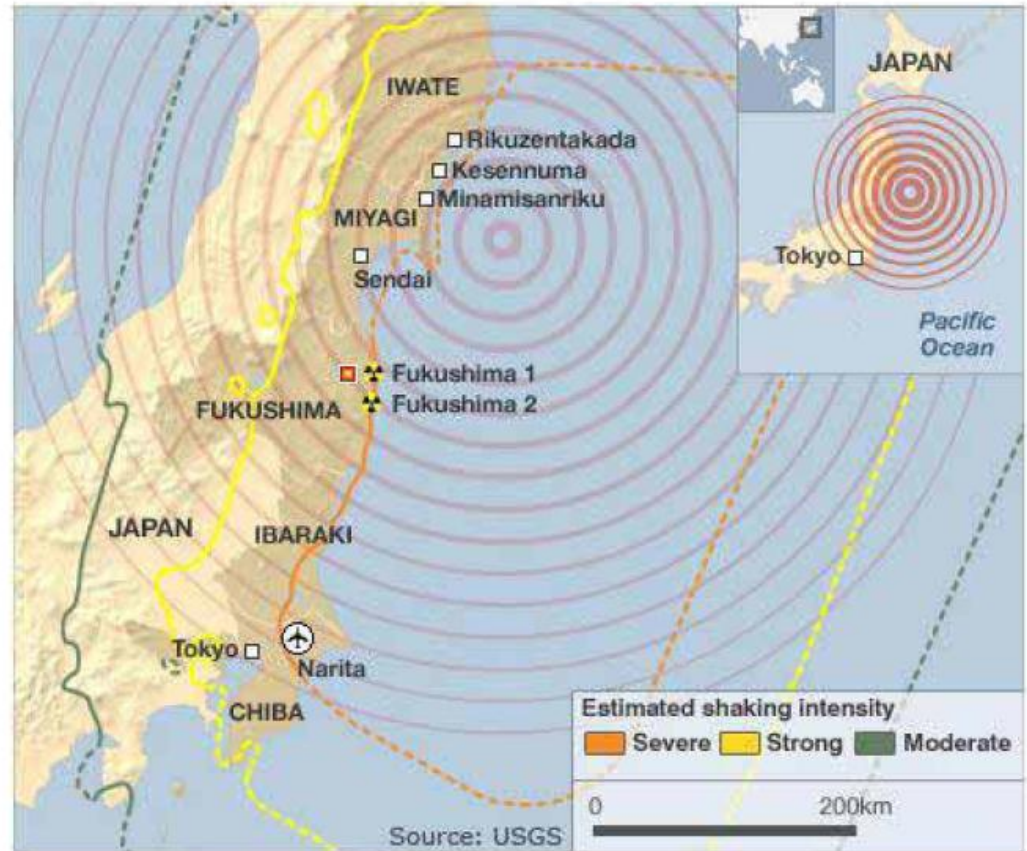
THE EARTHQUAKE

March 11, 2011, 14:46 JST

Magnitude 9 earthquake lasting approximately 3.5 minutes with 3 major energy releases at depth of 24 km

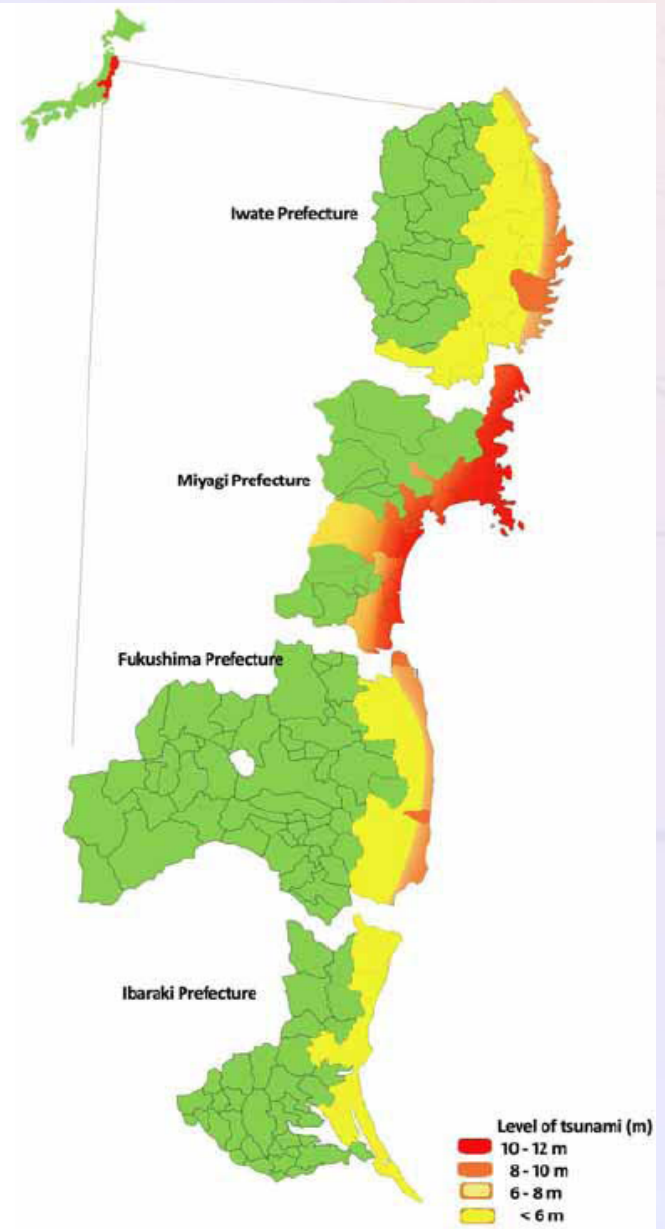
Aftershocks on 11th March

7.0	15:06 JST Sanriku Oki
7.4	15:15 JST Ibaraki-ken Oki
7.2	15:26 JST Sanriku Oki
6.1	15:57 JST Ibaraki-ken Oki
6.8	16:15 JST Fukushima-ken Oki
6.6	16:29 JST Sanriku Oki
6.7	17:19 JST Ibaraki-ken Oki
6.0	17:47 JST Fukushima-ken Oki
6.4	20:37 JST Iwate-ken Oki
6.1	21:13 JST Miyagi-ken Oki
6.0	21:16 JST Iwate-ken Oki

