Radionuclides 101

The Chalk River "Megadump"

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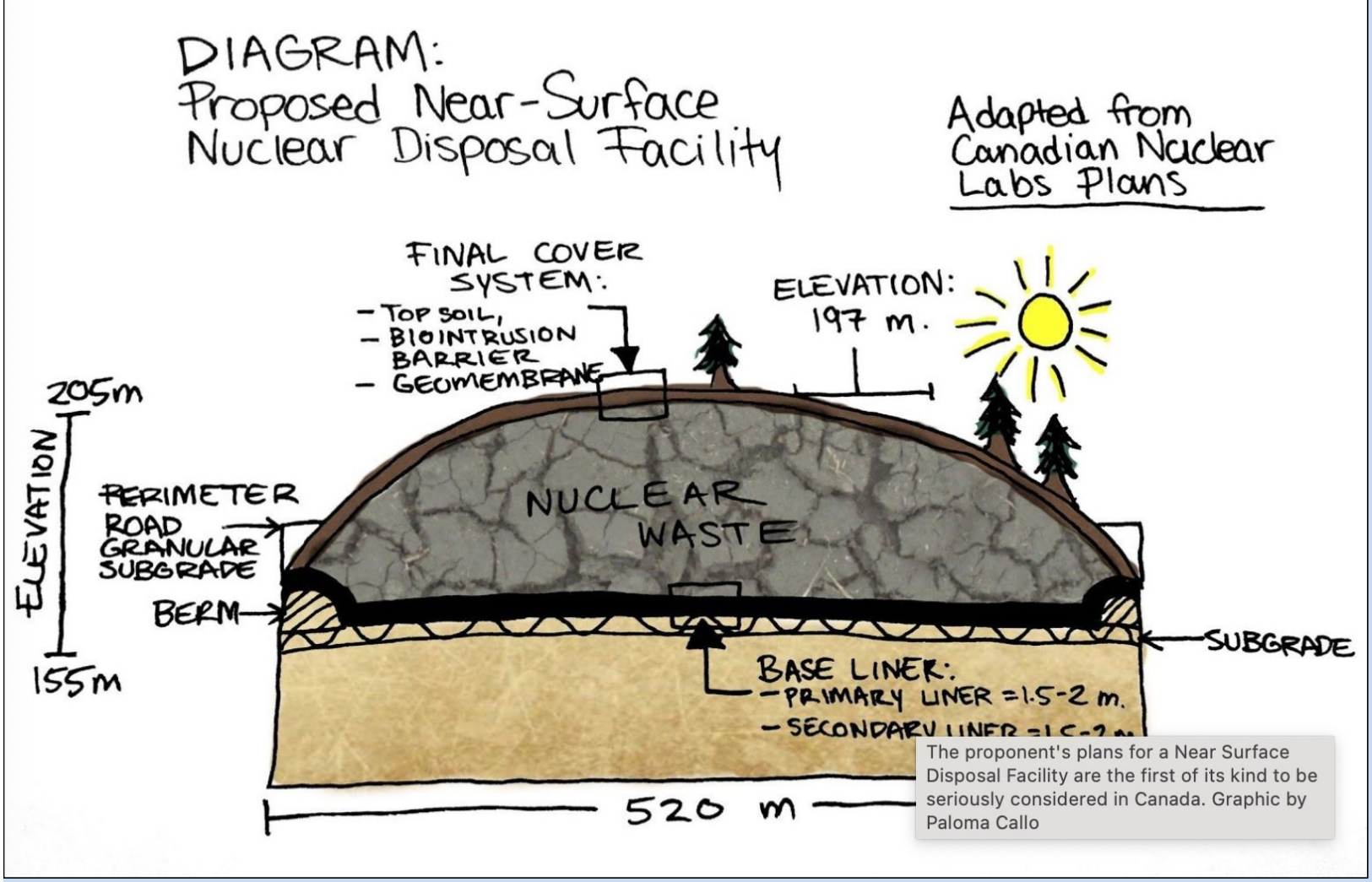
PART 1

WHAT ARE RADIONUCLIDES

AND

WHY ARE THEY DANGEROUS?

THE PROPOSED CHALK RIVER MEGADUMP – ONE KILOMETRE FROM THE OTTAWA RIVER



NSDF

"Near surface disposal facility"

AS TALL AS

A 15-STORY HIGH-RISE APARTMENT BUILDING

INTENDED TO HOLD ONE MILLION TONNES OF TOXIC WASTES

- *RADIONUCLIDES*
- *NON-RADIOACTIVE toxic materials*

The word “radionuclide”
combines two other words:
“radioactive” and “nucleus”

In brief, a radionuclide is a material made with atoms that have a “radioactive nucleus”.

SO – WHAT DO THOSE WORDS MEAN?

The Atom

The NUCLEUS of an atom
is at the center, surrounded by orbiting electrons

Sculpture at
Elliot Lake
Ontario

The force that holds the nucleus together
is the strongest force in the universe

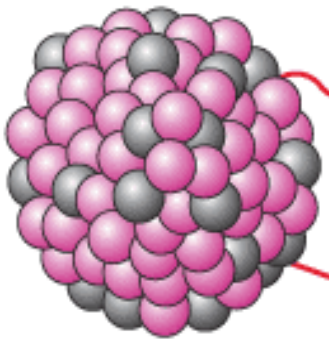
FACTS ABOUT ATOMS AND RADIOACTIVITY

- Atoms are the basic building blocks of matter (solid, liquid, gas).
- Atoms combine to form molecules (many atoms bound together).
- Most atoms are stable, unchanging, eternal – just recombining with other atoms.
- Unstable atoms also exist, they are "radioactive" – the nucleus suddenly "disintegrates".
- Disintegrating atoms emit projectiles ("atomic radiation") that damage nearby cells.

* "Atomic radiation"(or "nuclear radiation") breaks chemical bonds and scrambles DNA

- In a few cases, damaged cells can reproduce and slowly develop into cancers years later.
- That is why radioactive materials must be kept out of the environment of living things.

Radioactive emissions: Alpha, Beta and Gamma



Radioactive Atom

(also called a radionuclide)

gamma

(sometimes)

Energy

alpha or beta

(always)

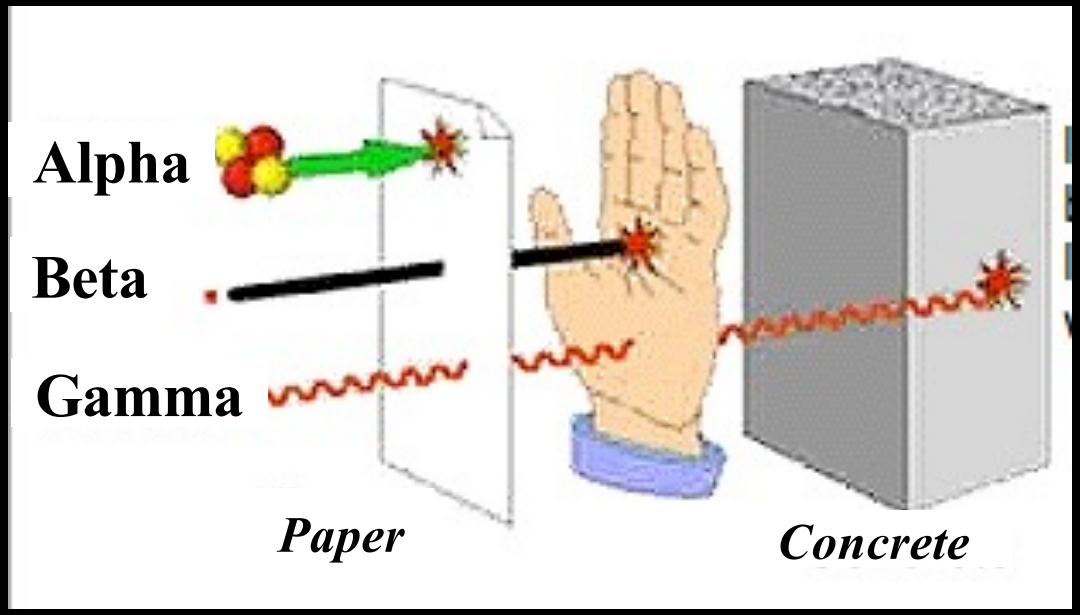
Particle

Atomic Radiation

"IONIZING" ENERGY

A radionuclide emits either an alpha or a beta particle.
These particles are electrically charged and move very fast.
In some cases, a powerful gamma ray is also given off.
All three types of atomic radiation damage living cells.

Alpha particles can be stopped by a sheet of paper.
Alpha emitters are harmless outside the body, but exceedingly dangerous when ingested or inhaled.



Beta particles penetrate only part-way.
They can damage eyes or skin externally but the main danger is internal exposure.

Gamma rays are highly penetrating.
They give "whole body" radiation.
Heavy shielding is often needed.

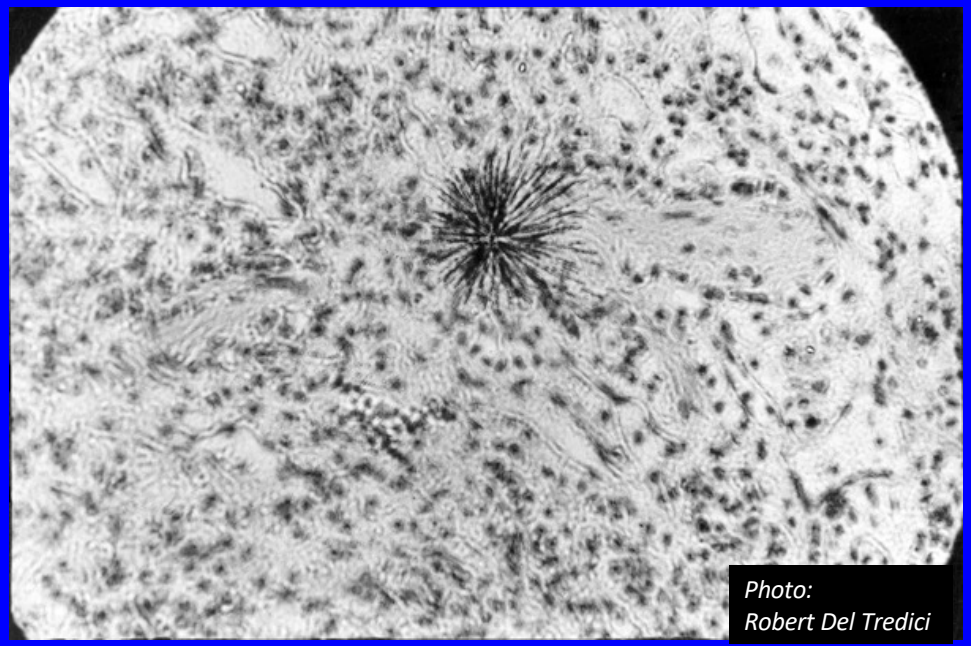
FACTS:

