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Environmental Aspects of Nuclear Energy

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- Environmental Impact Assessment
- Nuclear energy
- Production of fissile materials
- In Situ Leaching
- Radioactivity and Ionizing Radiation
- Radiation Exposure
- Protection against radiation
- Effects on human organism

Environmental aspects assessment

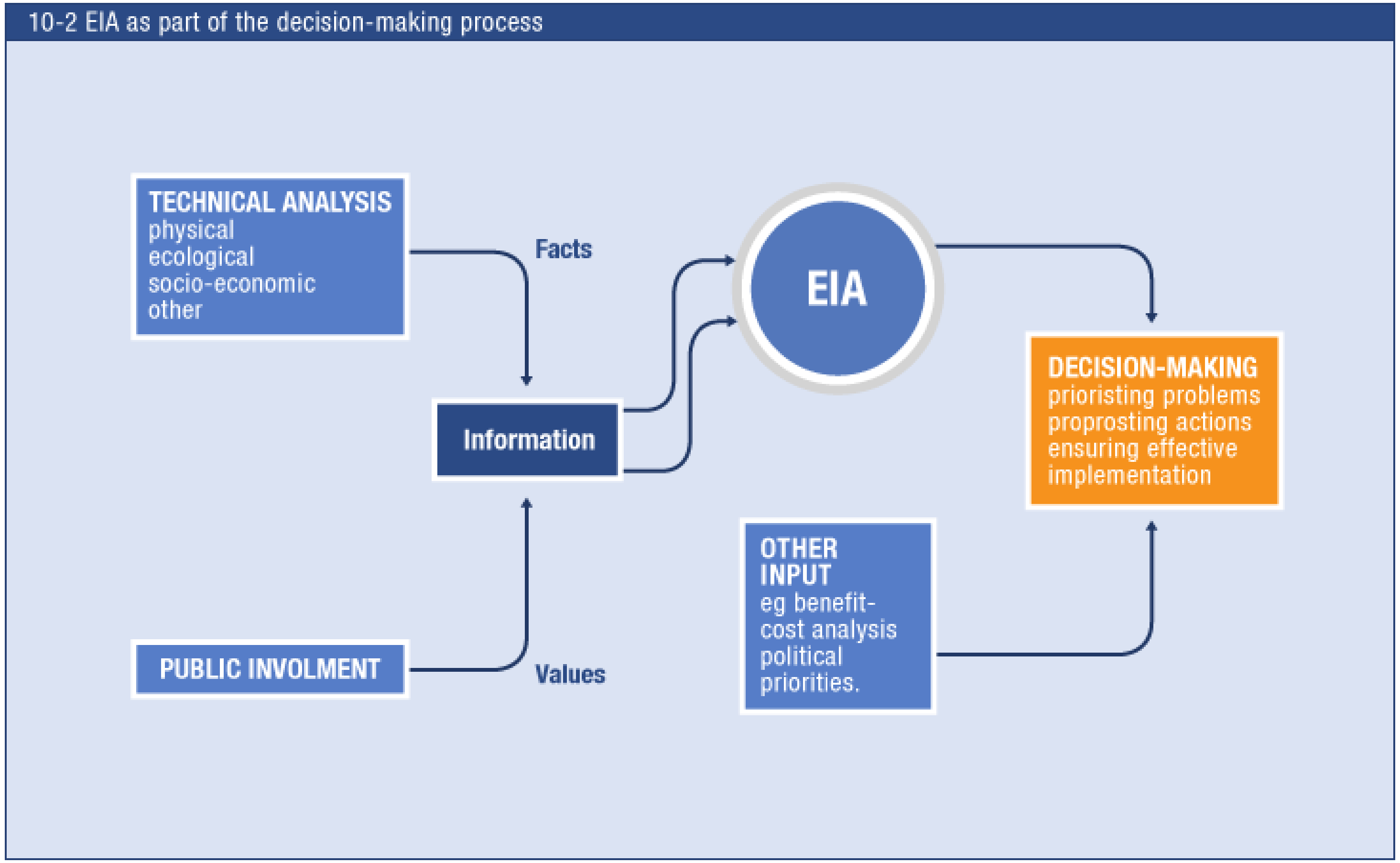
– Over the next five minutes each of you write pros and cons of nuclear energy in terms of national energy security.

Environmental aspects assessment

– Over the next five minutes each of you write pros and cons of nuclear energy in terms of purely subjective, personnal point of view.

Environmental aspects assessment

- To bridge the conflict between state and industry interests and personal subjective perception of the problem serves the EIA.



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Environmental aspects assessment

What is an environmental aspect ?

According to ČSN EN ISO 14001 definition:

„*The environmental aspect is an element of the activities, products or services that can interact with the environment*.“

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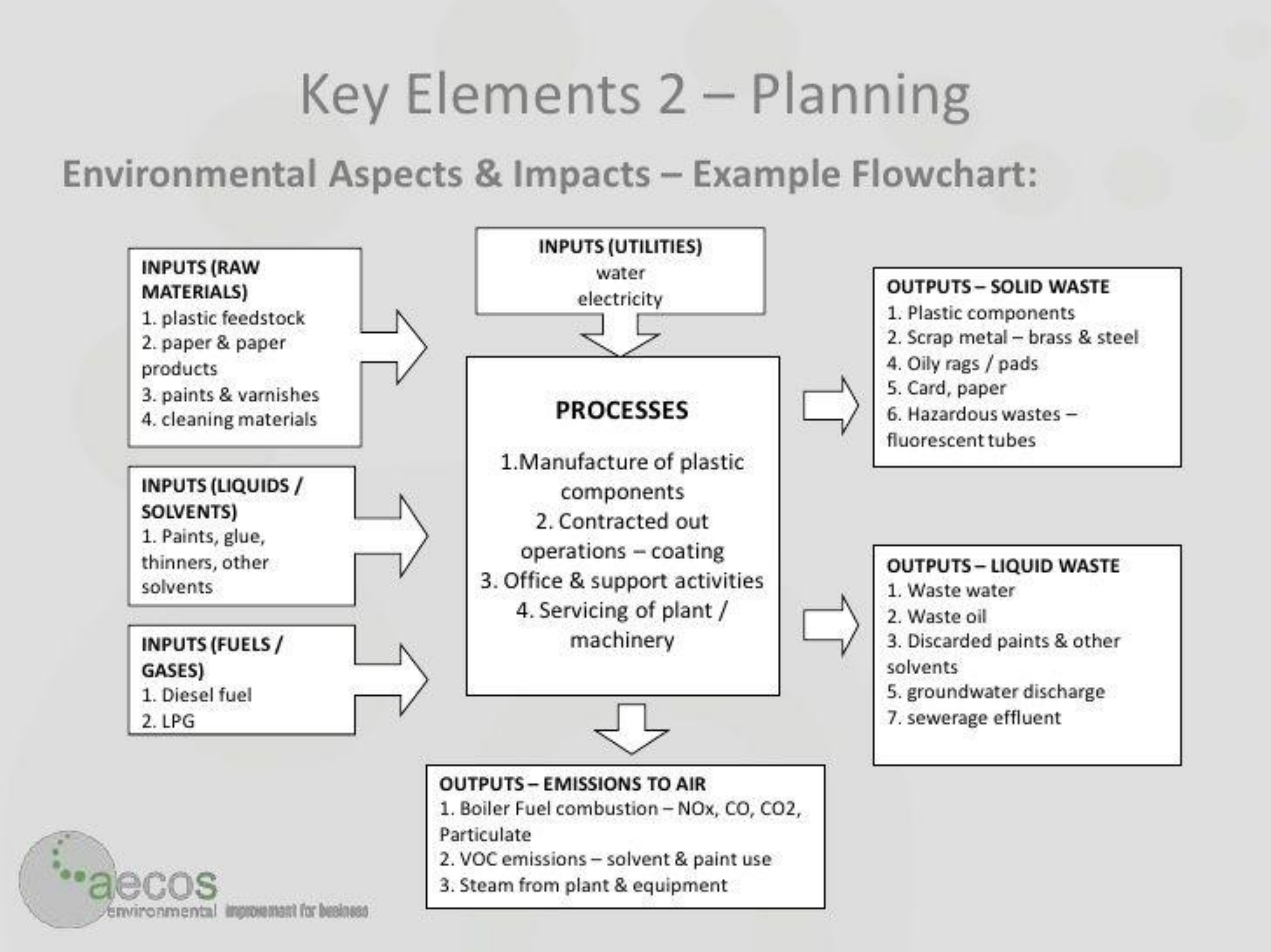
Environmental aspects assessment

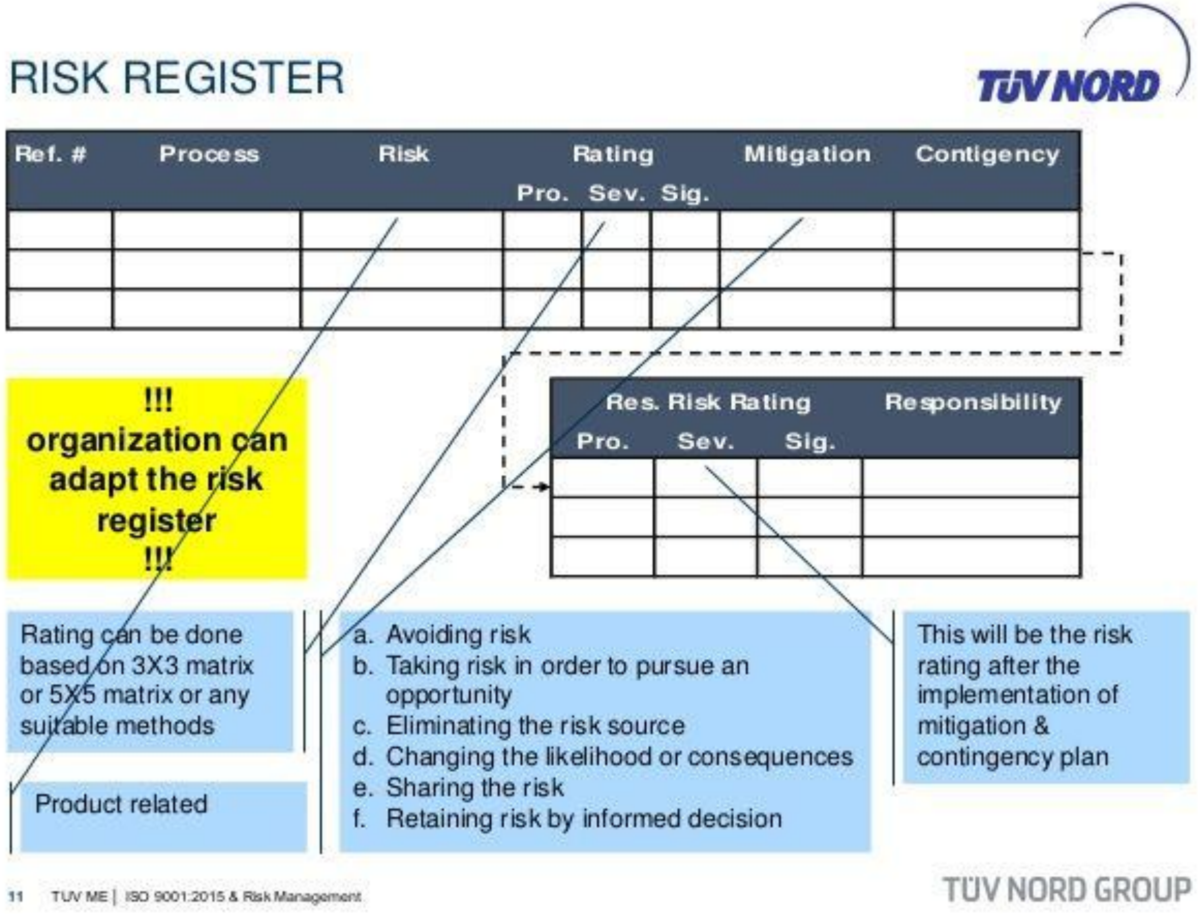
ISO 14001 (voluntary norm of the International Organization for Standardization on environmental management, prestige of the company, the norm requires to have an **environmental policy and environmental risk assessment**)

EMAS (Environmental management and audit system developed by EC in 1993, it requires ISO 14001 and other requirements such as the involvement of employees, etc., EMAS is thus perceived as a **premium tool** for environmental management. As part of this process so called **Environmental review** takes place - own risk identification, preparation of environmental policy, determining environmental aspects, objectives, programs)

Environmental aspects register



Environmental aspects register



A RISK RATINGS MATRIX

High	Not currently controlled. In breach of legislation or policy. Sensitive environment (groundwater proximity, conservation area, residential area). Repeated complaints.
Medium	Not fully controlled under normal or abnormal conditions. Above-average probability of occurrence and/or low probability of detection. Financial threat. Rising concern of shareholders. Complaint received.
Low	Controlled under normal and abnormal conditions. Low probability of occurrence and/or high probability of detection. Minimal impact.