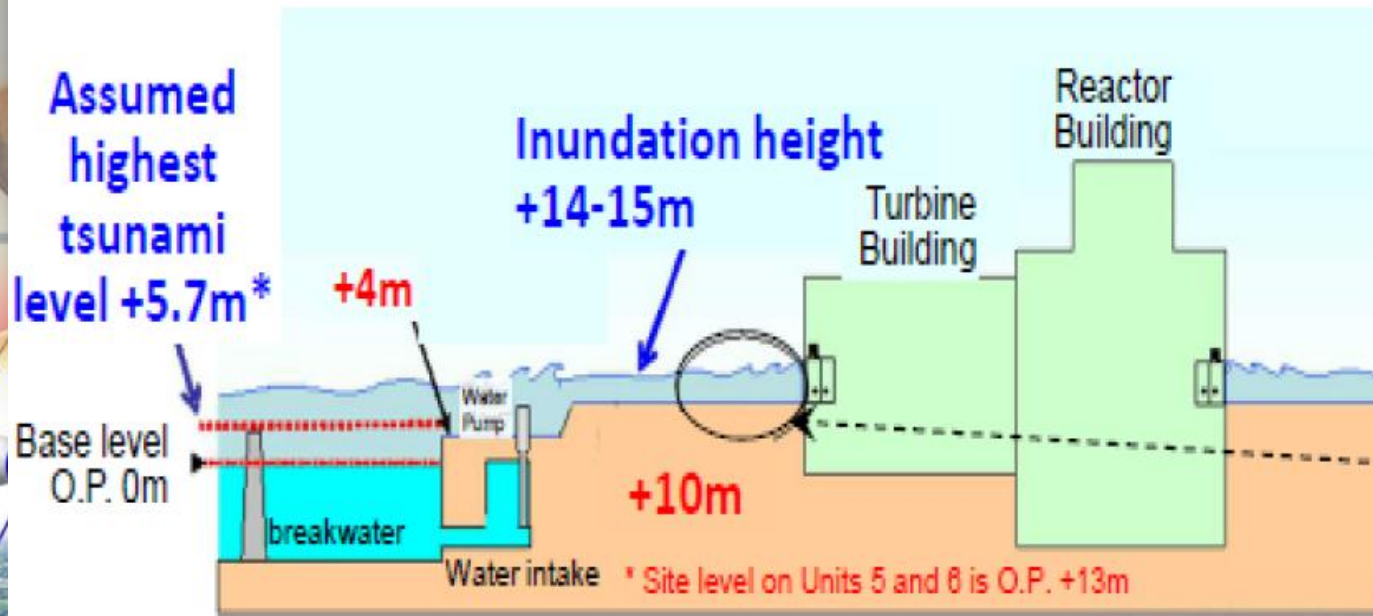


THE TSUNAMI

- Within 30 min to 1 hour after the earthquake a series of tsunami waves hit the coast affecting primarily 4 prefectures.
- Tsunami wave height accentuated by the coast line subsiding ≈ 1 m with horizontal shift between 3 and 4 m
- Net tsunami wave height at Fukushima Daiichi was 14 m
- Units 1-4 at a nominal elevation of 10m above sea level; Units 5 & 6 at elevation of 13m



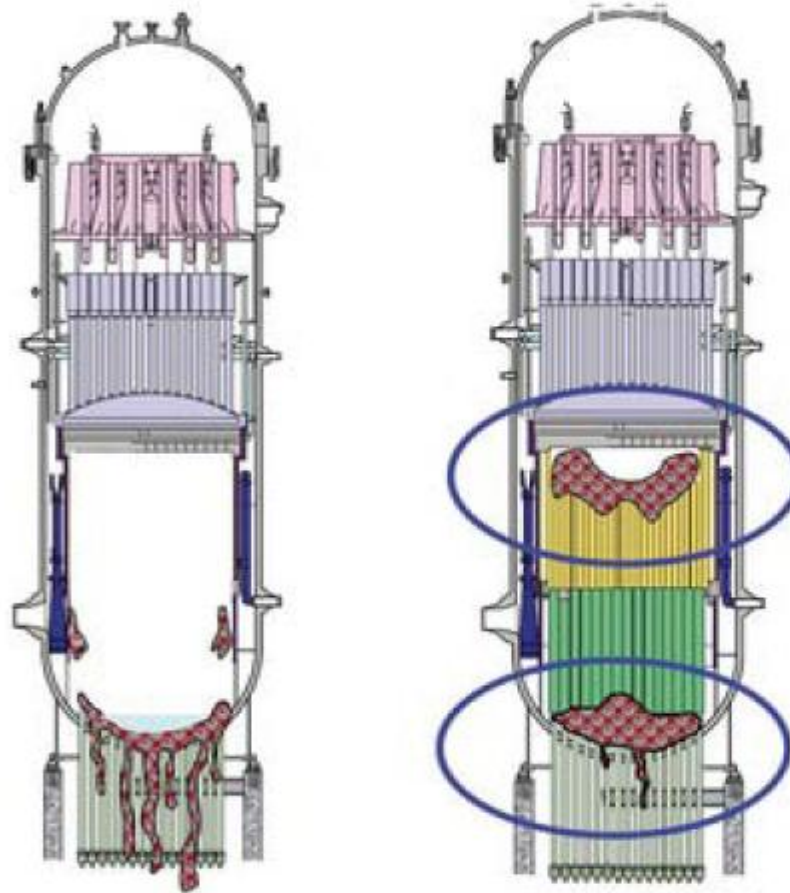
TSUNAMI INUNDATION UNITS 1 – 4



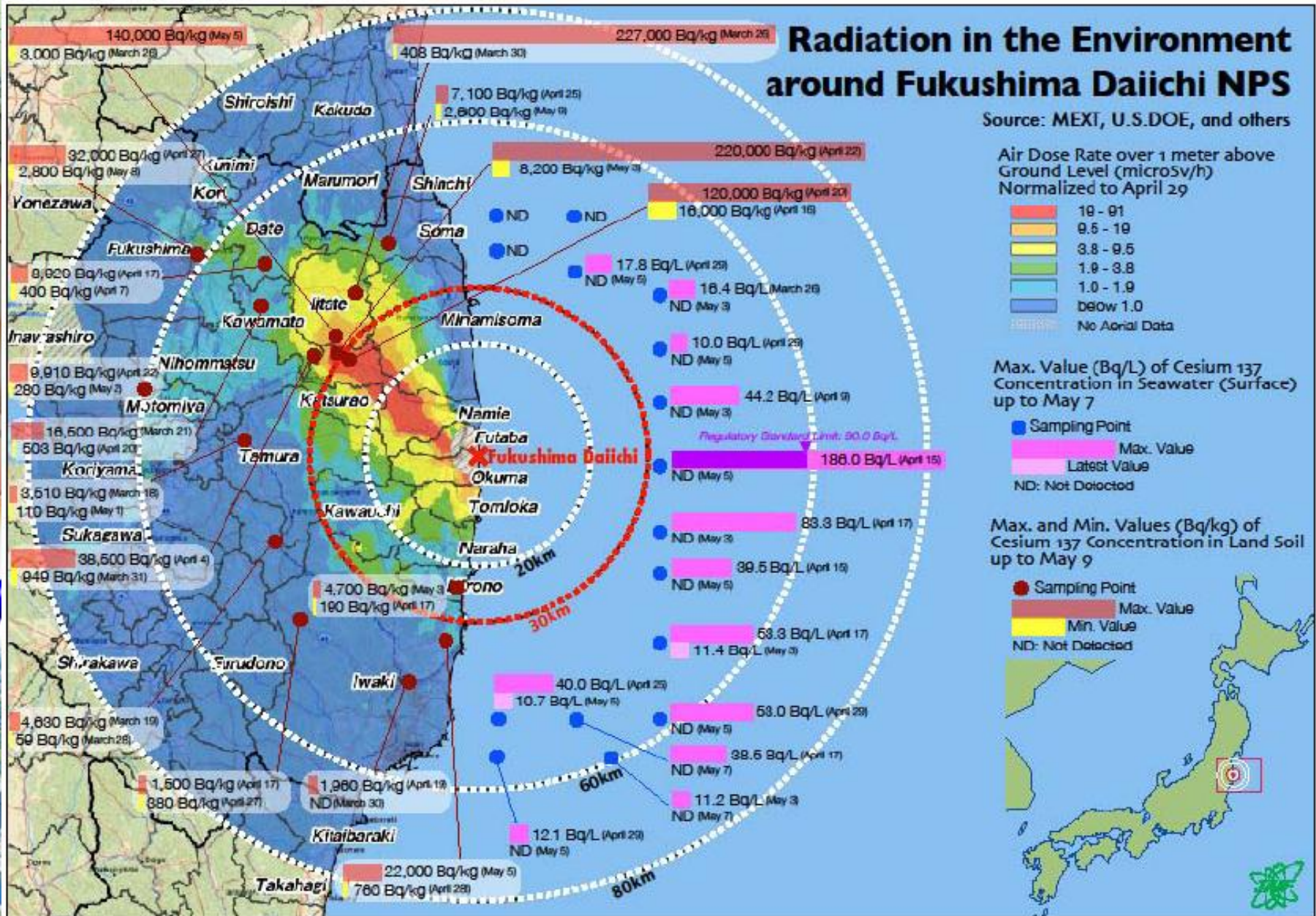
Unit 1 melted down; units 2&3 mostly unmelted

