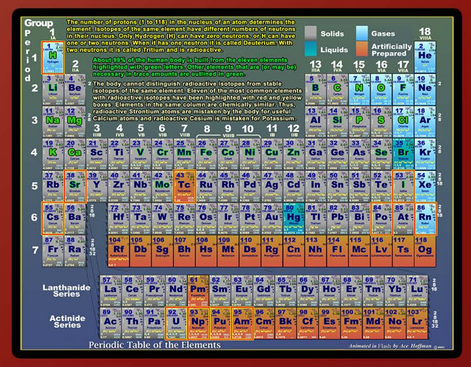
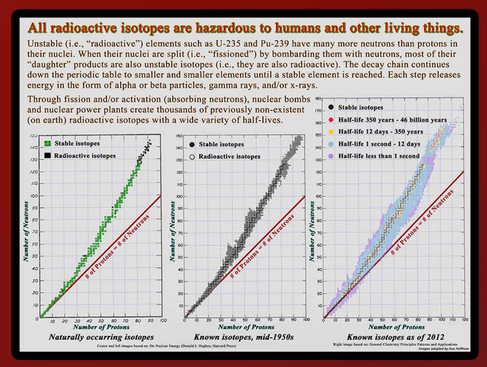
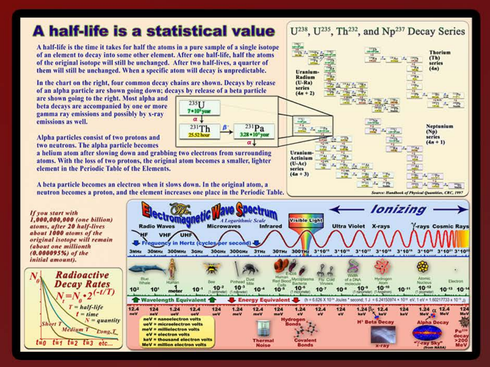
NUCLEAR POWER AND NUCLEAR WEAPONS

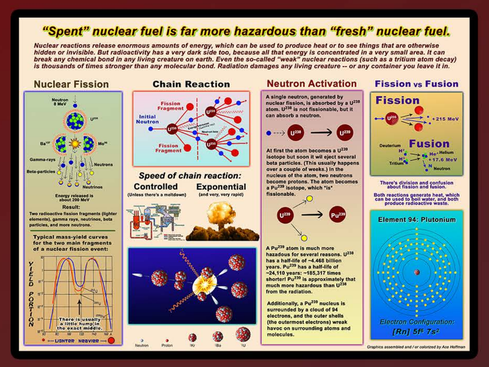
A BEGINNER'S GUIDE -- IN PICTURES AND DIAGRAMS

PART 1: WHAT IS RADIATION? WHY IS IT DANGEROUS?



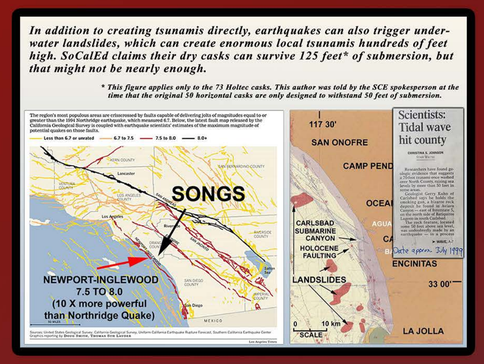






+ 4 MORE!

PART 2: [MIS]HANDLING WHAT'S LEFT BEHIND



+ 7 MORE!

PART 3: VIRTUAL MUSEUM OF NUCLEAR EVENTS

+ 3 MORE!

BY ACE HOFFMAN © 2022

The number of protons (1 to 118) in the nucleus of an atom determines the element. Isotopes of the same element have different numbers of neutrons in their nucleus. Only Hydrogen (H) can have zero neutrons, or H can have one or two neutrons. When it has one neutron it is called Deuterium. With two neutrons it is called Tritium and is radioactive.

About 99% of the human body is built from the eleven elements highlighted with green letters. Other elements that are (or may be) necessary in trace amounts are outlined in green.

The body cannot distinguish radioactive isotopes from stable isotopes of the same element. Eleven of the most common elements with radioactive isotopes have been highlighted with red and yellow boxes. Elements in the same column are chemically similar. Thus, radioactive Strontium atoms are mistaken by the body for useful Calcium atoms and radioactive Cesium is mistaken for Potassium.

Solids
Liquids
Gases
Artificially Prepared

Group / Period

1 IA, 2 IIA, 3 IIIB, 4 IVB, 5 VB, 6 VIB, 7 VIIB, 8, 9, 10 VIIIB, 11 IB, 12 IIB, 13 IIIA, 14 IVA, 15 VA, 16 VIA, 17 VIIA, 18 VIIIA

Period	Elements	Shells
1	1 H Hydrogen; 2 He Helium	
2	3 Li Lithium; 4 Be Beryllium; 5 B Boron; 6 C Carbon; 7 N Nitrogen; 8 O Oxygen; 9 F Fluorine; 10 Ne Neon	2
3	11 Na Sodium; 12 Mg Magnesium; 13 Al Aluminum; 14 Si Silicon; 15 P Phosphorus; 16 S Sulfur; 17 Cl Chlorine; 18 Ar Argon	2 8
4	19 K Potassium; 20 Ca Calcium; 21 Sc Scandium; 22 Ti Titanium; 23 V Vanadium; 24 Cr Chromium; 25 Mn Manganese; 26 Fe Iron; 27 Co Cobalt; 28 Ni Nickel; 29 Cu Copper; 30 Zn Zinc; 31 Ga Gallium; 32 Ge Germanium; 33 As Arsenic; 34 Se Selenium; 35 Br Bromine; 36 Kr Krypton	2 8 8
5	37 Rb Rubidium; 38 Sr Strontium; 39 Y Yttrium; 40 Zr Zirconium; 41 Nb Niobium; 42 Mo Molybdenum; 43 Tc Technetium; 44 Ru Ruthenium; 45 Rh Rhodium; 46 Pd Palladium; 47 Ag Silver; 48 Cd Cadmium; 49 In Indium; 50 Sn Tin; 51 Sb Antimony; 52 Te Tellurium; 53 I Iodine; 54 Xe Xenon	2 8 18
6	55 Cs Cesium; 56 Ba Barium; 72 Hf Hafnium; 73 Ta Tantalum; 74 W Tungsten; 75 Re Rhenium; 76 Os Osmium; 77 Ir Iridium; 78 Pt Platinum; 79 Au Gold; 80 Hg Mercury; 81 Tl Thallium; 82 Pb Lead; 83 Bi Bismuth; 84 Po Polonium; 85 At Astatine; 86 Rn Radon	2 8 18
7	87 Fr Francium; 88 Ra Radium; 104 Rf Rutherfordium; 105 Db Dubnium; 106 Sg Seaborgium; 107 Bh Bohrium; 108 Hs Hassium; 109 Mt Meitnerium; 110 Ds Darmstadtium; 111 Rg Roentgenium; 112 Cn Copernicium; 113 Nh Nihonium; 114 Fl Flerovium; 115 Mc Moscovium; 116 Lv Livermorium; 117 Ts Tennessine; 118 Og Oganesson	2 8 18 32

Lanthanide Series

Elements	Shells
57 La Lanthanum; 58 Ce Cerium; 59 Pr Praseodymium; 60 Nd Neodymium; 61 Pm Promethium; 62 Sm Samarium; 63 Eu Europium; 64 Gd Gadolinium; 65 Tb Terbium; 66 Dy Dysprosium; 67 Ho Holmium; 68 Er Erbium; 69 Tm Thulium; 70 Yb Ytterbium; 71 Lu Lutetium	2 8 18

Actinide Series

Elements	Shells
89 Ac Actinium; 90 Th Thorium; 91 Pa Protactinium; 92 U Uranium; 93 Np Neptunium; 94 Pu Plutonium; 95 Am Americium; 96 Cm Curium; 97 Bk Berkelium; 98 Cf Californium; 99 Es Einsteinium; 100 Fm Fermium; 101 Md Mendelevium; 102 No Nobelium; 103 Lr Lawrencium	2 8 18 32

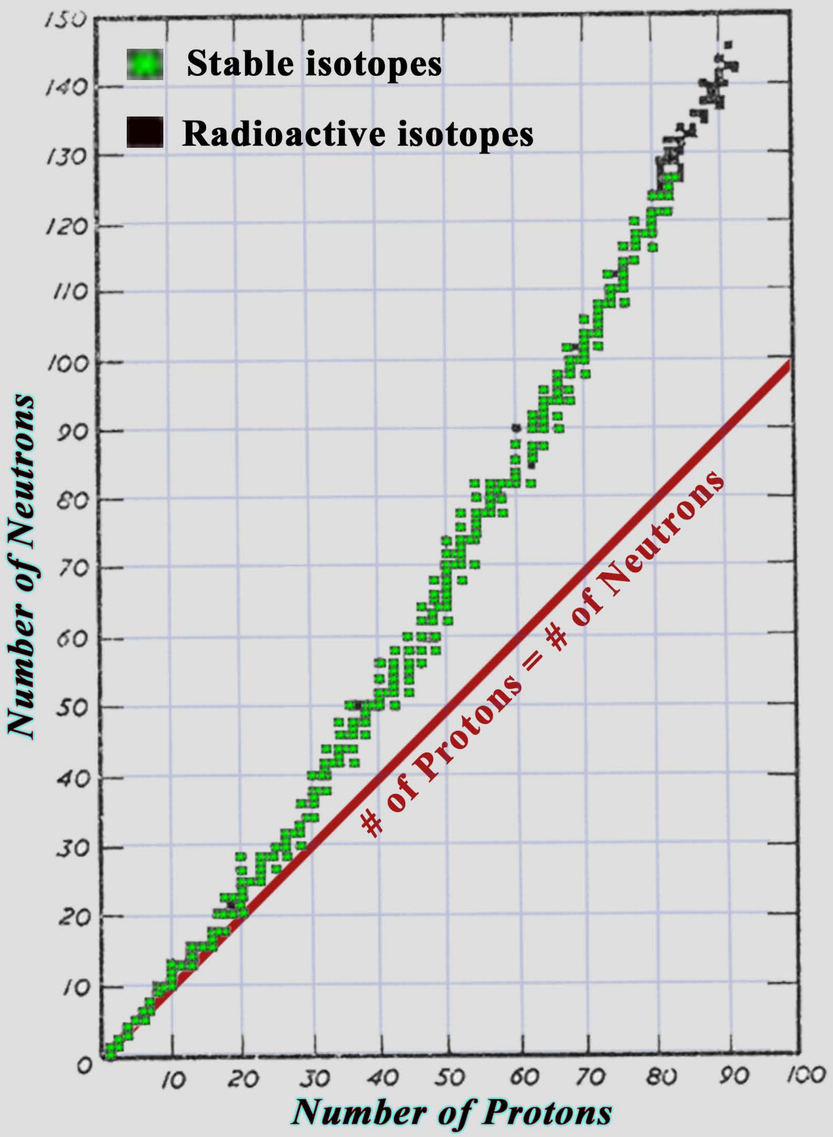
Periodic Table of the Elements

Animated in Flash *by Ace Hoffman* © MMVI

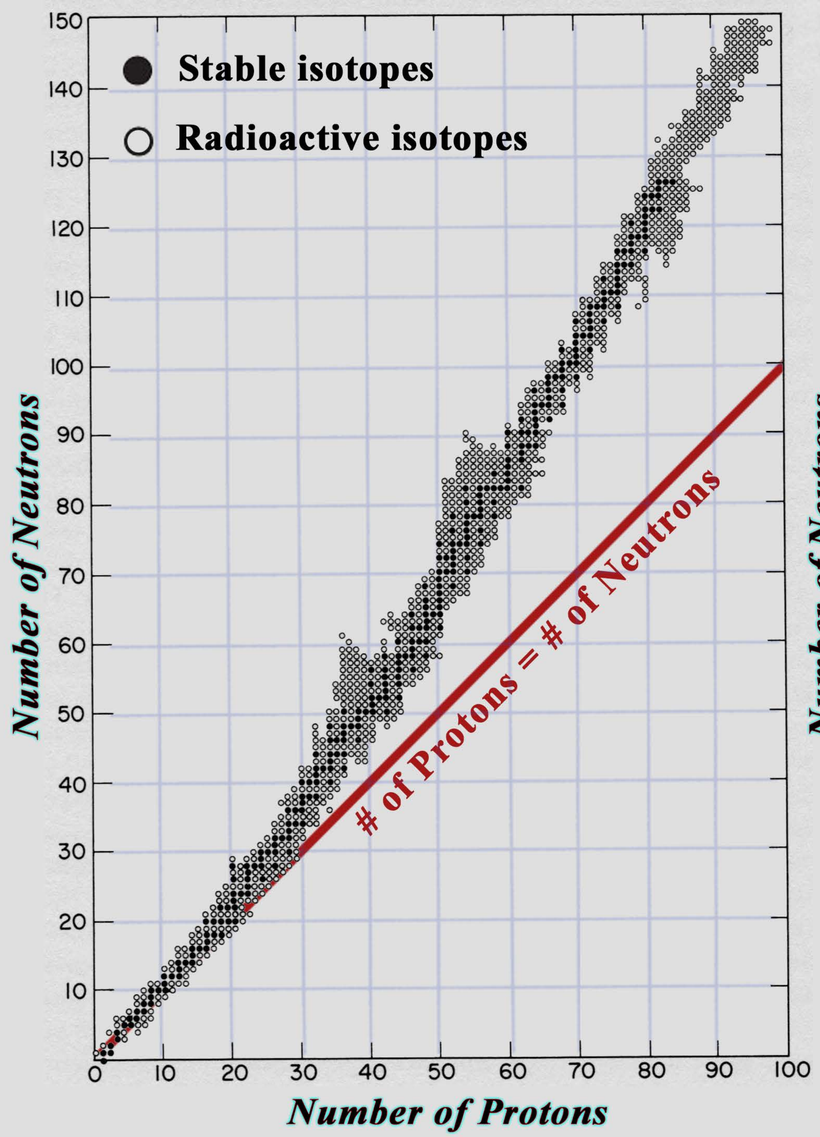
All radioactive isotopes are hazardous to humans and other living things.