Environmental aspects assessment

Methodology for assessing the environmental aspects

Assessment of the EA is performed using following 4 criteria.

Criteria:

-compliance with the limits and mandatory requirements

-frequency impact

-impact associated with the effects on the environment (size, persistence, scale)

-impact on society (its economy and image)

Environmental aspects register

ISO 14001:2015 – OBJECTIVES EXAMPLE

Activity	Aspect	Impact	Interested parties	Risk/opp - ortunity	Control	Objective
Production of the final product	Use of energy	Global warming	Employees Shareholders Customers	Energy heavy Use of renewables. Invest in green energy	Energy efficiency measures	5% carbon reduction per year
Sourcing of raw materials	Consumpti on of materials	Resource depletion/ ground pollution	Customers Pressure groups	Modify design to use recycled materials Demonstrate CSR Increase sales	Design control and verification measures. Monitor suppliers	50% increase in recycled content in 3 years 10% growth in sales in 3 years
Use of the product	Disposal of product	Ground and water pollution	Employees Shareholders Customers Pressure groups	Take back for re-use/re-working. Sales promotion	Programme to offer take back of product to re-use materials	Increase sales and take back by 10% per year

nqa.
NEVER STOP IMPROVING

Risk Assessment & Management cont,

Section of Appendix 04 – Aspects, impacts, objectives, risk register

Midfield Meat International Pty Ltd
Appendix 04 - Aspects, impacts, objectives, risk register

Activity	Aspect	Impact	Consequence	Likelihood	Significance	Objective / remedial action	Issues that need to be addresses	Roles /Authority
***246 Plant* - General Abattoir Operations**								
Stock and yard washing	Water consumption	Overuse of potable water	2	5	10	Reduce water use/use grey water	Water Balance	
	Wastewater generation	Increasing waste loads	2	3	6	Pre-treat drainage water/create on-site ponds		Stock yard manager
Sterilising equipment	Water consumption	Excess use of potable water	2	2	4	Investigate recycling options with Distech		
	Wastewater generation	Increased waste water volume	2	6	12	Look for possible water saving techniques		

THE MIDFIELD GROUP

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Environmental aspects register

Appendix 2: General Environmental Aspects / Impacts Assessment														Sheet No:	2
Site	Head office and site activities													Date	September 2015
Location	Ref.	ACTIVITY	ENVIRONMENTAL ASPECT	ENVIRONMENTAL IMPACT	CONDITION			LEGAL REQUIREMENTS	CONTROL OR INFLUENCE	SIGNIFICANCE			RISK RATING	CURRENT CONTROLS	
					Normal	Abnormal	Emergency			Policy	Legal	Other			
Office	6	Paper Waste Management	Paper reused and recycled Small amount to Landfill	RD(+ve); CW	✔			EPA 1990 (Part II)	C	✔	✔	✔	#	Client's & Brith Services Limited Environmental Policy / Site Plan Awareness Training Recycle paper Monitoring records	
Office	7	Office Waste Management	Glass, Plastic Composting Cans Cardboard	RD(+ve); CW	✔			EPA 1990 (Part II)	C	✔	✔	✔	#	Client's & Brith Services Limited Environmental Policy / Site Plan Awareness Training Segregate separate waste for recycling Monitoring records	
Office	8	Use of electrical and electronic equipment	Resource Use Material Use Electricity Consumption Computers, Display Screens, Printers, Heaters, Faxes, Kitchen Appliances	RD; SN	✔			EPA 1990 (Part II)	C	✔	✔	✔	C	Client's & Brith Services Limited Environmental Policy / Site Plan Awareness Training Turn off electrical equipment when not in use Use of energy saving electrical equipment Minimise the use of electrical equipment and its consumables Maintenance, servicing and PAT controls Monitoring records	

Environmental aspects register

Tabulka registru aspektů a dopadů – část A – přímé

VEA – významný environmentální aspekt,NEA – nevýznamný environmentální aspekt, H- stav havarijní , B –běžný provoz, M – mimořádný stav   S - součet

Poř. číslo	Místo vzniku (pracoviště, proces)	Činnost	Aspekt	Dopad	Provoz B/M/H	Významnost	L	D	P	S	Opatření,odpovědnost (měření, cíl atd.)
1	Ředitelství ZZS OK	administrativa	vznik sběrového papíru	čerpání přírodních zdrojů	B	NEA	1	1	1	3	optimalizace spotřeby papíru v administrativě
			spotřeba el. energie	čerpání přírodních zdrojů	B	NEA	1	1	1	3	nesvítit zbytečně, el. energii odebírat co nejrovnoměrněji
			spotřeba pitné vody	čerpání přírodních zdrojů	B	NEA	1	1	1	3	kontrolovat vypnutí kohoutků, neplýtvat pitnou vodou
			vznik odpadních splaškových vod	zátěž přírody v podobě odpadních vod	B	NEA	1	2	1	4	neznečišťovat splaškové vody závadnými látkami
			spotřeba zářivek	vznik nebezpečného odpadu	B	VEA	1	2	2	**5**	nesvítit zbytečně, zářivky opakovaně nezapínat a nevypínat ***EMS 1/2013***
			spotřeba tonerů	vznik nebezpečného odpadu	B	VEA	1	2	2	**5**	maximální šetření při tisku dokumentů, zpětný odběr zajištěn smluvně
			vznik komunálního i ostatního odpadu	zátěž přírody v podobě ukládání odpadů	B	NEA	1	1	1	3	maximální množství obalů vracet k recyklaci, třídit odpady

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Environmental Impact Assessment

Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment

The EIA Directive of 1985 has been amended three times, in 1997, in 2003 and in 2009

Mandatory EIA: all projects listed in Annex I are considered as having significant effects on the environment and require an EIA

Discretion of Member States (screening): for projects listed in Annex II, the national authorities have to decide whether an EIA is needed. This is done by the "screening procedure", which determines the effects of projects on the basis of thresholds/criteria or a case by case examination. However, the national authorities must take into account the criteria laid down in Annex III.

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0052

Environmental Impact Assessment

Crude-oil refineries, gasification and liquefaction of 500 tonnes or more of coal or bituminous shale per day, Thermal power stations, Nuclear power stations, Installations for the reprocessing of irradiated nuclear fuel, fuel enrichment, processing, waste disposal, smelting of cast iron and steel, production of non-ferrous crude metals from ore, Installations for the extraction of asbestos and for the processing and transformation of asbestos and products containing asbestos, installations for the manufacture on an industrial scale of substances using chemical conversion processes, Construction of lines for long-distance railway traffic and of airports, motorways and express roads, new road of four or more lanes, or realignment and/or widening of an existing road of two lanes or less so as to provide four or more lanes, Inland waterways and ports for inland-waterway traffic, Waste disposal installations, Groundwater abstraction, Waste water treatment plants, Extraction of petroleum and natural gas, Dams and other installations designed for the holding back or permanent storage of water, Pipelines with a diameter of more than 800 mm and a length of more than 40 km, Installations for the intensive rearing of poultry or pigs with more than, Industrial plants for the production of pulp and paper, Quarries and open-cast mining, Construction of overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15 km, Installations for storage of petroleum, petrochemical, or chemical products, Storage sites of carbon dioxide, Installations for the capture of CO_2

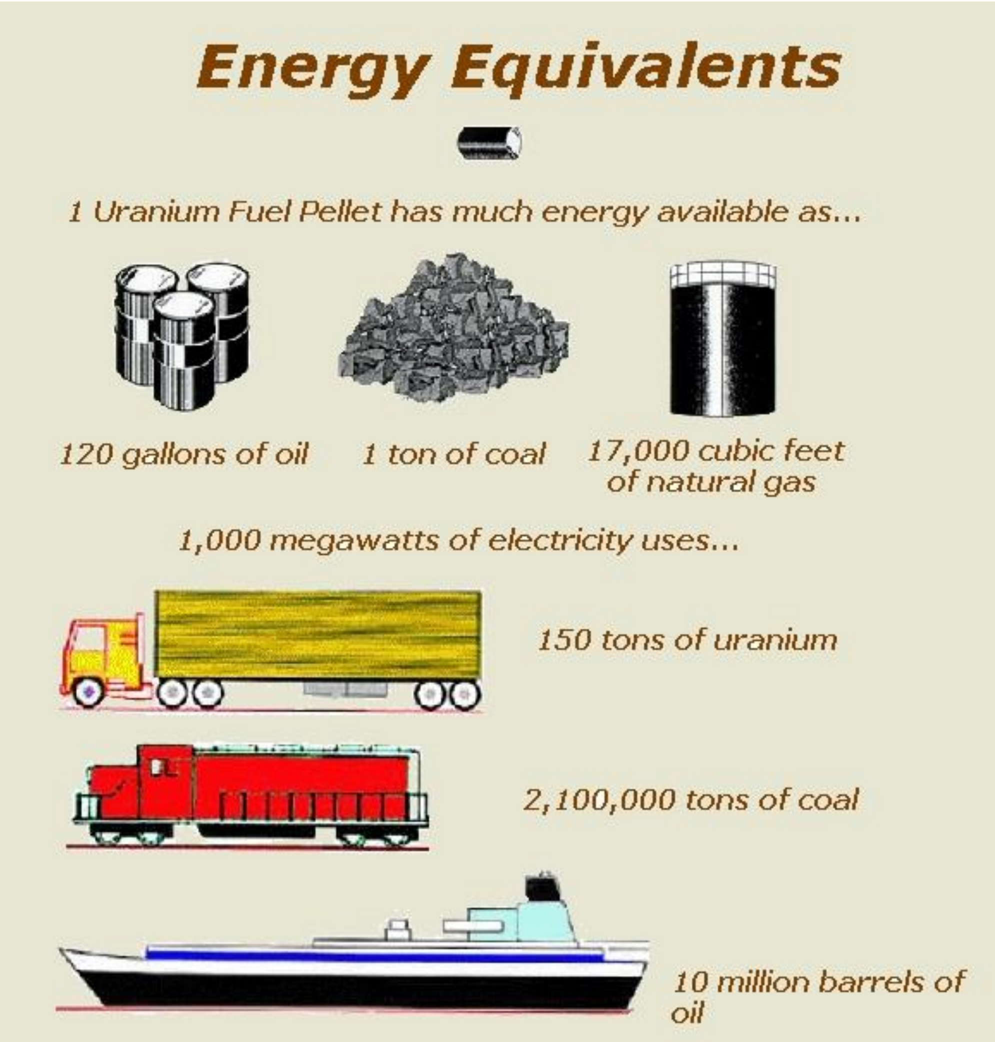
Environmental Impact Assessment

The process is:

- announcement to the authorities (Region, ME)
- official publication/announcement by the competent authorities
- 20-day deadline for comments
- screening procedure
- documentation
- preparing the report (90 days)
- Comments (30 days)
- the final opinion as a professional basis for related procedures (eg. land, construction) valid for 5 years and with the possibility of extension

Nuclear energy in general

- **production of fissile materials (conventional mining, chemical treatment, in-situ leaching)**
- production of electricity in nuclear power plants
- release of nuclear energy from the atomic nucleus
- chain fission in nuclear fuel
- accompanying phenomenon - **ionizing radiation**



Production of fissile materials

Mining in the open pit mines:

- extraction in open pit mines very similar to coal production
- generally the least impact on the environment with respect to other methods of mining
- extraction of nuclear fuel is just as harmful as other methods of mining
- intervention in the landscape depends on the amount of ore and yield (percentage of) nuclear fuel




Production of fissile materials

Chemical processing of mined ore

- Czech example: Mydlovary MAPE, 20 km from Temelín NPP
- leaching with sodium bicarbonate (higher content of carbonates) or sulfuric acid (reduced content of carbonates)
- ratio of sulfuric acid up to 560 g of 94% acid per one liter of the leached material
- processed 16.7 mil. tonnes of ore, formation of tailing ponds with a total area of 300 ha - 36 mil. tonnes of sludge
- heavy metals and radioactive substances

