

Nuclear Power

(Fission)

Bruno Piqani
Chem671

11-15-2007

Composition

- Brief history
- From atom to energy.
- Effect of radiation on human body
- Chernobyl
- Conclusions

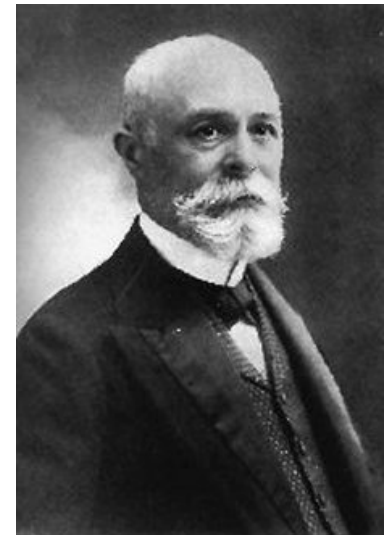
HISTORY

A.H. Becquerel in 1896, discovered by accident that uranium ore gave off certain invisible rays that could penetrate the light proof covering of a photographic plate.

In 1932, Chadwick proved the existence of *neutrons* - elementary particles devoid of any electrical charge.

In 1938 Hahn, Meitner and Strassmann discovered that the uranium atom, when bombarded by neutrons, actually split.

In Dec. 1951, an experimental reactor in Idaho produced the first usable electric power from the atom, lighting four light bulbs.



A.H. Becquerel.

Facts

- Name: uranium
- Symbol: U
- Atomic number: 92
- Atomic weight: 238.02891 g/cm³
- CAS Registry ID: 7440-61-1
- Group name: Actinoid
- Period number: 7 (actinoid)
- Block: f-block
- Standard state: solid at 298 K
- metallic grey Colour:
- Classification: Metallic



In 1798 Martin Klaproth, isolated an oxide of uranium while analyzing pitchblende.

Was named after the planet Uranus, discovered in 1791.

Uranium was isolated in 1841 by French chemist Eugène Péligot.

Common types of radiation.

- Gamma rays, are pulses of high-energy electromagnetic radiation.
- Neutrons are what make nuclear reactors work and nuclear bombs explode in NCR.
- Beta particles, which are high velocity electrons.

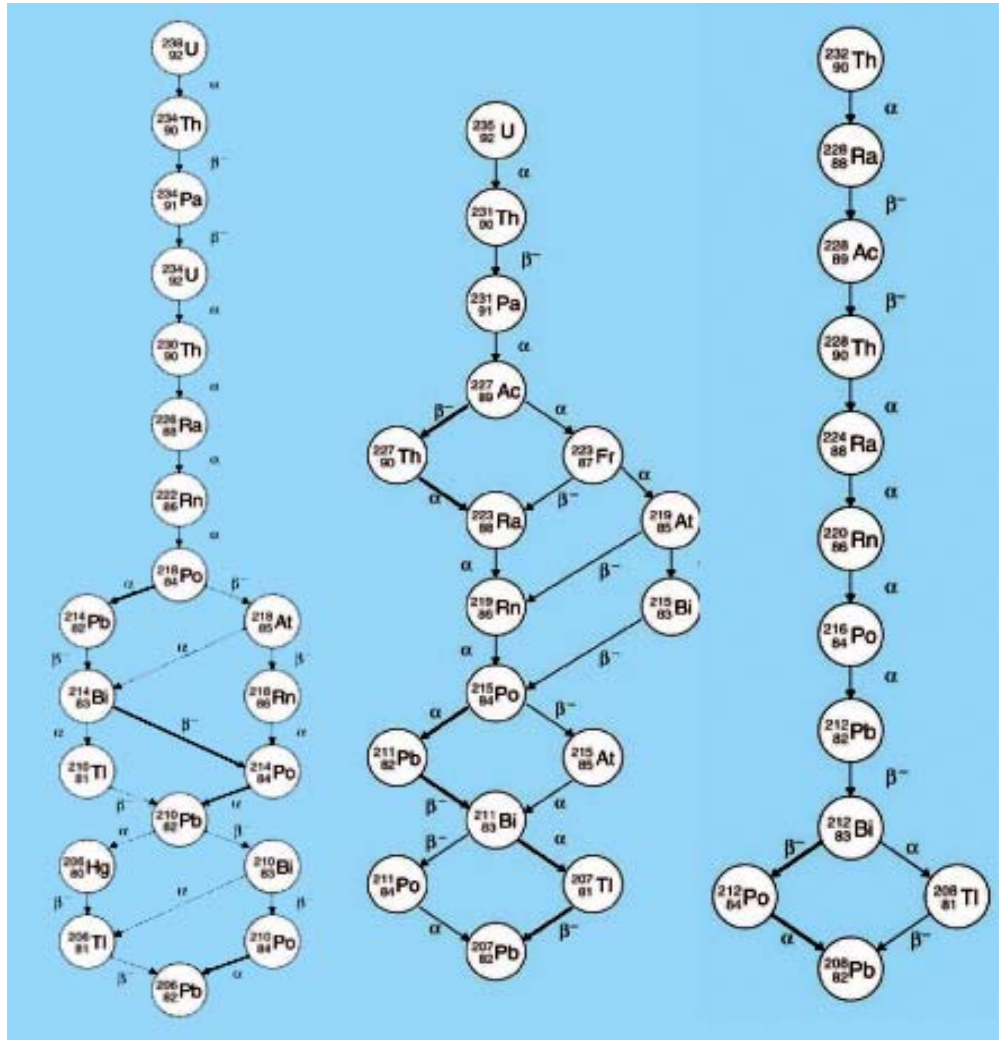
Loss of a beta particle causes an atom to change into the next higher element on the Periodic Table while keeping the same mass number. Thorium-234 (element 90) becomes protactinium-234 (element 91).

- Alpha particles, which are high velocity helium nuclei.

Loss of an alpha particle causes an atom to change into an element two steps lower on the periodic table, along with a loss of four mass units.

So an atom of U-238 (element 92) becomes thorium-234 (element 90).