Unstable (i.e., "radioactive") elements such as U-235 and Pu-239 have many more neutrons than protons in their nuclei. When their nuclei are split (i.e., "fissioned") by bombarding them with neutrons, most of their "daughter" products are also unstable isotopes (i.e., they are also radioactive). The decay chain continues down the periodic table to smaller and smaller elements until a stable element is reached. Each step releases energy in the form of alpha or beta particles, gamma rays, and/or x-rays.

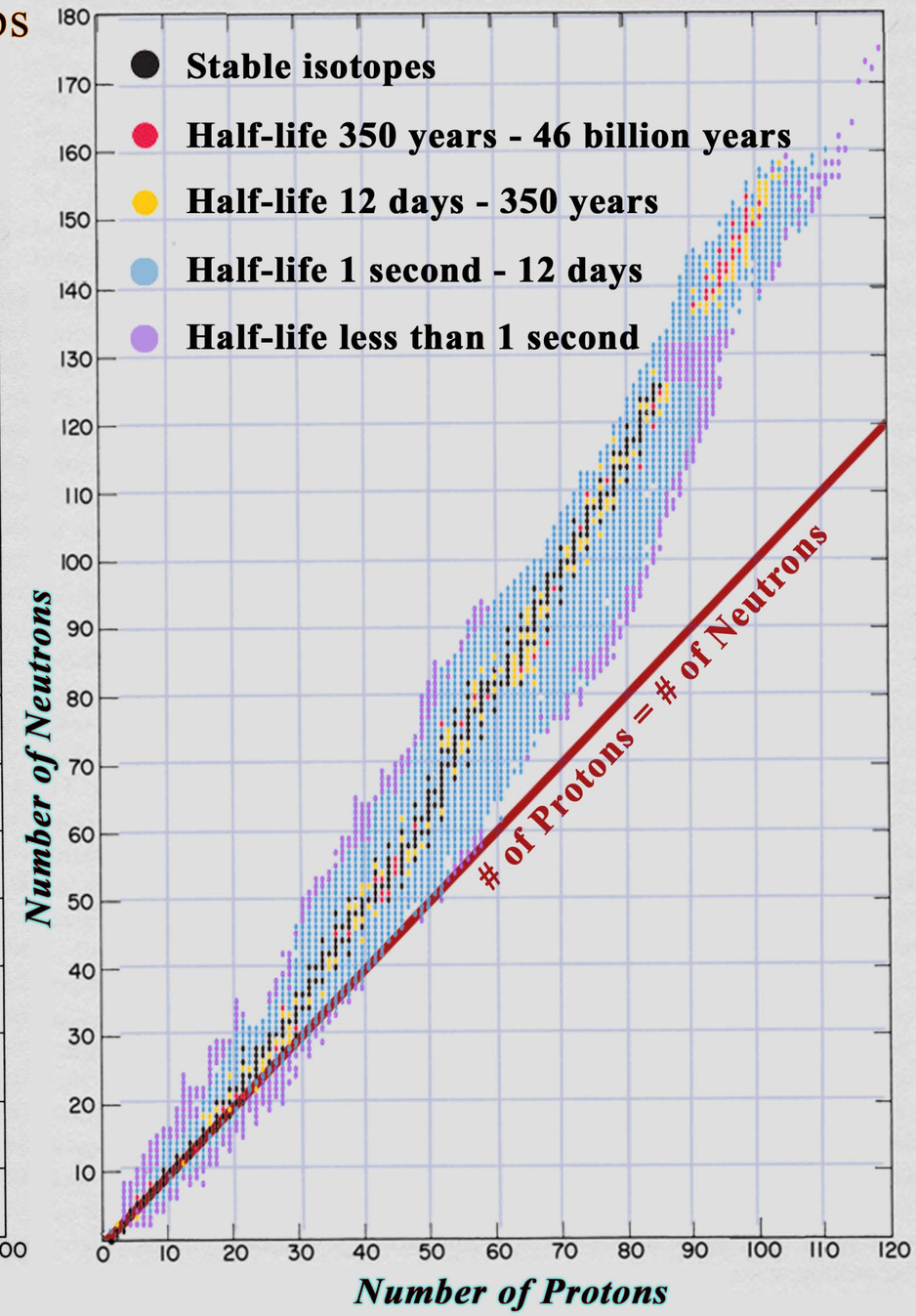
Through fission and/or activation (absorbing neutrons), nuclear bombs and nuclear power plants create thousands of previously non-existent (on earth) radioactive isotopes with a wide variety of half-lives.



Naturally occurring isotopes



Known isotopes, mid-1950s



Known isotopes as of 2012

Center and left images based on: On Nuclear Energy (Donald J. Hughes; Harvard Press)

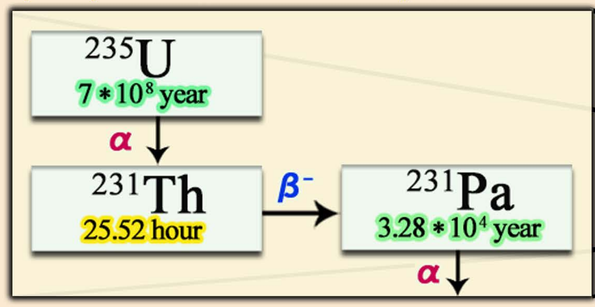
Right image based on: General Chemistry Principles Patterns and Applications

Images adapted by Ace Hoffman

A half-life is a statistical value

A half-life is the time it takes for half the atoms in a pure sample of a single isotope of an element to decay into some other element. After one half-life, half the atoms of the original isotope will still be unchanged. After two half-lives, a quarter of them will still be unchanged. When a specific atom will decay is unpredictable.

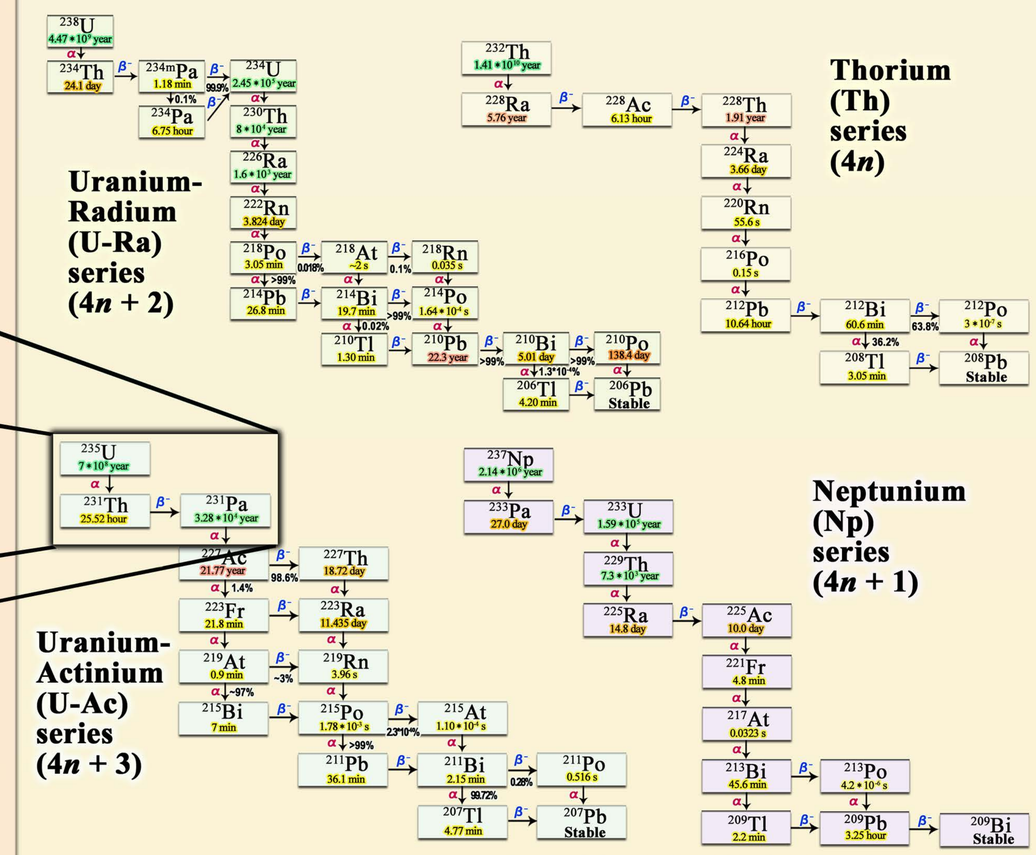
In the chart on the right, four common decay chains are shown. Decays by release of an alpha particle are shown going down; decays by release of a beta particle are shown going to the right. Most alpha and beta decays are accompanied by one or more gamma ray emissions and possibly by x-ray emissions as well.



Alpha particles consist of two protons and two neutrons. The alpha particle becomes a helium atom after slowing down and grabbing two electrons from surrounding atoms. With the loss of two protons, the original atom becomes a smaller, lighter element in the Periodic Table of the Elements.

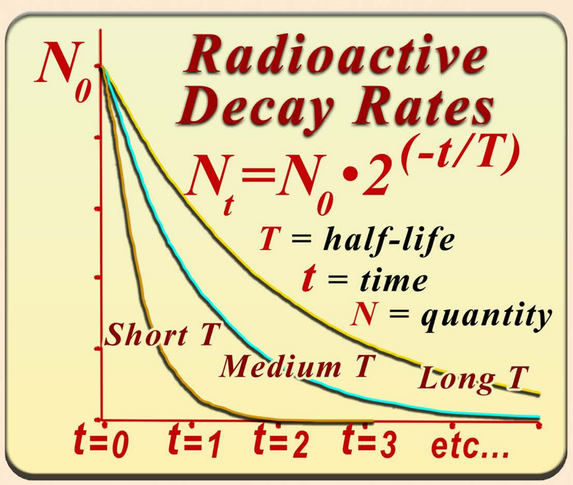
A beta particle becomes an electron when it slows down. In the original atom, a neutron becomes a proton, and the element increases one place in the Periodic Table.

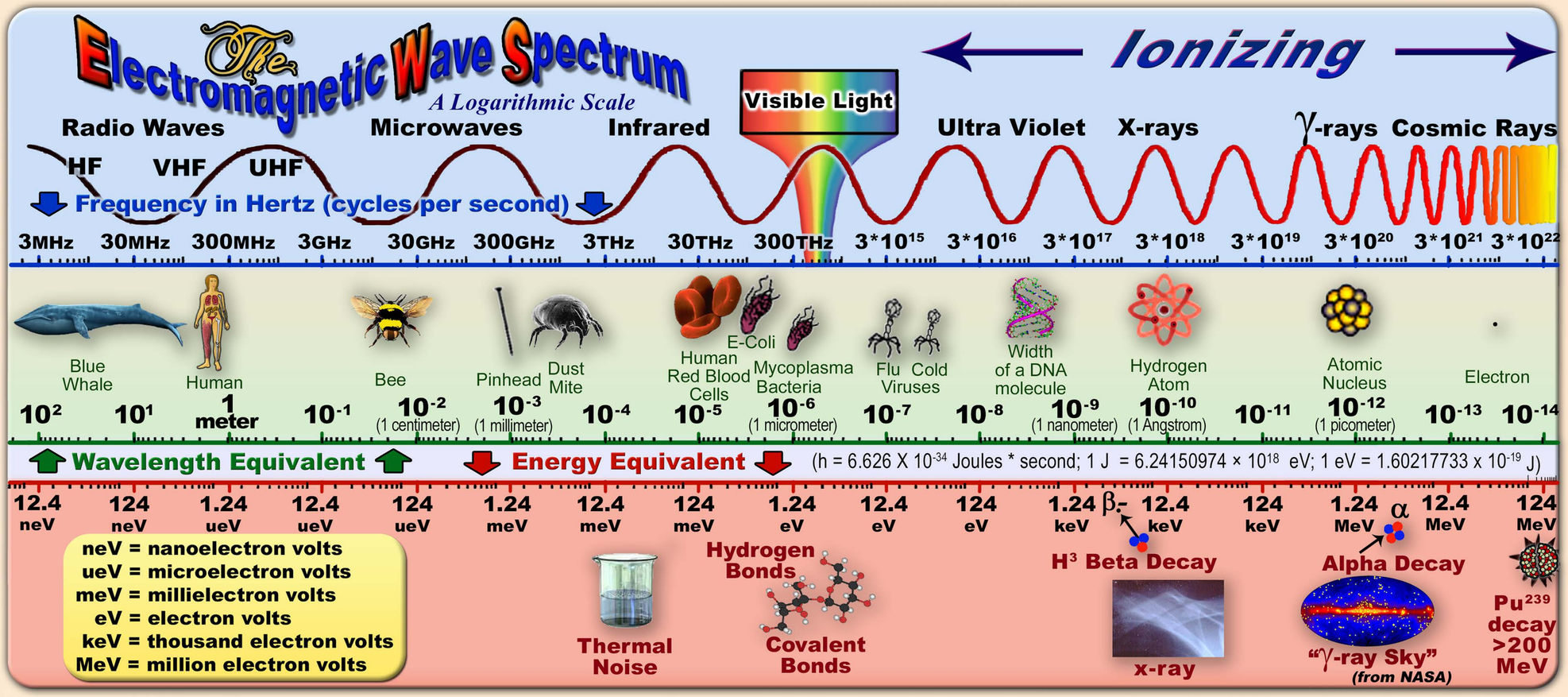
U^{238}, U^{235}, Th^{232}, and Np^{237} Decay Series



Source: Handbook of Physical Quantities, CRC, 1997

If you start with 1,000,000,000 (one billion) atoms, after 20 half-lives about 1000 atoms of the original isotope will remain (about one millionth (0.000095%) of the initial amount).

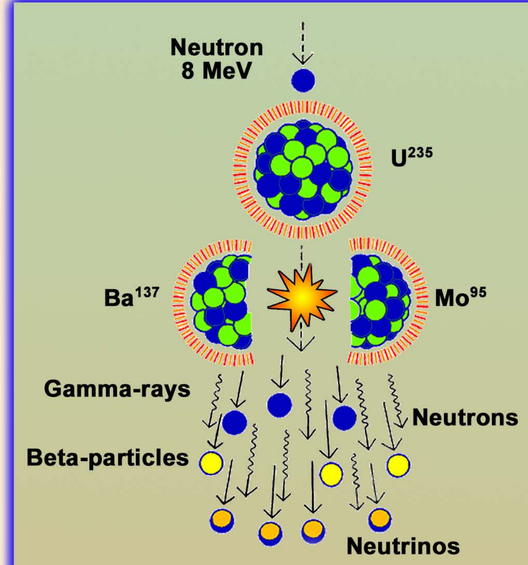




"Spent" nuclear fuel is far more hazardous than "fresh" nuclear fuel.

