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Nuclear Energy and Health

And the Benefits of Low-Dose Radiation Hormesis

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PubMed Central Search Journal List

DOSE-RESPONSE
AN INTERNATIONAL JOURNAL
Assessing the Nature, Mechanisms, and Implications of Dose-Response Relationships

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Abstract

Energy needs worldwide are expected to increase for the foreseeable future, but fuel supplies are limited. Nuclear reactors could supply much of the energy demand in a safe, sustainable manner were it not for *fear of potential releases of radioactivity*. Such releases would likely deliver a low dose or dose rate of radiation, within the range of naturally occurring radiation, to which life is already accustomed. The key areas of concern are discussed. Studies of actual health effects, especially thyroid cancers, following exposures are assessed. Radiation hormesis is explained, pointing out that beneficial effects are expected following a low dose or dose rate because protective responses against stresses are stimulated. The notions that no amount of radiation is small enough to be harmless and that a nuclear accident could kill hundreds of thousands are challenged in light of experience: more than a century with radiation and six decades with reactors. If nuclear energy is to play a significant role in meeting future needs, regulatory authorities must examine the scientific evidence and communicate the real health effects of nuclear radiation. Negative images and implications of health risks derived by unscientific extrapolations of harmful effects of high doses must be dispelled.

Keywords: sustainable nuclear energy, radiation health effects, radiation hormesis, social acceptance, regulatory implications

http://www.acsh.org/news/newsID.1791/news_detail.asp

"On the thirtieth anniversary of Three Mile Island, end the scare stories"

Posted: Friday, March 27, 2009

PRESS RELEASE
Publication Date: March 27, 2009

New York, NY -- March 27, 2009. The end of this month marks the thirtieth anniversary of the Three Mile Island nuclear accident -- and for too long, the tiny handful of such mishaps have been used to exaggerate the dangers of nuclear power.

A report called "Nuclear Energy and Health, And the Benefits of Low-Dose Radiation Hormesis," commissioned by the American Council on Science and Health (ACSH) and published this month in the journal *Dose-Response* (Volume 7, Issue 1), dispels some of the most common fears about nuclear energy.

There has recently been a renewed global interest in using nuclear energy to address the environmental concerns that accompany our continued combustion of coal, oil, and gas to sustain our standard of living. However, new construction of nuclear plants is impeded by powerful anti-nuclear political activists -- and by media reporters who communicate unwarranted fears about small doses of radiation.

In this publication, nuclear engineering expert Jerry M. Cuttler, D.Sc., P.Eng. (past president of the Canadian Nuclear Society) and Myron Pollycove, M.D. (formerly of the U.S. Nuclear Regulatory Commission) present important biological realities and scientific explanations that are being ignored. On the thirtieth anniversary of Three Mile Island, end the scare stories about nuclear energy, suggests this report, so that a safe and highly efficient source of energy can be utilized for the benefit of humanity at a time when energy production is a top priority.

The American Council on Science and Health is a public health, consumer-education consortium of over 350 scientists and physicians, experts who serve on ACSH's scientific advisory panel. ACSH publishes reports on issues pertaining to the environment, nutrition, pharmaceuticals, and tobacco and helps the public deal with the real health risks productively. SEE ALSO: ACSH's short brochure on nuclear energy and health, available as PDF file and in hard copy.

Contact: Dr. Gilbert Ross, ACSH Medical Director: rossG@acsh.org (212-362-7044)

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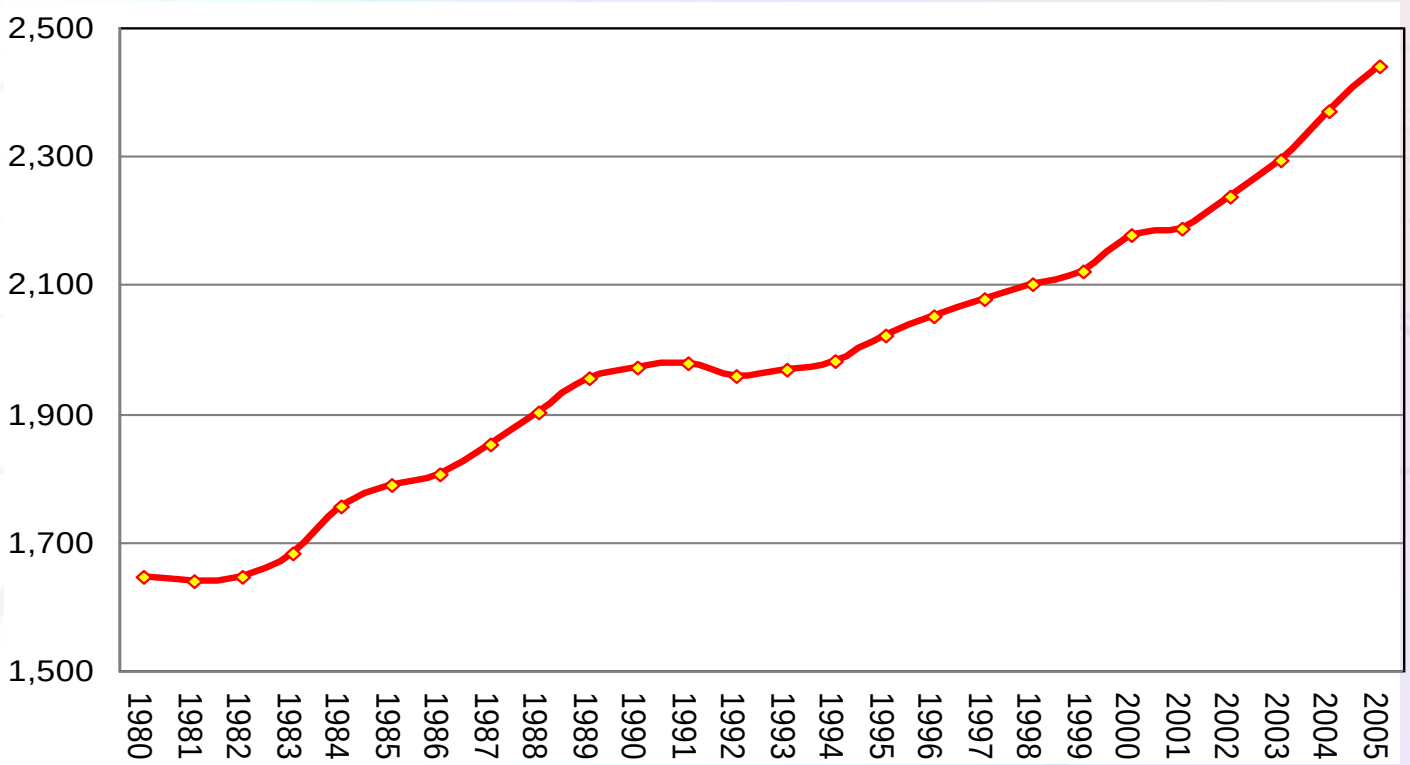


Average global electricity use (kWh/person/year) 1980-2005

By 2030, double electricity use

Don't burn coal, hydrocarbons (89% of primary energy)

Environmentalists reject nuclear

Radiation and weapons scares

Cover nuclear energy and health

Challenge assumption: cancer is proportional to radiation

Nuclear Radiation and Fission

Ionizing vs. non-ionizing radiation

Ionizing radiation damages cells; they send signals; defensive responses

Roentgen discovers x-rays in 1895

Becquerel discovers radioactivity of uranium (unstable) in 1896

Many studies on x-rays and radioactivity; and applications

Pierre and Marie Curie discover polonium and radium in 1898

Rutherford hit alphas on gold atoms; discovers nuclear atom in 1911

Chadwick discovers neutron in 1932

Neutrons on U; discover fission 1939

Releases enormous energy, neutrons, radiations and fission products

Molecular Energy Release
Comparing Combustion vs. Fission

$$H_2 + \tfrac{1}{2}O_2 \rightarrow H_2O + 3.0\ eV$$

$$C + O_2 \rightarrow CO_2 + 4.1\ eV$$

$$U + n \rightarrow 2FPs + 2.5n + 200{,}000{,}000\ eV$$

The amount of radioactive waste is very small and is contained.

Nuclear Fission and Weapons

Fission reaction: ~ 50 million times energy of chemical combustion

Can end WWII, if self-sustaining chain reaction possible

Manhattan Project: separated U-235 and bred Pu-239 from uranium

U-235 and Pu-239 bombs destroyed two cities; Japan surrendered

USSR and others develop and test nuclear weapons

Arms race; bomb size escalated from 20 kT to > 50 MT TNT equivalent

USA and USSR make 10,000s bombs

Atmosphere testing to develop and optimize bombs

Peaceful Applications of Nuclear Energy

After WWII, conceived nuclear reactor to propel submarines

Nautilus began Aug 1950 “Underway on nuclear power” in Jan 1955

Hundreds of nuclear naval vessels and ice breakers

Nuclear electric power plant began in UK in 1956 and in US in 1957

Atoms for Peace in 1955; (IAEA)

IAEA promoted peaceful applications

More than 500 power reactors built in 32 countries; > 440 are operating

Nuclear generates significant fraction of electricity in many countries

Nuclear controversial; exaggerated concerns: safety, affordability, sustainability, accidents, used fuel, radioactive waste and weapons

Capital cost ~ $2,500/kW; operating cost ~$0.04/kWh; affordable!