Production of fissile materials

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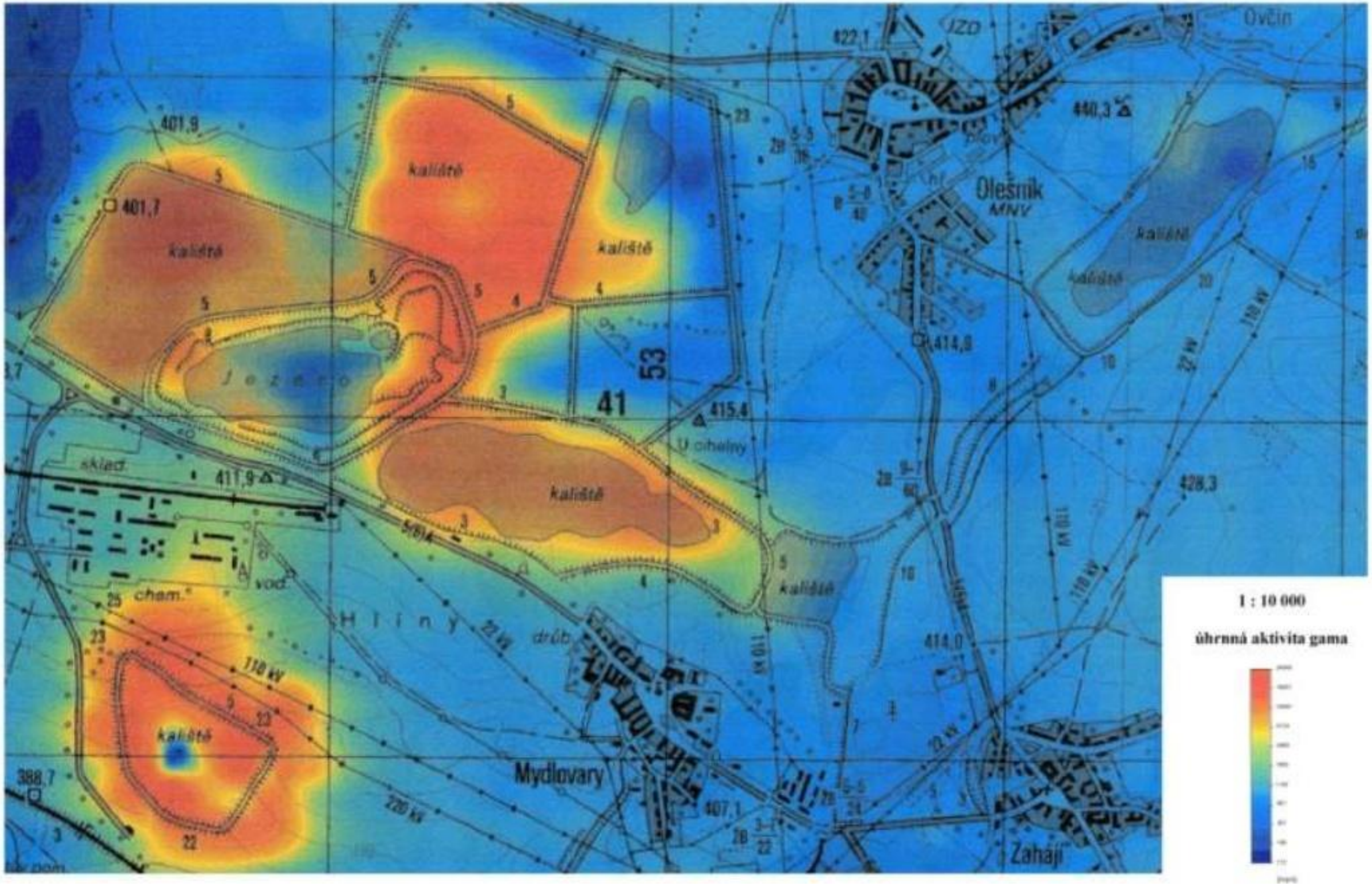
Radiokontaminace půd a sedimentů:



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Production of fissile materials

Production of fissile materials - ISL

In situ leaching (ISL), also known as solution mining, or in situ recovery (ISR) in North America, involves leaving the ore where it is in the ground, and recovering the minerals from it by dissolving them and pumping the pregnant solution to the surface where the minerals can be recovered.

Consequently there is **little surface disturbance and no tailings or waste rock generated**.

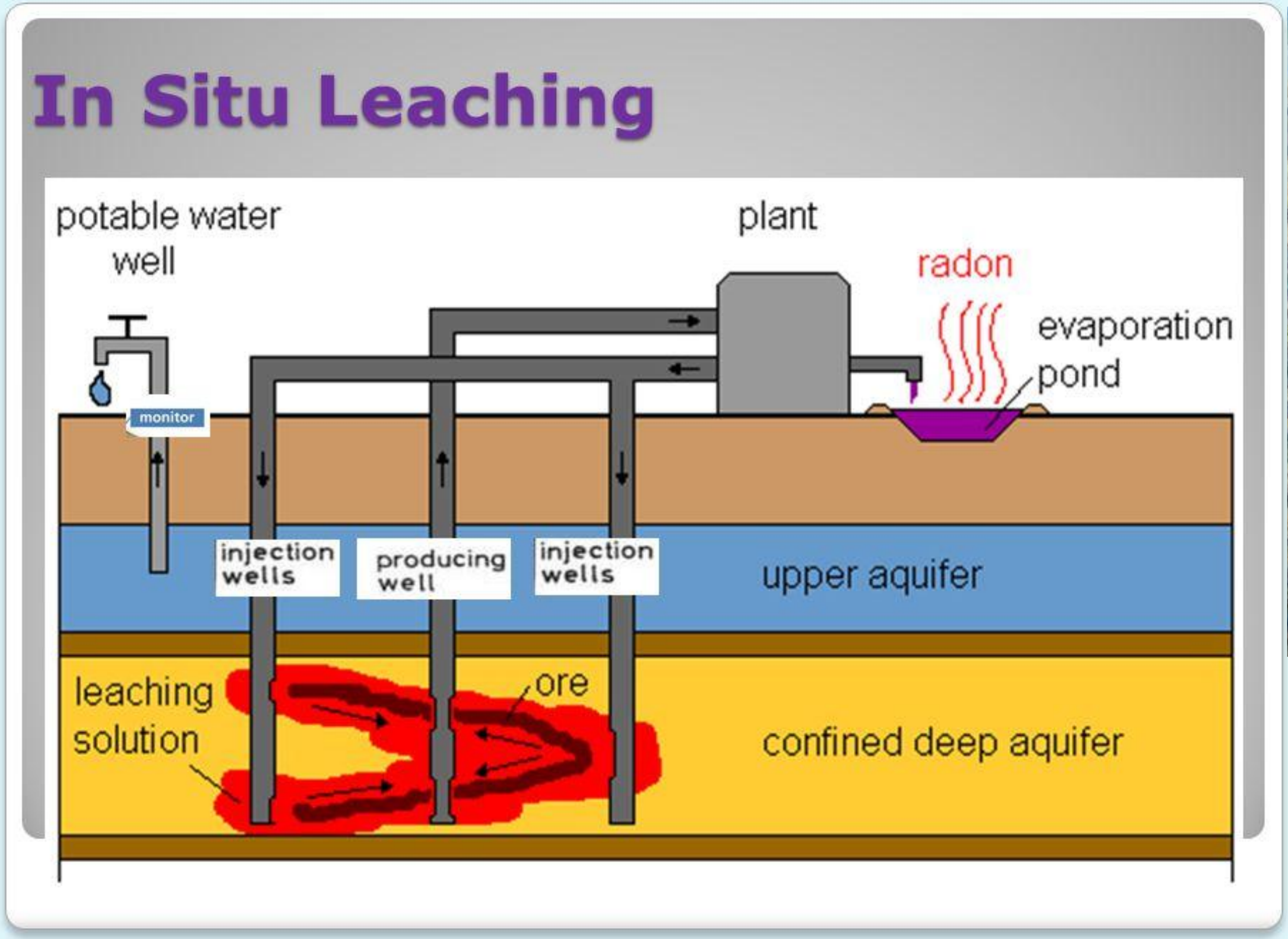
However, the orebody needs to be permeable to the liquids used, and located so that they do not contaminate groundwater away from the orebody.

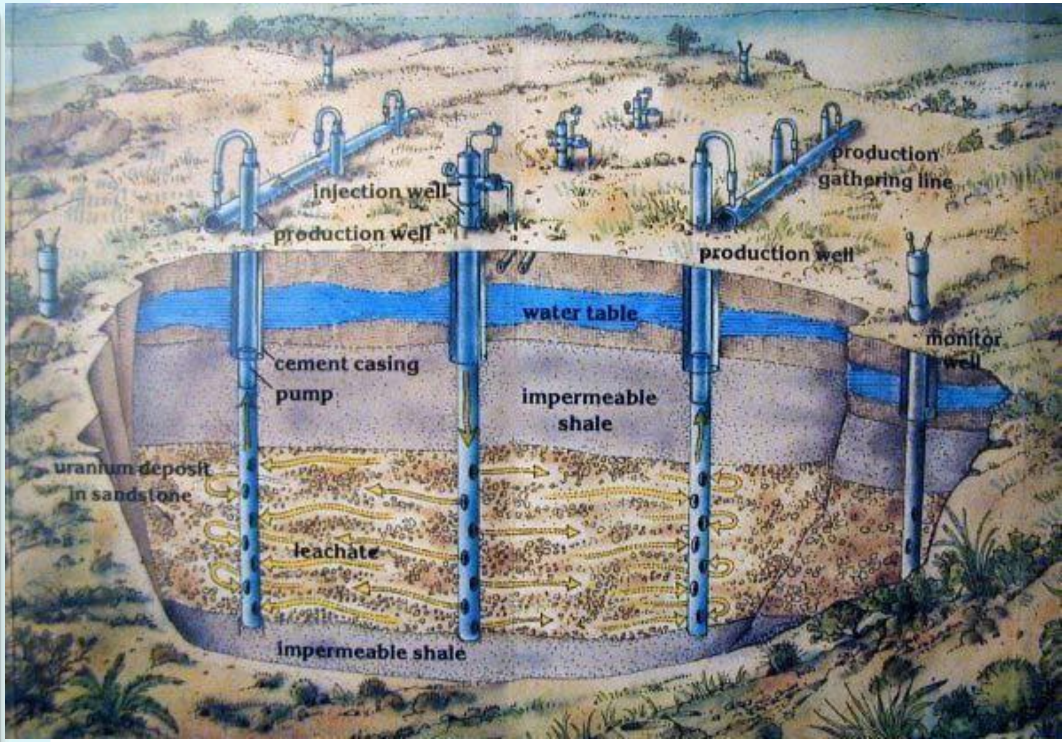
In the last five years, 48-51% of world uranium mined was from ISL operations. Most uranium mining in the USA, Kazakhstan and Uzbekistan is now by in situ leach methods, also known as in situ recovery (ISR).

ISL mining of uranium is undertaken in Australia, China, and Russia as well.

In USA ISL is seen as the most cost effective and environmentally acceptable method of mining, and other experience supports this.

Production of fissile materials - ISL





Production of fissile materials - ISL

Production of fissile materials - ISL

The advantages of this technology are:

- the reduced hazards for the employees from accidents, dust, and radiation,
- the low cost;
- no need for large uranium mill tailings deposits.

Spill after pipe failure

The disadvantages of the in-situ leaching technology are:

- the risk of spreading of leaching liquid outside of the uranium deposit, involving subsequent groundwater contamination,
- the unpredictable impact of the leaching liquid on the rock of the deposit,
- the impossibility of restoring natural groundwater conditions after completion of the leaching operations.
- Moreover, in-situ leaching releases considerable amounts of radon, and produces certain amounts of waste slurries and waste water during recovery of the uranium from the liquid.

