Life / Cancer Resource | Life | Toronto Star

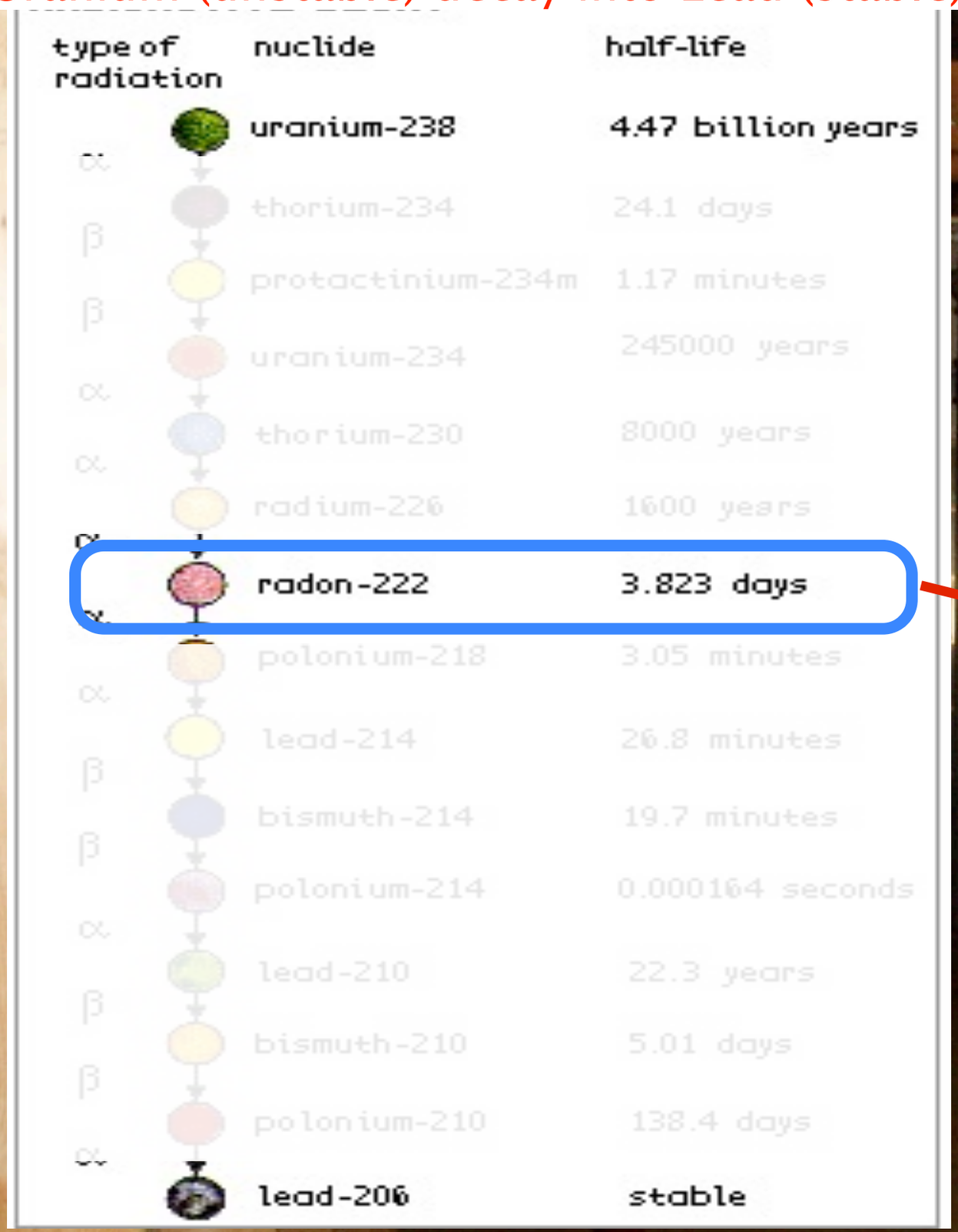
Radon is responsible for 16 per cent of lung cancer

"Nobody knows about it, which is a problem," says the Canadian Cancer Society

Dec. 17, 2013

Radioactivity in your basement

Uranium (unstable) decay into Lead (stable)



- Uranium is a relatively abundant metal on Earth. Uranium is not stable and radio-actively decays into lead. This releases **Nuclear Energy**.

- Nuclear energy comes out in the form of heat and energetic particles. **Heat = Nuclear power; particles = radio-activity.**

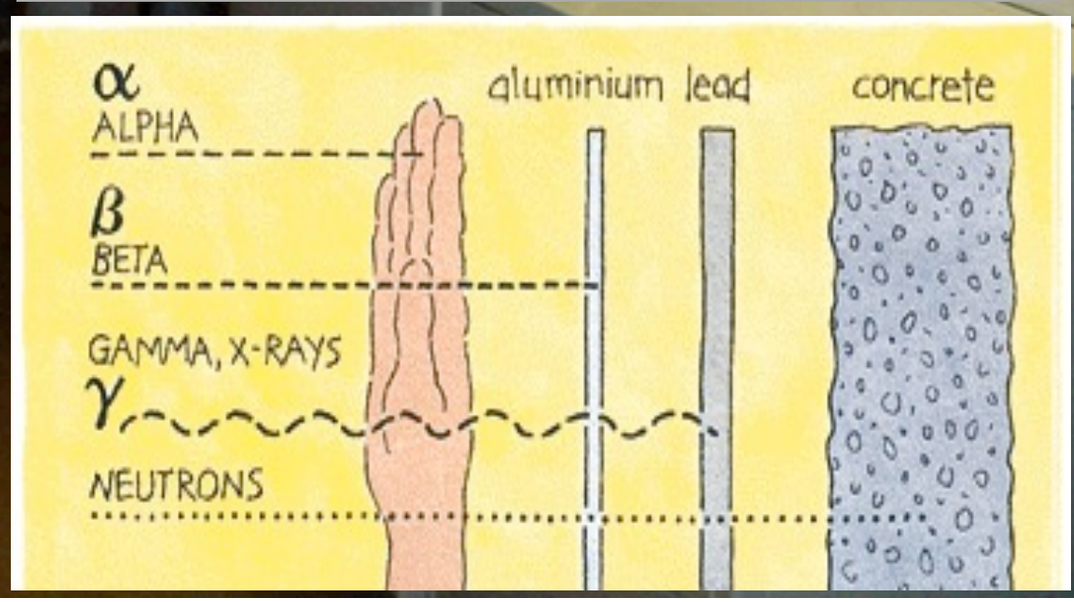
- Uranium (and especially its daughter product Radon) is responsible for most of the radioactivity received by an average person.

- Uranium is made by dying stars. Deposited in Earth when Earth was being formed.

- radon is the only gaseous product in this long decay chain. It is a heavy gas that hugs ground.

- when inhaled, radon decay (half-life 3.823 days) yields a so-called alpha-particle (a helium nucleus) inside your body.

- this can damage the DNA, possibly leading to cancer in the long run.



Which of the following is more radio-active?