- **radioactivity cannot be turned off**

- the **half-life** is how long it takes for half the atoms to disintegrate

- the unit of radioactivity is the ”becquerel” – **one becquerel is one disintegration per second.**

Viewed through a microscope, here is an alpha-emitting speck of material in the lung tissue of an ape



Tracks of alpha particles emitted during a 48-hour period.
Any of the damaged cells may later become lung cancer – or not.

radionuclide (common name)	initial activity (becquerels)	half-life (years)
americium-241	60.4 billion	433
americium-243	52.6 million	7.36 thousand
carbon-14	1.71 trillion	5.7 thousand
chlorine-36	3.97 billion	301 thousand
cobalt-60	90.6 quadrillion	4.25
cesium-135	519 million	2.3 million
cesium-137	5.59 trillion	30
hydrogen-3 (tritium)	891 trillion	12.3
iodine-129	30.3 billion	15.7 million
molybdenum-93	147 thousand	4 thousand
niobium-94	23.4 billion	20.3 thousand
nickel-59	1.21 billion	76 thousand
nickel-63	311 billion	101
neptunium-237	17.4 million	2.14 million
plutonium-239		24.1 thousand
.....	87.7 billion	
plutonium-240		6.65 thousand
plutonium-241	1.67 trillion	14
plutonium-242	63.2 million	375 thousand
radium-226	38.5 billion	1.8 thousand
selenium-79	92.6 million	327 thousand
silver-108m	27.3 billion	438
strontium-90	6.05 trillion	29
technetium-99	316 billion	211 thousand
thorium-230	5.3 billion	75.4 thousand
thorium-232	27 billion	14 billion
tin-126	124 million	230 thousand
uranium-233	274 million	159 thousand
uranium-234	68.8 billion	246 thousand
uranium-235	2.96 billion	704 million
uranium-238	75.7 billion	4.47 billion
zirconium-93	492 billion	1.61 million

Here are the 31 Radionuclides listed by CNL for the "Near Surface Disposal Facility" NSDF

("The Chalk River Megadump")

- radioactivity ("activity") is measured in "becquerels": one becquerel is one disintegration per second.
- a billion becquerels indicates that 1,000,000,000 atoms are disintegrating each and every second. That's a thousand million disintegrations per second.
- 21 of these 31 radionuclides have half-lives of more than 5,000 years, longer than the pyramids ….
- 13 of these radionuclides have half-lives of more than 100,000 years – longer than all human records.
- The Megadump has an expected life of only 550 years.

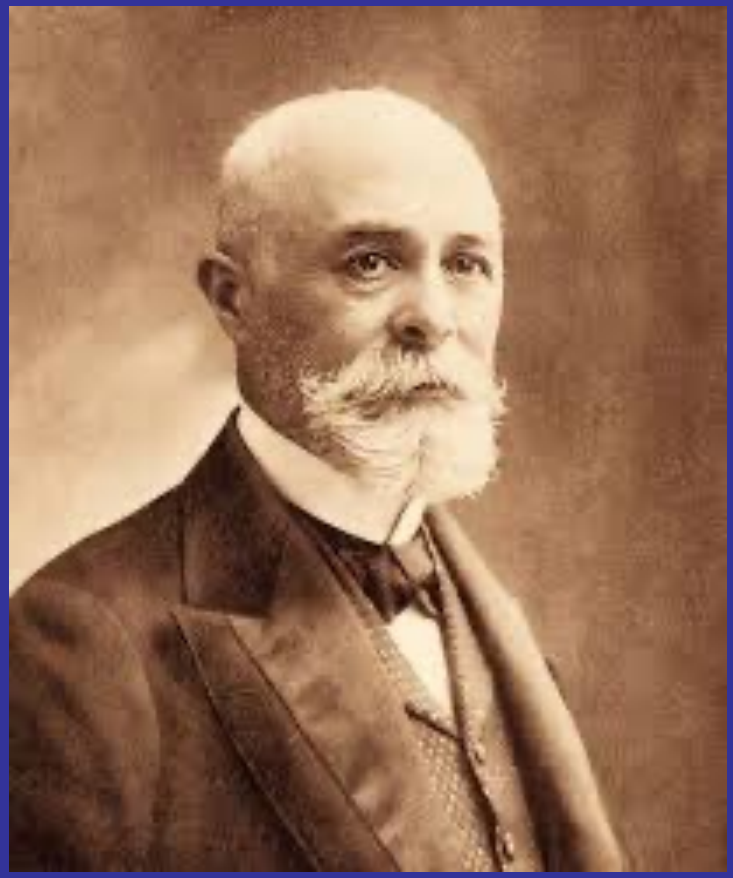
Note: A trillion is a thousand billions; a quadrillion is 1000 trillions.

PART 2

THE DISCOVERY OF RADIOACTIVITY

AND

THE HARMFUL EFFECTS OF IONIZING RADIATION



Henri Becquerel 1896

discovered radioactivity of uranium & thorium
~ invisible energy given off ceaselessly ~

1896

Radioactivity

- invisible energy from ores
- exposes photographic plates
- causes “ionization”
- causes radiation burns
- **cannot be shut off**

In a “cloud chamber” you can see the tracks of radioactive emissions from uranium ore.
Enough energy given off in a few 1000 years to destroy the Earth ~ but no obvious trigger at hand…

Marie Curie 1898

Marie Curie discovered other radioactive materials – radium and polonium – byproducts of uranium – as well as radon gas

We now know that uranium atoms disintegrate, giving off ionizing radiation, and changing into a series of other unstable elements.

The byproducts are called the "progeny" of "decay products" of uranium.

Each disintegration creates a new element called a "decay product"
(they are also called "progeny")

Uranium has a long "decay chain" with about two dozen progeny

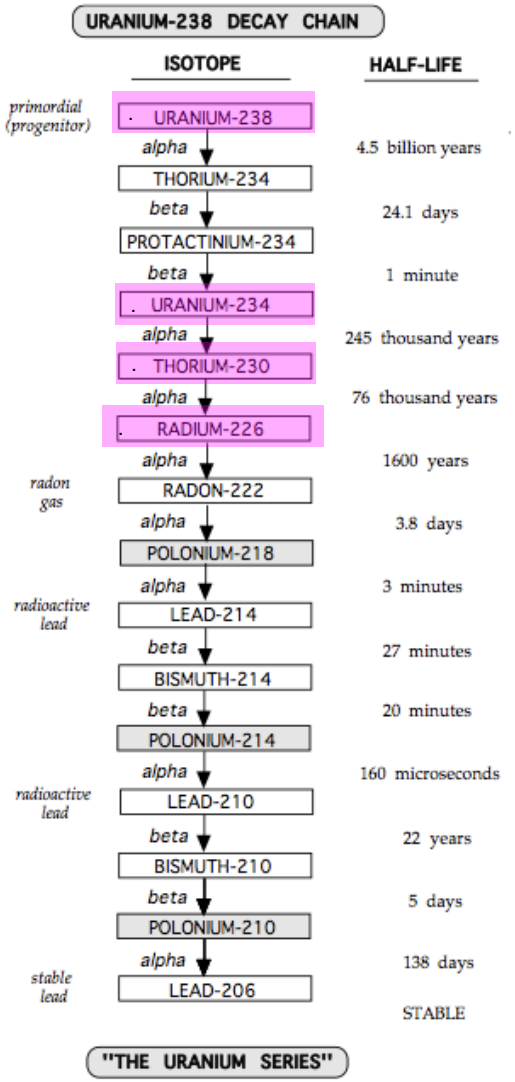
Every decay product is much more toxic than uranium itself

There are 13 radionuclides that are created when uranium-238 atoms disintegrate – they are called "uranium progeny"

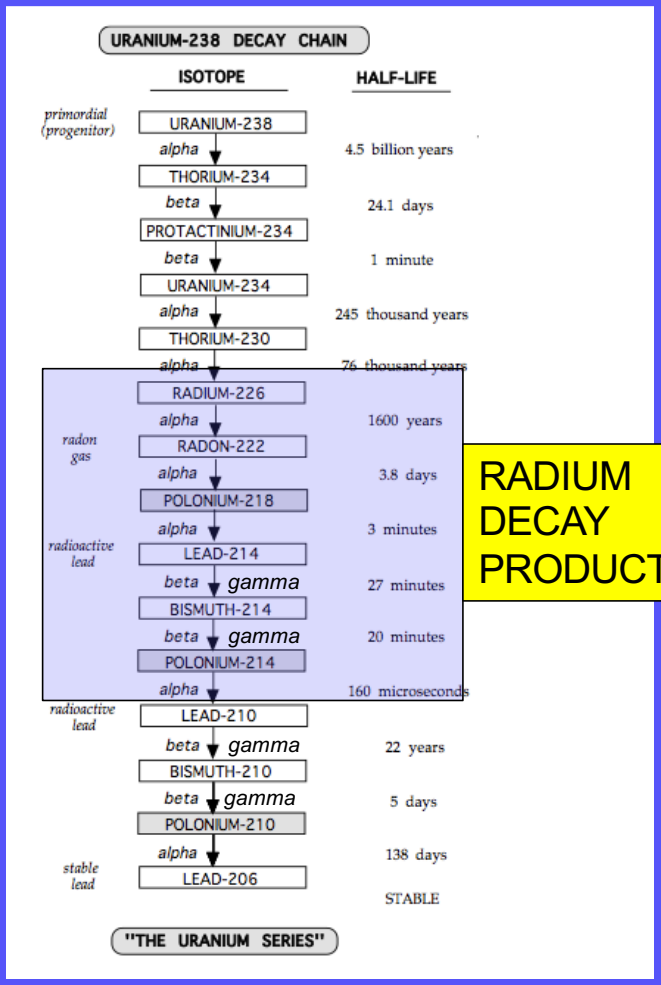
Sometimes they are called "decay products" of uranium-238.

The last decay product, lead-206, is not radioactive.