Decay chains



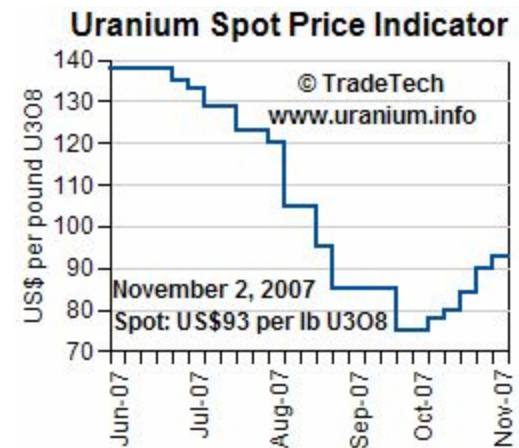
Uranium-radium

Uranium-actinium

Thorium chain

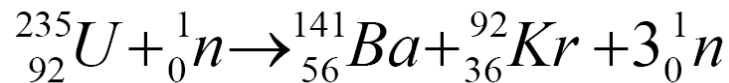
Nuclear Fuel

- Is cheap compared to the energy equivalent of Petroleum or Coal.
- One ton of natural uranium can produce more than 40 million kilowatt-hours of electricity. This is equivalent to burning 16,000 tons of coal or 80,000 barrels of oil.
- Is it Green ???!!!
- Nuclear power plants helped avoid 90 % of all carbon emissions averted in the U.S. energy sector between 1981 and 1994.

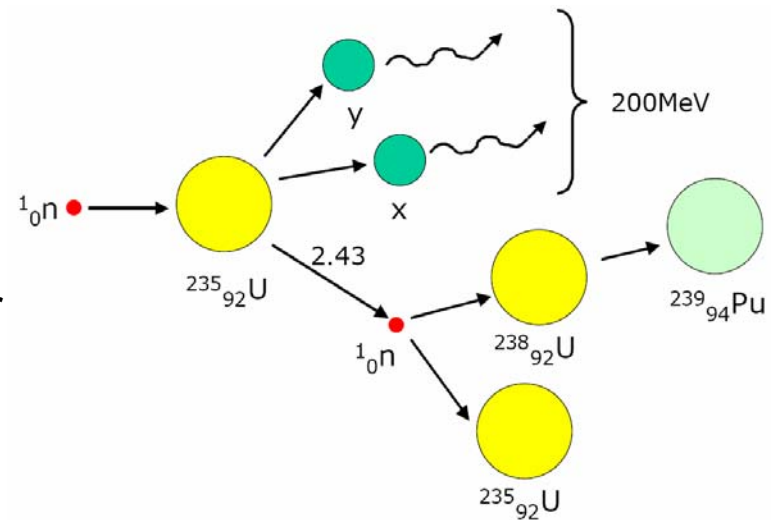


Nuclear Fission

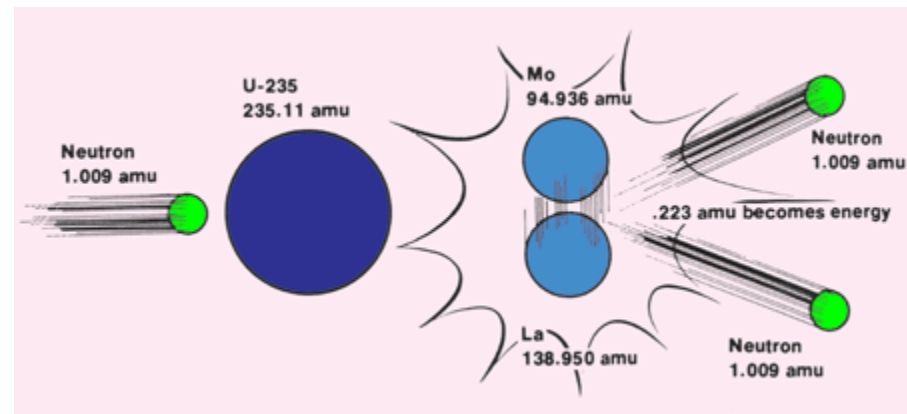
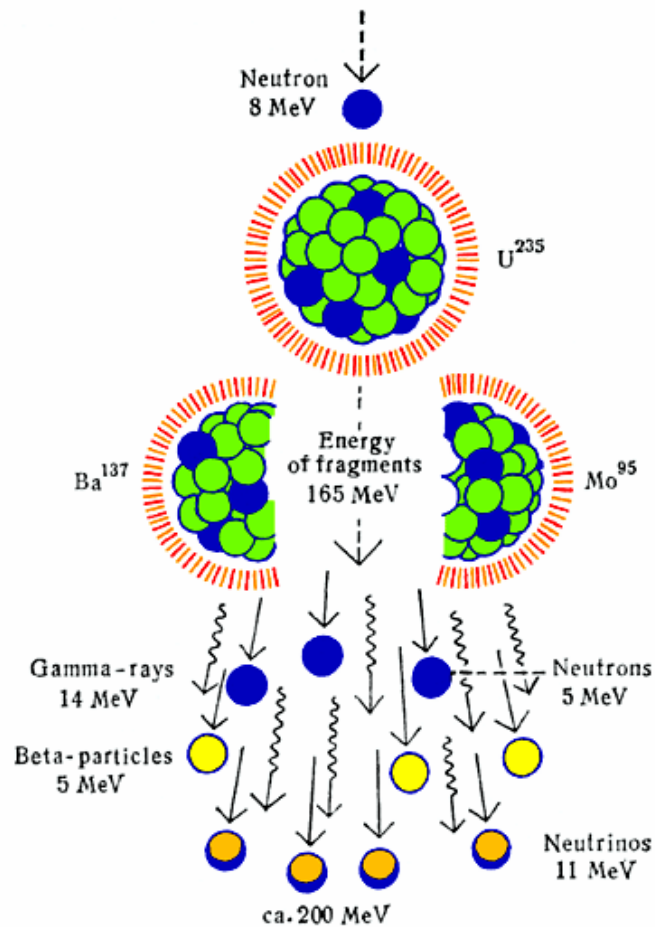
- Fission is a nuclear process in which a heavy nucleus splits into two smaller nuclei usually by neutron bombarding.
- An example of a fission reaction that was used in the first atomic bomb and is still used in nuclear reactors is:



- A particular reaction path during a nuclear fission is called a reaction channel