A) your cellphone

B) the air in your basement

A) a liter of gasoline

B) a glass of orange juice

Radio-active elements -- elements that yield radioactivity

1. mostly large nuclei (^{238}U), but also some small ones (^{14}C)
   (with unbalanced number of neutron & protons)

2. undergo spontaneous decay (radio-activity)
   and in some cases, induced nuclear fission

3. spontaneous decay has a characteristic timescale
   --- Half-life time of radionuclides

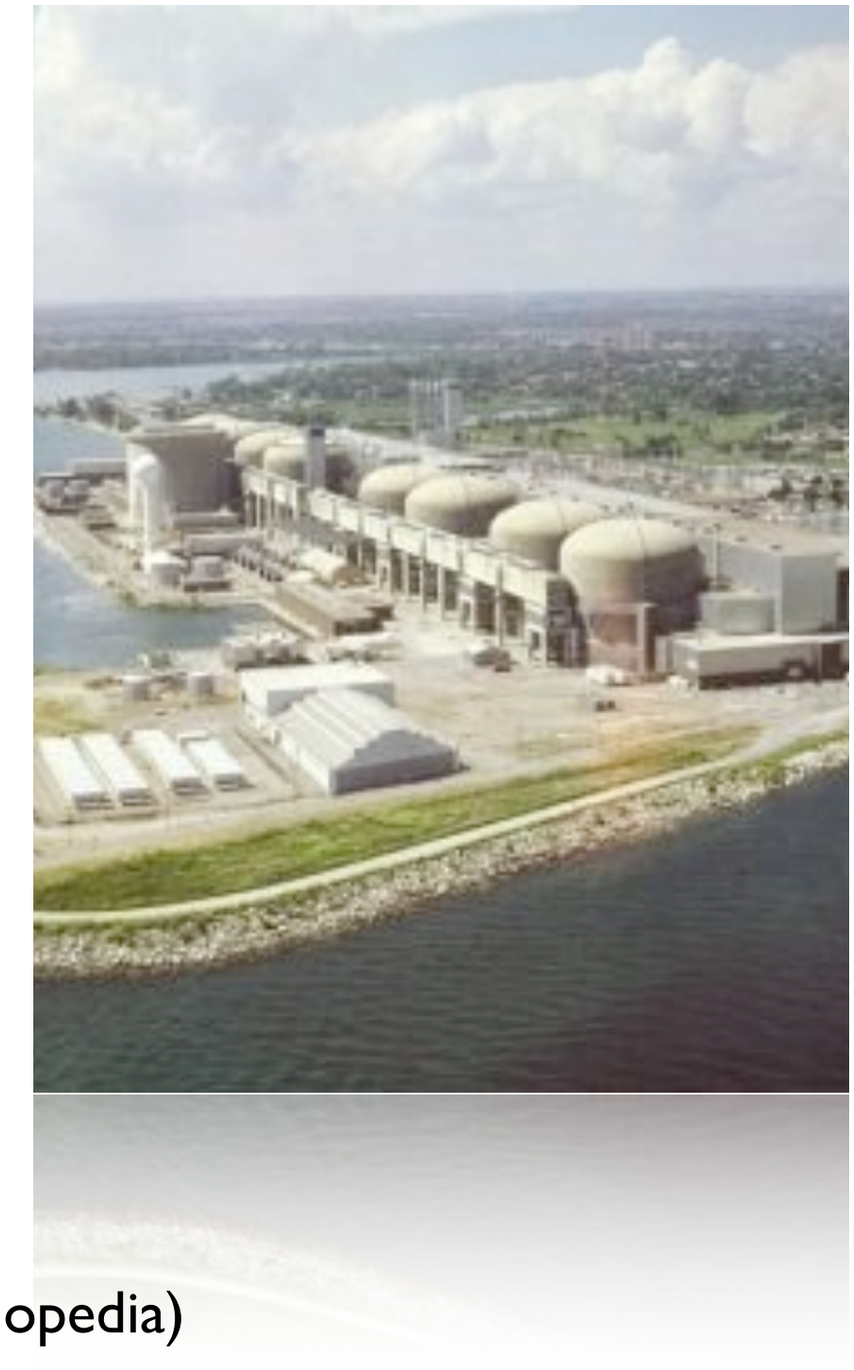
a few notable examples:

Carbon14 (^{14}C) half-life 6000 yrs, continuously produced by cosmic ray particles, and taken up by living beings; can be used for carbon dating (archeology).

Uranium 238 (^{238}U) 4.5 billion yrs (primordial, currently 99.3% of all natural Uranium)

Uranium 235 (^{235}U) 700 million yrs (primordial, minority 0.7% of natural U)

Nuclear Energy



- *radioactivity: Radon in your basement*
- *why is Canada 'privileged'?*
- *how to build a nuclear reactor?*
- *the nuclear fear factor: the case of Green Peace*

Reading: 1. Nuclear Energy (the Canadian Encyclopedia)

http://www.thecanadianencyclopedia.com/en/article/nuclear-energy/

2. Muller (Energy for future presidents) Chapter 1

-- the Fukushima disaster, cancer and radioactivity

Three 'Big' Drivers in Canadian (Energy) History

- Canada's endowments of
  - Freshwater lakes and river systems
  - Biomass forests
  - Hydrocarbons coal, oil, natural gas

Also endowed with: rich uranium mines

Canada's uranium production is ~20% of total world output (after Kazakhstan)

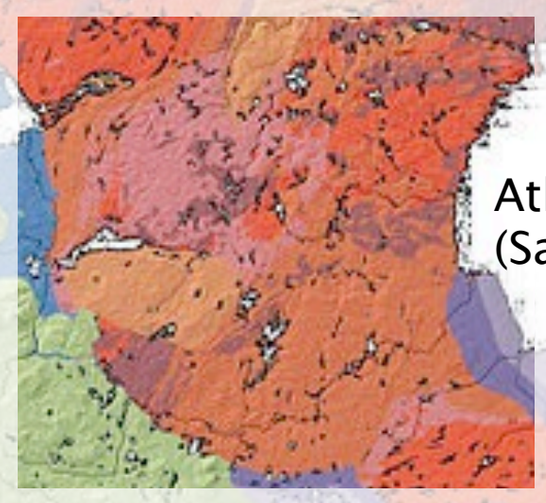
together with exporting CANDU technology, nuclear industry is an important economics sector.

Uranium abundances:

Earth crust average ~ 2ppm (2 parts per million)
Granite rock average ~ 4ppm (2x of sedimentary rock)

Athabasca basin mines: ~20% (100,000 x of sedimentary rock)

uranium seeps through permeable granitic rock and accumulate near the overlying sandstone



Athabasca Basin
(Saskatchewan)

Canadian Shield:
ancient volcanic bedrock; scraped clean of soil by glaciation; granitic; rich in minerals