Critique of EIS for Matoush Project: Violating the Directives on Radioactivity

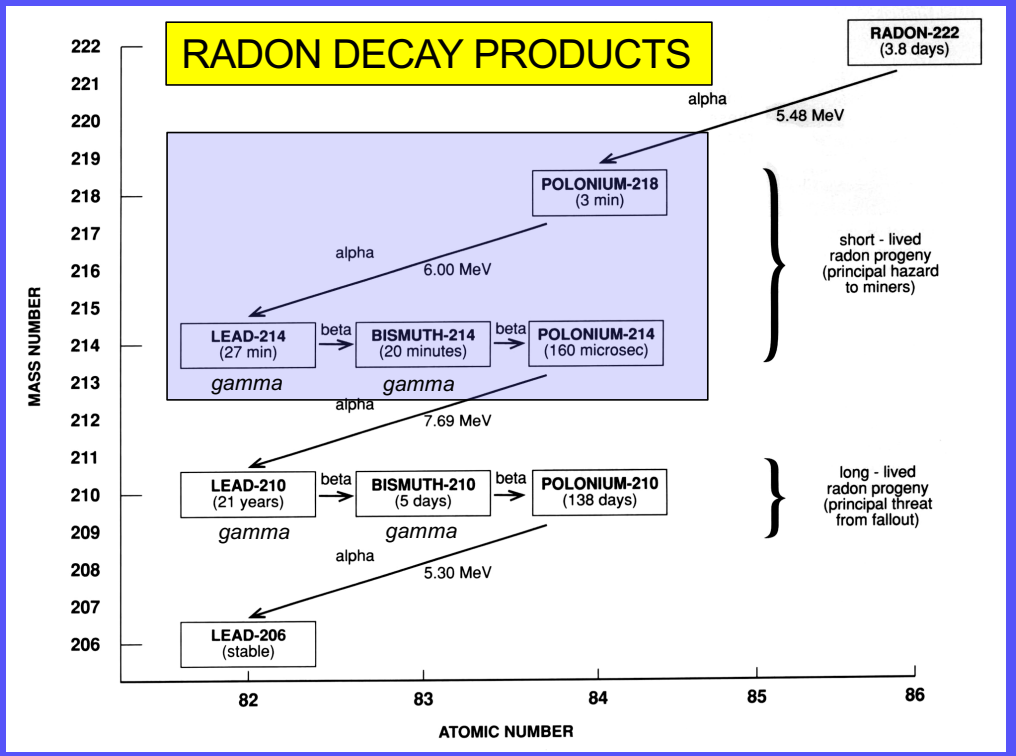


ONLY FOUR OF THESE RADIONUCLIDES ARE LISTED IN THE NSDF INVENTORY, BUT THEY WILL ALL SHOW UP AS TIME GOES BY.



RADIUM DECAY PRODUCTS

Radium and radon are mainly alpha emitters, but they both produce gamma-emitters lead-214 and bismuth-214 and alpha-emitting polonium isotopes. It doesn't take long!



Buried radium-226 will become 6 times more radioactive in just a month because of decay products.

Henri Becquerel got a nasty radiation burn from radium in his shirt pocket – very difficult to heal.

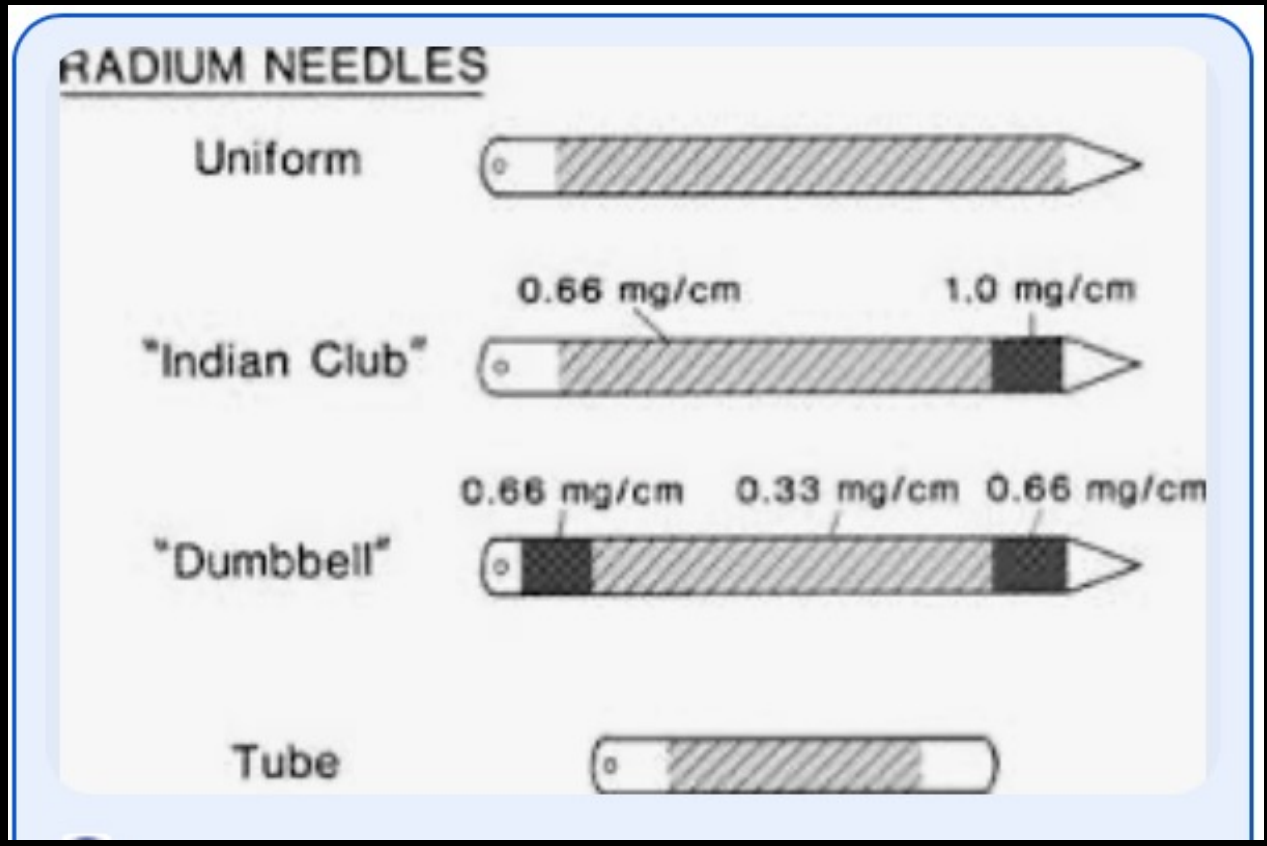
Marie Curie realized that the harmful “burning” of nuclear radiation can be used to kill solid cancers.

From 1910 on, radium needles became a preferred treatment for shrinking solid tumours.

Radium disintegrates and produces gamma-emitting “decay products”.

PROBLEM: Radium has a half-life of 1600 years!!

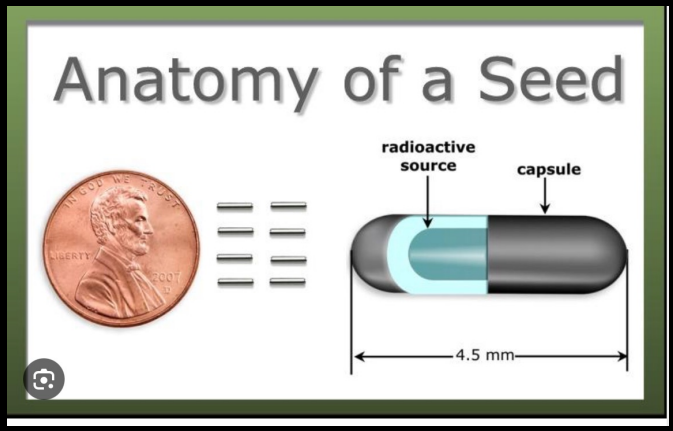
What to do with the leftovers? (maybe send them to Chalk River?)



Since 1925, “radon gas” (a decay product of radium) was used instead – it has a half-life of 3.8 days, and it produces the same gamma-emitting decay products.

The radon gas is sealed inside a “seed” that can then be injected into a solid tumour.

You still get radioactive waste – lead-210 has a 22 year half-life and is quite dangerous.



These are examples of radon seed injectors used at that time.

NOTE: Radon has a 3.8 day half-life; it’s all gone in a few months (but lead-210 remains!)

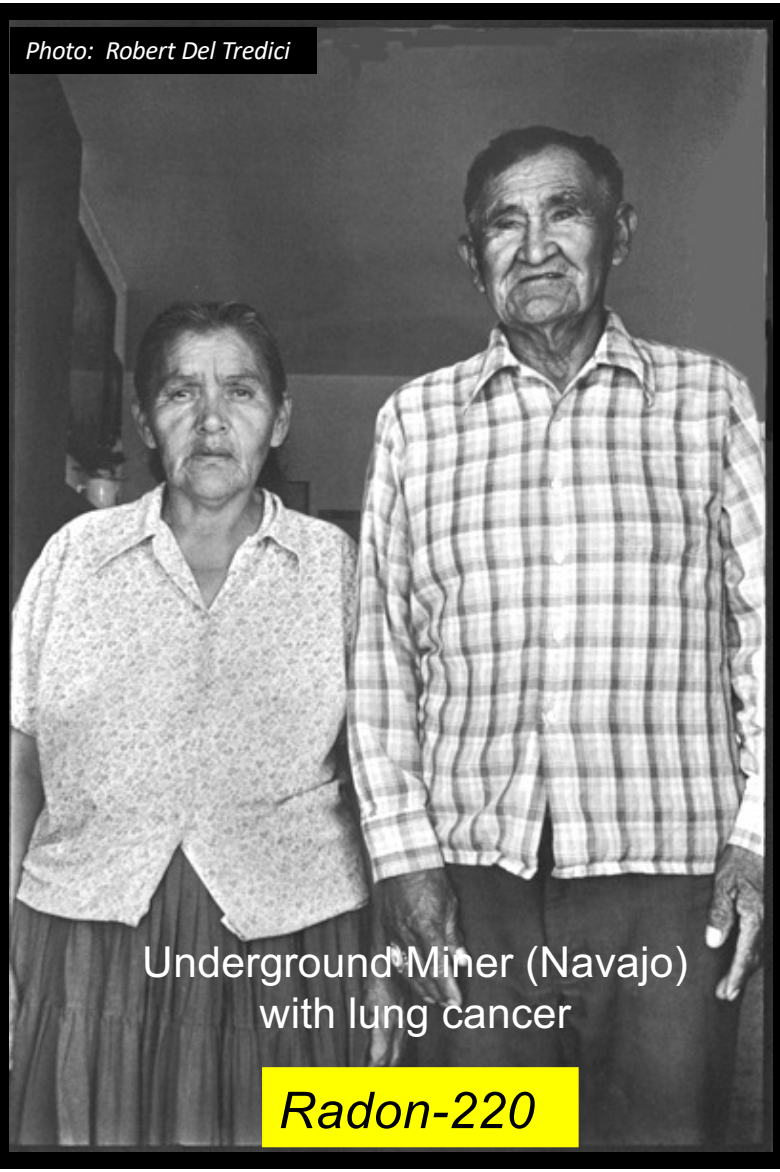
Radium Dial Painters 1920

radium-226

Girls hired to use radium-based paint to coat numerals on dials to make them glow in the dark …

… ingested minute amounts of radium when they licked the tips of their brushes to get a very fine point .

