Radiation in the Natural Environment

(and a few relevant consequences)

A presentation to the Radioactive & Hazardous Materials Committee
of the New Mexico Legislature
Santa Fe, NM, October 31, 2016

by

Norbert T. Rempe

Carlsbad, NM

rempent@yahoo.com
575-885-3836

(independent radioactive geologist - past employment: 23 years with WIPP)

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General Caution

1. Presentations are open to misinterpretation without (or likely even with) the presenter's interaction with his audience.
2. Data, ideas, and conclusions that are extracted may be in error outside the original context or intent.
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Special Note

Norbert T. Rempe prepared this presentation as a private individual, not for profit. This work was *NOT* sponsored by any private organization or government agency.

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As Earth historians

and broad-spectrum natural scientists,

geologists are (or at least: should be)

quite well qualified to address

terrestrial radioactivity

and radioactive background

through time and space

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Two random examples of language that should trigger an educated person's

BS-ALERT

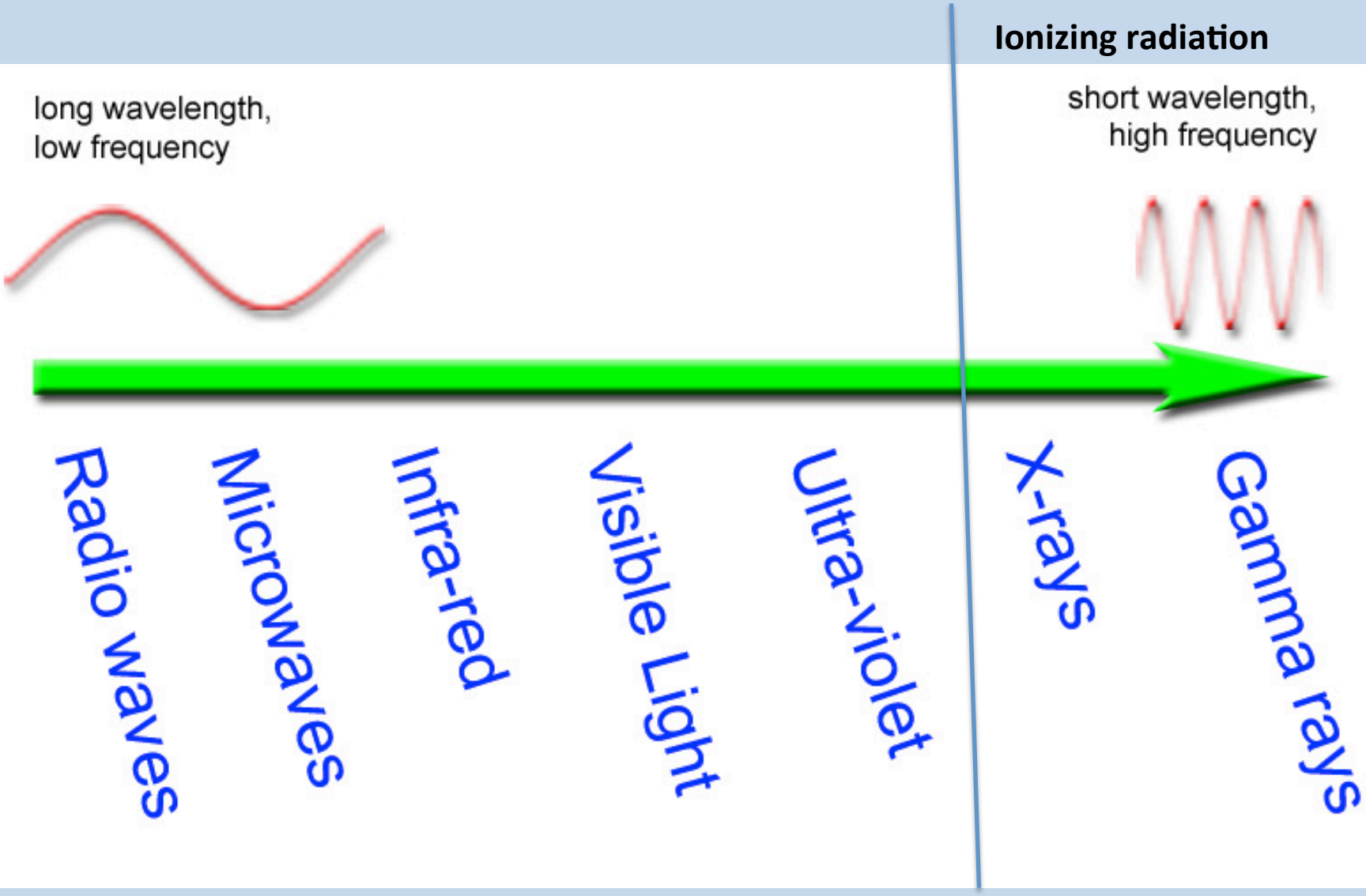
A headline … announces what he thinks he's selling: "the fusion of entertainment and enlightenment." If by this … means that his product is radioactive, he's got that right. We can only hope that its toxic charge will fade over time. But that seems unlikely.

from *The New Yorker*, November 23, 2009

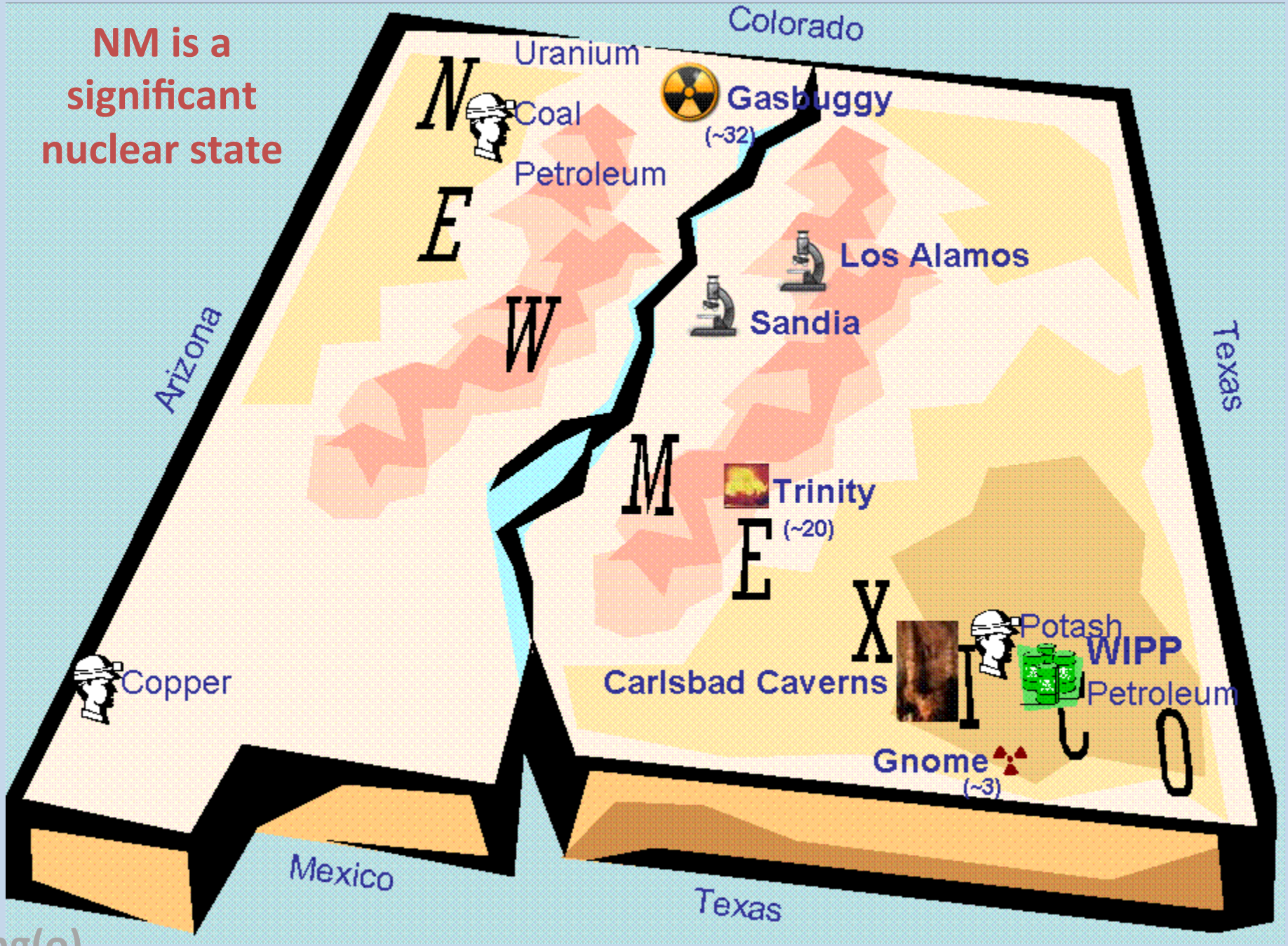
Sacred Cow

Ionizing radiation is mostly unnatural and unusual, and always dangerous

Electromagnetic spectrum



augmented from http://www.darvill.clara.net/emag/


NM is a significant nuclear state
Colorado
Uranium
Coal
Petroleum
Gasbuggy
(~32)
Los Alamos
Sandia
Trinity
(~20)
Potash
WIPP
Petroleum
Carlsbad Caverns
Gnome
(~3)
Copper
Arizona
Texas
Mexico
Texas
NEW MEXICO

Background radiation (µR/hr)

Regional

Carlsbad	16
El Paso	16
Mt. Cristo Rey	18
Alamogordo	20
Albuquerque	22
Santa Fe	22
Cloudcroft	23
San Augustin Pass	24
Socorro	26
Radium Springs	27
Wheeler Peak	~30?

Miscellaneous measurements

WIPP underground	0.7	(before 2014)
surface	10	?
Bochnia salt mine	1.5	
surface	16.3	
Carlsbad potash mine	??	
Chicago, Minneapolis	12	
Casper	24	
potash, packed	54-78	
Chernobyl 2014	64	
34-35,000' flight	320	(IAH-AMS)
~38,000' flight	450	(Greenland)

recorded by Norbert T. Rempe 2013-2016, except for WIPP and question marks

Decrease in the activity of the earth's crust due do the decay of long-lived radioactive isotopes

Million years ago	Relative decrease in radioactivity			
	U-238	**U-235**	**Th-232**	**K-40**
5000	2.14	128	1.29	14.3
2000	1.35	7.05	1.08	2.82
present	~1	~1	~1	~1

Simplified from L.A. Pertsov, The Natural Radioactivity of the Biosphere, Israel Program for Scientific Translations, Jerusalem, 1967

http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/37/004/37004130.pdf


Nigeria
CAMEROON
Gulf of
Guinea
EQUITORIAL
GUINEA
LIBREVILLE
Gabon
Lambaréné
CONGO
Oklo
ATLANTIC
OCEAN
ANGOLA

Established 1845 **SCIENTIFIC AMERICAN** July 1976 Volume 235 Number 1

ARTICLES

GEORGE A. COWAN ("A Natural Fission Reactor") heads the nuclear-chemistry division of the Los Alamos Scientific Laboratory. He writes: "I became involved with

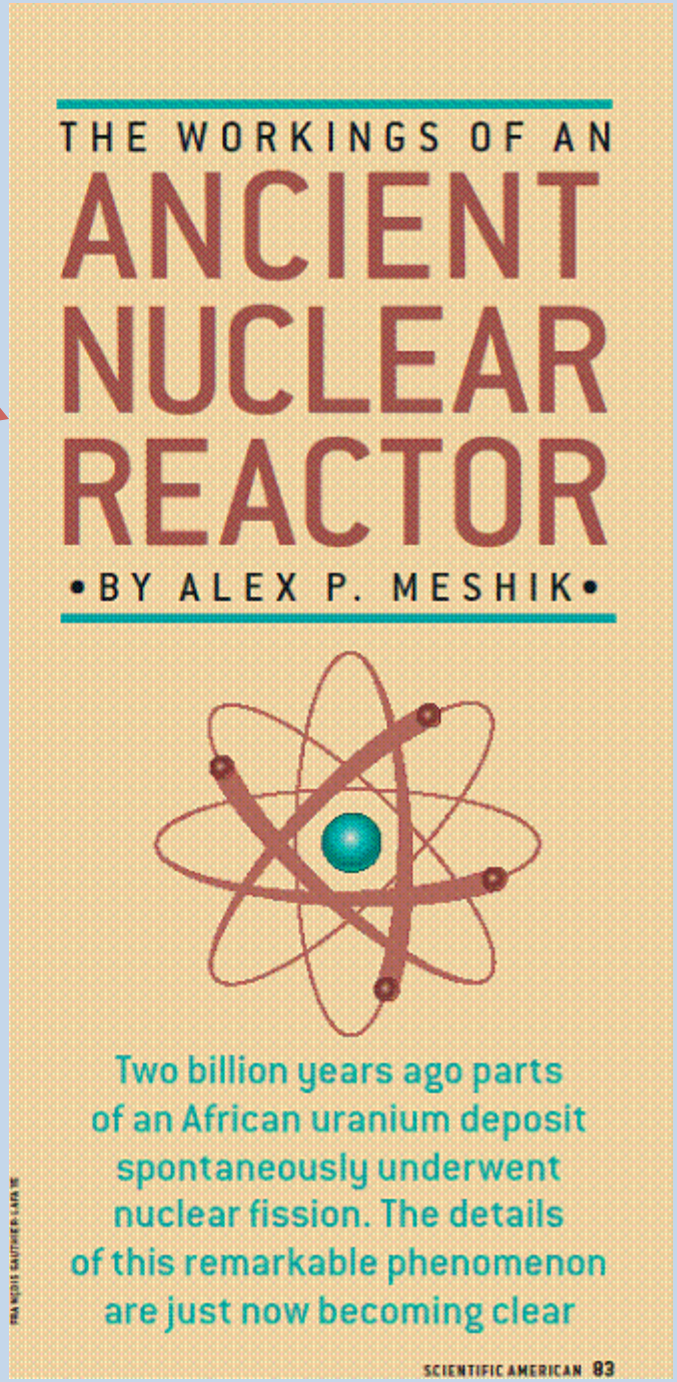
based on the study of nuclear explosions. I am just now greatly intrigued by the information that can be obtained from a fossil reactor, particularly by the possibility that the Oklo investigation will demonstrate an acceptably safe pattern for the permanent disposal of plutonium."

"In the design of fission reactors man was not an innovator but an unwitting imitator of nature"

"I (first) thought it was a phony" (Los Alamos Monitor, July 14, 2002)

Scientific American

November 2005

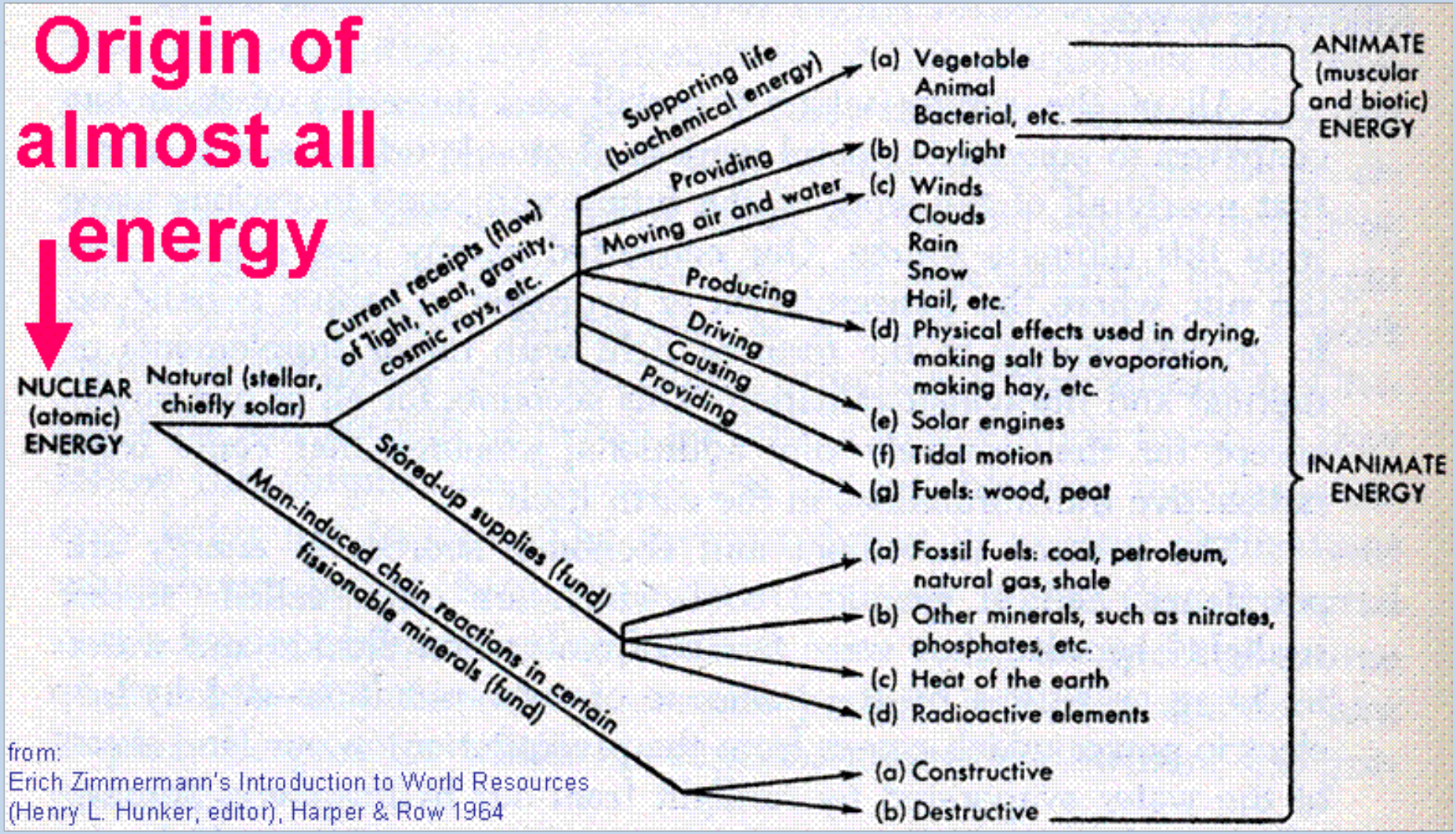


Oklo Nuclear Geysers (16 individual reactors)

- Operated 1.8 billion years ago,
  - for >150 000 years,
  - in 30-min pulses with 2.5 hr dormant periods,
  - consuming >5t U.
- **Prove nuclear fission is natural.**
- **Suggest other natural reactors waiting to be found.**

We also know that nuclear fusion (sun and other stars) is natural

Origin of almost all energy



from:
Erich Zimmermann's Introduction to World Resources
(Henry L. Hunker, editor), Harper & Row 1964

OVEREXPOSED

Had a CT scan lately? Maybe a couple of X-rays? Many of those tests are unnecessary—and potentially cancer-causing. But you can protect yourself from excessive radiation by knowing when to say no.

Consumer Reports, March 2015

UNDER-EXPOSED

What If Radiation Is Actually GOOD for You?

by Ed Hiserodt

Laissez Faire Books
a division of the Center for Libertarian Thought, Inc.
Little Rock, Arkansas

2005
ISBN 0-930073-35-5

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Background Radiation and EPA and NRC Regulations

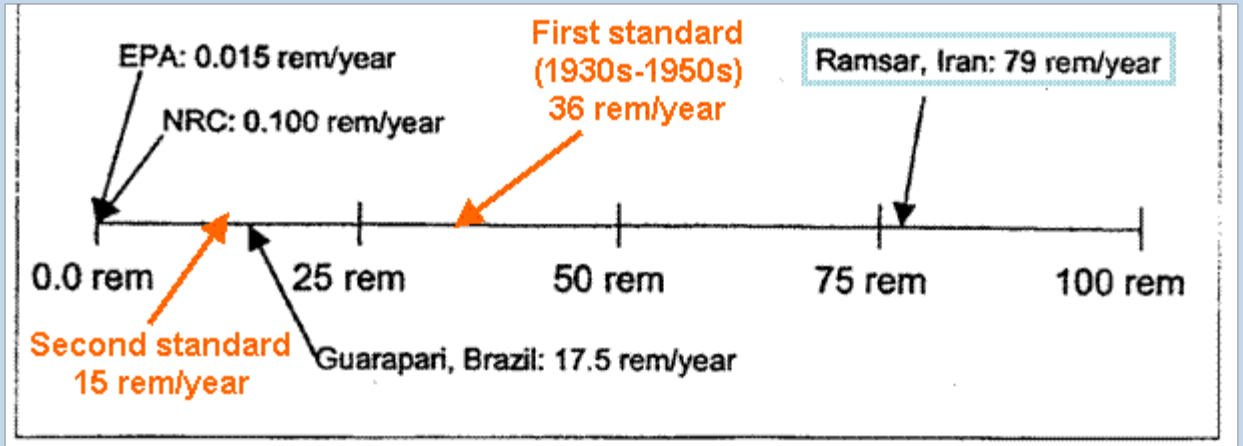


Fig. 2. Scale comparing EPA and NRC regulatory limits to natural background radiation environments (100 rem = 1 sievert; 100 rad = 1 gray)