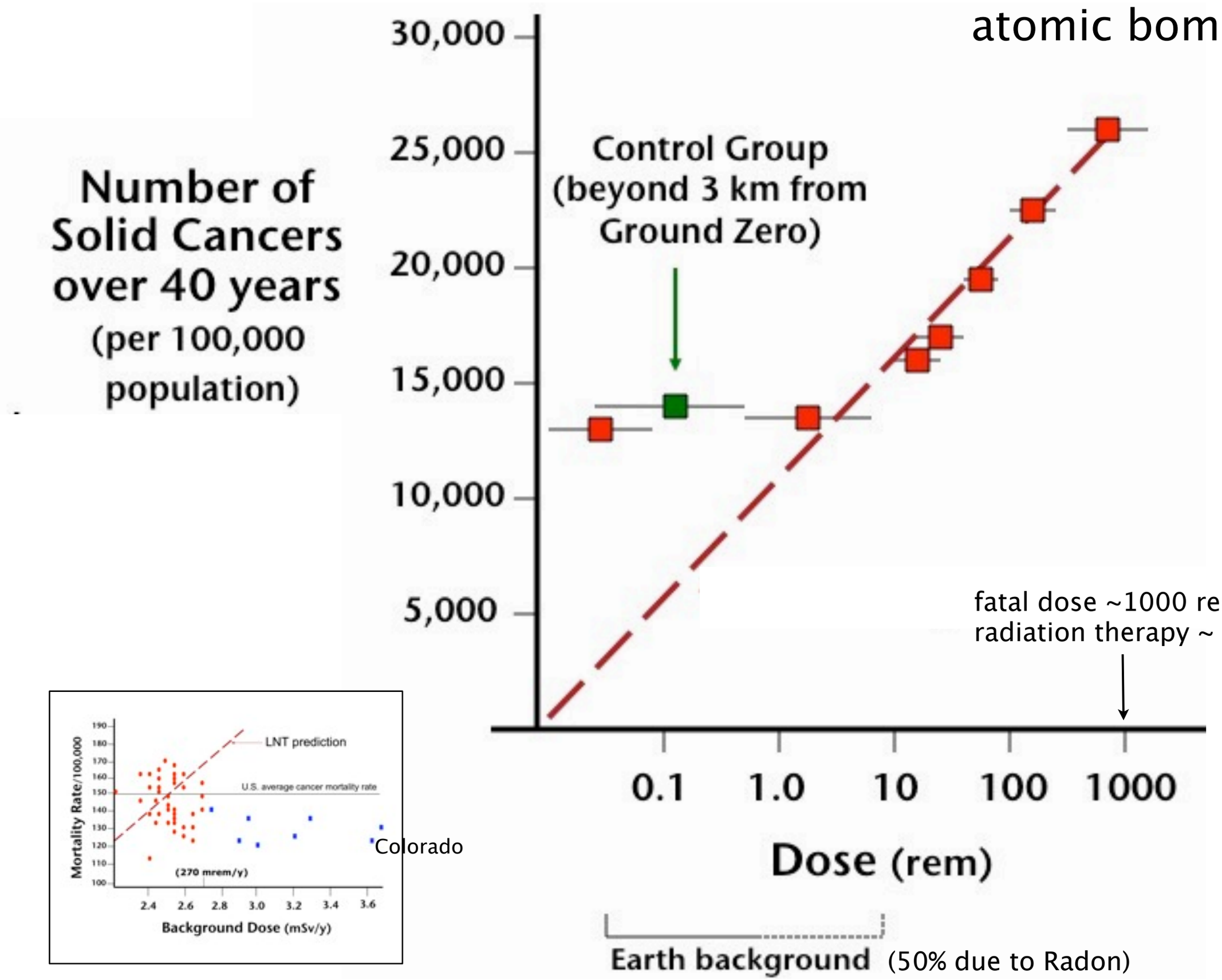
MCARTHUR RIVER OPERATION

McArthur River miner Ken Pederson uses a remote controller to run the scoop tram, keeping himself at distance from the high grade uranium ore being moved from the extraction chamber to the underground grinding circuit.

www.cameco.com

Higher cancer rate in Athabasca Basin?

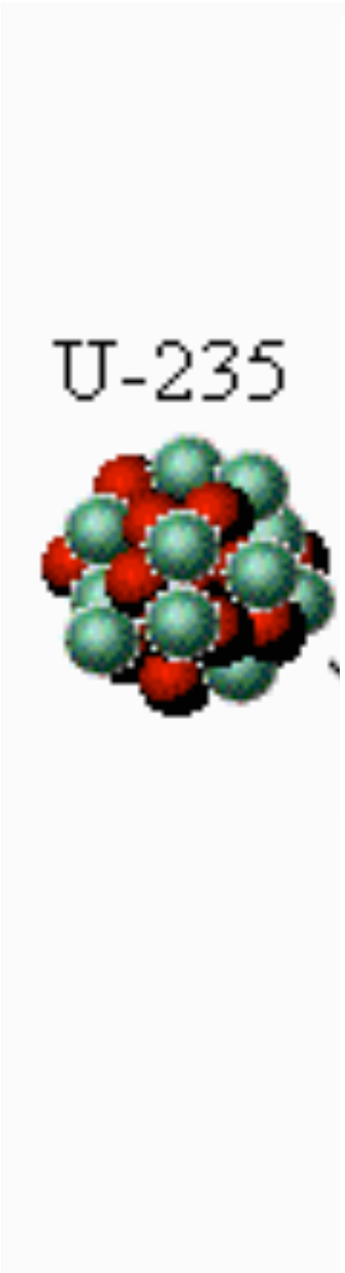
data from Japanese atomic bomb survivors



fatal dose ~1000 rem
radiation therapy ~ 500 rem

Colorado

Two types of fission:
spontaneous decay vs. stimulated fission

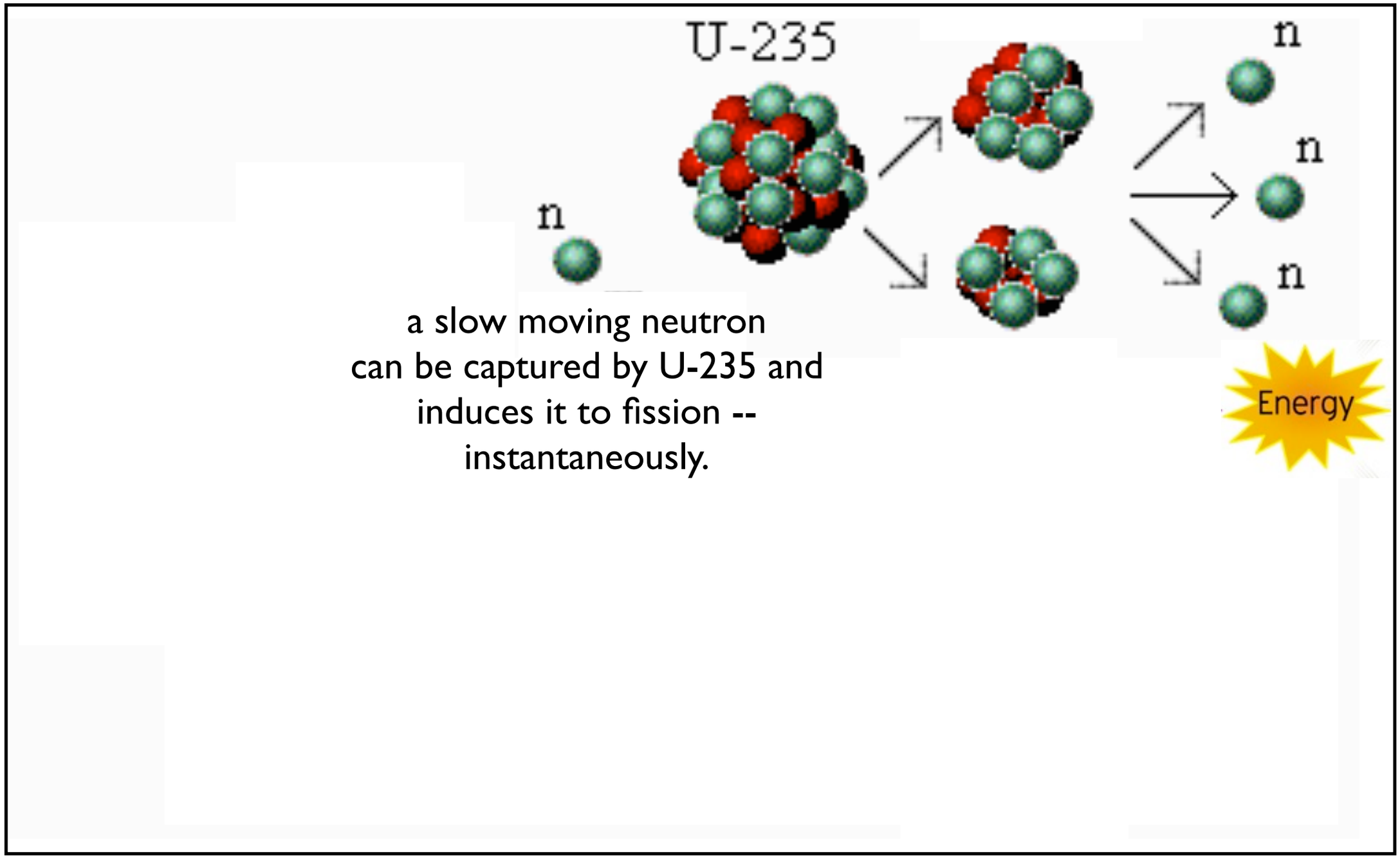


Uranium 235: spontaneous decay half-life ~ 700 Myrs,

or, you have to wait 700 million years to harvest the nuclear energy.