Many deaths from
- *Fatal anemias*
- *Bone cancers*
- *Head cancers*



- radioactive **radon gas** is produced when radium atoms disintegrate

- radon is the leading cause of **lung cancer** among non-smokers

- radon causes lung cancers and other lung diseases in **uranium miners**

- radon gas deposits solid **radioactive materials** in lung tissue

- radon is seven times **heavier than air** and travels great distances in a light breeze …

Alexander Litvinenko 2006

polonium-210

murdered by polonium poisoning in London England
(a very tiny amount of polonium added to a cup of tea)

polonium is chemically similar to potassium – it attaches itself to the **red blood** corpuscles … damaging **soft organs** …

polonium is 250 billion times **more toxic than hydrogen cyanide** …

polonium is produced by the **disintegration of radon** atoms …

Photo: Robert Del Tredici

The Stanrock uranium tailings at Elliot Lake. Behind this wall of radioactive waste, 10 metres high, there is a lake of the same stuff.

When uranium is mined, 85 percent of the radioactivity in the ore is left behind in the wastes called “tailings”.

Canada has about 225 million tons of radioactive sandy tailings, with an effective half-life of 76,000 years.

All of the uranium decay products are left behind in the tailings. It will take 76,000 years for each of them to be reduced by half.

radionuclide
(common name)

americium-241
americium-243
carbon-14
chlorine-36
cobalt-60
cesium-135
cesium-137
hydrogen-3 (tritium)
iodine-129
molybdenum-93
niobium-94
nickel-59
nickel-63
neptunium-237
plutonium-239
.....
plutonium-240
plutonium-241
plutonium-242
radium-226
selenium-79
silver-108m
strontium-90
technetium-99
thorium-230
thorium-232
tin-126
uranium-233
uranium-234
uranium-235
uranium-238
zirconium-93

NATURALLY OCCURRING RADIONUCLIDES

Six of the radionuclides listed for inclusion in the Megadump are naturally occurring isotopes of uranium, thorium, and radium.

All the rest are human-made radionuclides.

HOWEVER, the list does not include the radioactive progeny of these natural radionucldes, including **radioactive radon gas and radioactive varieties of bismuth, lead, and polonium**.

Each of these materials will be about 6 to 13 times more radioactive after burial because of the inevitable build-up of the radioactive decay products

All of the uranium and thorium and radium in the Megadump Inventory came from outside Chalk River – likely from Port Hope.

Port Hope started as a private company (1930) profiting from the sale of radium. Later, from 1941 to 1965 Port Hope sold uranium for US bombs; since then uranium from Port Hope has been sold for peaceful purposes.

Some of the most radiotoxic contamination from Port Hope (radium) was brought to Chalk River in the mid-1970s (just to get it “out of town”).

There is a $2.6 billion dollar radioactive cleanup going on in Port Hope for many years, as hundreds of homes and properties were contaminated.

PART 3

THE DISCOVERY OF NUCLEAR FISSION

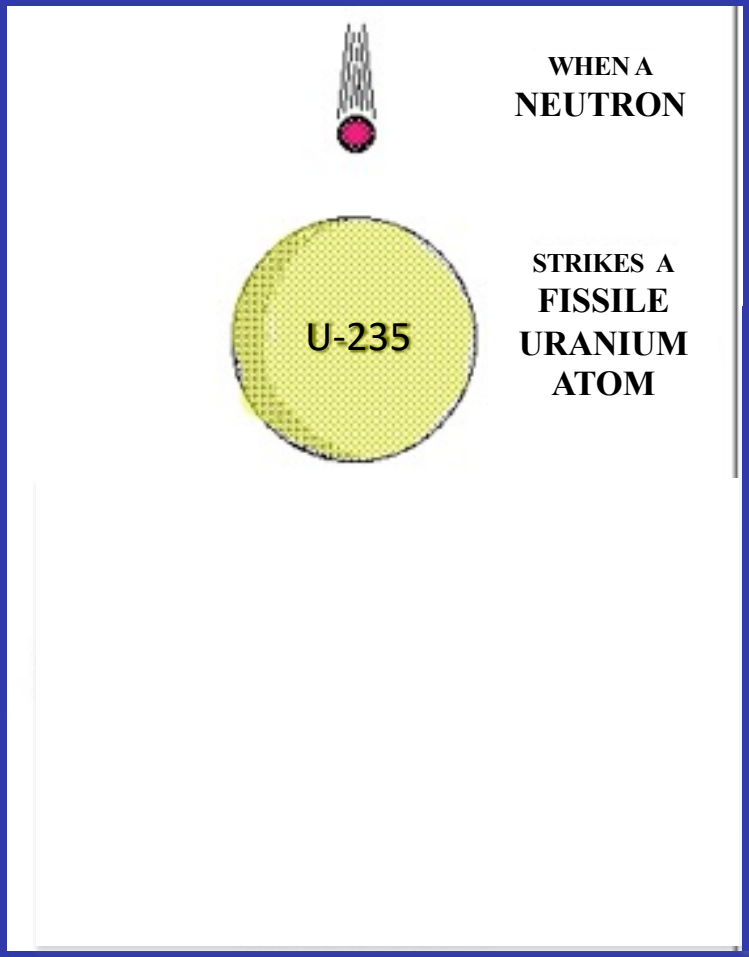
AND

THE CREATION OF HUMAN-MADE RADIONUCLIDES

What is Nuclear Fission?

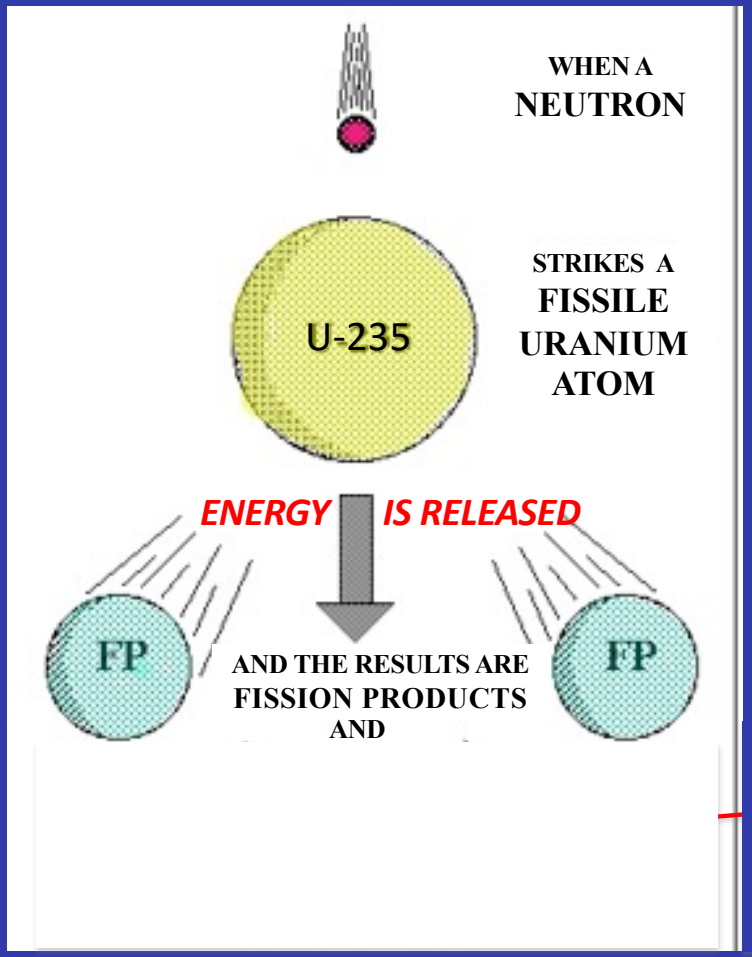
1938-39

THE NEUTRON IS THE "TRIGGER" NEEDED TO GET A LOT OF ENERGY ALL AT ONCE!!



A subatomic projectile called a neutron starts a nuclear chain reaction by splitting a nucleus of "fissile uranium" (U-235).

Splitting the Nucleus



1938-39

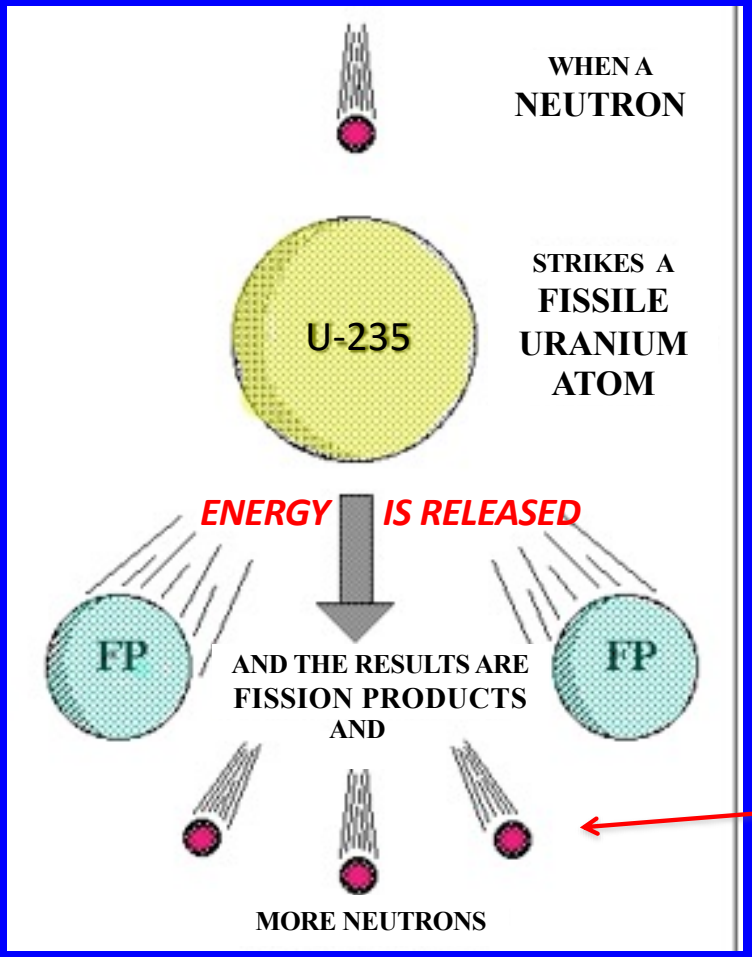
A subatomic projectile called a neutron starts a nuclear chain reaction by splitting a nucleus of "fissile uranium" (U-235).