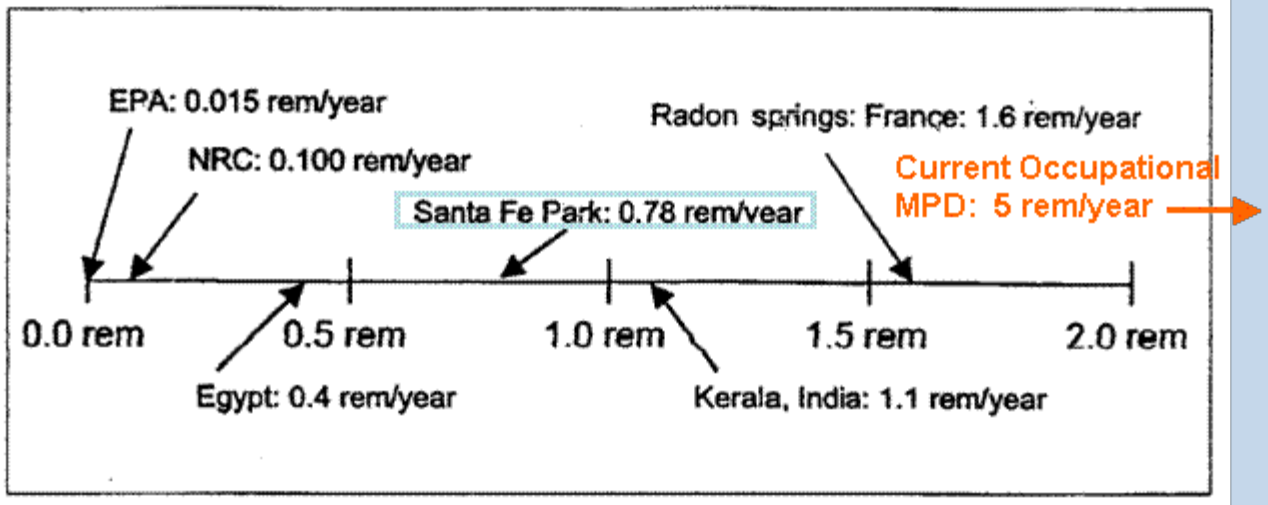
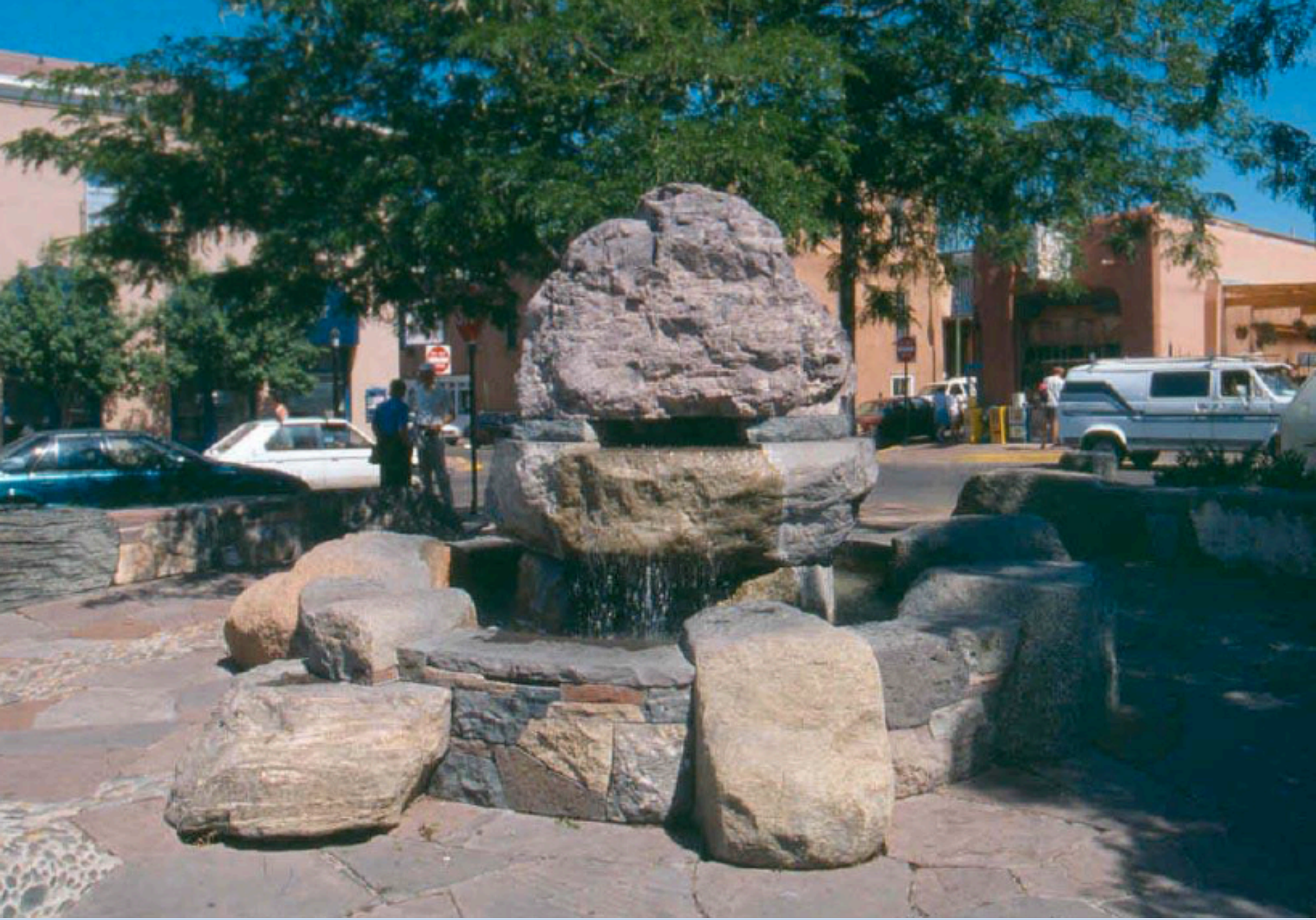
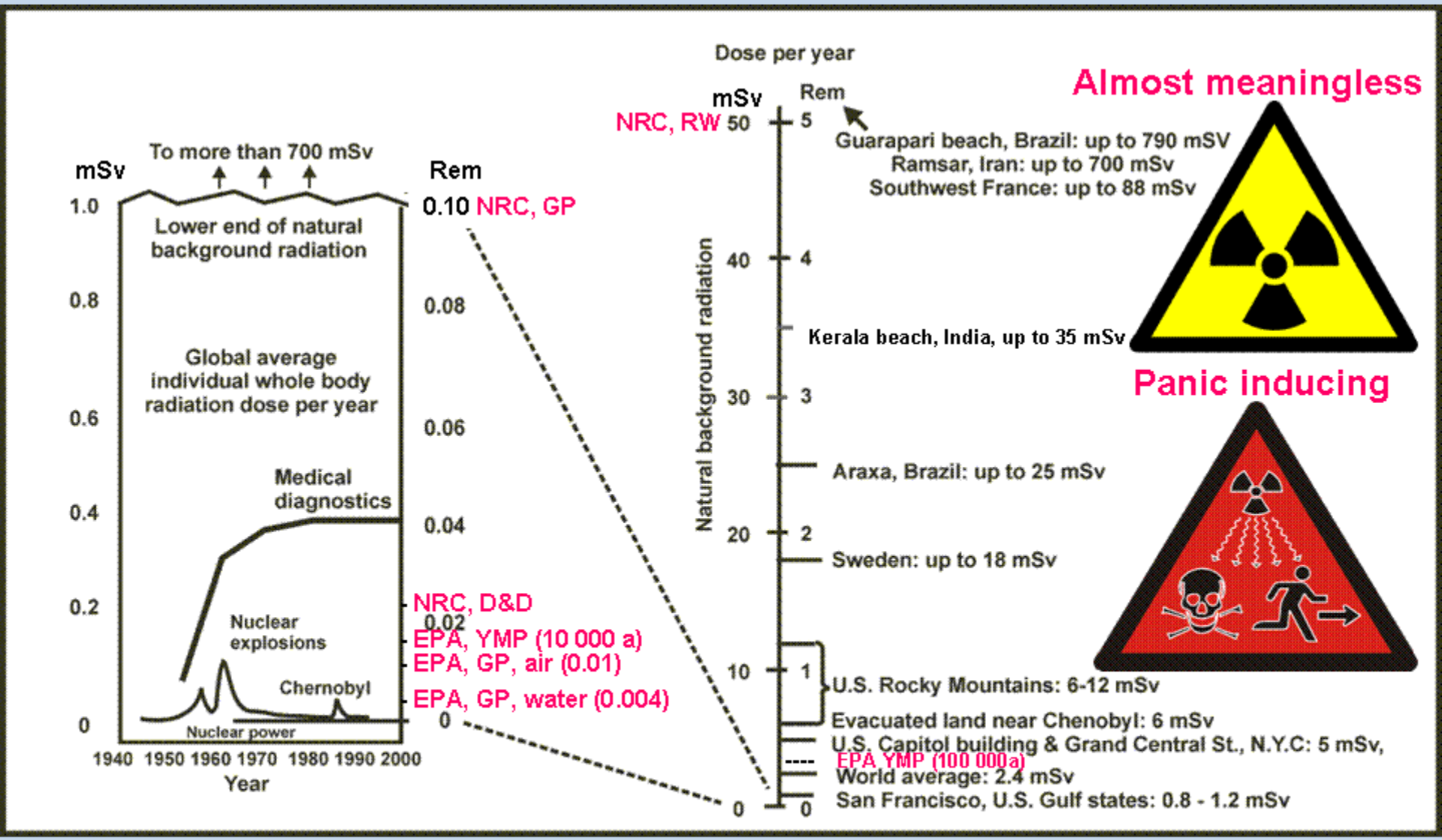


Fig. 3. Expanded scale comparing EPA and NRC regulatory limits to natural background radiation environments (100 rem = 1 sievert; 100 rad = 1 gray)

From Mark M. Hart, "Disabling the terror of radiological dispersal," *Nuclear News* July 2003



Fountainhead Rock, corner of Don Gaspar and Water Streets (80-90 µRem/hr)



Modified from a
Figure prepared by Ted Rockwell from data found in "Radiation Risk and Ethics", Z. Jaworoski, published in Physics Today, American Institute of Physics, September, 1999 and "Ionizing Radiation and Radioactivity in the 20th Century", Z. Jaworoski, presented at the International Conference on Radiation and its Role in Diagnosis and Treatment", Tehran, Iran October, 2000.

http://www.cns-snc.ca/media/uploads/branch_data/branches/Toronto/radiation/natural_and_human_radiation.html
http://hps.org/publicinformation/ate/faqs/regdoselimits.html
http://dspace.mit.edu/bitstream/handle/1721.1/41588/213482682.pdf?sequence=1

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"Normal" or average v. highest known natural background radiation on Earth

	"normal"	Ramsar
Radium in groundwater (Bq/l)	<10	~500
Radium in soil, rock, food (Bq/g)	<0.5	~350
Radon inside homes (Bq/l)	<0.5	>4
Population dose (mSv/yr.)	2-3	20-250

"no consistent detrimental effect has been detected so far"

http://www.ecolo.org/documents/documents_in_english/RamsarHLNRAPaper.doc

Source:
The Very High Background Radiation Areas of Ramsar, Iran: Geology, Radiobiology, and Policy
Andrew Karam, Ph.D., CHP
University of Rochester
Presented to NO CHPS, Radiation Safety Without Borders
November 12, 2002

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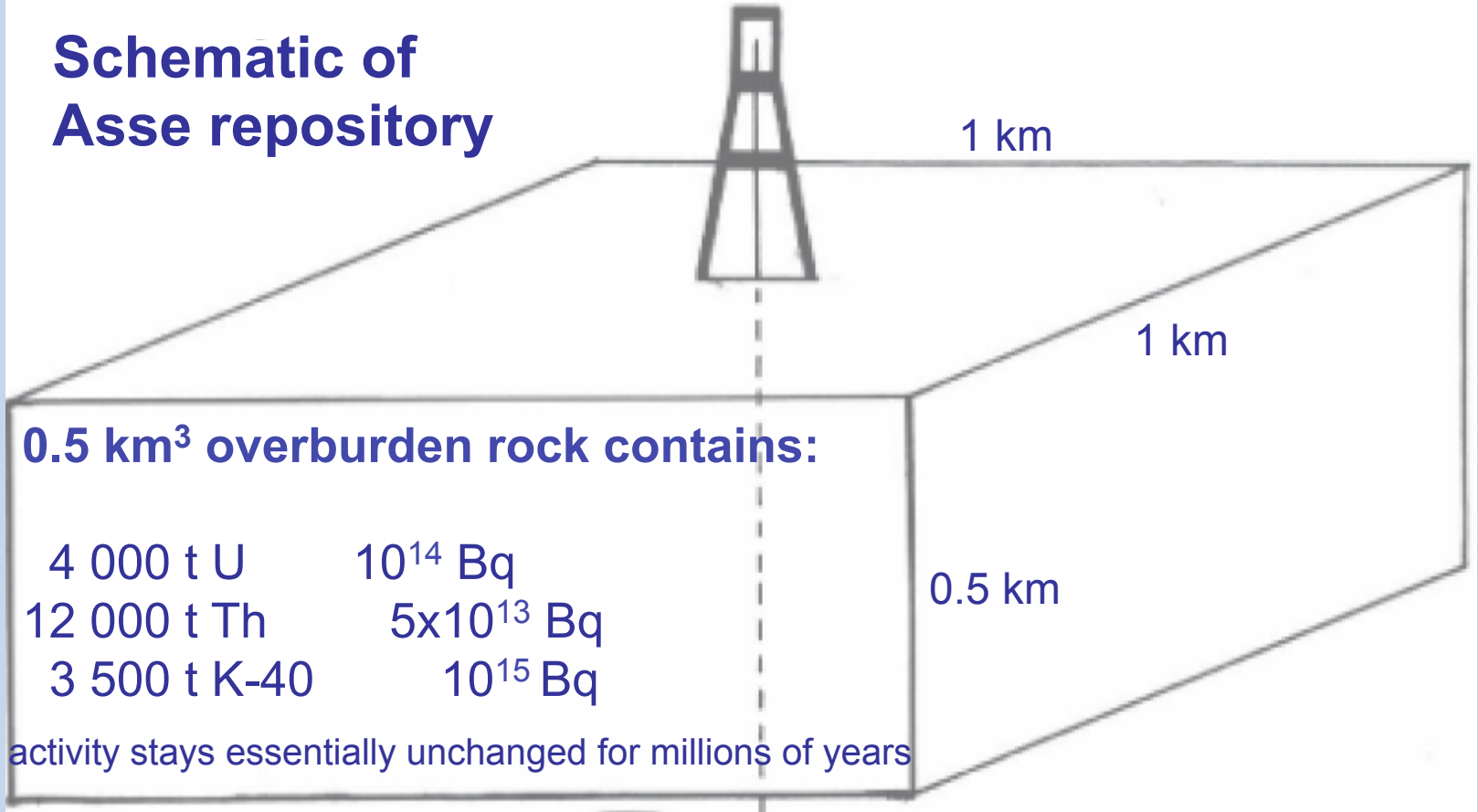
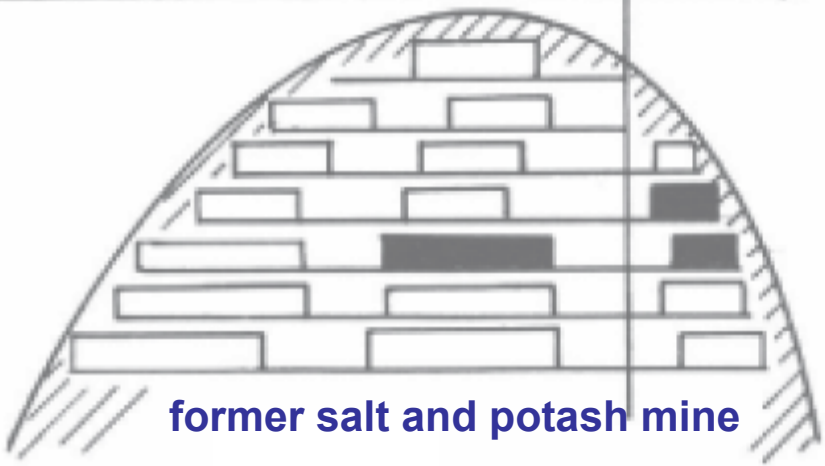
Schematic of Asse repository



0.5 km³ overburden rock contains:

4 000 t U	10^{14} Bq
12 000 t Th	5×10^{13} Bq
3 500 t K-40	10^{15} Bq

activity stays essentially unchanged for millions of years



former salt and potash mine

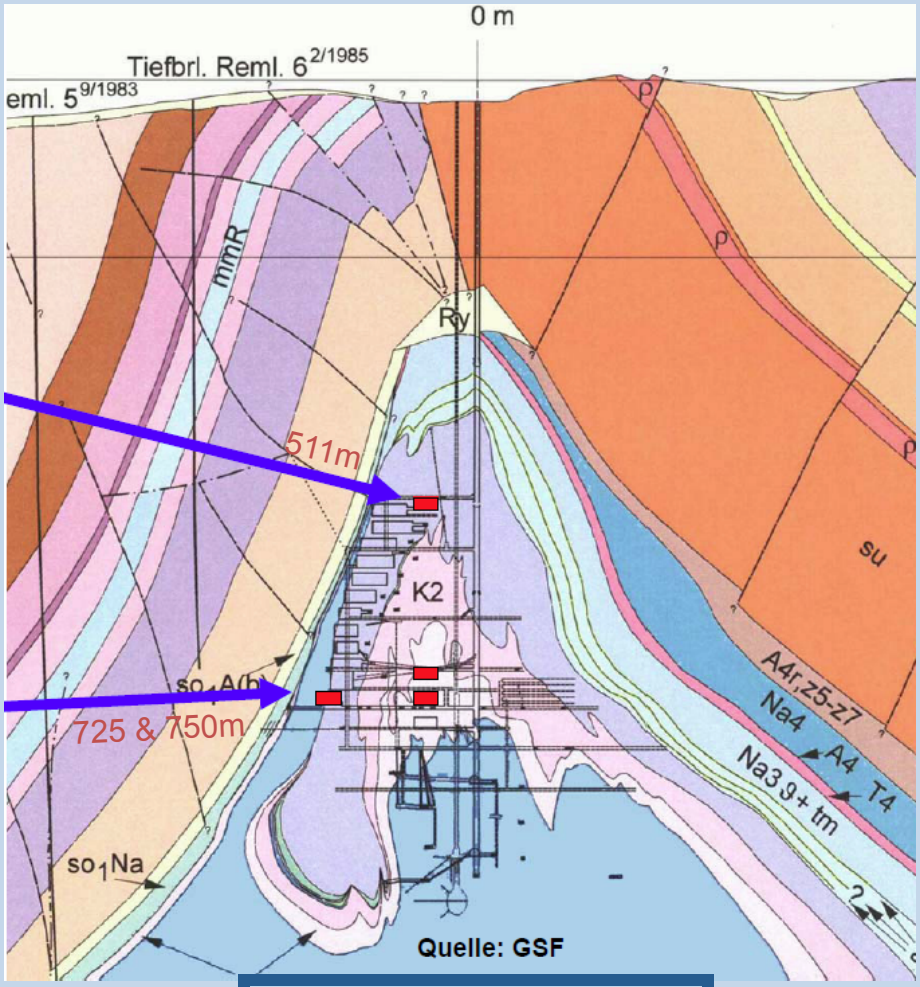
Waste inventory:

100 t U
100 t Th
10 kg Pu

Activity of all waste:

In 2000: 3×10^{15} Bq
In 2140: $< 3 \times 10^{13}$ Bq

translated from: http://www.novo-argumente.com/artikel/99/novo9943.pdf

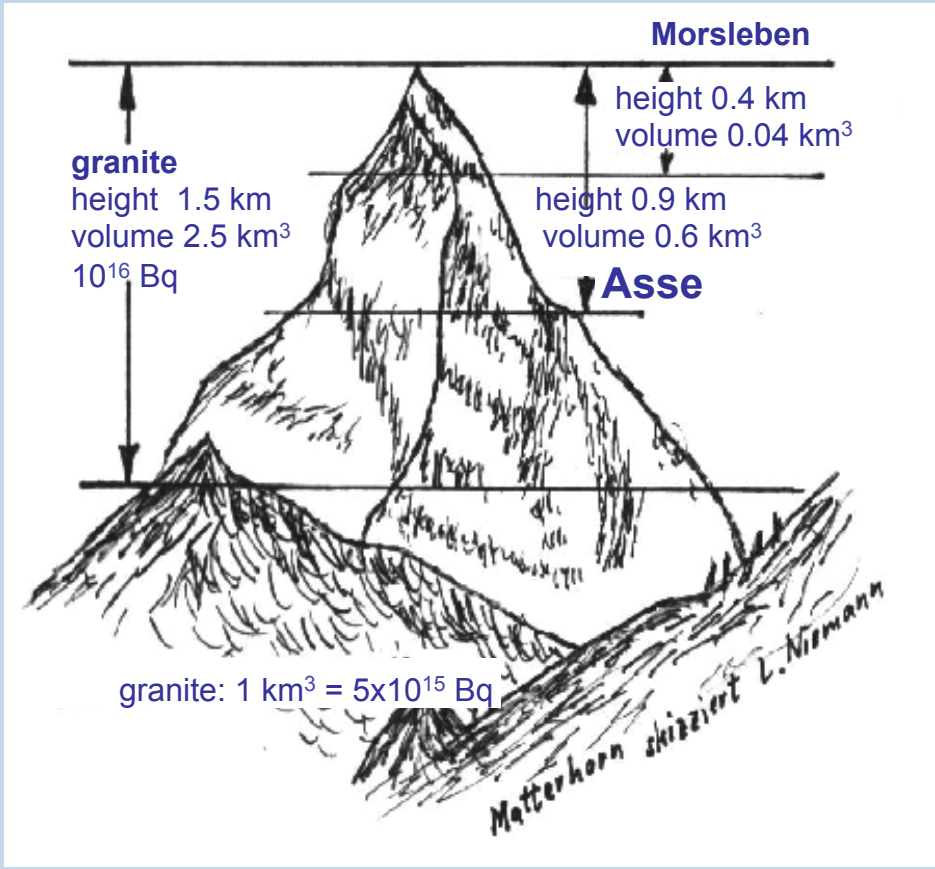


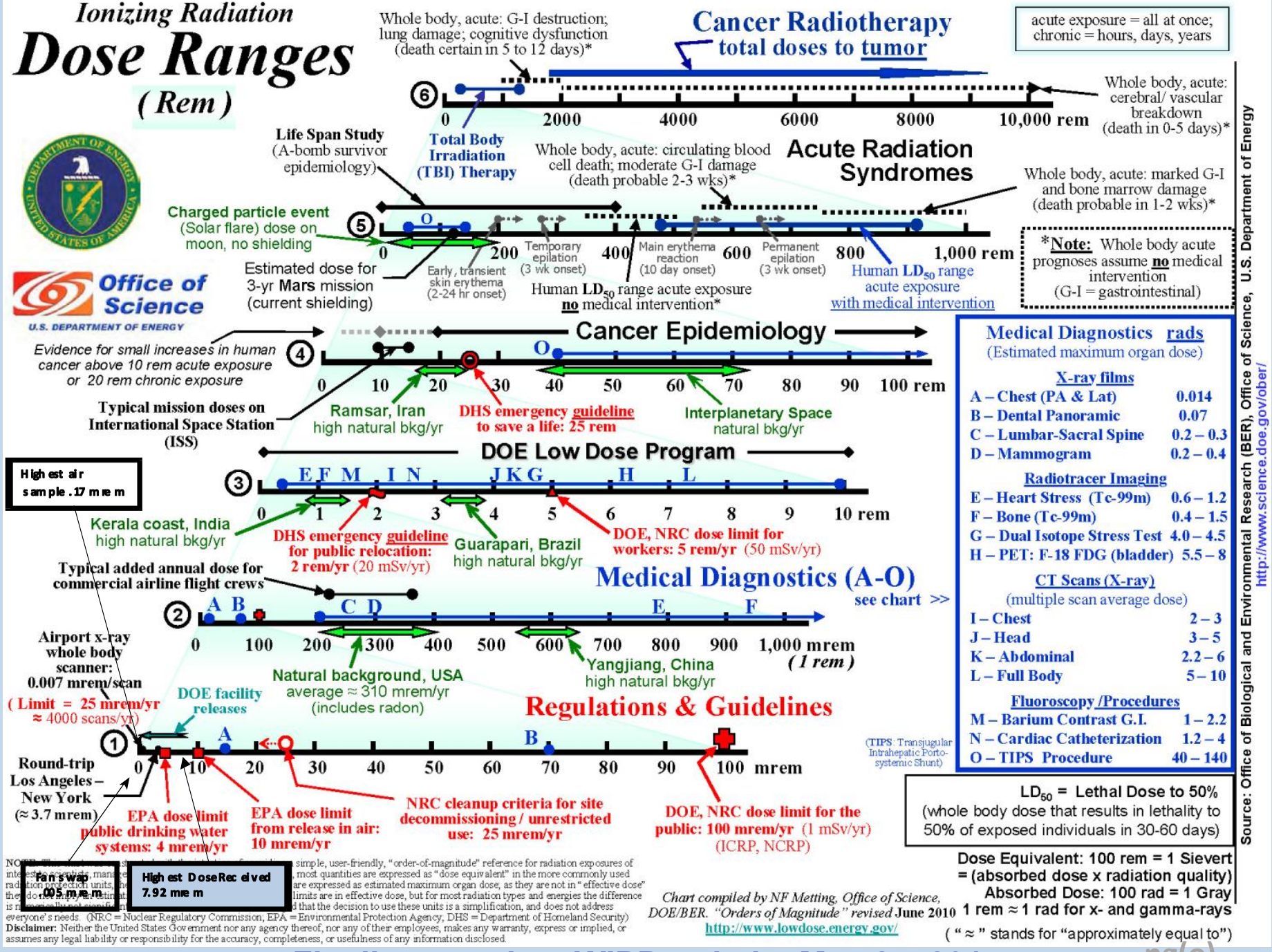
Asse

(German rad. waste repository in a salt dome)

(Morsleben: German rad. waste repository in a salt pillow)