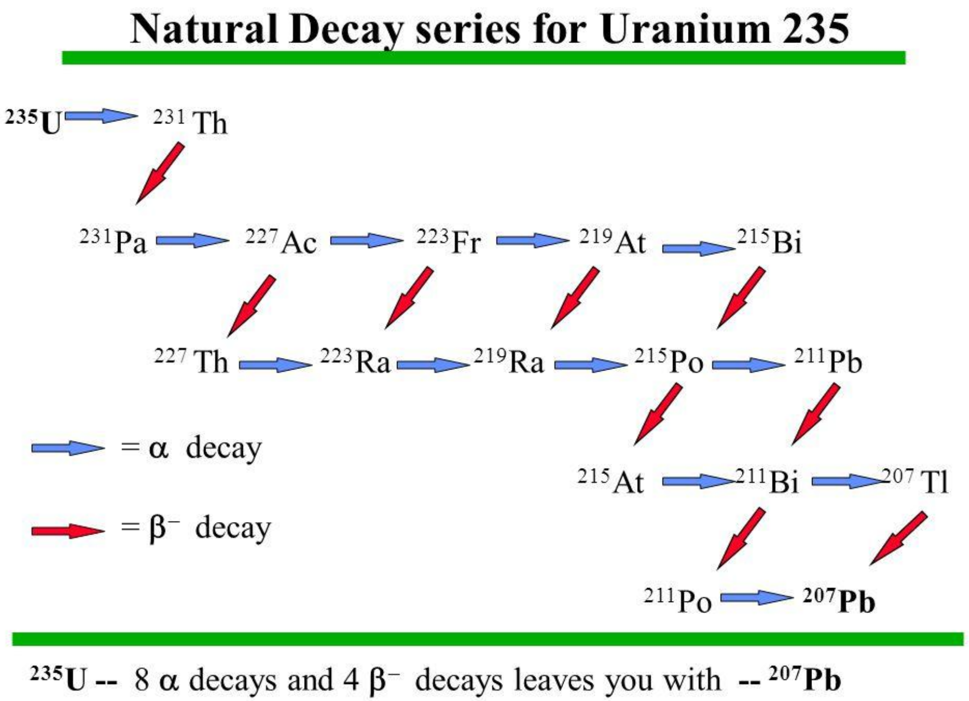
Production of fissile materials - ISL

- In the case of **Königstein (Germany),** a total of 100,000 tonnes of sulfuric acid was injected with the leaching liquid into the ore deposit. At present, 1.9 million m3 of leaching liquid are still locked in the pores of the rock leached so far.
- Groundwater impact is much larger at the **Czech Republic‘s** in-situ leaching site of **Stráž pod Ralskem**: 28.7 million m3 of contaminated liquid is contained in the leaching zone, covering an area of 5.74 km2. This zone contains a total of 1.5 million tonnes of sulphate, 37,500 tonnes of ammonium, and others. In addition to the chemicals needed for the leaching operation (including 3.7 million tonnes of sulfuric acid, among others), 100,000 tonnes of ammonium were injected; they were a waste product resulting from the recovery of uranium from the leaching liquid.

  Moreover, the contaminated liquid has spread out beyond the leaching zone horizontally and vertically, thus contaminating another area of 28 km2 and a further 235 million m3 of groundwater.
- In **Bulgaria**, a total of 2.5 million tonnes of sulfuric acid was injected into the ore deposits exploited by in-situ leaching. It is estimated that about 10% of the surface area used for ISL could be contaminated from solution spills.
- The **Devladovo** site in **Ukraine** was leached with sulfuric and nitric acid. The surface of the site was heavily contaminated from spills of leaching solutions. Groundwater contamination is spreading downstream from the site at a speed of 53 m/year. It has traveled a distance of 1.7 km already and will reach the village of Devladovo after 24.5 years.

Radioactive decay

- radioactivity (or radioactive decay) is a spontaneous transformation of unstable nuclides or process by which an unstable atomic nucleus loses energy by emitting radiation
- new lighter elements emerge from the decay along with ionizing radiation
- **natural radioactivity**: natural transmutations, decay of nuclei by decay series and established principles
- **artificial radioactivity**: transmutation, chain reaction, particle acceleration (artificial radioactivity is induced by external force)



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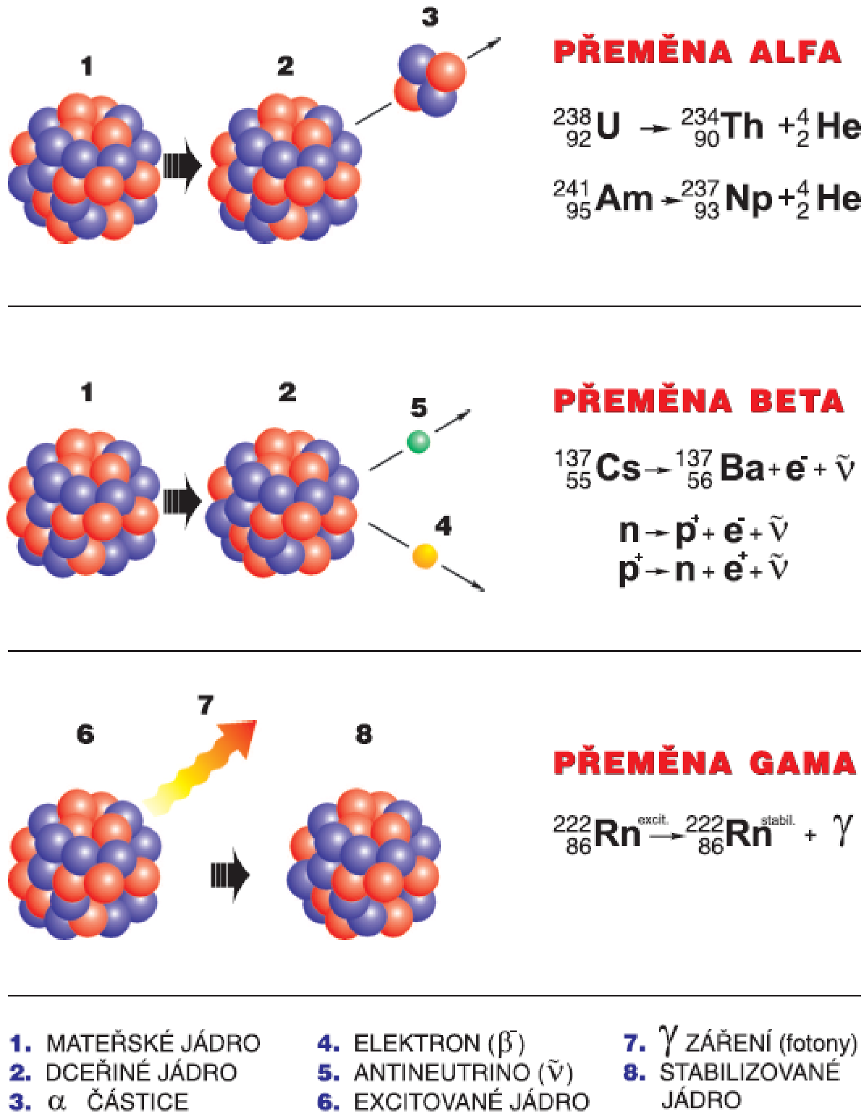
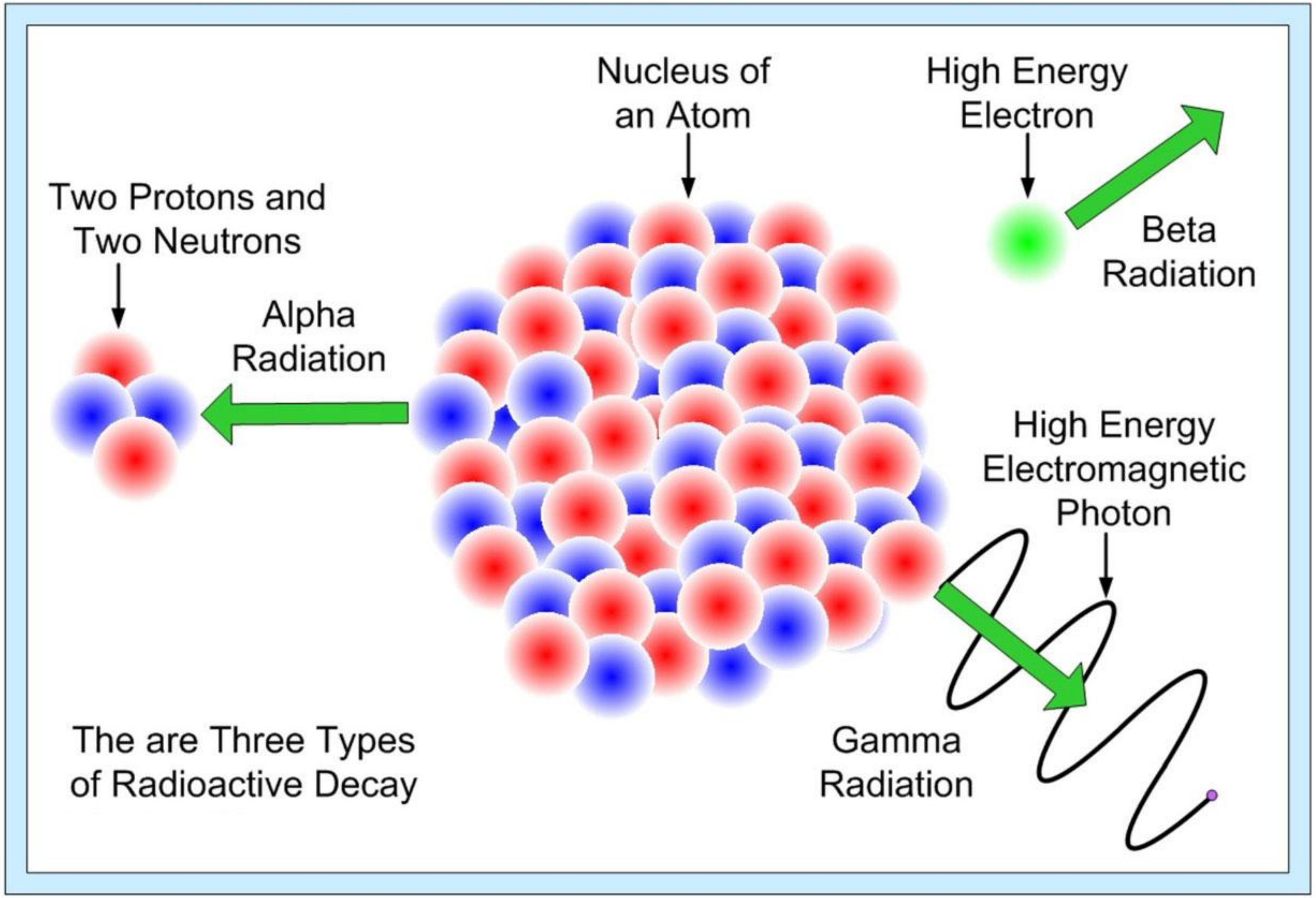
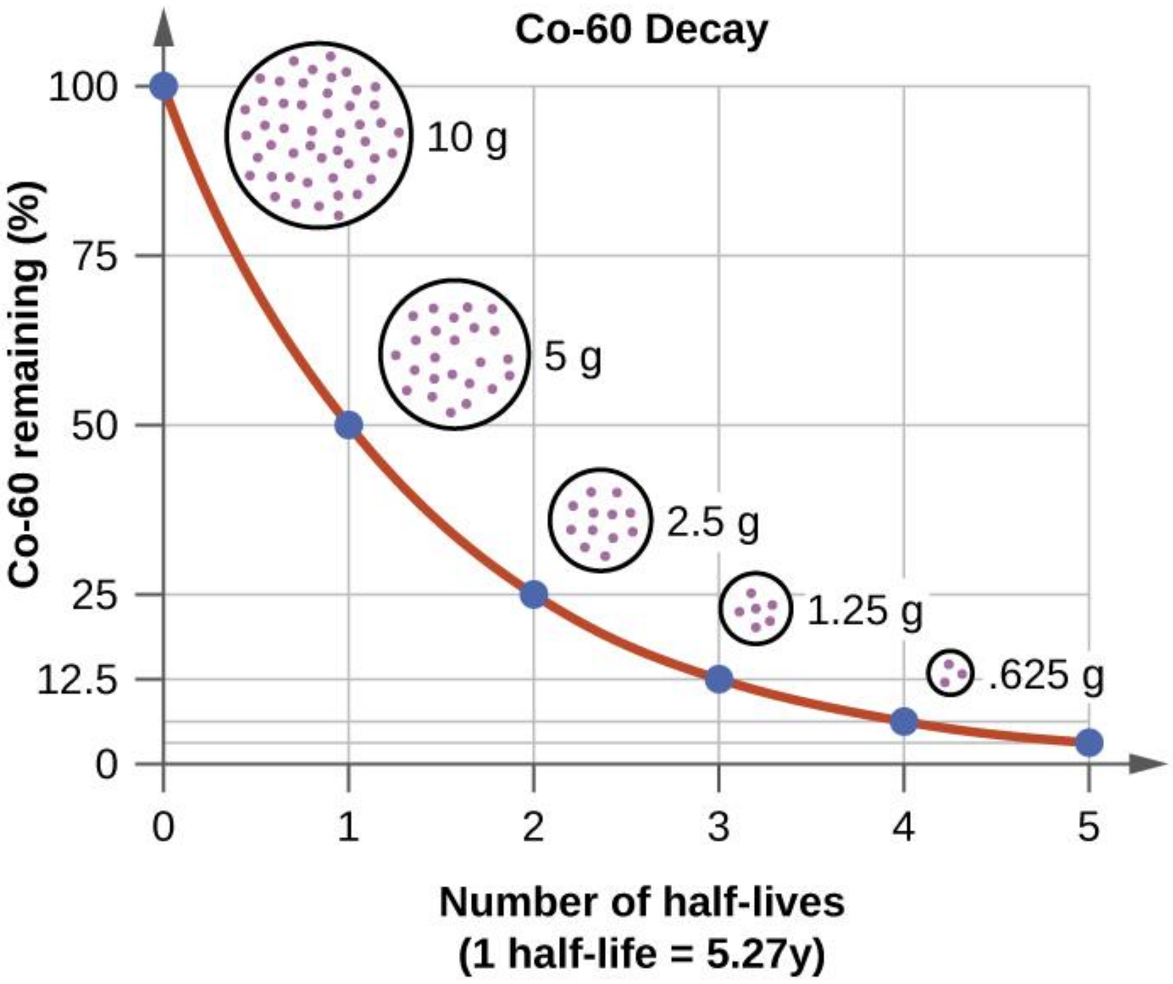
Radioactive decay - types