The atom splits into two smaller atoms and energy is released – along with 2 or 3 extra neutrons.

The 2 smaller atoms are new radioactive materials called "fission products".

Chain Reaction

1938-39



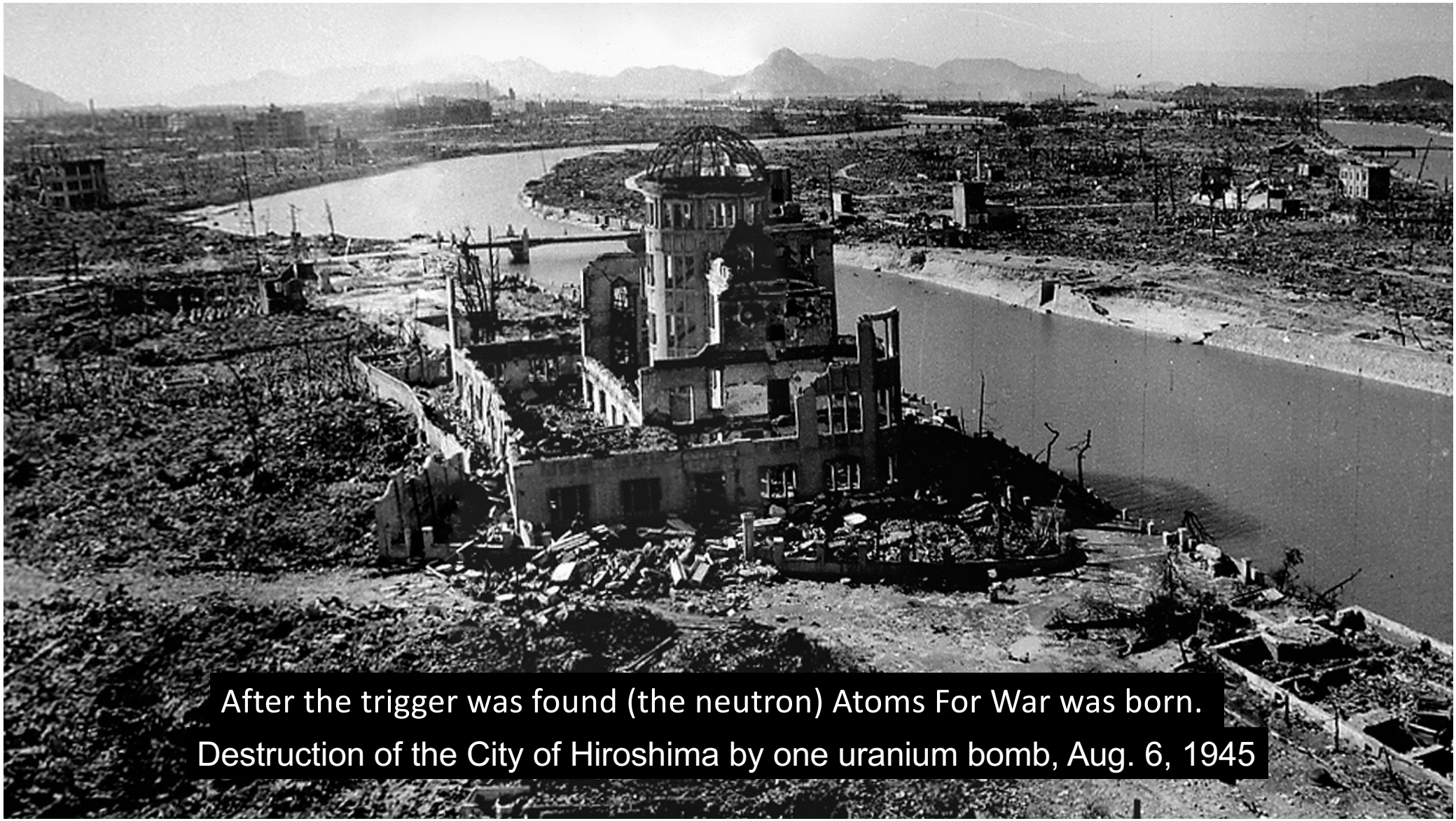
The atom splits into fragments In hundreds of different ways.

The broken pieces are highly toxic radioactive atoms that constitute the bulk of the waste in the used nuclear fuel.

More neutrons trigger more fissions, and some go on to produce more radioactive byproducts.

What do the extra neutrons do?

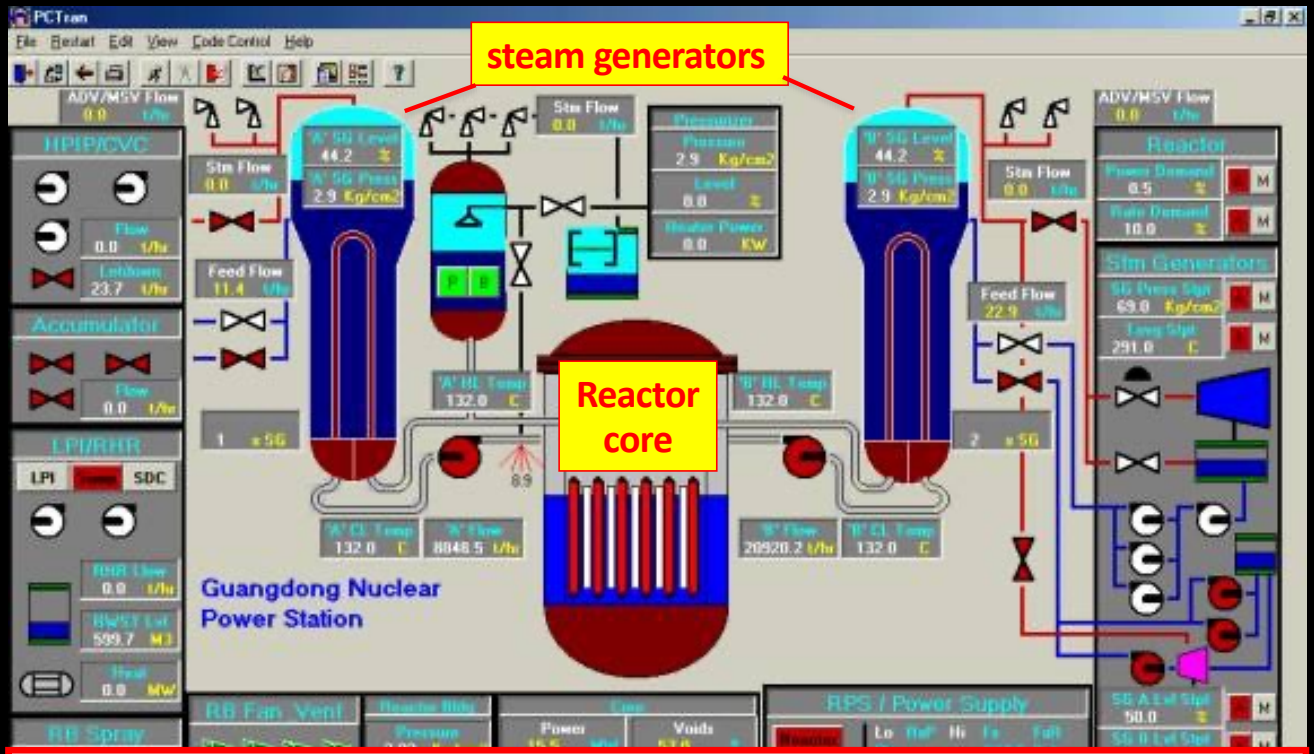
- *They keep producing fission products*
- *They turn some uranium into plutonium*
- *They "activate" everything in the core*



After the trigger was found (the neutron) Atoms For War was born.

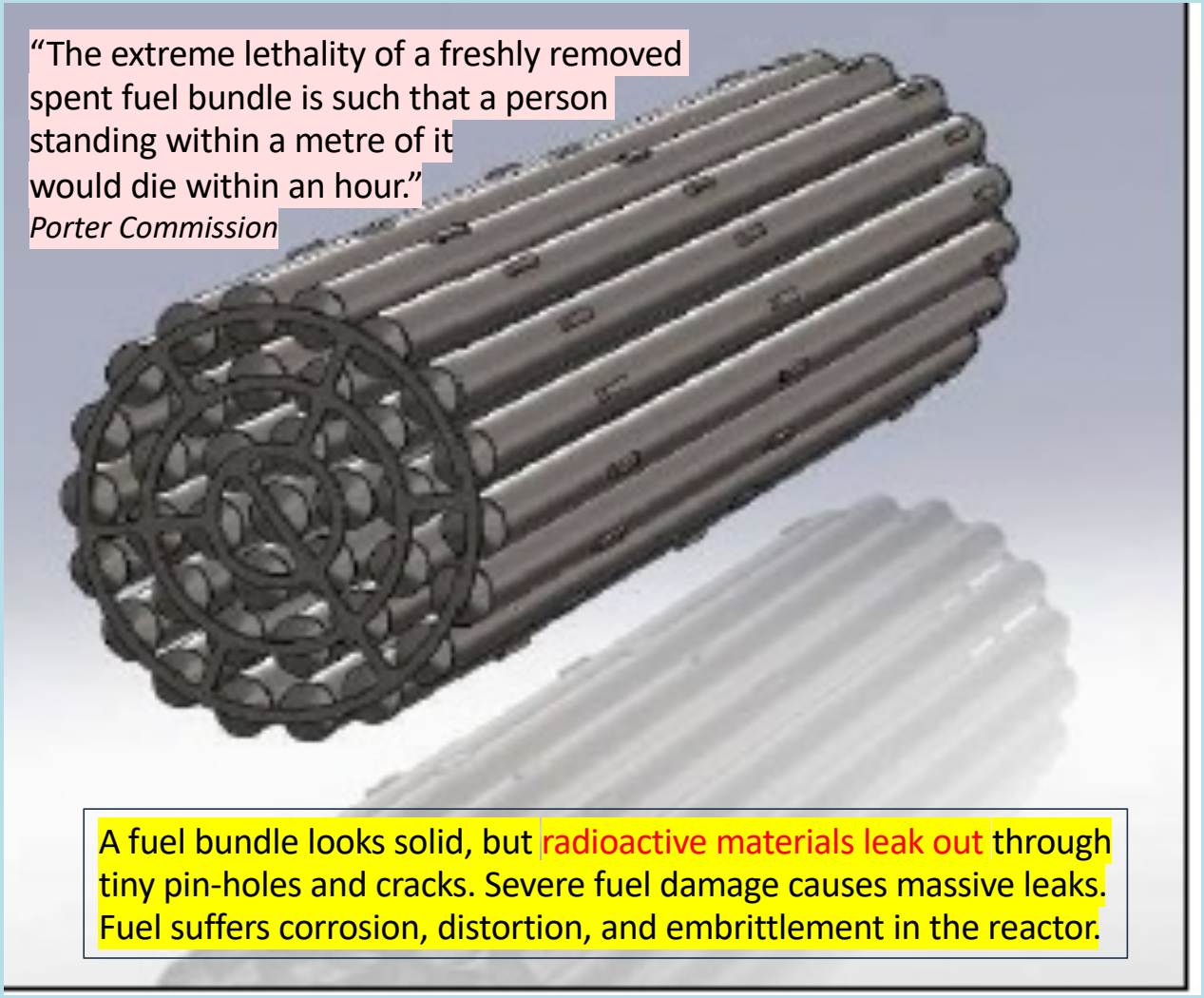
Destruction of the City of Hiroshima by one uranium bomb, Aug. 6, 1945