Two types of fission:

spontaneous decay vs. stimulated fission

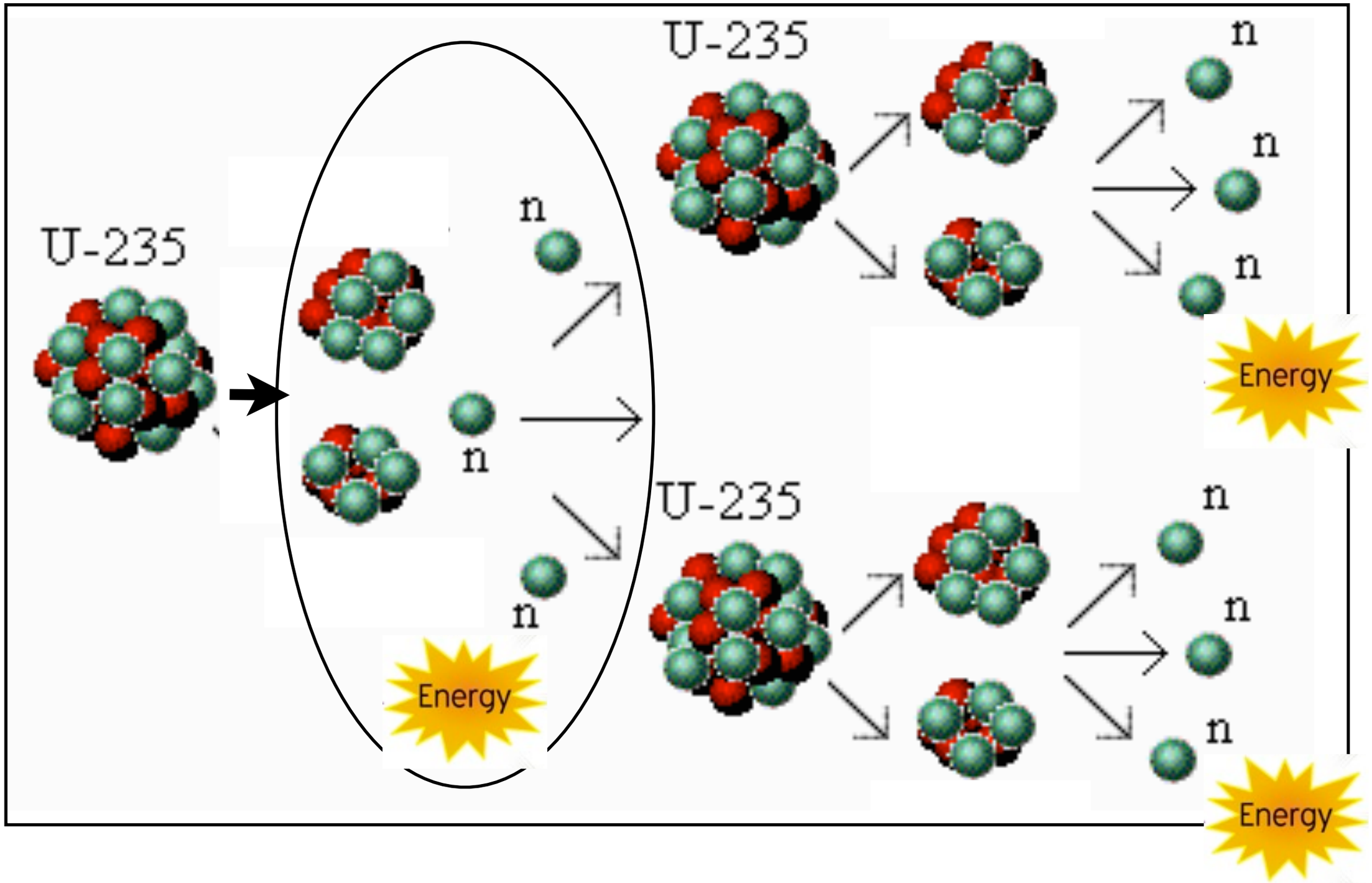


a slow moving neutron
can be captured by U-235 and
induces it to fission --
instantaneously.

Uranium-235 is one of those rare elements that
can undergo stimulated (induced) fission,
making it useful for nuclear reactor (and bomb).

Chain reaction: compounded fissions

if 2 out of the 3 fast neutrons can be slowed down and captured by two uranium nuclei



So instead of 700 million years, instant energy release + a bunch of radioactive waste.
This heat is used to drive steam turbines and generate electricity.