Value of energy over plant life (up to 100 years) vs. capital investment

Source: World Nuclear Association, International Atomic Energy Agency, May 2008

Nuclear Energy's Potential to Sustain Humanity

Supply of affordable power essential for healthy economy

Power drives industry and commerce; pays salaries, public health

Unemployment leads to poverty; one of the greatest health risks

Water supply essential for health and food production; power plants can desalinate and pump seawater

Environmentalists urge shift to renewable energy sources and ***the hydrogen economy*** instead of burning coal, oil and gas

Hydrogen does not exist separated; can make it using nuclear energy

Current reactors designs release less than 1% of energy in uranium; conventional reserves ~ 300 years

Breeder Reactors can Sustain Humanity

Breeder release > 90% of energy in U and can make U-233 from thorium which is 3 times more abundant

Breeders can extend supply of fuel to many tens of thousands of years

Fuels can be fabricated in a form not useable for weapons

Can extract U from the oceans at an affordable cost; rivers bring 6,500 tons annually to oceans

Adequate to generate 10 times world's present electricity usage

Fission is a ***renewable*** energy source with little environmental impact

Sustainable development is a nuclear advantage

Progress on hindered by health scares; fear of any exposure to radiation

Human-made radiation doses small vs. natural radiation doses

Small exposure ***stimulates*** biological defences, which is a health ***benefit***

Managing Used Fuel and Wastes

Excellent reactor safety; anti-nukes focus on ***unsolvable problems*** of radioactive waste, weapons

Enormous energy release results in very small used fuel volume vs. coal/oil/gas combustion

Used fuel stored in water tanks, later in heavy, sealed concrete-steel containers that will last centuries

Constantly measured radiation levels same as surrounding environment

No added dose; therefore no harm

No one being injured; no reason to believe anyone injured in future

Several countries intend to put rad waste deep underground, but unfounded concerns on surface radiation after 100,000 years

Science show surface dose rate would hardly exceed average dose rate of natural radiation, more than 1000 times below level of adverse health effects

Managing and Recycling Fuel

Range of natural background extends >100 times above average value

Ridiculous dose limit for repository after 10,000 years: 0.15 mSv/year, only 5% average US background

Used fuel management not a heavy burden on future Canadians; it is resource for their energy needs

Recycling removes fission products that impair the chain reaction

PUREX, UREX can separate Pu, but pyro-processing makes a mixture of Pu and transuranics; difficult to divert, but an ideal fast reactor fuel

Managing radioactive waste and avoiding weapons proliferation is feasible and affordable

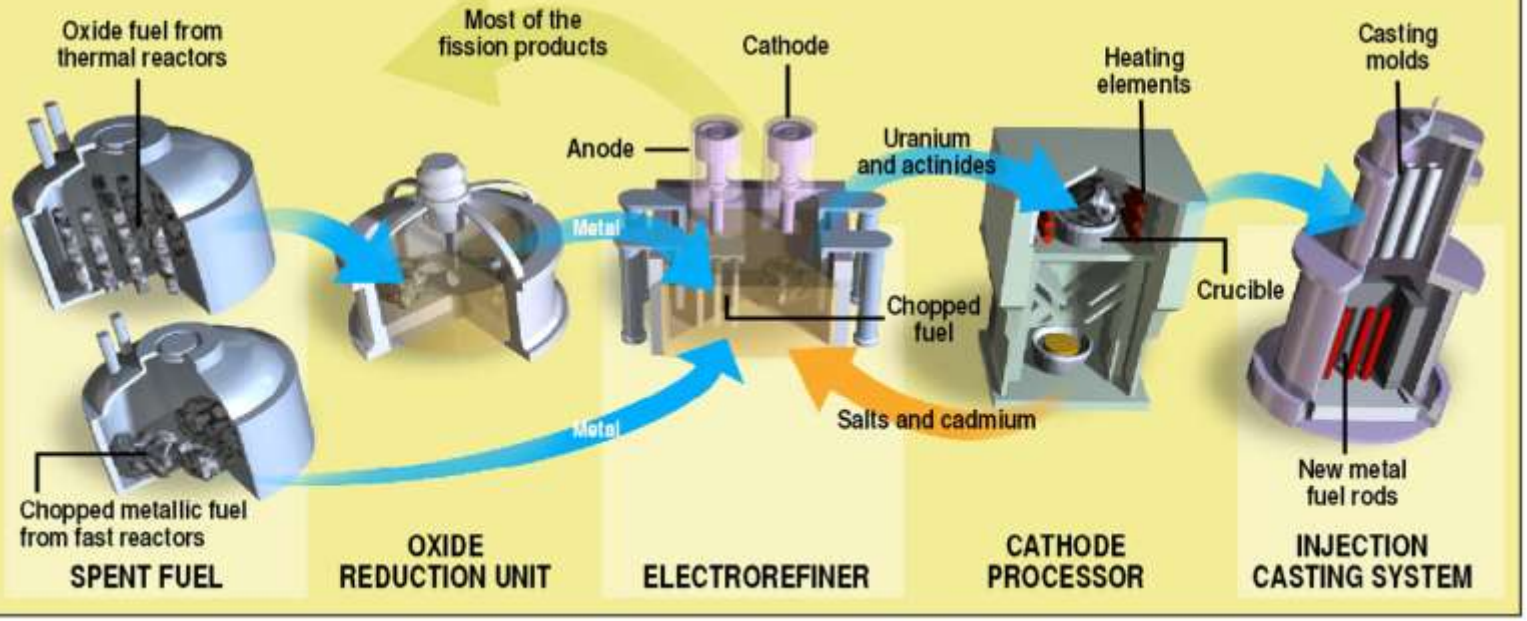
Costs much lower and predictable if regulatory standards were based upon radiobiological science and realistic risk assessments

Pyro-processing to Recycle Nuclear Fuel

NEW WAY TO REUSE NUCLEAR FUEL

The key to pyrometallurgical recycling of nuclear fuel is the electrorefining procedure. This process removes the true waste, the fission products, from the uranium, plutonium and the other actinides (heavy radioactive elements) in the spent fuel. The actinides are kept mixed with the plutonium so it cannot be used directly in weapons.

Spent fuel from today's thermal reactor (uranium and plutonium oxide) would first undergo oxide reduction to convert it to metal, whereas spent metallic uranium and plutonium fuel from fast reactors would go straight to the electrorefiner. Electrorefining resembles electroplating: spent fuel attached to an anode would be suspended in a chemical bath; then electric current would plate out uranium and other actinides on the cathode. The extracted elements would next be sent to the cathode processor to remove residual salts and cadmium from refining. Finally, the remaining uranium and actinides would be cast into fresh fuel rods, and the salts and cadmium would be recycled.



Reactor Life Extension and Replacement

Chemical plants eventually become old and worn; equipment obsolete

Nuclear plants are expensive; owners focus on life management/extension

Can extend life to 100 years; 1) assess condition of structures, systems and components, 2) refurbish equipment and 3) upgrade designs

World experience is studied, events are analyzed and standards are revised

Reactor suppliers offer many design improvements; better performance

When extend operating licence, owners make cost-effective plant upgrades

If life extension not economical, can shut down and decommission using available technologies; affordable

An existing site may be reused for a new nuclear plant

Is Nuclear Power a Significant Health Risk?

Scientific evidence about health effects of radiation is surprising

Plants designed, constructed and operated to retain radioactivity

Safety culture; detailed procedures
Continuous inspection and review

Releases < 1% of permissible levels

If an accident occurs, people informed and emergency measures taken to prevent injury

Adverse effects; shorter life span?

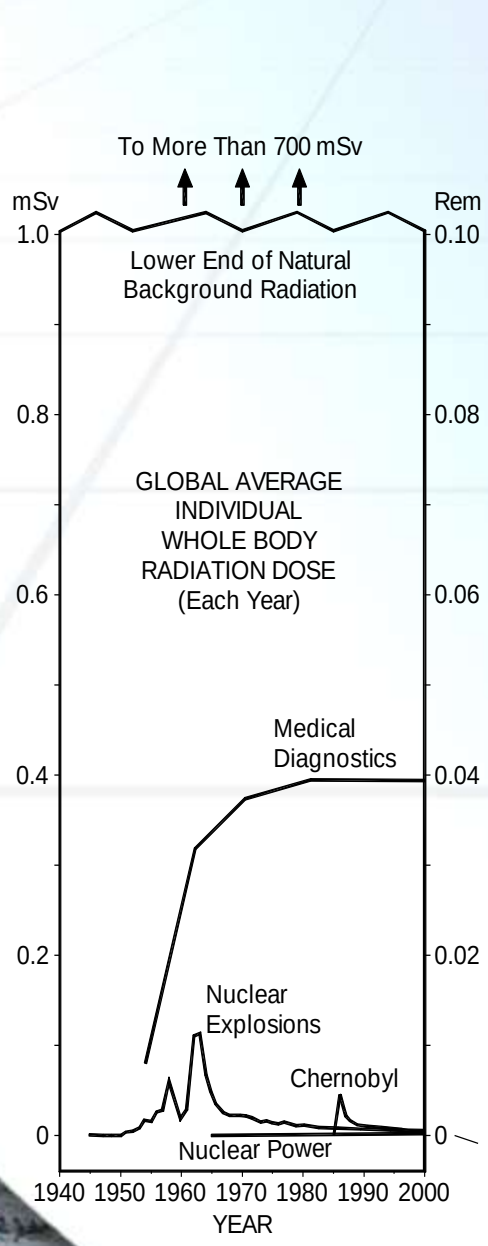
Research: a low dose is stimulatory - *no* harm; it is *beneficial*

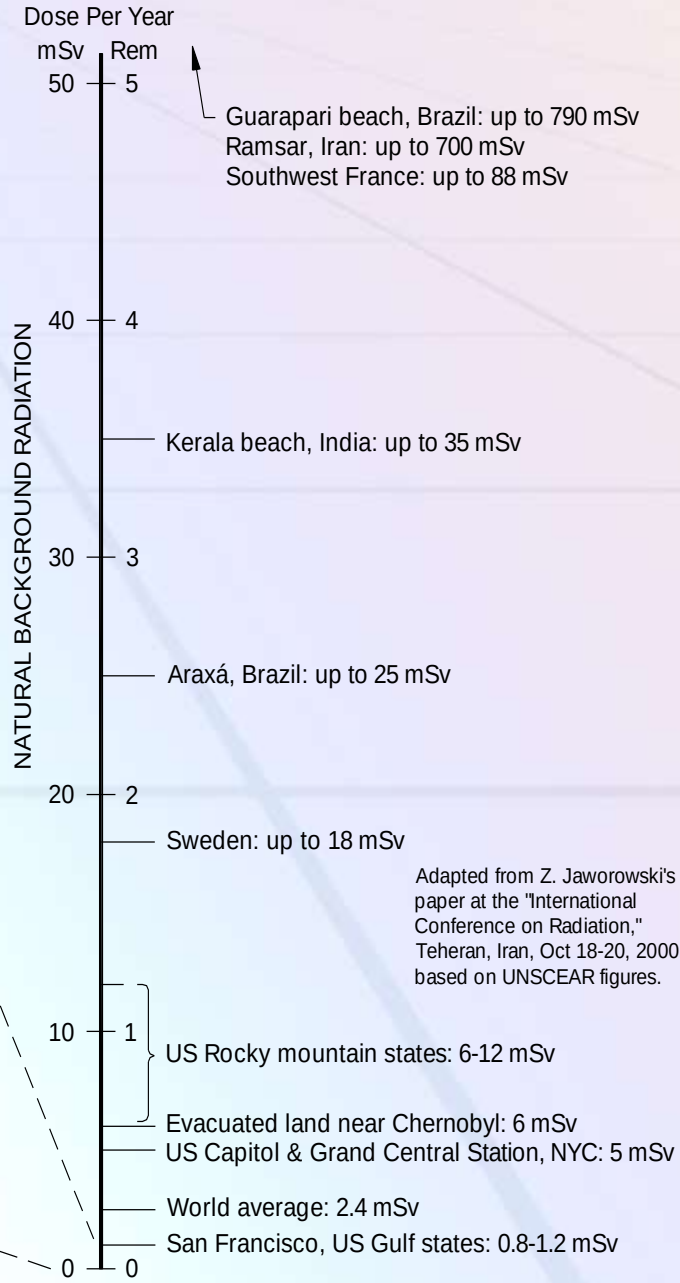
Beneficial effects after low doses; harmful effects after high doses
Recent information: bio mechanisms, antioxidants, cell repair, altered and mutated cell removal