"Atoms for Peace" came later – boiling water to make electricity.



1. In the core, uranium atoms are split, releasing heat.
2. The heat boils water in vessels called steam generators
3. The steam is used to spin a turbine to generate electricity.
4. *Meanwhile **hundreds of unwanted radioactive byproducts are created**.*

How a nuclear reactor (PWR) works


"The extreme lethality of a freshly removed spent fuel bundle is such that a person standing within a metre of it would die within an hour."
Porter Commission
A fuel bundle looks solid, but radioactive materials leak out through tiny pin-holes and cracks. Severe fuel damage causes massive leaks. Fuel suffers corrosion, distortion, and embrittlement in the reactor.

WHAT DO THE EXTRA NEUTRONS DO?

New Radionuclides are created:

CLASS 1. TRANSURANICS

- *dozens of heavier-than-uranium elements*
- *most abundant is plutonium – extremely toxic*
- *plutonium is also a powerful nuclear explosive*
- *the first reactors made plutonium for bombs*

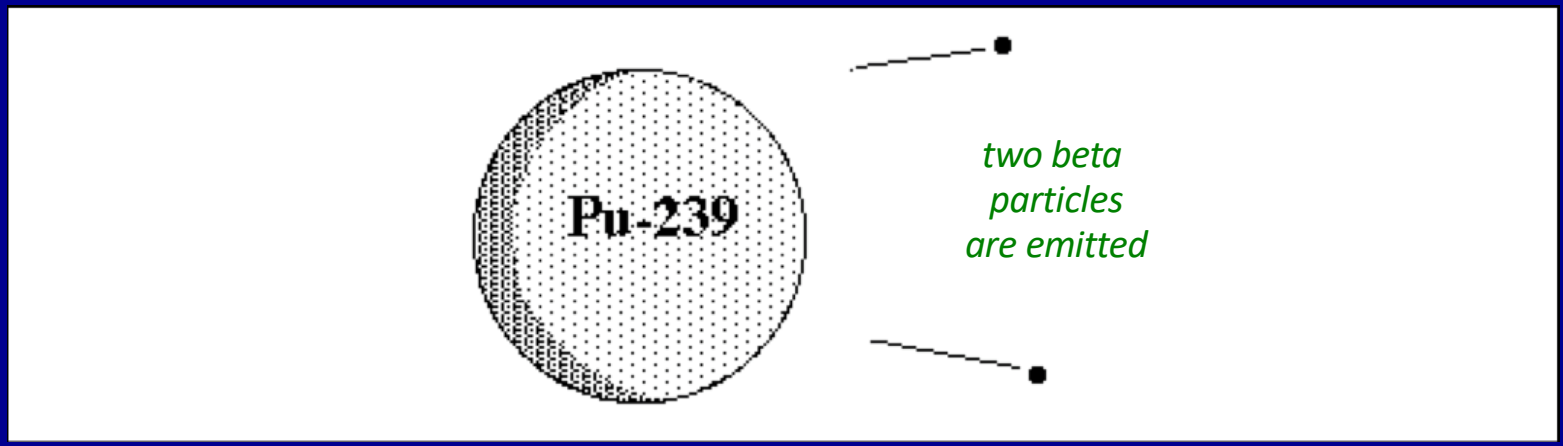
What do the extra neutrons do?

Creation of plutonium inside a nuclear reactor …

. . . when an atom of uranium-238 absorbs a neutron

Absorption of neutrons creates heavier ("transuranic") elements…

. . . it is transformed into an atom of **plutonium-239**



The first reactors were built to produce plutonium for bombs.

Other transuranic radionuclides are produced in a similar way.

radionuclide (common name)
americium-241
americium-243
carbon-14
chlorine-36
cobalt-60
cesium-135
cesium-137
hydrogen-3 (tritium)
iodine-129
molybdenum-93
niobium-94
nickel-59
nickel-63
neptunium-237
plutonium-239
.....
plutonium-240
plutonium-241
plutonium-242
radium-226
selenium-79
silver-108m
strontium-90
technetium-99
thorium-230
thorium-232
tin-126
uranium-233
uranium-234
uranium-235
uranium-238
zirconium-93

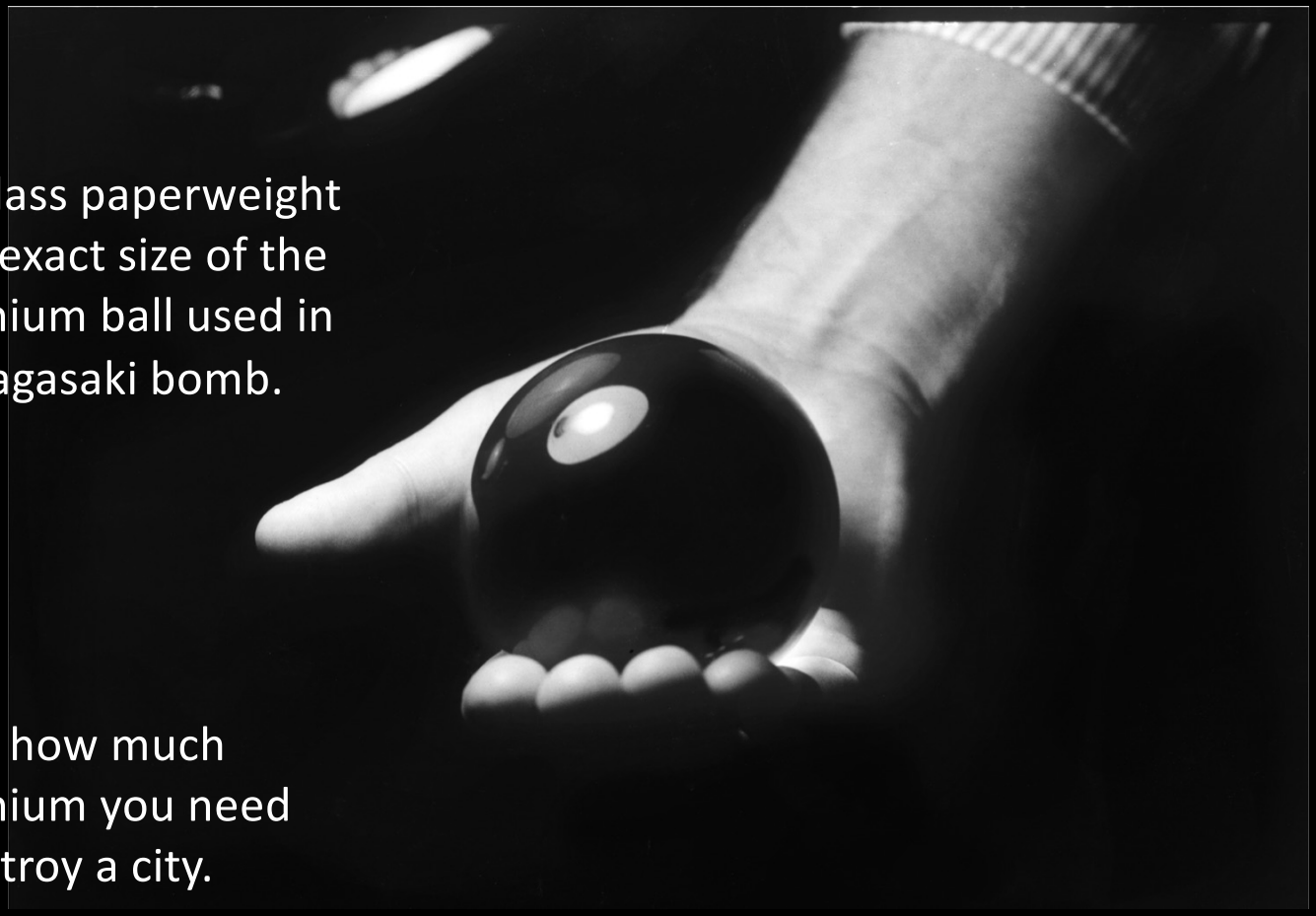
All of the transuranic radionuclides listed in the Megadump inventory came from used nuclear fuel bundles or “targets” taken from Chalk River Reactors.

The first reactors were built for the express prupose of producing plutonium for bombs. Plutonium became the backbone of the world’s nuclear arsenals during the Cold War. Canada sold plutonium to the US military for use in the US nuclear weapons program in order to finance the expensive nuclear research establishment at Chalk River.

None of these **extraordinarily radiotoxic** transuranic nuclides would be candidates for the Megadumpo if nuclear scientists had not extracted them from used nuclear fuel, creating 21 tanks of high-level liquid waste (high-level waste – too radioactive to go into the Megadump mound).

Uranium-233 is a human-made radionuclide not found in nature.
Like plutonium, it is an excellent nuclear explosive material for bombs.

This glass paperweight is the exact size of the plutonium ball used in the Nagasaki bomb.



That’s how much plutonium you need to destroy a city.