06 December 2011

A technical analysis by TEPCO has concluded that fuel in Fukushima Daiichi unit 1 has mostly melted out of the reactor pressure vessel and into the primary containment vessel. It also concluded that fuel has melted in units 2 & 3, but has mostly remained within the RPVs.



$$91 \mu\text{Sv/h} \times 8766 \text{ h/y} = 798 \text{ mSv/y}$$



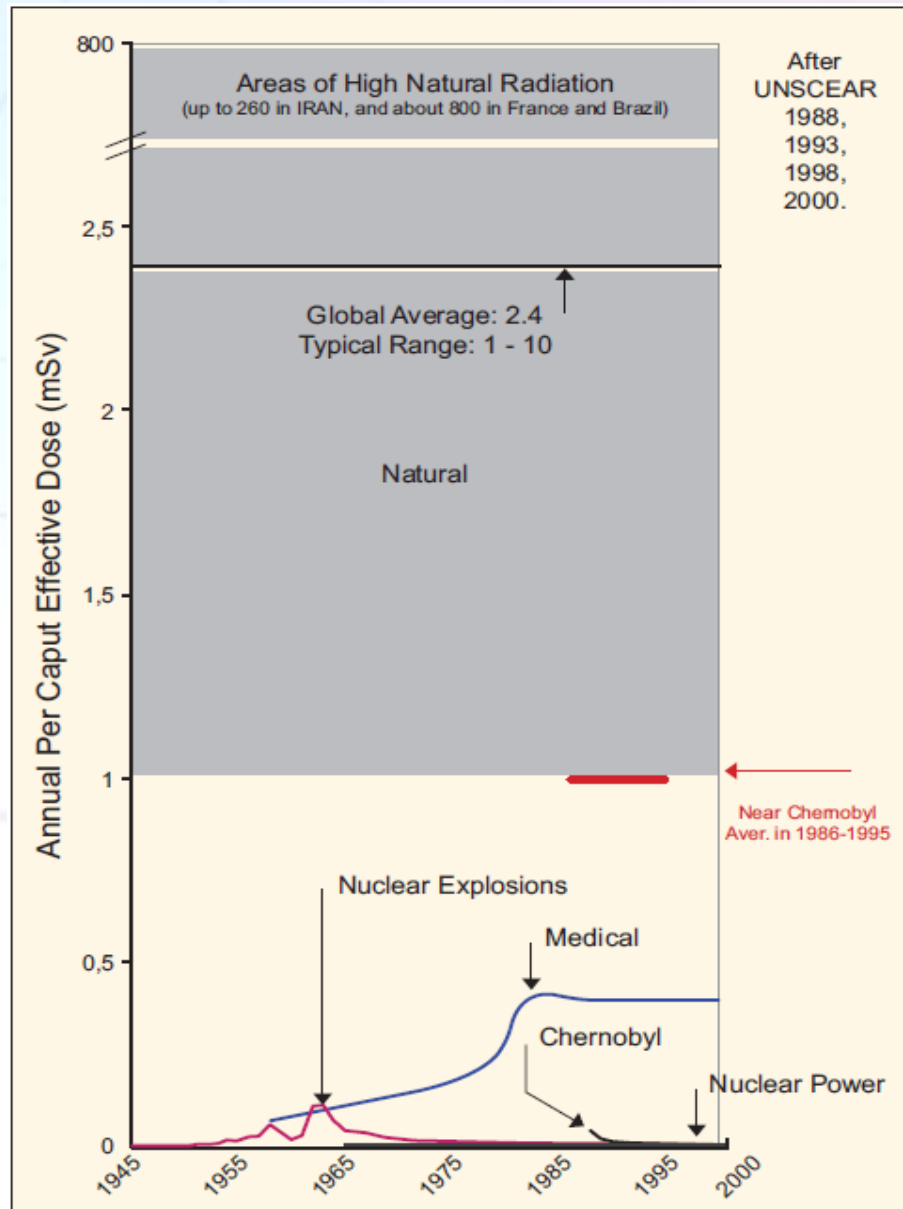


Figure 1. Worldwide and local (near Chernobyl and in areas of high natural radiation) average annual radiation doses from natural and man-made sources. Based on UNSCEAR (1988, 1993, 1998, 2000b).

Mortality of 1338 British Radiologists 1897-1976

Cause of death	Observed (O) and expected (E) numbers of deaths					
	Entry prior to 1921			Entry after 1920		
	O	E	O/E	O	E	O/E
All causes	319	(1) 334.42 (2) 308.03 (3) 327.97	0.95 1.04 0.97	411	541.77 461.14 469.97	0.76*** 0.89* 0.87**
All neoplasms	62	(1) 49.11 (2) 43.07 (3) 35.39	1.26* 1.44** 1.75***	72	114.93 91.07 68.65	0.63*** 0.79* 1.05
Other causes	257†	(1) 285.31 (2) 264.96 (3) 292.58	0.90* 0.97 0.88*	339†	426.84 370.07 401.32	0.79*** 0.92 0.84**

(1) Based on rates for all men in England and Wales.