Positive radiation effects understood

Effects measured vs. energy deposit
1 rad = 100 erg/gm; 1 Gy = 1 joule/kg

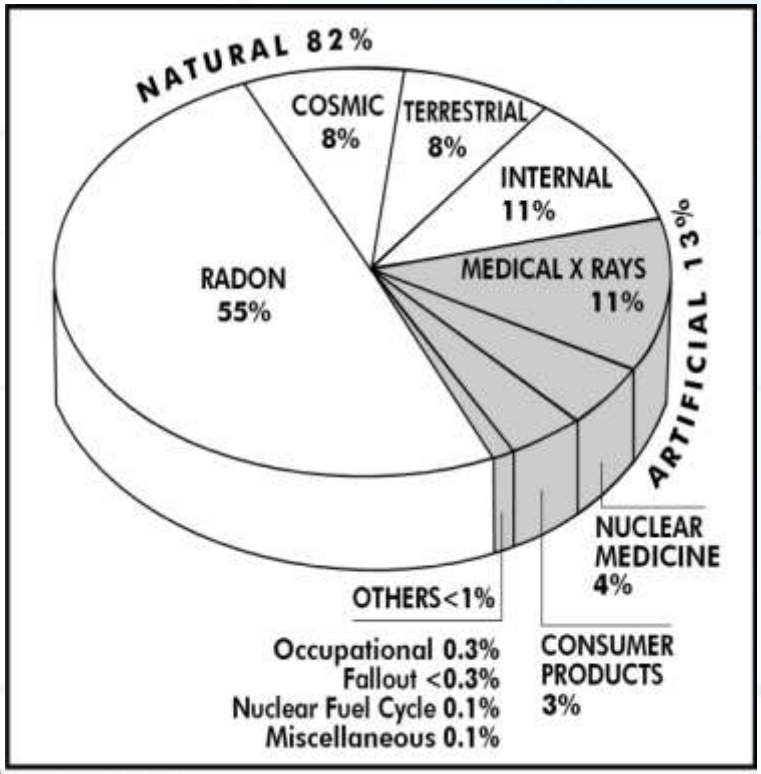
Human-made vs Natural Radiation



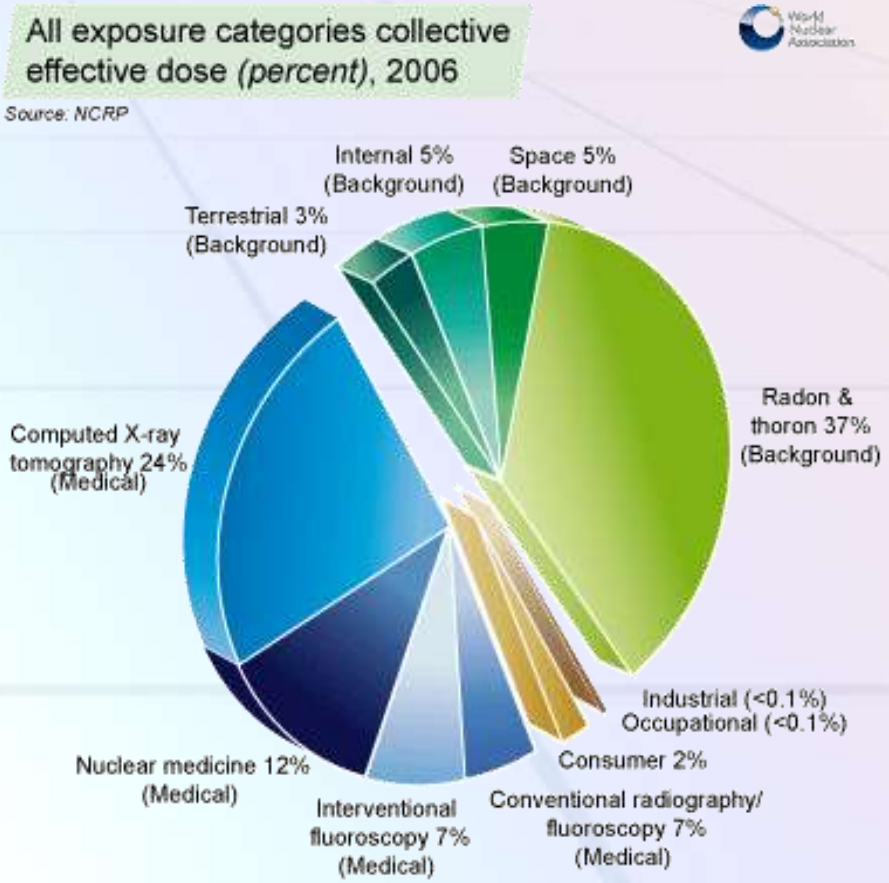


Adapted from Z. Jaworowski's paper at the "International Conference on Radiation," Teheran, Iran, Oct 18-20, 2000 based on UNSCEAR figures.

“Effective” Dose to a Person in the United States



Source: NCRP, 1987



Life Span Study of Hiroshima-Nagasaki Survivors

LSS on cancer mortality of H-N survivors grossly overstates the effects of radiation; does not reflect real risks

Enormous heat from bombs killed ~200,000 of the 429,000 people

Study cohort 86,572; half of survivors within 2.5 km of bomb positions

How many survivors cancer deaths do we expect after 40 years, in excess of normal cancer mortality?

Actual data: 344 excess solid cancer deaths, 87 excess leukemia deaths; less than 1% (lower than expected)

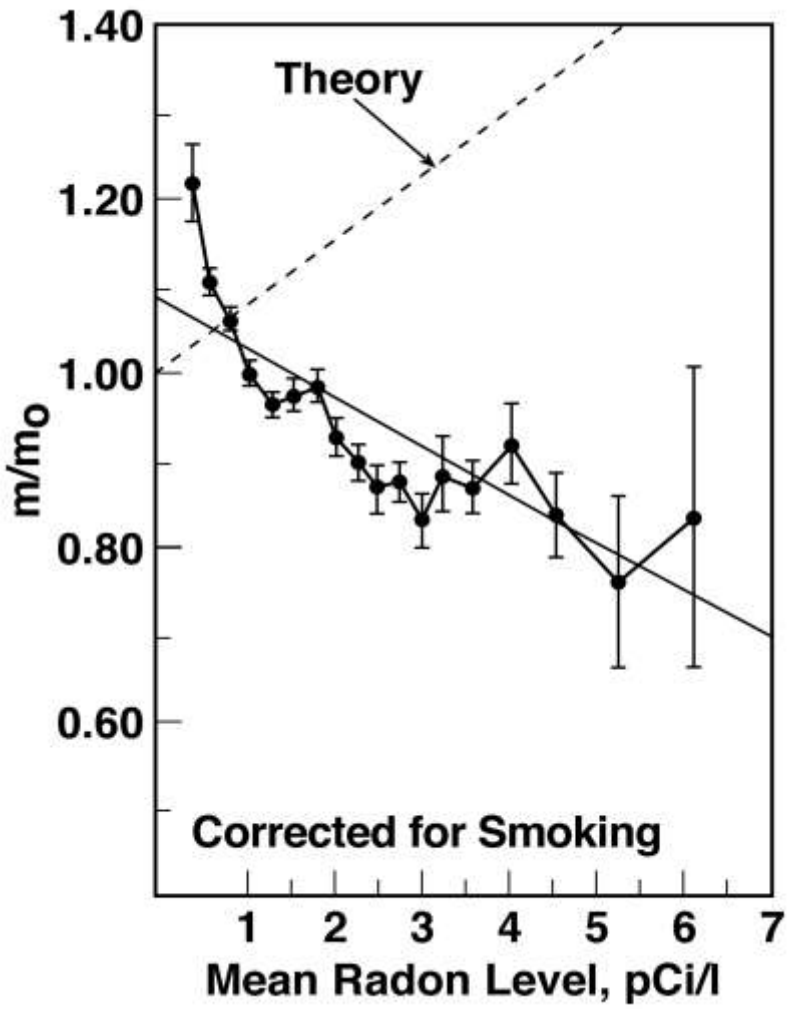
Confounding survivors risks: thermal burns, wounds, infection, thirst, starvation, pollution, sanitation, shelter, medical care, family support

The 344 excess cancer deaths are the basis for risk of excess fatal cancers from any radiation in environment

LSS made line from > 50 rem data to zero dose; “the LNT model”

LSS ignored the beneficial effects

Radon Exposure Study Disproves the LNT Hypothesis



Greatest natural radiation exposure is inhalation of radon gas in air, from uranium radioactivity

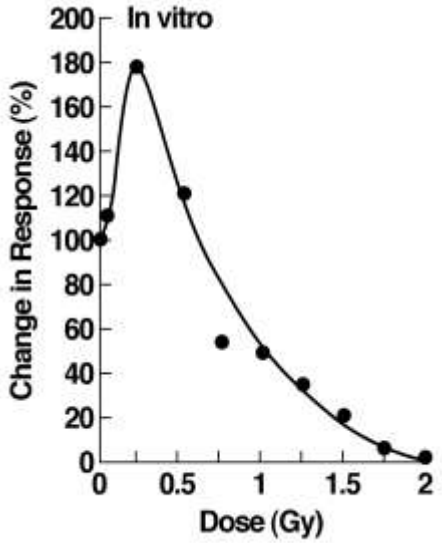
Scientific test of LNT model, as used, clearly disproved it; lung cancer mortality *lower* where radon *higher*