Photo: Robert Del Tredici

Howard Morland with a model of an H-bomb (thermonuclear bomb) showing the plutonium ball (called a “pit”).

This small fission bomb Is needed to raise the temperature to 100 million degrees so that nuclear fusion can start.

Photo: Robert Del Tredici

WHAT DO THE EXTRA NEUTRONS DO?

New Radionuclides are created:

CLASS 2. FISSION PRODUCTS

- *Hundreds of different radionucliudes*
- *Most were never seen in nature before 1940*
- *They can be very "radiotoxic" inside the body*
- *They are normally trapped in the fuel bundles*

radionuclide (common name)
americium-241
americium-243
carbon-14
chlorine-36
cobalt-60
cesium-135
cesium-137
hydrogen-3 (tritium)
iodine-129
molybdenum-93
niobium-94
nickel-59
nickel-63
neptunium-237
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silver-108m
strontium-90
technetium-99
thorium-230
thorium-232
tin-126
uranium-233
uranium-234
uranium-235
uranium-238
zirconium-93

All of the fission products slated for the Megadump inventory came from used nuclear fuel bundles or special irradiated “targets” in the Chalk River Reactors.

Radioactive fission products like molybdenum-199, iodine-131, xenon-133 and others were extracted from irradiated targets by dissolving the latter in nitric acid, producing a lot of highly radioactive liquid and solid waste

If these fission products had not been extracted from the used nuclear fuel they would not have been available to be “disposed of” in the Megadump.

In that case, the wastes are going into the Megadump because those who made the profits are not required to take responsibility for the wastes.

Radioactive Materials are chemical substances which are also radioactive.

They all have their own unique pathways through the environment and through the human body.

IONIZING RADIATION

THYROID
iodine–131
beta (gamma) ; 8 days

SKIN
sulphur–35
beta ; 87 days

LIVER
cobalt–60
beta (gamma) ; 5 years

OVARIES
iodine–131
beta (gamma) ; 8 days
cobalt–60
beta (gamma) ; 5 years
krypton-85
gamma ; 10 years
ruthenium–106
gamma ; 1 year
zinc–65
gamma ; 245 days
barium–140
gamma ; 13 days
potassium–42
gamma ; 12 hours
cesium–137
gamma ; 30 years
plutonium–239
alpha ; 24 000 years

MUSCLE
potassium–42
gamma ; 12 hours
cesium–137
gamma ; 30 years

LUNGS
radon–222 (and whole body)
alpha ; 3,8 days
uranium–233 (et os)
alpha ; 162 000 years
plutonium–239 (and bone)
alpha ; 24 000 years

SPLEEN
polonium–210 (and whole body)
alpha ; 138 days

KIDNEYS
uranium–238 (and bone)
alpha ; 4 500 000 years
ruthenium–106
gamma (beta) ; 1 year

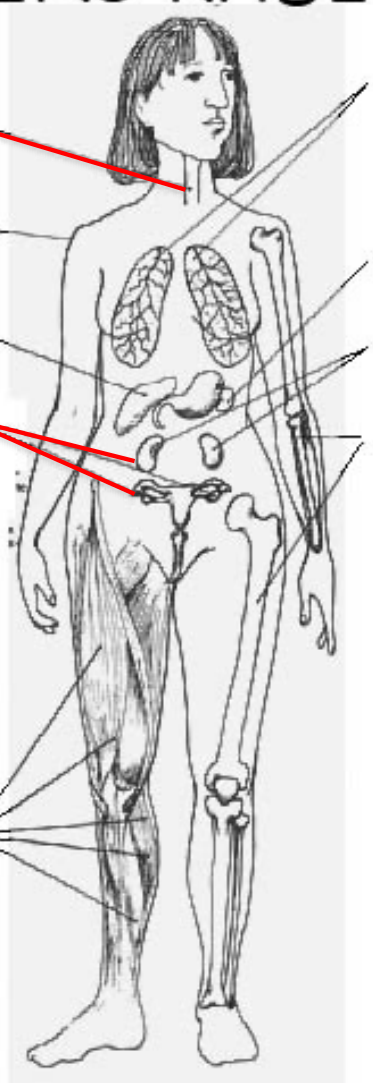
BONE
radium–226
alpha ; 1 620 years
zinc–65
gamma ; 245 days
strontium–90
beta ; 28 years
yttrium–90
beta ; 64 hours
promethium–147
beta ; 2 years
barium–140
beta (gamma) ; 13 days
thorium–234
beta ; 24,1 days
phosphorus–32
beta ; 14 days
carbon–14 (and fat)
beta ; 5 600 years

Iodine-129 goes to the thyroid gland (in the throat) and damages it

thyroid cancer, mental retardation, and stunted growth can result

young children are especially at risk

IONIZING RADIATION



THYROID
iodine–131
beta (gamma) ; 8 days

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plutonium–239
alpha ; 24 000 years

MUSCLE
potassium–42
gamma ; 12 hours
cesium–137
gamma ; 30 years

LUNGS
radon–222 (and whole body)
alpha ; 3,8 days
uranium–233 (et os)
alpha ; 162 000 years
plutonium–239 (and bone)
alpha ; 24 000 years

SPLEEN
polonium–210 (and whole body)
alpha ; 138 days

KIDNEYS
uranium–238 (and bone)
alpha ; 4 500 000 years
ruthenium–106
gamma (beta) ; 1 year

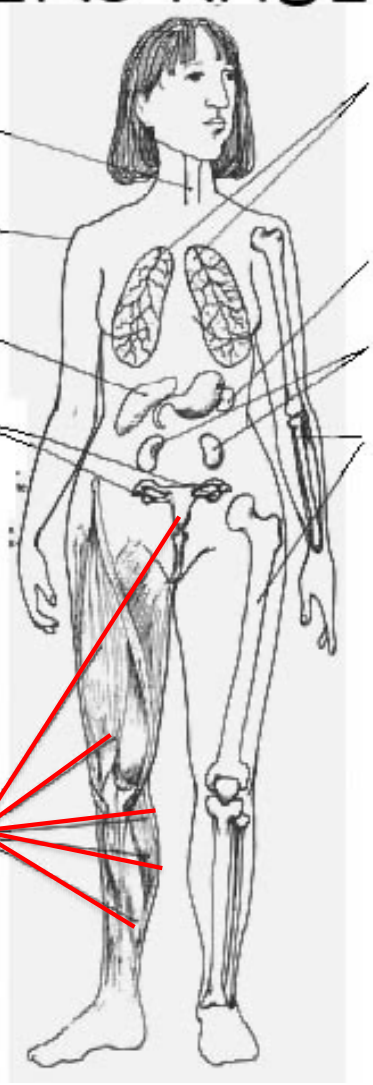
BONE
radium–226
alpha ; 1 620 years
zinc–65
gamma ; 245 days
strontium–90
beta ; 28 years
yttrium–90
beta ; 64 hours
promethium–147
beta ; 2 years
barium–140
beta (gamma) ; 13 days
thorium–234
beta ; 24,1 days
phosphorus–32
beta ; 14 days
carbon–14 (and fat)
beta ; 5 600 years

Cesium-137
goes to the
soft tissues

it makes meat unfit for human consumption

it stays in the food chain for decades

IONIZING RADIATION



THYROID
iodine–131
beta (gamma) ; 8 days

SKIN
sulphur–35
beta ; 87 days

LIVER
cobalt–60
beta (gamma) ; 5 years

OVARIES
iodine–131
beta (gamma) ; 8 days
cobalt–60
beta (gamma) ; 5 years
krypton-85
gamma ; 10 years
ruthenium–106
gamma ; 1 year
zinc–65
gamma ; 245 days
barium–140
gamma ; 13 days
potassium–42
gamma ; 12 hours
cesium–137
gamma ; 30 years
plutonium–239
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beta ; 2 years
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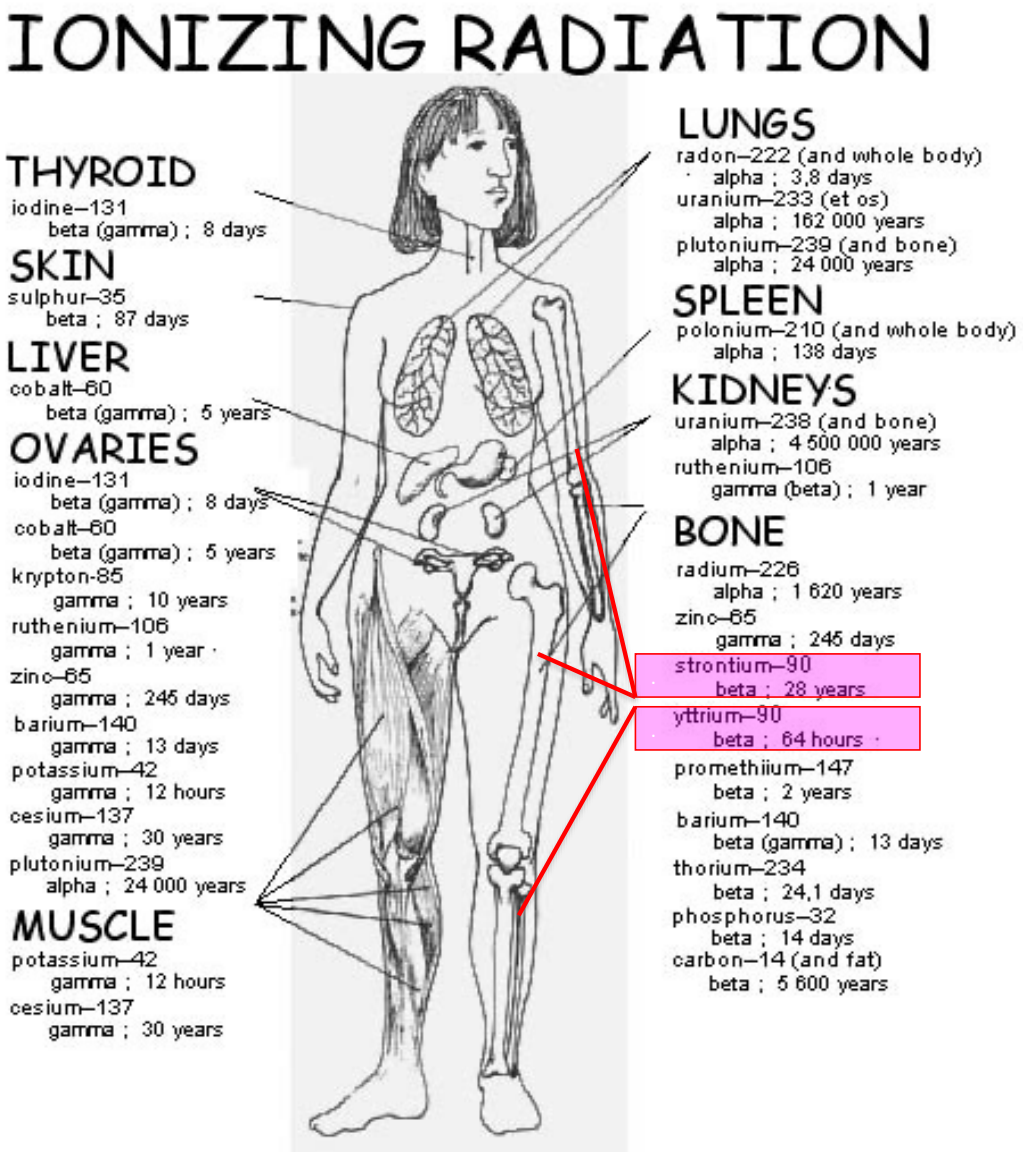
beta (gamma) ; 13 days
thorium–234
beta ; 24,1 days
phosphorus–32
beta ; 14 days
carbon–14 (and fat)
beta ; 5 600 years