Nuclear reactions release enormous amounts of energy, which can be used to produce heat or to see things that are otherwise hidden or invisible. But radioactivity has a very dark side too, because all that energy is concentrated in a very small area. It can break any chemical bond in any living creature on earth. Even the so-called "weak" nuclear reactions (such as a tritium atom decay) is thousands of times stronger than any molecular bond. Radiation damages any living creature -- or any container you leave it in.

Nuclear Fission

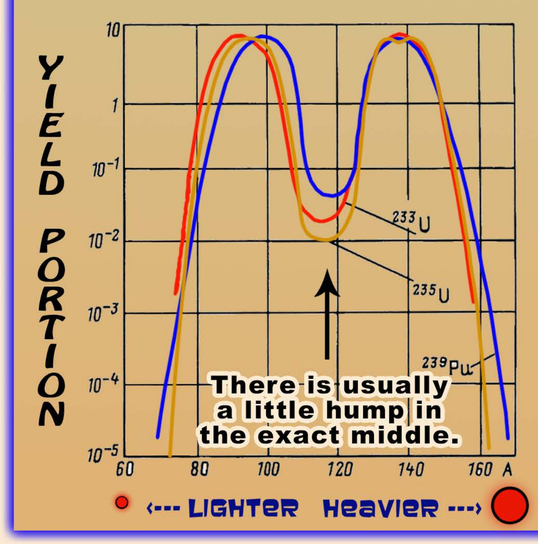


Energy released is about 200 MeV

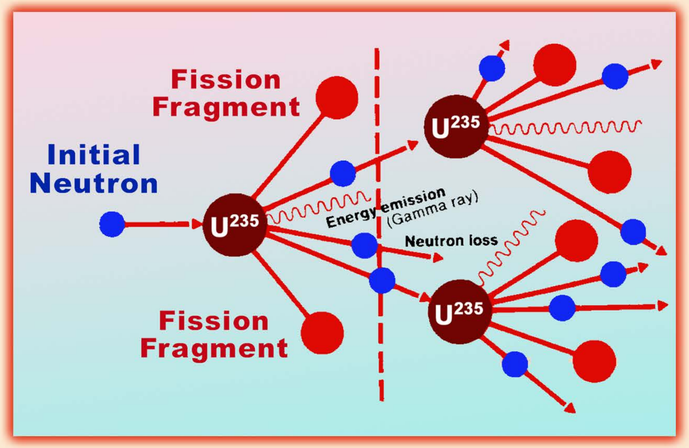
Result:

Two radioactive fission fragments (lighter elements), gamma rays, neutrinos, beta particles, and more neutrons.

Typical mass-yield curves for the two main fragments of a nuclear fission event:

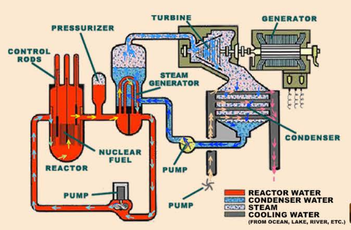


Chain Reaction

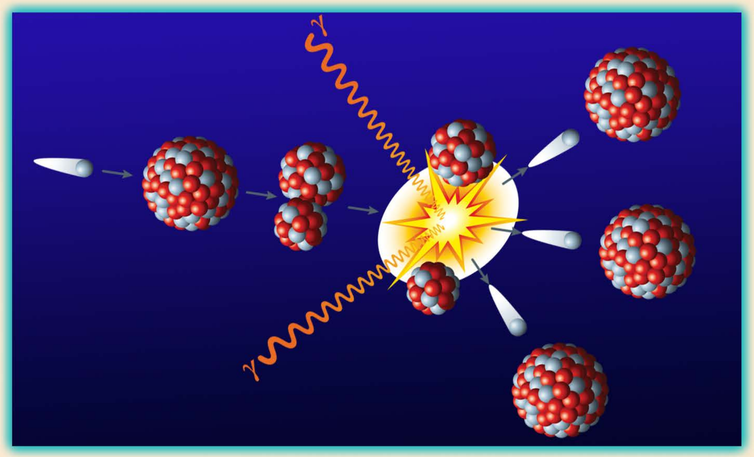


Speed of chain reaction:

Controlled
(Unless there's a meltdown)



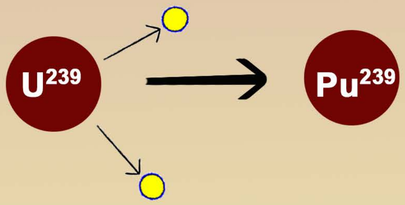
Exponential
(and very, very rapid)



Neutron Activation

A single neutron, generated by nuclear fission, is absorbed by a U^{238} atom. U^{238} is not fissionable, but it can absorb a neutron.

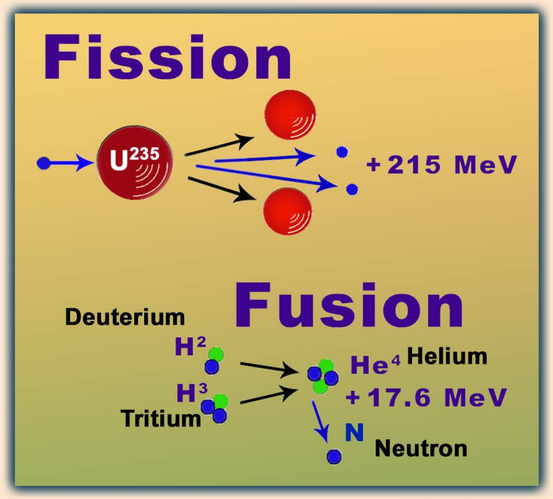
At first the atom becomes a U^{239} isotope but soon it wil eject several beta particles. (This usually happens over a couple of weeks.) In the nucleus of the atom, two neutrons become protons. The atom becomes a Pu^{239} isotope, which *is* fissionable.



A Pu^{239} atom is much more hazadous for several reasons. U^{238} has a half-life of ~4.468 billion years. Pu^{239} has a half-life of ~24,110 years: ~185,317 times shorter! Pu^{239} is approximately that much more hazardous than U^{238} from the radiation.

Additionally, a Pu^{239} nucleus is surrounded by a cloud of 94 electrons, and the outer shells (the outermost electrons) wreak havoc on surrounding atoms and molecules.

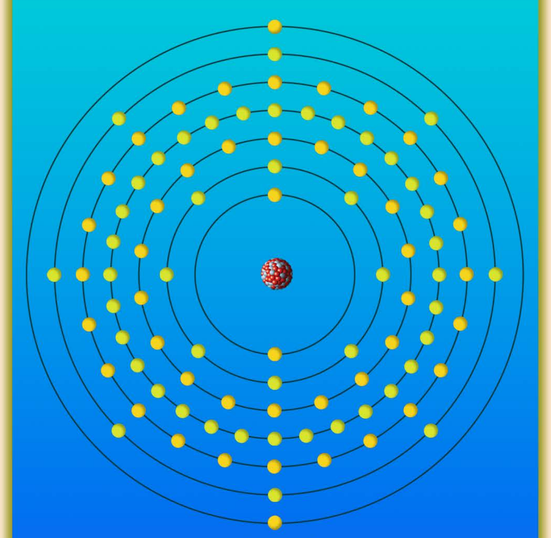
Fission vs Fusion



There's division and confusion about fission and fusion.

Both reactions generate heat, which can be used to boil water, and both produce radioactive waste.

Element 94: Plutonium



Electron Configuration:

[Rn] $5f^6$ $7s^2$

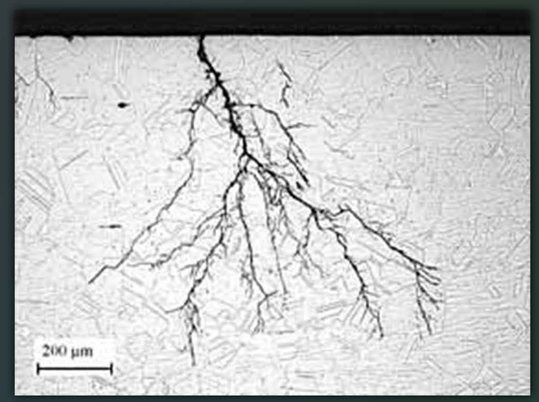
Graphics assembled and / or colorized by Ace Hoffman

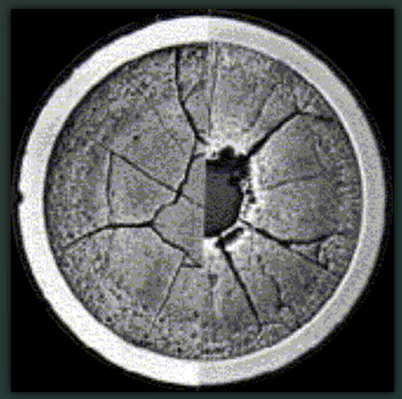
MECHANISMS FOR RADIATION DAMAGE

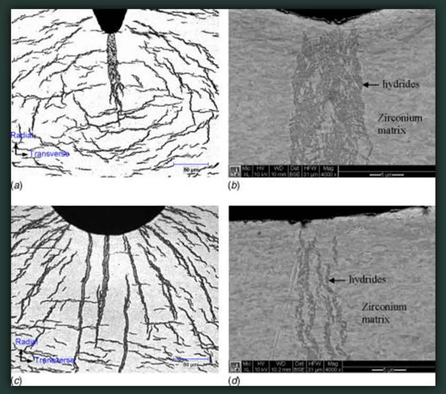
"In the typical nuclear environment, the average energy of a neutron is about 2 MeV while the threshold energy to displace an atom from its lattice position in metals is just 20-40 eV; this means that about 50,000 atoms are displaced in a typical collision."

About 10% of these displacements remain out of position.

Source: Stanford University report

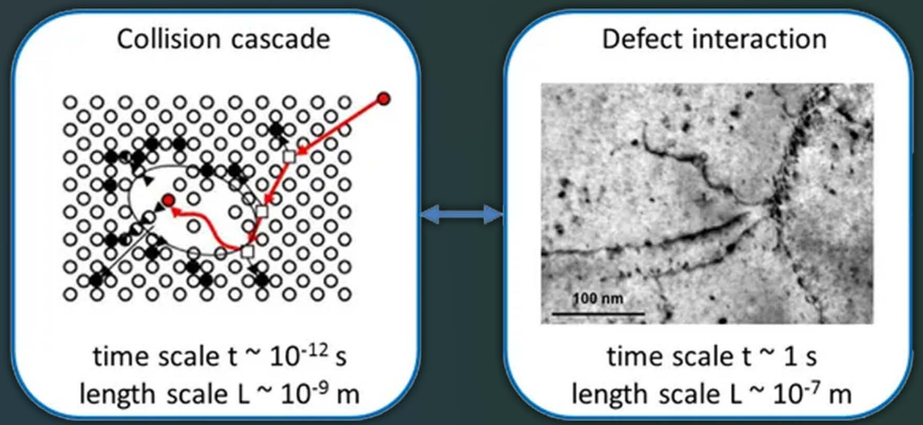






Common threats to metals in a nuclear environment include embrittlement, swelling from void formation, creep, phase transitions, and swelling due to gas bubbles.

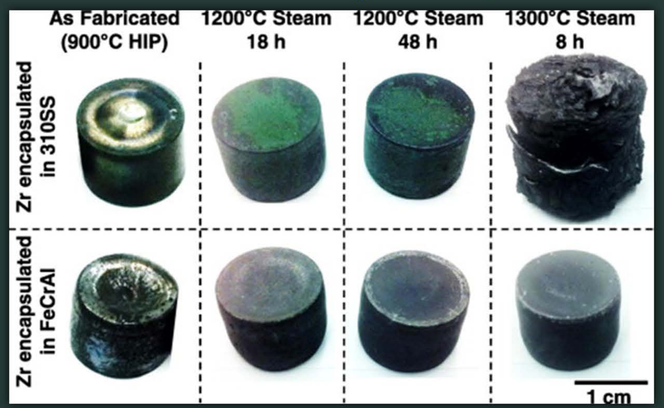
Source: Stanford University report



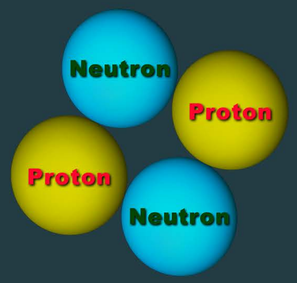
One radiation-initiated collision event can lead to a cascade of additional collision events, leading to embrittlement and parts failures.

Source: Helmholtz Labs

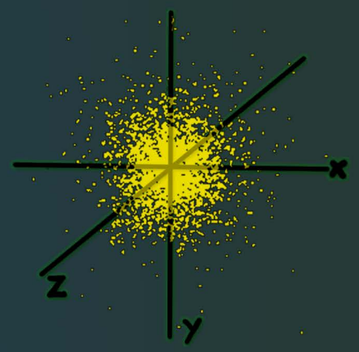
Swelled and damaged fuel pellets.



Alpha particles and beta particles are highly charged, (+2 electron volts (eV) for alpha, -1 eV for beta). These particles do not need to collide with other charged particles to knock them out of their proper location -- they can cause damage at a distance. Gamma rays do not have a charge, but if they do hit a nucleus or an electron, they are also very damaging.



One alpha particle consists of two neutrons and two protons. It is about 8,000 times heavier than one beta particle. (A beta particle at the same scale would be smaller than the period at the end of this sentence.)



Typical electron positions around a hydrogen nucleus.

This is a very high resolution image of a human cell. Human cells contain a curled-up strand of DNA that would be about six feet long if stretched out. Cells can be easily damaged by alpha or beta particles or gamma rays, leading to cancer and other health effects.