Fusion: the ultimate clean energy

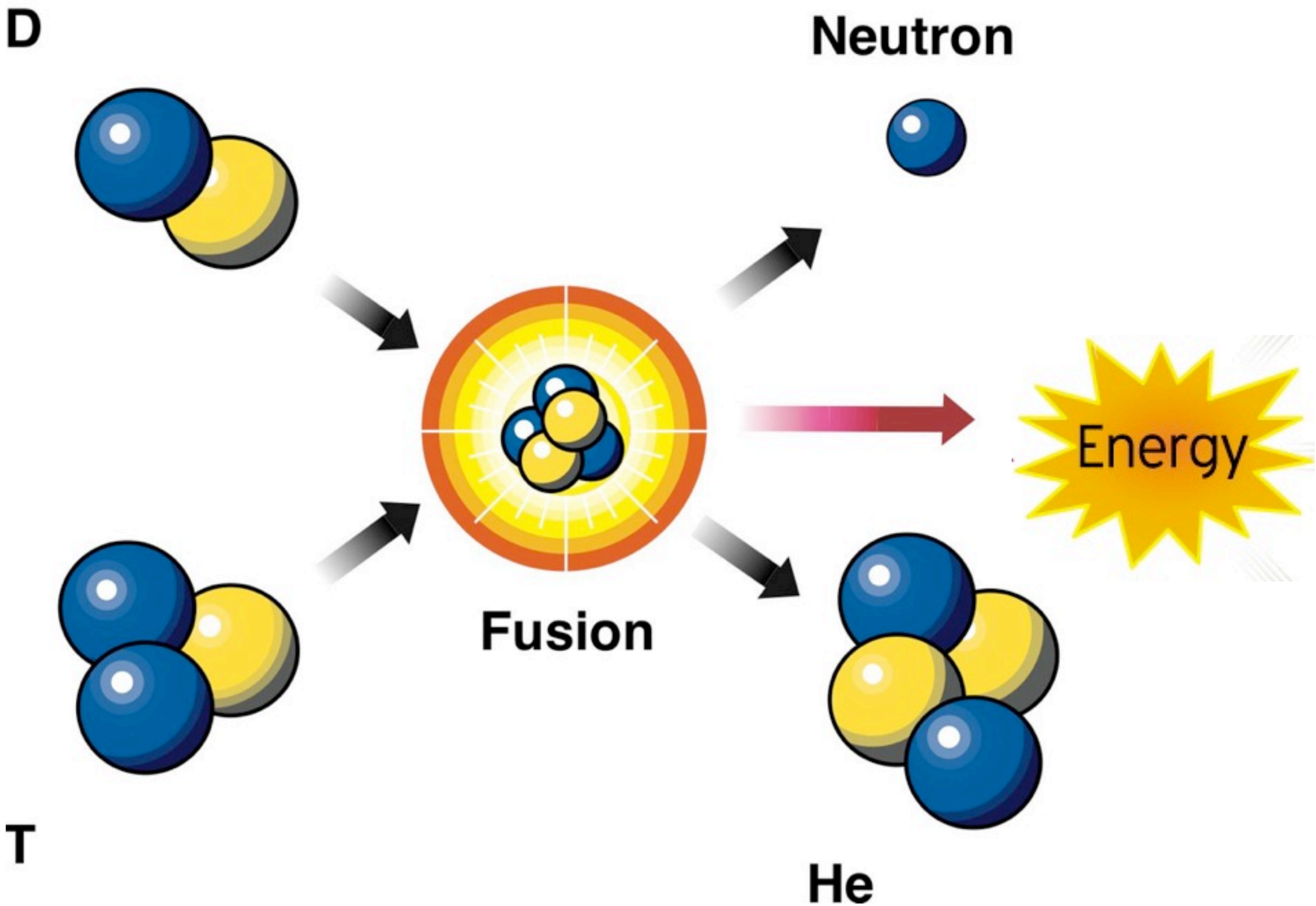


Table 1.1 Energy per Gram

Object	Calories (kCal) (or watt-hou
Bullet (at sound speed, 1000 ft/s)	0.01
Battery (auto)	0.03
Battery (rechargeable computer)	0.1
Flywheel (at 1 km/s)	0.125
Battery (alkaline flashlight)	0.15
TNT (the explosive trinitrotoluene)	0.65
Modern high explosive (PETN)	1
Chocolate chip cookies	5
Coal	6
Butter	7
Alcohol (ethanol)	6
Gasoline	10
Natural gas (methane, CH_4)	13
Hydrogen gas or liquid (H_2)	26
Asteroid or meteor (30 km/s)	100
Uranium-235	20 million

Note: Many numbers in this table have been rounded off.

Uranium is a very concentrated energy source.

all fossil fuels yield similar energy per unit weight

nuclear is a whole different class

Muller '10 (Physics & Technology for future presidents)

The cost of nuclear power

fuel type	coal	nuclear
cost ($/kg)	$0.06	$200
energy content (kWH/kg)	6	10 million
fuel efficiency	30%	30%
cost of electricity ($/kWH)	$0.03	$0.007 (fuel only) $0.02 (overall)
CO_2 emission (kg/kWH of electricity)	1	**0**

- 1 gram of Uranium can power a typical household (1kW) for two years.
- fuel alone, nuclear is ~500 times cheaper than coal
- high upfront-cost, ~ $10B/reactor,
- auxiliary costs (construction, interest, operation, waste...) included, still economically feasible
- even more so if carbon tax is imposed

How to build a nuclear reactor?

- find an element that can undergo induced nuclear fission

  all nuclear reactors now use Uranium 235;

  U-235 is only 0.7% of all natural Uranium (mostly U-238);

  most reactors (except for, e.g., **CANDU**) need enriched fuel;

  typically only 1% fuel is used after one-through.

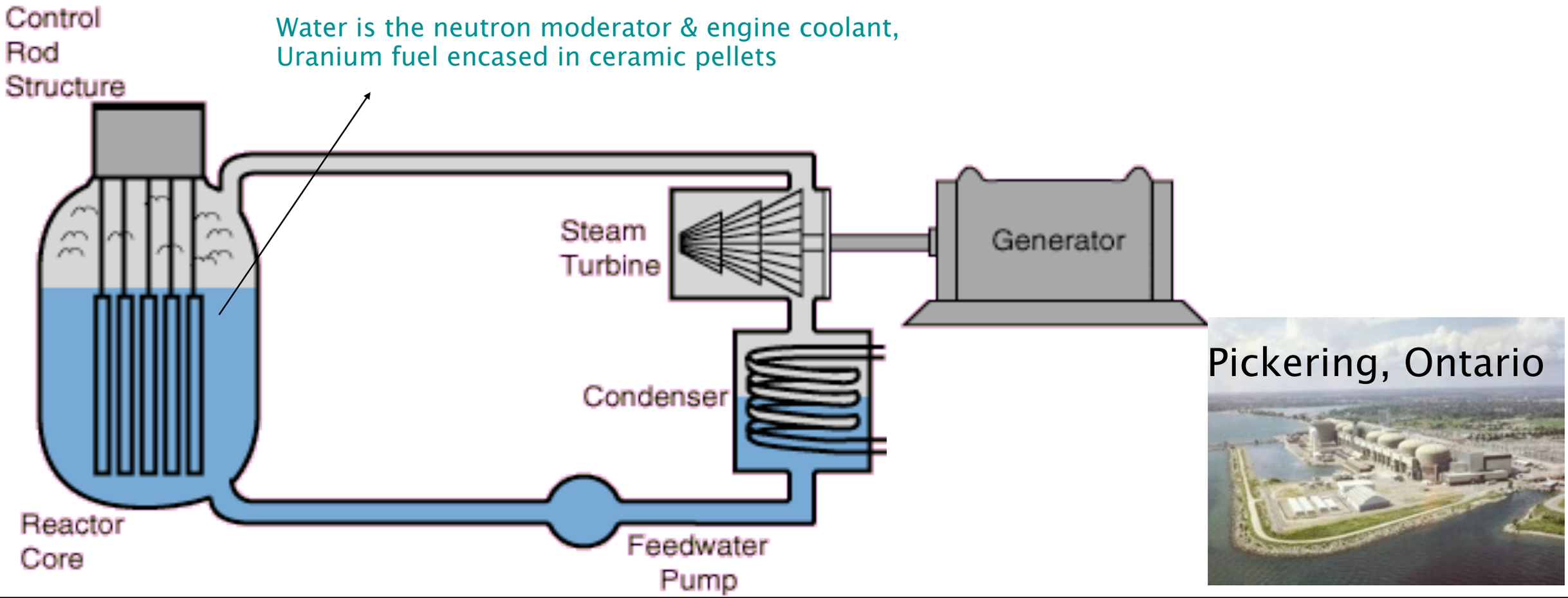
- insert a moderator to capture/slow down neutrons -- chain reaction

  most reactors use H_2O as neutron moderator (also for the turbine)

  a basket-ball of pure U-235 can be its own moderator (bomb)

  also need a control rod (neutron absorber)

How to build a nuclear reactor? (in Canada)