Strontium-90 behaves like calcium; it goes to the bones, the teeth and mother´s milk

bone cancer or blood diseases may result



Atomic Radiation ~ Lessons from Science

Chronic exposure increases the incidence of cancer, leukemia, genetic damage, strokes, heart attacks, and low intelligence

BUT there is a “latency period” :

. . . the onset of disease occurs years or decades after exposure.

The targets of low-level radiation exposures are populations – communities of humans or groups of other living things.

Radioactive materials enter into the air, water and soil.
They get into fish, plants, animals, and humans.

A small fraction of the population will develop cancer, years later. Infants and children are especially vulnerable.

If a larger population is exposed to the same level of contamination, we say that the “population dose” is greater.

The greater the population dose, the more cases of adverse heath effects – like cancer – will be seen.

WHAT DO THE EXTRA NEUTRONS DO?

New Radionuclides are created:

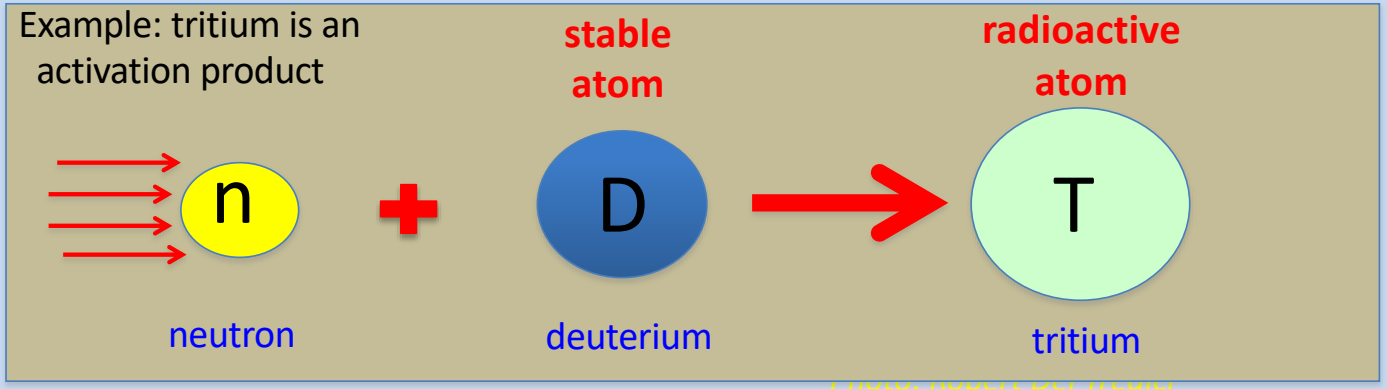
CLASS 3: ACTIVATION PRODUCTS

- *non-radioactive atoms become radioactive*
- *a stray neutron "destabilizes" a stable nucleus*
- *some radioisotopes are produced for sale*
- *cobalt-60, an intense gamma emitter, sells a lot*

What do the stray neutrons do?

Creation of "Activation Products"

When a stray neutron is absorbed by a non-radioactive atom the result is often a radioactive atom – an "activation product".



The diagram shows how a non-radioactive atom of deuterium becomes a radioactive atom of tritium when it absorbs a stray neutron.

radionuclide (common name)
americium-241
americium-243
carbon-14
chlorine-36
cobalt-60
cesium-135
cesium-137
hydrogen-3 (tritium)
iodine-129
molybdenum-93
niobium-94
nickel-59
nickel-63
neptunium-237
plutonium-239
.....
plutonium-240
plutonium-241
plutonium-242
radium-226
selenium-79
silver-108m
strontium-90
technetium-99
thorium-230
thorium-232
tin-126
uranium-233
uranium-234
uranium-235
uranium-238
zirconium-93

Here are nine radionuclides that are activation products. Some of them were produced for sale as commercial products (cobalt-60, tritium, carbon-14) but the profit-making companies do not accept responsibility for the radioactive wastes.

Some fission products listed here were also produced for commercial sales (cesium-137 for example). Technetium-99 was not produced for sale but it is the "decay product" of Molybdenum-99 (not listed here) which was one of the biggest selling radionuclides mass-produced as a fission product at Chalk River.

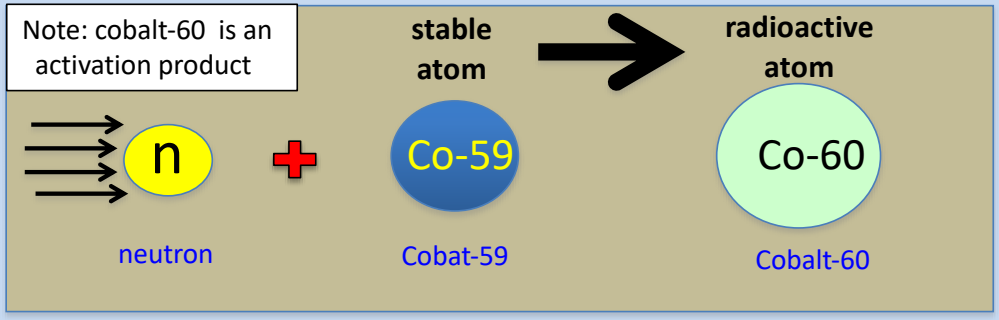
Carbon-14 has a half-life of 5,700 years. Chlorine-36 has a half-life of 300,000 Years. Cesium-135 has a half-life of over two million years. What is the justification for putting these extremely long-lived toxic wastes in a near-surface dump that has an expected lifetime of 550 years?

Tritium and carbon-14 are very mobile in the environment and will easily escape from the Megadump in the form of radioactive water molecules and radioactive carbon dioxide gas.

a marketable activation product

Cobalt-60 was sold for use in cancer therapy, but it is being replaced by non-radioactive cancer therapies.

Lots of cobalt-60 is still used to sterilize equipment (by killing Insects and micro-organisms), but that use is also being replaced by non-radioactive sterilization.



The diagram shows how a non-radioactive atom of cobalt-59 becomes a radioactive atom of cobalt-60 when it absorbs a stray neutron.

99 percent of the radioactivity in the Megadump (initially) is disused cobalt-60 sources

What gets activated?

Water is activated and produces radioactive tritium (T) (chemically identical to ordinary hydrogen, but radioactive)

Air is activated and produces radioactive carbon-14 (C-14).

All organic molecules have carbon and hydrogen in them, so these radioactive varieties become incorporated into our DNA.

Even the **structural materials** in the core area of the reactor become radioactive waste, dangerous for 1000s of years.

Steel, concrete, zirconium, and other materials are activated – so **cannot be recycled** – but must be stored as radioactive waste.

Impurities in the fuel and in the cladding are also activated.

Longevity of Some Activation Products

Radionuclide	Half-Life	Ten Half-Lives
Nickel-59,	76,000 years	760 thousand years
Nickel-63,	100 years	1 thousand years
Niobium-94,	20,300 years	203 thousand years
Chlorine-36,	301,000 years	3.01 million years
Calcium-41,	102,000 years	1.02 million years

The amount of radioactivity decreases by a factor of 1000 after 10 half-lives.

Data from the draft EIS, in-situ decommissioning of the Whiteshell WR-1 Reactor

Cobalt-60 is a very powerful emiiter of gamma rays.
Gamma rays are like x-rays but much more penetrating.

People have been killed by being too close to cobalt-60 since radioactivity cannot be detected by any of our human senses.

When cobalt-60 is put into the Megadump it will be in special 'sealed' packages, shielded to reduce worker exposures.
This is not really "low-level" radioactivity!

Cesium-137 emits gamma rays very similar to those of cobalt-60
The use of both of these radionuclides is being greatly reduced.

In the following picture notice how far away the cesium-137 is from the truck driver. That's to give him some protection.

Nationwide Recovery Of Radioactive Devices By Los Alamos National Lab Hits Major Milestone

October 2024: Off-Site Source Recovery Program removed a high-activity radioactive device. The truck departed the facility at 1:18 a.m. to minimize impacts to city roadways. Photo: LANL

SIDEBAR 1.2 Cesium Irradiator Replacement Project (CIRP)

CIRP is operated by the National Nuclear Security Administration (NNSA) and works with domestic users to facilitate voluntary replacement of cesium chloride and cobalt-60 blood and research irradiators with x-ray devices on a cost-share basis (typically 50 percent). Further CIRP financial incentives include removal and disposal of the cesium chloride or cobalt-60 device by NNSA with no cost to the owner.

There were approximately 750 cesium-137 irradiators (420 blood irradiators and 330 research devices) and 100 cobalt-60 (20 blood and 80 research) in the United States at the beginning of CIRP in 2015 (Itamura and Lieberman, 2020).

As of April 2021, CIRP has helped remove more than 165 cesium-137 irradiators, and another 150 irradiators were being scheduled for removal. The financial incentives offered by CIRP, powered by technological advancements that have improved the reliability of x-ray irradiation devices, have made the program successful in replacing cesium irradiators domestically.

When x-ray machines are turned off, they are harmless – there is no radioactive waste.
But radioactivity can't be turned off; so cobalt-60 & cesium-137 remain dangerous for decades

Is this sad Soviet experience a harbinger of things to come?

These young women have just learned that high-level liquid waste was dumped into the Techa River that flows past their village, decades ago, explaining a rash of diseases since.

The End

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