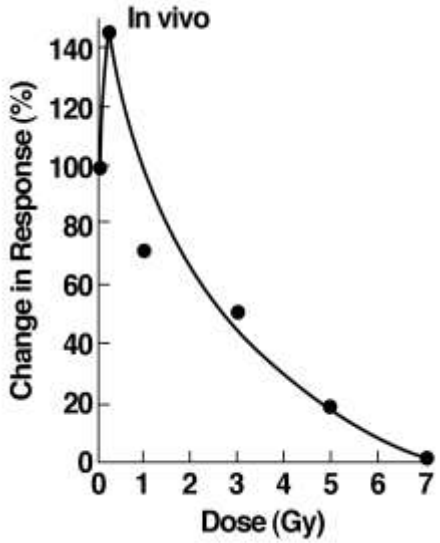
Lung cancer *higher* where radon is *lower* than the average of 1.7 pCi/L

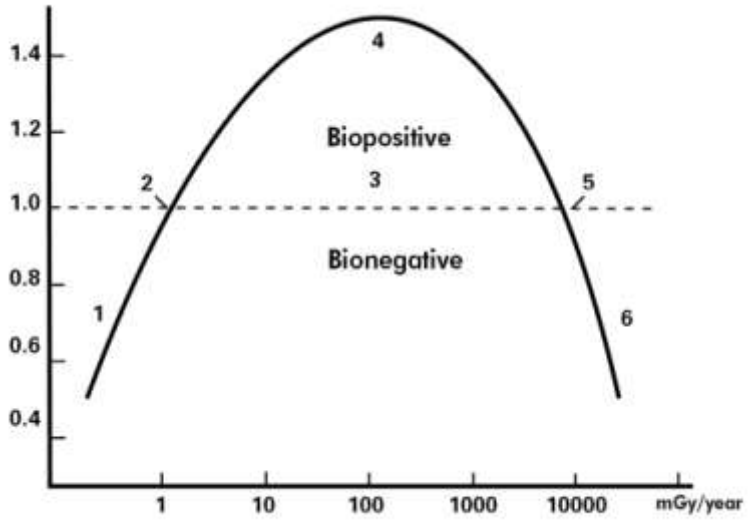
Instead of discarding LNT assumption, LNT fans raise objection (ecological study) not applicable to test

Authorities still accept LNT assumption

Radiation Hormesis







Organisms get radiation, plus physical, chemical and biological stresses

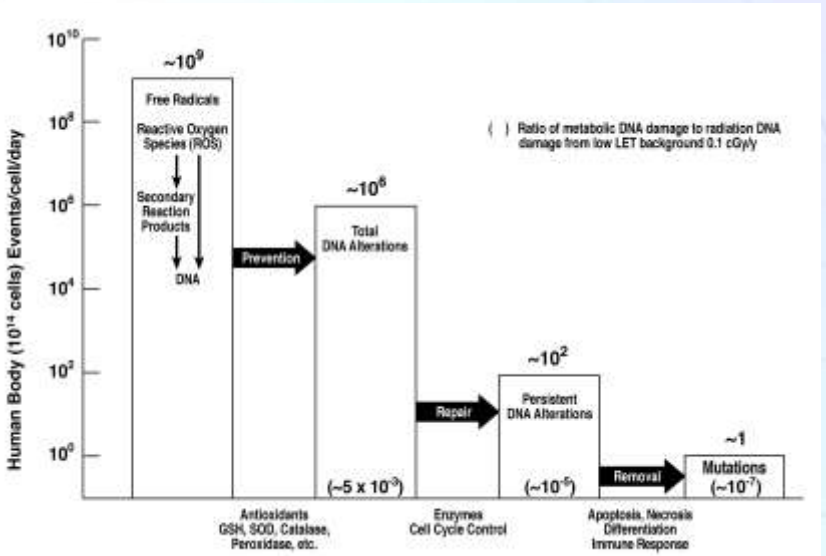
Radioactivity half-lives up to billions of years; intensities up to several hundred times the world average dose rate

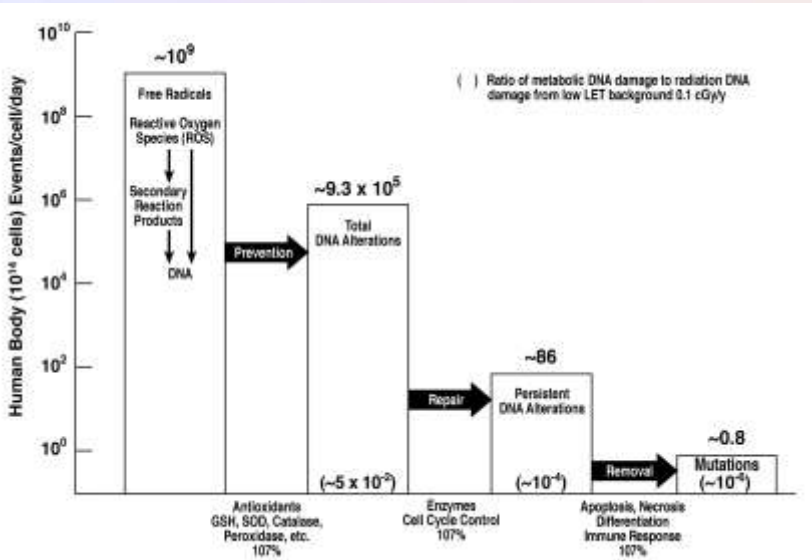
Paracelcus: “nothing is without poison; only the dose makes something not poison”

Radiation causes stress; perturbs equilibrium; organisms adapt

Low dose reduces cancer; stimulates prevention of endogenous cell damage, cell repair, damaged cell replacement, removal

Radiation Hormesis





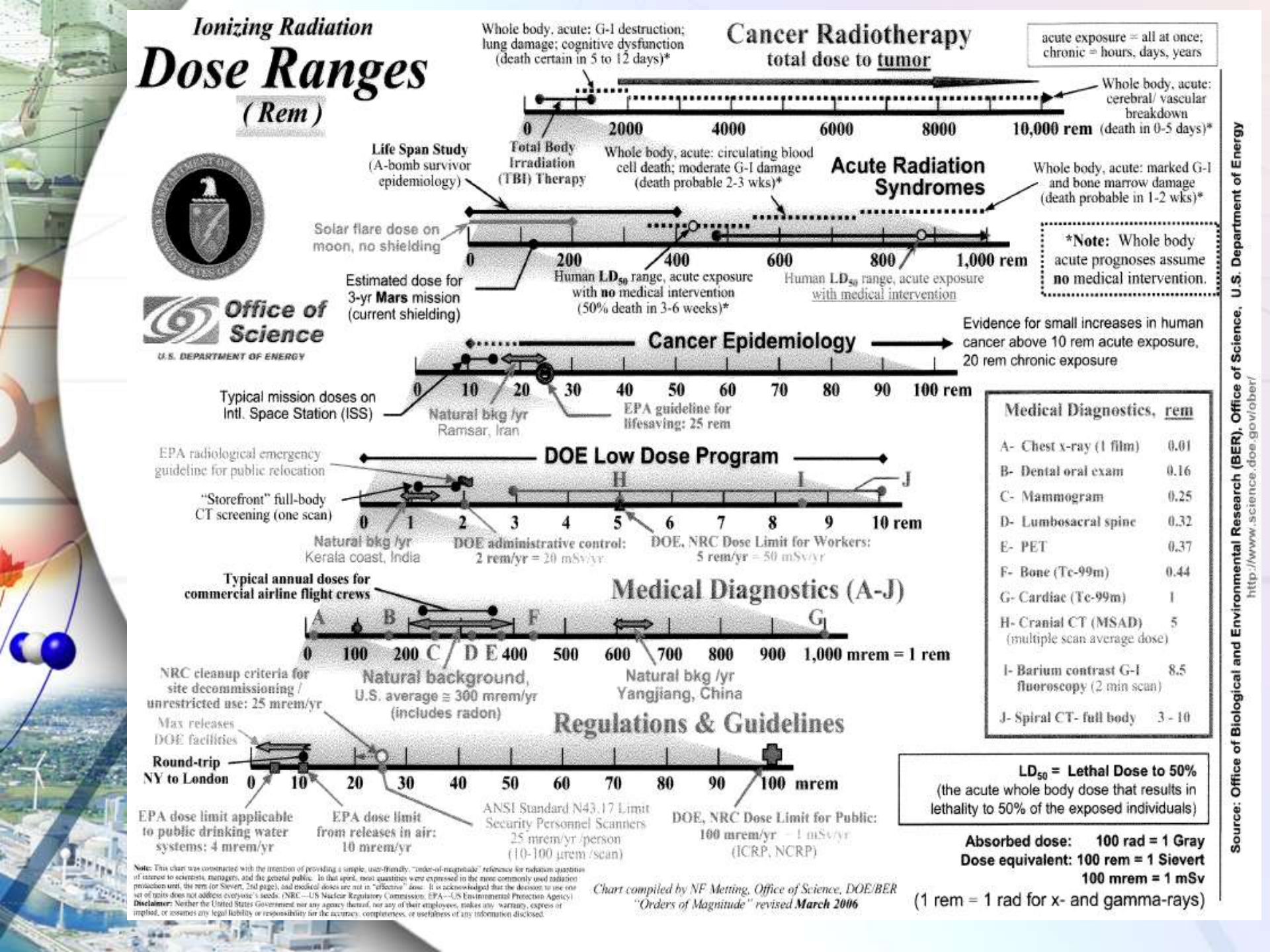
The stimulation by radiation of bio-defences: prevention, repair and removal of cell alterations due to <u>natural</u> metabolic leakage of ROS (reactive oxygen species)

Accumulation of mutations is associated with mortality and cancer mortality

Low-dose <u>stimulates</u>: production of ***antioxidants*** etc., ***repair*** of DNA damage, killer T cell ***destruction*** of damaged cells, and p53 ***self-destruction***