Matterhorn





Finally posted on WIPP website May 27, 2015

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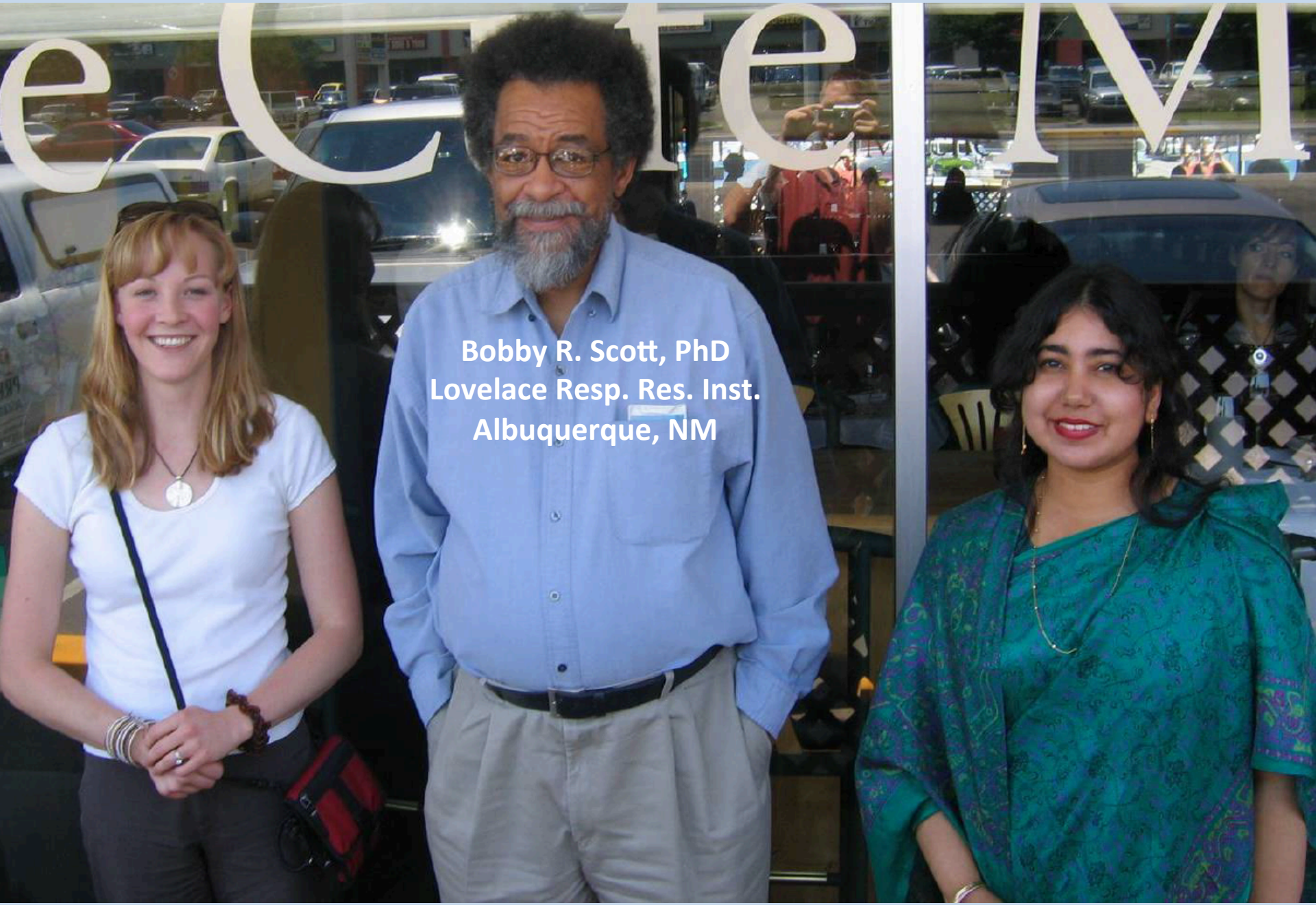

Bobby R. Scott, PhD
Lovelace Resp. Res. Inst.
Albuquerque, NM

Cumulative Natural Radiation Hits to Your Body

2-year old: more than 60 trillion

4-year old: more than 120 trillion

6-year old: more than 180 trillion

8-year old: more than 250 trillion

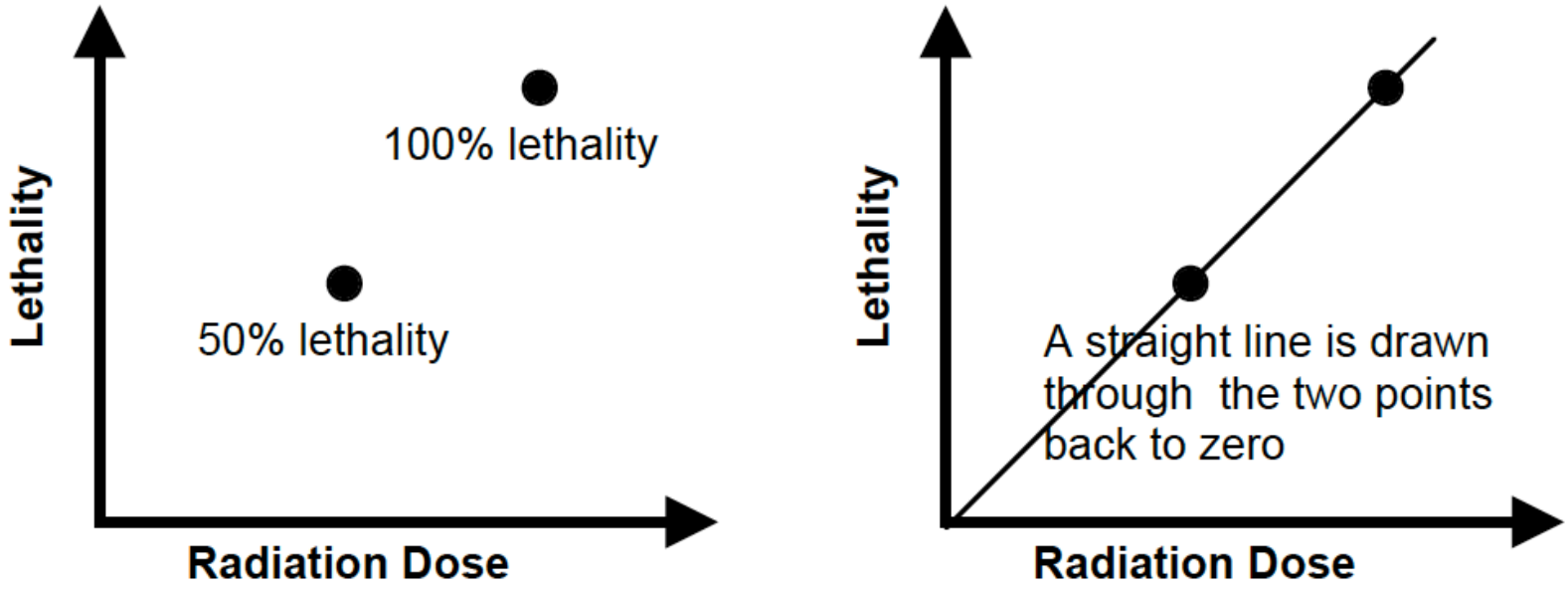
10-year old: more than 300 trillion

20-year old: more than 630 trillion

These radiation hits do not cause any measurable harm!

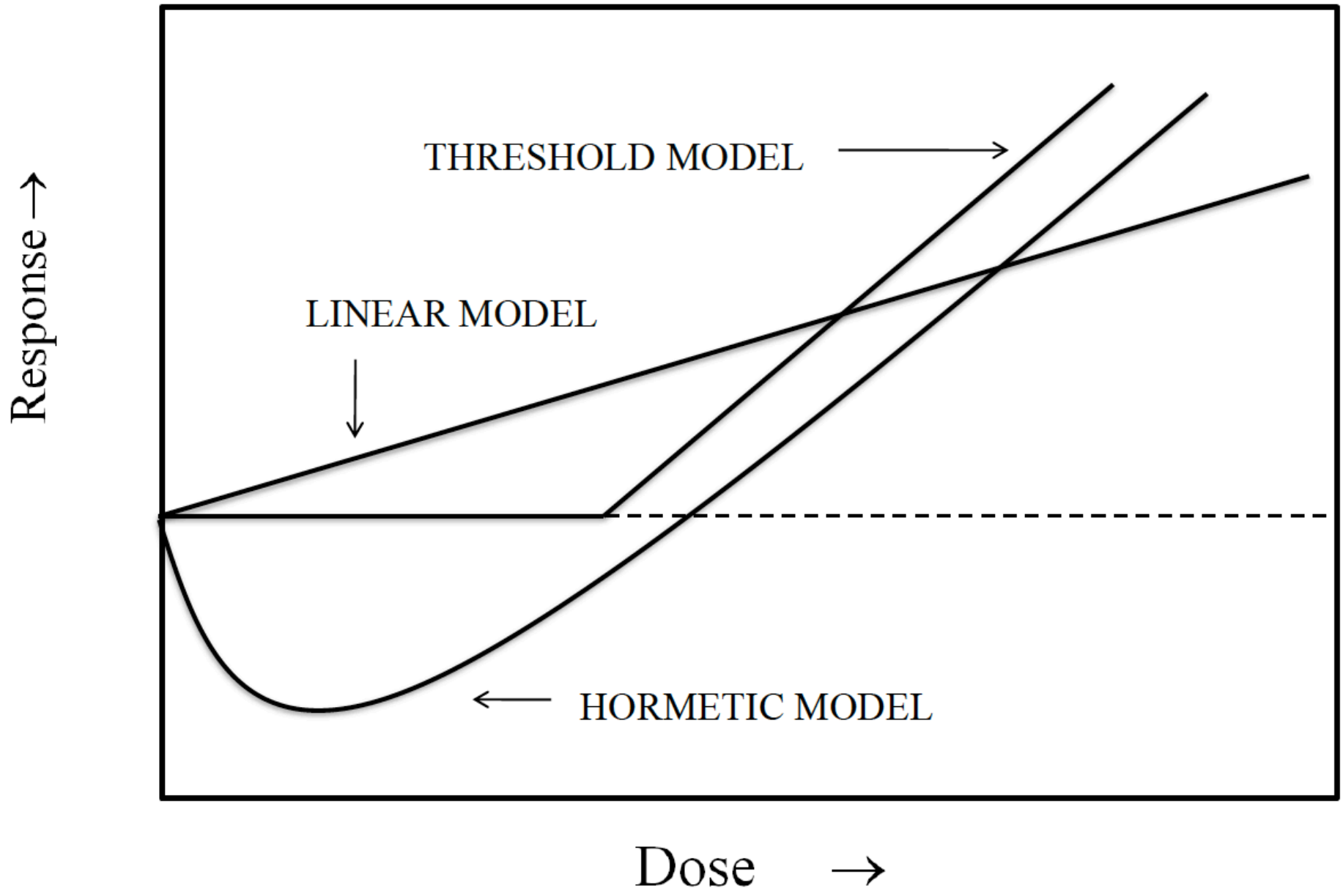
During the next second you will have received more than 1 million additional harmless natural radiation hits to your body.

from Bobby Scott



The Linear Hypothesis Assumes That Any Amount Of Radiation is Harmful

From Hart 2000



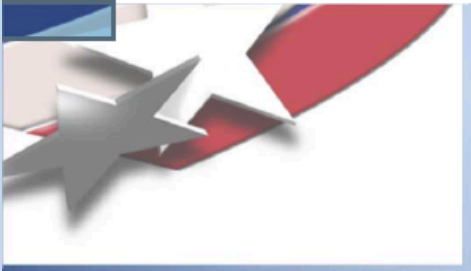
from Calabrese presentation

Low Dose Cancer Risks Usually Based on LNT Hypothesis

Linear-no-threshold hypothesis: even the smallest amounts of radiation are harmful:

- **Cancer risk doubles when dose doubles.**
- **It triples when dose triples.**

from Bobby Scott



The Imperative for Sound Science

- Our profession has known for 30+ years that LNT has no scientific basis for low dose, low-dose-rate exposures
- Knowing deception by Muller (Nobel Prize 1946)? *
- Failure to pursue a strategic assault of the status quo on ALL fronts will result in more of the same!

* Muller's Nobel Prize Lecture: When Ideology Prevailed Over Science
Edward J. Calabrese, TOXICOLOGICAL SCIENCES 0(0), 1–4 (2011) doi:10.1093/toxsci/kfr338
Advance Access publication December 13, 2011

from Miller 2012

Sandia National Laboratories

Schopenhauer said: "All truth goes through three stages.

1. First it is ridiculed.
2. Then it is opposed.
3. Finally it is accepted as self-evident."

At <u>what stage</u> is the Radiation Protection Community?

from Miller 2012

Sandia National Laboratories

WIPP radiation levels average 10+ µR/hr at the surface,
0.7 µR/hr 655m underground

WIPP underground is a radiation-deprived environment

based on Grof, Guilmette, and Smith, ~2008

“If I can avoid one additional mRem, I will.”

Neither statement is supported by testable evidence

“Radon is the largest cause of lung cancer.”

(WIPP’s M&O general manager, personal communication, fall 2014)

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Now that the site is no longer in "start clean – stay clean" mode

LNT and ALARA threaten WIPP's viability, mission, and existence

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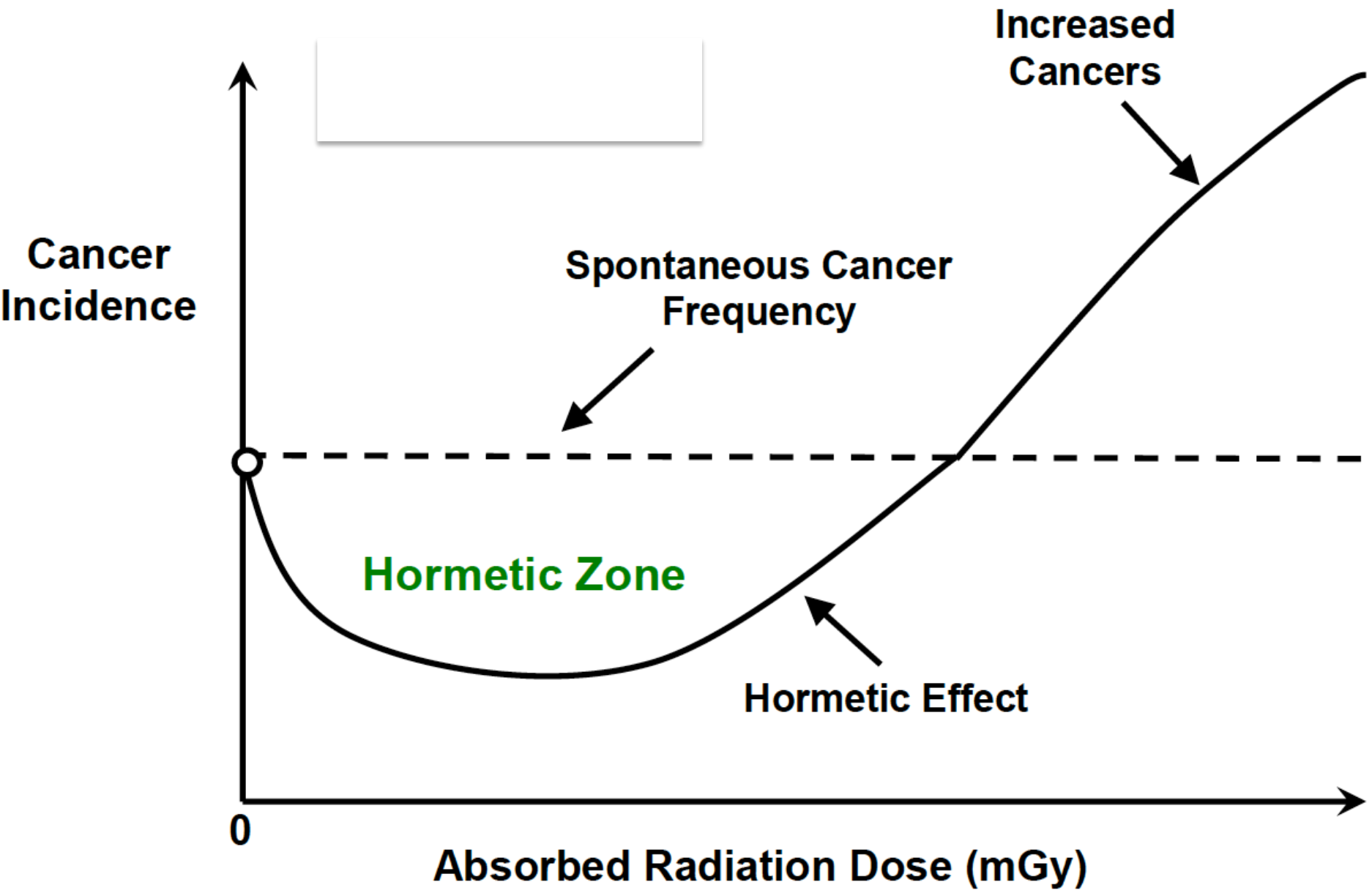
LNT-Caused Harm

"The psychosomatic disorders observed in the 15 million people in Belarus, Ukraine, and Russia… who were affected by the April 1986 Chernobyl accident are probably the accident's most important effect on public health… These disorders could not be attributed to the ionizing radiation but were assumed to be linked to the popular belief that any amount of man-made radiation… can cause harm."

Zbigniew Jaworowski, Physics Today, September 1999, pp. 24-29.

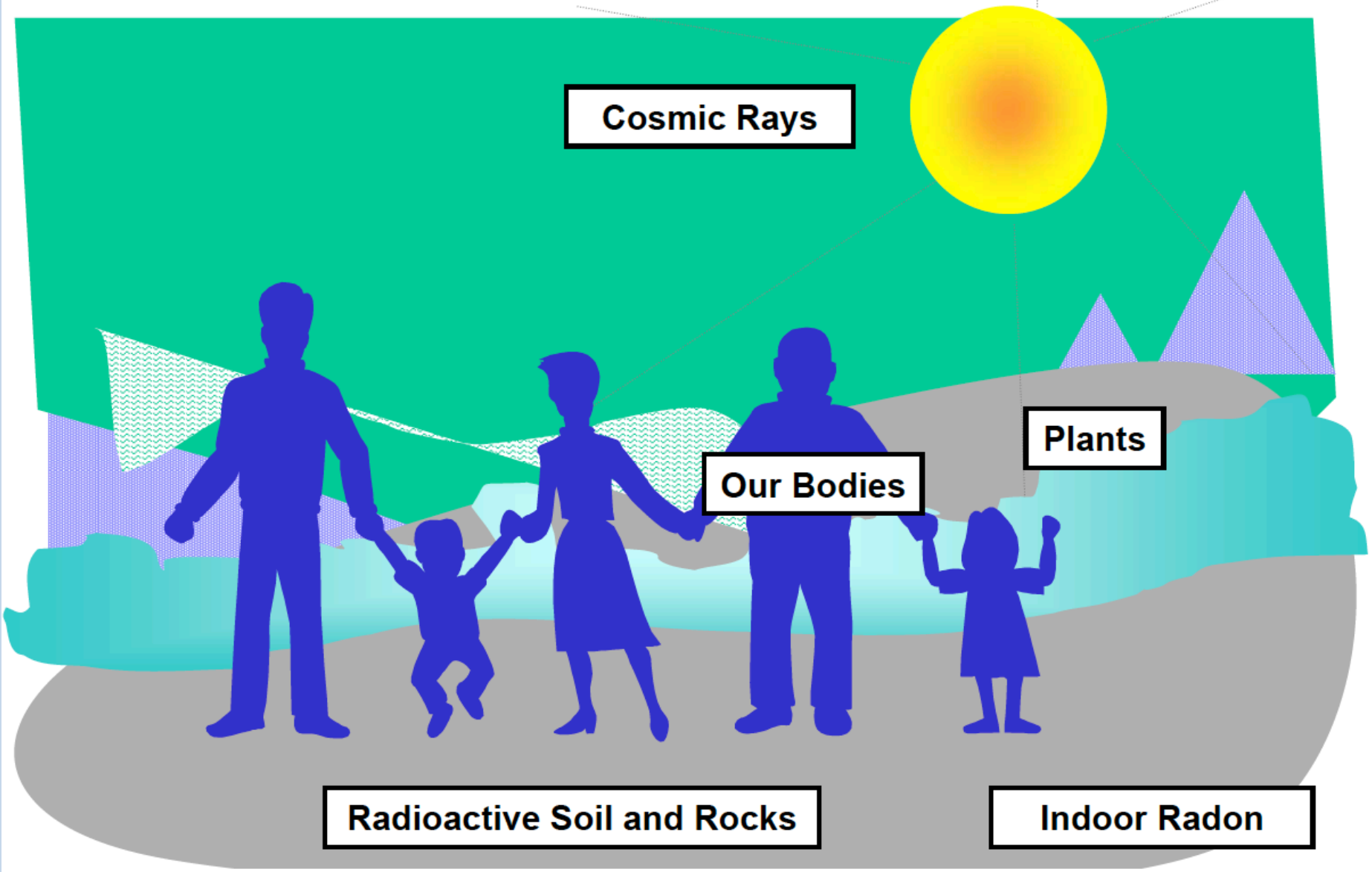
from Bobby Scott

Hormetic Risk (J-Shaped) Curve



simplified from Bobby Scott

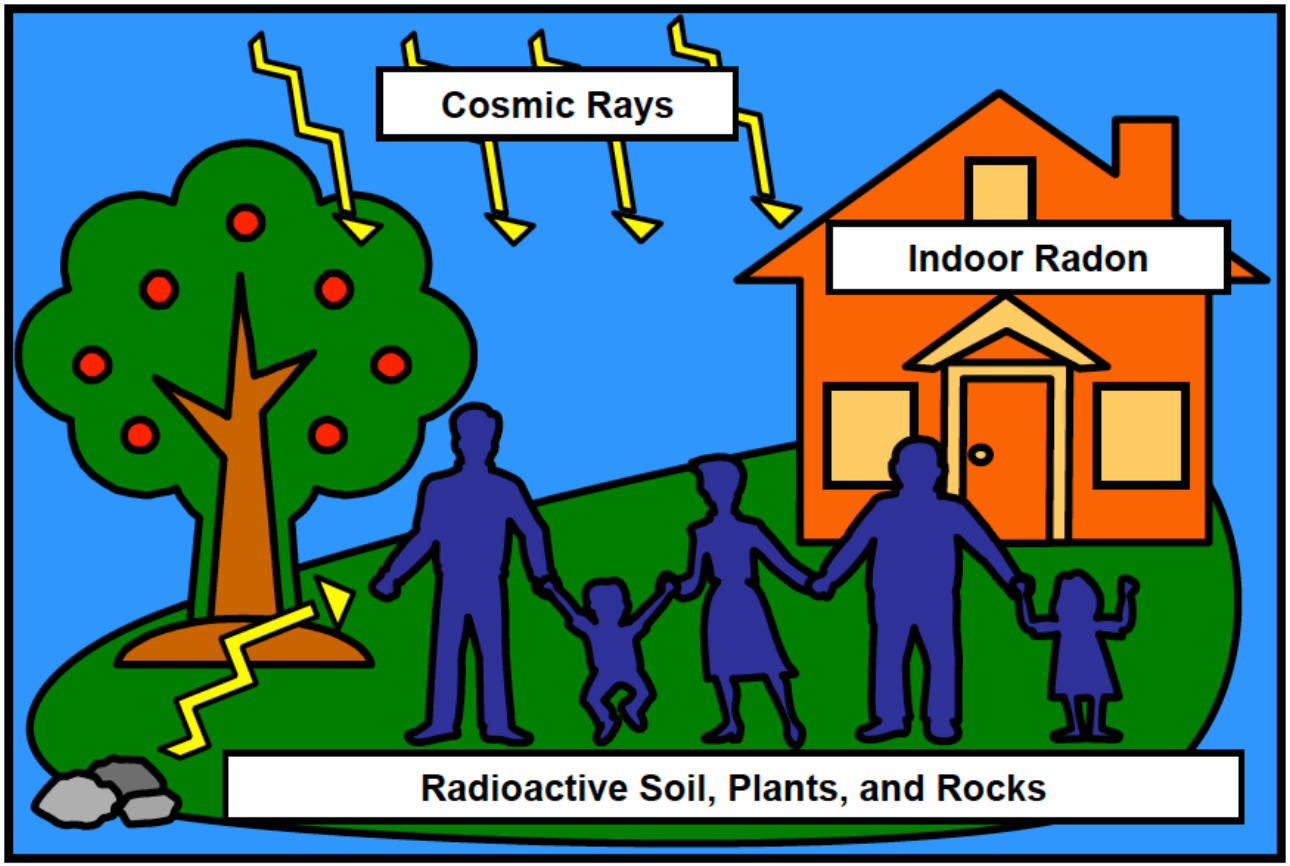
Natural Background Radiation Protects Us From Cancer And Other Diseases



simplified from Bobby Scott

Environmental Radiation Hormesis

Natural and human-activity-related background radiation induced hormetic effects have been found to be associated with the suppression of spontaneous cancers and other diseases.



from Bobby Scott

Implications of Dismissing Radiation Hormesis

"By dismissing hormesis, regulatory agencies such as EPA deny the public the opportunity for optimal health and avoidance of disease."

Edward J. Calabrese

Human & Experimental Toxicology (2005) 24:265-270.

from Bobby Scott

Leo Tolstoy, 1899:

I KNOW that most men — not only those considered clever, but even those who are very clever, and capable of understanding most difficult scientific, mathematical, or philosophic problems — can very seldom discern even the simplest and most obvious truth if it be such as to oblige them to admit the falsity of conclusions they have formed, perhaps with much difficulty — conclusions of which they are proud, which they have taught to others, and on which they have built their lives.

Short version:

Truths fatal to preconceived views are not readily recognized

Precautionary Principle

Anneken Hendriks, Amsterdam, executed 1571

In Action

In view of the total absence of negative effects of low doses of radiation, say less than 100 mSv/year, the ALARA principle should be replaced by a new ecological concept more in accordance with the scientific facts. The concept might be called ALAIN (As Low As In Nature).