(2) Based on rates for social class 1.

(3) Based on rates for medical practitioners.

† includes one death with unknown cause.

*P < 0.05 } One sided in
 **P < 0.01 } direction of
 ***P < 0.001 } difference.

Smith and Doll Study published 1981

Origin of Tolerance Dose

In September 1924, at a meeting of the American Roentgen Ray Society, Arthur Mutscheller was the first person to recommend this “tolerance” dose rate for radiation workers, a dose rate that could be **tolerated indefinitely** (Inkret et al 1995).

The level was **0.2 roentgen (R) per day** in 1931, based on applying a factor of 1/100 to the commonly accepted average erythema dose of 600 R, to be spread over one month (30 days).

- This level is equivalent to **680 mSv/year**.

Calabrese 2009, ICRP Road to Linearity

Three drivers for change from 'safe level' to low-dose linearity

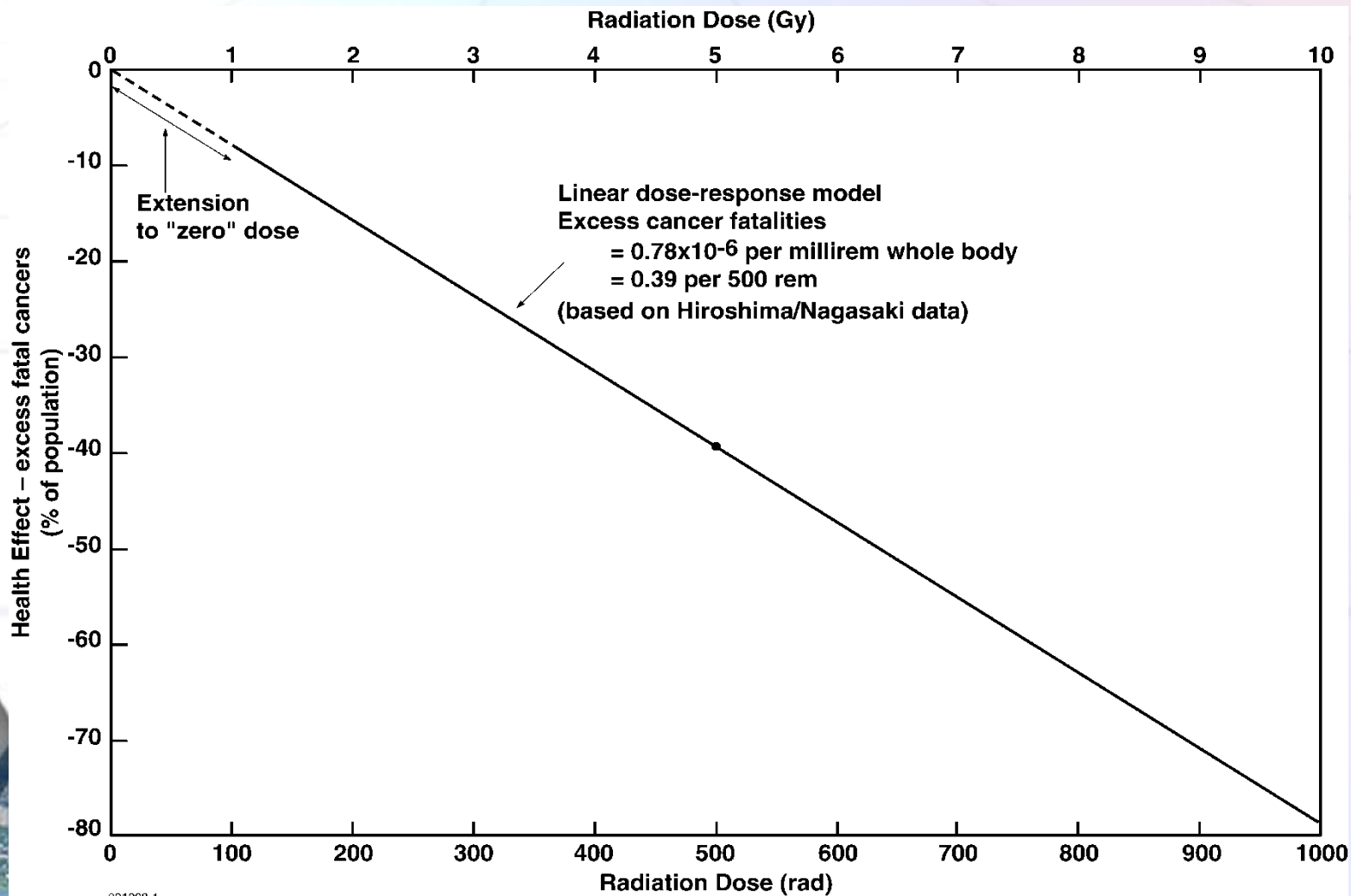
- Theory of eugenics (pseudoscience) postulated a crisis of the gene pool leading to the deterioration of the human race (geneticists very keen to protect population gene pool)
- Muller's 1927 paper in *Science* radiation-induced mutations (fruit flies; dose > 2.7 Gy!)
- Fallout radiation scare, promoted by renowned scientists to stop the nuclear arms race

By 1955 ICRP policy changed due to Muller Nobel Prize, political activities

- Rejected permissible dose concept (no safe radiation level)
- Radiation-induced DNA damage is linear with dose, cumulative (no repair) and harmful
- Adopted concept of cancer and genetic risks, kept small compared to other risks in life
- "Since no radiation level higher than natural background can be regarded as absolutely 'safe,' the problem is to choose a practical level that, in the light of present knowledge, involves negligible risk."

As Low As Reasonably Achievable (ALARA)

LNT Assumption



991008-1

Lauriston Taylor in 1980

- The founder and former president of the NCRPM denounced using the LNT model to calculate annual deaths from x-ray diagnoses:
- “These are deeply immoral uses of our scientific heritage.”
- “No one has been identifiably injured by radiation while working within the first numerical standards set by the ICRP in 1934.”

COMMENTARY

Spontaneous DNA Damage and Its Significance for the "Negligible Dose" Controversy in Radiation Protection

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BILLEN, D. Spontaneous DNA Damage and Its Significance for the "Negligible Dose" Controversy in Radiation Protection. *Radiat. Res.* 124, 242-245 (1990). © 1990 Academic Press, Inc.

One of the crucial problems in radiation protection is the reality of the negligible dose or *de minimus* concept (1-4). This issue of a "practical zero" and its resolution is central to our understanding of the controversy concerning the existence of a "safe" dose in radiological health. However, for very low levels of environmental mutagens and carcinogens including low doses of low-LET radiations (less than 1 cGy or 1 rad), spontaneous or endogenous DNA damage may have an increasing impact on the biological consequences of the induced cellular response. It is this issue that is addressed in this communication.

The following discussion is intentionally limited to a comparison of low-LET radiation since its effects are due primarily to indirect damage in cellular DNA brought about

modification events occur per hour in each mammalian cell due to intrinsic causes.