<u>Metabolic</u> DNA damage rate is ~10 million times the damage rate caused by 0.1 cGy/y bkgd

Factor of 10 radiation <u>increase</u> <u>reduces</u> mutation rate by 20%


Ionizing Radiation
Dose Ranges
(Rem)
Office of Science
U.S. DEPARTMENT OF ENERGY
Cancer Radiotherapy
total dose to tumor
acute exposure = all at once; chronic = hours, days, years
Whole body, acute: G-I destruction; lung damage; cognitive dysfunction (death certain in 5 to 12 days)*
Whole body, acute: cerebral/ vascular breakdown (death in 0-5 days)*
0 2000 4000 6000 8000 10,000 rem
Total Body Irradiation (TBI) Therapy
Life Span Study (A-bomb survivor epidemiology)
Whole body, acute: circulating blood cell death; moderate G-I damage (death probable 2-3 wks)*
Acute Radiation Syndromes
Whole body, acute: marked G-I and bone marrow damage (death probable in 1-2 wks)*
Solar flare dose on moon, no shielding
Estimated dose for 3-yr Mars mission (current shielding)
0 200 400 600 800 1,000 rem
Human LD50 range, acute exposure with no medical intervention (50% death in 3-6 weeks)*
Human LD50 range, acute exposure with medical intervention
*Note: Whole body acute prognoses assume no medical intervention.
Cancer Epidemiology
Evidence for small increases in human cancer above 10 rem acute exposure, 20 rem chronic exposure
0 10 20 30 40 50 60 70 80 90 100 rem
Typical mission doses on Intl. Space Station (ISS)
Natural bkg /yr Ramsar, Iran
EPA guideline for lifesaving: 25 rem
DOE Low Dose Program
EPA radiological emergency guideline for public relocation
"Storefront" full-body CT screening (one scan)
H I J
0 1 2 3 4 5 6 7 8 9 10 rem
Natural bkg /yr Kerala coast, India
DOE administrative control: 2 rem/yr = 20 mSv/yr
DOE, NRC Dose Limit for Workers: 5 rem/yr = 50 mSv/yr
Medical Diagnostics, rem
A- Chest x-ray (1 film) 0.01
B- Dental oral exam 0.16
C- Mammogram 0.25
D- Lumbosacral spine 0.32
E- PET 0.37
F- Bone (Tc-99m) 0.44
G- Cardiac (Tc-99m) 1
H- Cranial CT (MSAD) (multiple scan average dose) 5
I- Barium contrast G-I fluoroscopy (2 min scan) 8.5
J- Spiral CT- full body 3 - 10
Typical annual doses for commercial airline flight crews
Medical Diagnostics (A-J)
A B F G
0 100 200 C D E 400 500 600 700 800 900 1,000 mrem = 1 rem
Natural background, U.S. average ≅ 300 mrem/yr (includes radon)
Natural bkg /yr Yangjiang, China
NRC cleanup criteria for site decommissioning / unrestricted use: 25 mrem/yr
Max releases DOE facilities
Round-trip NY to London
Regulations & Guidelines
0 10 20 30 40 50 60 70 80 90 100 mrem
EPA dose limit applicable to public drinking water systems: 4 mrem/yr
EPA dose limit from releases in air: 10 mrem/yr
ANSI Standard N43.17 Limit Security Personnel Scanners 25 mrem/yr /person (10-100 μrem /scan)
DOE, NRC Dose Limit for Public: 100 mrem/yr = 1 mSv/yr (ICRP, NCRP)
LD50 = Lethal Dose to 50% (the acute whole body dose that results in lethality to 50% of the exposed individuals)
Absorbed dose: 100 rad = 1 Gray
Dose equivalent: 100 rem = 1 Sievert
100 mrem = 1 mSv
(1 rem = 1 rad for x- and gamma-rays)
Note: This chart was constructed with the intention of providing a simple, user-friendly, "order-of-magnitude" reference for radiation quantities of interest to scientists, managers, and the general public. In that spirit, most quantities were expressed in the more commonly used radiation protection unit, the rem (or Sievert, 2nd page), and medical doses are not in "effective" dose. It is acknowledged that the decision to use one set of units does not address everyone's needs. (NRC—US Nuclear Regulatory Commission; EPA—US Environmental Protection Agency)
Disclaimer: Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information disclosed.
Chart compiled by NF Metting, Office of Science, DOE/BER
"Orders of Magnitude" revised March 2006
Source: Office of Biological and Environmental Research (BER), Office of Science, U.S. Department of Energy
http://www.science.doe.gov/ober/

Three Nuclear Reactor Accidents

1957 Windscale UK accident; graphite core burned; large fission products release; diluted by wind; milk restricted; very low doses

I-131 greatest concern for thyroid cancer in children; set safe limit of 20 rad or 200 mGy

1979 Three Mile Island; valve stuck; ignorance; incorrect action stopped heat removal; 50% of fuel melted; activity contained; authorities did not inform real health effects; great public fear; stopped nuclear power

1986 Chernobyl significant for safety

Unsafe design and procedures; poor safety culture; improper operation; safety systems disabled during test

Manoeuvres made reactor unstable; power rise to > **50 times full power**; six tons fuel, radioactivity released

3 workers killed; 134 high radiation and 28 died; 106 recovered; 19 died in 18 years (normal mortality 1%/y); 4000 thyroid cancer cases screened

Doses to evacuees and cleanup workers within range of normal background, well below adverse health threshold

Based on 31 deaths, nuclear is very safe for large-scale energy production

Local Environmental Effects of Chernobyl Accident

Important evidence of actual effects; less severe than a forest fire

Dose rates reached ~ 1 Gy/h in two 0.5 km2 areas, S-E, in a few hours

Short-lived activity dropped rapidly; lethal to stand there for 24 h

Pine severely damaged by β doses > 100 Gy; deciduous trees partially

Moderate effects in 12,000 hectare zone included growth suppression, needle loss, but in summer of 1986 showed new growth

By 1988-89, tree growth everywhere; 1986-87, fewer small insects in 30 km Exclusion Zone; rodent doses above lethal to mid-May 1986

No single species eliminated; they adapted to altered conditions; populations continue to survive

No acute effects in plants and animals outside Exclusion Zone

Removal of people and cessation of agricultural and industrial activity helped recovery; populations of plants and animals expanded

Environmental conditions have had such a positive impact on biota that the Exclusion Zone became a unique sanctuary for biodiversity

Thyroid Cancer in Children

Palpable thyroid nodules common
~5% women, ~1% men; detect by ultrasound in 19-67% people

Biopsy excludes thyroid cancer, which appears in 5-10% nodules

Thyroid cancer attribution to recent radiation dose is doubtful

I-131 for hyperthyroidism > 60 y; cancer concerns led to 3 studies that demonstrated decreases in overall cancer incidence and mortality (avg. dose 54 mGy to body, large 308 Gy to thyroid)

Are children are more susceptible?

CDC study: 509,000-2,600,000 children nasal radium shrinks adenoids; dose 20 Gy contact, 2 Gy at 1 cm; 20 yr follow-up: very few excess cancer

Study 14,351 infants; radiation for skin condition; 17 thyroid cancer deaths
Study of 58,000 exposed children didn't resolve issue; insufficient statistics
10,834 children x-ray for hair ringworm; 60 thyroid cancers; pituitary effect?

High rate of natural thyroid cancer; can thyroid cancer be due to radiation?

Papillary thyroid cancer; no symptoms; hard to screen radiation effect from natural *occult* thyroid cancers; explains the risks reported when patients compared to population

Thyroid Cancer in Chernobyl Children

Is observed increase due to better reporting, heightened awareness and screening? not radiation effect

Screening program in USA revealed incidence of thyroid cancers and of nodules 7 and 17 times higher than before screening; same as Belarus

Extremely brief time between exposure and cancer diagnosis is striking

First increase, 9.1 in 100,000 children in Russia in 1987, one year after dose, contrary to all previous knowledge; showed 30-year latency

Increased medical surveillance and early detection screening were carried out; comparing incidence ***before*** and ***after*** is misleading

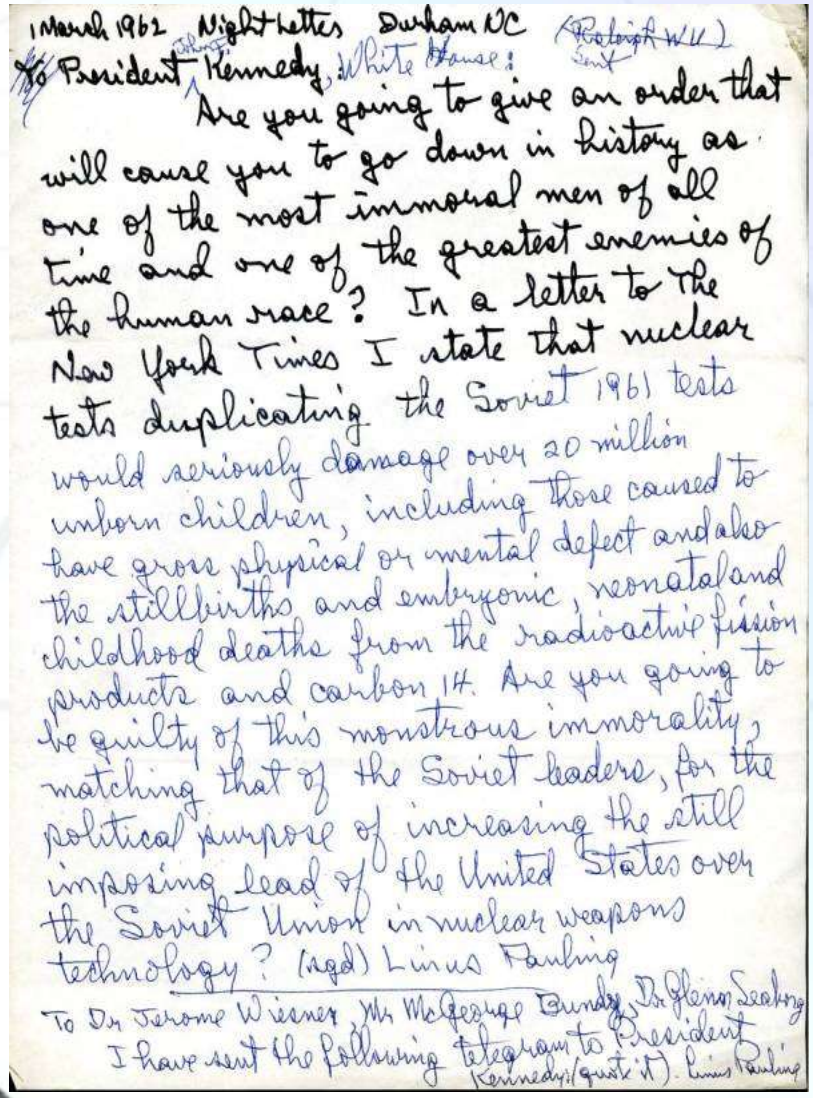
Incidence was ***lower*** in ***highly*** contaminated Bryansk region (Belarus) than in general Russia

Any serious study should discuss the problem of occult thyroid cancers, related to the effect of enormous screening and better reporting

Incidence of occult thyroid cancers is much higher than that of the "Chernobyl cancers"

Up to 90% of Chernobyl children are still being screened every year!

Safety Concern is Greatest Barrier to Social Acceptance



1 March 1962 Night Letter Durham NC (Raleigh NC)
To President Kennedy, White House:
Are you going to give an order that will cause you to go down in history as one of the most immoral men of all time and one of the greatest enemies of the human race? In a letter to the New York Times I state that nuclear tests duplicating the Soviet 1961 tests would seriously damage over 20 million unborn children, including those caused to have gross physical or mental defect and also the stillbirths and embryonic, neonatal and childhood deaths from the radioactive fission products and carbon 14. Are you going to be guilty of this monstrous immorality, matching that of the Soviet leaders, for the political purpose of increasing the still imposing lead of the United States over the Soviet Union in nuclear weapons technology? (sgd) Linus Pauling
To Dr Jerome Wiesner, Mr McGeorge Bundy, Dr Glenn Seaborg
I have sent the following telegram to President Kennedy (quote it) Linus Pauling

Radiation scares invented by many well-meaning prominent scientists (e.g. Linus Pauling) who agonized over their roles in development and use of the atomic bomb

Statements still being made:

"No amount of radiation is small enough to be harmless"

"A nuclear casualty could kill as many as hundreds of thousands of people"

Need to Communicate Real Radiation Health Effects

Communicating the real health effects of radiation will remove objections to more nuclear plants

Exposures residents get from nearby plants do not add detectably to their doses from natural sources

Negative ***publicity*** of two accidents; people fear potential exposures

Accidents showed residents received only low exposures, in the range of natural radiation, to which they are already accustomed

Major accident would not give public dose above threshold for adverse health effects, if people evacuated

Applies to people genetically more cancer prone or radiation sensitive

Real risk is electricity interruption

Radiobiology evidence requires new radiation protection regulations

Would remove the very expensive constraints on nuclear projects

More than 200 reactors planned; radiation concerns will decide the number actually built

Need to Revise Precautionary Radiation Regulations

Government regulates all activities; extreme measures to minimize ***risk*** of human-made radiation

Based on ICRP advice; assumes fatal cancer proportional to DNA hit by radiation, LNT ***assumption***

HPS and ANS: risk of adverse effects below 5-10 rem is too small or nonexistent; don't estimate risk

Authorities do not accept evidence of low dose stimulation, reduction of damage; ignore biology

Lauriston Taylor denounced "deeply immoral uses of our scientific heritage." No one identifiably injured while working within the 1934 ICRP standards

ICRP 1934 limit: 0.2 rad/day; people are now limited to 0.1 rad/year!

Renowned scientists question the ethics of assuming radiation causes cancer without evidence

Radiation protection costs hundreds of billions of dollars annually

Recent data indicates major changes needed to radiation protection

Probabilistic Risk Assessment for Reactors

The reactor and all other radioactive materials are isolated inside containers (multiple barriers) and surrounded by shielding, with redundant means to transfer energy to ***heat sinks*** to avoid overheating barriers

Fault tree analysis for accidents and probability of harm

US NRC set 2 safety goals in 1986:

- Probability of early death by radiation
- Probability of increased cancer death

NUREG-1150 analysis: freq. of core damage, source term, containment failure prob'ty and off-site conseq's

Pessimistic assumptions and LNT model yielded early death prob'ty 10 to 10,000 times ***below*** this goal and delayed death prob'ty 1000 to 10,000 times ***below*** goal

Why do regulators urge improvements?

Catastrophe is impossible by laws of nature and properties of materials and processes

In light of radiation hormesis, use PRA only for improving reactor design; cost/benefit analysis on practicality, not for estimating cancer deaths

Conclusions

Coal, HC supply 89% global energy; environmental and health effects; not sustainable; hostile countries

Sustainable nuclear energy blocked by health myths, anti-nuclear policies

Plants safe; small failures: no releases; worst-case event: no public deaths

Safety first priority; accidents are very costly: employees, electricity loss, high repair costs, revenue loss and loss of social acceptance (fear)

Amount of sealed used fuel 100 million times less than coal, oil, gas waste

Advanced reactors can recycle safely

Social acceptance is challenging; public fear of any radiation is real

Low dose causing thyroid cancer in children is unscientific assumption

Radioiodine treatment does not cause cancer; decrease in cancer reported; contrary to reactor safety assumption

Health effects of nuclear radiation on human and living things have been extensively studied for more than a century; including many studies of long-term health effects over 50 yrs

More Conclusions

Excess H-N cancer incidence after high dose; fitted by straight-line function of dose in high range

Cannot detect excess cancer in low range; line extended to zero dose to predict risk—LNT hypothesis

Scientists created fear of any dose; anti-nuclear activists endorsed it

Analysts ignore prof. societies advice not to predict cancer at low doses; regulators ignore hormesis model

Based on human data, **a single whole body dose of 150 mSv is safe; a continuous exposure of 700 mSv/year is also a safe dose limit;** both dose limits are also beneficial

Studies of effects show rising stimulation with dose until maximum benefit; and falling beyond this optimum, then into inhibition—the hormesis model

Low doses used extensively in medical treatments since ~1900; many serious infections and illnesses cured until ~1960; mechanisms now understood

Advent of antibiotics in 1940s; radiation was abandoned as a stimulatory agent

1970s-present, low-dose irradiation used to prevent/cure various cancers

Recommendations

Professional and scientific societies should organize discussions on benefits of low dose radiation and changes to regulatory codes and standards, which are based on the LNT assumption

Nuclear regulatory authorities and health organizations to examine extensive scientific evidence and their own attitudes about the health effects of radiation

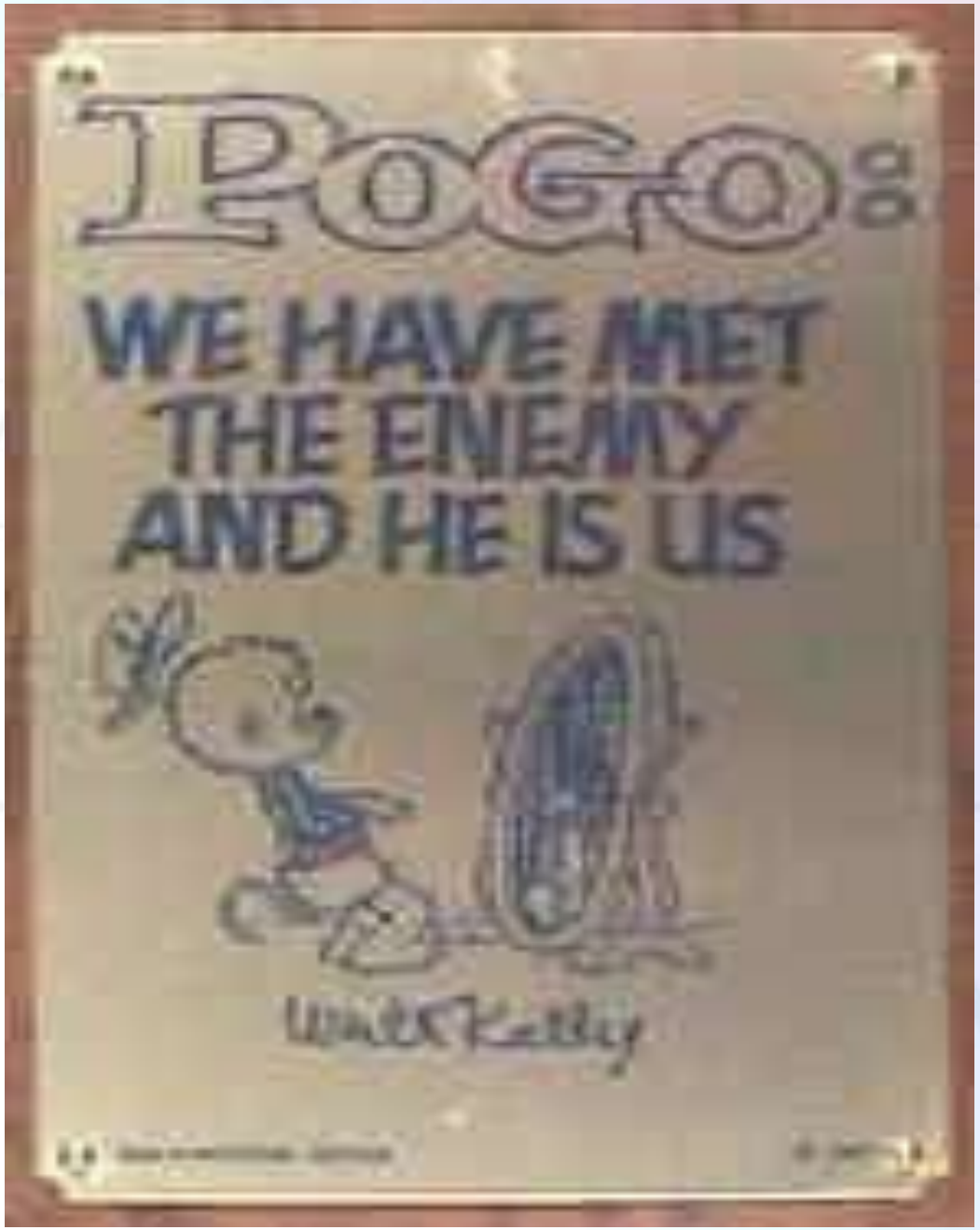
Stop regulating harmless and beneficial doses of radiation