Radioactive decay – half life



Radioactive decay – half life examples

Half-lives of selected radioactive isotopes

Isotope	Half-life
Uranium-238	4.5×10^9 years
Uranium-235	0.7×10^9 years
Plutonium-239	24,000 years
Carbon-14	5730 years
Lead-210	22 years
Tritium (H-3)	12.5 years
Cobalt-60	5.27 years
Polonium-210	140 days
Iodine-125	60 days
Bismuth-210	5 days
Radon-222	3.8 days
Polonium-218	3 minutes

Examples of Radioactive Materials

Radionuclide	Physical Half-Life	Activity	Where Found
Cesium-137	30 y	1.5×10^6 Ci	Food Irradiator
Cobalt-60	5 y	15,000 Ci	Cancer Therapy
Plutonium-239	24,000 y	600 Ci	Nuclear Weapon
Iridium-192	74 d	100 Ci	Ind. Radiography
Hydrogen-3	12 y	12 Ci	Exit Signs
Strontium-90	29 y	0.1 Ci	Ocular Therapy
Iodine-131	8 d	0.015 Ci	Nuclear Medicine
Technetium-99m	6 h	0.025 Ci	Diagnostic Imaging
Americium-241	432 y	0.000005 Ci	Smoke Detectors
Radon-222	4 d	1 pCi/l	Environment

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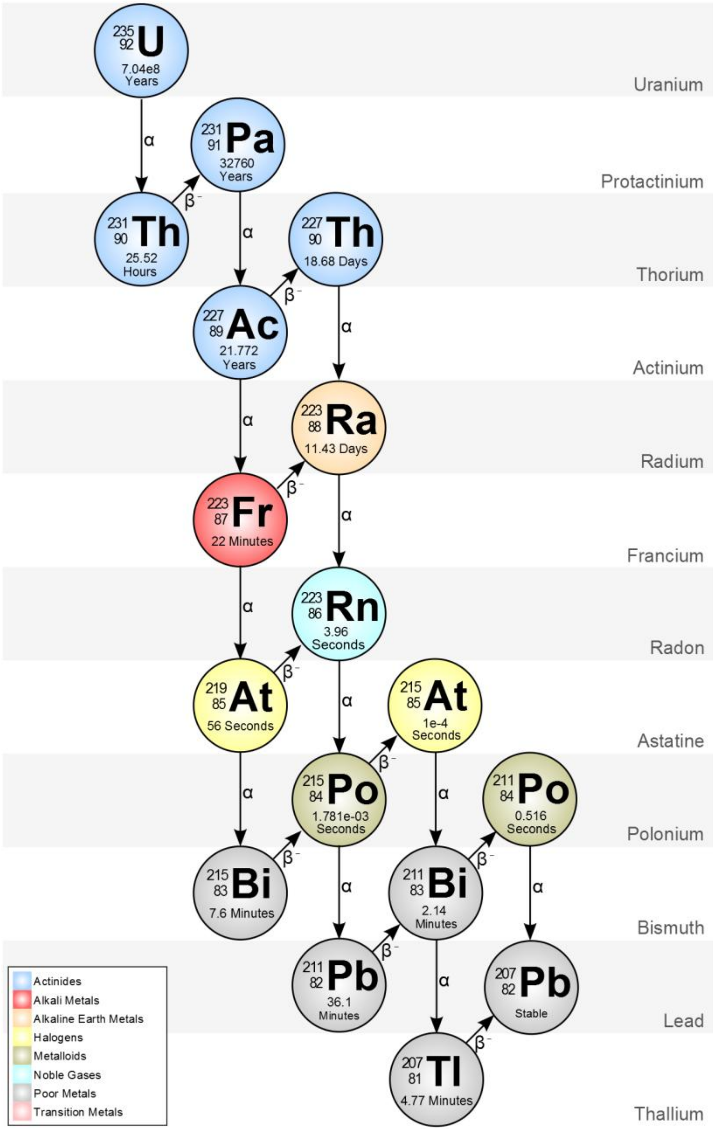
Radioactive decay – half life examples

Isotope	Emits	Half Life
Uranium-238	Alpha	4500 000 000 years
Thorium-234	Beta, Gamma	24.1 days
Proactinium-234	Beta, gamma	60 seconds
Uranium-234	Alpha, Gamma	245 000 years
Thorium-230	Alpha, Gamma	76 000 years
Radium-226	Alpha, Gamma	1600 years
Radon-222	Alpha	3.8 days
Polonium-218	Alpha	3 minutes
Lead-214	Beta, Gamma	27 minutes
Bismuth-214	Beta, Gamma	20 minutes
Polonium-214	Alpha	160 microseconds
Lead-210	Beta, Gamma	22 years
Bismuth-210	Beta, Gamma	5 days
Polonium-210	Alpha	138 days
Lead-206		Stable



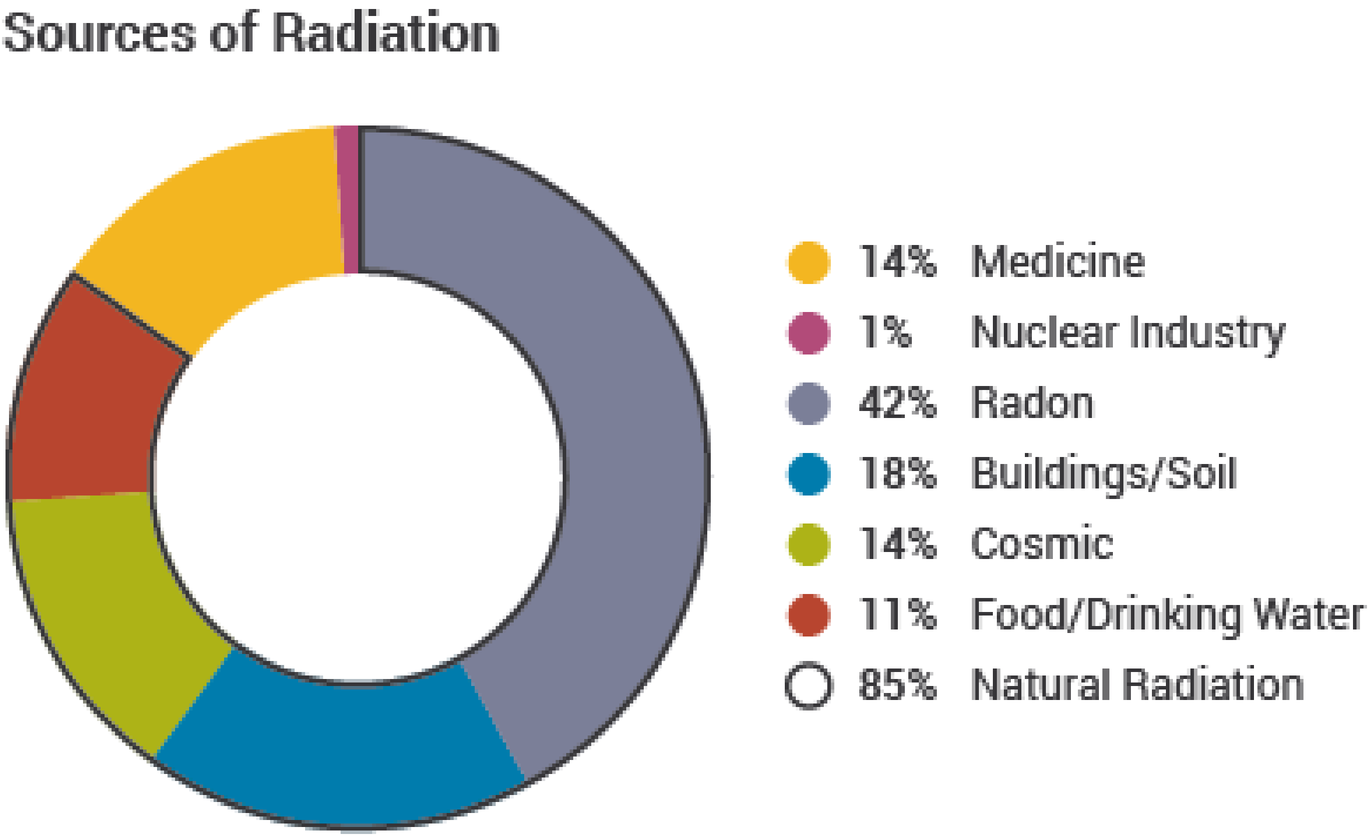
Radionuclides

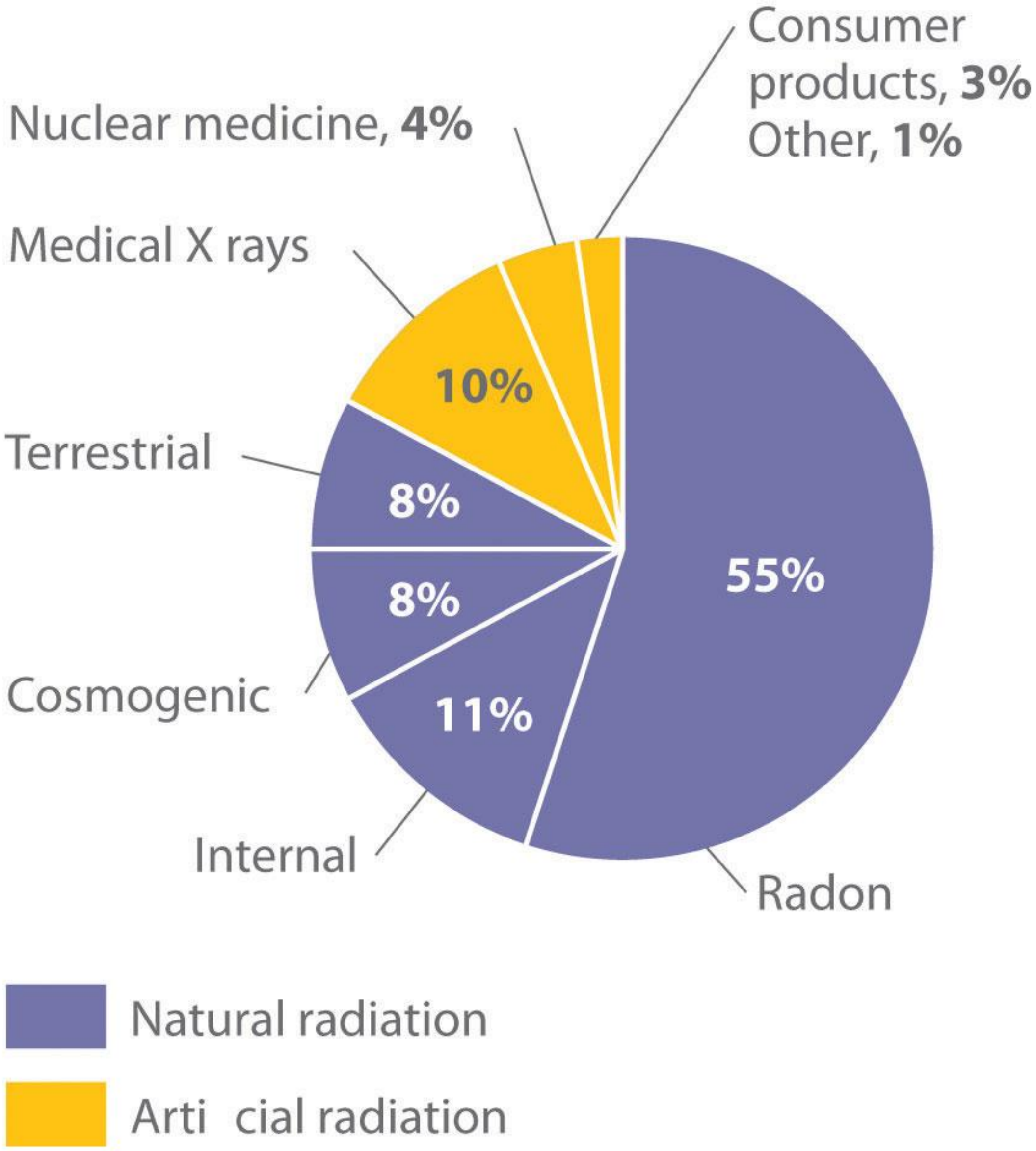
Cosmogenic radionuclides: tritium ^{3}H (half-life 12,5 years), carbon ^{14}C (half-life 5730 years)