The current radiation literature will be interpreted to show that ~100 (or fewer) measurable DNA alterations occur per centigray of low-LET radiation per mammalian cell. Therefore every *hour* human and other mammalian cells undergo at least 50-100 times as much spontaneous or natural DNA damage as would result from exposure to 1 cGy of ionizing radiation. Since background radiation is usually less than 100-200 mrem (1-2 mSv)/y, it can be concluded, as discussed by Muller and Mott-Smith (15), that spontaneous DNA damage is due primarily to causes other than background radiation.

"INTRINSIC" OR "SPONTANEOUS" DNA DAMAGE

DNA is not as structurally stable as once thought. On the contrary, there appears to be a natural background of chemical and physical lesions introduced into cellular DNA by thermal as well as oxidative insult. In addition, in the

Daniel Billen in Radiation Research 1990

DNA is not as structurally stable as once thought

Natural background of lesions: thermal and oxidative insult

Cells have mechanisms to bypass or repair these lesions

- **Spontaneous rate = 2×10^5 DNA alterations/cell/day**

- Radiation-induced: 10-100 DNA alterations per cell/**cGy**

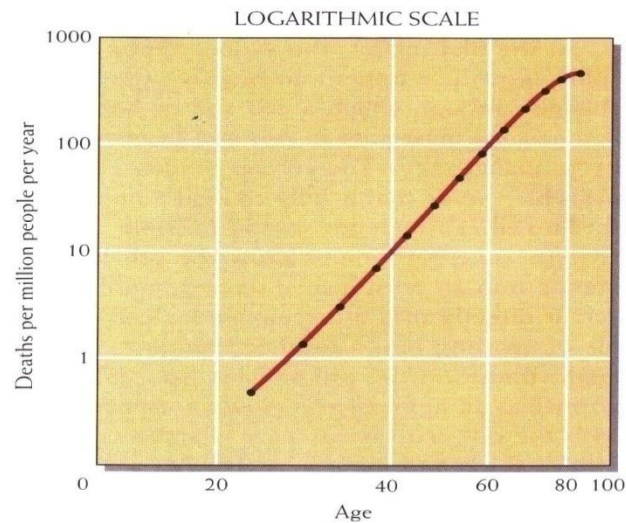
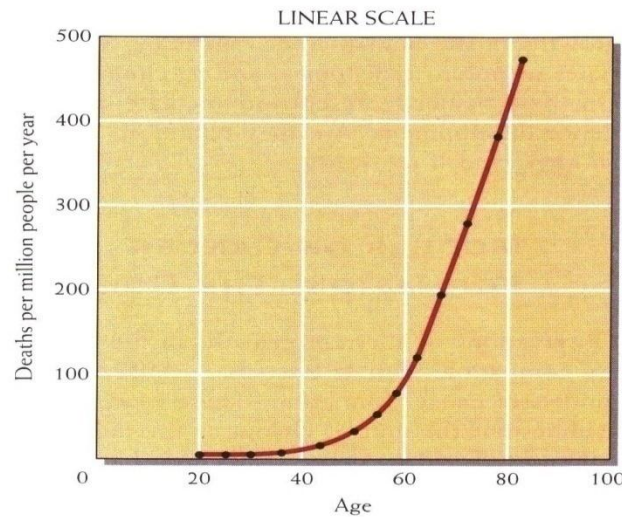
1 mGy/year radiation < 3×10^{-2} DNA alteration/cell/day

This is > **6 million times** lower than spontaneous rate!!!

So radiation is not a significant cause of cancer.

We've known this for more than 20 years!

Cancer death rate rises exponentially with age

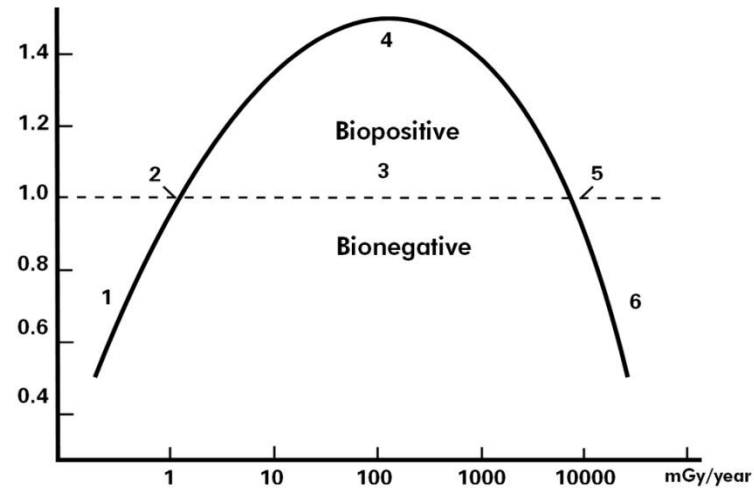
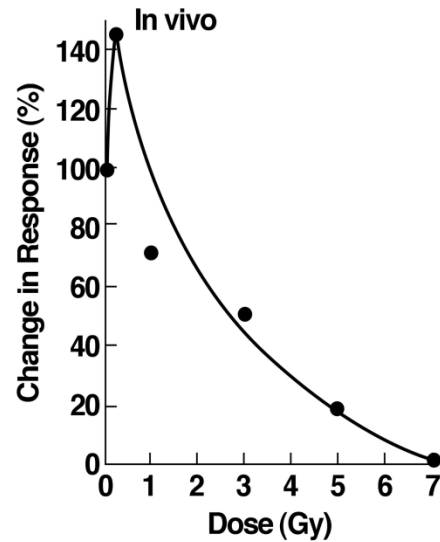
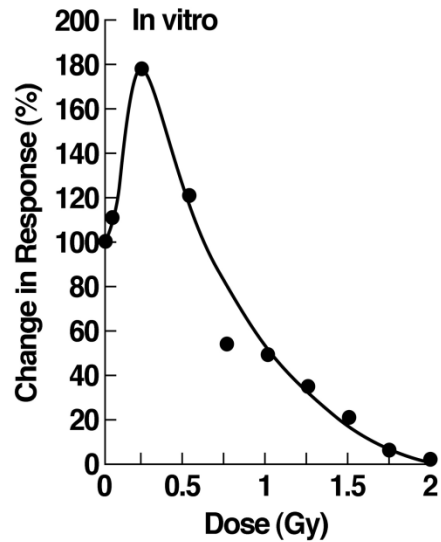


Actual annual U.S. death rate from colon cancer in relation to age, 1986.