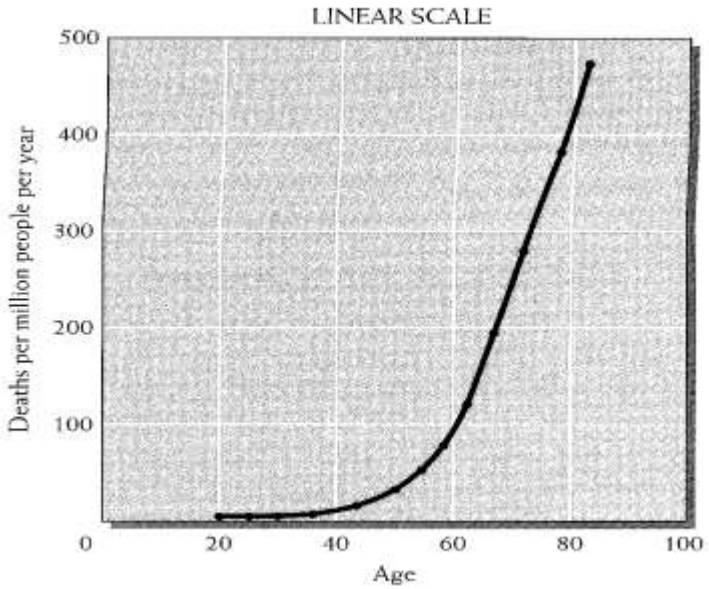
Develop public information program including a strategy for explaining reality of low-dose hormesis; with objective of social acceptance of nuclear technology to supply energy and provide medical benefits

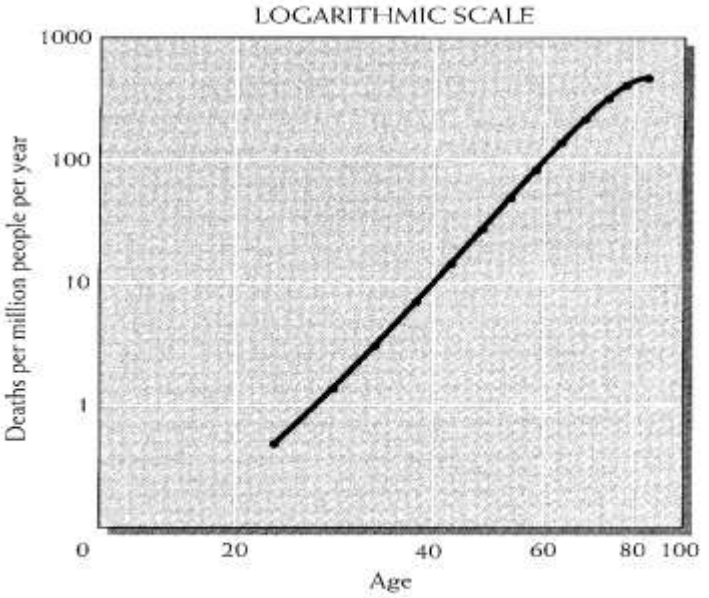
Teach emergency response staff the reality of radiation effects, to deal rationally with radioactive releases

Reorient used fuel management from geological disposal to recycling

Use probabilistic risk assessments for potential improvements in plant design; however, predicting higher cancer risk rather than a lower risk following a low dose would be both erroneous and misleading


POGO:
WE HAVE MET
THE ENEMY
AND HE IS US
Walt Kelly





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

Ron Mitchel article in CNS Bulletin 2006 Dec

Biology implications for radiation protection system

- Conceptual basis for present system appears to be incorrect
- Belief that the current system and the LNT assumption are precautionary appears incorrect
- Concept of dose additivity appears incorrect
- Effective dose (Sv) and the weighting factors appear to be invalid
- There may be no constant and appropriate value of DDREF for radiological protection dosimetry
- The use of dose as a predictor of risk needs to be re-examined
- The use of dose limits as a means of limiting risk needs to be re-evaluated

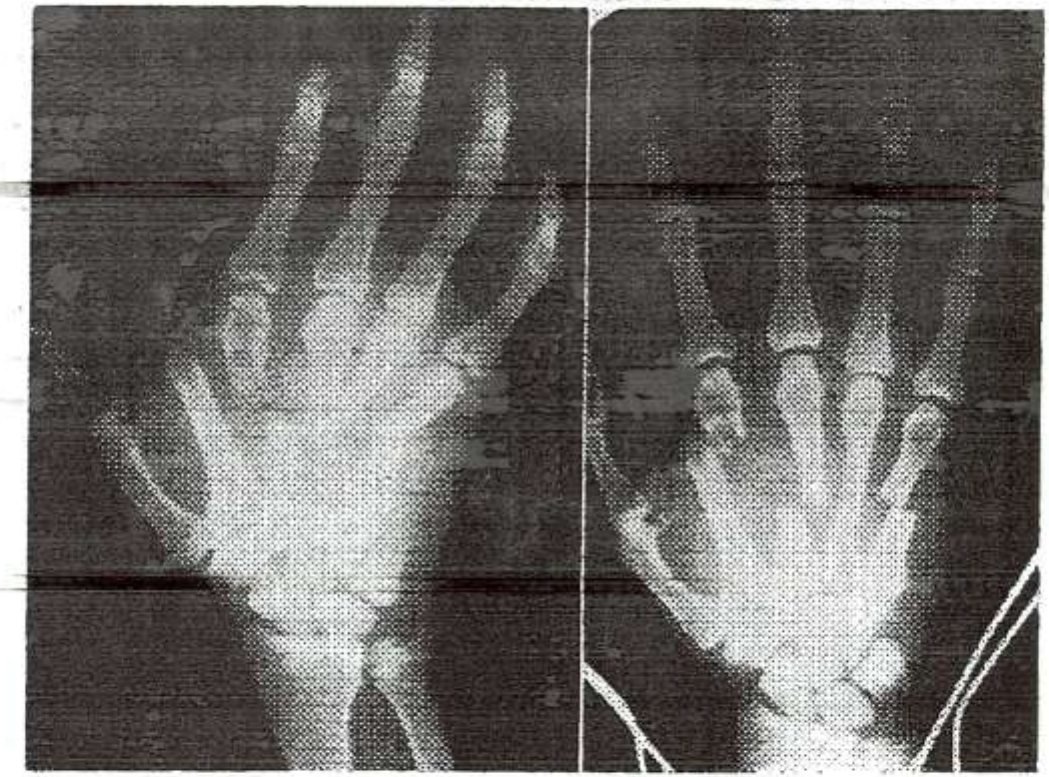
Medical applications of low doses

- Prevent cancer (DNA repair, cell apoptosis)
- Cure cancer (immune system stimulation)
- Treat diabetes, hypertension
- Delay aging, rejuvenate cells
- Relieve pain (arthritis, gout, cancer, etc.)
- Moderate stress (enzyme release)
- Cure infections (gas gangrene, skin)
- Enhance HDI tumor cell killing
- Enhance performance of chemotherapy

Appearance of db/db mice at 90th week of age

Irradiated Group

Control Group



Figs. 7–8. Case 1: Severe hand injury, with multiple compound fractures and some gas in tissues (left). Fig. 8 (right) shows same hand a few days after prophylactic x-ray irradiation: no gas in the tissues, no infection, hand on way to complete recovery.

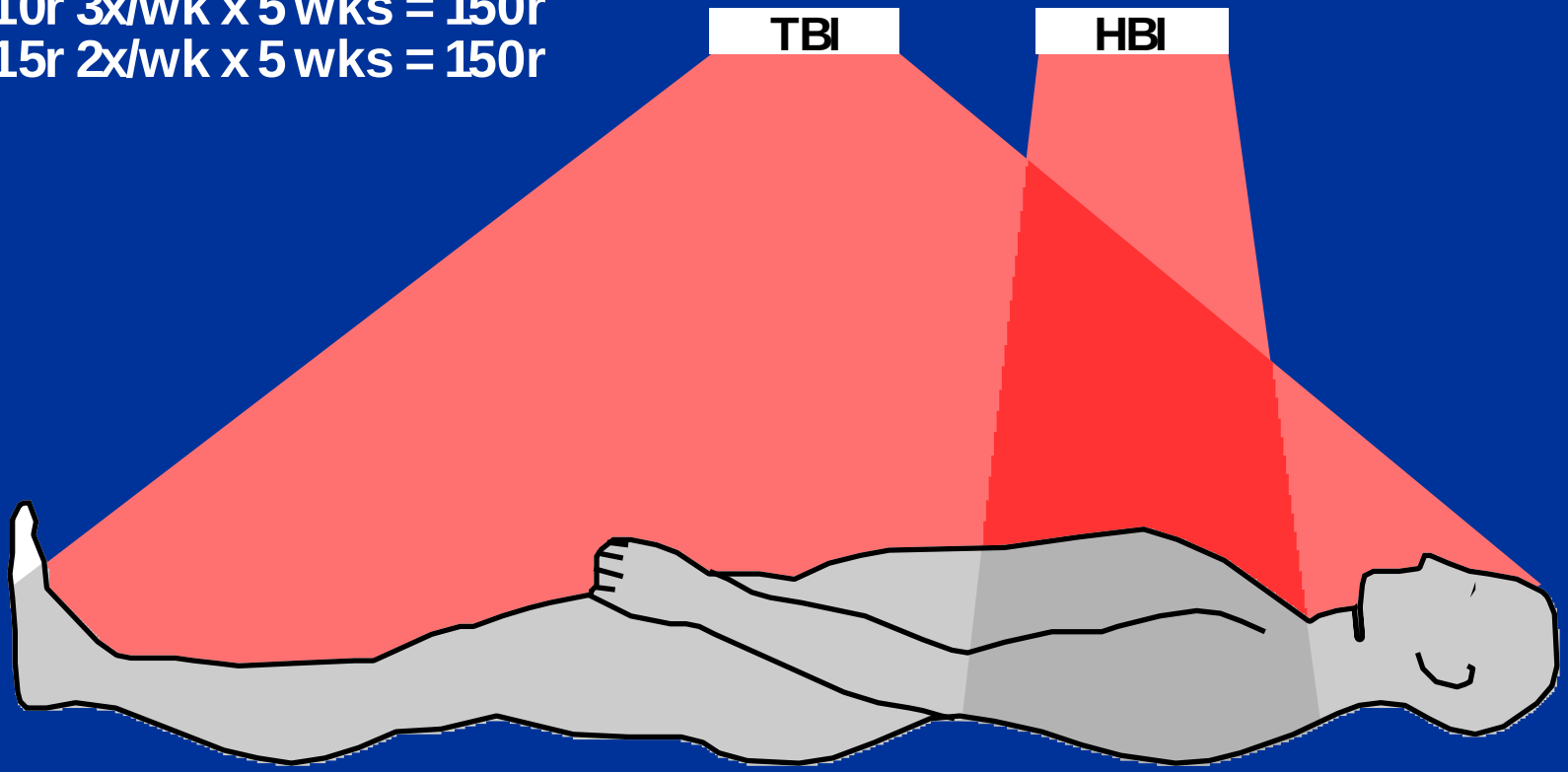
TABLE V: CASES WHICH RECEIVED PROPHYLACTIC IRRADIATION AND HAVE BEEN REPORTED IN THE LITERATURE

Cases Which

those which do not appear until three or four days have elapsed. It is evident from Figure 6 that the second, third, and

LOW DOSE IRRADIATION OF HALF BODY (HBI) OR TOTAL BODY (TBI) OF PATIENTS WITH NON-HODGKIN'S LYMPHOMA

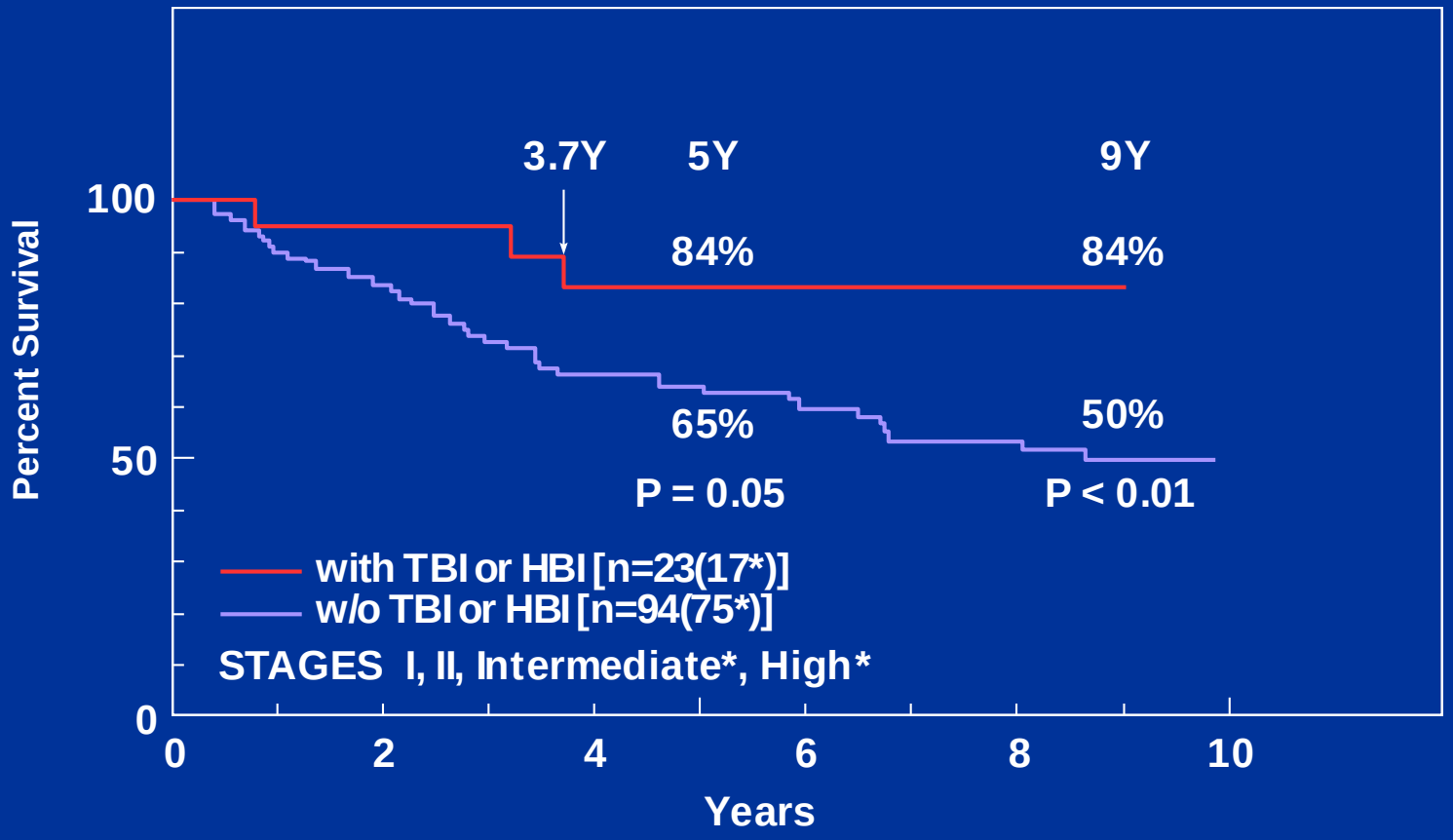
10r 3x/wk x 5 wks = 150r
15r 2x/wk x 5 wks = 150r



Sakamoto, et. al. J Jpn Soc Ther Radiol Oncol 9:161-175, 1997

COMPARISON OF LOW-DOSE IRRADIATION OF HALF BODY (HBI) OR TOTAL BODY (TBI) OF PATIENTS WITH NON-HODGKIN'S LYMPHOMA

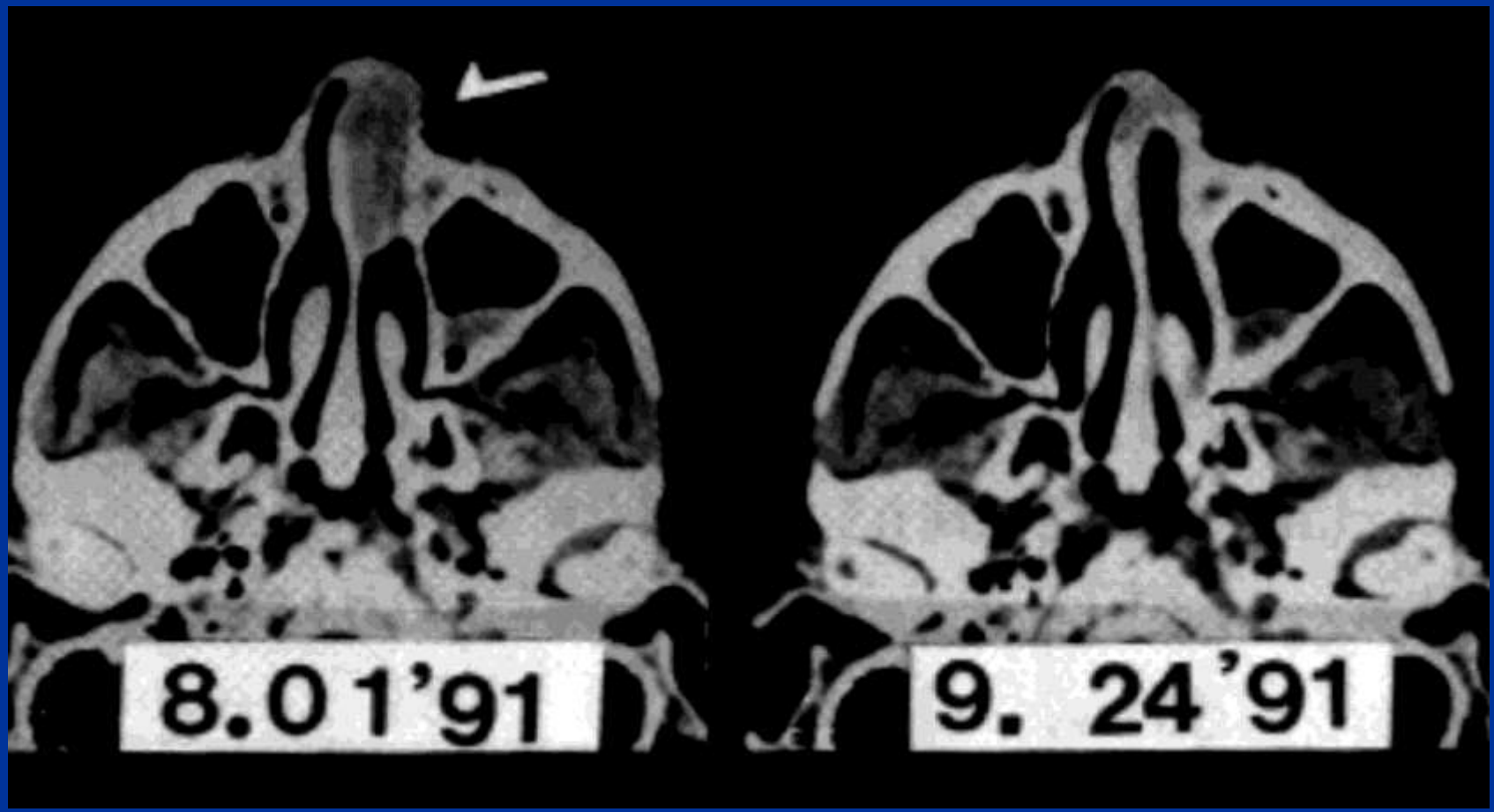
4 year survival: TBI-HBI 84% Chemotherapy 66% (79% of TBI-HBI Survival)
9 year survival: TBI-HBI 84% Chemotherapy 50% (60% of TBI-HBI Survival)



Patients in both groups received chemotherapy and localized tumor high-dose radiation.

Sakamoto, et. al. J Jpn Soc Ther Radiol Oncol 9:161-175, 1997

RAPID REGRESSION OF NON-HODGKIN'S LYMPHOMA TUMORS IN RESPONSE TO LOW-DOSE HBI OR TBI



CT (computerized tomographic) scan of upper nasal cavity before and after half body irradiation (HBI). Nasal tumor, though outside HBI field, disappeared after low-dose HBI.

Takai Y, Yamada S, Nemoto K, et. al. (1992)

Lymphoma Latency