Rare Earths

and Radioactivity

a backgrounder prepared by
Dr. Gordon Edwards

Temiscamingue May 13 2014

Canadian Coalition for Nuclear Responsibility

www.ccnr.org

Fact #1

All Rare Earth Mining Produces Radioactive Wastes

Rare Earth Elements

There are 92 naturally occurring elements, listed according to the "atomic number", ranging from the lightest to the heaviest. Element number 1 is hydrogen. Element number 92 is uranium.

Uranium is radioactive, and it has two dozen "progeny" that are also radioactive. They are called the uranium "decay products".

Elements numbered 57 to 71 are called "rare earths". They are not radioactive, but they have a "chemical affinity" with uranium. (Elements 21 and 39 are also often considered to be rare earths.)

Wherever you find rare earths in nature, you find uranium as well. It is impossible to mine the rare earths without bringing uranium and its two dozen "decay products" to the surface.

The ore is radioactive even though the rare earths are not. So, when rare earths are mined, radioactive waste is left behind.

Rare Earth Elements (1)

Z	Symbol	Name	Etymology	Selected applications
21	Sc	Scandium	from Latin *Scandia* (Scandinavia).	Light aluminium-scandium alloys for aerospace components, additive in metal-halide lamps and mercury-vapor lamps,[4] radioactive tracing agent in oil refineries
39	Y	Yttrium	after the village of Ytterby, Sweden, where the first rare earth ore was discovered.	Yttrium aluminium garnet (YAG) laser, yttrium vanadate (YVO_4) as host for europium in TV red phosphor, YBCO high-temperature superconductors, yttria-stabilized zirconia (YSZ), yttrium iron garnet (YIG) microwave filters,[4] energy-efficient light bulbs,[5] spark plugs, gas mantles, additive to steel
57	La	Lanthanum	from the Greek "lanthanein", meaning *to be hidden*.	High refractive index and alkali-resistant glass, flint, hydrogen storage, battery-electrodes, camera lenses, fluid catalytic cracking catalyst for oil refineries
58	Ce	Cerium	after the dwarf planet Ceres, named after the Roman goddess of agriculture.	Chemical oxidizing agent, polishing powder, yellow colors in glass and ceramics, catalyst for self-cleaning ovens, fluid catalytic cracking catalyst for oil refineries, ferrocerium flints for lighters
59	Pr	Praseodymium	from the Greek "prasios", meaning *leek-green*, and "didymos", meaning *twin*.	Rare-earth magnets, lasers, core material for carbon arc lighting, colorant in glasses and enamels, additive in didymium glass used in welding goggles,[4] ferrocerium firesteel (flint) products.
60	Nd	Neodymium	from the Greek "neos", meaning *new*, and "didymos", meaning *twin*.	Rare-earth magnets, lasers, violet colors in glass and ceramics, didymium glass, ceramic capacitors
61	Pm	Promethium	after the Titan Prometheus, who brought fire to mortals.	Nuclear batteries

Rare Earth Elements (2)

Z	Symbol	Name	Etymology	Selected applications
62	Sm	Samarium	after mine official, Vasili Samarsky-Bykhovets.	Rare-earth magnets, lasers, neutron capture, masers
63	Eu	Europium	after Europe.	Red and blue phosphors, lasers, mercury-vapor lamps, fluorescent lamps, NMR relaxation agent
64	Gd	Gadolinium	after Johan Gadolin (1760–1852), to honor his investigation of rare earths.	Rare-earth magnets, high refractive index glass or garnets, lasers, X-ray tubes, computer memories, neutron capture, MRI contrast agent, NMR relaxation agent, magnetostrictive alloys such as Galfenol, steel additive
65	Tb	Terbium	after the village of Ytterby, Sweden.	Green phosphors, lasers, fluorescent lamps, magnetostrictive alloys such as Terfenol-D
66	Dy	Dysprosium	from the Greek "dysprositos", meaning *hard to get*.	Rare-earth magnets, lasers, magnetostrictive alloys such as Terfenol-D
67	Ho	Holmium	after Stockholm (in Latin, "Holmia"), native city of one of its discoverers.	Lasers, wavelength calibration standards for optical spectrophotometers, magnets
68	Er	Erbium	after the village of Ytterby, Sweden.	Infrared lasers, vanadium steel, fiber-optic technology
69	Tm	Thulium	after the mythological northern land of Thule.	Portable X-ray machines, metal-halide lamps, lasers
70	Yb	Ytterbium	Ytterby, Sweden.	Infrared lasers, chemical reducing agent, decoy flares, stainless steel, stress gauges, nuclear medicine
71	Lu	Lutetium	after Lutetia, the city which later became Paris.	Positron emission tomography – PET scan detectors, high refractive index glass, lutetium tantalate hosts for phosphors

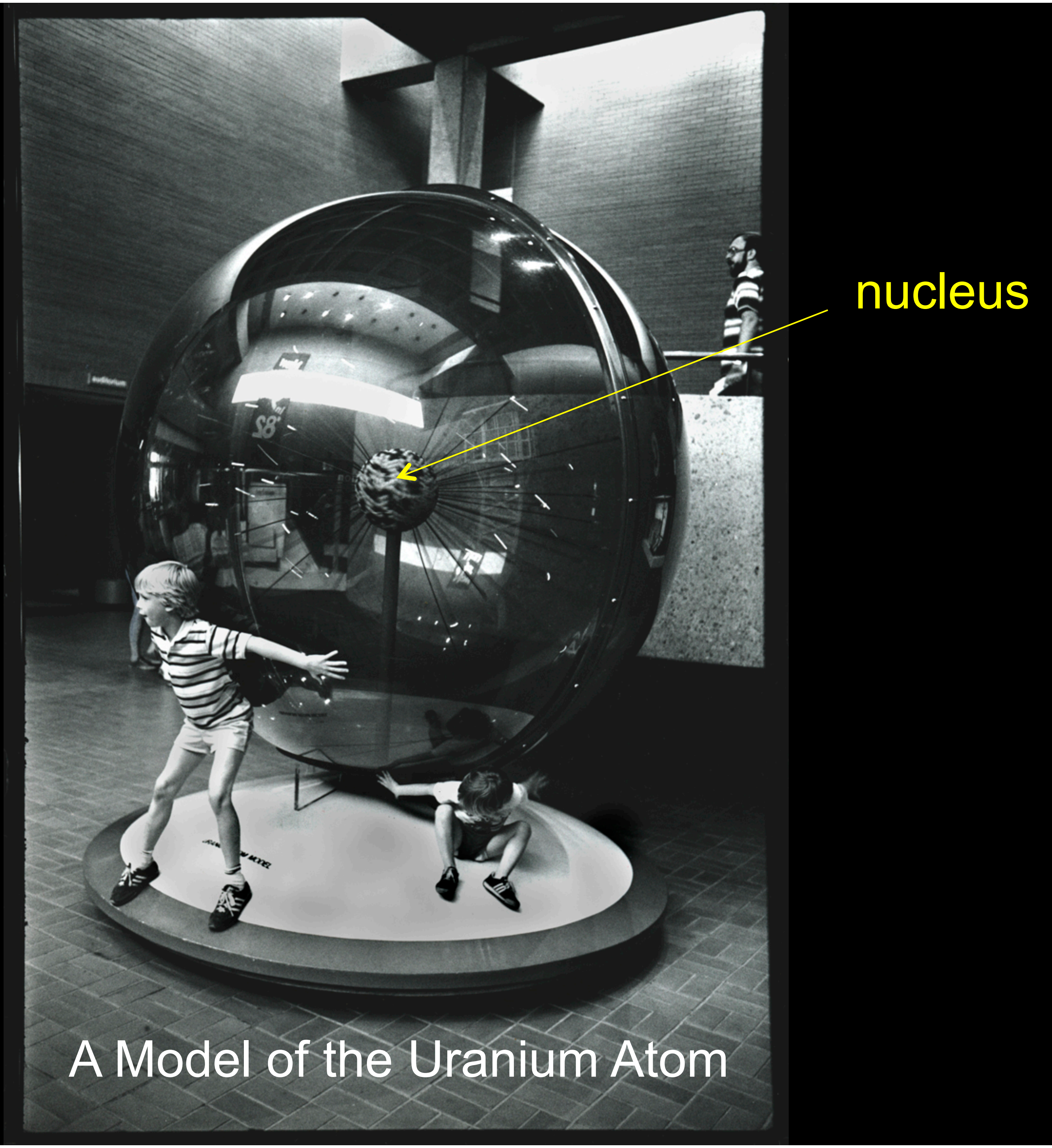
Radioactive Uranium and Thorium are always present in any ore that is rich in rare earths.

Warnings From the EPA

"Thorium-232 and Uranium-238 are rather benign, but some of the decay products can represent a danger to the environment due to the energetic particles and gamma rays released during radioactive decay.."

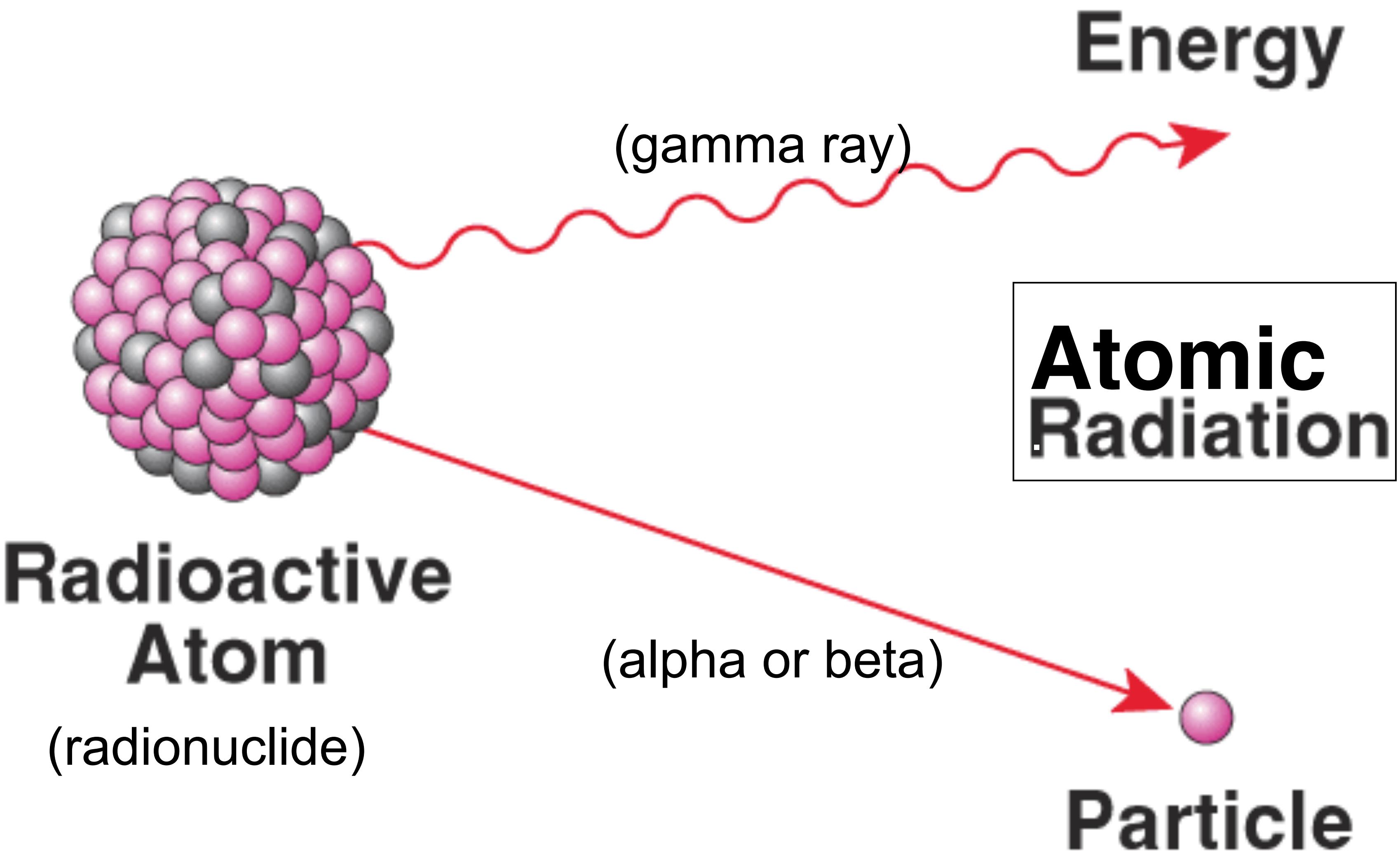
"If best management practices are not used and/or operations are not carefully monitored, rare earth element production may put human health and the environment at risk.."

US EPA, Investigating Rare Earth Element Mine Development, 2011


nucleus
A Model of the Uranium Atom

What is Radioactivity?

- Most materials have stable atoms (they *never* change).
- Radioactive materials have unstable atoms (they *will* change).
- Unstable atoms will **disintegrate** **(suddenly and violently)**.
- The moment of disintegration is when biological harm is done.
- One “becquerel” indicates one disintegration (decay) per second.
- The “half-life” is how long it takes for ½ the atoms to disintegrate.


Energy
(gamma ray)
Atomic Radiation
Radioactive Atom
(radionuclide)
(alpha or beta)
Particle

A gamma ray is like an x-ray, but more powerful.

highly penetrating

A beta particle is like a sub-atomic bullet.

moderately penetrating

An alpha particle is like a subatomic cannon ball.

not very penetrating

~ but extremely damaging! ~

Alpha and Beta particles are INTERNAL hazards.

What is a Decay Product?

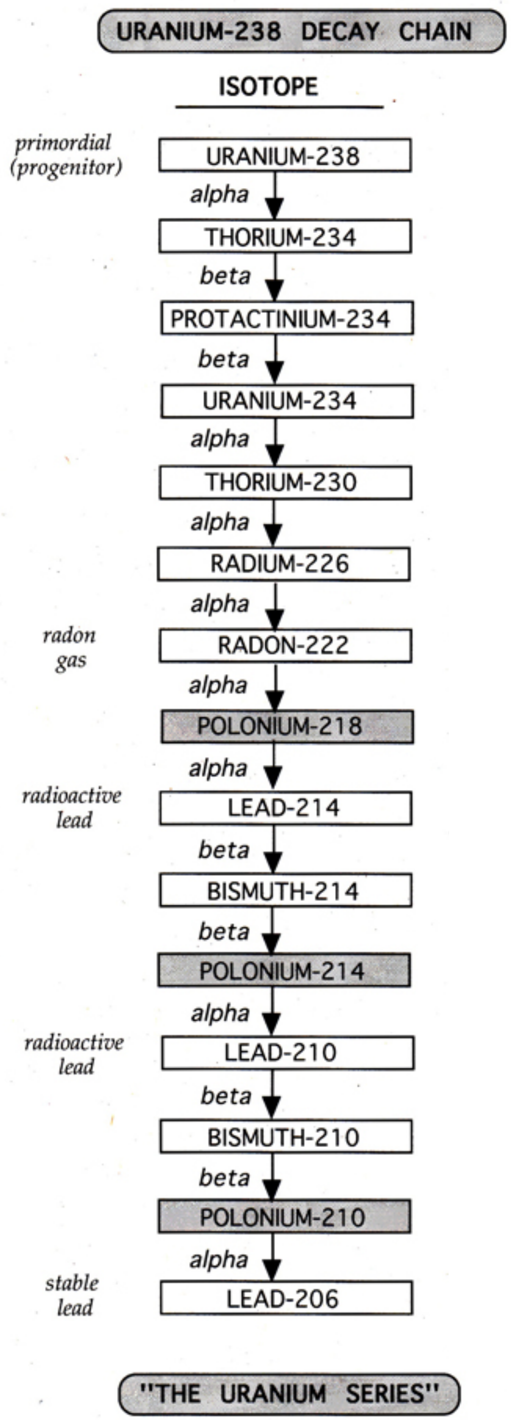
- ***When disintegration (decay) occurs, a radioactive atom becomes a new kind of atom – it is fundamentally altered***.

- So in a radioactive material, new atoms are being created; they are called “decay products” or “progeny”.

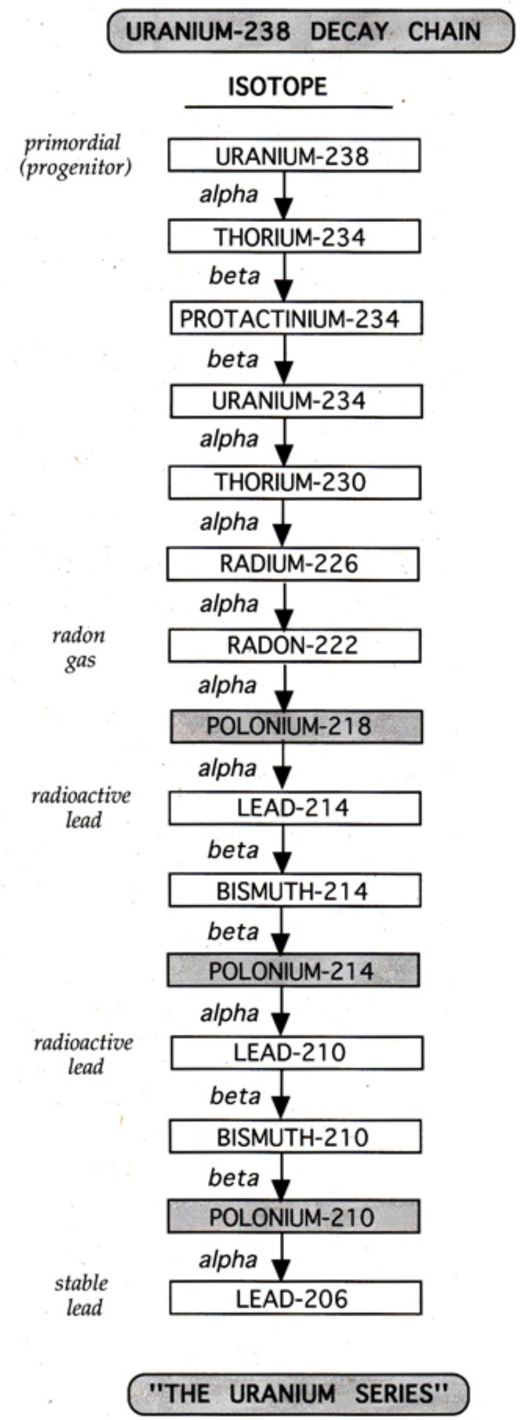
- If a given decay product is also radioactive, then it will have its own decay products, and so on and so on . . .

. . . this gives rise to a “decay chain” or “decay series”.

Here is the decay chain of uranium-238, the most common type of uranium found in nature



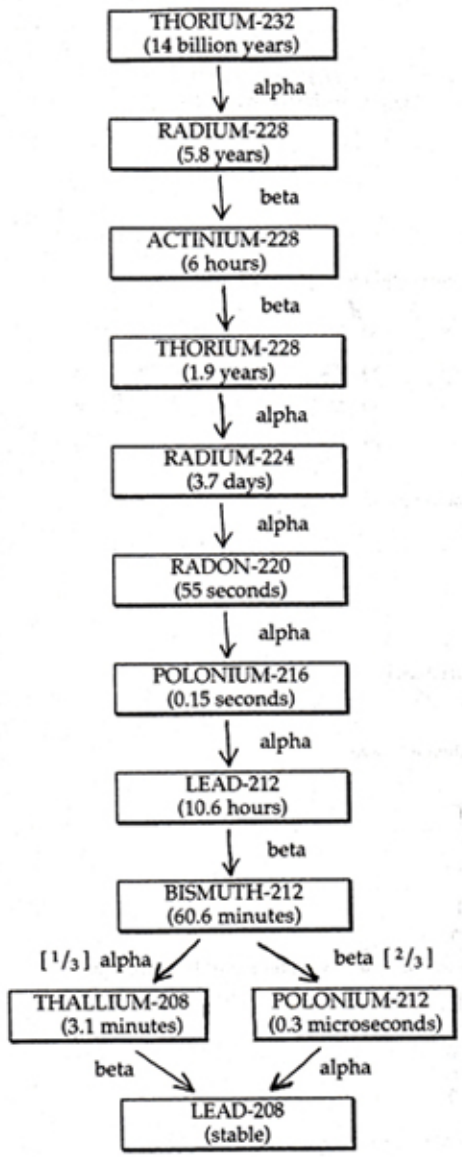
It´s like a family of radioactive elements – the great-great-great grandfather is uranium



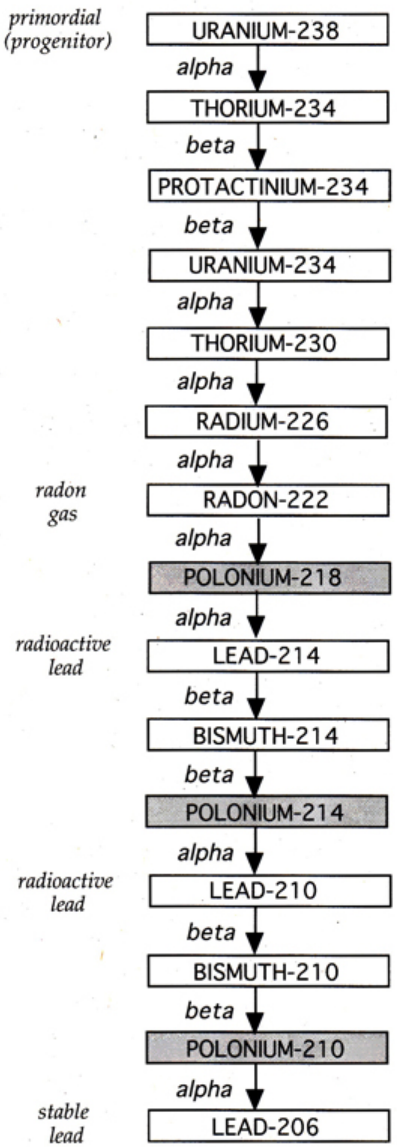
On a weight-by-weight basis, all of the uranium decay products are much more radioactive and much more dangerous than uranium itself.

The 3 types of polonium are most dangerous of all.

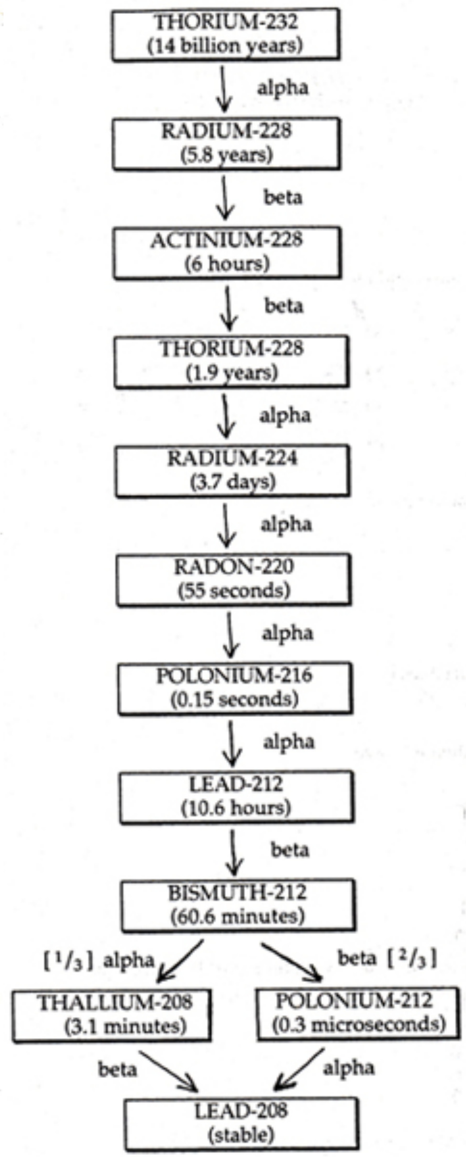
THORIUM
SERIES



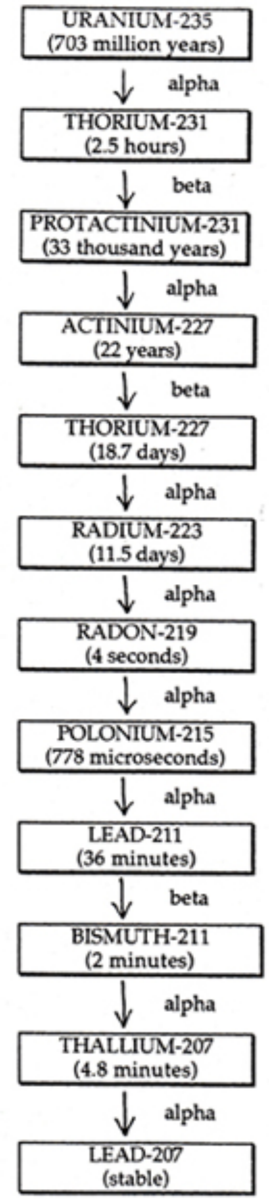
URANIUM SERIES



THORIUM SERIES



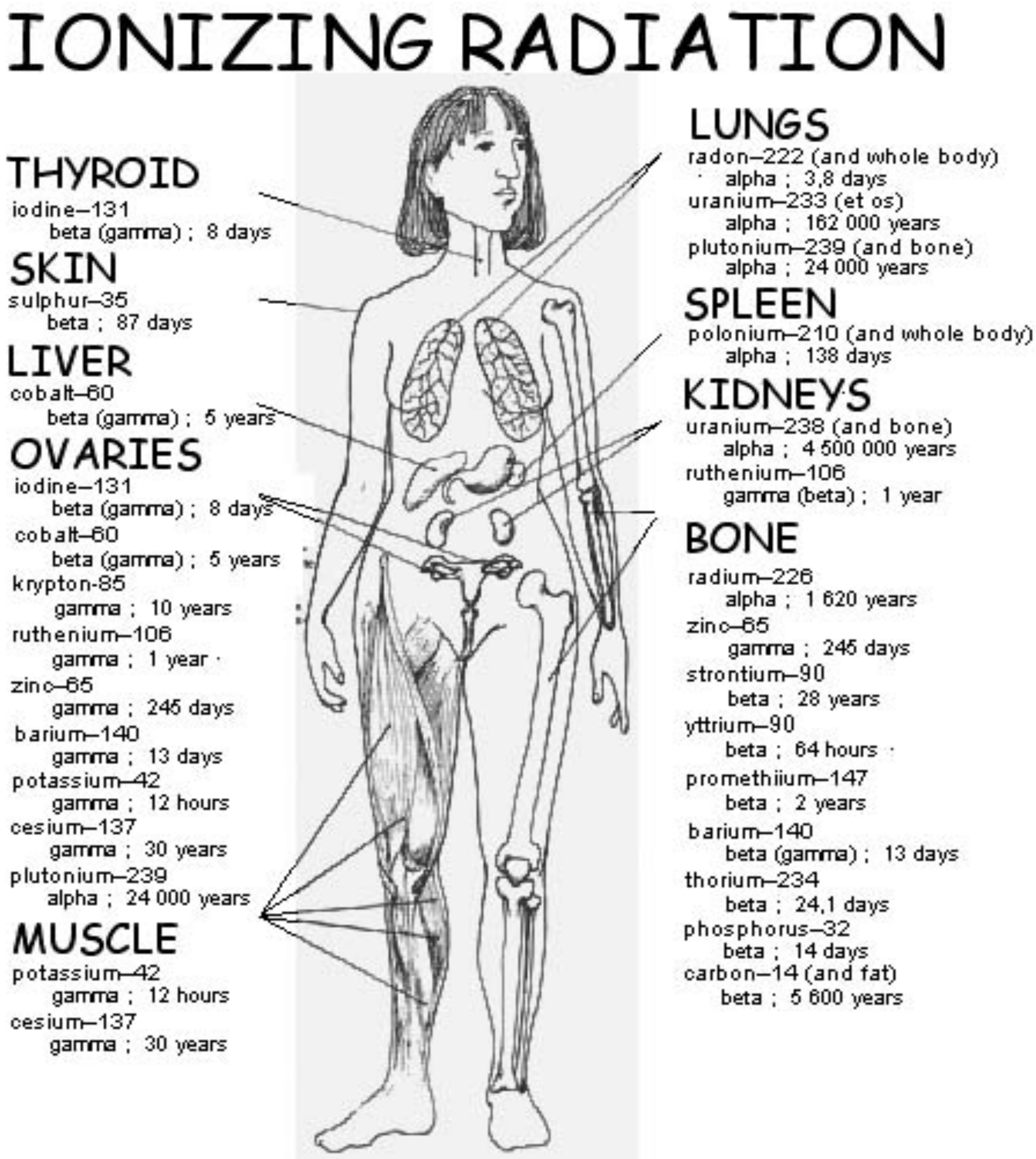
ACTINIDE SERIES



Fact #2

Radioactive
Mine Residues
Are A Health Danger

Radionuclides are chemical substances which are also radioactive.

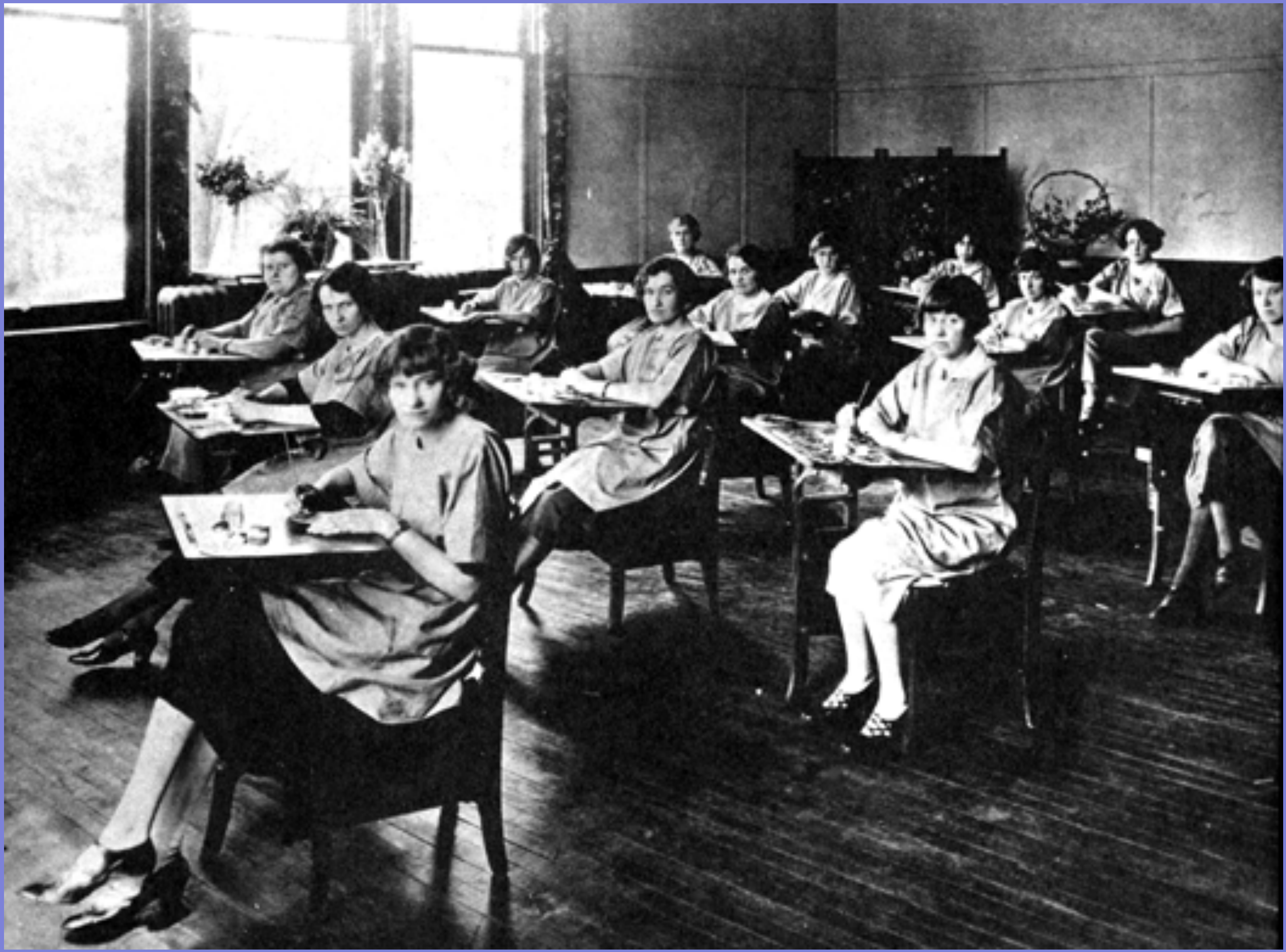


Uranium Decay Products

1. Radium - the silent killer

Canadian Coalition for Nuclear Responsibility

www.ccnr.org



Dial Painters 1920

Radium-226

Radium, like calcium, goes to bones & teeth.

Dial painters suffered from

Phase 1: Fatal anemia (blood disease)
Phase 2: Bone cancers (skeletal damage)
Phase 3: Head cancers (sinuses and mastoid)

Phase 3 : radon gas is produced in the bones by radium disintegration -- then carried by the blood to the head where the radioactive gas builds up.

In 1920s, radium sold for $100 000 per gram.
Now it is discarded as a waste byproduct.

BCMA: "Radium is a superb carcinogen"

Uranium Decay Products

2. Polonium - the deadliest element

Canadian Coalition for Nuclear Responsibility

www.ccnr.org

Alexander Litvinenko 2006

Polonium-210

Los Alamos National Laboratory's Chemistry Division

http://periodic.lanl.gov/elements/84.html

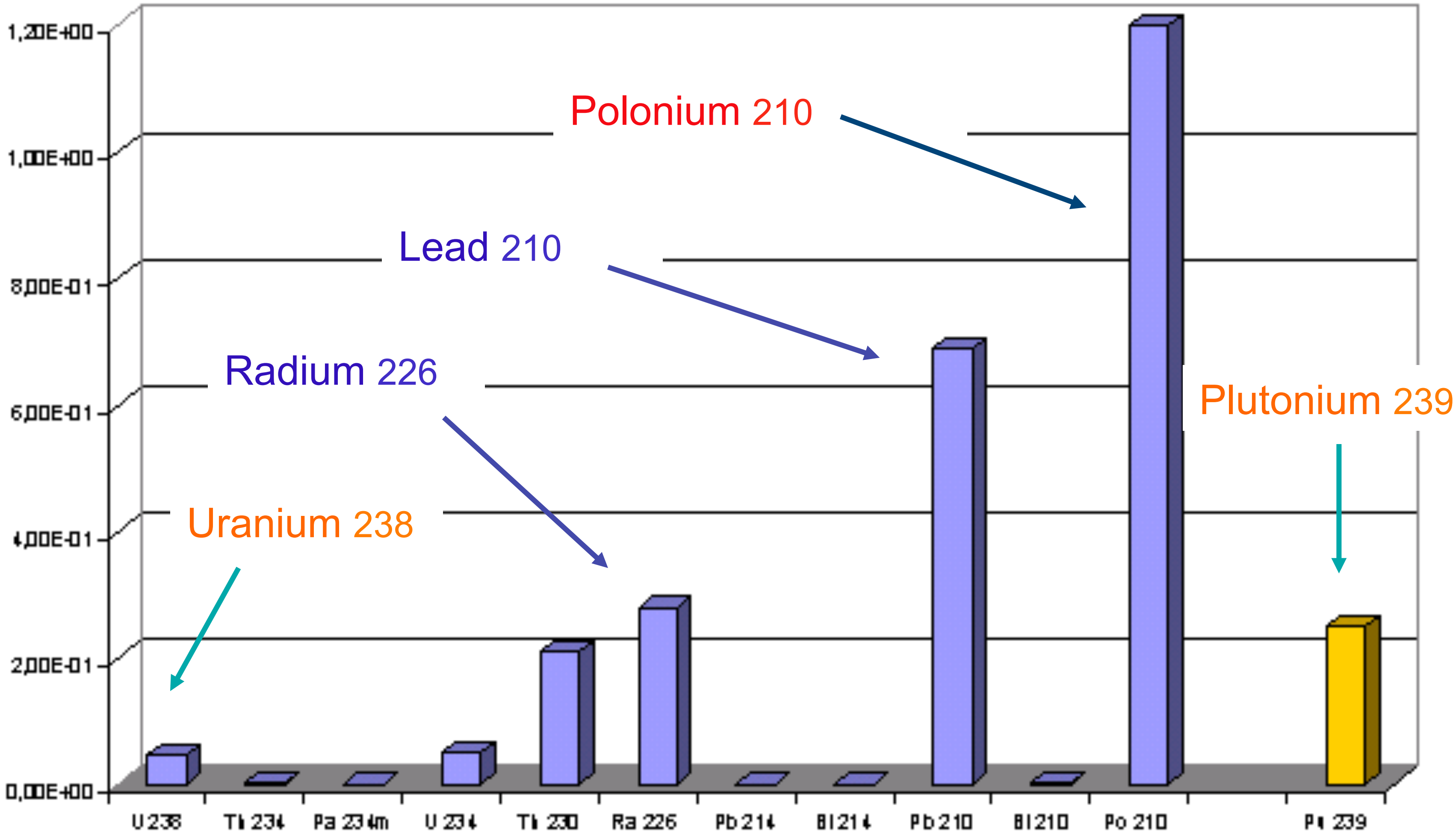
Polonium-210

Weight by weight

it is about **250 billion times**

as toxic as cyanide.

Dose Coefficients for an adult (ingestion) in microSieverts per Becquerel (official figures from EURATOM 96/29)



American Health Physics Society

Polonium-210

… is probably the cause of

up to **90 percent of the deaths**

attributed to tobacco.

(lung cancers, heart attacks, strokes)

Uranium Decay Products

3. Radon -
major public health hazard

Canadian Coalition for Nuclear Responsibility

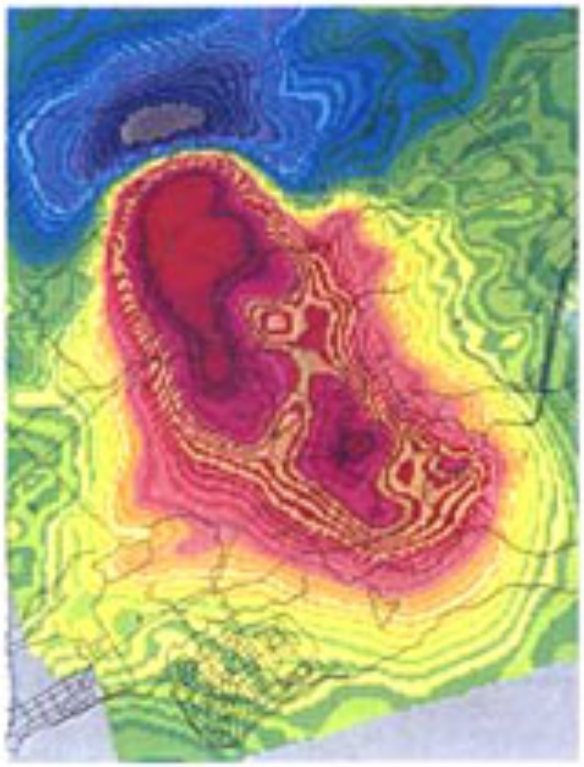
www.ccnr.org

RÉGIE RÉGIONALE
DE LA SANTÉ ET DES
SERVICES SOCIAUX
DES LAURENTIDES

la santé *mieux* pensée

LE RADON À OKA

Rapport d'intervention de santé publique



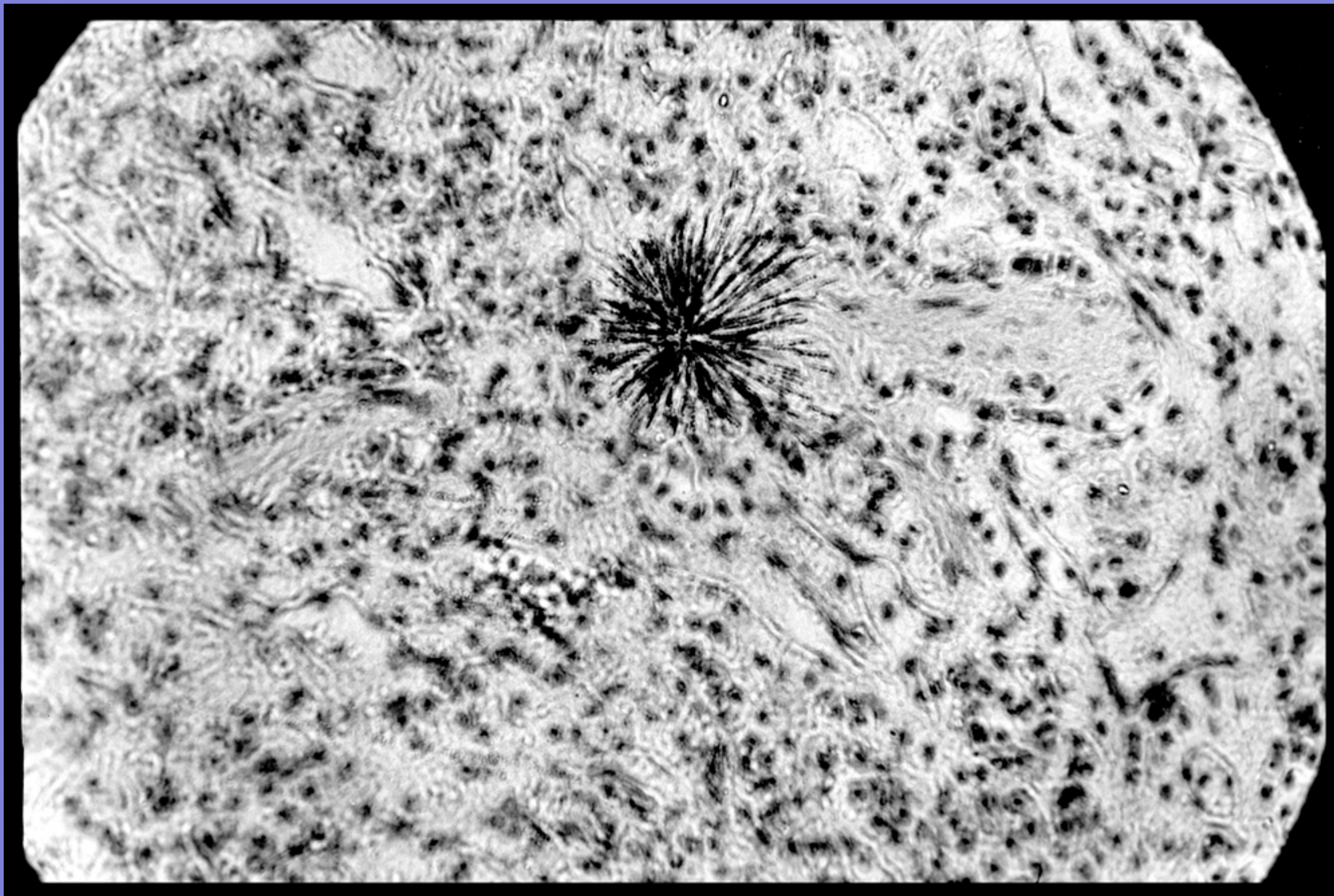
1998

Direction régionale de la santé publique

Quebec Health Professionals find Canada's radon limits alarming & unacceptable

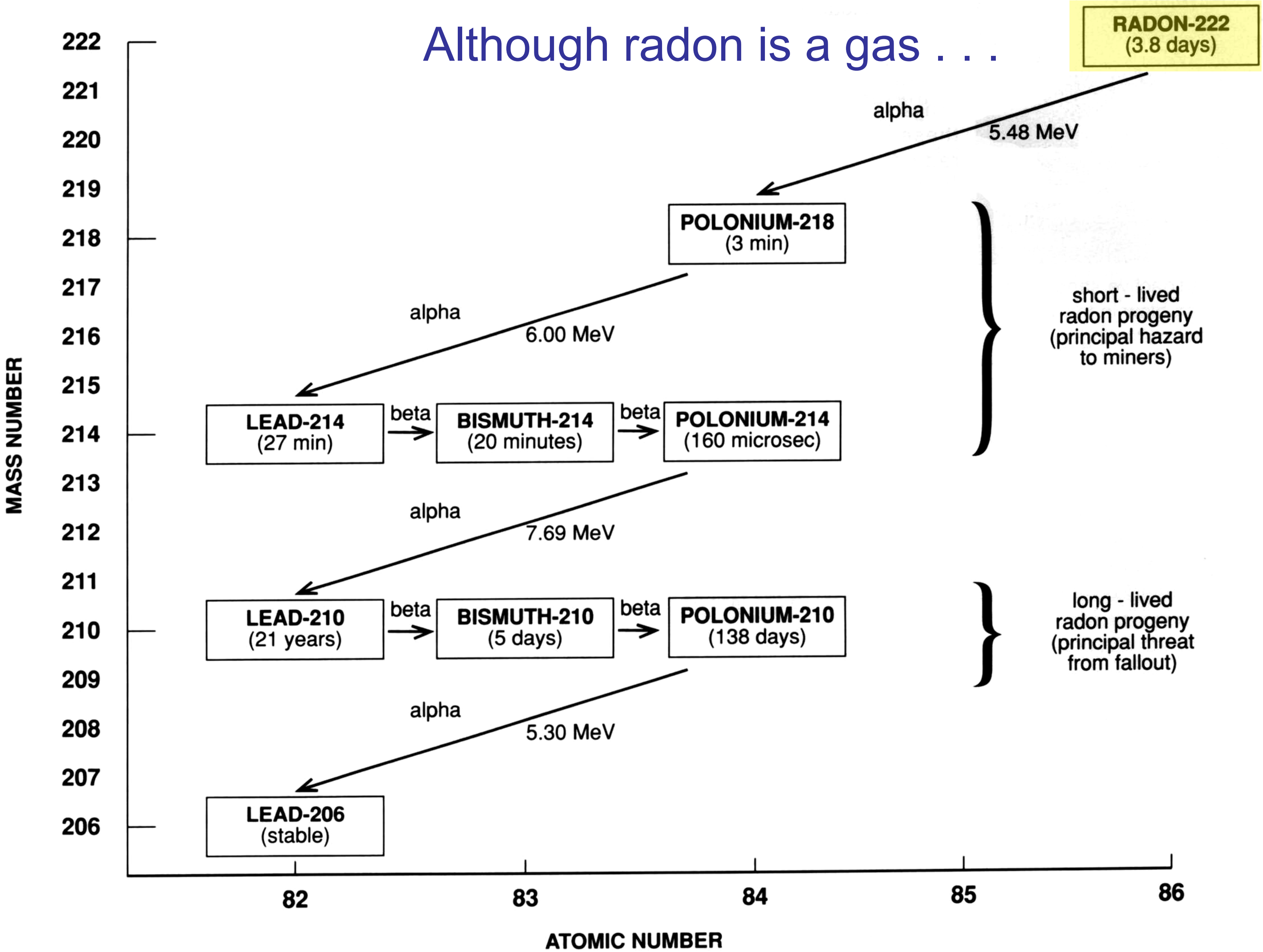
Underground Miner (Navajo)

Radon



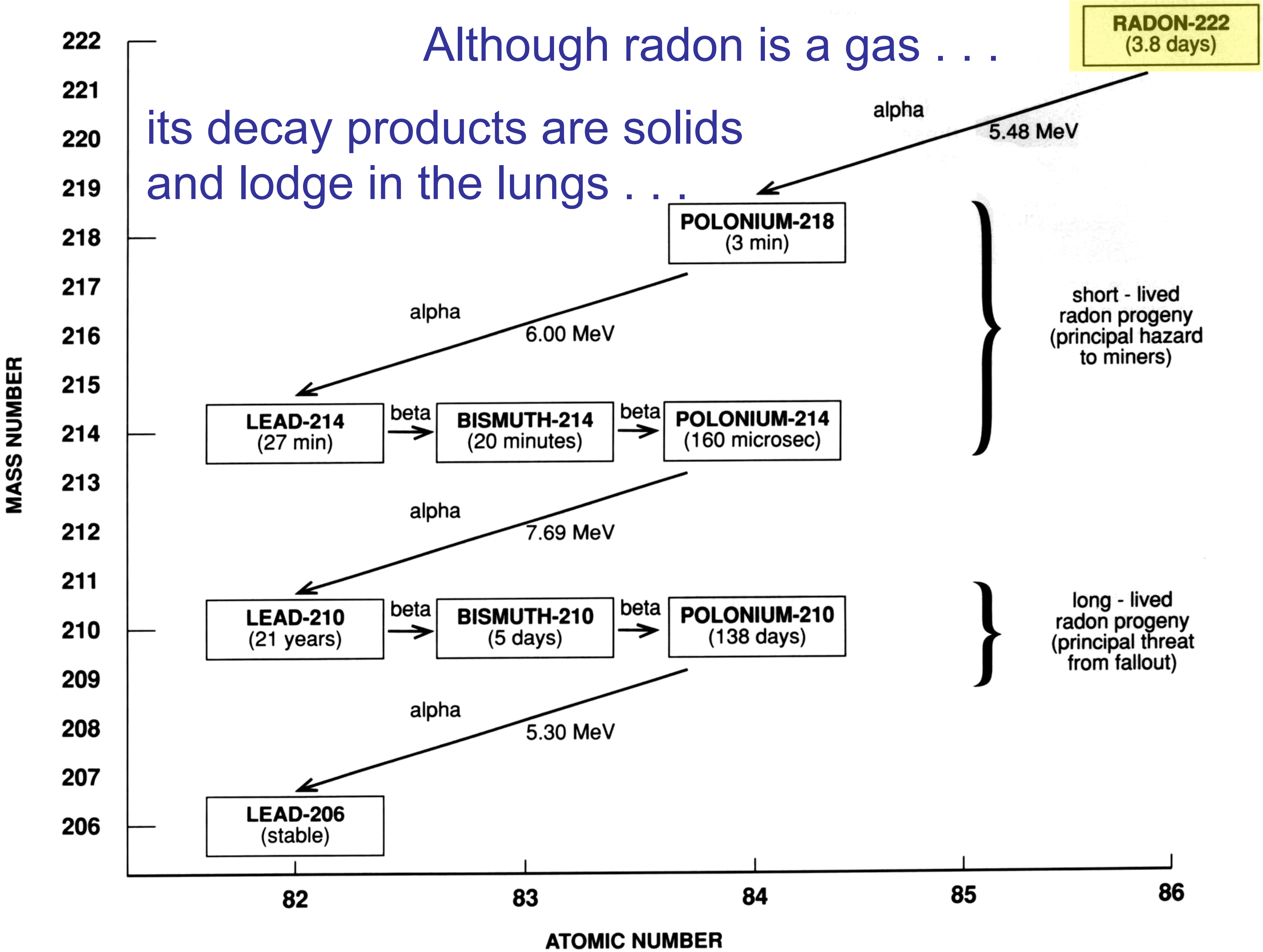
“Alpha Radiation” from a tiny radioactive particle in lung tissue

Although radon is a gas . . .



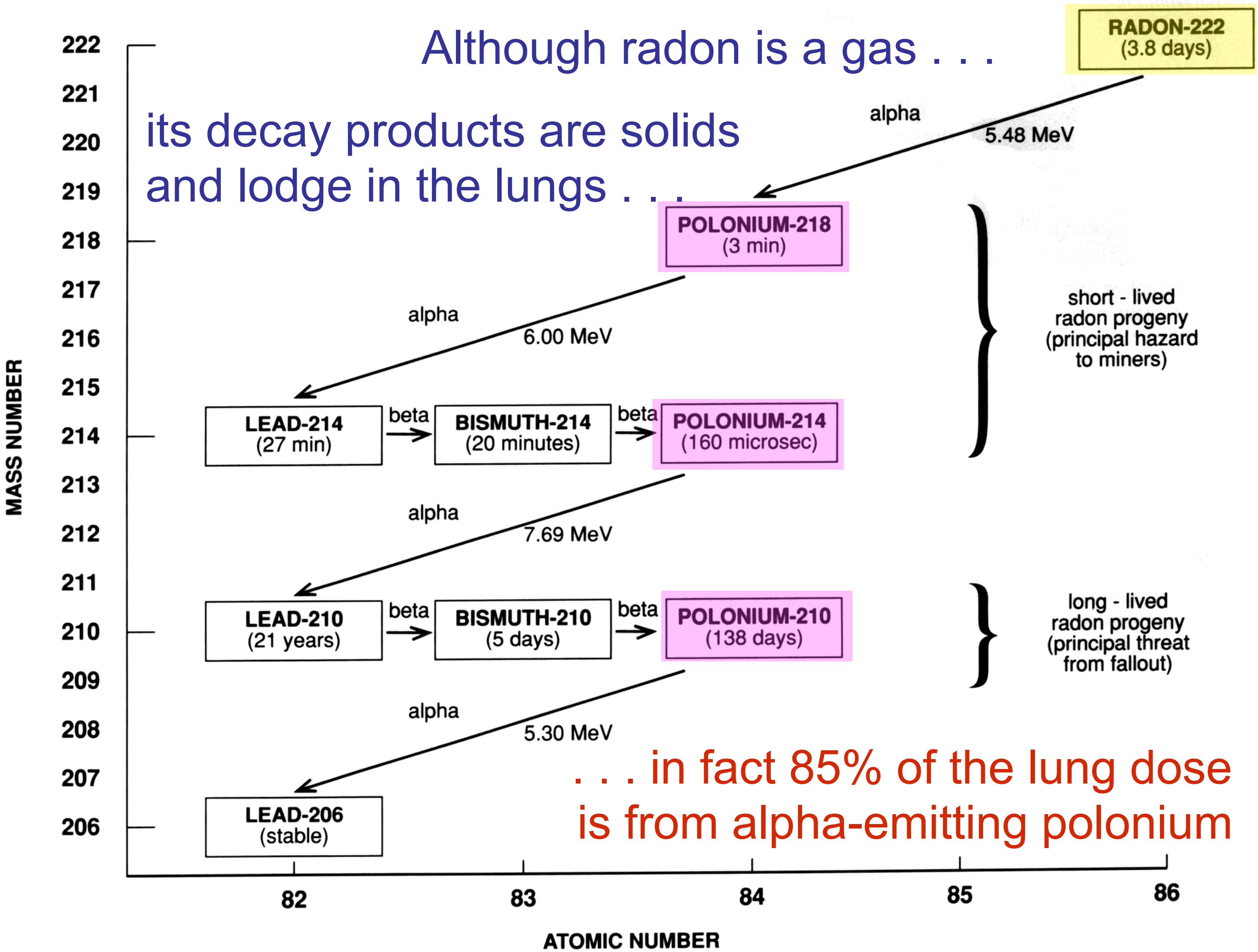
Although radon is a gas . . .

its decay products are solids and lodge in the lungs . . .



Although radon is a gas . . .

its decay products are solids
and lodge in the lungs . . .



. . . in fact 85% of the lung dose
is from alpha-emitting polonium

WASHINGTON (June 2007) — A preponderance of scientific evidence shows that even low doses of ionizing radiation, such as gamma rays and X-rays, are likely to pose some risk of adverse health effects, says a new report from the National Academies' National Research Council

2007 press release announcing publication of the National Academy of Sciences' BEIR-VII Report on the Biological Effects of Ionizing Radiation

. . . such radiation can cause DNA damage that eventually leads to cancers. However, more research is needed to determine whether low doses of radiation may also cause other health problems, such as heart disease and stroke, which are now seen with high doses

2007 press release announcing publication of the National Academy of Sciences' BEIR-VII Report on the Biological Effects of Ionizing Radiation

"The scientific research base shows that there is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial," said committee chair Richard R. Monson, Harvard School of Public Health, Boston.

2007 press release announcing publication of the National Academy of Sciences' BEIR-VII Report on the Biological Effects of Ionizing Radiation

CANADA
DEPARTMENT OF MINES

INVESTIGATIONS IN ORE DRESSING AND METALLURGY

1931
OTTAWA

PRECAUTIONS FOR WORKERS IN THE TREATMENT OF RADIUM ORES

W. R. McClelland

The hazards involved in the handling of high grade radioactive materials make necessary the adoption of certain precautions. Recent investigations in the field of radium poisoning have led to the conclusion that precautions are necessary even in the handling of substances of low radioactivity. The ingestion of small amounts of radioactive dust or emanation over a long period of time will cause a build up of radioactive material in the body, which eventually may have serious consequences. lung cancer, bone necrosis and rapid anemia are possible diseases due to deposition of radioactive substances in the cell tissue or bone structure of the body.

Fact #3

Radioactivity
also endangers
the environment

International Physicians for the Prevention of Nuclear War
(IPPNW) August 2010 [Nobel Prize 1985]

- Uranium ore mining . . . represents a grave threat to health and to the environment . . . and an incalculable risk for world peace and disarmament.
- IPPNW issues a global call to action for a ban on uranium mining worldwide.

Basel, Switzerland, August 29 2010

Warnings From the EPA

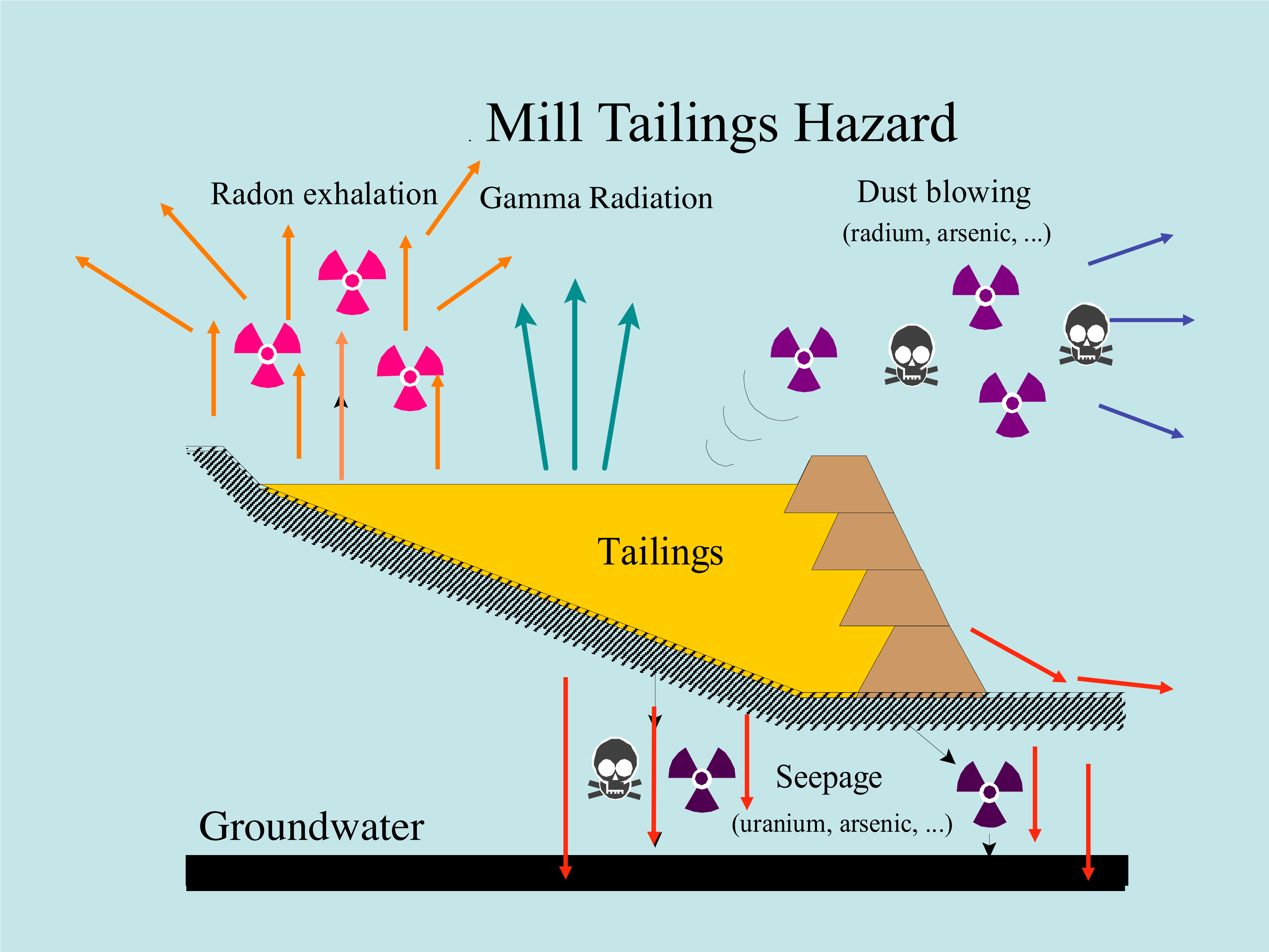
“. . . mining and refining processes can introduce radionuclides . . . into the environment at unnaturally high rates.”

“This makes the handling of materials associated with Rare Earth element production of utmost concern. Extreme care should be used to ensure . . . contaminants are not released into the environment.”

US EPA, Investigating Rare Earth Element Mine Development, 2011


Photo:
Robert Del Tredici

Behind this 10 meter wall is 70 million tonnes of Uranium tailings.


Mill Tailings Hazard
Radon exhalation
Gamma Radiation
Dust blowing
(radium, arsenic, ...)
Tailings
Seepage
(uranium, arsenic, ...)
Groundwater

Warnings From the EPA

“Ores containing uranium-238 and thorium-232 are very mobile as dust resulting in air and soil contamination, [from] where radon-222 gas is constantly released”

“Stories of environmental pollution and human sickness remain frequent in areas near Chinese Rare Earth element production facilities.”

US EPA, Investigating Rare Earth Element Mine Development, 2011

Fact #4

There are many unanswered questions

Warnings From the EPA

"Unless the ores and wastes are carefully collected and monitored, contaminants could be easily introduced Into the environment."

"In fact, it is more likely the possible contaminants from waste rock piles will be introduced into the environment considering these possible contaminants are not contained in a pit . . ."

US EPA, Investigating Rare Earth Element Mine Development, 2011

Key Questions

1. *How will radioactive wastes be safely secured?*
2. *Who will pay for monitoring and remediation?*
3. *Will advanced milling techniques be required?*
4. *Will human use of radwastes be prevented?*
5. *Will wildlife and food chain be checked?*
6. *Will Quebec get needed radiological expertise?*
7. *Will children be educated on radioactive risks?*

The End

of a backgrounder prepared by
Dr. Gordon Edwards

Temiscamingue May 13 2014

Canadian Coalition for Nuclear Responsibility

www.ccnr.org