Main cancer cause is spontaneous DNA damage due to free radicals, reactive oxygen species (ROS), thermal effects

- **Mutations add up**
- **Defences get old**

Radiation Hormesis



Organisms are stressed: physical, chemical, biological, radiation

Organisms adapt to stress

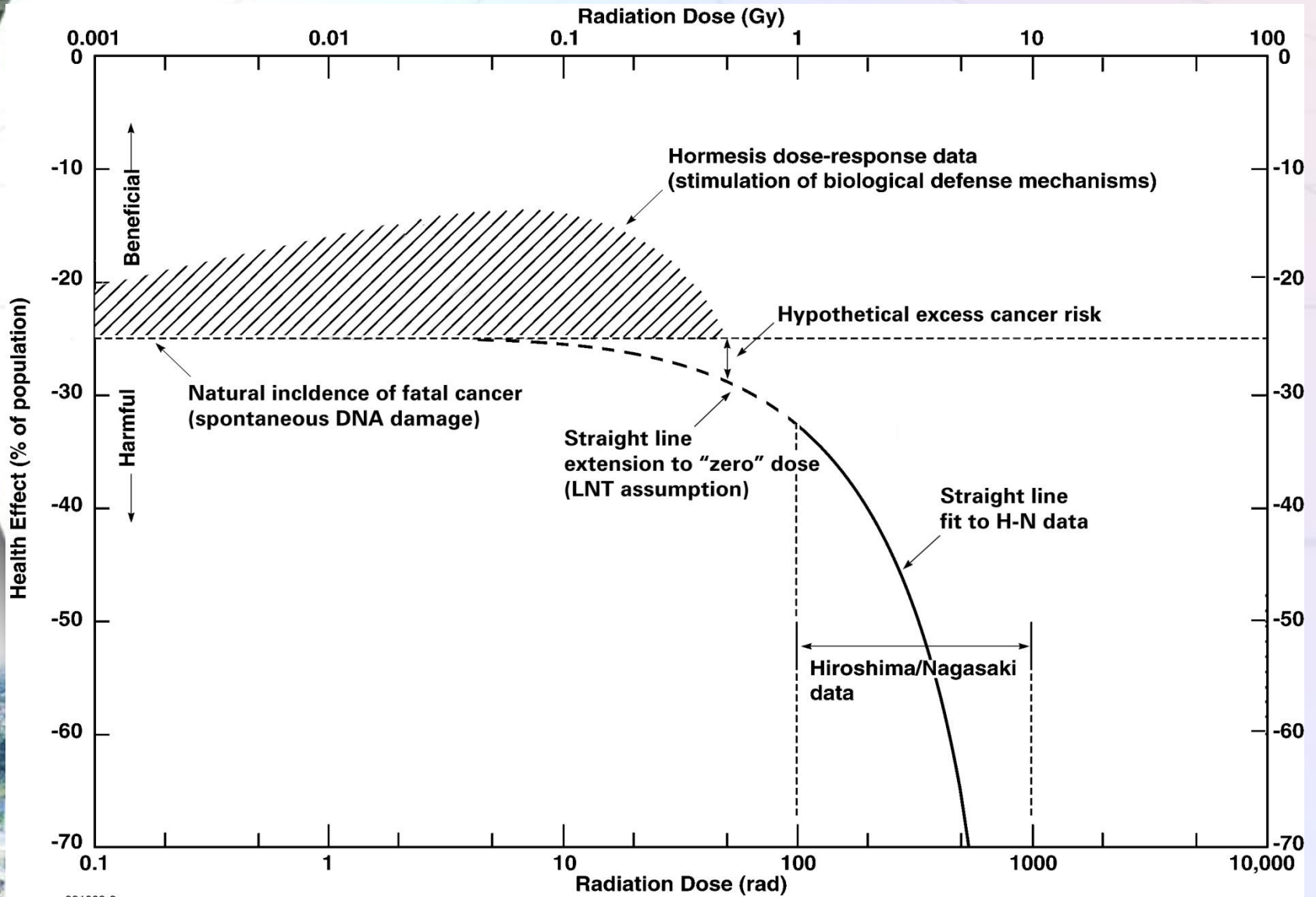
Radiation modulates organism's defenses

Low radiation dose/dose-rate reduces cancer incidence because it stimulates:

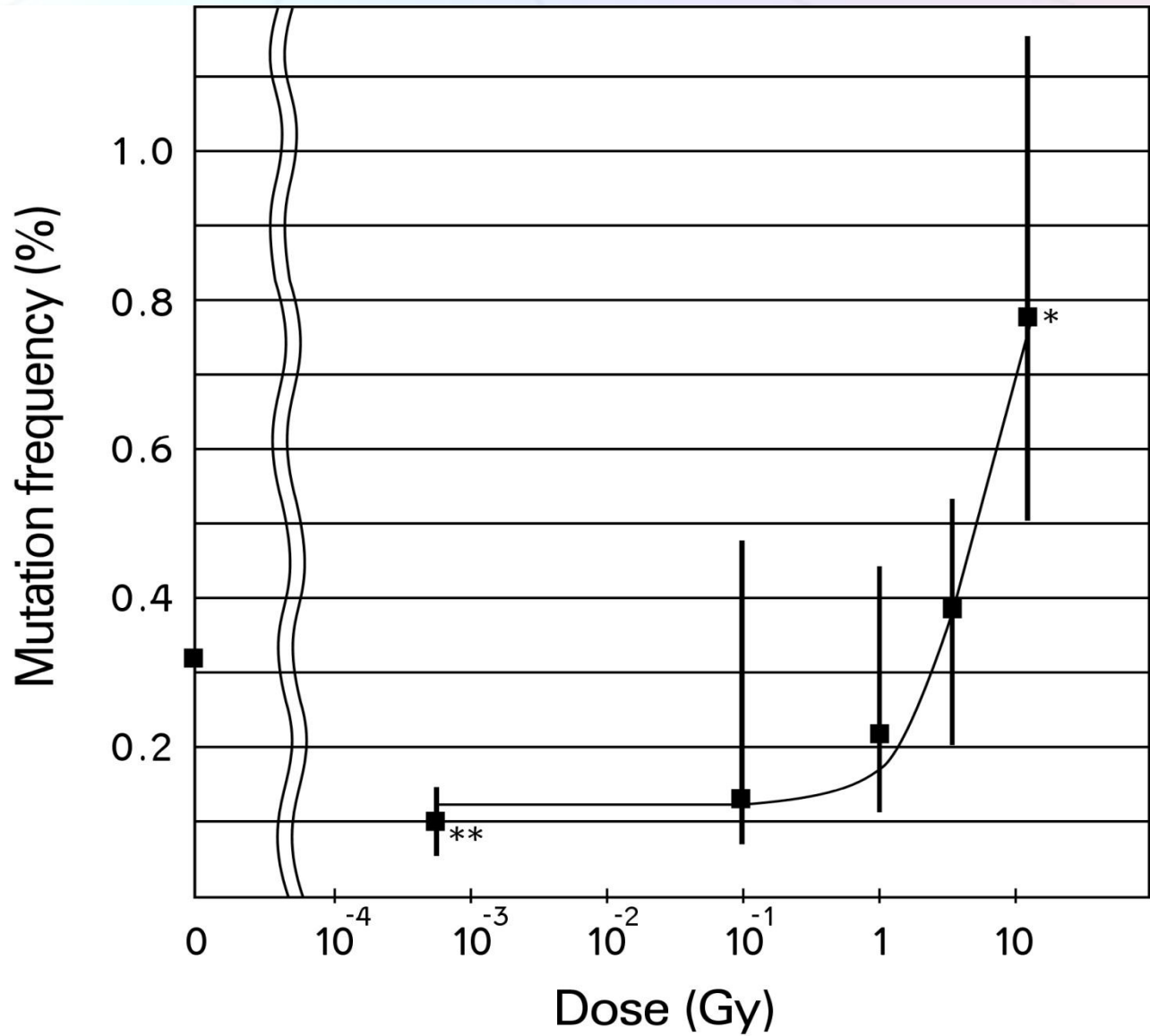
- prevention of DNA damage
- repair of DNA damage
- removal of damaged cells and removal of cancer cells