Bruno Comby (2006), *Environmentalists for Nuclear Energy;* chapter 3*: "Natural variability. The Naturality principle. ALAIN (As Low As In Nature.)*

Cost per (hypothetical) Life-year saved[1]

Radiation Emission Standards for Nuclear Power Plants: $100 Million/life-yr

Radionuclide Emission Control at NRC-licensed facilities: $2.6 Billion/life-yr

Widen lanes on Rural Roads by 2 ft: $120,000/life-yr

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1. Tengs et al., *Risk Analysis 15*, 369-390, 1995

http://www.hpschapters.org/northcarolina/spring2007/Faith-Based%20Rradiation%20Protection-Dixon.pdf

August 1979

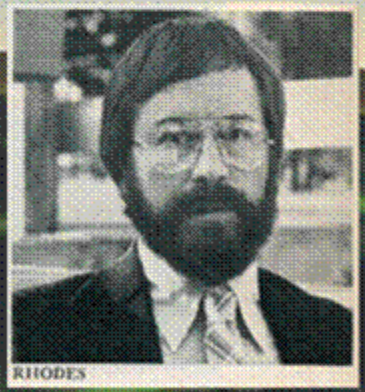
August 2009

article By RICHARD RHODES

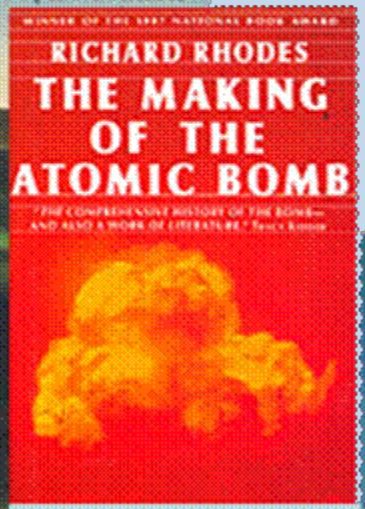
WASTE OF THE PECOS

carlsbad have a question: government bury nuclear wastes in your town, is it also going to bury you?

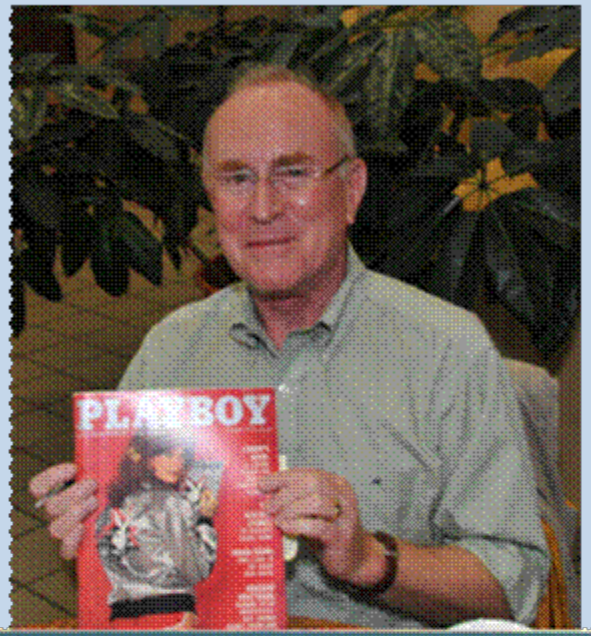
The Pecos rises green and cool through Carlsbad, New Mexico, the town that gave its name to the famous caverns, down in the southeastern corner of the state. If you meet a man in Carlsbad named Bob Light, and if you get on with him, he'll show you the river. He'll put you in one of the factory-silver flake jet boats he sells as a sideline to his oil-prospecting business and take you for a cruise up the Pecos past the expensive riverside

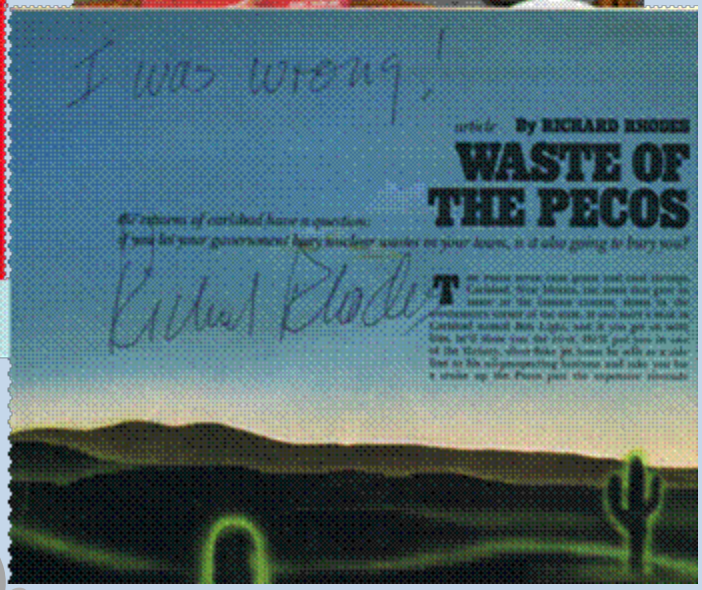


RHODES



Pulitzer 1988





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Thanks for the opportunity
to let your minds play
“outside the box”

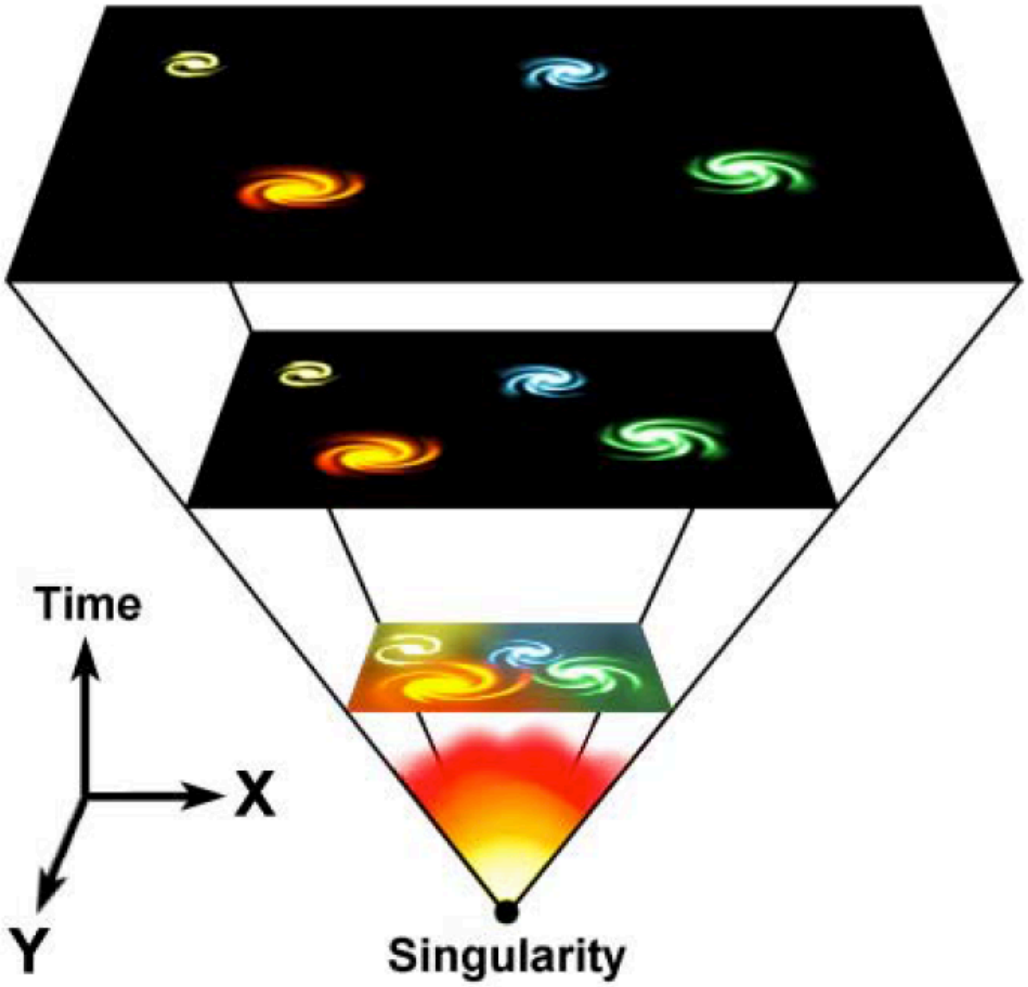
Miscellaneous Supplemental Information

To accept information about a matter on which totally contradictory evidence exists, and in which investigation of major disputes on the matter is prevented,
is not a rational act.

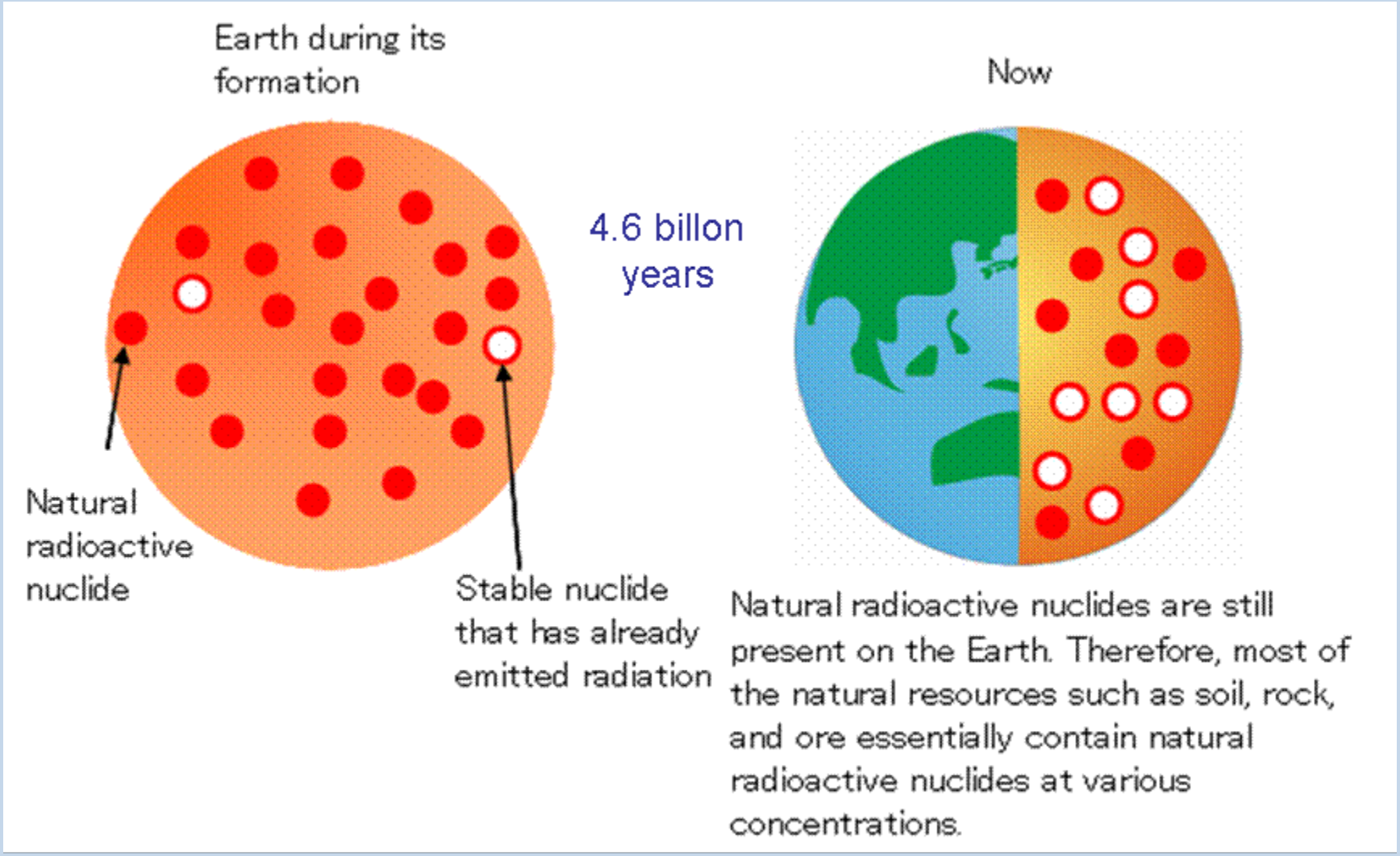
Robert Conquest

Radiation Has Existed Since the Beginning of the Universe

Universe created 10 - 20 billion years ago from a cosmic explosion

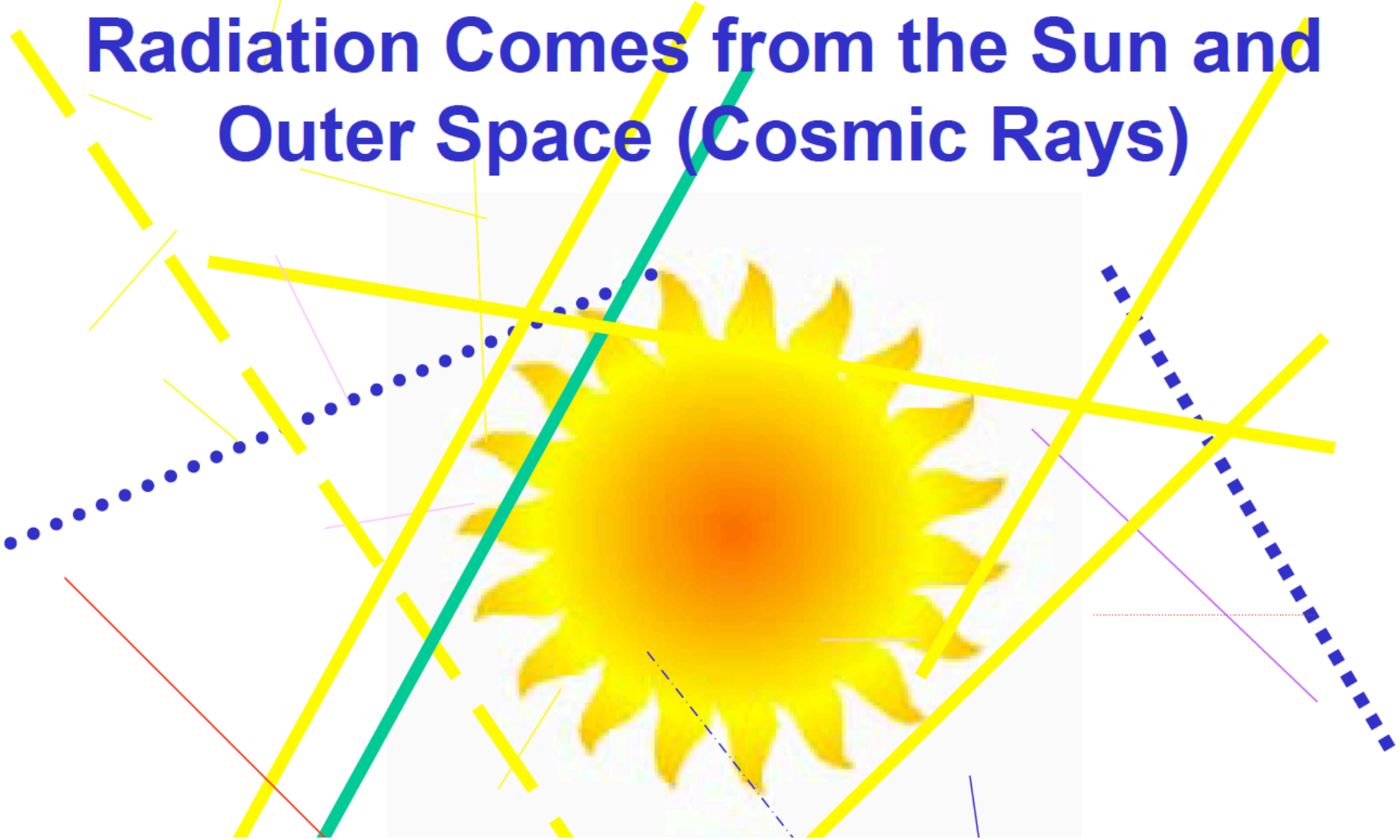


from Bobby Scott



http://www.nirs.go.jp/db/anzendb/NORMDB/ENG/1_sizen.php

Radiation Comes from the Sun and Outer Space (Cosmic Rays)



Cosmic ray interactions with the earth's atmosphere produces cosmogenic radiation

from Bobby Scott

Passing through the spiral arms of the Milky Way, our Solar System moves periodically through areas of intensive star creation.

In these regions, the intensity of galactic cosmic radiation reaching the Earth is 10 to 100 times* higher than average.

*David S. Smith, Seth Redfield, and John Scalo,
3rd Astrobiology Science Conference, Ames Research Center, 2004 (poster)

Never in Earth history has any part of Earth's surface been void of radioactive isotopes or not exposed to ionizing radiation

Paraphrased from L.A. Pertsov, The natural radioactivity of the biosphere, Israel Program for Scientific Translations, Jerusalem, 1967
http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/37/004/37004130.pdf

Natural Radioactivity by the Square Mile, 1 Foot Deep

Total volume: 7.894 x 10^5 m^3. Activity levels vary greatly depending on soil type, mineral make-up, and density (~1.58 g/cm^3 is the basis of this calculation).

Nuclide	Activity used in calculation	Nuclide mass	Activity found in soil volume
U	0.7 pCi/g (25 Bq/kg)	2,200 kg	0.8 curies (31 GBq)
Th	1.1 pCi/g (40 Bq/kg)	12,000 kg	1.4 curies (52 GBq)
K 40	11 pCi/g (400 Bq/kg)	2000 kg	13 curies (500 GBq)
Ra	1.3 pCi/g (48 Bq/kg)	1.7 g	1.7 curies (63 GBq)
Rn	0.17 pCi/g (10 kBq/m^3) soil	11 µg	0.2 curies (7.4 GBq)
		Total:	>17 curies (>653 GBq)

http://www.physics.isu.edu/radinf/natural.htm

Background Radiation Exposure

- US average: 3.6 mSv y^{-1}
  Worldwide average: 2.4 mSv y^{-1}

- Recommended max. dose for radiation workers: 20 mSv y^{-1}
  Goal for members of the public: <1 mSv y^{-1}

- Inhabitants of Ramsar, Iran: 240 mSv y^{-1}

- Exposure of people in Ramsar is >200 times the recommended maximum goal

The lack of ill effects from receiving this dose cannot be reconciled with current radiation protection standards

Modified from: http://www.ecolo.org/documents/documents_in_english/ramsar-Monfared-HLR-06.ppt#257,2,Introduction

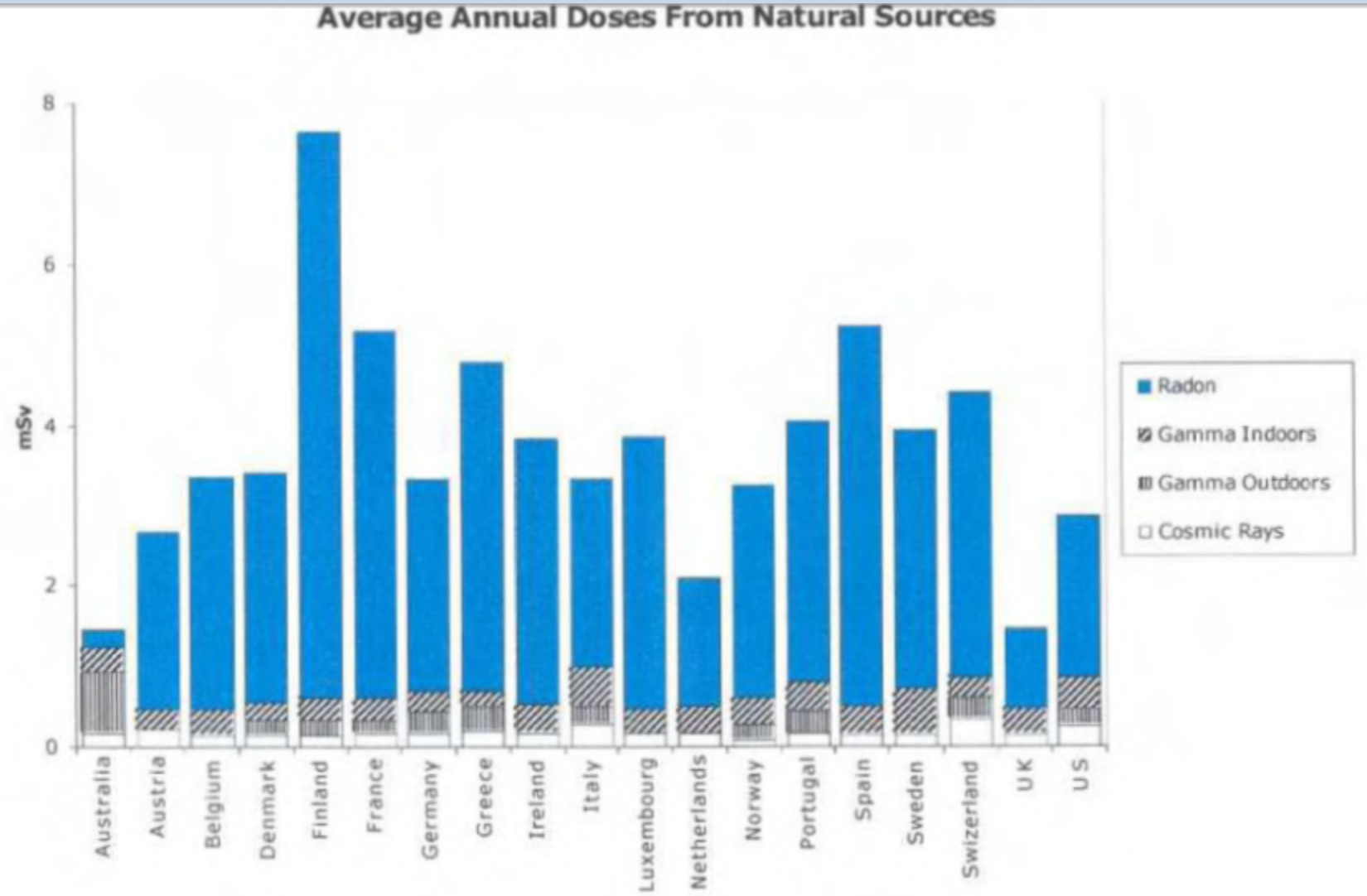
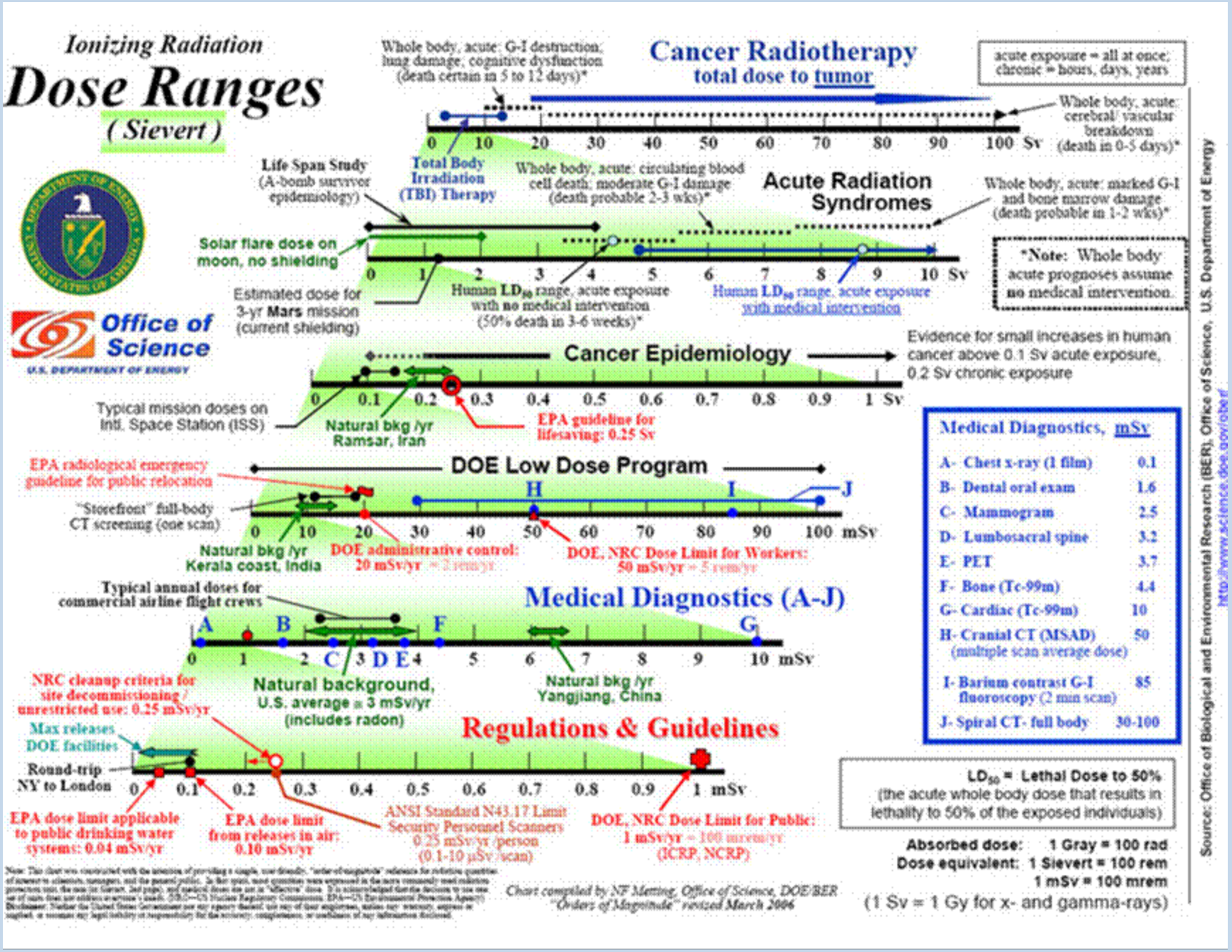


Figure 2-1. A bar graph showing average annual natural radiation doses worldwide. The radiation is measured in mSv and shows the approximate distribution of natural radiation doses from radon, indoor gamma, outdoor gamma and cosmic rays (http://www.uic.com.au/ral.htm).