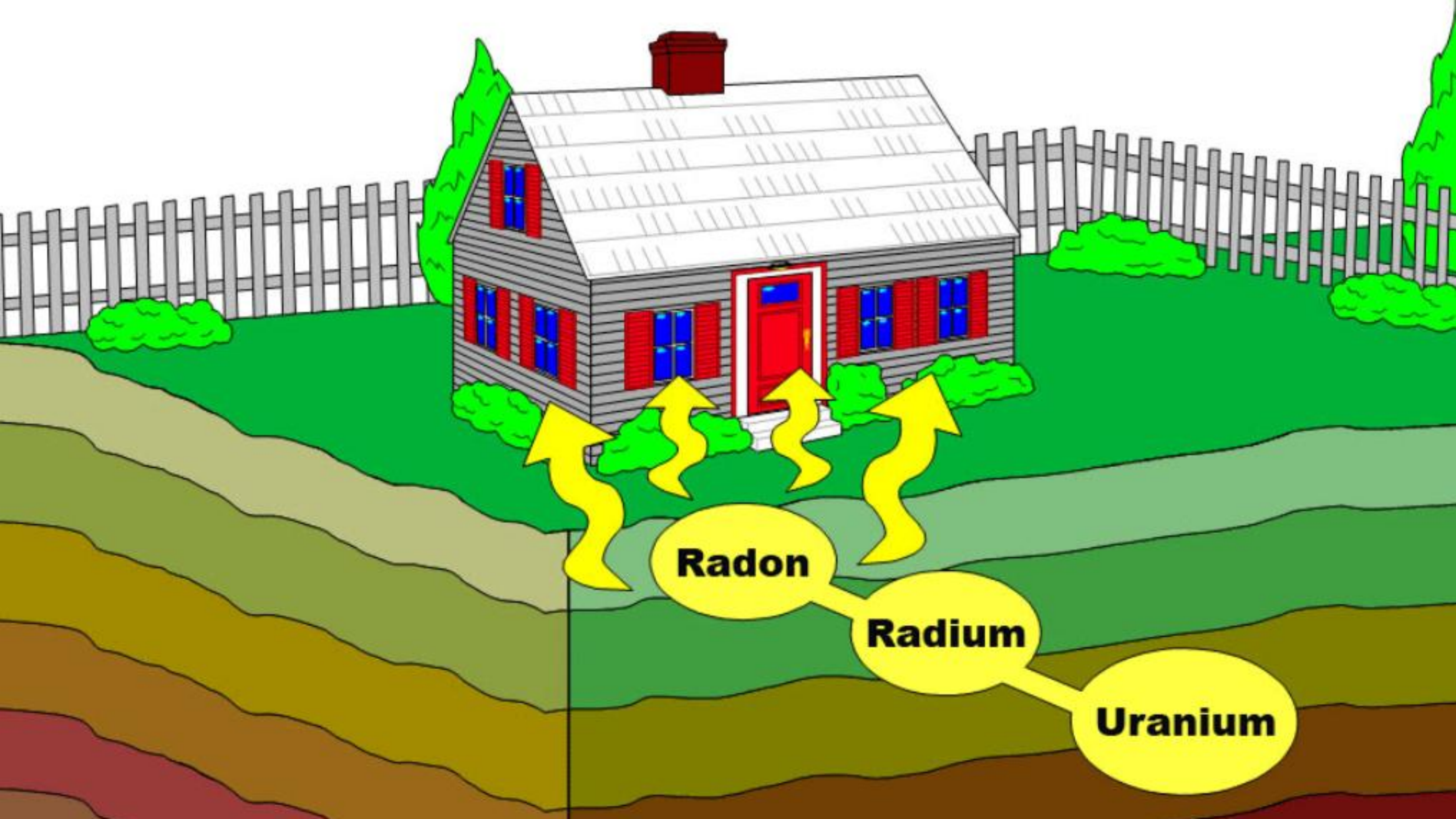
Primary radionuclides : potassium ^{40}K (half-life 1,26x109 years), thorium ^{232}Th (half-life 1,4x1010 years), uranium ^{238}U (half-life 4,5x109 years), ^{235}U (7x108 years)

Secondary radionuclides: radionuclides of decay series – thorium, uranium, aktinouranium, neptunium