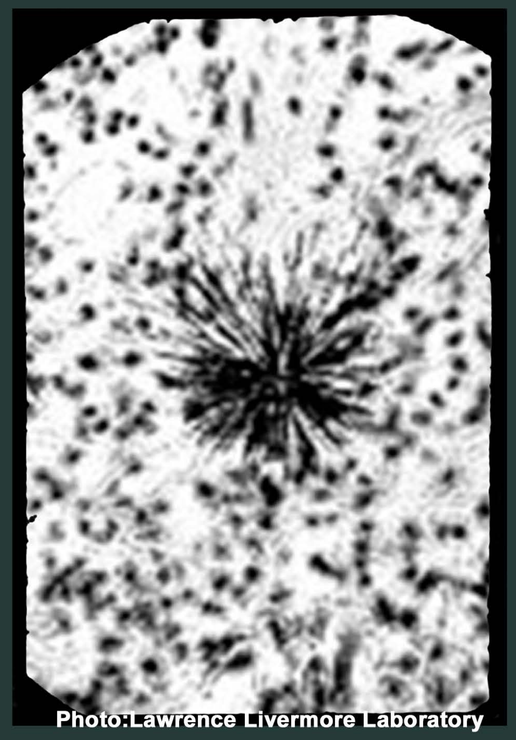
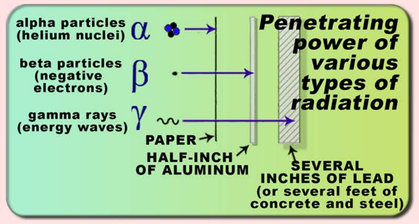


Photo:Lawrence Livermore Laboratory

Alpha radiation from Plutonium in ape lung.

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 atomic weight *emission type* [max. MeV] (2nd type), half life / biological half-life (2nd component)

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

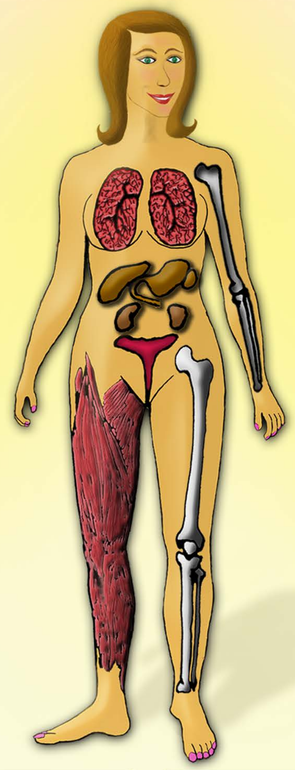
OVARIES

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

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



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.

Hidden Effects of Radiation

Inflammation

Your body's ability to repair itself is remarkable, but NOT infinite. Your DNA is most vulnerable during cell division.

Inflammation occurs when your body uses its white blood cells and other tools to fight an invading organism or poison. When a cut gets infected or inflamed it is easy to see the effects, but when ionizing radiation damages your body, the effect is not necessarily visible. A person receiving a fatal dose of radiation may feel nothing at the time and show no signs of distress for some period of time after the dosing.

So-called low levels of radiation also do the same kind of damage, but not to a fatal degree. However, these doses can cause premature aging, neuromuscular problems, cardiovascular problems, and many other diseases.

Ionization Damage

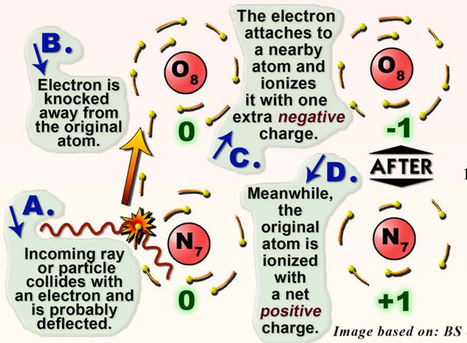
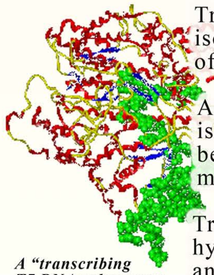


Image based on: BS of A

One radioactive decay can create thousands of "pairs" of positive and negative ions.

These ions can be very damaging to biological systems.

Leftover / Recoil Damage



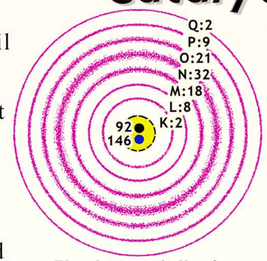
A "transcribing T7 RNA polymerase initiation complex" (from LLNL)

Tritium (H_3) and other radioactive isotopes also cause damage by the recoil of the remaining nucleus after a decay.

Additionally, whatever the new element is, it's not the element that might have been part of some complex protein molecule, for instance, or DNA, etc..

Tritium atoms masquerade as common hydrogen atoms, so they might be found anywhere in your body. When the tritium atom decays, it becomes a helium atom, which the body cannot use.

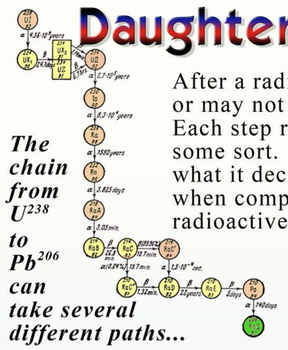
Catalytic Damage



The electron shells of a uranium atom hold 92 electrons, making U both adaptive and destructive.

Many radioactive elements are significant catalysts, as well as heavy metal hazards, in addition to their radiological threat. The nuclear process releases these dangerous elements into the environment where they have been shown to mimic hormones in mice, and to cause dozens of serious ailments. Catalytic effects of DU are considered one possible factor in "Gulf War Syndrome."

Daughter Products



The chain from U^{238} to Pb^{206} can take several different paths...

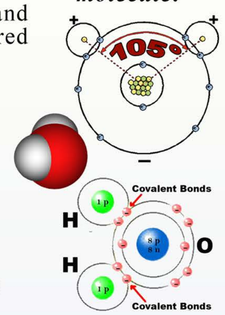
After a radioactive atom decays, it may or may not decay a second time, or more. Each step releases ionizing energy of some sort. How an isotope decays, and what it decays into, must be considered when comparing dangers of various radioactive exposures.

Decays by Alpha
Decays by Beta
Stable

Image source: Atoms A- Z

"Free Radical" Damage

Three ways to depict the H_2O molecule:



A particularly damaging type of atom or molecule is known as a free radical. A free radical has one or more unpaired electrons. Uranium has four unpaired electrons in its outer shells.

The free radical will find an atom which holds its outermost electron less tightly, and will grab that electron. Then that atom will be "ionized," and so on down the ladder of energy levels, one atom ionizing another, in a long sequence.

When tritium decays, the decayed atom might have been part of a water molecule. The left-over OH molecule is a free radical and is particularly hazardous to living cells because it is a strong oxidizer and can suddenly appear anywhere in the body when created by this method.

Hot Particles

A single particle of Depleted Uranium one milligram in size is very small. Many U.S. soldiers, enemy combatants and civilians caught in the crossfire have far more than that lodged in their bodies. Such particles are known as "hot" particles and leave a path of destruction in their wake.

Despite DU's long half-life of **4.5 billion years**, and its extremely high density, there are still enough atoms of DU in one milligram (about **2,530,000,000,000,000,000**) so that more than **a million atoms** will decay every day.

Bystander Effect

When one cell in your body is damaged, the death or altered behavior of that cell can cause other cells to also fail. When mice were irradiated on just the lower half of their bodies, they developed brain tumors.

. . . THERE ARE MANY OTHER HIDDEN AND SUBTLE EFFECTS OF RADIATION POISONING . . .

These two pages are from the author's online book The Code Killers, available as a free download or viewed online at: www.acehoffman.org

Uranium is mined all over the world. In New Mexico and other parts of the southwestern United States, hundreds of abandoned uranium mines poison the earth, air and water (and the people who live nearby) from the "tailings" that have been left behind. But mine tailings have only a tiny fraction of the toxic radioactivity of the fission and activation products that nuclear reactors produce -- some with extremely short half-lives, others with half-lives of eons...

Prospecting for Uranium Ore

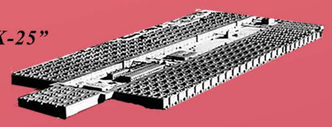
Mining the Uranium Ore

Milling to U_3O_8 ("yellowcake")

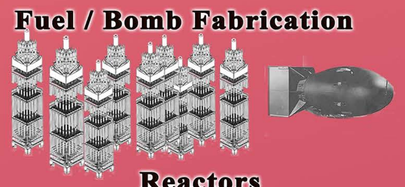
Conversion to UF_6 ("hex")

U^{235} Enrichment

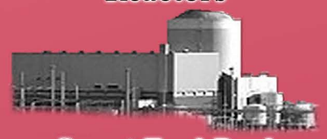
"K-25"