Radiation and Life

- Life evolved in a radiation field ("vitamin-R") that was much more intense than today:
  - Higher Concentration of Radioactive Elements
  - Natural Reactors
- Natural background radiation levels on Earth vary by at least two orders of magnitude.

after S. M. J. Mortazavi, 2006, at:
http://www.ecolo.org/documents/documents_in_english/ramsarMORTAZAVI-HLR-06.ppt



http://www.lowdose.energy.gov/pdf/Dose-Ranges-pdf.pdf

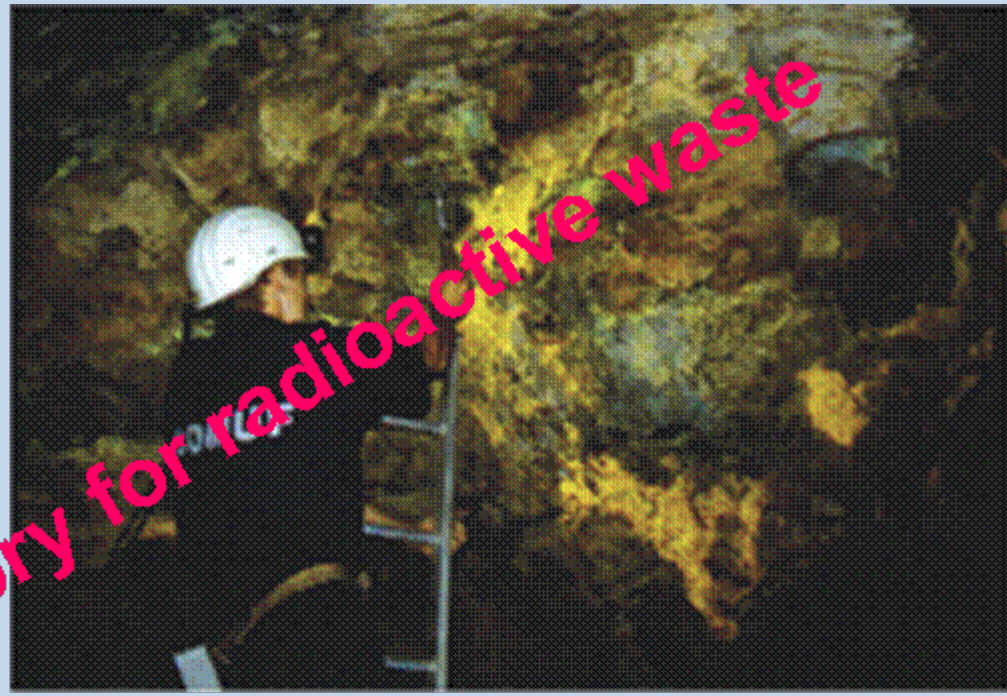
ng(o)$_3$

Paul K. Kuroda, 1917-2001

Paul Kazuo Kuroda
1917-2001

- Was inspired by Francis W. Aston lecture on mass spectra and isotopes 1936 and Niels Bohr's lectures at Tokyo University 1937
- Emigrated from Japan 1949; became US citizen 1955
- Taught chemistry, U. of AR 1952-1987
- Published theory of Pre-Fermi natural reactor in *Journal of Chemical Physics*, v. 25. p. 781 (1956) (Oklo discovery 1972)

"99 out of 100 graduate students are neither smart enough nor truly motivated to become good scientists. I clearly belonged to that group."



earliest known repository for radioactive waste

pre-Fermi (*natural*) reactors

Oklo

Gabon

Geologic Repositories in Germany


Rolf Steinkampf,
farmer and principal
Asse surface owner


Asse underground
Durchgang
verboten !
Kontrollbereich
Radioaktiv

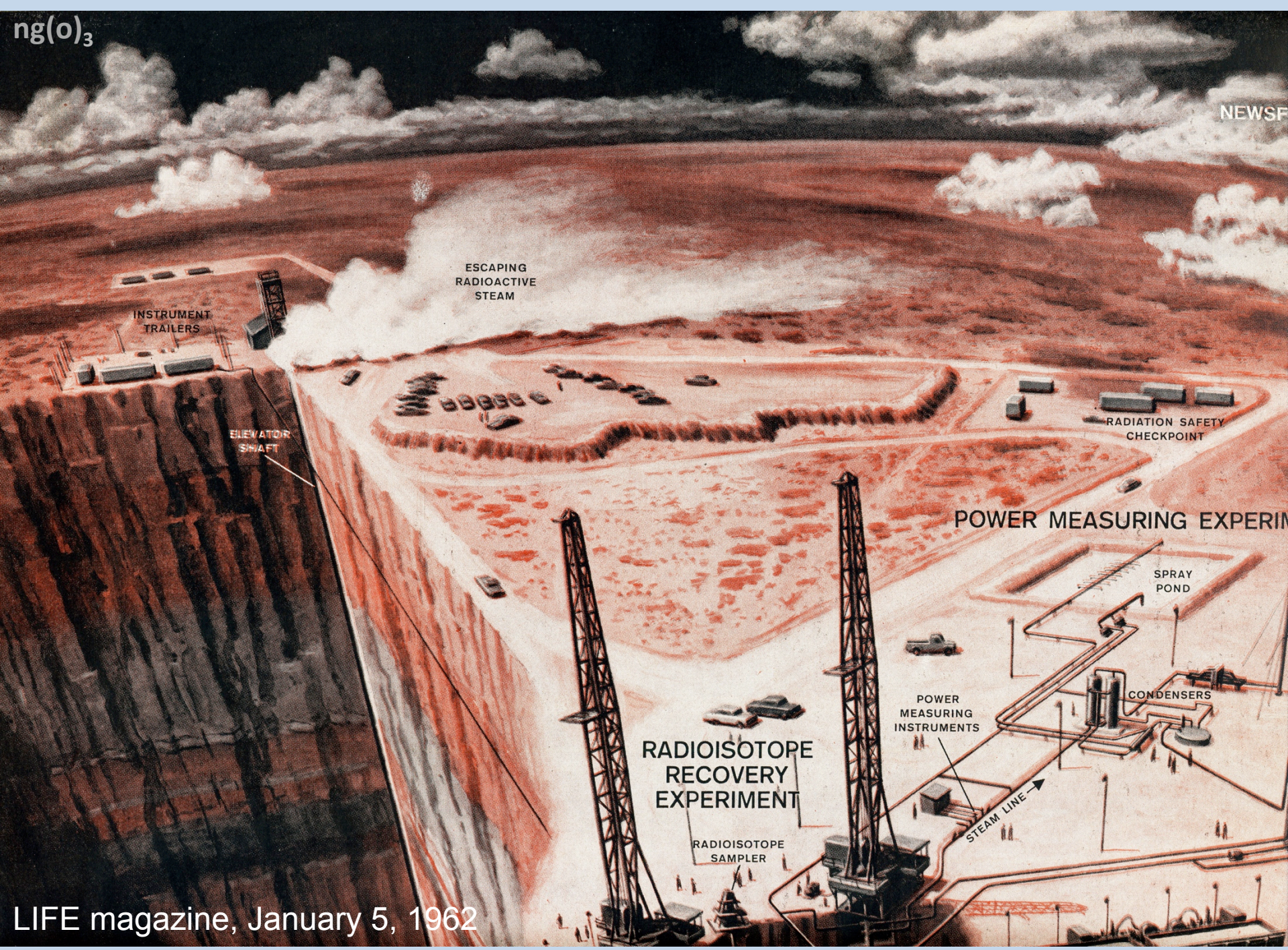
(http://www.laradioactivite.com/en/site/illustration/images/DecayPotassium40_En.htm)

Underground operations at IMC potash mine, Carlsbad

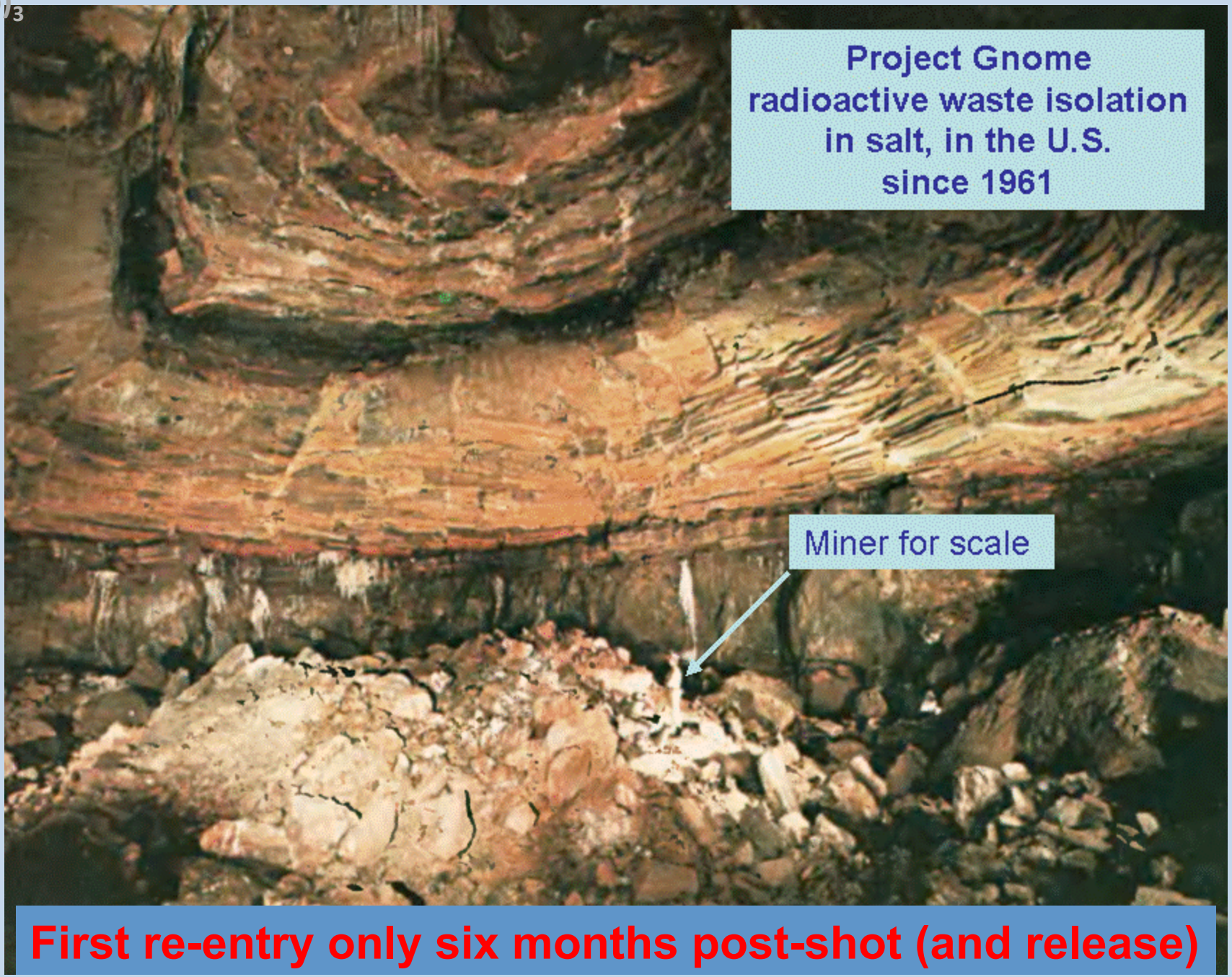
ng(o)$_3$

Gnome cavity and waste repository

$g(o)_3$



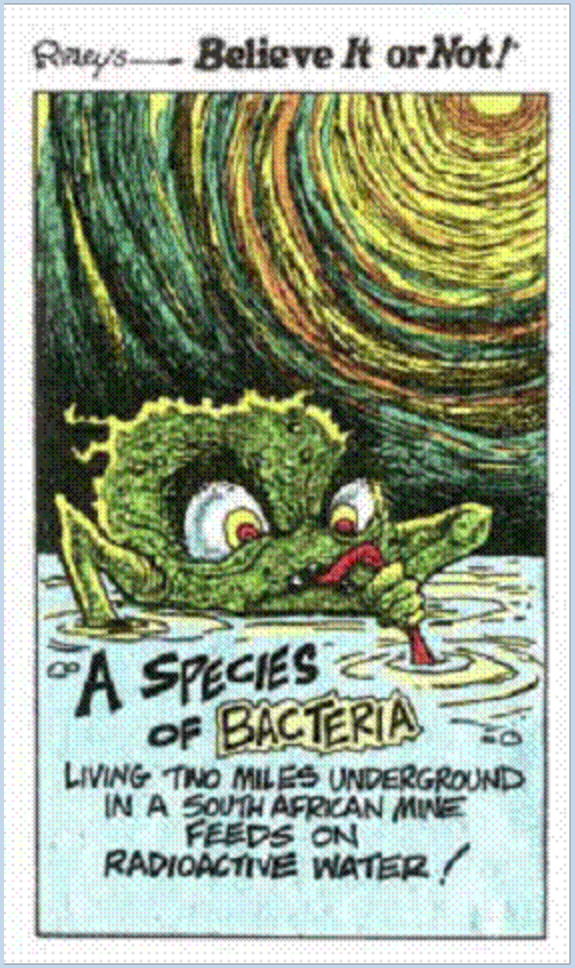
LIFE magazine, January 5, 1962



First re-entry only six months post-shot (and release)

"Microbes from Hell's Zip Code"

S. African gold mine & Nevada Test Site



Water plus rock plus radiation can sustain life for millennia

Radiation may keep life going, thriving, and evolving

Tullis Onstott, Princeton

(Hometown: Carlsbad, NM)

http://www.cemp.dri.edu/cemp/workshop2009/presentations/Moser-Deep_Earth_Life.pdf

2005

ISBN 0-930073-35-5

UNDER-EXPOSED

What If Radiation Is Actually GOOD for You?

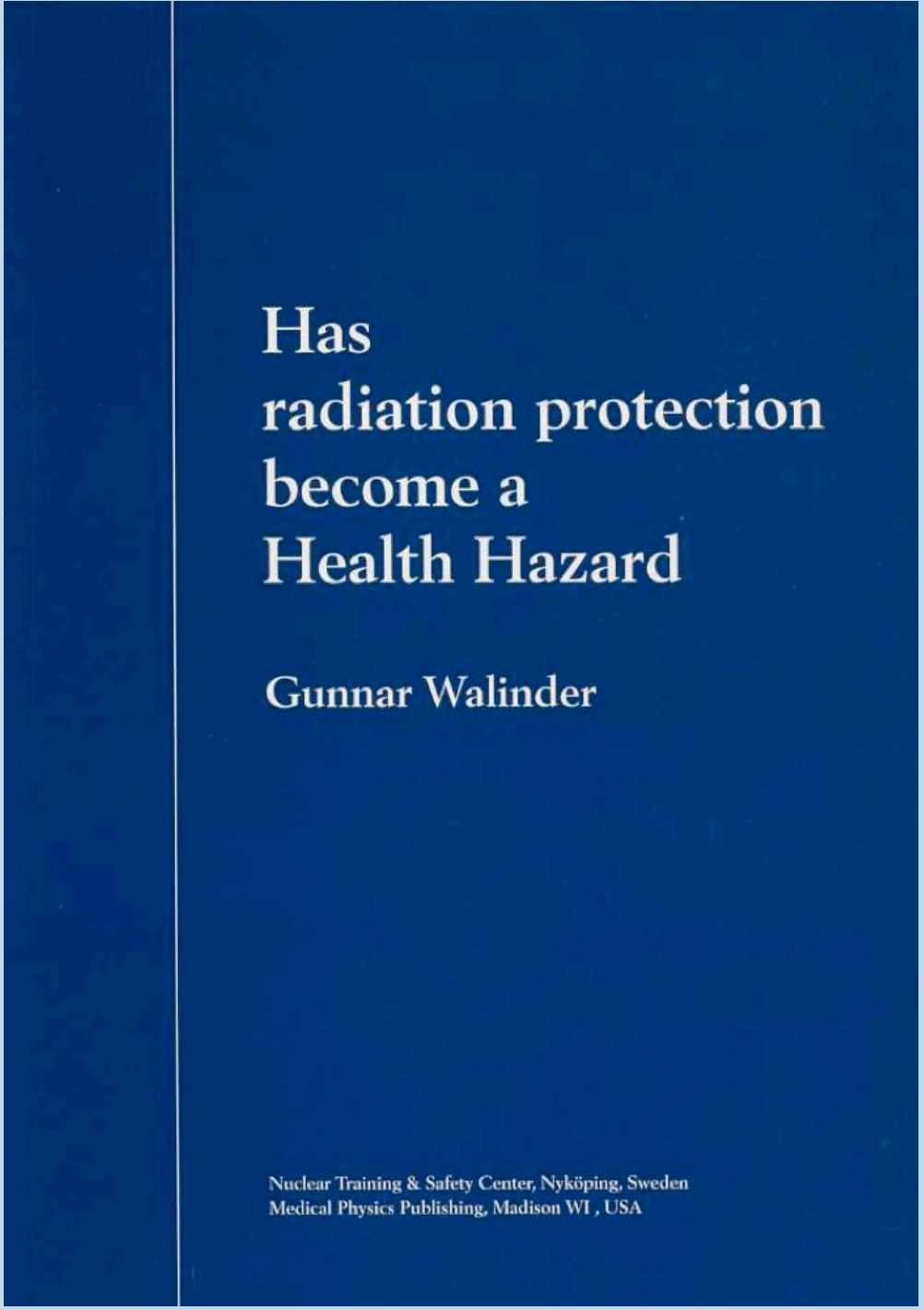
by Ed Hiserodt

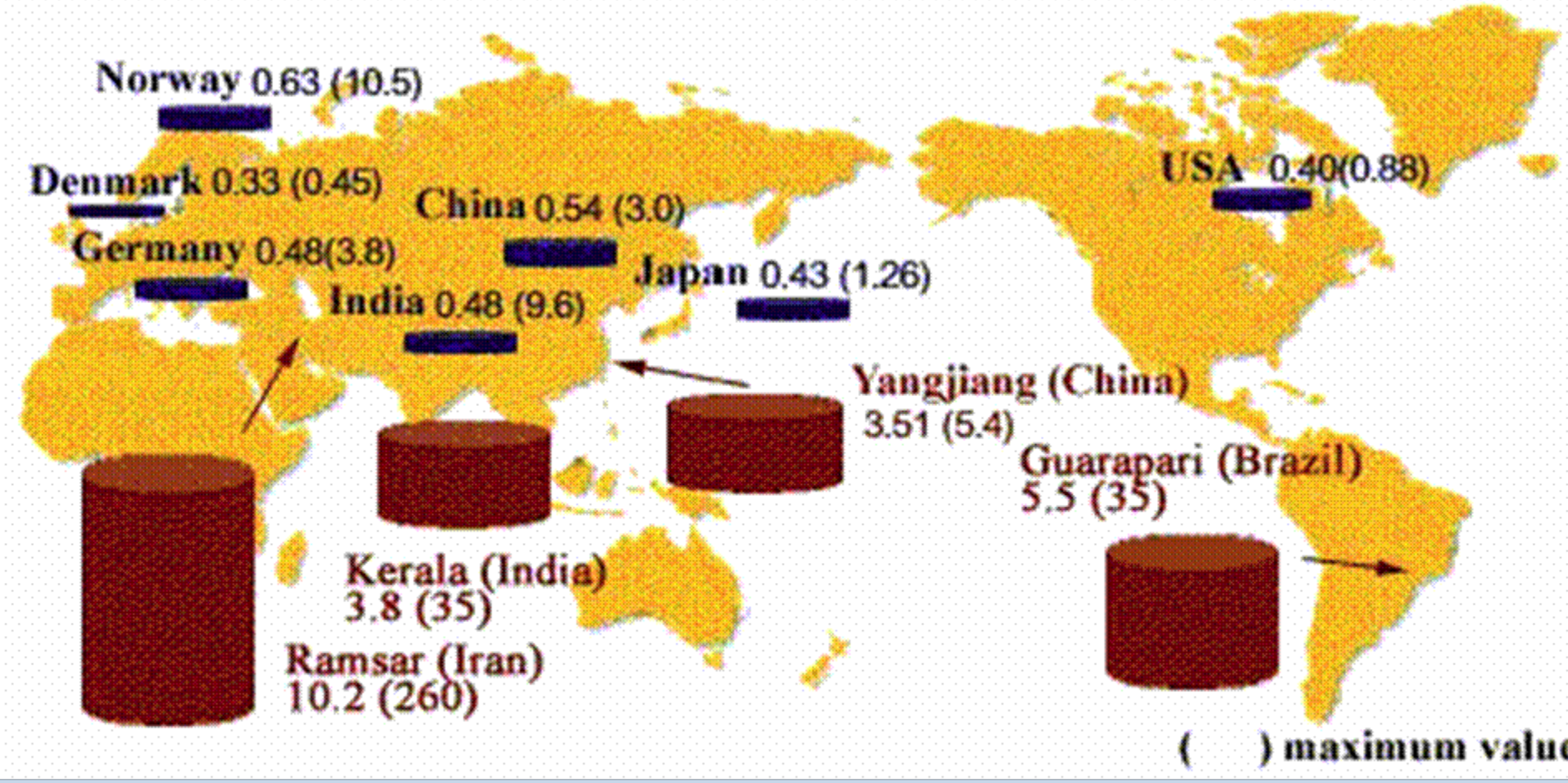
Laissez Faire Books

a division of the Center for Libertarian Thought, Inc.