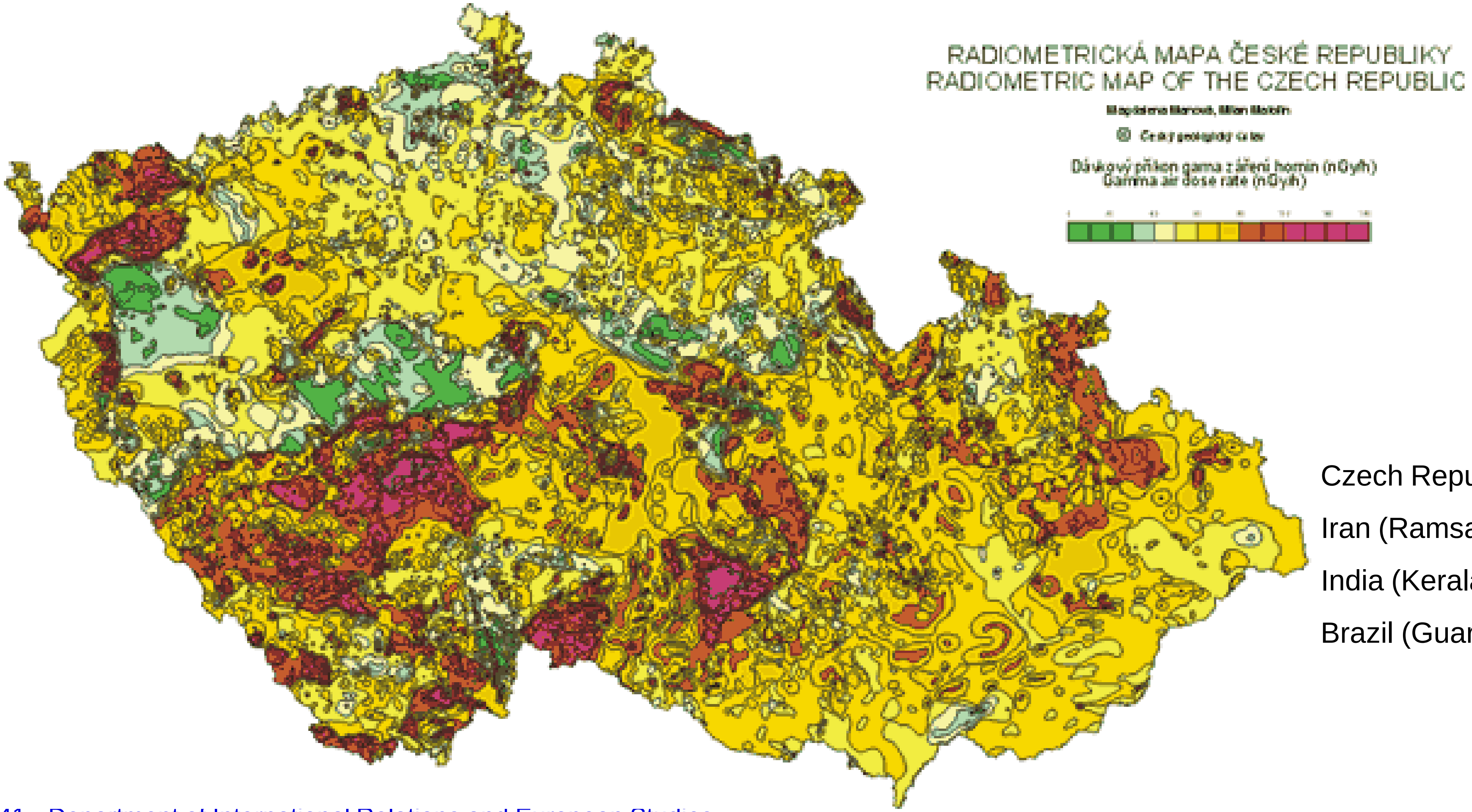
Sources of human radiation exposure






Radon
Radium
Uranium

Radiation exposure



Czech Republic - cca 3 mSv/year

Iran (Ramsar) - up to 400 mSv/year

India (Kerala) - up to 17 mSv/year

Brazil (Guarapari beach) - up to 175 mSv/year

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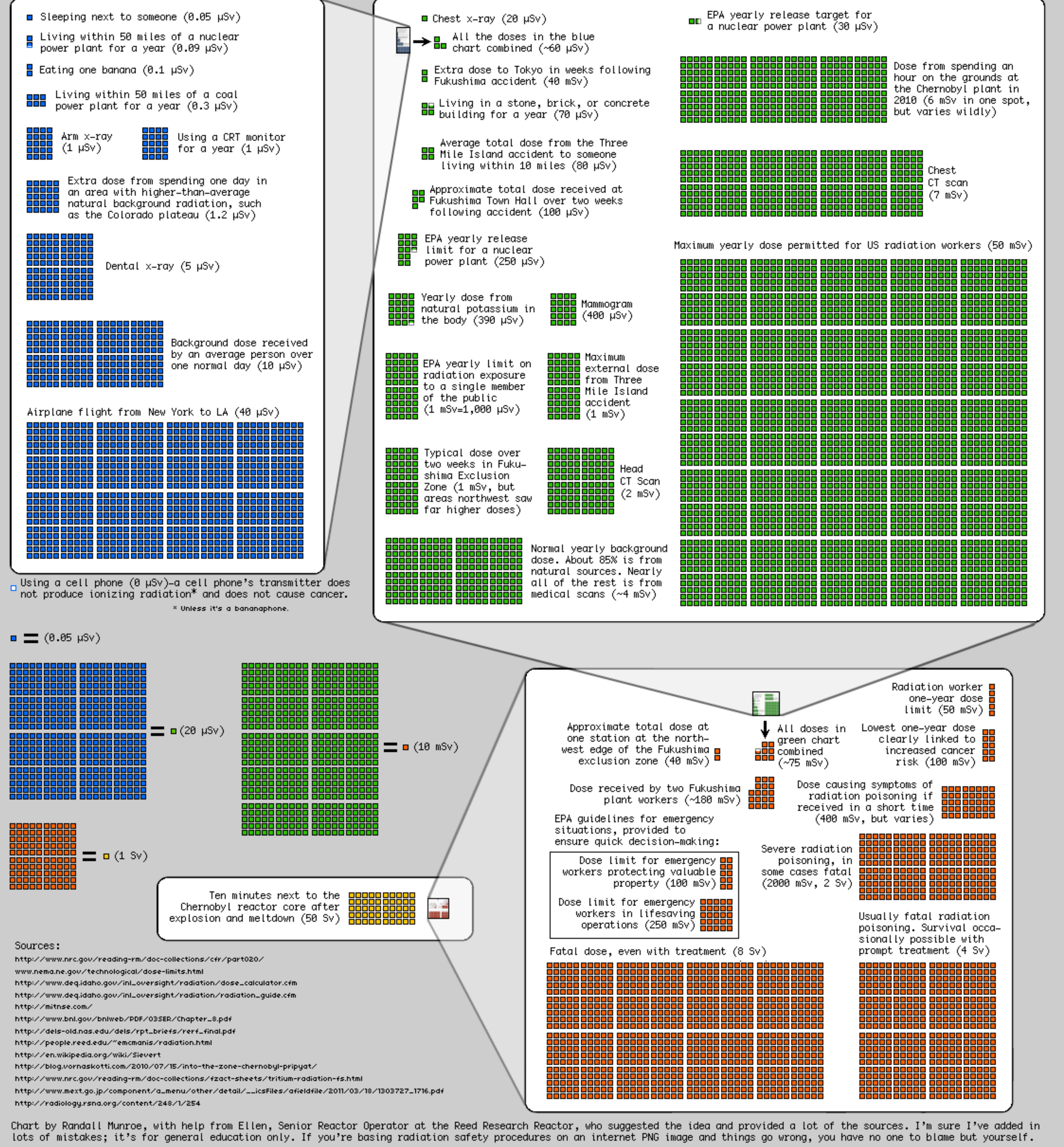
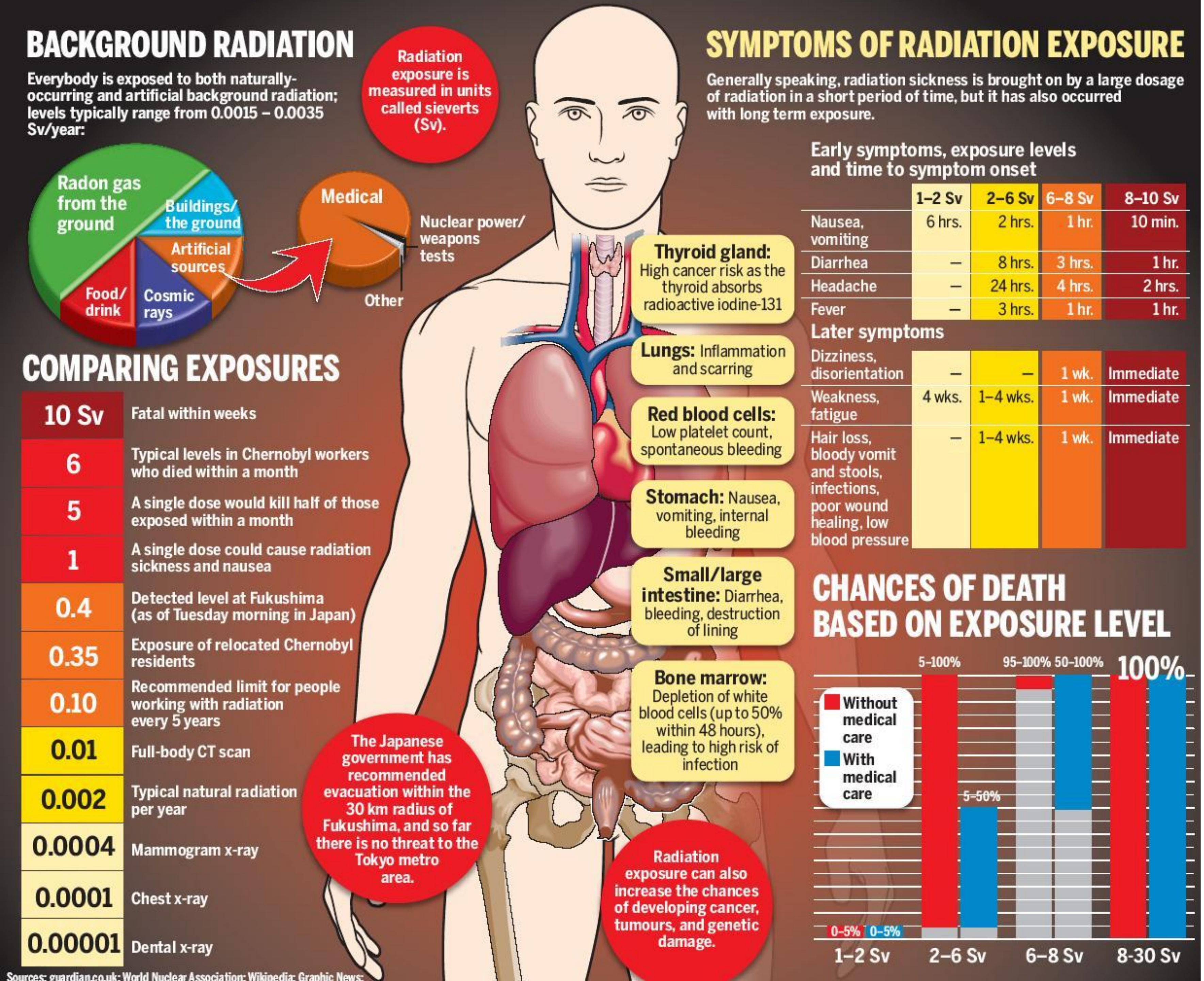
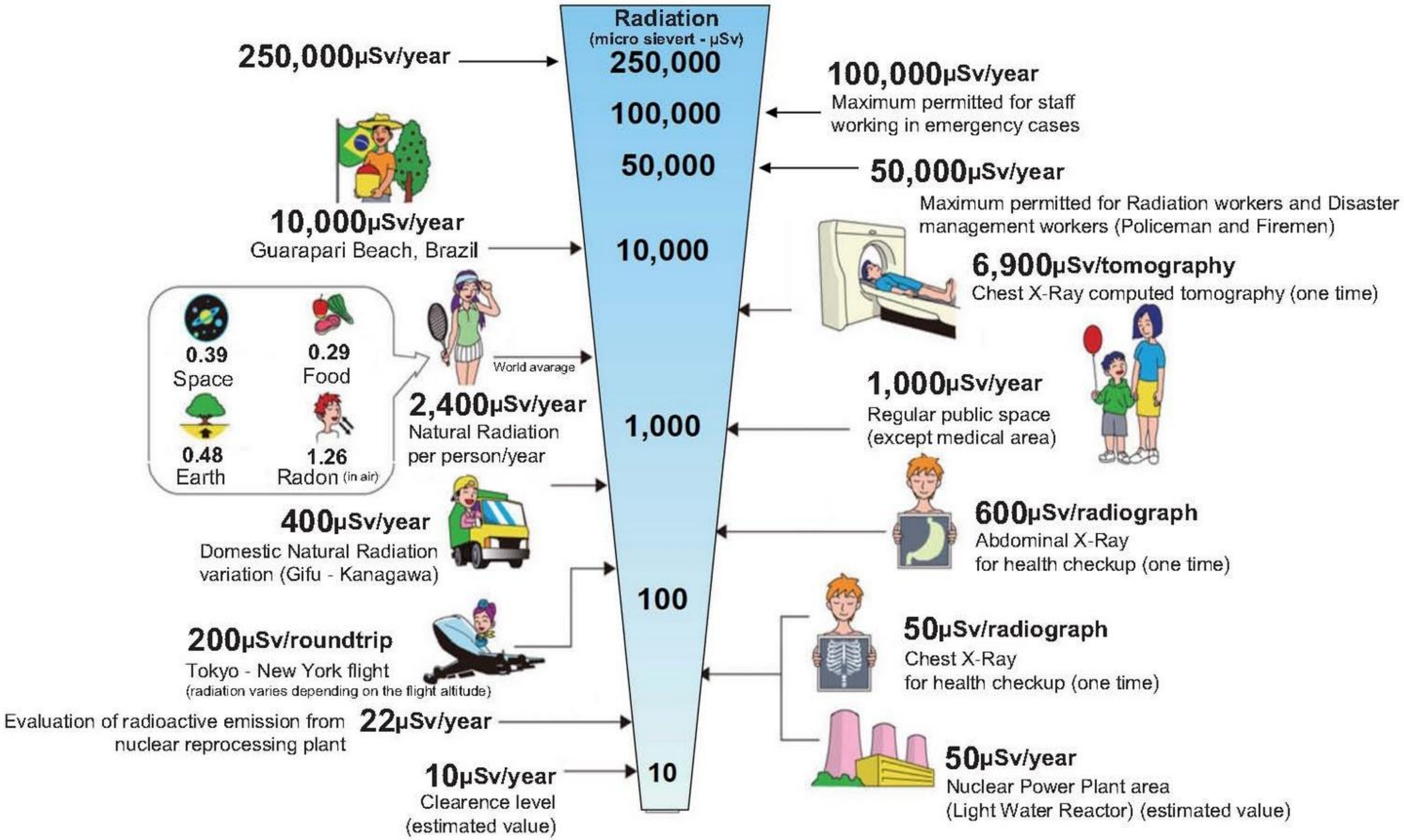
Type of Radiation (dose in mSv)†	Equivalent Period of Natural Background Radiation‡	Estimated Lifetime Risk of dying from cancer that results from a single exposure§
Airport Security x-ray scanner [23] (~0.0001mSv)	less than one hour	Almost 0 (less than 1 in 100,000,000)
7 hour airplane flight [9] (~0.03 mSv)	a few days	Almost 0 (1 in 1,000,000 – 100,000)
Chest x-ray [6] (~0.1 mSv)	~ one week	Almost 0 (1 in 1,000,000 – 100,000)
Mammogram [27] (~0.4 mSv)	a few months (~2 months)	1 in 100,000 to 10,000
CT of chest [27] (~7 mSv)	a few years (~2.3 years)	1 in 10,000 to 1,000
Fluoroscopy: colon (barium enema) [27] (~8mSv)	a few years (~2.7 years)	1 in 10,000 to 1,000
CT of heart (angiography) [27] (~16 mSv)	a few years (~5.3 years)	1 in 10,000 to 1,000
PET scan, whole body [5] (~14 mSv)	a few years (~4.6 years)	1 in 10,000 to 1,000
Fluoroscopy: kidneys, ureters and bladder [5] (~15mSv)	a few years (~5 years)	1 in 10,000 to 1,000
Whole-body CT scan [5] (~22.5 mSv)	several years (~7.5 years)	1 in 1,000
Nuclear Medicine: Cardiac stress-rest test (thallium) [27] (~40.7mSv)	many years (~13.6 years)	~2 in 1,000
Transjugular intrahepatic portosystemic shunt placement [27] (~70mSv)	many years (~23.3 years)	1 in 100 – 1,000
Lifetime risk of cancer death NOT caused by radiation§§		1 in 5





Sievert is a measure of the health effect of low levels of ionizing radiation on the human body

Radiation Exposure in Daily Life



Sv (sievert) = *constant of biological effects of radiation** **x** *Gy (Gray)*

(*) X-Ray, Y-Ray = 1

Translated by volunteer students of Keio University from material created by the MEXT based in the "Shigenryoku 2002" (Agency for Natural Resources)