Fuel / Bomb Fabrication



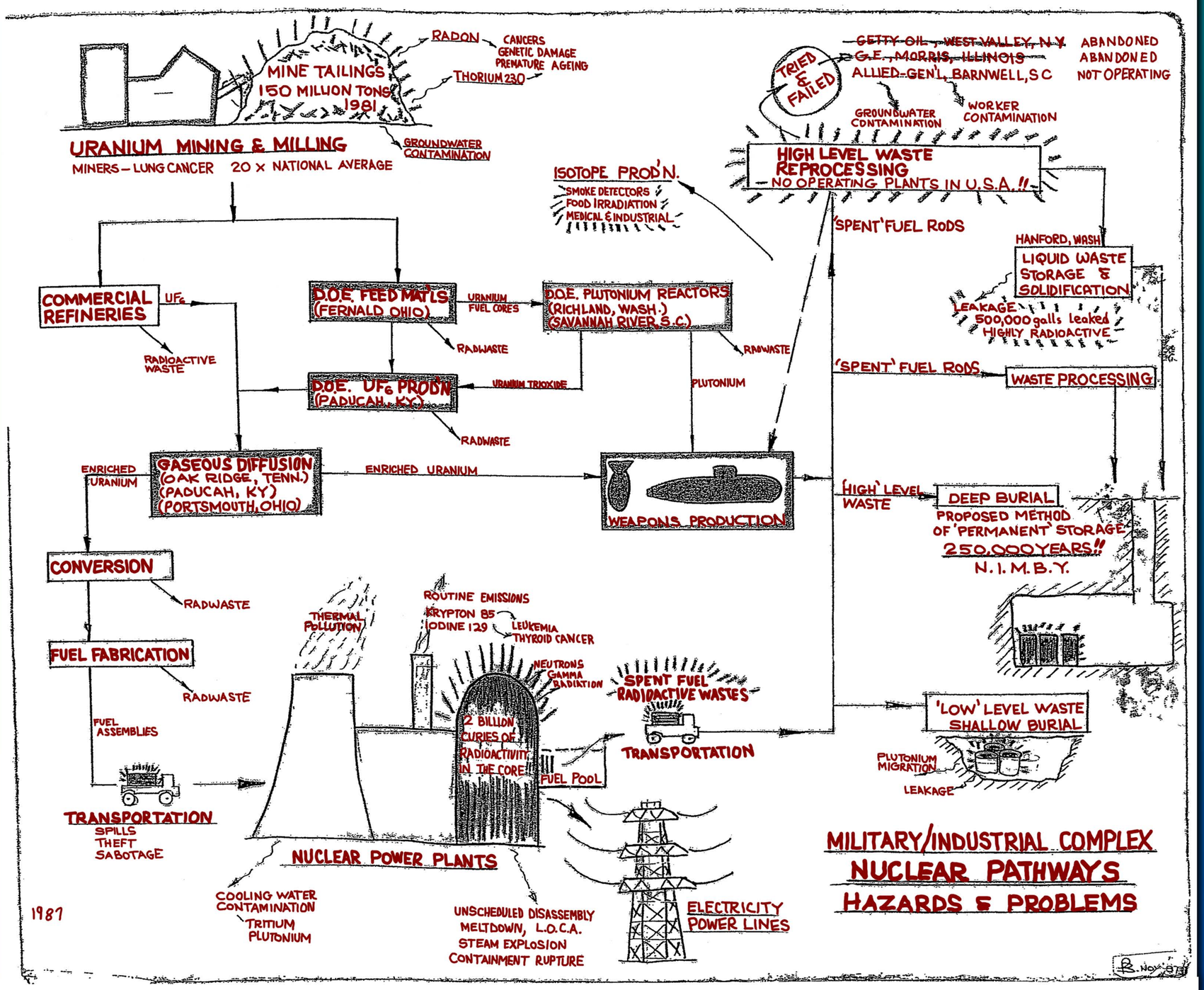
Reactors



Spent Fuel Pools

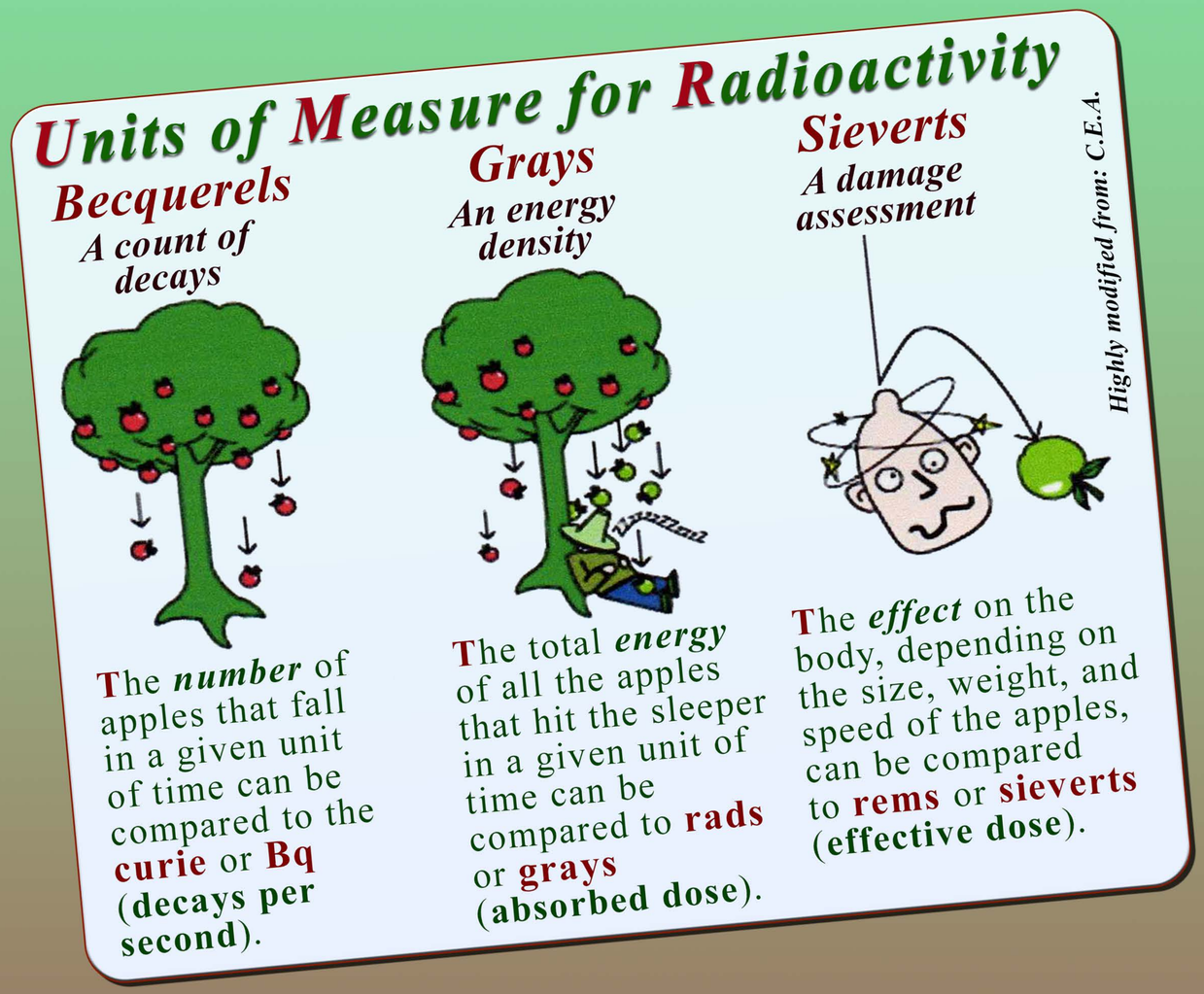
Dry Storage Casks

NUCLEAR FUEL CYCLE

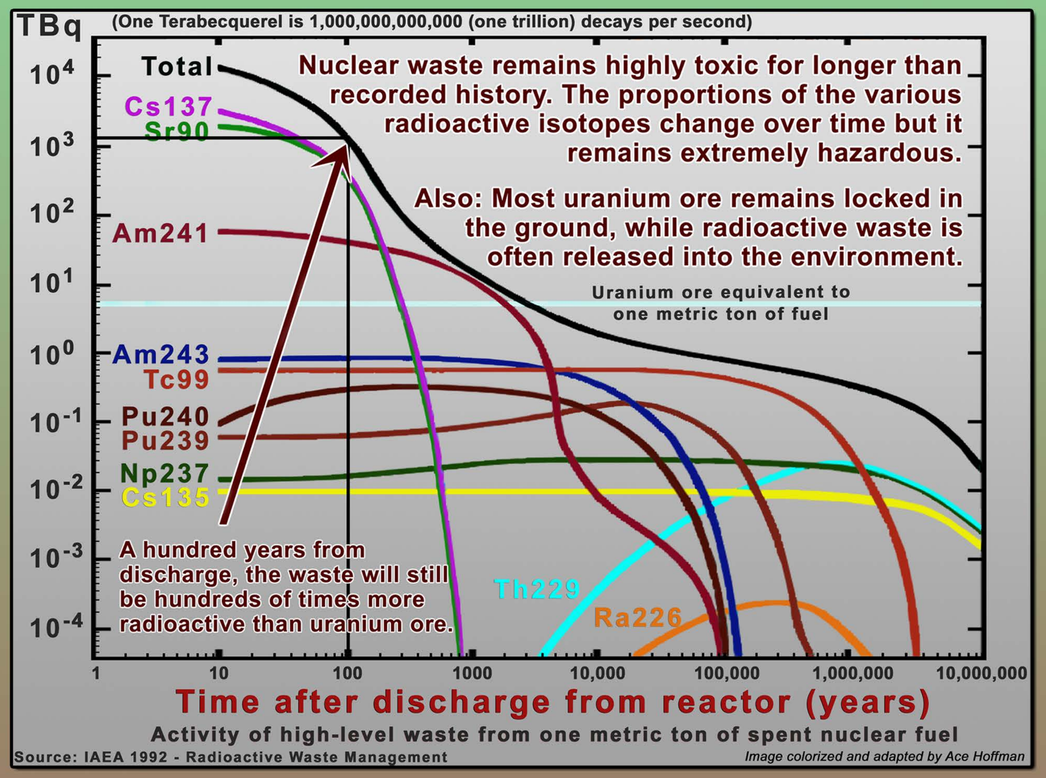


CARBON-BASED, GLOBAL WARMING ENERGY IS USED TO ENABLE NUCLEAR REACTORS, ATOMIC AND RADIOACTIVE WEAPONS, TRANSPORTATION AND WASTE HANDLING

Why "Becquerels" don't tell the whole story...



If you only talk about Becquerels (Bq), chances are you'll *minimize* other people's understanding of the dangers from radiation. There's a lot more to it...



Other important factors include:

- What type of radiation is emitted? (Alpha, Beta, Gamma, X-ray, Neutron, etc.)?
- What energy level is the emission? (What is its wavelength?)
- What is the electrical charge of the emission (Positive, Negative, or Neutral?)
- For particles, how much kinetic energy does it have? (What does it weigh?)
- What element released the emission?
- What element(s) does it decay to? (What is its entire decay chain?)
- What molecules are each of those elements likely to combine with?
- What is the element's biological affinity? (Do living things seek it out?)
- Is the emission internal or external?
- ...and many more...

Radiation Conversion Factors

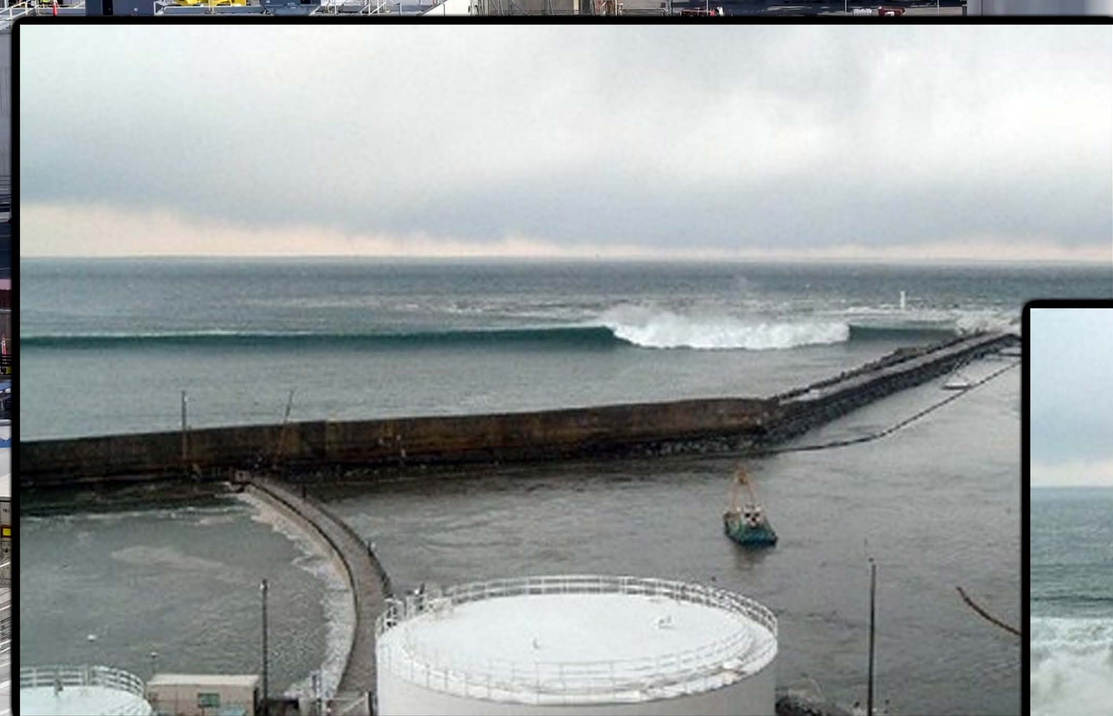
1 rad = an ***absorbed dose*** of **0.01 joules (J)** of energy per **kilogram (kg)** of tissue, or **100 erg** per **gram**
1 rad = 1,000 millirad
1 gray (Gy) = 100 rad = 1 J / kg
1 roentgen = 0.876 rads (***in air***)
1 rem = 1.07185 roentgen
(**rem** stands for "**r**oentgen **e**quivalent in **m**an")
1 rem = 1,000 millirem
1 sievert = 100 rem
1 becquerel = 1 disintegration per second
1 curie = 37,000,000,000 disintegrations per second
1 curie = 37,000,000,000 becquerel
1 becquerel = 2.7E-11 curies
1 becquerel = 27 picocuries
1 curie = 1,000,000,000,000 picocuries
1 picocurie = 0.037 disintegrations per second
1 microcurie = 37,000 disintegrations per second
1 megacurie = 1,000,000 curies
1 kilocurie = 1,000 curies

Page/Screen designed by Ace Hoffman utilizing assorted sources...

San Onofre has more than three million pounds of nuclear waste sitting on the beach in San Clemente, California. The waste is packed into 123 stainless steel containers just 5/8th inch thick.

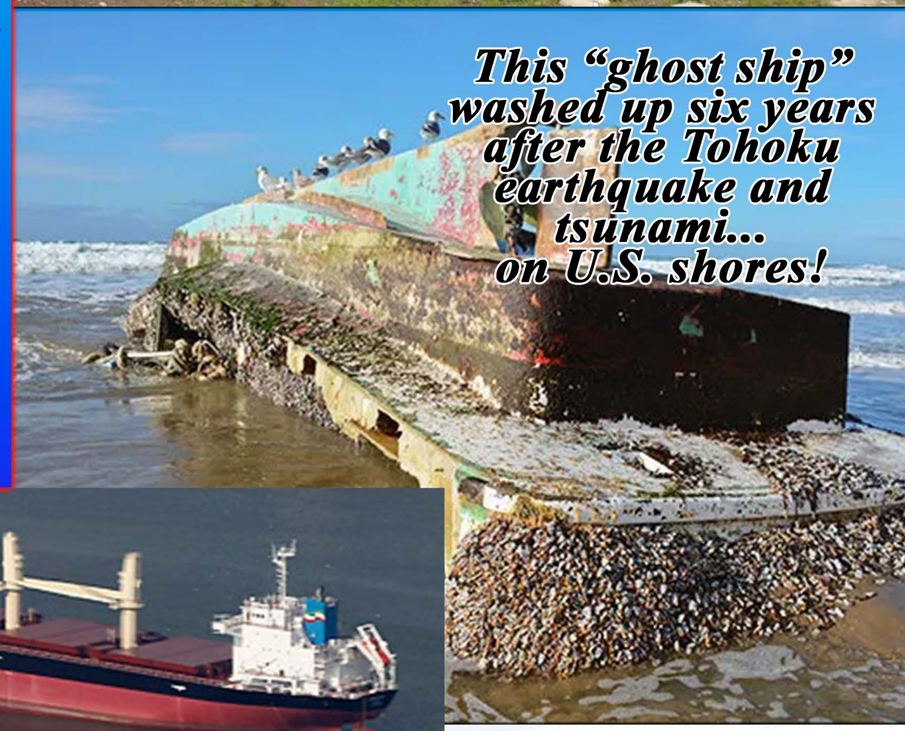
What could go wrong? Lots of things...

San Onofre's sea wall is a lot like this one...
But look what happened in March, 2011:



Large ships were pushed far inland by the tsunami that devastated Japan and inundated the Fukushima Daiichi nuclear reactors.

San Onofre Nuclear Waste Dump is also vulnerable.



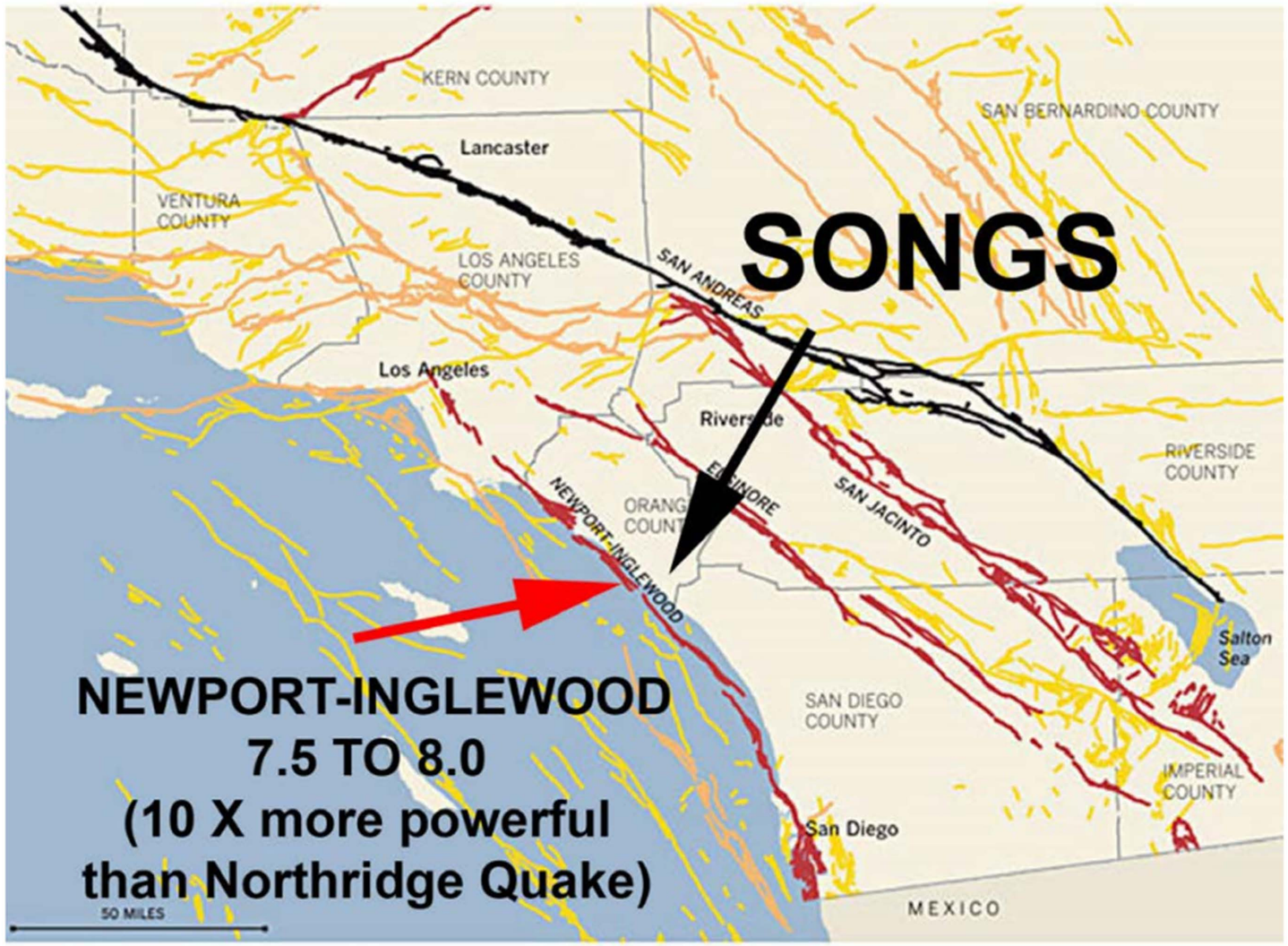
This "ghost ship" washed up six years after the Tohoku earthquake and tsunami... on U.S. shores!