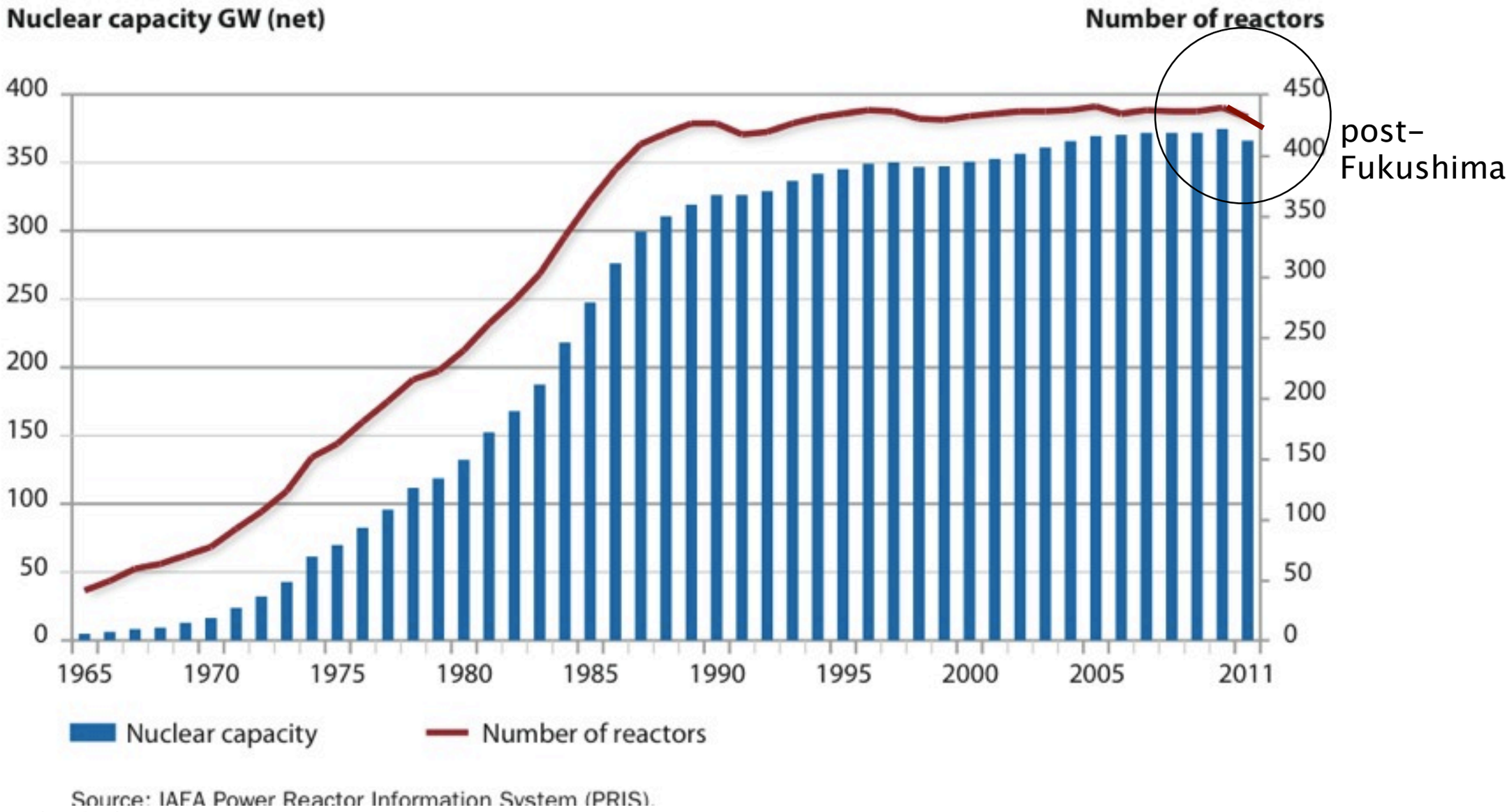
- starting with Ernest Rutherford, Canada has been a world leader in nuclear technology. Uranium ore + CANDU export, an important economics sector
- Canada's CANDU reactors uses heavy water as moderator.
- No need for enriched fuel (no enrichment facility, no fuel reprocessing)
- By design, overheating (and explosion) is unlikely.

. Electricity from nuclear power: ~ 14% globally; ~15% Canada; ~53% Ontario;
. If rise to 100%, can cut CO_2 emission by ~ a factor of 2.

Will it, should it rise majorly?

PUBLIC OPINION!

Figure 1.1: Worldwide nuclear generating capacity and numb
of operating reactors (1965-2011)



Source: IAEA Power Reactor Information System (PRIS).

Welcome to Greenpeace International

Greenpeace exists because this fragile Earth deserves a voice. It needs solutions. It needs change. It needs action.

Greenpeace website, Jan 14, 2014

Nuclear

Greenpeace fights nuclear power because it poses a serious threat to the environment and humanity. The expansion of nuclear power must be halted and nuclear plants shut down so that we can develop a clean energy future. That's why we are working to stop Darlington in Ontario and protect electricity consumers from a new round of nuclear debt.

The reality of nuclear power is no different now than it was in the 20th Century - it is inherently dangerous. -- Greenpeace website

"Nuclear power plants are, next to nuclear warheads themselves, the most dangerous devices that man has ever created. Their construction and proliferation is the most irresponsible, in fact the most criminal, act ever to have taken place on this planet."
Patrick Moore (co-founder of Greenpeace), *Assault on Future Generations*, 1976

- **Going Nuclear**

A Green Makes the Case
By Patrick Moore
Sunday, April 16, 2006, Washington Post

.... Thirty years on, my views have changed, and the rest of the environmental movement needs to update its views, too, because nuclear energy may just be the energy source that can save our planet from another possible disaster: catastrophic climate change....

. Why is nuclear power controversial?

. Where did our nuclear fear come from?

. Is the public well informed?

(also take part in the tutorial discussions!)

vs.

arguments against:

high capital cost

reactor accidents

nuclear terrorist

waste disposal

→ danger of radio-activity

...

arguments pro:

no CO_2 emission, no air pollution

The ‘perceived’ danger of radioactivity?