Little Rock, Arkansas

1995
ISBN 0-944838-96-0

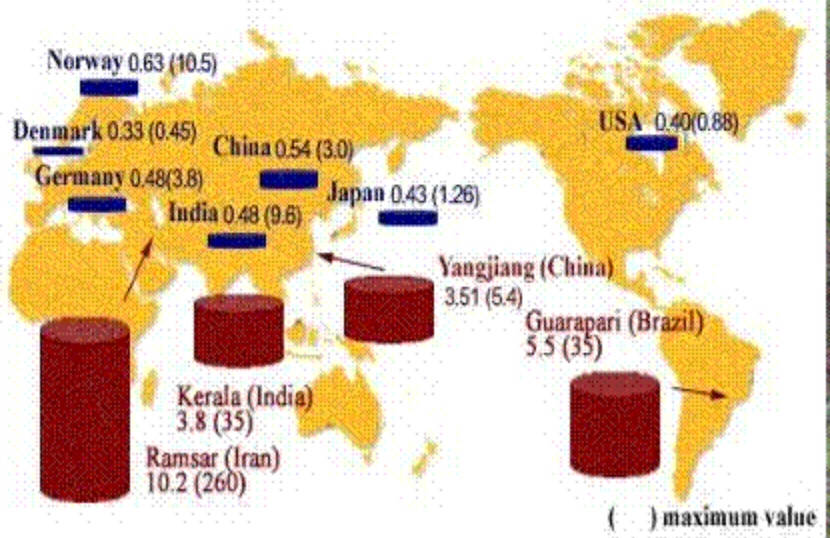




Average and maximum annual background absorbed doses (mGy/yr) to inhabitants of some countries and for areas with high levels of natural radiation

http://ajes.in/PDFs/05-1/02-Mortazavi.pdf

Ramsar


Norway 0.63 (10.5)
Denmark 0.33 (0.45)
China 0.54 (3.0)
USA 0.40(0.88)
Germany 0.48(3.8)
Japan 0.43 (1.26)
India 0.48 (9.6)
Yangjiang (China)
3.51 (5.4)
Guarapari (Brazil)
5.5 (35)
Kerala (India)
3.8 (35)
Ramsar (Iran)
10.2 (260)
( ) maximum value

Annual terrestrial radiation doses in the world

Area	mean (mGy/year)	maximum (mGy/year)
Ramsar, Iran	10.2	(260)
Guarapari, Brazil	5.5	(35)
Kerala, India	3.8	(35)
Yangjiang, China	3.51	(5.4)
Hong Kong, China	0.67	(1.00)
Norway	0.63	(10.5)
France	0.60	(2.20)
China	0.54	(3.0)
Italy	0.50	(4.38)
World average	0.50	
India	0.48	(9.6)
Germany	0.48	(3.8)
Japan	0.43	(1.26)
USA	0.40	(0.88)
Austria	0.37	(1.34)
Ireland	0.36	(1.58)
Denmark	0.33	(0.45)

http://www.taishitsu.or.jp/radiation/

Natural background radiation: 3 mSv/y. (range: 1-10 mSv/y.)

20 *Int. J. Low Radiation, Vol. 2, Nos. 1/2, 2006*

Cancer incidence in areas with elevated levels of natural radiation[1]

S.M.J. Mortazavi* **Senior author: A. Niroomand-Rad**

National Radiation Protection Department (NRPD),
Iranian Nuclear Regulatory Authority (INRA),
PO Box 14155-4494, Tehran, Iran

Natural background radiation levels
"… in Ramsar are approximately 55-200 times higher than that of the global average rate." (typ. 260 mSv/y.)
"… no increased level of chromosome aberrations. … It can be concluded that prolonged exposure … decreases the frequency of chromosome aberration and the cancer incidence rate."

http://www.imp.uni-erlangen.de/lehre/Q11%20Strahlenschutz%202009.pdf

Radiation Background in Kerala India

- Unusually high natural radiation background has been known for many years due to natural thorium in the monazite sands of the region
- Annual outdoor exposure levels as high as 7000 mrem have been measured where people live
- Recent epidemiological studies have concluded no excess cancers in over 69,000 residents studied for 10 years[1]

[1] R Naire, B Rajan, et al; Background radiation and cancer incidence in Kerala,India—Karunagappally cohort study; Health Physics, 96,1, January, 2008

SENES Consultants

SHB, Inc.

http://www.nma.org/pdf/urw/brown.pdf

Annual Background Radiation Exposure vs. Annual Public Exposure Limits: U Mines and Mills

- Background Levels (from previous slide)
  - > Colorado average = 400 mrem
  - > Leadville, Colorado = 526 mrem
  - > U.S. average = 310 mrem
- Regulatory Limits
  - > EPA drinking water standard = 4 mrem[1]
  - > EPA limit for all exposure pathways = 25 mrem[2]
  - > NRC Limit with radon = 100 mrem; excluding radon = 25 mrem[3]

[1] U.S. Environmental Protection Agency. Radionuclides in drinking water. Available at: http://www.epa.gov/safewater/radionuclides/index.html.

[2] U.S. Environmental Protection Agency. Environmental radiation protection for nuclear power operations, 40 CFR 190.10; 2006.

[3] U.S. Nuclear Regulatory Commission; Domestic Licensing of Source Material ; 10 CFR 40

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http://www.nma.org/pdf/urw/brown.pdf

How Common are Uranium and its Daughter Products[1] in Nature?[2]

- Typical concentration in soil and rocks (pCi*/gram):
  - > Uranium = 0.6 – 3.0
  - > Uranium in phosphate rock used for fertilizers = 40 – 80
  - > Radium = 0.4 – 3.6
  - > Thorium = 0.2 – 2.2

[1] Daughter products = those chemical elements that uranium decays into as a result of its radioactive properties. Thorium and radium are also radioactive.

[2] Sources: (1) National Council on Radiation Protection and Measurements. Natural background radiation in the United States. Washington, DC: National Council on Radiation Protection and Measurements; NCRP Report No. 45; 1975. (2) National Council on Radiation Protection and Measurements. Exposure of the population in the United States and Canada from natural background radiation. Bethesda, MD: National Council on Radiation Protection and Measurements; NCRP Report No. 94; 1992 (updates and supersedes NCRP Report No. 45).

*pCi = picocurie, one-trillionth of a curie, the amount of radioactivity where approximately two atoms decay per minute. Picocurie is a measure of the amount of radioactivity.

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http://www.nma.org/pdf/urw/brown.pdf

Natural Uranium in Groundwater

- Can vary considerably from place to place depending on local mineralization, hydrology and geochemistry
- Although typically a few micrograms / liter (a few pCi / liter), U has been measured in public drinking water sources 10 -100 + greater than this
- No permanent health effects have been observed in populations drinking water for generations with these high natural levels

Sources:(1) *Assessing Potential Risks from Exposure to Natural Uranium in Well Water. Hakonson-Hayes A.C, P.R.* Fresqueza,, F.W. Whicker, Journal of Environmental Radioactivity, 59 (2002)
(2) *Public Health Goal for Uranium in Drinking Water.* Office of Environmental Health Hazard Assessment California Environmental Protection Agency, 1997 (3) U.S. Dept. of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Uranium. 1999.*

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http://www.nma.org/pdf/urw/brown.pdf

Example Conclusions from Studies on Health Impacts on Populations Living Near Uranium Mines and Mills

" The absence of elevated mortality rates of cancer in Montrose County over a period of 51 years suggests that the historical milling and mining operations did not adversely affect the health of Montrose County residents."[1]

"No unusual patterns of cancer mortality could be seen in Karnes County over a period of 50 years suggesting that the uranium mining and milling operation had not increased cancer rates among residents."[2]

[1] *Cancer and Noncancer Mortality in Populations Living Near Uranium and Vanadium Mining and Milling Operations in Montrose County, Colorado, 1950 -2000. Boice,* JD, Mumma, MT et al. Journal of Radiation Research, 167:711-726; 2007

[2] *Mortality in a Texas County with Prior Uranium Mining and Milling Activities, 1950 – 2001. Boice, JD,* Mumma, M et al. Journal of Radiological Protection, 23:247 – 262; 2003

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http://www.nma.org/pdf/urw/brown.pdf

Possible Interpretations of BEIR VII Implications

- Don't sit close to anyone in a seminar (we all are radioactive).
- Don't get medical/dental X rays.
- Don't fly on airplanes (cosmic rays).
- Don't purchase TVs (x rays).
- Don't live at high altitudes (cosmic rays).
- Don't breath too much (radon is in the air).
- Don't eat vegetables and fruits (they contain radioisotopes).

from Bobby Scott

Low-Dose-Rate Gamma Irradiation Suppresses Cancer

- 10,000 Taiwanese residents lived in Co-60 contaminated apartments 9 to 20 years.
- Average gamma-ray dose about 400 mGy.
- Cancer deaths reported to decrease by more than 95%!!!!

  Comment: 95% value being questioned by some US critics.

W.L. Chen et al., Journal of American Physicians and Surgeons 9(1):6, 2004.

from Bobby Scott

TD Luckey Appears to Be Right!

- **According to TD Luckey, 1/3 of all cancer deaths are premature and preventable by low-level ionizing radiation (e.g., elevated background).**
- **Reducing natural background low-LET radiation could cause reduced lifespan and increased cancers!**

Protective effect considered to be associated with low-LET radiation component of background radiation.

from Bobby Scott

Further Implications of our Research

- Background radiation appears to be protecting us from cancer and other diseases!
- Low-LET irradiation can reduce cancer risk below the spontaneous level!
- Low-LET irradiation appears to protect against cancer induction by other carcinogens!
- A dose-rate-dependent, effective threshold likely exists for inducing excess cancer by low-LET irradiation!

from Bobby Scott

When life commenced on Earth around three and a half billion years ago, the natural level of radiation was up to five times higher than today.

Peter A. Parsons, Dose Response. 2006; 4(3): 191–200.
Published online

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2477689/

The LNT hypothesis should be abandoned and be replaced by a hypothesis that is scientifically justified and causes less unreasonable fear and unnecessary expenditure. Feinendegen LE., Br J Radiol. 2005 Jan;78(925):3-7

http://www.ncbi.nlm.nih.gov/pubmed/15673519

Conclusions

- The LNT risk assessment paradigm is appropriate (for accurate risk assessment) only for a utopian world!
- Dose units such as Sv, mSv, and μSv belong in the indicated utopian world, not in our world! Their useful life for our world has expired.
- Radiation hormesis (adapted protection) is real and has a biological basis for effects such cancer.
- Natural background low-LET radiation protects us from cancer and other diseases via induced adapted protection. Doses just above background provide added protection.
- The gamma-ray component of radon exposure in our homes is likely protecting us from cancer and other genomic-instability-associated diseases.

from Bobby Scott

Paracelsus (1493 - 1541)

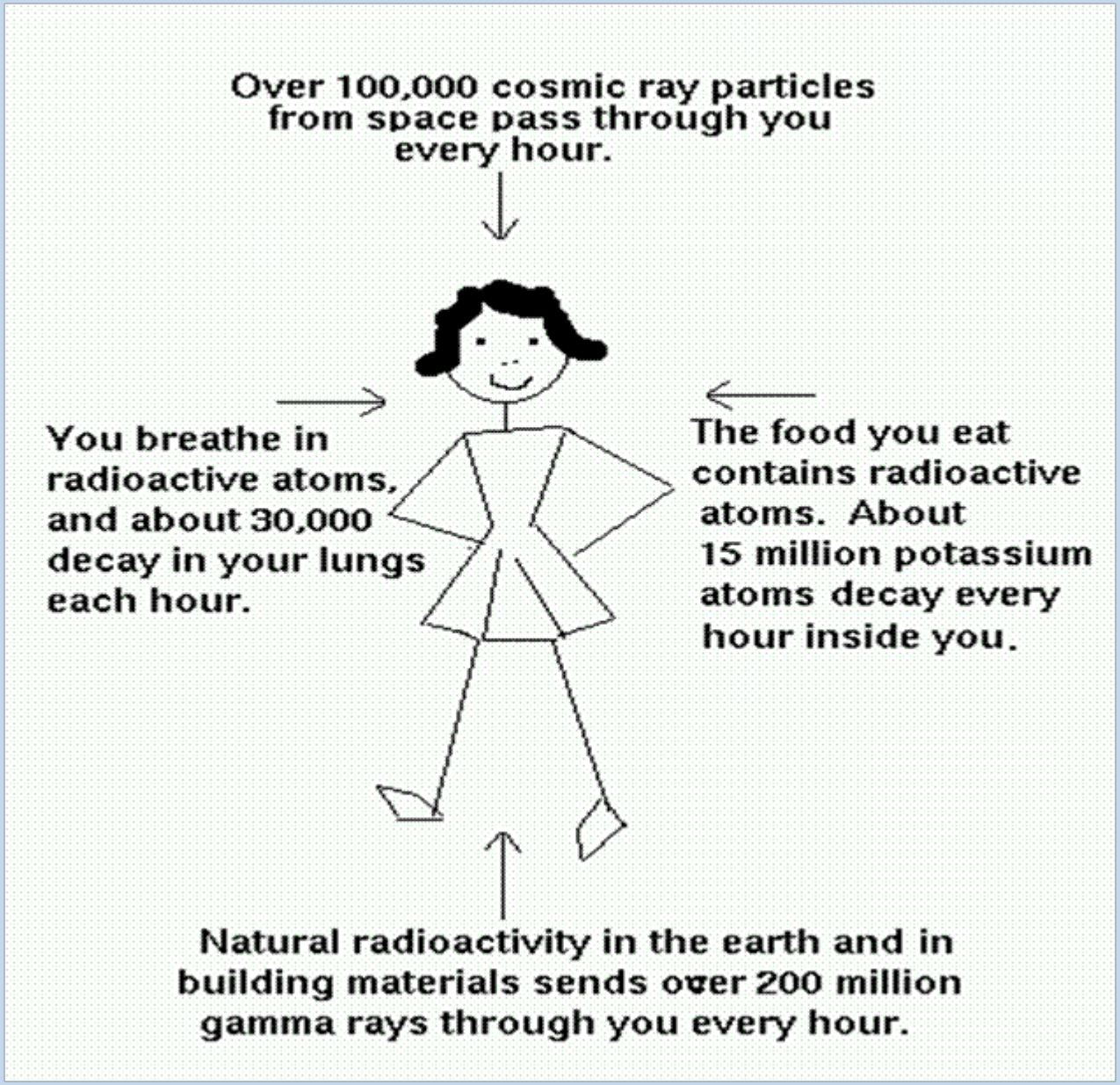
If you wish justly to explain poison, what is there that is not poison?

All things are poison, and nothing is without poison: *the dose alone makes a thing not poison*.

For example, every food and every drink, if taken beyond its dose, is poison: the result proves it.

Written 1538, published 1564, in the third of his seven "Defensiones"

RADIATION IN LIFE



http://www.state.tn.us/environment/rad/ppt/070507bsfrswac.ppt#541,1,Bulk Survey for Release (BSFR) Program

Natural Radioactivity in the Body of A Typical 70kg Adult Human

Nuclide	Approx. Total Mass	Disintegrations per day
Uranium isotopes	90 micrograms	95 thousand
Thorium isotopes	30 micrograms	9.5 thousand
Potassium-40	17 miligrams	380 million
Radium isotopes	31 picograms	95 thousand
Carbon-14	22 nanograms	320 million
Tritium isotopes	0.06 picograms	2 million
Polonium isotopes	0.2 picograms	3.2 million

Based on information from http://physics.isu.edu/radinf/natural.htm

Radioactive Isotope	Half Life (years)	Isotope Mass in the Body (grams)	Element Mass in the Body (grams)	Activity within the Body (Disintegrations/sec)
Potassium 40	1.26×10^{9}	0.0165	140	4,340
Carbon 14	5,730	1.6×10^{-8}	16,000	3,080
Rubidium 87	4.9×10^{10}	0.19	0.7	600
Lead 210	22.3	5.4×10^{-10}	0.12	15
Tritium (^{3}H)	12.43	2×10^{-14}	7,000	7
Uranium 238	4.46×10^{9}	1×10^{-4}	1×10^{-4}	3 - 5
Radium 228	5.76	4.6×10^{-14}	3.6×10^{-11}	5
Radium 226	1,620	3.6×10^{-11}	3.6×10^{-11}	3

Natural Radioactivity from Potassium-40

- Largest source of natural radioactivity for humans, followed by carbon-14.
- Physical half-life of 1.25 billion years.
- Mainly (88.8%) undergoes beta decay (0.51 MeV average energy) to stable calcium-40.

Natural Radioactivity from Potassium-40 in 1 Pound of Food

Food	Disintegrations per second (Becquerel)	Beta particle emissions per minute
Red meat	50	2682
Carrot	57	3040
White potato	57	3040
Banana	59	3147
Lima bean	78	4148
Brazil nut	94	5007

Based on information from http://physics.isu.edu/radinf/natural.htm

http://www.rerowland.com/BodyActivity.htm

RADIOACTIVE ELEMENTS IN THE HUMAN BODY

Radioactive Isotope	Half Life (years)	Isotope Mass in the Body (grams)	Element Mass in the Body (grams)	Activity within the Body (Disintegrations/sec)
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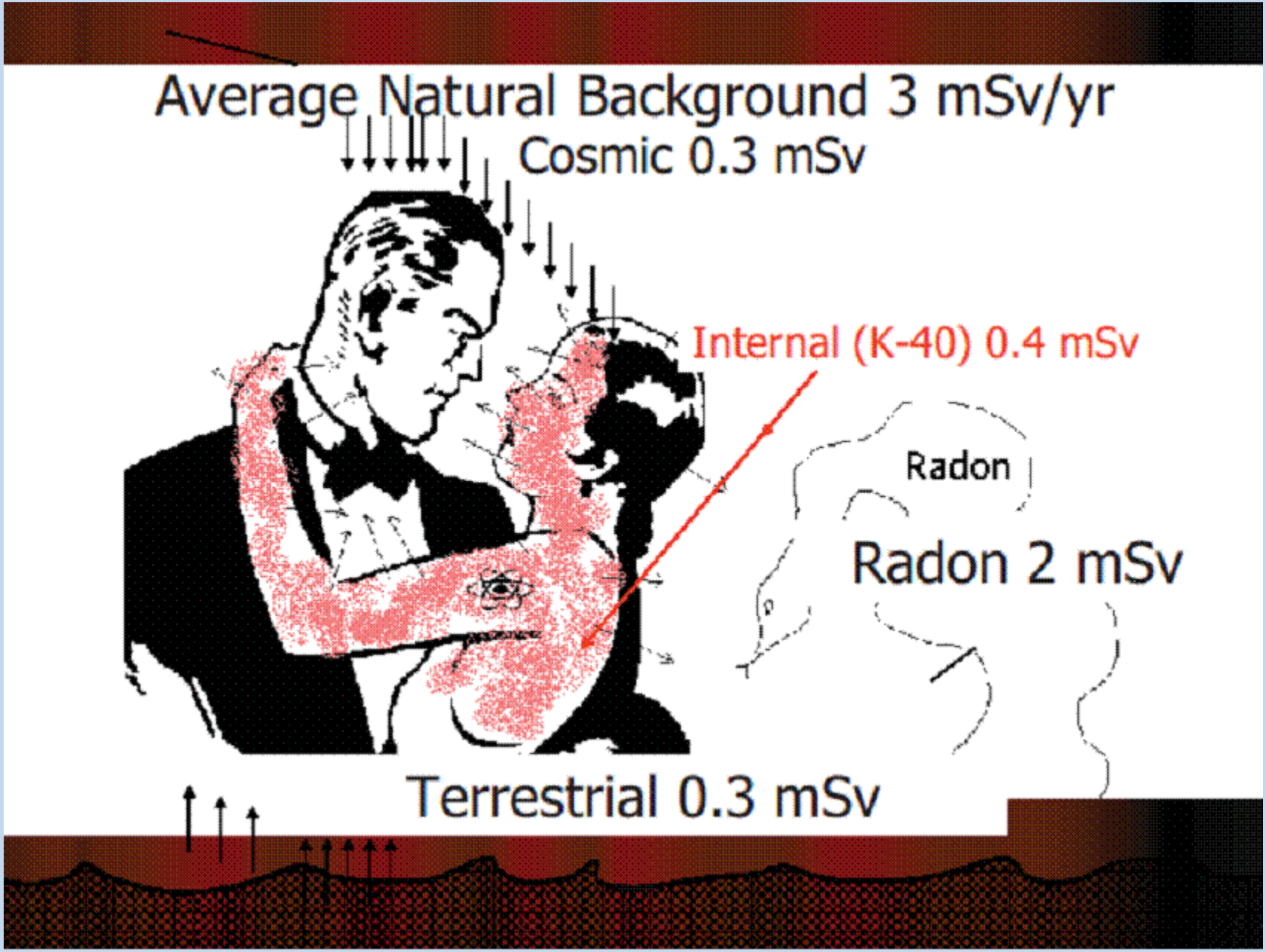
http://www.rerowland.com/BodyActivity.htm



http://www.hpschapters.org/northcarolina/spring2007/Faith-Based%20Rradiation%20Protection-Dixon.pdf

http://www.hpschapters.org/northcarolina/spring2007/Faith-Based%20Rradiation%20Protection-Dixon.pdf

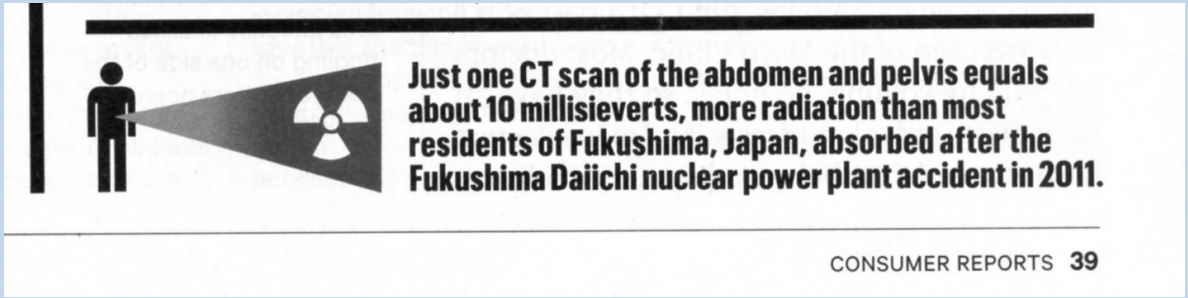
Tri-Valley CAREs
Communities Against a Radioactive Environment
2582 Old First Street, Livermore, CA 94550 • (925) 443-7148 • www.trivalleycares.org

Avner Vengosh, Duke University
Rooting Out Radioactive Groundwater (Geotimes, May 2006)
When the **Chernobyl** nuclear power plant exploded in 1986… The accident demonstrated the **fragility of any nuclear facility** and raised the level of awareness over the health **threats that radiation poses** to people and the environment.
…the general population is still **at risk from** a different source: **Naturally occurring radioactive particles** exist in many groundwater systems worldwide…
The global **community must aggressively address these challenges, to ensure a safe water supply**.

This is nuts!

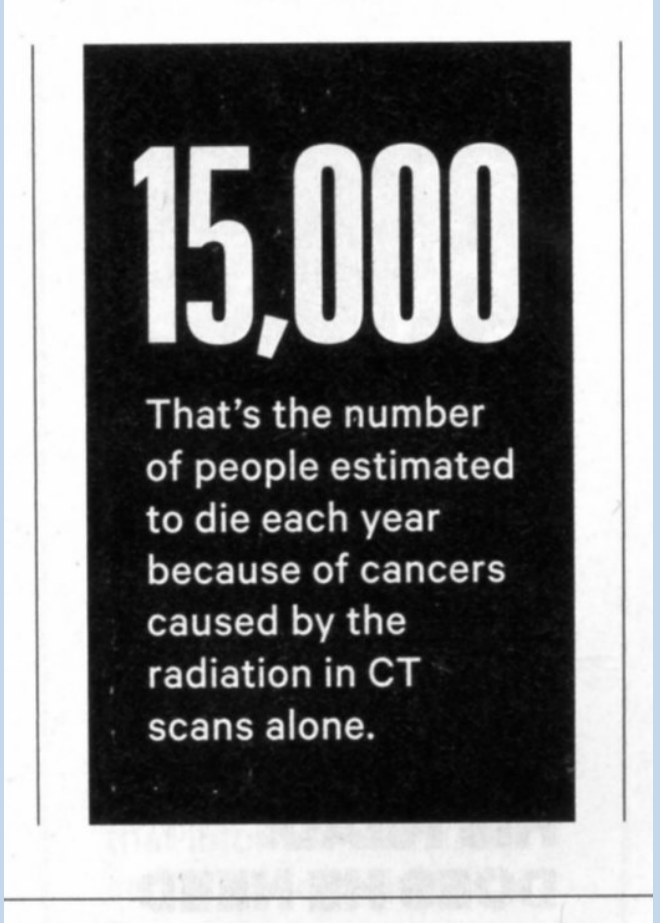
Laurence A. Coogan & Jay T. Cullen, University of Victoria
Did natural reactors form as a consequence of the emergence of oxygenic photosynthesis during the Archean? (GSA Today, October 2009)
Natural reactors act as point sources of…**toxic byproducts**.
Natural fission reactors would clearly be **environmentally detrimental**.
…whether the formation of these natural reactors had any significant **biocidal impacts**…

Alarmism



from Consumer Reports, March 2015

Pure Fiction



from Consumer Reports, March 2015

Contextual evidence

AVERAGE IONIZING RADIATION DOSES CAUSED BY THE CHERNOBYL DISASTER	MILLIREM PER YEAR
Chernobyl (1992)	490
Pripyat (1992)	2500
FROM NATURAL SOURCES (SOIL, ROCKS)	**MILLIREM PER YEAR**
Average in Poland	240
Grand Central Railway Station in New York City	540
Kerala, India	900
A region in Norway	1,000
A region in Sweden	3,500
Guarapari, Brazil	3,700
Tamil Nadu, India	5,300
A house in Ramsar, Iran, built over 100 years ago	8,900–13,200

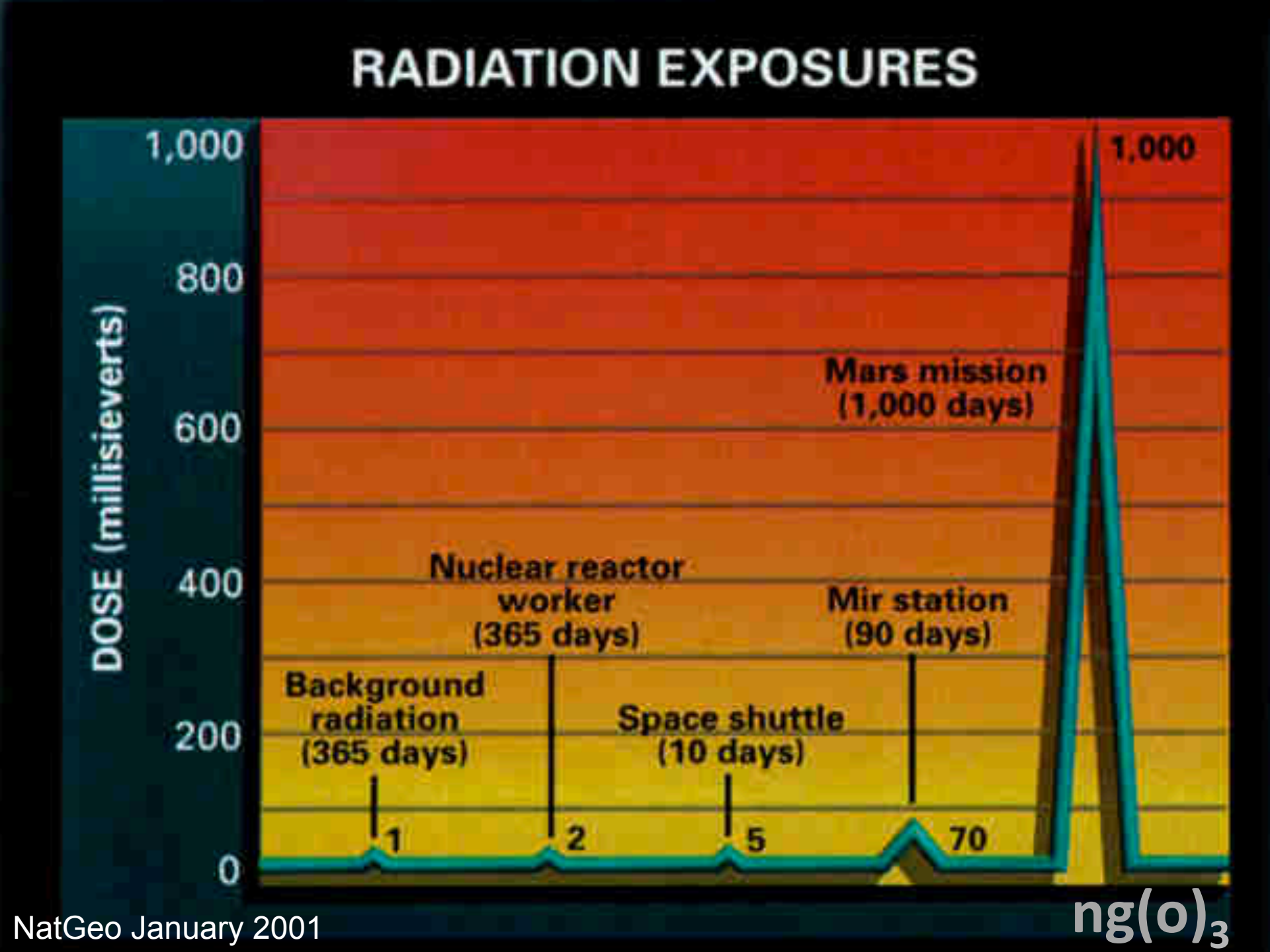
Source: UNSCEAR, Jovanovich, Sohrabi. Data from 1993, converted to millirem

from Cravens 2007

1 mSv=100 mRem
10 mSv=1,000 mRem

Hawking wasn't any more optimistic about humans reaching distant planets. He said: "The present breed of humans won't reach the stars. The distances are too great. The radiation exposure would be too severe."

CNET, Chris Matyszczyk, June 19, 2015
https://www.yahoo.com/tech/s/stephen-hawking-waxes-dismal-time-134642584.html



NatGeo January 2001

Dose Perspectives

100,000 mrem – Dose leading to ~5% chance of Fatal Cancer (UNSCEAR)

10,000 mrem/yr – IAEA mandatory intervention

5,000 mrem/yr – Worker dose standard

1,000 mrem/yr – IAEA reference level for intervention for cleanup situations

360 mrem/yr – US Average dose all sources (NCRP)

100 mrem/yr – All sources limit (IAEA practices, DOE)

25 mrem/yr – NRC and DOE LLW

15 mrem/yr – EPA Radiation (40 CFR 191)

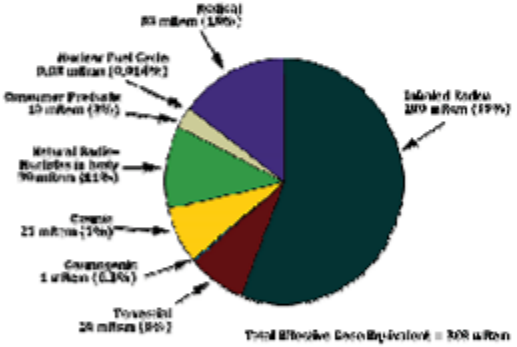
10 mrem/yr – Air (atmospheric) (40 CFR 61)

4 mrem/yr – Drinking Water (40 CFR 141)

1 mrem/yr – IAEA Exemption/Clearance

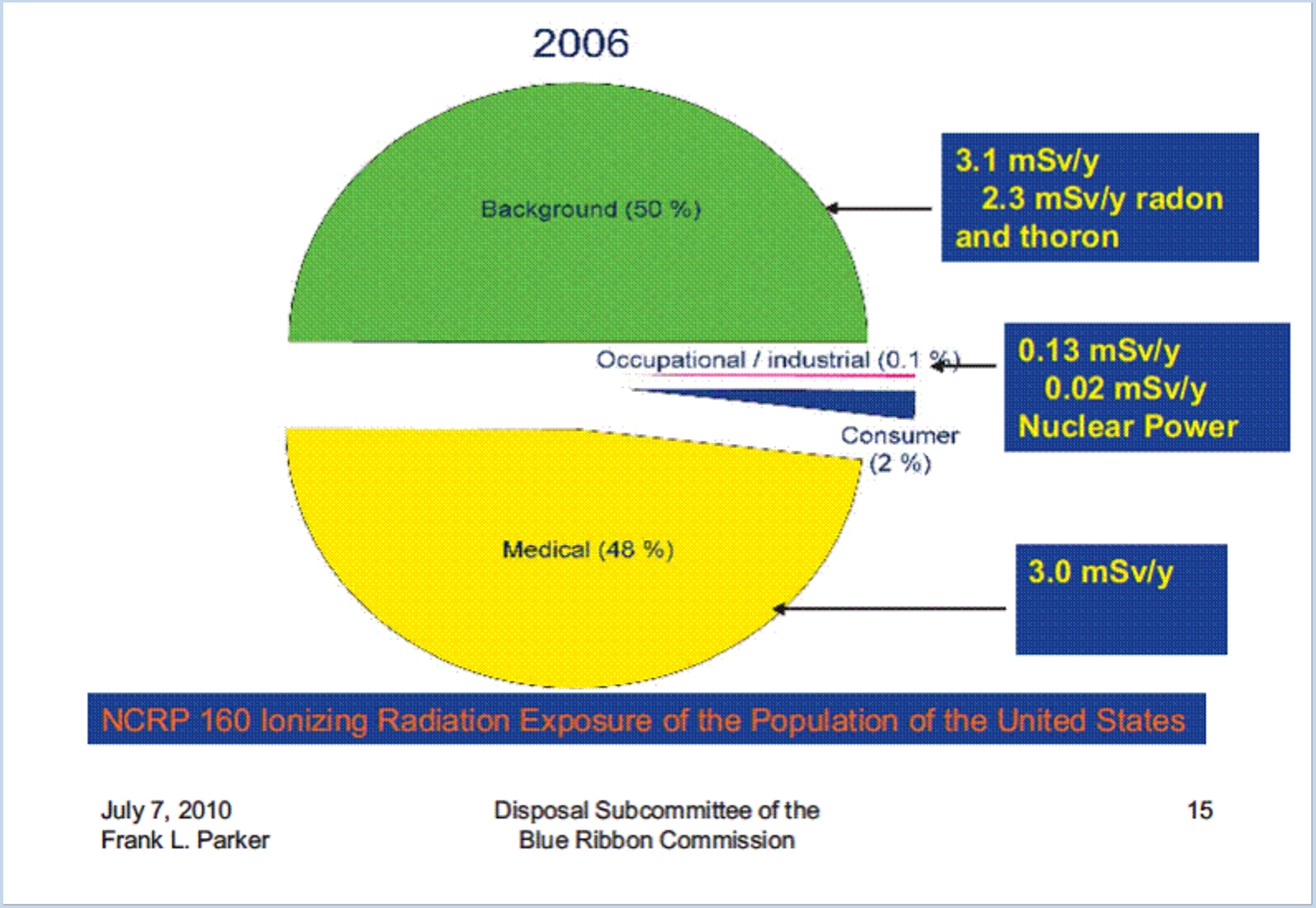
Note: Air crew average (300 mrem/yr)
From UNSCEAR (2000)

Typical Annual Sources of Public Exposure



Graphics from NCRP Report No. 93

http://www.cresp.org/PACOP/Presentations/Day%201%20July%2013%202009/02_LETOURNEAU_Marty%20slc%20final.pdf



http://brc.gov/Disposal_SC/docs/Frank%20Parker%20-%20disposal%20subcommittee%20office%20july%207,%202010%20final.pdf

Major U.S. Radiation Standards

Standard/agency	Numerical limit
General standards	
General public/NRC (10 C.F.R. 20)	100 millirem/year
Source-specific standards	
Uranium mill tailings/EPA, NRC (40 C.F.R. 192; 10 C.F.R. 40, App. A)	Radium 226, 228: 5 picocuries/gram surface, 15 picocuries/gram subsurface Radon 222: 20 picocuries/square-meter-second[a]
High-level waste operations/NRC (10 C.F.R. 60)	100 millirem/year
Spent fuel, high-level waste, transuranic waste disposal/EPA (10 C.F.R. 191)	All pathway: 15 millirem/year Groundwater 4 millirem/year[b]
Yucca Mountain high-level waste (proposed)/EPA (64 Fed. Reg. 46976)	All pathway: 15 millirem/year Groundwater 4 millirem/year[b]
Yucca Mountain high-level waste (proposed)/NRC (64 Fed. Reg. 8640)	25 millirem/year all pathway
Low-level waste/NRC (10 C.F.R. 61)	25 millirem/year
Drinking water/EPA (40 C.F.R. 141)	Radium: 5 picocuries/liter Gross alpha: 5 picocuries/liter Beta/photon: 4 millirem/year[b]
Uranium fuel cycle/EPA (40 C.F.R. 190)	25 millirem/year
Superfund cleanup/EPA (40 C.F.R. 300)	Risk range goals: 1 in 10,000 to 1 in 1 million[c]
Decommissioning/NRC (10 C.F.R. 20)	25 millirem/year
Occupational standards	
Occupational Safety and Health Administration, NRC, DOE (29 C.F.R. 1910; 10 C.F.R. 20; 10 C.F.R. 835)	5,000 millirem/year

[a]A picocurie is a trillionth of a curie, which is a commonly used unit of measurement of the activity of radiation.

[b]Radioactivity from human-made radionuclides in community drinking water systems.

[c]Lifetime risk of an individual's getting cancer.

http://www.gao.gov/new.items/rc00152.pdf

Table 1: Estimated Costs to Achieve Different Soil Cleanup Levels at Selected DOE Sites and Generic NRC-Licensed Sites

Dollars in millions

Agency/site/ analysis date	Cost of 100 millirem a year	Cost of 25 millirem a year	Cost of 15 millirem a year	Cost of less than 10 millirem a year
DOE/Nevada Test Site and test ranges/1995	35	131	240	1,003[a]
DOE/Brookhaven Laboratory waste facility/1998	15.9	24.4	28.2	64.5[b]
NRC-licensed power plant[c] /1997	0.17	0.31	0.41	1.44[d]
NRC-licensed metal extraction facility[c]/1997	5.30	6.21	7.33	13.86[d]

Note: Totals do not represent overall estimates of cleanup costs, which may include costs for activities other than soil cleanup, including the decontamination and removal of equipment and structures, as well as liquid waste treatment.

[a]5 millirem a year.

[b]1 millirem a year. Totals are present values.

[c]Generic site.

[d]3 millirem a year.

Source: GAO's presentation of data from DOE and NRC.

http://www.gao.gov/new.items/rc00152.pdf

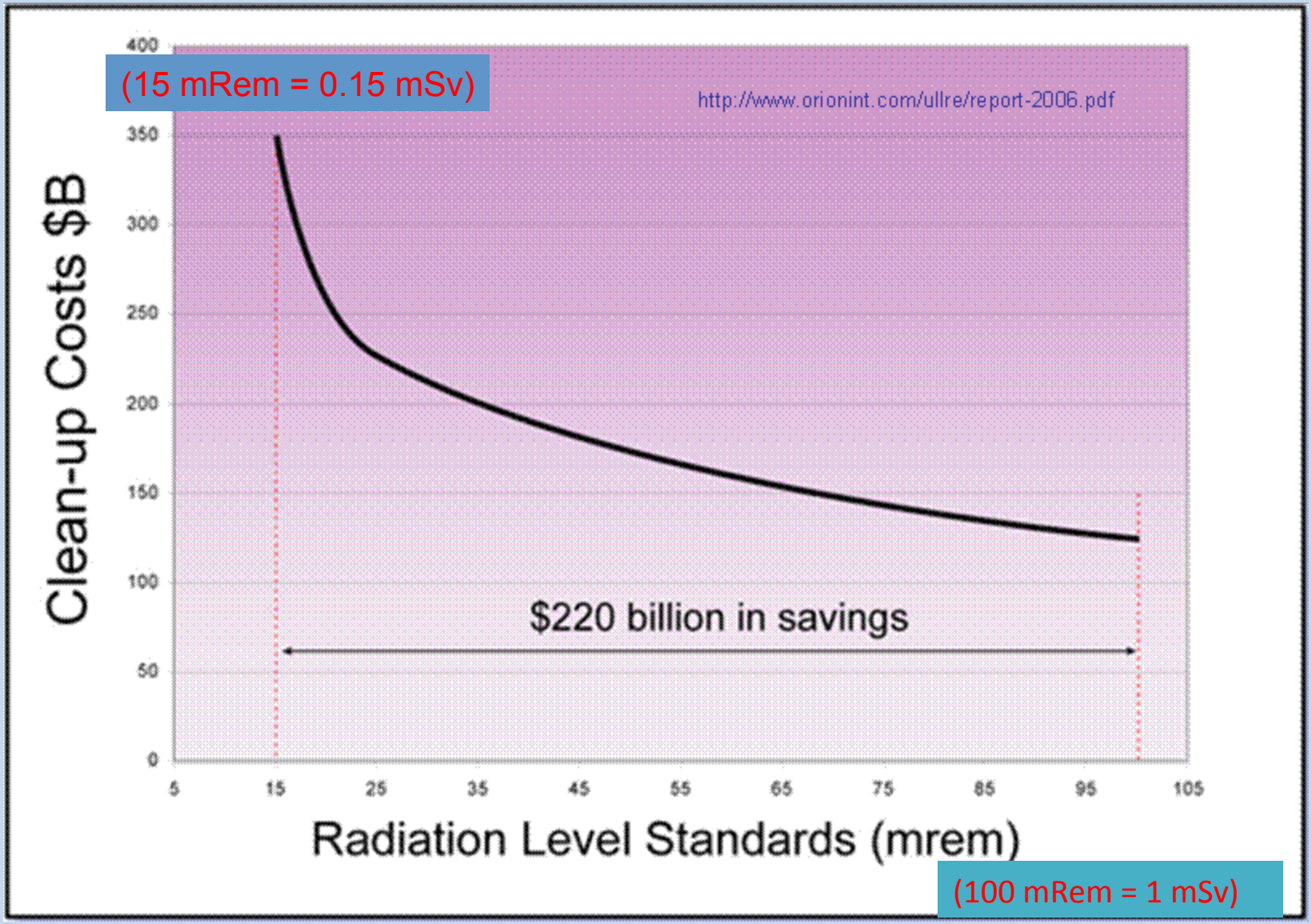
General radiation doses and expected effects (radiation doses are to the entire body).

- 0-5 rem received in a short period or over a long period is safe—we don't expect observable health effects.
- 5-10 rem received in a short time or over a long period is safe—we don't expect observable health effects. At this level, an effect is either nonexistent or too small to observe.
- 10-50 rem received in a short time or over a long period—we don't expect observable health effects, although at above 10 rem your chances of getting cancer are slightly increased. We may also see short-term blood cell decreases for doses of about 50 rem received in a matter of minutes.
- 50-100 rem received in a short time will likely cause some observable health effects and received over a long period will increase your chances of getting cancer. Above 50 rem we may see some changes in blood cells, but the blood system quickly recovers.
- 100-200 rem received in a short time will cause nausea and fatigue. 100-200 rem received over a long period will increase your chances of getting cancer.
- 200-300 rem received in a short time will cause nausea and vomiting within 24-48 hours. Medical attention should be sought.
- 300-500 rem received in a short time will cause nausea, vomiting, and diarrhea within hours. Loss of hair and appetite occurs within a week. Medical attention must be sought for survival; half of the people exposed to radiation at this high level will die if they receive no medical attention.
- 500-1,200 rem in a short time will likely lead to death within a few days.
- >10,000 rem in a short time will lead to death within a few hours.

http://hps.org/physicians/documents/Radiation_Benefit_and_Risk_Assessment.pdf

Current clean-up cost for US/DOE facilities is estimated at $350 billion for EPA standard of 15 mrem above background

(15 mrem is <5% of average natural background in USA)



ng(o)$_3$

The adoption of the LNT model for regulating radiation exposure produced a large industry dedicated to the elimination of the imaginary risks of low to moderate radiation exposure.

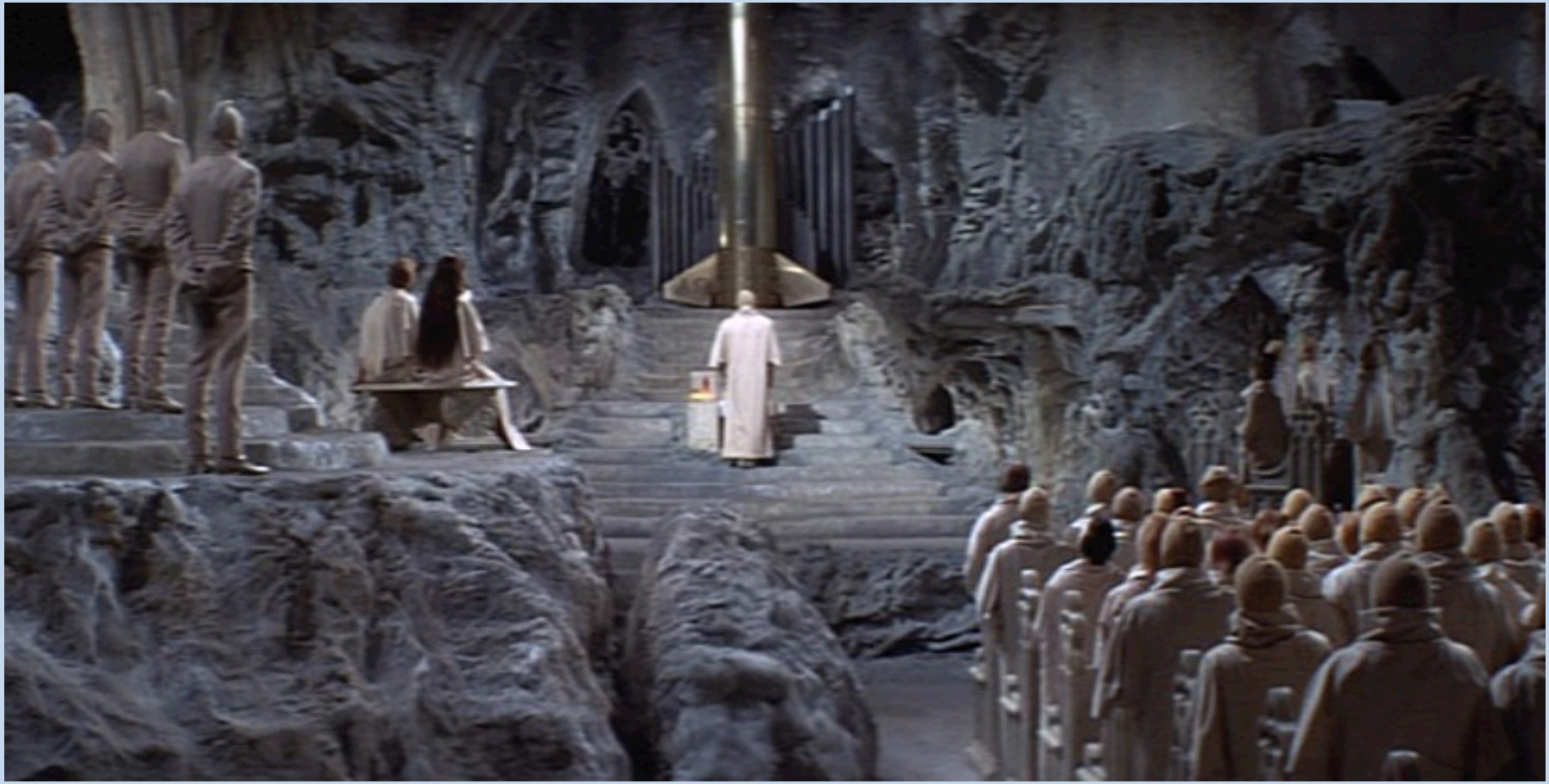
A similar approach has been applied to chemicals that are carcinogenic in large doses, based on the assumption that they must be harmful at low doses also.

The only reasonable approach to safety regulation is that if a supposed danger is too small to measure, it is too small to worry about.

A.D. Frawley, Florida State U., 2000

Almost everything in the world contains some radioactivity, mostly of natural origins; but **There is no accepted *legal* definition of what may be detectable as "radioactive,"** but of such a low public dose impact (i.e., health risk) as having little need for regulatory control

http://nrc-stp.ornl.gov/special/kirk.pdf



Challenge the Nuclear "Priesthood"

appropriately abbreviated "RadCon"

Embrace Radioactive Reality

(scene from 1970 movie "Beneath the Planet of the Apes")

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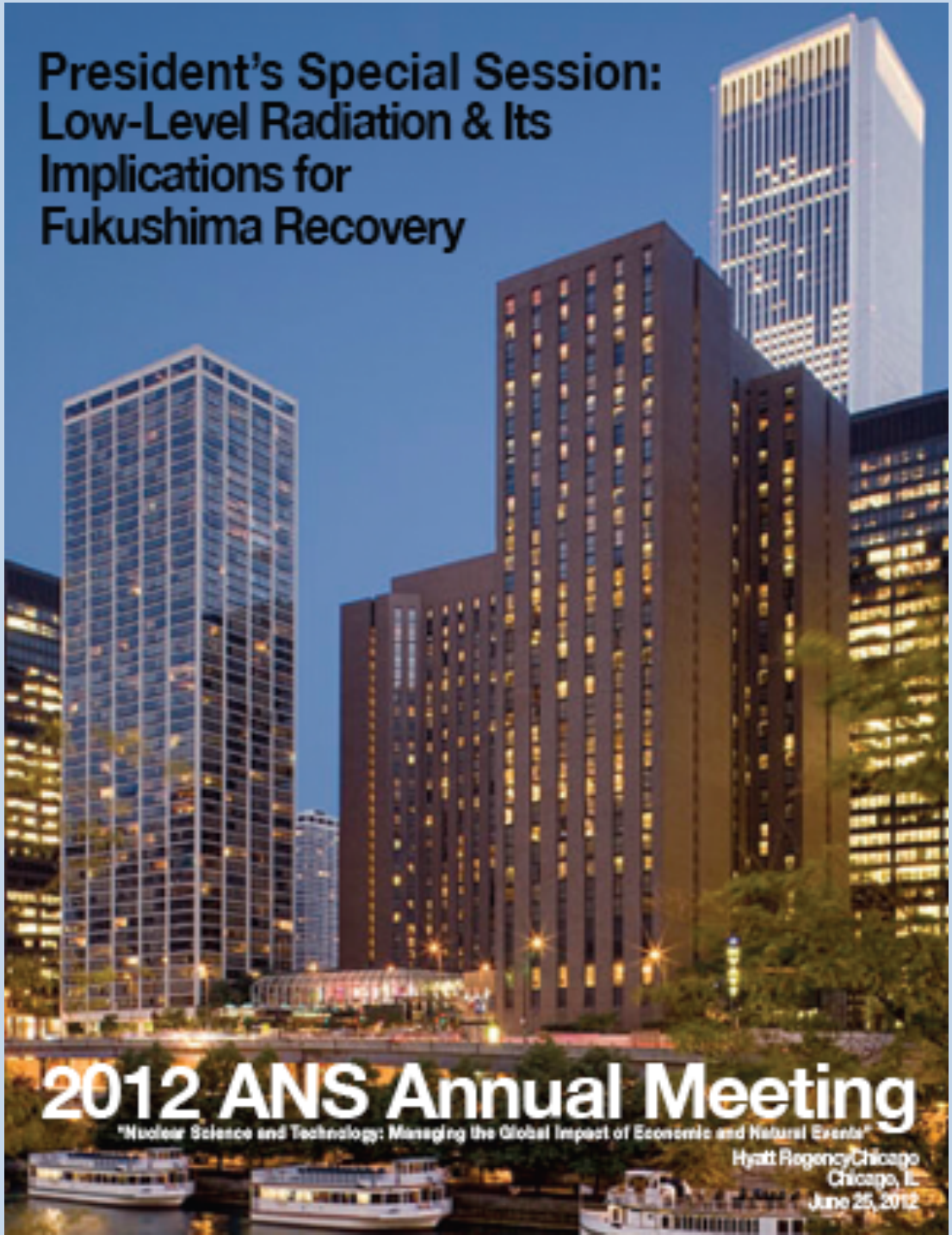

What and where are any consequences?

If not now, when?

If not us, who?

ng(o)$_3$

In radiation protection one ounce of gray matter outweighs one ton of lead

(F. Wachsmann, 1969)

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http://www.manmed.de/seiten/themen/veranstaltungen/kongresse/hannover/Strahlenschutz%20-%20Sinn%20und%20Unsinn-Roth.pdf

Radioactive Earth History and Its Implications for Current Issues

Norbert T. Rempe, 1403 N. Country Club Circle, Carlsbad NM 88220, USA,
rempent@yahoo.com

Historical and local variations in the radioactivity of geologic materials and in the natural background levels of ionizing radiation in geologic environments are not widely or sufficiently appreciated.

Background radiation levels much higher than today's natural average likely played a role in early organic evolution and may do so again. U-235/U-238 ratios in Precambrian uranium ores were high enough that some fission reactors operated spontaneously long before Hahn, Meitner, Strassmann, und Fermi. Little to no dispersal of fission products from such reactors and from uranium deposits in general demonstrates geologic isolation of radioactive waste to be a reasonable practical solution.

Ignorance and insufficient acknowledgement of the "marriage between geology and radioactivity" (G. Kirsch, 1928) breed irrational fear and opposition to anything nuclear or radioactive. An antinuclear geologist should therefore be an oxymoron.

Radiation-driven Ecosystems

Fusion is the process that takes place in stars like our Sun. Whenever we feel the warmth of the Sun and see by its light, we are observing the products of fusion. We know that all life on Earth exists because the light generated by the Sun produces food and warms our planet. Therefore, we can say that **fusion is the basis for our life**

http://www.lbl.gov/abc/Basic.html

The lowest cost source can only be the energy released from **the most basic reactions of all, nuclear fusion and fission**

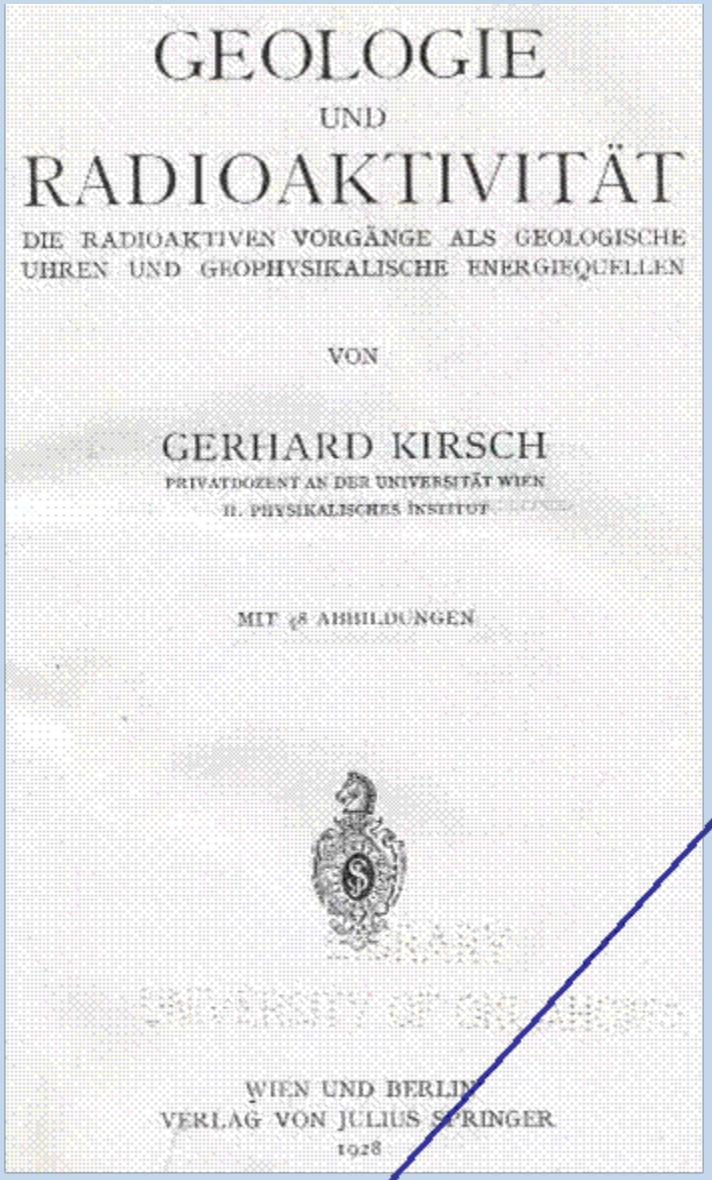
//newenergyandfuel.com/http:/newenergyandfuel/com/2009/08/11/solving-the-energy-issue-in-a-nutshell/

Such is the extent of nuclear anxiety that even scientists seem to forget our planet's radioactive history.

Life began nearly four billion years ago under conditions of radioactivity far more intense than those that trouble the minds of certain present-day environmentalists.

James Lovelock, in Bruno Comby (2006), Environmentalists for Nuclear Energy
(www.ecolo.org/aa_tiroir/Nuclear-en.doc)

1928


GEOLOGIE
UND
RADIOAKTIVITÄT
DIE RADIOAKTIVEN VORGÄNGE ALS GEOLOGISCHE UHREN UND GEOPHYSIKALISCHE ENERGIEQUELLEN
VON
GERHARD KIRSCH
PRIVATDOZENT AN DER UNIVERSITÄT WIEN
II. PHYSIKALISCHES INSTITUT
MIT 48 ABBILDUNGEN
WIEN UND BERLIN
VERLAG VON JULIUS SPRINGER
1928

"…theories - (that are) the youngest **children of the marriage between geology and radioactivity** …"

from the foreword:

…die im zweiten Abschnitt dargestellten Theorien ermöglicht werde. Diese letzteren als die jüngsten Kinder aus der Ehe zwischen Geologie und Radioaktivität weisen naturgemäß mehr Hypothetisches auf als die radioaktiven Altersbestimmungsmethoden. Wir haben daher den

ng(o)$_3$

83% of present surface heat flow is due to radioactive decay of U, Th, and K

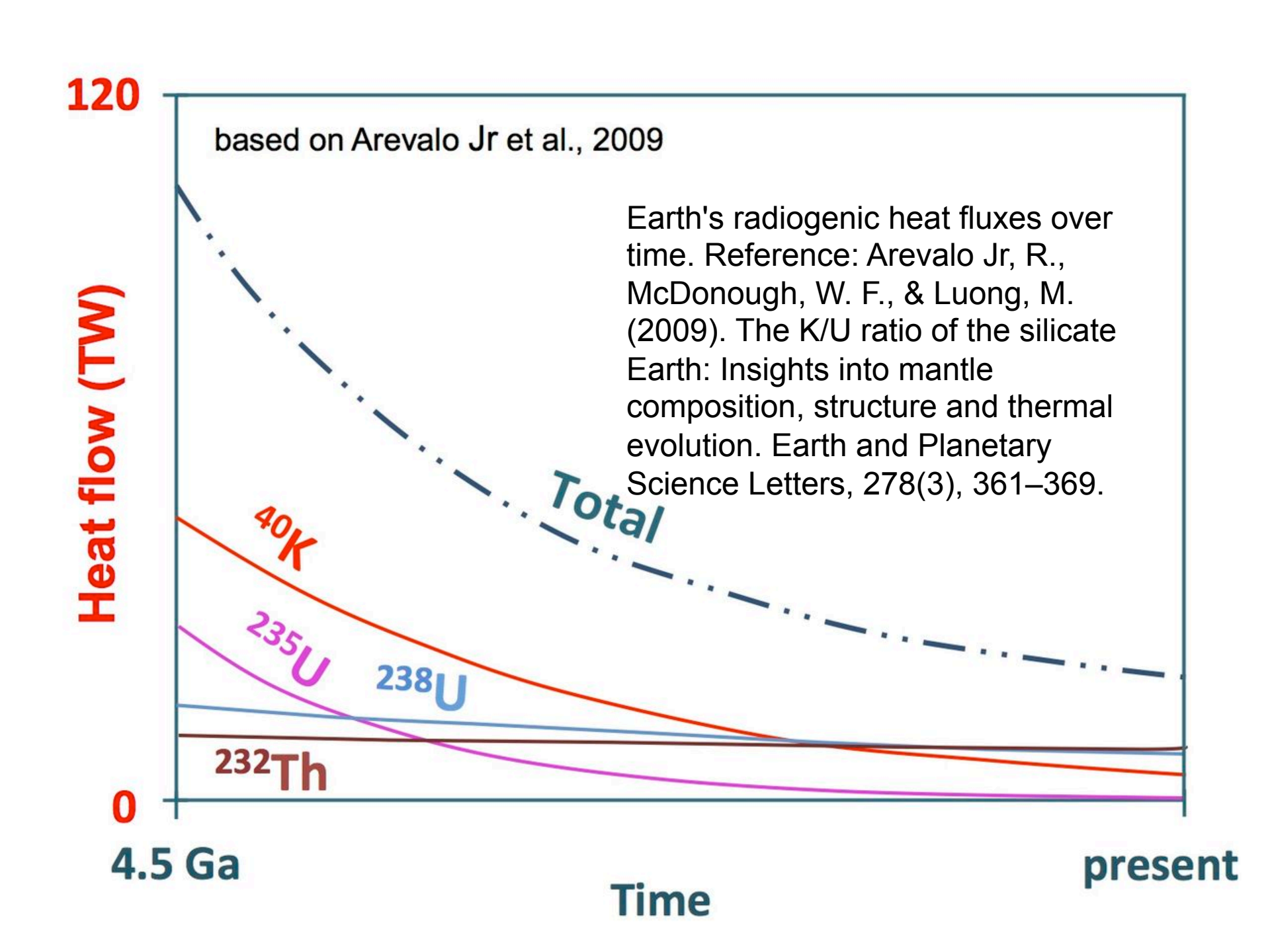
http://www.und.edu/org/ihfc/Gosnold_AAPG07.ppt#316,18,Global Heat Flow

Geothermal energy is the ethical energy source for the future

http://www.heatflow.und.edu/Gosnold2Geothermal.ppt#263,1,Geothermal Energy is the Ethical Energy Source for the Future

Not everybody realizes
that geothermal energy
is just another name
to describe
the radioactivity of our planet

(Bertrand Barré, 2005)

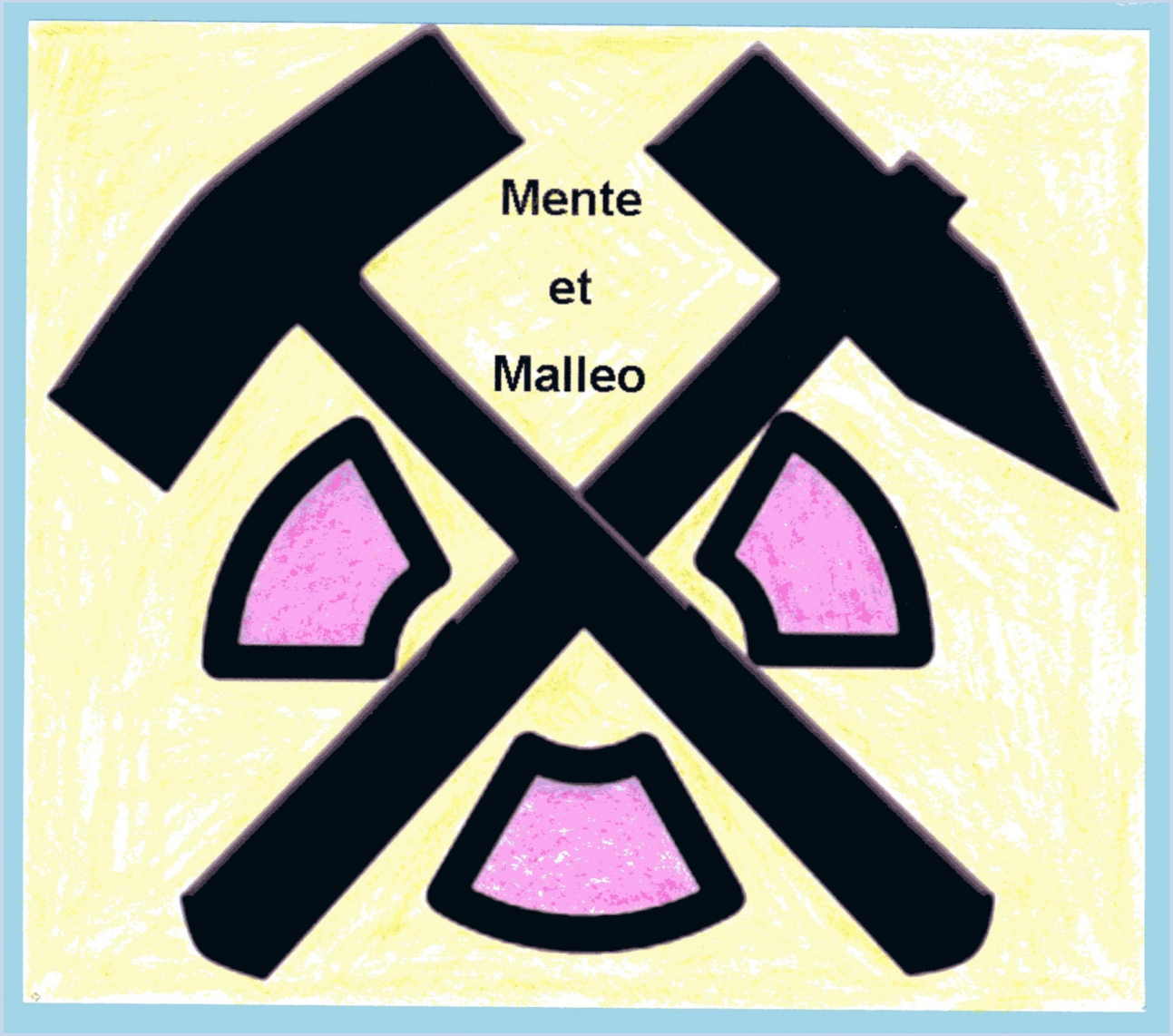

120
based on Arevalo Jr et al., 2009
Earth's radiogenic heat fluxes over time. Reference: Arevalo Jr, R., McDonough, W. F., & Luong, M. (2009). The K/U ratio of the silicate Earth: Insights into mantle composition, structure and thermal evolution. Earth and Planetary Science Letters, 278(3), 361–369.
Heat flow (TW)
Total
40K
235U
238U
232Th
0
4.5 Ga
present
Time

Nature solved the radioactive waste "problem" 2 billion years ago.

Any state is a "nuclear" state.

An educated "anti-nuclear" person is an oxymoron.

William C. Clark, 1980: "Neither the witch hunting hysterics nor the mindlessly rigid regulations characterizing so much of our present chapter in the history of risk management say much for our ability to learn from the past"



An anti-nuclear geologist is an oxymoron

$ng(o)_3$

We must acknowledge :

1. Any time we use the bathroom,
   we engage in radioactive waste disposal

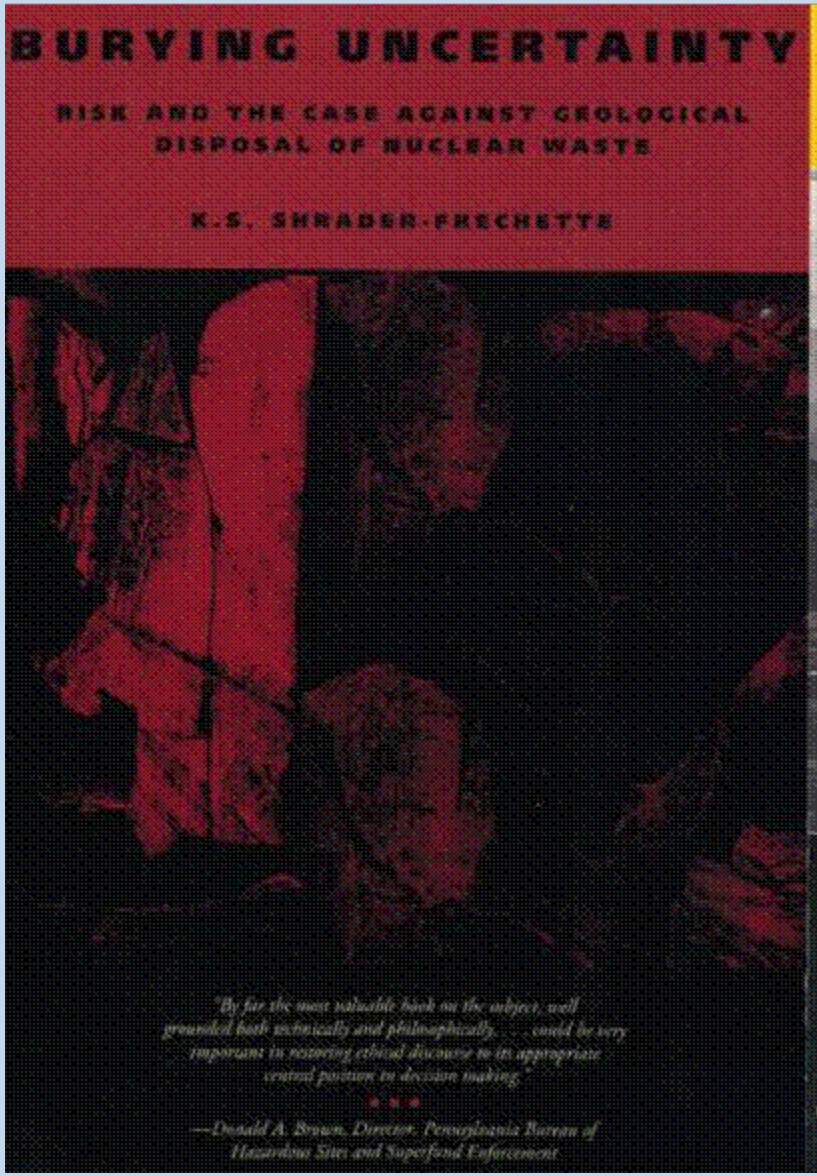
2. If we do not teach about Oklo
   (and natural nuclear reactors yet to be discovered),
   we commit educational malpractice

3. Geologic disposal and isolation of dangerous
   (including radioactive) waste is a fait accompli

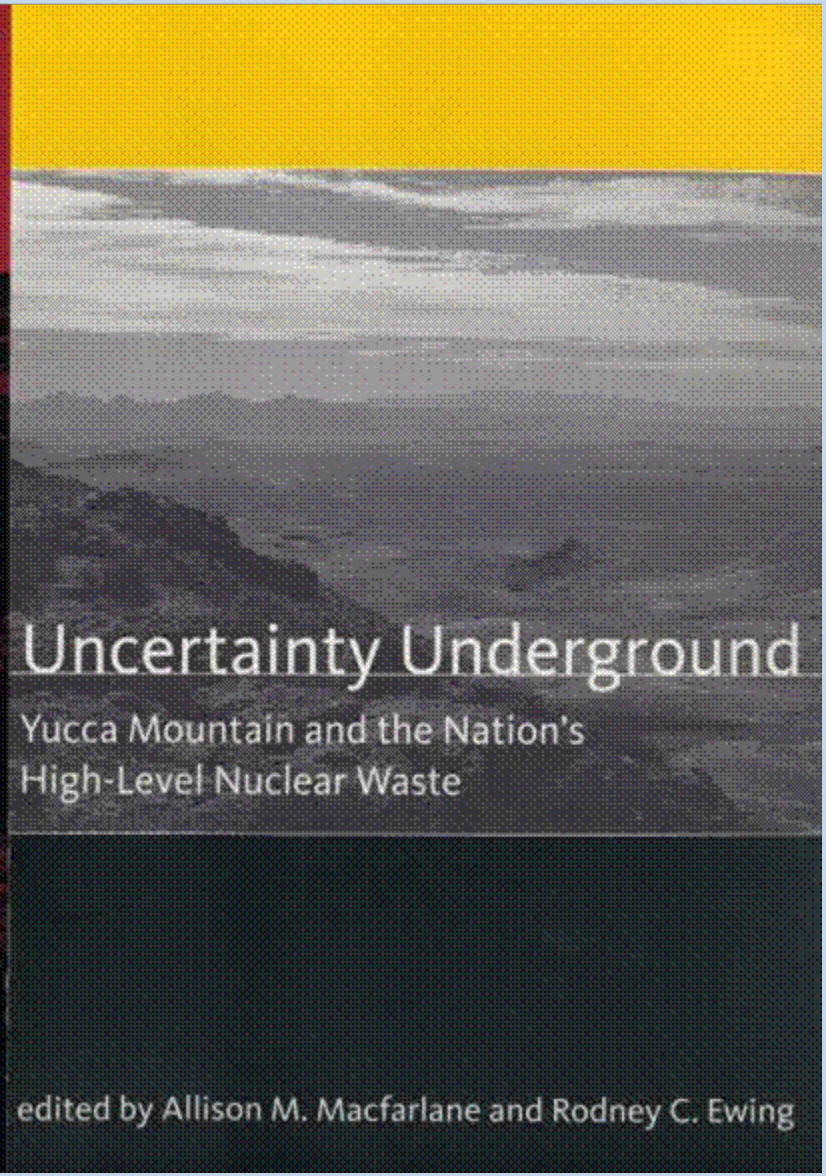
An anti-nuclear geologist is an oxymoron

Cottage Industry in Uncertainty

1993 University of California



2006 MIT



Some Final Thoughts # 2

The goal of science is the gradual removal of prejudices; which is belief in the absence of evidence

- Niels Bohr

- Atomic physics and human knowledge. John Wiley 1958 p 31

SENES Consultants

SHB, Inc.

http://www.nma.org/pdf/urw/brown.pdf

It is, indeed, perhaps the greatest prospect of humanistic studies to contribute through an increasing knowledge of the history of cultural development to that gradual removal of prejudices which is the common aim of all science.

Niels Bohr, *Atomic Physics and Human Knowledge* (1958).

Romantics might like to think
of themselves
as being composed
of **stardust**.

Cynics might prefer to think
of themselves
as **nuclear waste**.

Simon Singh, Big Bang: The Origin of the Universe, p. 389
(Fourth Estate 2004)

It is difficult to get a man to understand something when his salary depends upon his not understanding it.

Upton Sinclair

…but it is not impossible,
and we have a professional
and moral obligation
to join or even spearhead
the challenge
to the status quo

Insistence on,
and cadaverous compliance with,
regulations without continuously
questioning and justifying
their factual and rational basis

is the last refuge of the lazy,

incompetent, and malevolent