In addition to creating tsunamis directly, earthquakes can also trigger underwater landslides, which can create enormous local tsunamis hundreds of feet high. SoCalEd claims their dry casks can survive 125 feet* of submersion, but that might not be nearly enough.

**** This figure applies only to the 73 Holtec casks. This author was told by the SCE spokesperson at the time that the original 50 horizontal casks are only designed to withstand 50 feet of submersion.***

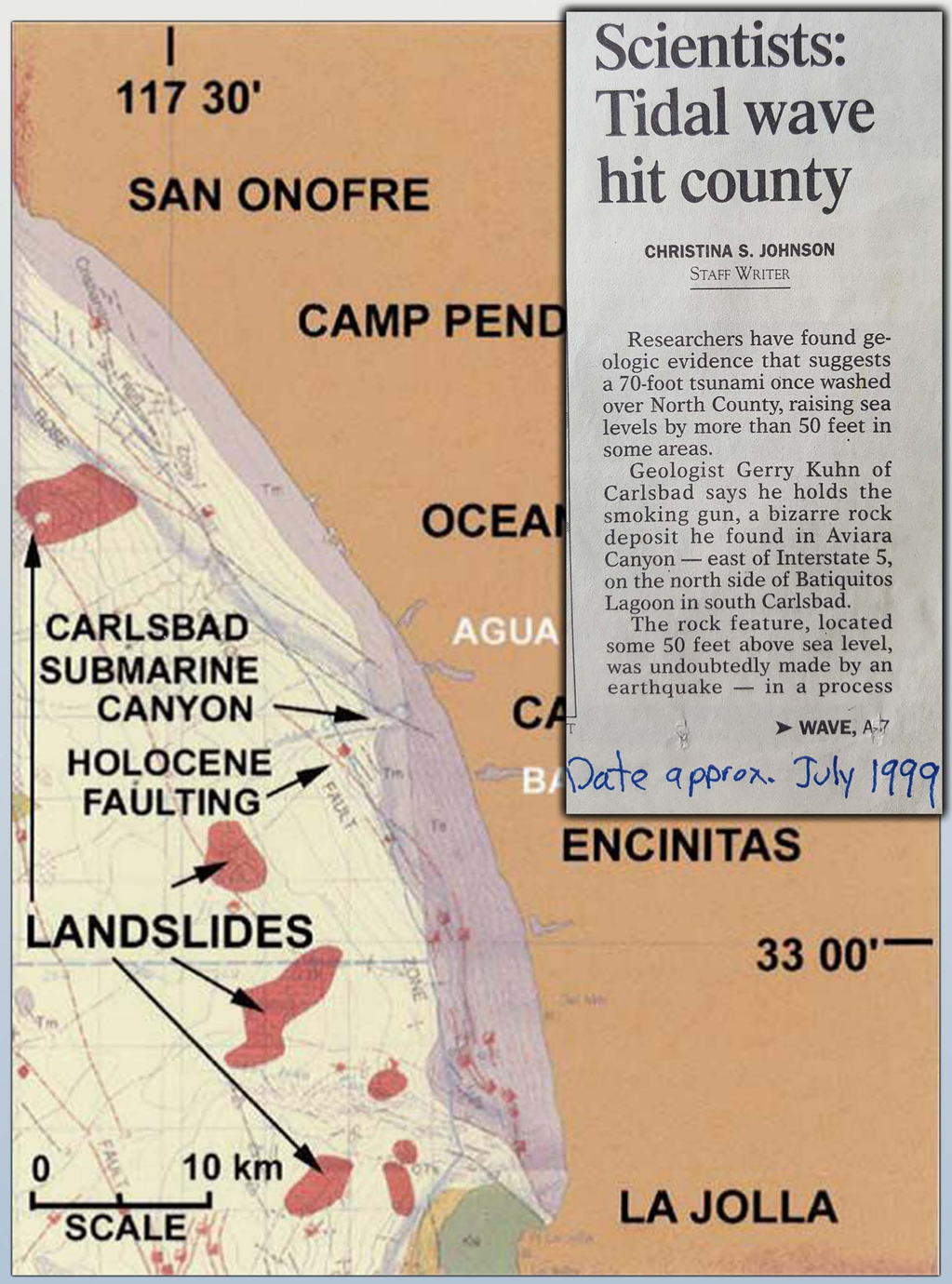
The region's most populous areas are crisscrossed by faults capable of delivering jolts of magnitudes equal to or greater than the 1994 Northridge earthquake, which measured 6.7. Below, the latest fault map released by the California Geological Survey is coupled with earthquake scientists' estimates of the maximum magnitude of potential quakes on those faults.

Less than 6.7 or unrated — 6.7 to 7.5 — 7.5 to 8.0 — 8.0+



Sources: United States Geological Survey, California Geological Survey, Uniform California Earthquake Rupture Forecast, Southern California Earthquake Center
Graphics reporting by DOUG SMITH, THOMAS SUH LAUDER

Los Angeles Times



Scientists: Tidal wave hit county

CHRISTINA S. JOHNSON
STAFF WRITER

Researchers have found geologic evidence that suggests a 70-foot tsunami once washed over North County, raising sea levels by more than 50 feet in some areas.

Geologist Gerry Kuhn of Carlsbad says he holds the smoking gun, a bizarre rock deposit he found in Aviara Canyon — east of Interstate 5, on the north side of Batiquitos Lagoon in south Carlsbad.

The rock feature, located some 50 feet above sea level, was undoubtedly made by an earthquake — in a process

➤ WAVE, A-7

Date approx. July 1999

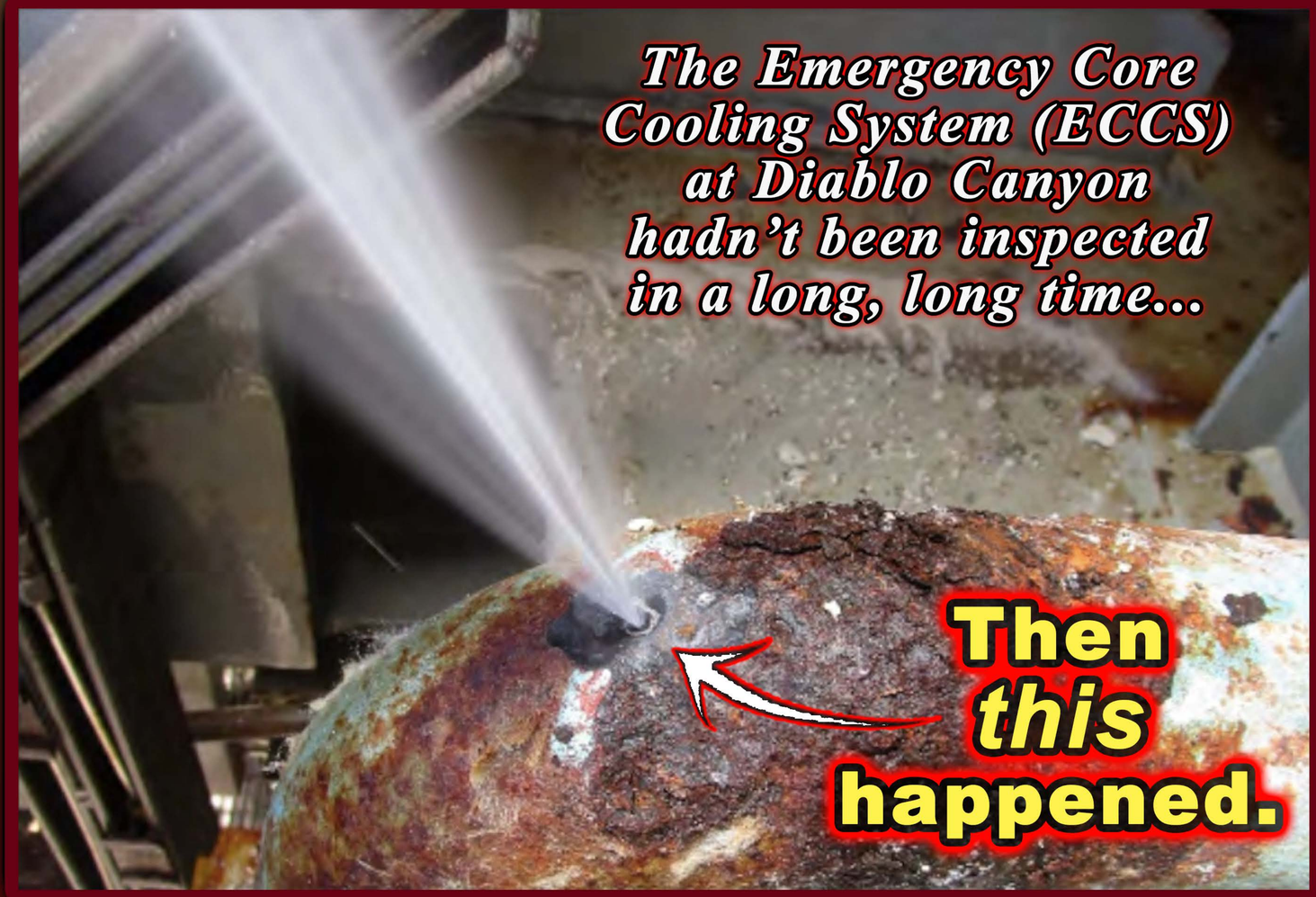
The ECCS at Monticello was completely *unavailable* for the first few decades! Fortunately, it wasn't needed in that time.

The Monticello ECCS was never tested (no ECCS has ever been fully tested). After several decades of plant operation, the ECCS was finally properly inspected. Massive baffles (to prevent backflow) had been bolted shut for transport from the manufacturer. After installation, the bolts were supposed to be removed, but they never were!

Improper maintenance, lax oversight, falsified records, and lying to the public (and even to the regulators) are common occurances at every nuclear power plant.

In normal businesses, these would all be serious "red flags."

But in the nuclear industry, it's just how things are done.



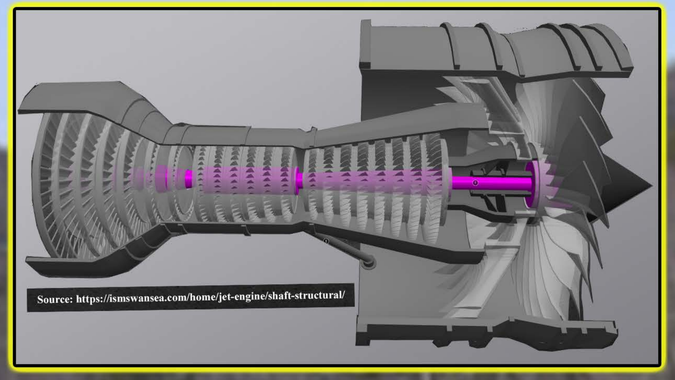
Operating nuclear reactor licenses are being extended to 60, 80 and even 100 years or more, because building new reactors is too expensive to be competitive with wind, solar, etc..

But the old reactors are full of rusted-out components and even have components that have *never* been tested at full size!

No one knows if a nuclear reactor can survive an airplane strike from a large jet aircraft intentionally flown into the reactor by a crazed pilot or terrorist. It is considered a "beyond design basis" event!

But in reality, everyone in the nuclear industry knows that no reactor has EVER been designed to handle that!

Commercial jet turbine shafts weigh more than a ton.



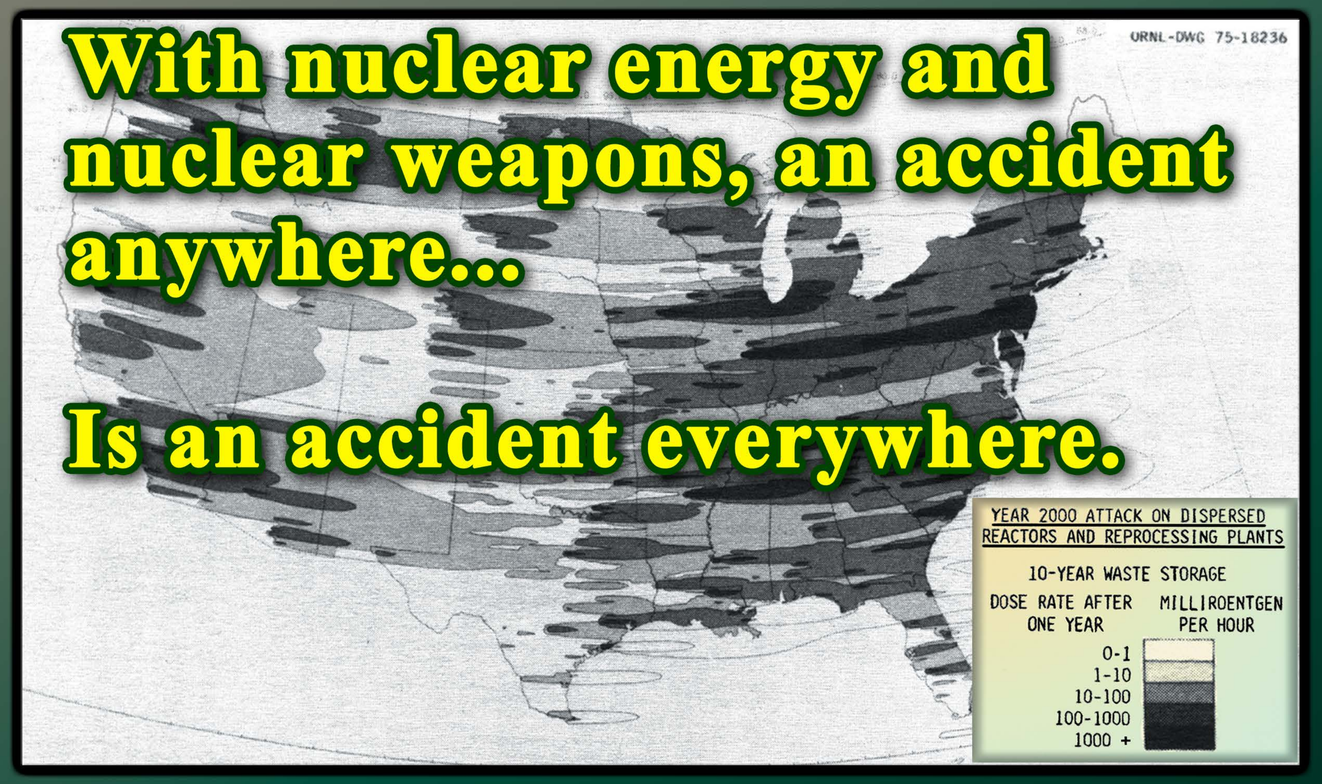
Landing gear, engine mounts and other parts are also extremely large, dense metal parts.