Life / Cancer Resource | Life | Toronto Star

Radon is responsible for 16 per cent of lung cancer

"Nobody knows about it, which is a problem," says the Canadian Cancer Society

Toronto Star reporter

↑

Health Canada

↑

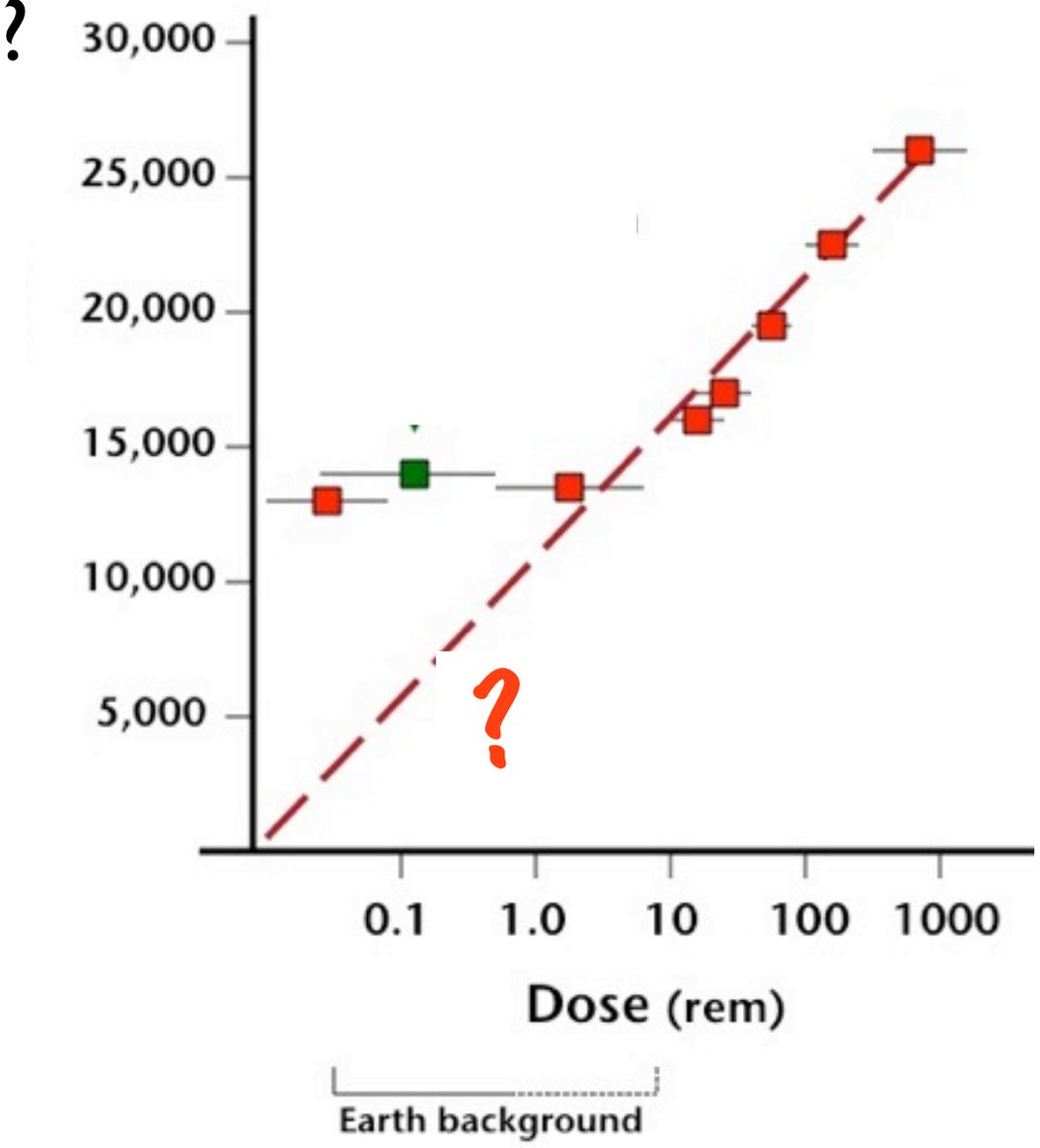
Canadian Radiation Protection Bureau

↑

United States Environment Protection Agency (EPA)

↑

Multiple scholarly journals



It is still being debated whether a low dose matters, i.e., if there is a threshold to radiation damage.

Life has evolved in this radiation background (stronger in the past).

Jan 21st, 2014

nuclear: ‘playing with fire’?

How much uranium is there and how long will it last us?

Earth Overall:

.Uranium 2ppm in Earth crust (1km)--> 0.2cm in thickness (in Assignment III: coal thickness 0.2cm)

. only 0.7% of this is U235

. 1 million times more energy per unit weight,

====> 10,000x more energy in Uranium

economically recoverable reserve:

Table 8. Reasonably Assured Resources (RAR) by deposit type
(tonnes U)

	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Total	**569 900**	**2 516 100**	**3 524 900**	**4 004 500**

.current reserve ~ energy in coal

.as price rises, more reserves are discovered/explored

. nuclear reactor uses ~ 1% of U235 that passes through

."If recycled, the world's nuclear fuels are virtually inexhaustible."

Government Must Continue Review of Nevada Nuclear Waste Site, Court Says

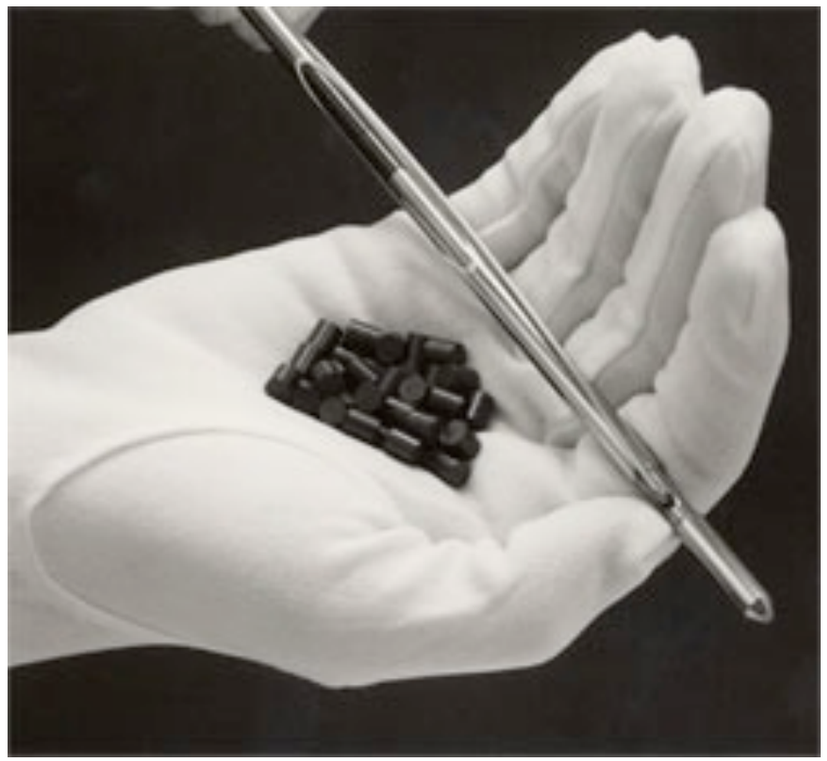
Joe Cavaretta/Associated Press

The south portal of Yucca Mountain, which is the proposed site of a national nuclear waste dump near Mercury, Nev., in 2002. Debate over the project has been going on for nearly 25 years.

By MATTHEW L. WALD
Published: August 13, 2013

Is it wise to store nuclear waste in an ancient volcano?
How does this affect our economy?
If you are a president, would you bar it? (President Obama did.)

reactor waste



no more fissionable, but still radioactive

.high grade uranium ore (level 1)

. refinement of uranium (level 2)

.enrichment of U-235 (level 3)

.daughter products of fission radioactive (level 4)

.half-life from a few years to a few million years,
back to level 1 after ~ 10,000 yrs

.world-wide, ~ 10,000 tons of wastes/year

.most dangerous pathway to human: food/water

sea ? ground ? mines ? space ? recycling (Japan, UK & Russia)

Key question: how safe is safe?