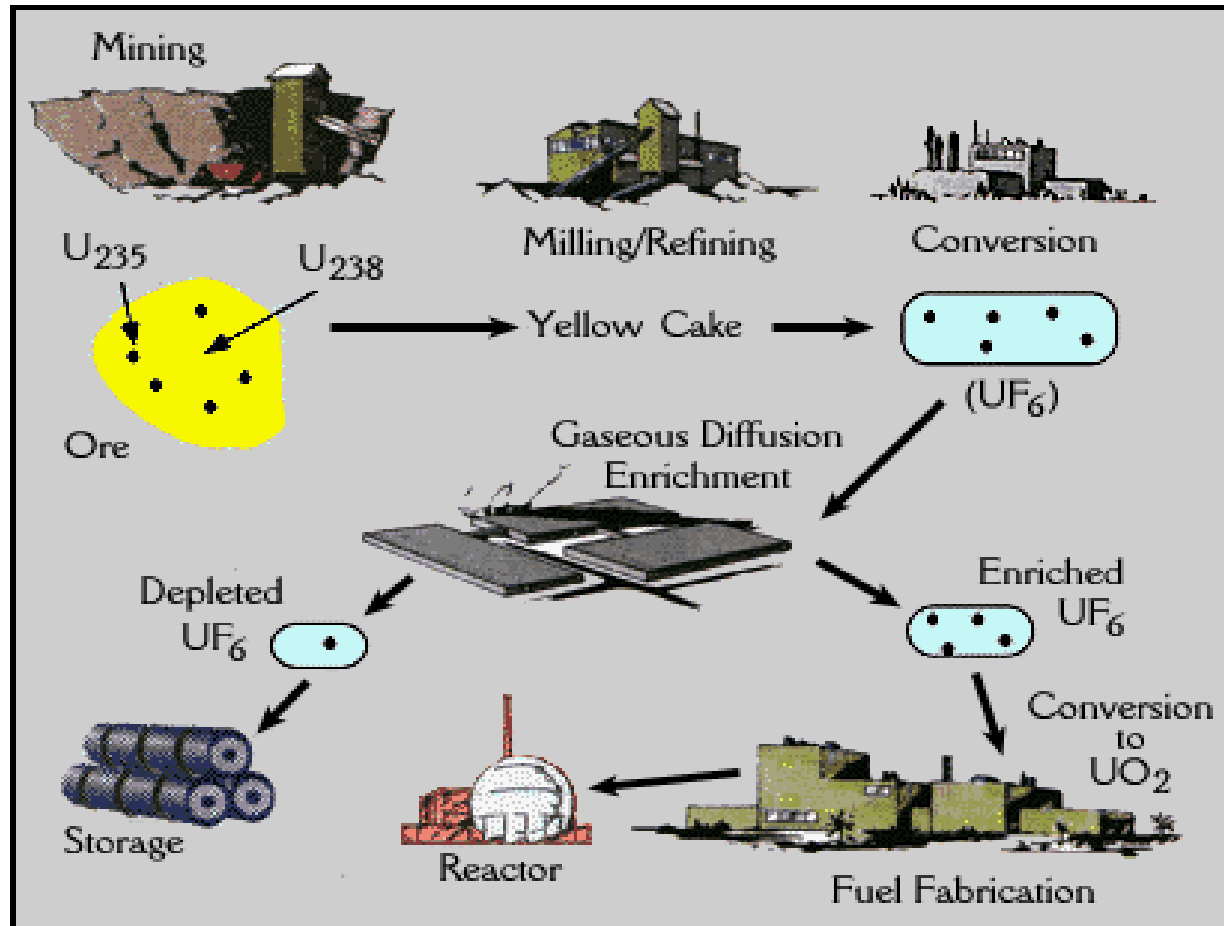


Where the energy comes from and how is distributed

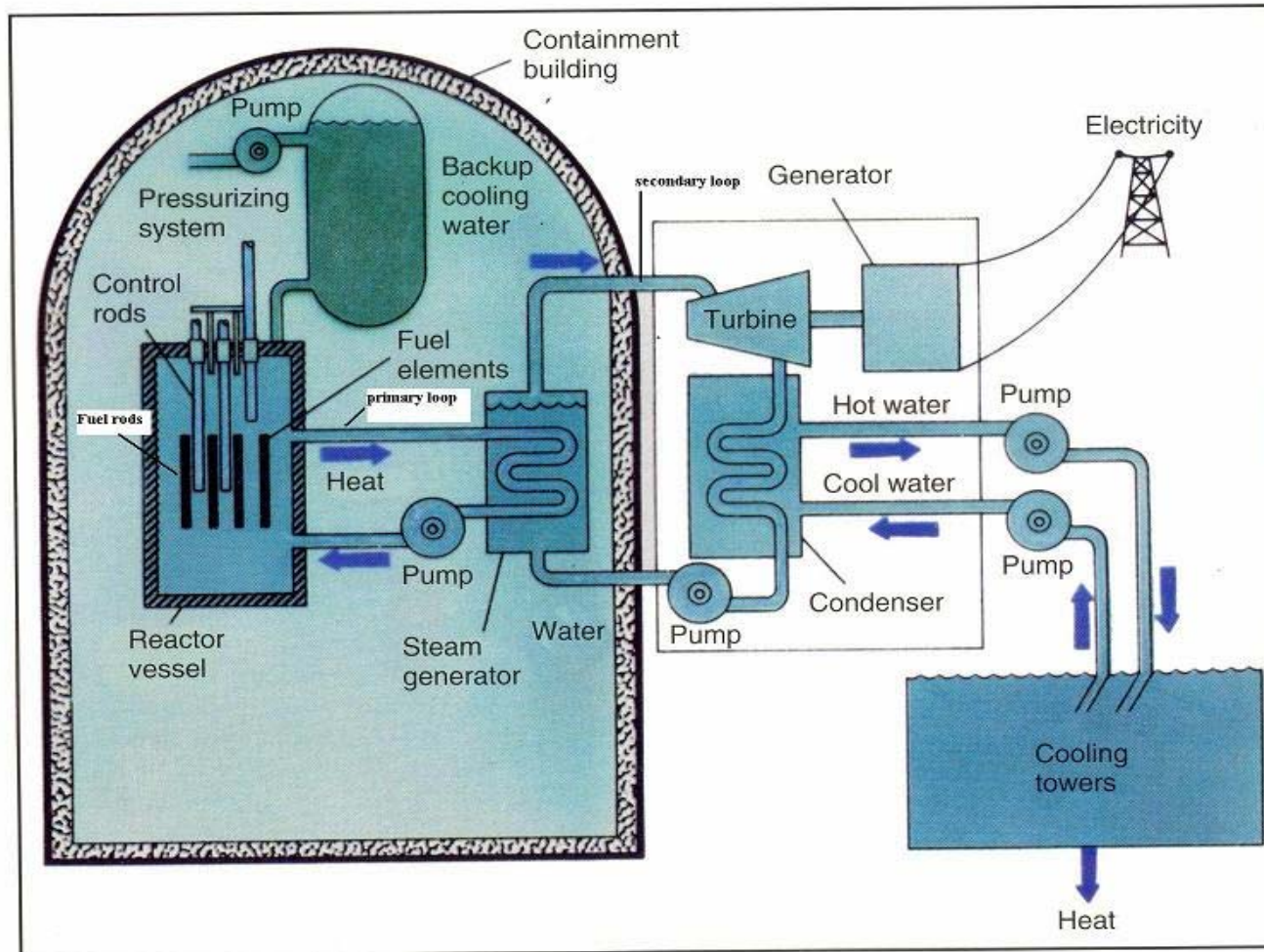


1 atomic mass unit = $1.66053886 \times 10^{-27}$ kilograms

Uranium - From Ore to Reactor Fuel



Schematic of a Nuclear Power Plant



Types of Nuclear Reactors

Reactor Type	Coolant	Moderator	Fuel	Comment
Pressurised water reactors (PWR, VVER)	Light water	Light water	Enriched uranium	Steam generated in secondary loop
Boiling water reactors (BWR)	Light water	Light water	Enriched uranium	Steam from boiling water fed to turbine
Pressurised heavy water reactor (PHWR)	Heavy water	Heavy water	Natural uranium	
Gas-cooled reactors (Magnox, AGR, UNGG)	CO ₂	Graphite	Natural or enriched uranium	
Light water graphite reactors (RBMK)	Pressurised boiling water	Graphite	Enriched uranium	Soviet design

Energy equivalent of lethal radiation dose

Total body irradiation

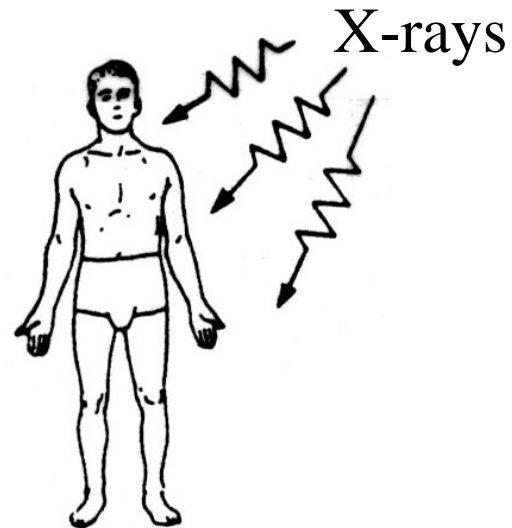
Mass = 70 kg

LD = 4 Gy

4 Gy = 400 rad =

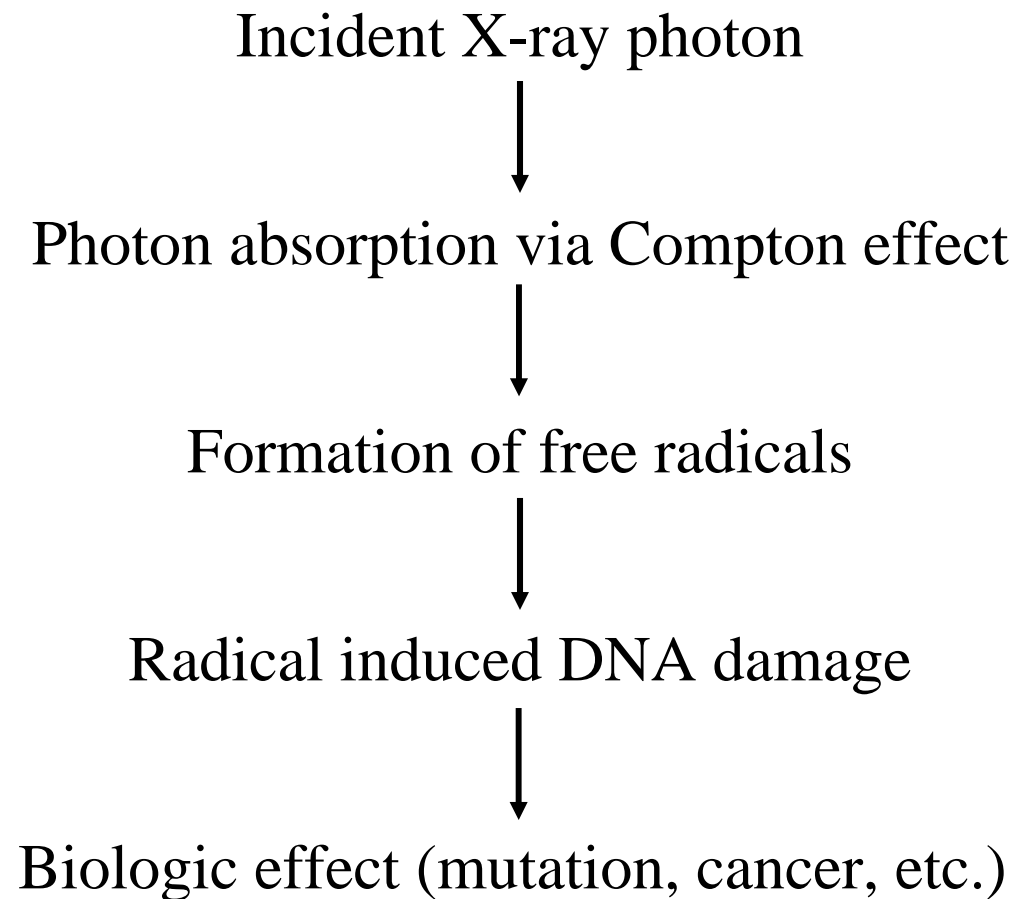
67 calories

67 calories equivalent
to energy in one sip
(3 ml) of hot coffee



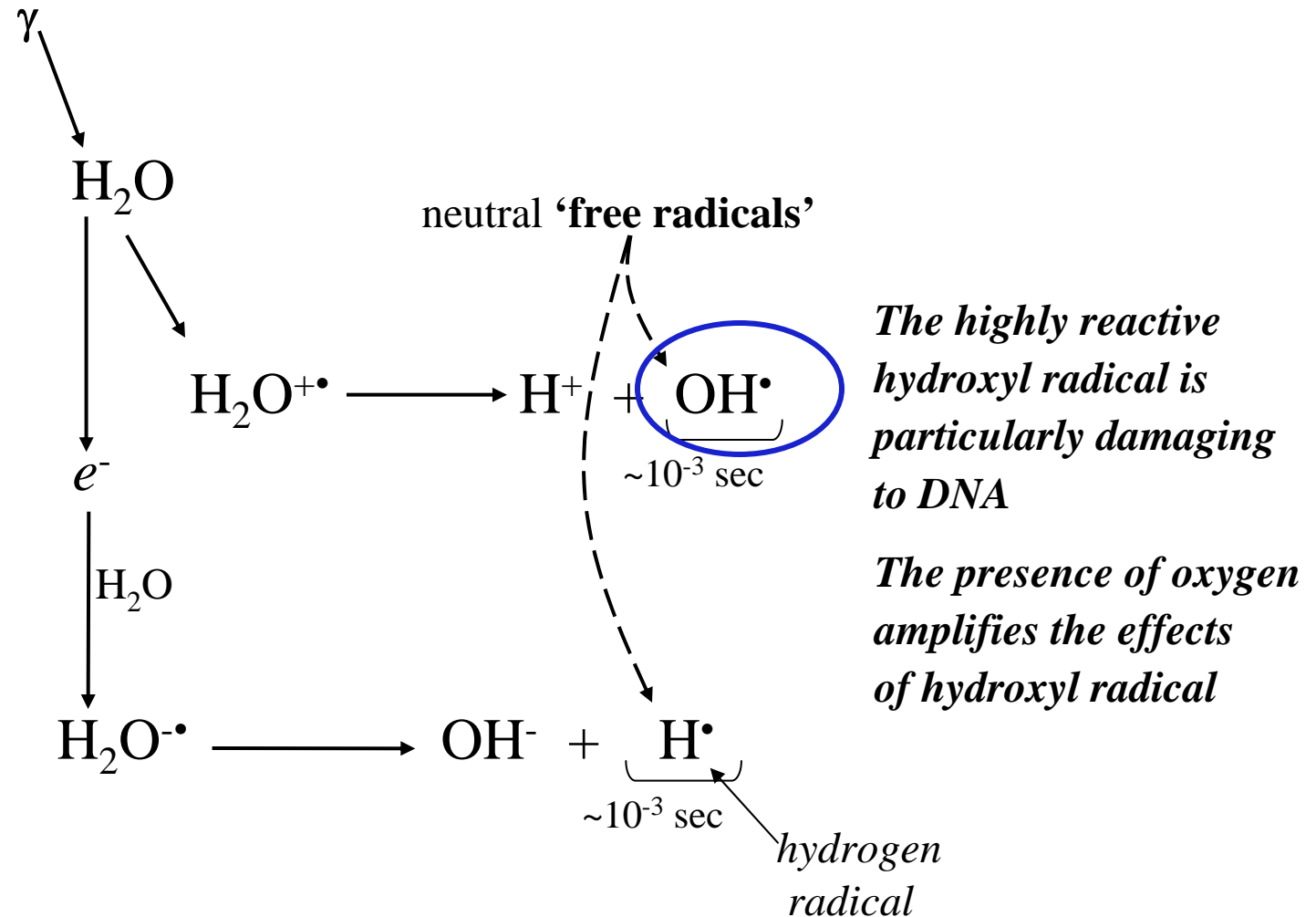
*Lethal dose is
relatively modest
amount of energy*

Sequence of Radiation Effects

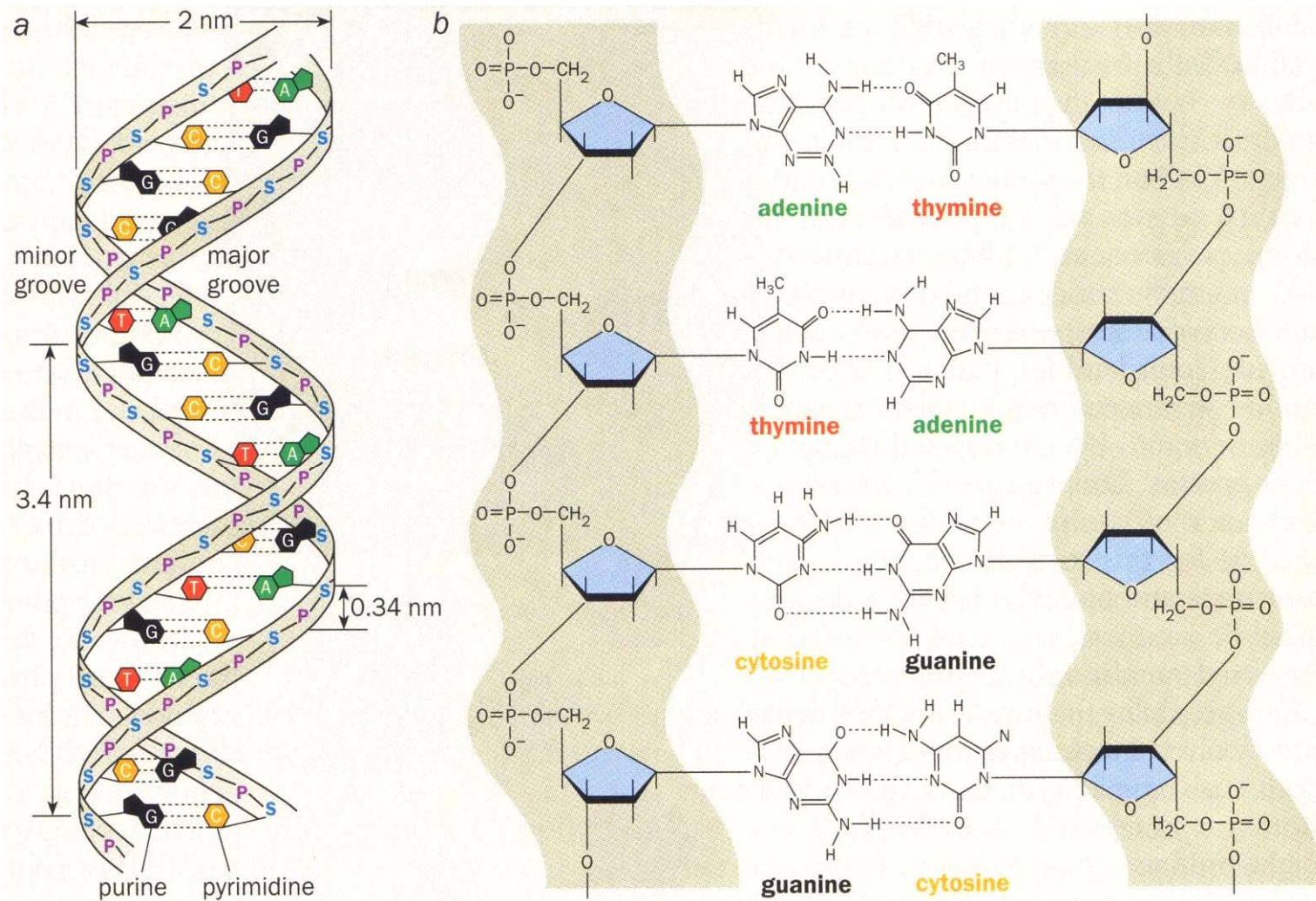


Radiation interaction with water

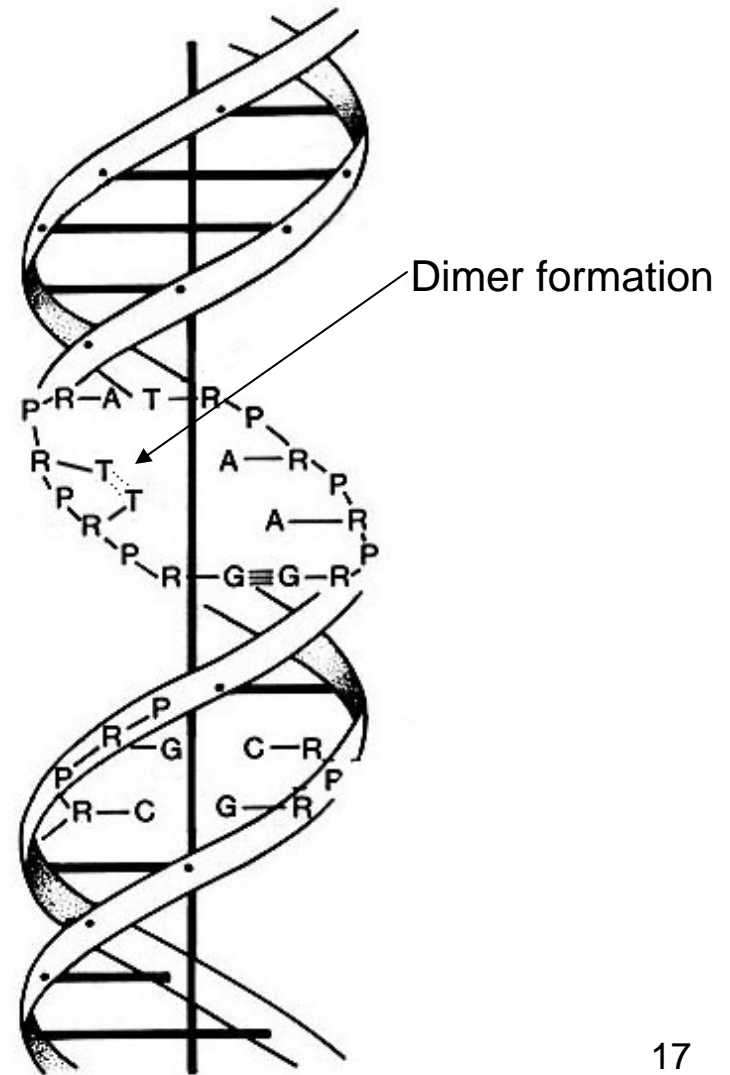
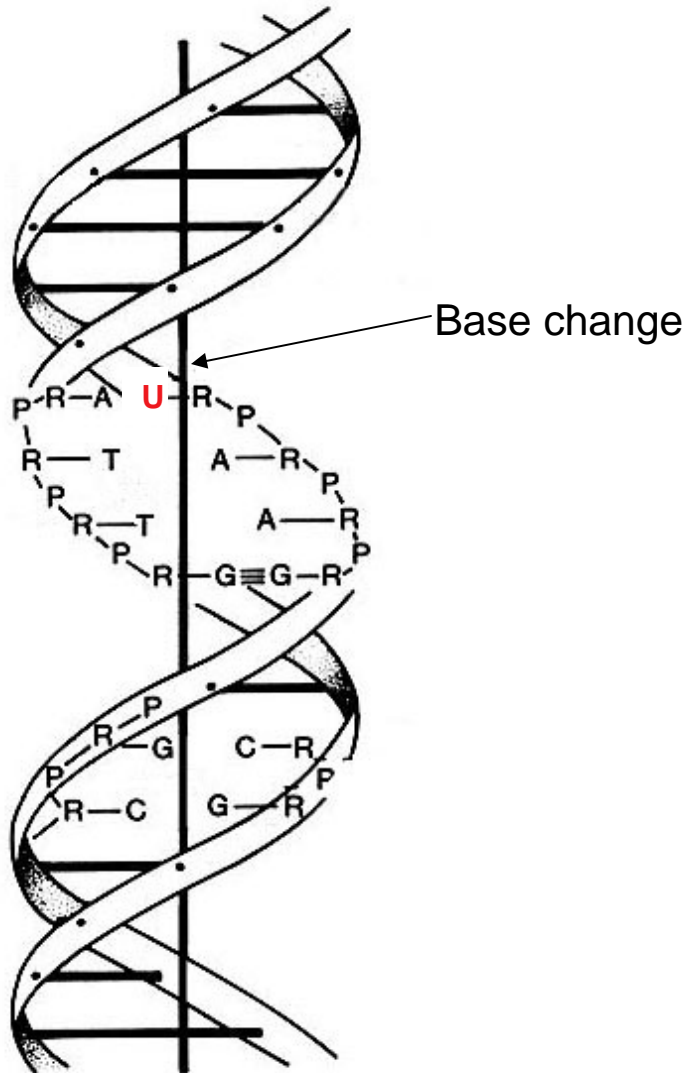
Initial reaction with cells



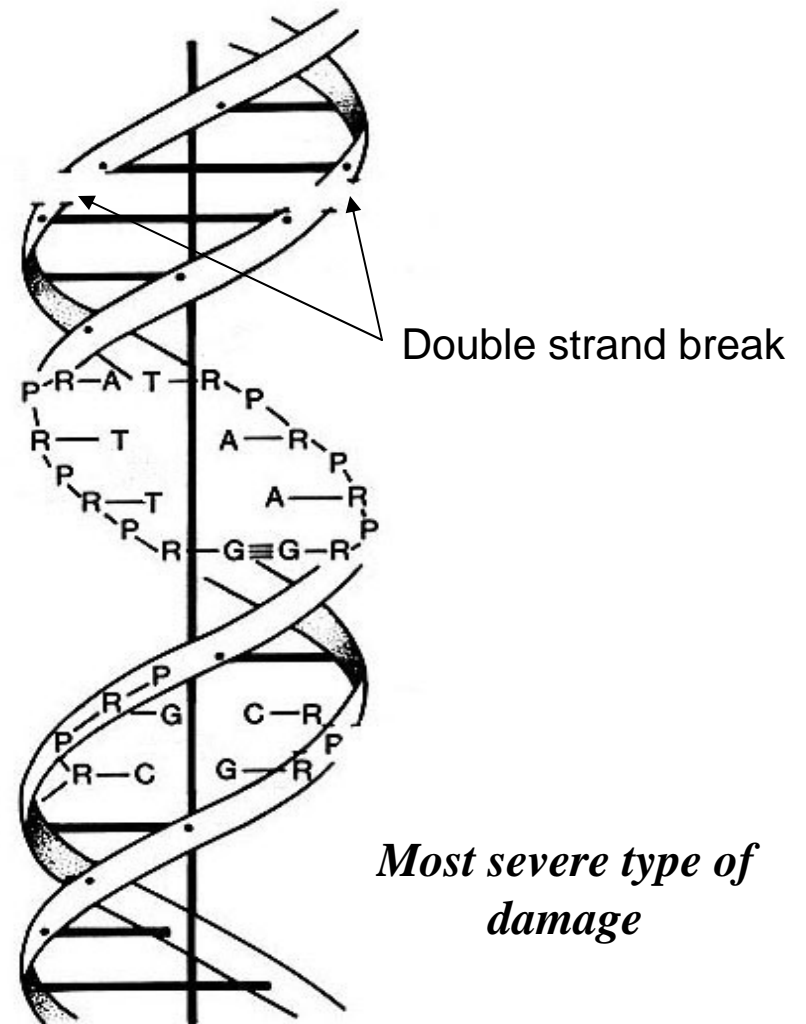
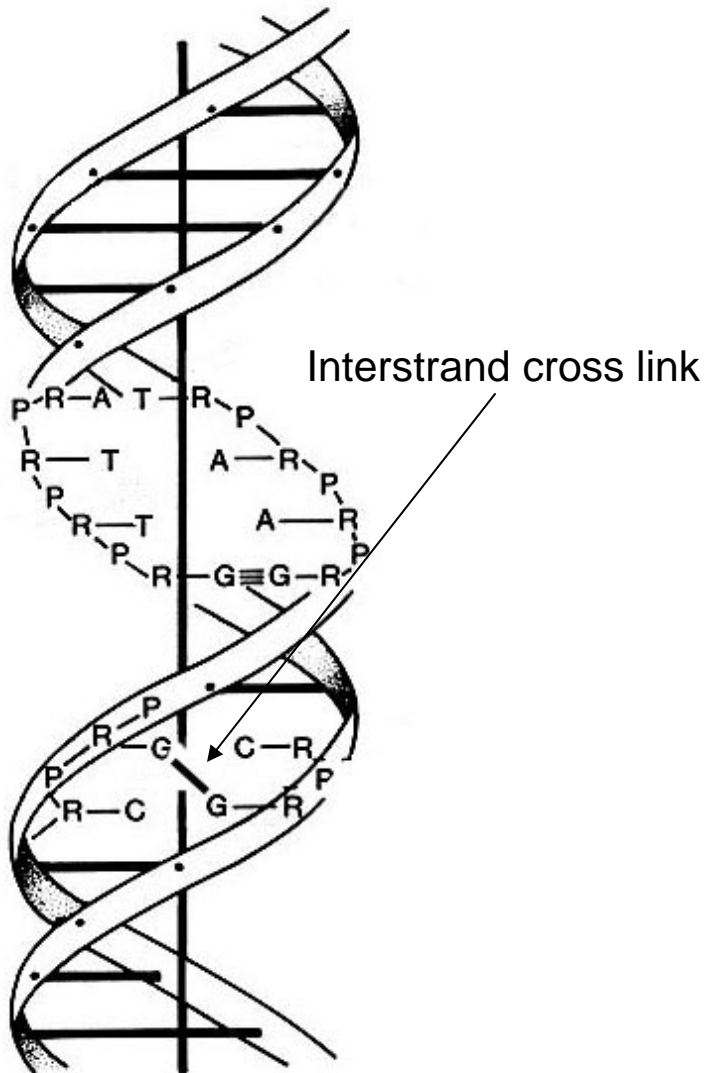
The DNA double helix



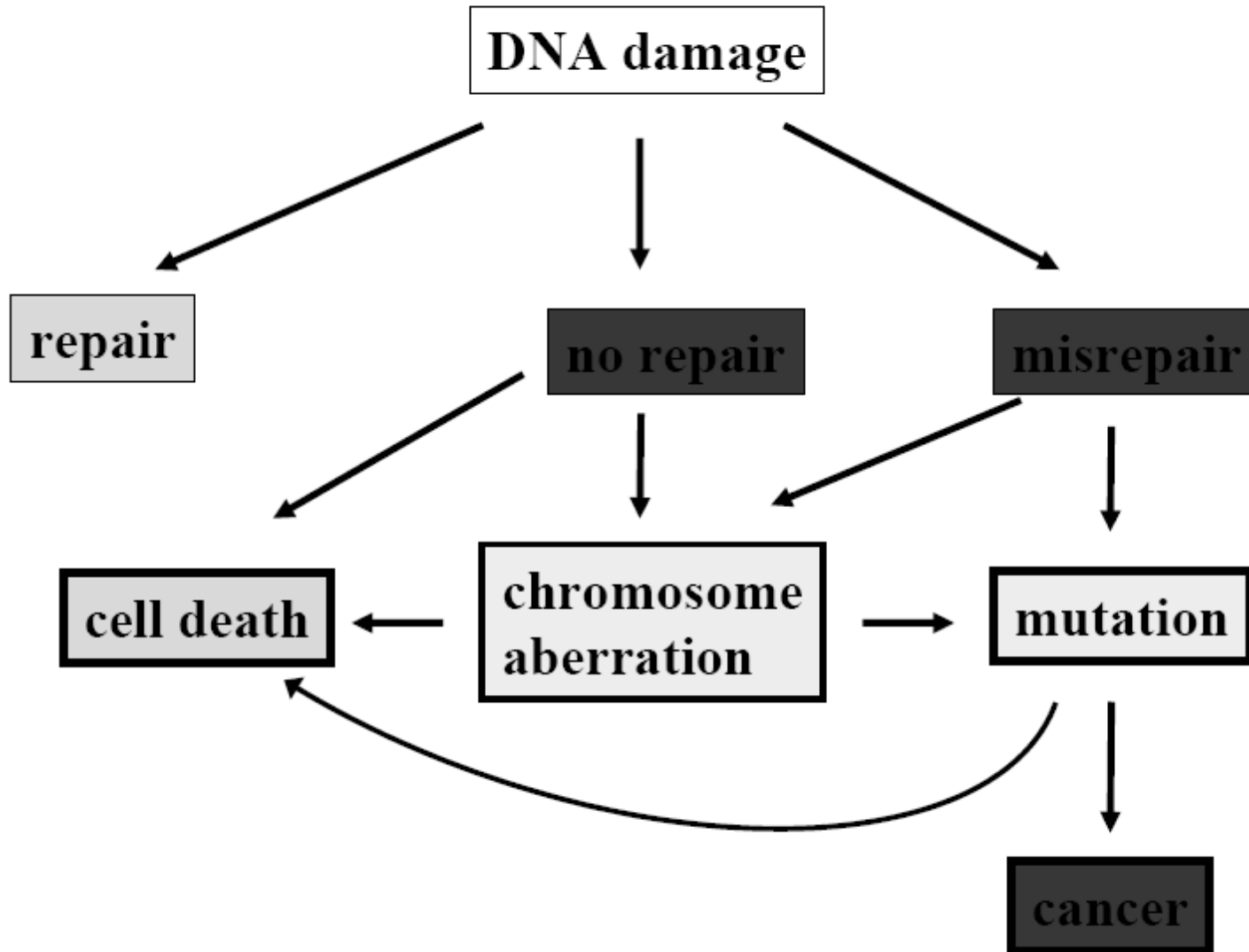
Examples of DNA lesions induced by Radiation



Examples of DNA lesions induced by Radiation



DNA damage and its consequences



DNA Damage from Ionization.