Large jet accidents can happen anywhere. But also, there have been seven suicide-mass murder large jet crashes already *this century.**

* Four on 9-11, plus GermanWings, MH-370 (probable), and the China Airlines crash in 2022 (also probable suicide-mass murder).

With nuclear energy and nuclear weapons, an accident anywhere...

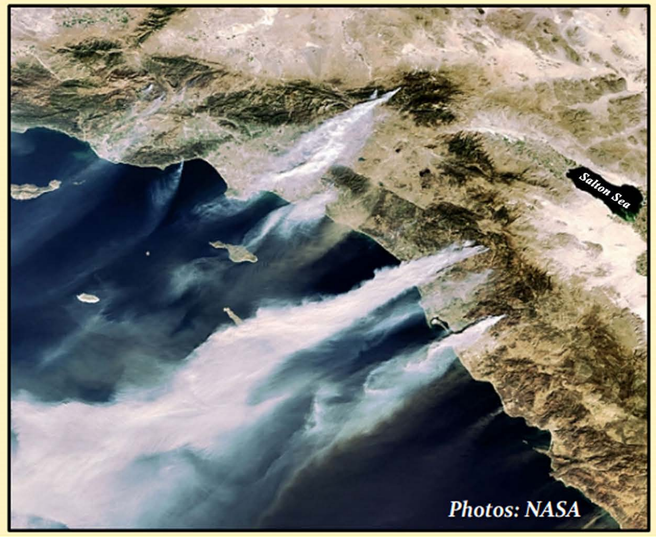
Is an accident everywhere.



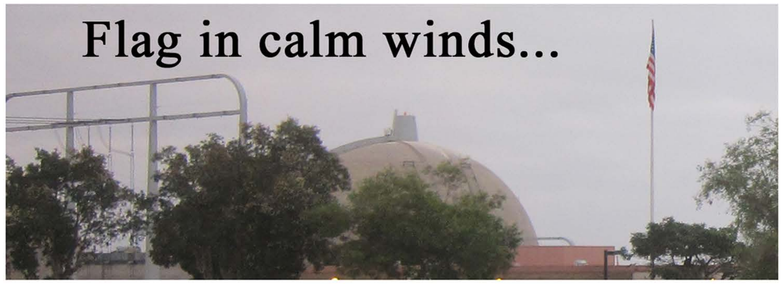
Smoke gets in your eyes:

Left: Plume from Sept. 2007 brush fire barely spreads as it travels over 200 km. across the Mojave Desert. **Right:** Plumes from Oct. 2007 fires drift out to sea.

Radioactive plumes are odorless, colorless, tasteless (except in very high doses) but can cause permanent evacuations and latent cancers hundreds of miles away.

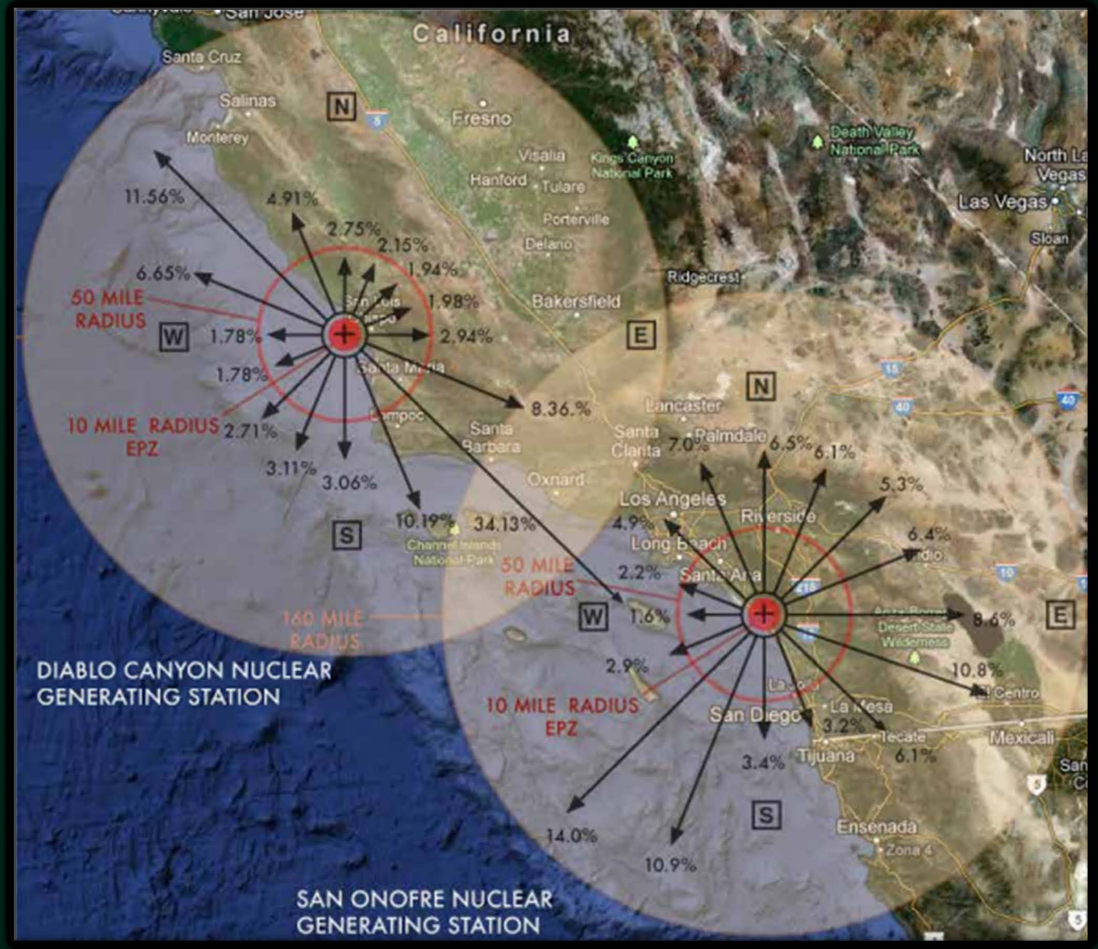


Photos: NASA

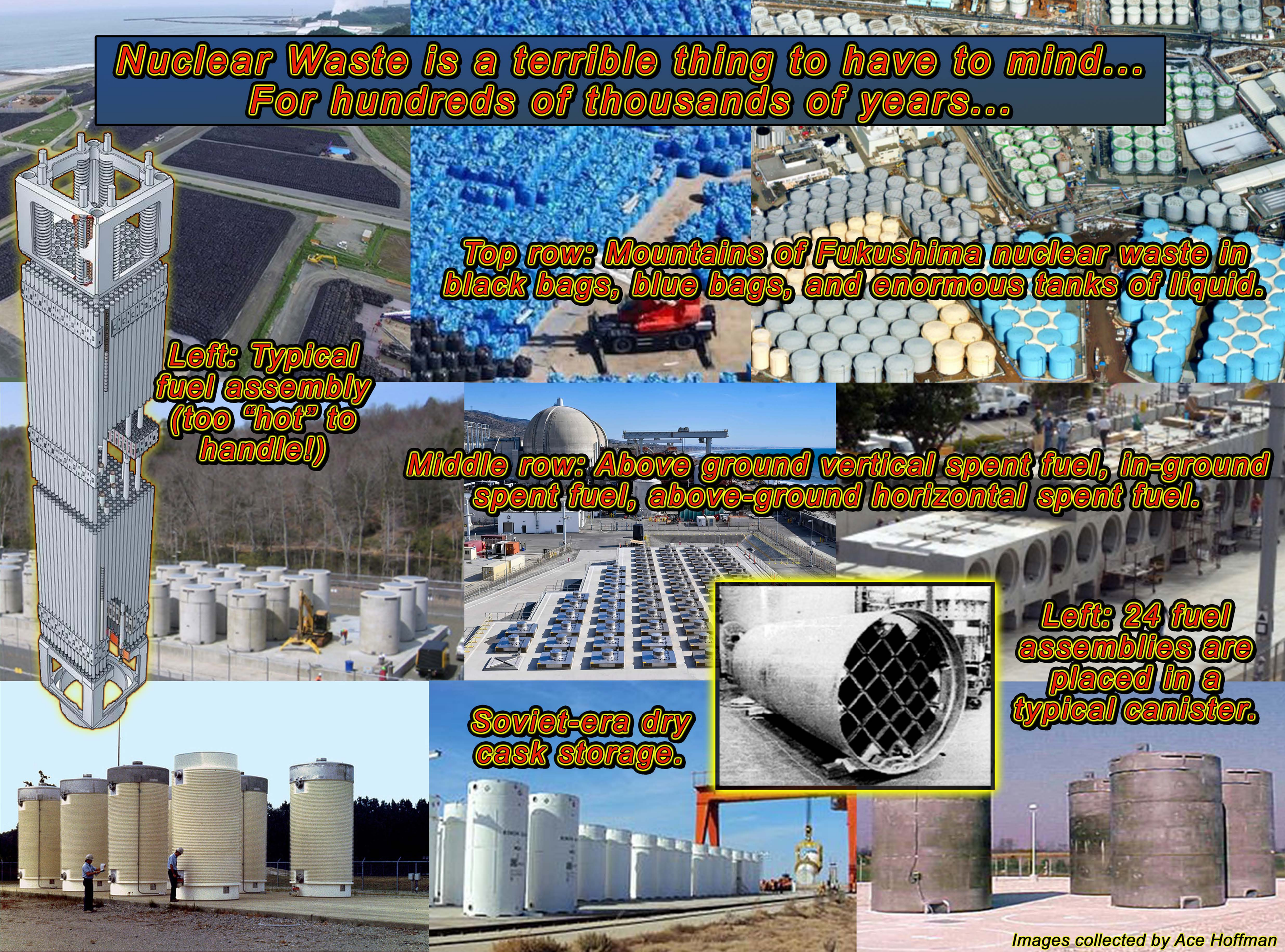


If you live anywhere near the San Onofre Nuclear Waste Dump and there is a spent fuel fire or other accident, you will be in the path of its poisons at some point...

Photos by Ace Hoffman



Nuclear Waste is a terrible thing to have to mind...
For hundreds of thousands of years...



Top row: Mountains of Fukushima nuclear waste in black bags, blue bags, and enormous tanks of liquid.

Left: Typical fuel assembly (too "hot" to handle!)

Middle row: Above ground vertical spent fuel, in-ground spent fuel, above-ground horizontal spent fuel.

Left: 24 fuel assemblies are placed in a typical canister.

Soviet-era dry cask storage.

Images collected by Ace Hoffman

Hanford, WA Nuclear Waste Storage Tanks

There are 177 tanks at Hanford, containing various toxic brews of rad waste...

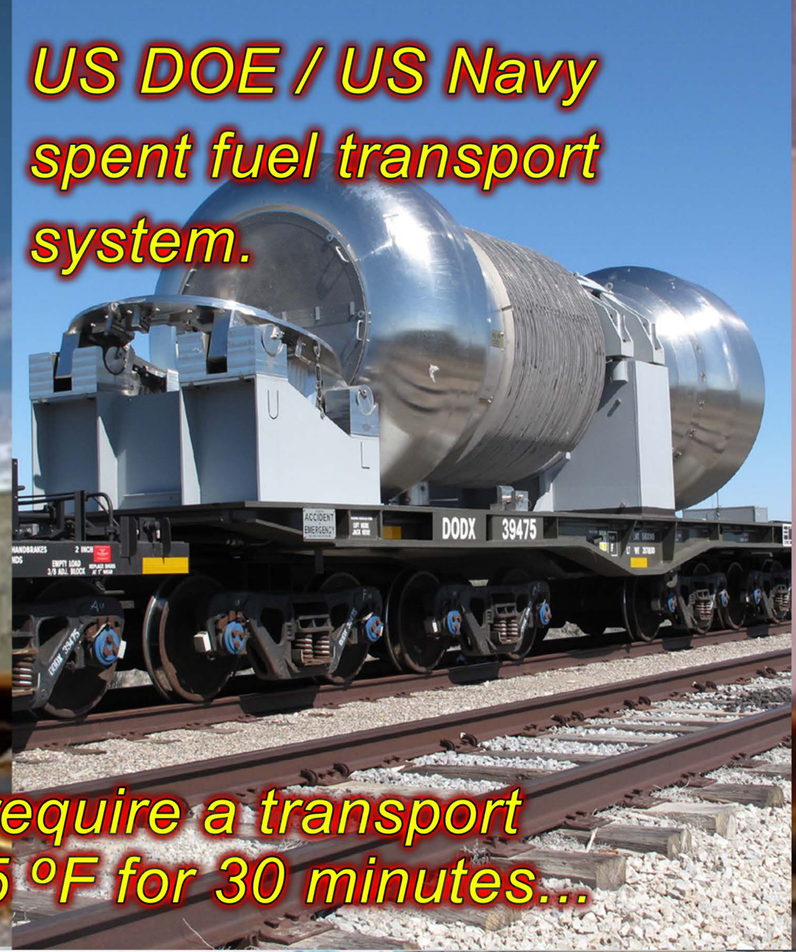
Shown under construction in the 1940s; now well beyond expected years of use.
Some tanks are already leaking radioactive effluents into the groundwater.

Welding inside a tank under construction.

Currently there are three "Superfund" areas at the Hanford "reservation." A fourth "Superfund" area has been cleaned up...at least, enough to be taken off the list...