Nuclear reactor & Waste: Nature does it fine

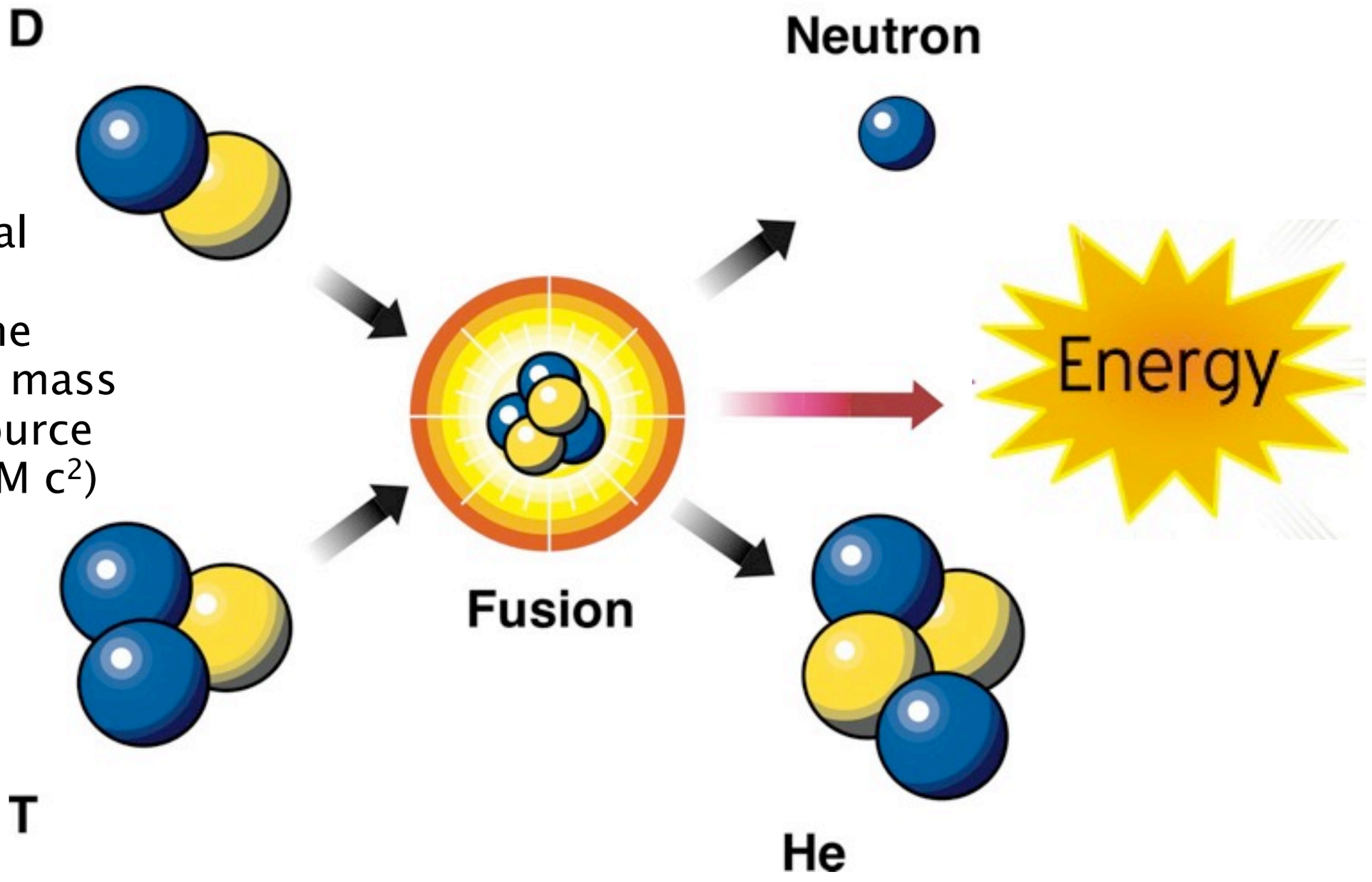
Oklo, Gabon, Africa: Ancient Nuclear Reactor

(~1.7 Byrs ago)

The uranium isotopes found at Oklo strongly resemble those in the spent nuclear fuel generated by today's nuclear power plants.

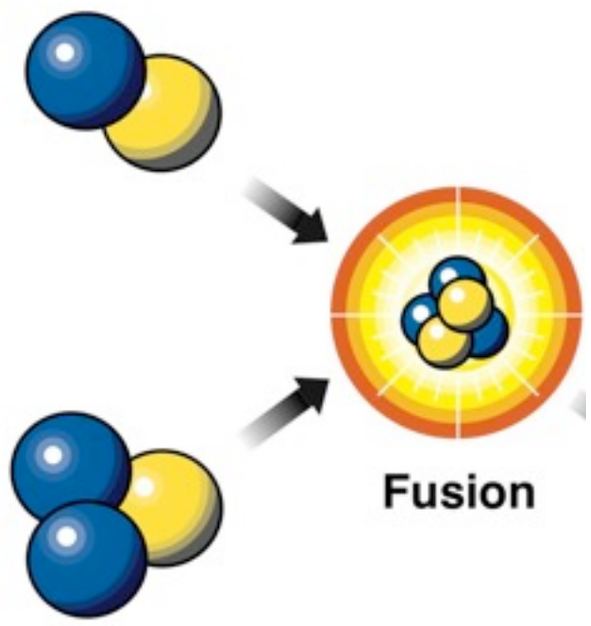
Fusion: the ultimate clean energy

mass in the final products
is lower than the initial sum, the mass deficit is the source of energy ($E = M c^2$)



total budget for fusion study: ~ $30 Billion (since the 1950s)

Why don't we have fusion power yet?



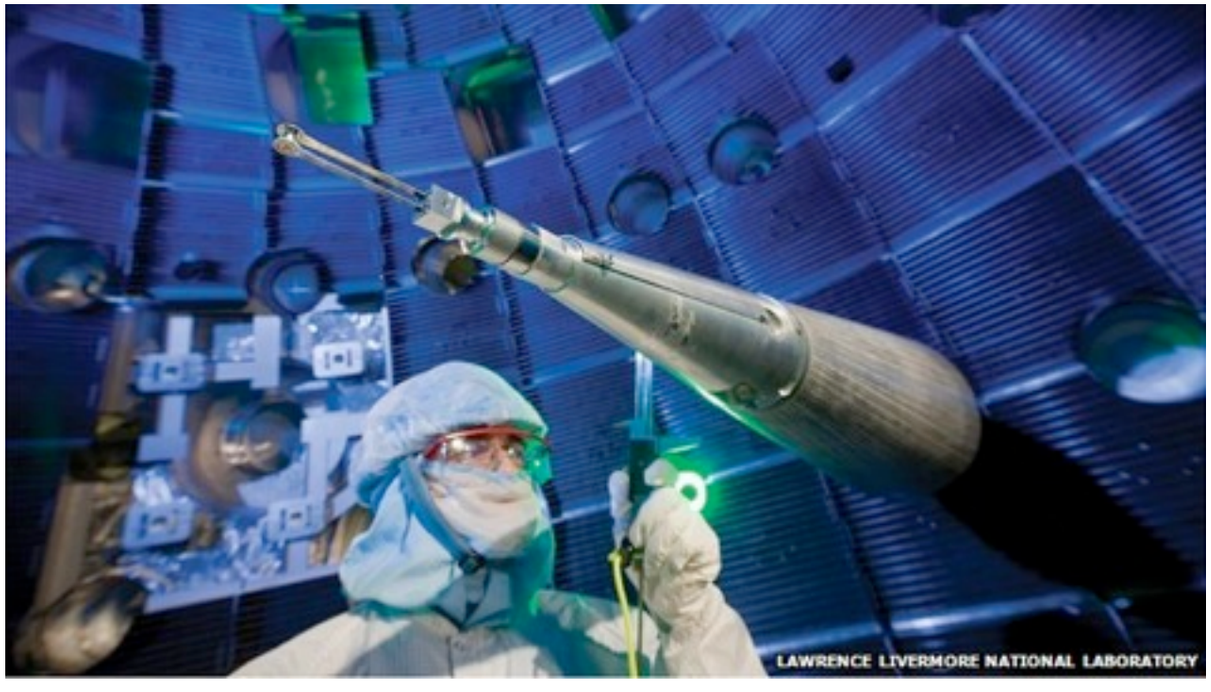
- fusion requires two nuclei to get as close as $1/10^{15}$ meters.

- needs immense pressure to squeeze two nuclei (both positively charge) to such a distance.

- hot plasma has higher pressure

- demands temperature ~ 10 million degrees.

- controlled fusion needs stable confinement (laser, magnetic field)



one break-through:
Sept. 2013, Lawrence Livermore lab:
energy break-even in fusion reactor

next break-through: