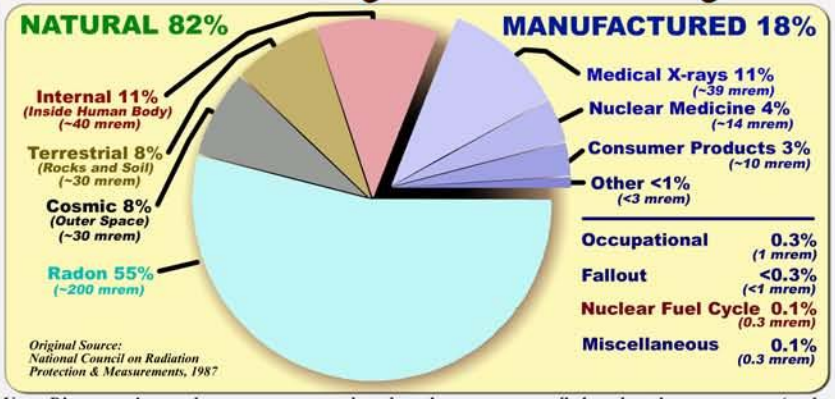
Radiation: What's in you today?

200 **Radon 55%**

Annual Exposure Expressed in "Effective Dose Equivalent"	mrem
Natural:	
Radon	200
Other	100
Occupational	0.90
Nuclear Fuel Cycle	0.05
Consumer Products:	
Tobacco	(?)
whole body dose equivalent	
dose estimate to a portion of lung	16,000
Other	5 - 13
Environmental Sources	0.06
Medical:	
Diagnostic X-rays	39
Nuclear Medicine	14
Approximate Total:	360

Source: U.S. NRC; NCRP Report #93, 1987



Original Source: National Council on Radiation Protection & Measurements, 1987

Note: Discrepancies, math errors, etc., even when the values are supposedly based on the same source (such as with the nuclear fuel cycle values shown above) are not uncommon in science...

55 **External Background Radiation 15%**

53 **Medical 15%**

39 **Internal (in the body) 11%**

10 mrem Consumer Products 3%

3 mrem Other 1%

Source: Yucca Mountain, 2001

They used to say (1940s and earlier) that you got about 100 mrem per year. Then 160. Then 240. Then 320. Now 360, and sometimes 380 or more. What changed?

It's as if you took a plane from LA to NYC...

You get about 4 mrem (0.04 mSv) round trip. If there is a solar storm and/or the pilot flies at an unusually high altitude, your exposure could be significantly higher.

Medical Procedure	mSv	chest x-ray equivalent	natural background time equivalent
Chest x-ray (PA film)	0.023	1	2.4 days
Skull x-ray	0.07	4	8.5 "
Lumbar spine	1.3	65	158 "
CT head	2	100	243 "
I.V. urogram	2.5	125	304 "
Upper G.I. exam	3	150	1 year
Barium enema	7	350	2.3 years
CT abdomen	10	500	3.3 "

Source: Radiology Today, 2004, adapted from the European Commission

The longer you live, the more radiation your body must endure. Radiation is everywhere. But nevertheless, the less you get, the better. To some extent, and maybe to a large extent, your cumulative dose determines your risk.

Natural radioactive "hits" per second: ~15,000*

∴ cumulative over 80 years: ~38,000,000,000,000

"Hits" per second in your body allowed by U.S. EPA from tritium alone: 29,600

∴ cumulative over 80 years: ~75,000,000,000,000

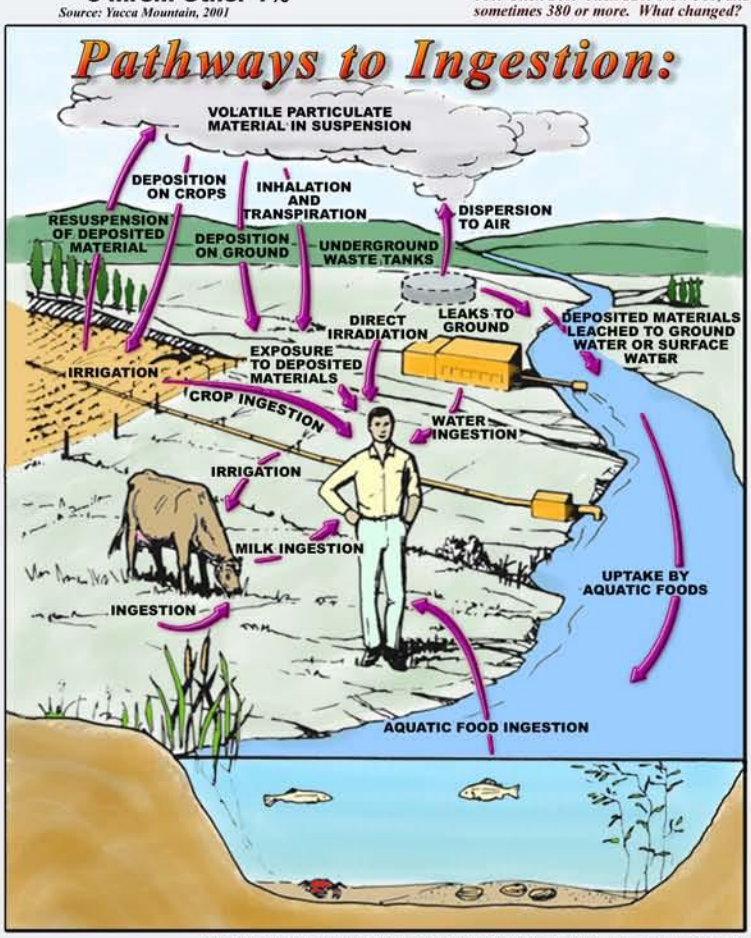
From a "typical" medical x-ray: >1,000,000,000,000*

∴ from one CT-Scan ~500,000,000,000,000

The risk of cancer from one CT Scan is currently estimated at about one in one thousand -- but even after all these years, nobody really knows.

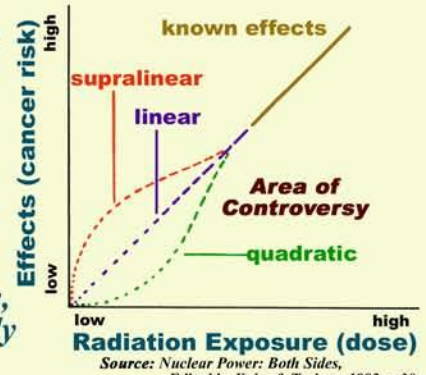
** Source: Cohen: The Nuclear Energy Option, Chapter 5.*

Pathways to Ingestion:



Colorized from: Understanding Radioactive Waste, 3rd Edition, by Raymond L. Murray, 1989 p. 98

The controversy about so-called low-level radiation, (greatly simplified: Cancer, for example, isn't the only "effect").



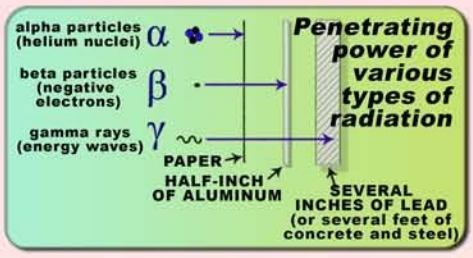
Source: Nuclear Power: Both Sides, Edited by Kaku & Trainer, 1982, p.30

Biological Half-life

The biological half-life of an element (the point in time when half of a foreign substance once in the body is no longer in the body) is NOT the same as the radiological half-life. After 20 radiological half-lives, only 2^{-20} of a substance will remain (about one millionth of the original amount). But when, for example, tritium poisons the body, some of it will bind "permanently," masquerading as a stable, useful hydrogen atom, until the moment of radioactive decay.

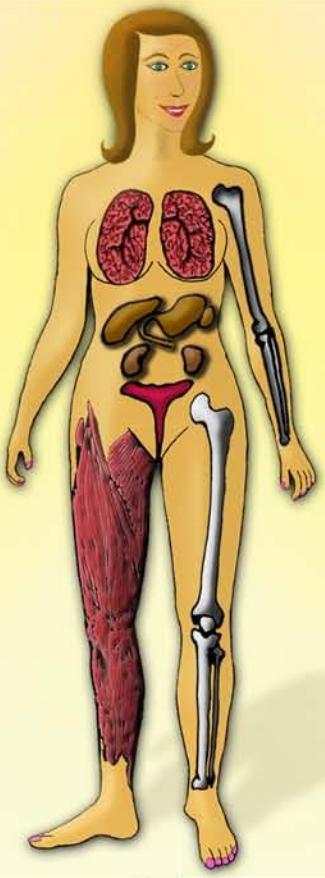
IONIZING RADIATION

High-energy, high-speed emissions, such as alpha (α) and beta (β) particles, neutrons, protons, x-rays and gamma (γ) rays, penetrate the human body and other things, causing biological, chemical, and /or physical damage. Energy of emissions is usually measured in megavolts (MeV). The biological half-life will be the same for all isotopes of a substance but will *not* always be the same for all organs. In any case, the biological half-life should be taken with a large "grain of salt" since some portion of any biological assault usually remains permanently in your body. Short radiological half-lives have no biological half-life listed: The assumption is that they will probably decay internally before the body might expel them.



Key: Symbol $^{\text{atomic weight}}$ *emission type* [max. MeV] (2^{nd} type), half life / biological half-life (2^{nd} component)

She is smiling because radiation is odorless, tasteless, and colorless. It cannot be detected by any sense organ. She cannot feel herself being irradiated.



BRAIN

At^{211} α [5.87 MeV], 7 h

SKIN

S^{35} β [0.16 MeV], 87.4 d / 623 d (90 d)

If you are contaminated with beta emitters on your skin:

"First, decontaminate yourself! ***Flush*** with plain soap and water (***no*** scrub-brush!). Remove any contaminated clothing."

(Source: Duke U.)

THYROID

Tc^{99} β [0.29 MeV], 211,000 y / 12 h
I^{131} β [0.97 MeV] (γ), 8 d / 110 d
I^{132} β [2.12 MeV] (γ), 2.3 h
I^{133} β [1.27 MeV] (γ), 20.8 h
I^{135} β [2.63 MeV] (γ), 6.6 h

LIVER

Mn^{56} β [3.70 MeV] (γ), 2.6 h / 4 d (40 d)
Co^{60} β [0.31 MeV] (γ), 5.72 y / 6 d (60 d)
Ce^{141} β [0.58 MeV] (γ), 32.5 d / 9 y
Ce^{144} β [0.31 MeV] (γ), 285 d
Pr^{143} β [0.93 MeV] (γ), 13.5 d
Pr^{144} β [2.99 MeV] (γ), 0.3 h
Nd^{147} β [0.90 MeV] (γ), 11 d
Pu^{242} α [4.98 MeV], 373,300 y / 82 y

PANCREAS

H^{3} β [0.02 MeV], 12.3 y

OVARIES

K^{42} β [3.52 MeV] (γ), 12.36 h
Kr^{85} β [0.67 MeV] (γ), 10.72 y
Co^{60} β [2.82 MeV] (γ), 5.27 y
Cs^{134} β [2.06 MeV] (γ), 2.1 y
I^{131} β [0.97 MeV] (γ), 8 d / 4 d
Pu^{241} α [4.90 MeV] (β,γ), 14.4 y / 80 y

MUSCLE

K^{42} β [3.52 MeV] (γ), 12.36 h
Cs^{135} β [0.21 MeV], 2,300,000 y / 70 d

WHOLE BODY

H^{3} β [0.02 MeV], 12.3 y / 9.4 d
C^{14} β [0.16 MeV], 5,715 y / 12 d
P^{32} β [1.71 MeV], 14.3 d / 257 d
Cs^{137} β [1.18 MeV] (γ), 30 y / 70 d
Ce^{144} β [0.31 MeV] (γ), 285 d / 9 y
Pu^{240} α [5.17 MeV] (γ), 6,563 y / 175 y

LUNGS

Kr^{85} β [0.67 MeV] (γ), 10.72 y
Ce^{144} β [0.31 MeV] (γ), 285 d / 180 d
Rn^{222} α [5.59 MeV] (γ), 3.8 d / 10 y
U^{238} α [4.2 MeV] (γ), 4,500,000,000 y / 3.8 y
Pu^{238} α [5.50 MeV] (γ), 87.75 y / 1.5 y

SPLEEN

Po^{209} α [4.88 MeV] (γ), 103 y / 50 d
Po^{210} α [5.31 MeV] (γ), 138.4 d

KIDNEYS

Ru^{106} β [0.04 MeV], 372 d / 7.2 d
....and everything else...

BLADDER

Po^{210} α [5.31 MeV] (γ), 138.4 d
....and everything else...

BONE

P^{32} β [1.71 MeV], 14.3 d / 3 y
Ca^{45} β [0.26 MeV], 163 d
Mn^{56} β [3.70 MeV] (γ), 2.6 h / 40 d
Sr^{89} β [1.46 MeV] (γ), 55.6 d / 40 d
Sr^{90} β [0.55 MeV] (γ), 29 y
Y^{90} β [2.27 MeV] (γ), 64.1 h
Y^{91} β [1.55 MeV] (γ), 58.5 d
Ba^{140} β [1.02 MeV] (γ), 12.7 d
La^{140} β [3.76 MeV] (γ), 40.3 h
Ce^{144} β [0.31 MeV] (γ), 285 d / 9 y
Nd^{147} β [0.90 MeV] (γ), 11 d
Ra^{226} α [4.78 MeV] (γ), 1,600 y / 10 y
U^{233} α [4.82 MeV] (γ), 160,000 y / 200 y
U^{235} α [4.70 MeV] (γ), 710,000,000 y
Pu^{239} α [5.15 MeV] (γ), 24,131 y / 200 y

"It is the ability of some radioisotopes to masquerade as their close chemical cousins (e.g., strontium 90 as calcium, radioactive iodine as natural iodine, cesium 137 as potassium), and thus be absorbed into the body, that makes them particularly dangerous. The body has very efficient mechanisms for capturing iodine and concentrating it in the thyroid gland, for directing calcium and other bone-seeking elements to the skeleton and holding them there, and for concentrating other elements at specific points. Consequently the full destructive force of a radioactive material may focus on a single organ."

-- W. O. Caster, From Bomb to Man (Fallout, Basic Books, 1960, p 41)

All reproductive organs are attacked by radiation. Many isotopes cross the placenta. Plutonium also concentrates in the gonads. Radiation causes birth defects, mutations and miscarriages in the first and / or successive generations after exposure. A fetus is much more vulnerable to radiation than an adult. Girls are more vulnerable than boys. Women are more vulnerable than men. Nevertheless, radiation "safety" standards are based mainly on adult male resistance levels. Cancers, leukemia, heart failure, amnesia, neuromuscular diseases, and many other health effects may take years to develop. There is no minimum dose; *any* dose can be fatal and any dose causes some amount of damage.