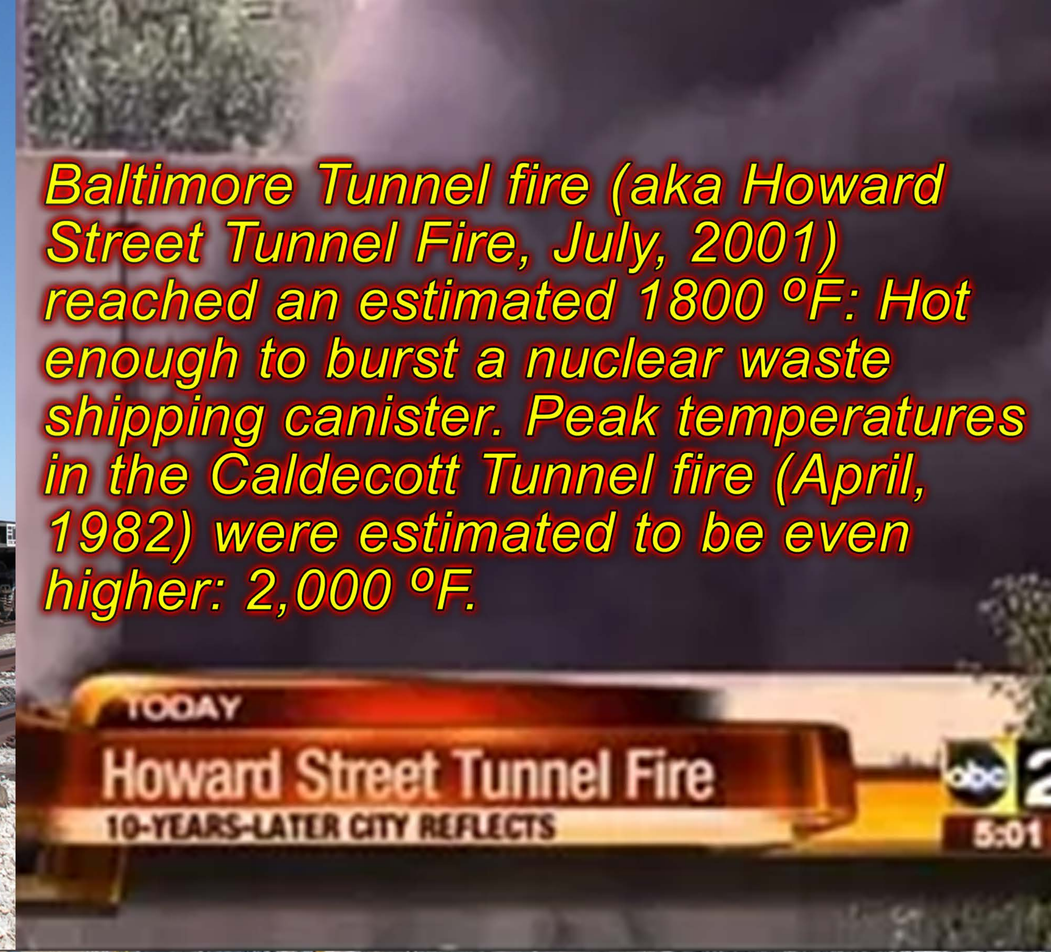
Images collected by Ace Hoffman

Holtec illustration of a rail car for nuclear spent fuel transportation.



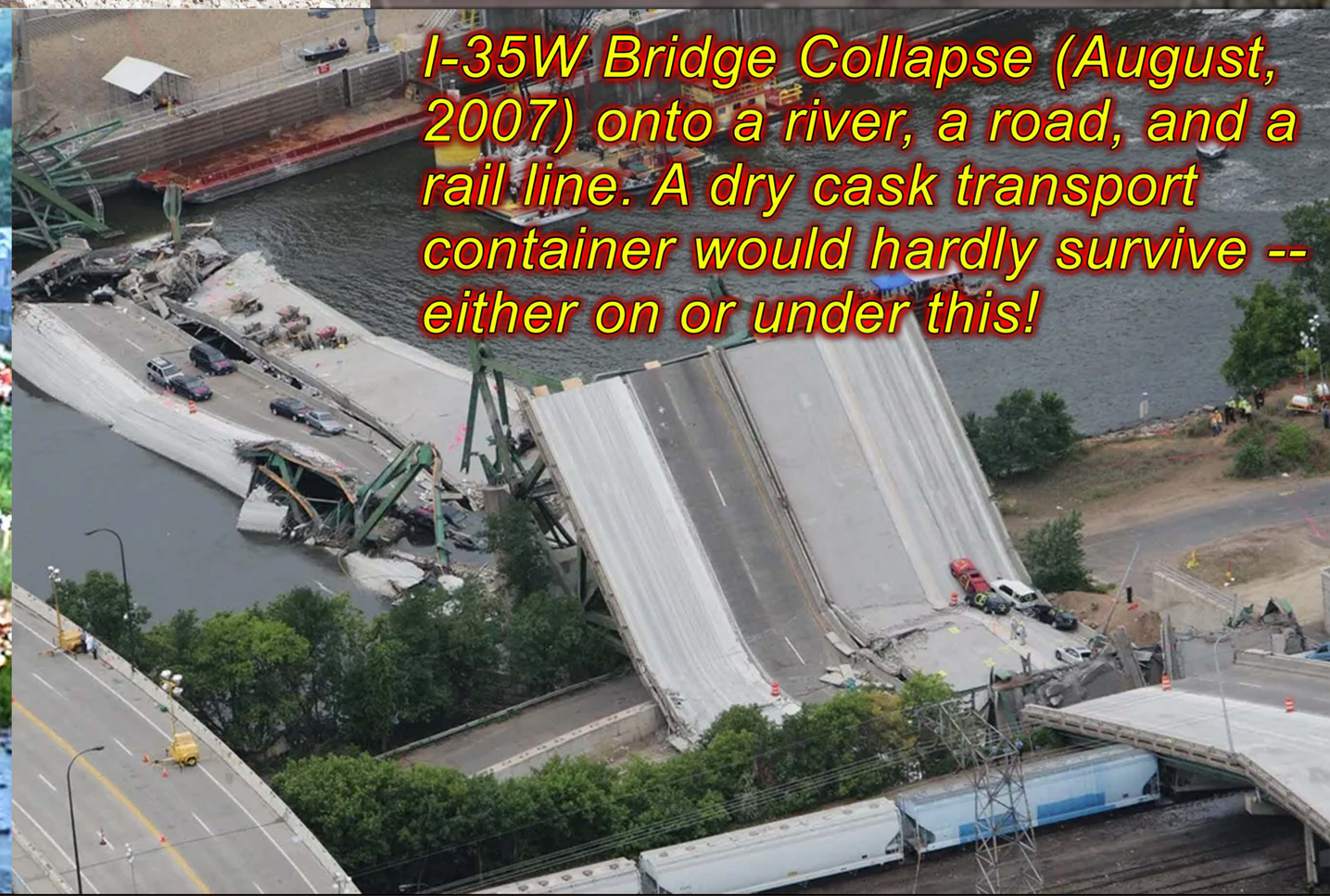
US DOE / US Navy spent fuel transport system.

NRC regulations only require a transport cask to survive a 1,475 ºF for 30 minutes...



Baltimore Tunnel fire (aka Howard Street Tunnel Fire, July, 2001) reached an estimated 1800 ºF: Hot enough to burst a nuclear waste shipping canister. Peak temperatures in the Caldecott Tunnel fire (April, 1982) were estimated to be even higher: 2,000 ºF.

Mianus River Bridge Collapse (June, 1983). Much further drop than a transport cask can survive.



I-35W Bridge Collapse (August, 2007) onto a river, a road, and a rail line. A dry cask transport container would hardly survive -- either on or under this!

San Diego

to win Wimbledon in 77 years.

NC

8, 2013 • THE WORLD'S GREATEST COUNTRY & AMERICA'S FINEST CITY • UTSanDiego.com

JET TOO SLOW BEFORE CRASH

Investigators say pilots tried to abort landing at the very last moment

JASON DEAREN & JOAN LOWY
ASSOCIATED PRESS

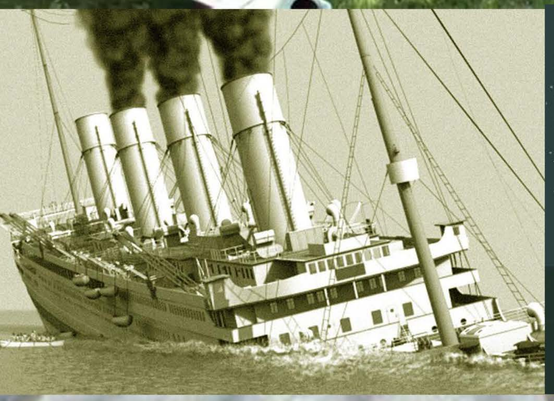
ing that the jetliner could stall, and they tried to abort the landing but crashed barely a second later, the head of the National Transportation Safety Board said Sunday.

The South Korean airline said the pilot at the controls had little experience flying that type of plane,

gan piecing together what led to the crash, San Mateo County Coroner Robert Foucrault disclosed that he was looking into the possibility that one of the two teenage passengers who died Saturday actually survived the crash but was run over by a rescue vehicle

ber were critically injured.

Accident investigators are trying to determine whether pilot error, mechanical problems or something else was to blame for the crash. At a news conference, NTSB chief Deborah Hersman disclosed the Boeing 777 was traveling at speeds



TIGER SEVERELY INJURES WORKER

Indiana woman bitten on head while cleaning exotic cat's cage

ASSOCIATED PRESS

CENTER POINT, IND.

A worker cleaning a cage

believed to be life-threatening.

Dub was working at the Exotic Feline Rescue

hold a bit, he sprayed it with a water hose and the tiger released Dub, Gambill said.

Which are you going to choose?

Both systems can generate *plenty* of electricity.

But one only costs a few hundred million dollars to build, while the other costs dozens of billions. One uses materials that can be recycled and used again. The other requires armed guards starting before it is even turned on, and then leaves extremely hazardous radioactive waste which must be isolated from the environment for a quarter of a million years (and no one knows how to do that).

Trinity was the first of many atmospheric, underwater, and underground explosions.

America exploded 1151 nuclear bombs before testing was abandoned by most countries.

From Hiroshima to Three Mile Island to Chernobyl to Fukushima to...San Onofre?

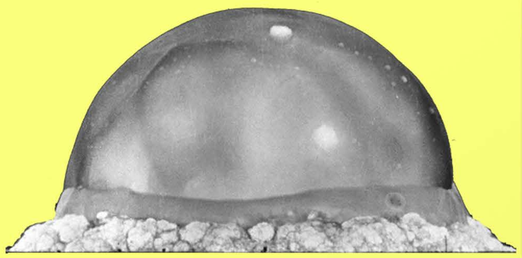
Many precise measurements have already been made...

Virtual Museum of Nuclear Events

Virtual Museum of Nuclear Events

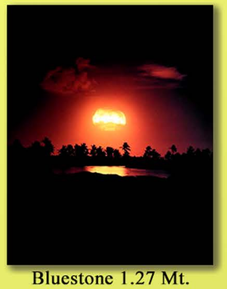
Despite decades of global opposition, money and power still make the wrong choice.

There are many connections between nuclear waste from nuclear power plants and nuclear weapons. Nuclear weapons are made from isotopes extracted from nuclear waste. And worse: Nuclear weapons can vaporize nuclear waste, creating a global health catastrophe.


Trinity 1945


Bikini 1946


Baker Operation Crossroads 1946


Bluestone 1.27 Mt.


Operation Plumbbob Smoky 1957

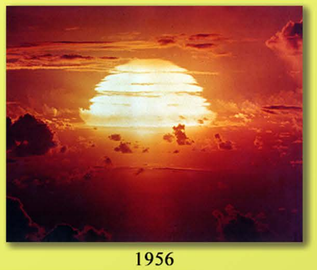

1952


Seminole 1956


Ess 1.2 Kt


1956


Owens 1957

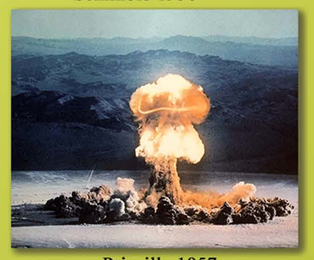

1956


1956


Yukon


George


Apache


Priscilla 1957


Romeo 1954


Bravo


Castle Bravo 1954


Operation Ivy King 1952

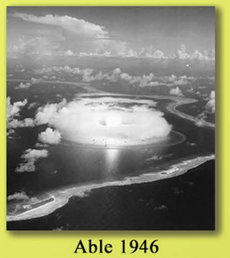

Castle


Truckee


Tinian


Sedan 104 Kt Shallow Underground


Operation Ivy Mike Enewetok 1952


Able 1946


Able 1946


Hardtack


Ivy Mike


Ivy Mike


Johnston Is. 1962

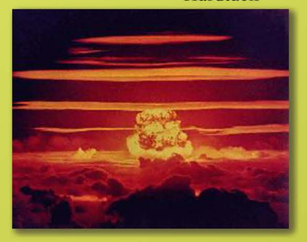

Johnston


Baker (late stage)


Mohawk


Operation Climax 1953


Banberry 10Kt Underground


Redwing


Enewetok 1958t


Cactus


Grable 1953


Dog 1951


Castle Romeo 1954


Bravo

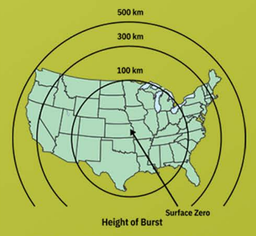

Little Boy August 6, 1945


Fat Man August 9, 1945


Hiroshima Victim

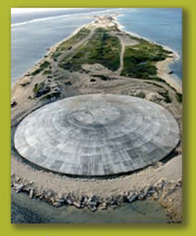

Hiroshima Peace Memorial

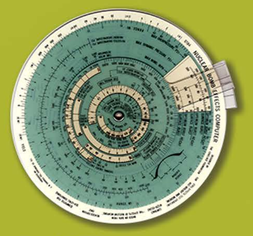

Bomb Effects Test



EMP effects vs. altitude


Cactus crater


Cactus cover


Bomb Effects Computer

Collection of nuclear images from the library of Ace Hoffman

Books on nuclear topics published from 1945 through 2008

(from the private collection of Ace Hoffman)