High radiation dose/level has opposite effects

LNT Assumption (dose on log scale)



Mutation Frequency in Fruit Flies: Japanese vs. Muller



<http://www.sciencedaily.com/releases/2011/09/110920163320.htm>

No Safe Level of Radiation Exposure? Researcher Points to Suppression of Evidence On Radiation Effects by Nobel Laureate

ScienceDaily (Sep. 20, 2011) — University of Massachusetts Amherst environmental toxicologist **Edward Calabrese**, whose career research shows that low doses of some chemicals and radiation are benign or even helpful, says he has uncovered evidence that one of the fathers of radiation genetics, **Nobel Prize winner Hermann Muller knowingly lied when he claimed in 1946 that there is no safe level of radiation exposure.**

Calabrese's interpretation of this history is supported by letters and other materials he has retrieved, many from formerly classified files. Published findings in three articles, in scientific journals

Radiation Exposures of 18,846 Plant Workers 2011 March 11 to December 31

Workers vs Dose since Mar 11

135 100 to 150 mSv

23 150 to 200 mSv

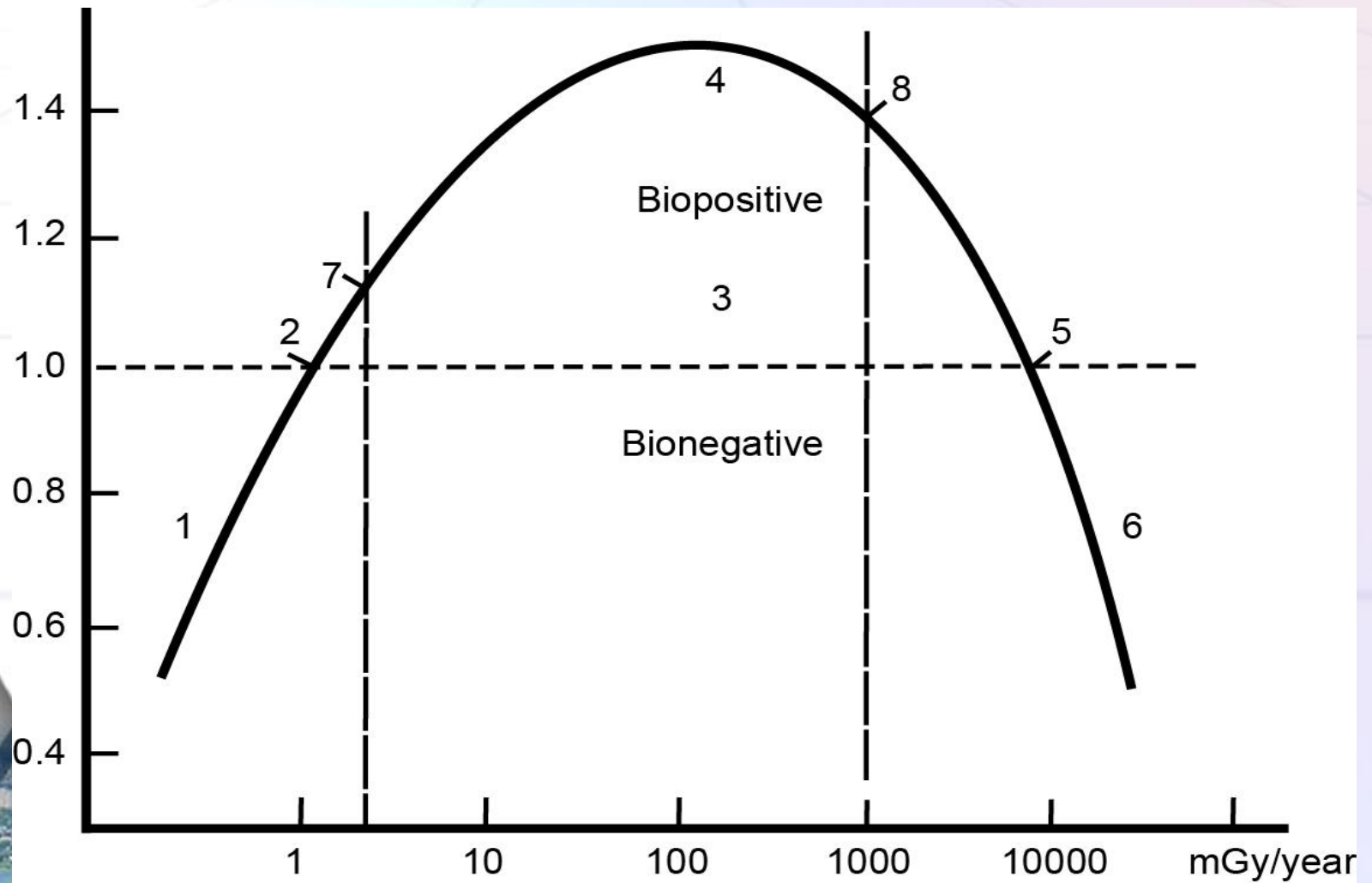
3 200 to 250 mSv

6 309 to **678** mSv

167 total, more than 100 mSv

Compare **678 mSv** with TBI LDI therapy:
 $150 \text{ mGy} \times 2/\text{wk} \times 5 \text{ wk} = \mathbf{1500 \text{ mGy}}$

Radiation Stimulates Biological Defences



As High As Reasonably Safe (AHARS)