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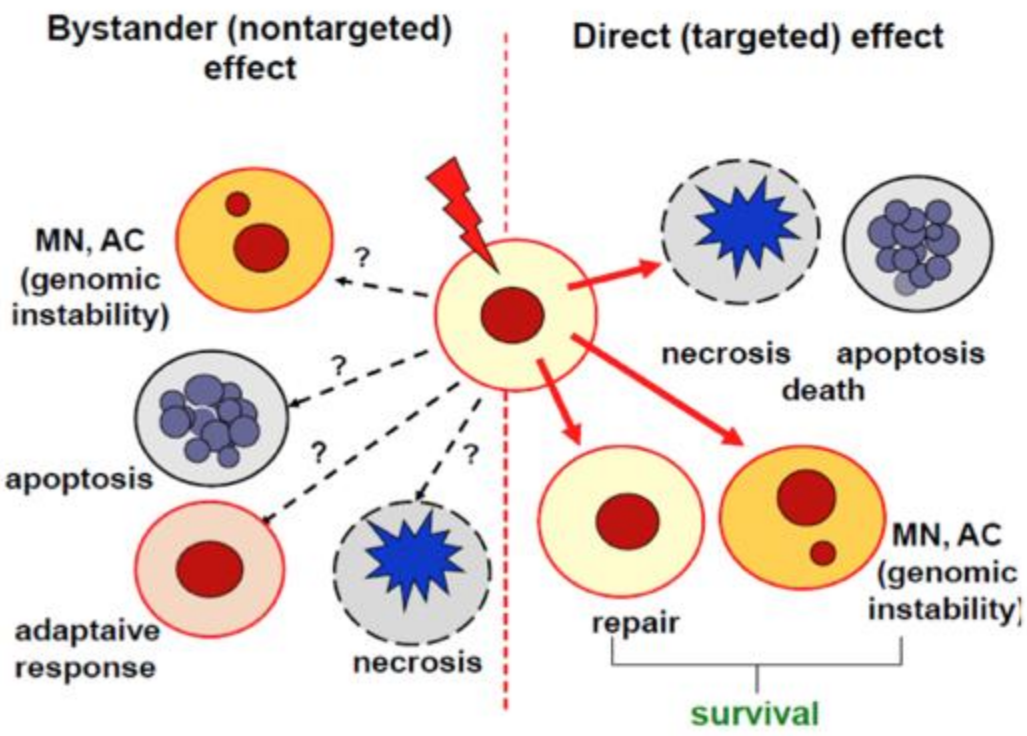
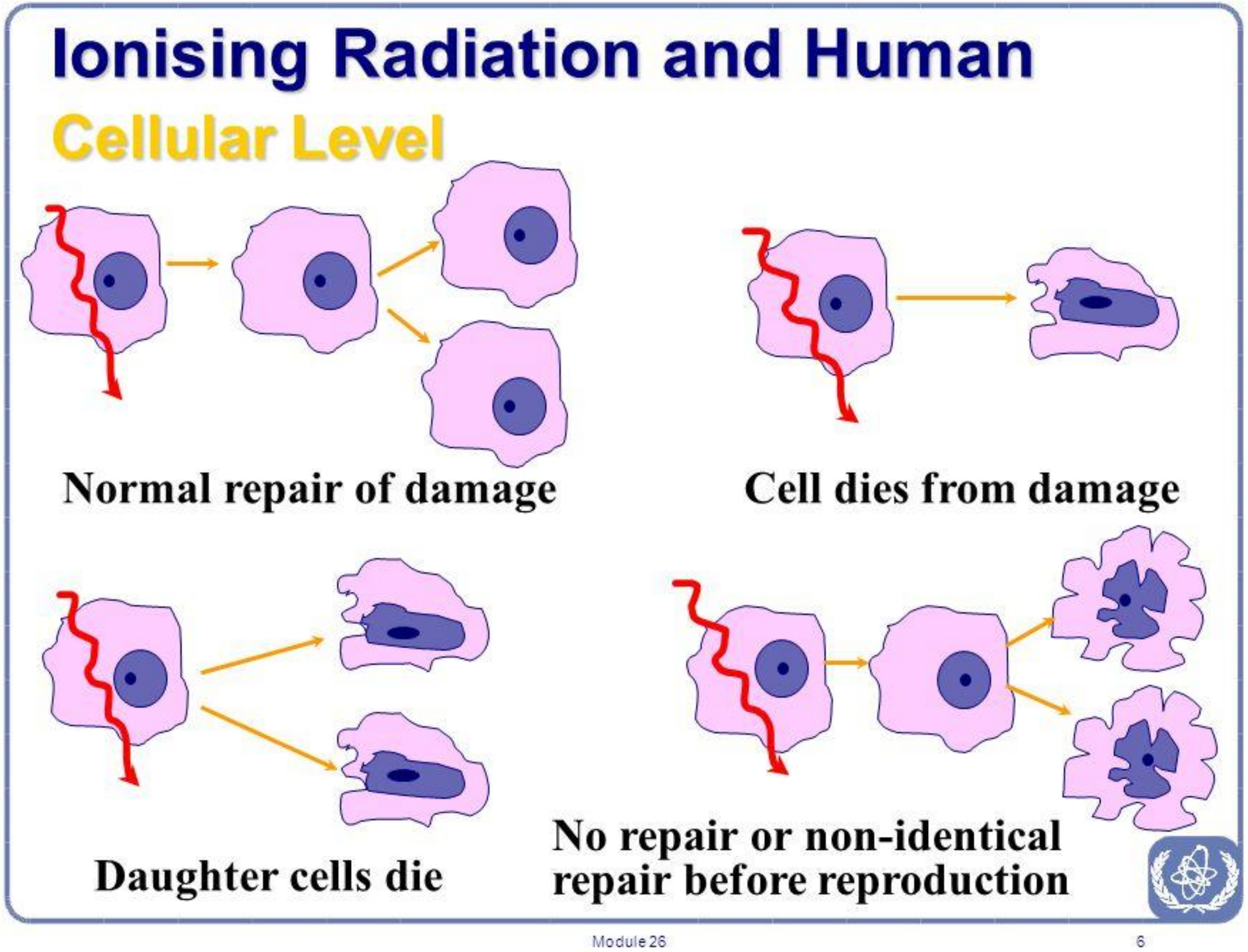
Radioactive exposition

Effects on human organism





Effects on human organism

Stochastic (random) - few cells damaged, subliminal dose or repeated small doses.

- we can only calculate the probability of injury, no injury may in fact occur.
- can be detected only by observing a large number of people. Risk of small doses? Scientists still do not match, they can not confirm nor deny it for there is not a sample of people who are not exposed to any radiation at all. No control sample.
- It is known that there is a "protective effect" radiation (hormesis) - in places with higher radioactivity there is less incidence of cancer (cells repair any damage).

Effects on human organism

Non-stochastic effects (deterministic) - after a large dose of radiation, many cells, appear in a short time.

Examples:

local dermatitis

Lenticular opacities

birth defects

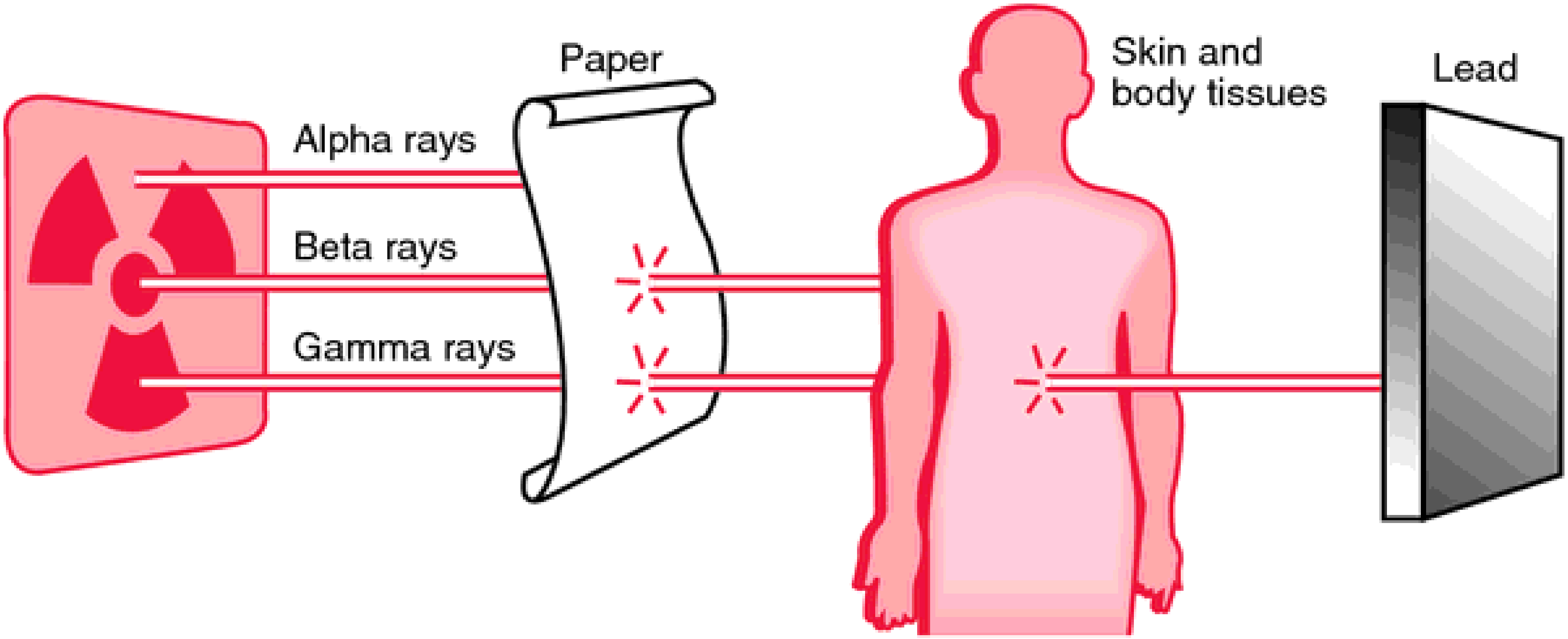
fertility

Acute radiation sickness

Protection against radiation

- **Distance** - ionizing radiation intensity decreases with the square of the distance, ie. after 10 m it is 100 times lower, after 100 m it is 10000 times lower, after 1 km it is a million times lower.
- **Time** - the shorter the exposure, the smaller the cumulative dose
- **Shielding** - depending on the type of radiation: alpha radiation skin tones, clothing, paper; beta radiation, aluminum sheet; gamma rays concrete, a layer of water, soil; neutron radiation, water, polystyrene, paraffin.
- **Diffusion and dilution** – wind, rain etc.

Protection against radiation



Radiation vs. radiocontamination

– **Radiation**: subject or object directly exposed to ionizing radiation from a radioactive source; the subject or object does not become radioactive but is damaged by radiation.
– **Radiocontamination**: radioactive particles get in direct contact with organism. We distinguish between ***outer radiocontamination*** (dust and particles on the surface) and ***inner radiocontamination*** (dust and particles inhaled, consumed or penetrated through skin injuries).

Protection against radiation

Objective of the radiation protection

To ensure that during normal operation the radiation exposure inside the device and/or the release of radioactive materials into the environment is as low as reasonably achievable, taking into consideration economic and social factors and prescribed limits and ensure mitigate the extent of exposure to radiation accidents.

The principle of ALARA

- Observe the rules and seek new and better ways of performing work
- Already applied in the design

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Protection against radiation

- the use of nuclear energy is regulated by law
- nuclear safety is not a mere formality, it is an enforceable requirement
- all effects are monitored and evaluated
- responsibility is transferred to the operator's license holder

Protection against radiation

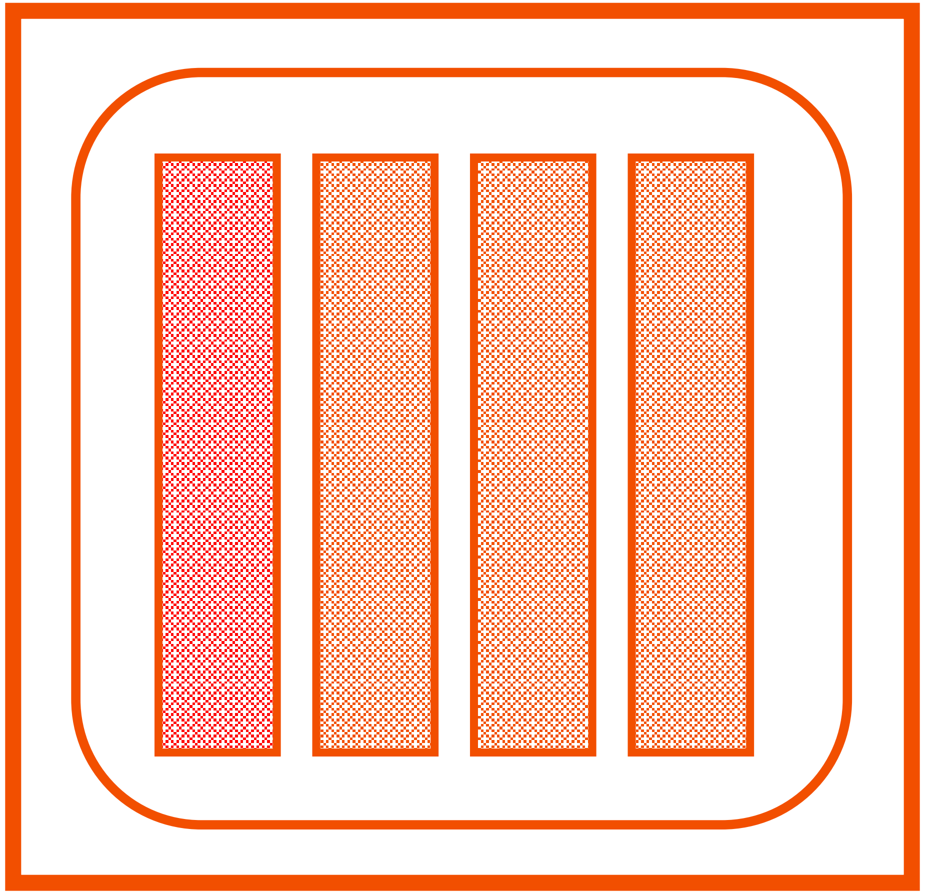
Deep protection = means to achieve the basic objective of safety

First barrier: molecular matrix fuel (almost all the fission products resulting from fission are captured in the matrix of the uranium tablets)

Second barrier: hermetic fuel cladding (an alloy of zirconium-niobium)

Third barrier: the primary circuit pressure limit (resistant to high pressure, temperature, radiation and radiation dynamic conditions of operation)

Fourth barrier: hermetic borders of rooms - containment (building design protection, resists airplane crash, blast wave, explosion, storm, extreme temperatures, extreme precipitation, etc.)



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Thank you for your attention.