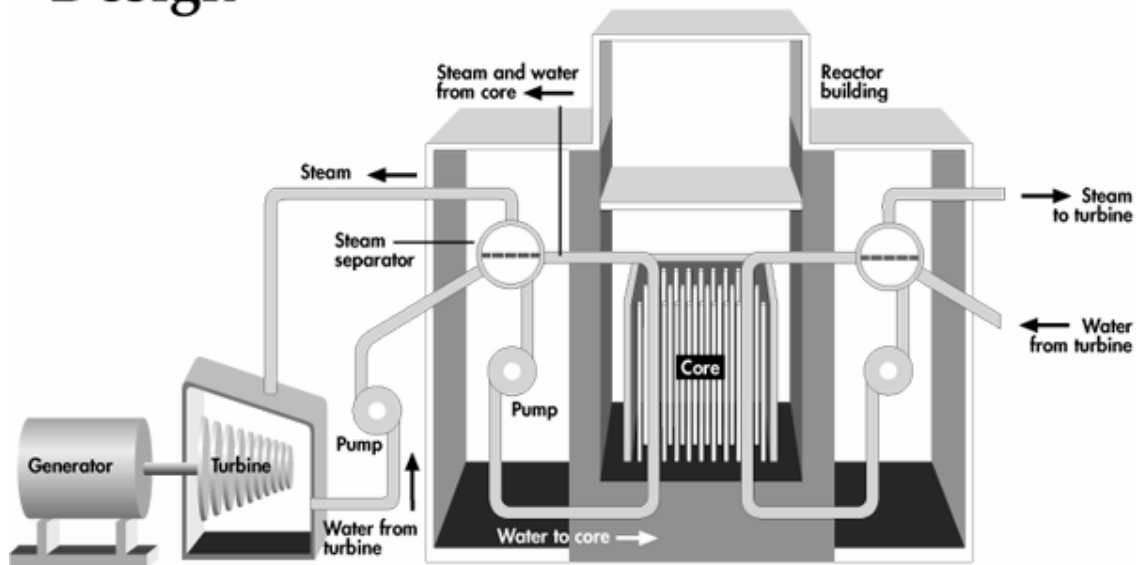
Чернобыль как это было



Chernobyl how it happen

RBMK Reactor Design

RBMK a Russian acronym for
Reactor Bolshoi Moschnosti Kanalnyi
"Canalized Large Power Reactor"



Source: Nuclear Energy Institute

RBMK light water graphite reactor

Reactor Bolshoi Moschnosti Kanalnyyi

Pressure tubes

each fuel assembly is positioned in its own pressure channel.

Graphite moderator

moderator to slow down the neutrons released during fission.

Control rods

B4C control rods. Can be dropped into the core to reduce or stop reactor activity.

Coolant

95% of the heat from fission is transferred to the coolant.

Emergency core cooling system operation if coolant circuit is interrupted.

Steam separator

Steam from the heated coolant ,to turbines produce electricity

The steam is condensed and fed back into the circulating coolant.

Containment

Reactor core is located in a concrete lined cavity that acts as a radiation shield.

The upper shield or pile cap above the core, is made of steel

On April 26, 1986, an accident occurred at unit 4 of the nuclear power station

The accident, destroyed the reactor and released massive amounts of radioactive material into the environment.

Pripyat, the town near Chernobyl was evacuated several days after the accident



Chernobyl Nuclear Power Station

- 135 000 people were removed from an area within a radius of 30 km.
- The smoke and radioactive debris reached a height of 1200 m and travelled across Russia, Poland and Scandinavia.
- A cloud of material from the accident reached the UK and, with heavy rain, there was material deposited on parts of north Wales, Cumbria and Scotland.
- This caused certain farm animals (e.g. lambs) to be banned from sale as they had absorbed radiation from the grass.

Total Fallout

	Half-life	Activity released (PBq)
<i>Inert gases</i>		
Krypton-85	10.72 a	33
Xenon-133	5.25 d	6500
<i>Volatile elements</i>		
Tellurium-129m	33.6 d	240
Tellurium-132	3.26 d	-1150
Iodine-131	8.04 d	-1760
Iodine-133	20.8 h	2500
Caesium-134	2.06 a	-47 ^b
Caesium-136	13.1 d	36
Caesium-137	30.0 a	-85
<i>Elements with intermediate volatility</i>		
Strontium-89	50.5 d	-115
Strontium-90	29.12 a	-10
Ruthenium-103	39.3 d	>168
Ruthenium-106	368 d	>73
Barium-140	12.7 d	240
<i>Refractory elements (including fuel particles)^f</i>		
Zirconium-95	64.0 d	84
Molybdenum-99	2.75 d	>72
Cerium-141	32.5 d	84
Cerium-144	284 d	-50
Neptunium-239	2.35 d	400
Plutonium-238	87.74 a	0.015
Plutonium-239	24 065 a	0.013
Plutonium-240	6 537 a	0.018
Plutonium-241	14.4 a	-2.6
Plutonium-242	376 000 a	0.00004
Curium-242	18.1 a	-0.4



“Chernobyl is a grim reminder that nuclear power is a technology that simply cannot be controlled.”

Newsweek, May 1986

Conclusions

- There is an argument about the use of nuclear power for energy production
- The existence of nuclear power plants makes it more difficult to enforce a nuclear weapons ban
- A nuclear power plant accident can expose huge numbers of people to radiation
- Storage of radioactive products carries long-term dangers
- Nuclear power may cause less global warming than conventional power generation

References

- web.ead.anl.gov/uranium/guide/facts/
- www.euronuclear.org/info/encyclopedia/d/decay
- Atom from A to Z, by K. Gladkov, Moscow, 1971
- www.nuclearpower.co.nz
- www.radccore.org/
- world-nuclear.org
- Molecular Biology of the Cell by Bruce Alberts Mar 2003
- Radiation Effects *Andrew Holmes, Len Adams (2002)*
- <http://www-pub.iaea.org/MTCD/publications>

Thank you