Radiation Protection Activity

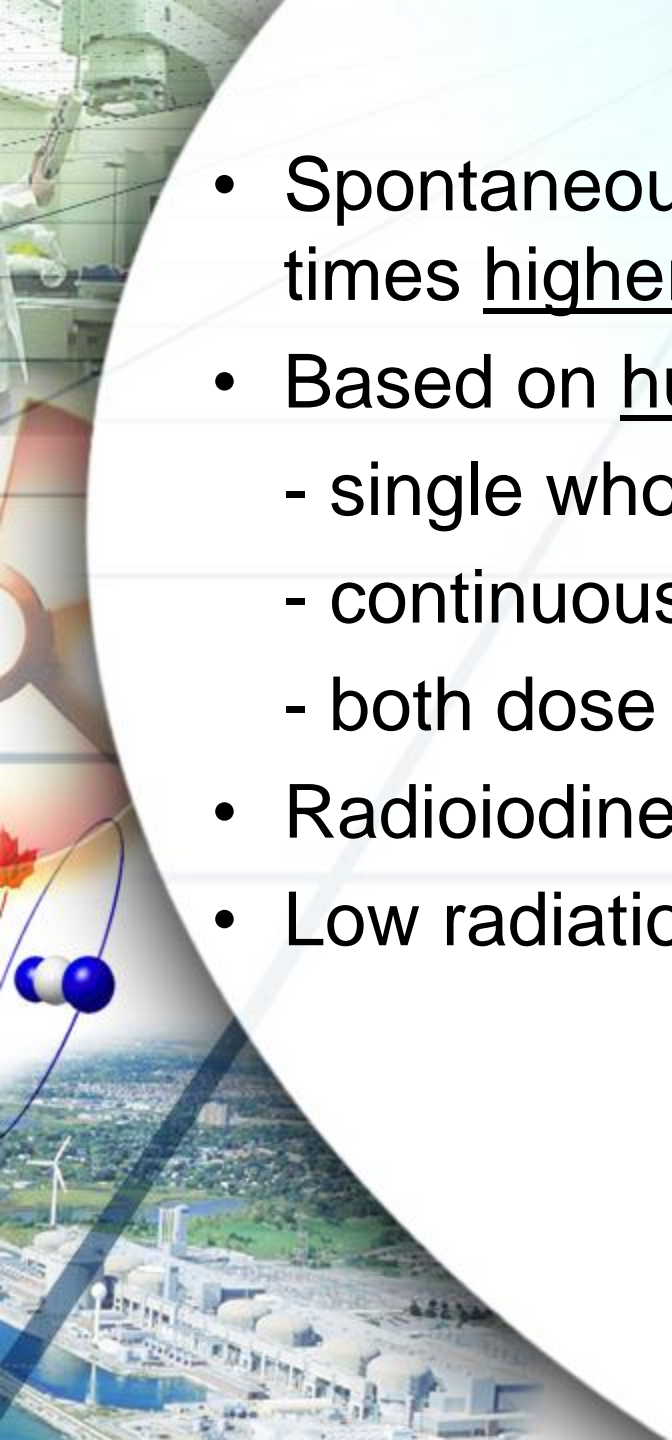


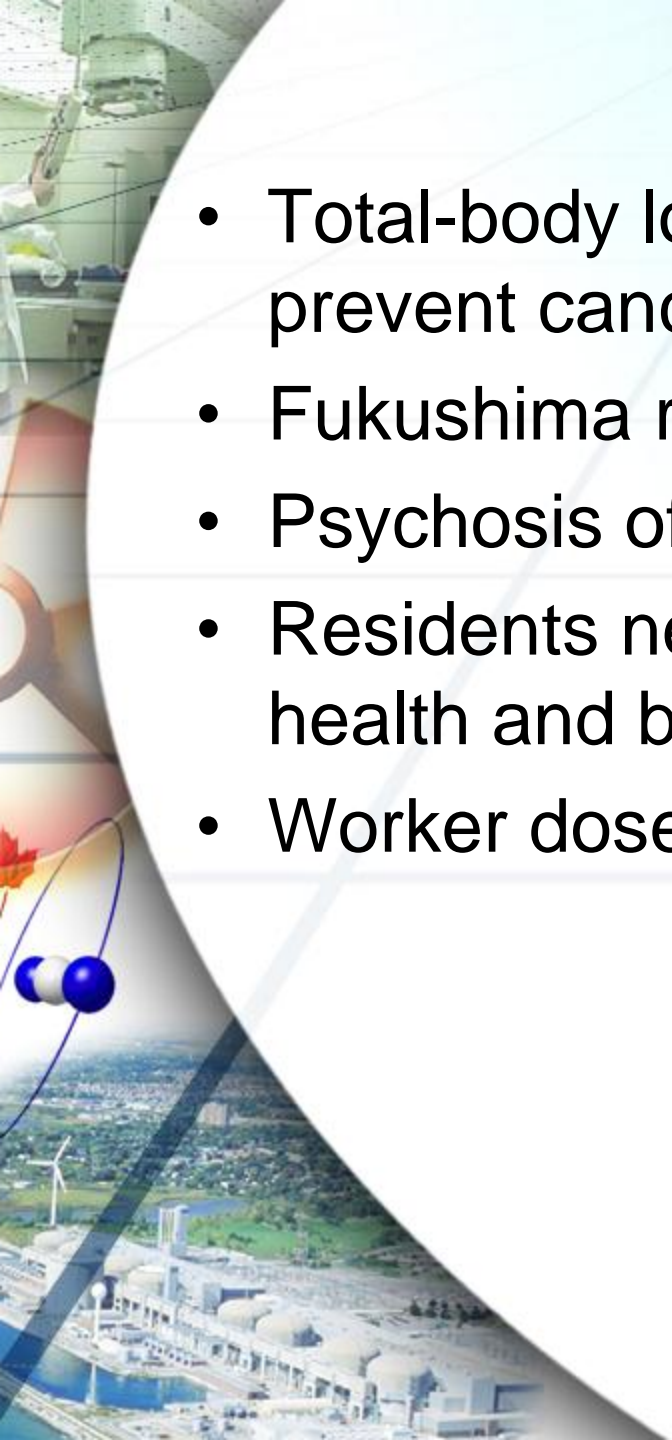
Conclusions

- Nuclear energy* is blocked by antinuclear activists communicating myths about radiation and cancer
- Radiation myth/scare is **not** debunked by anyone; there is no outrage from professionals
- Nuclear regulations are overprotective and very costly in dollars and project schedule
- Chernobyl victims suffered **not** from cancer, but from “vegetative vascular dystonia” (depression)

“psychosis of fear

*Medical applications are also blocked

- 
- Spontaneous DNA damage rate > 6 million times higher than 1 mSv/y DNA damage rate
 - Based on human data:
 - single whole-body dose of 150 mSv is safe
 - continuous exposure of 700 mSv/y is safe
 - both dose exposures are also beneficial
 - Radioiodine is not a significant cause of cancer
 - Low radiation stimulates defences, less cancer

- 
- Total-body low-dose radiation therapy can prevent cancers and eliminate metastases
 - Fukushima radiation insignificant cancer risk
 - Psychosis of fear is causing enormous suffering
 - Residents need to know true radiation effects on health and be urged to return home
 - Worker doses < radiologist 1931 tolerance limit

Recommendations

- Scientific societies should organize events to discuss radiation and health
- Regulatory bodies and health organization should examine the scientific evidence
- Stop calculating nuclear safety cancer risk
- Stop regulating harmless radiation sources
- Develop public communication programs
- **Raise radiation level for evacuation from 20 to 1000 mSv/year**