Radiation protection

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X-rays

- electromagnetic radiation of short to very short wavelengths
- 10 - 0,001 nm
- photons
- arises in electron orbitals
- energy depends on the wavelength –
  - the shorter the wavelength the higher the energy
- radiation
  - bremsstrahlung – used in diagnostic and radiotherapy
  - characteristic – used in analytical chemistry

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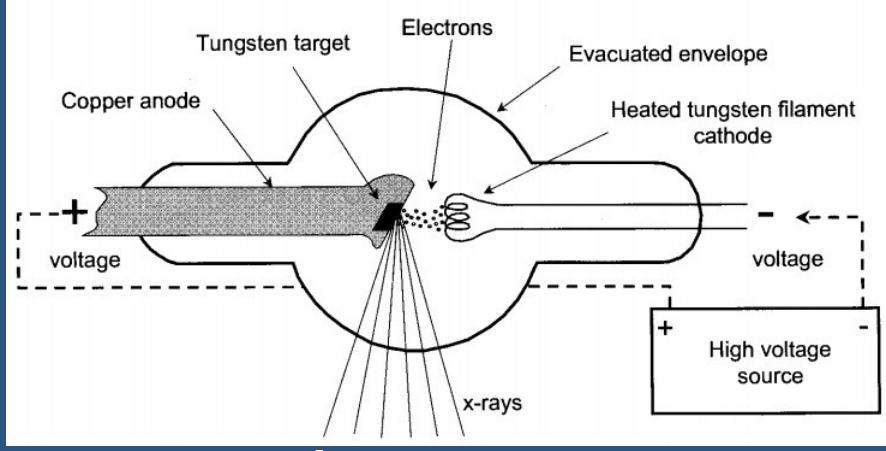
X-ray tube



- cathode - tungsten filament, incandescent current, temperature up to 2000 C
- electons emitting cathode, electon field between K. and A. speeds electons
- DC voltage of 10-500 kV
- anode - cold copper block, target disc (Wofram, Molybdenum)
- photon emission
- low-energy radiation - soft component
- high-energy radiation - hard component

interaction – ionizing radiation/matter

photon

↓

electric interaction (Compton scattering, photoeffect, electron-positron couple)

↓

ionisation

↓

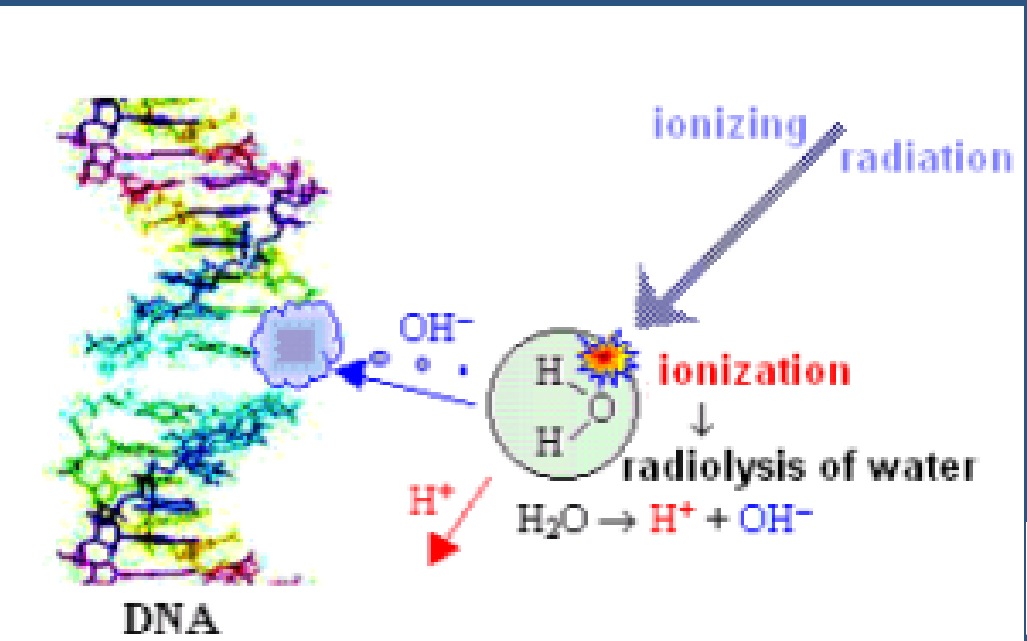
chemical changes

↓

0,001 – 1 s, interaction of ions, radicals, excited atoms with biological organic molecules (DNA, proteins)

biological effect

minutes – tens years, functional and morfological changes in cells, organs and whole organism

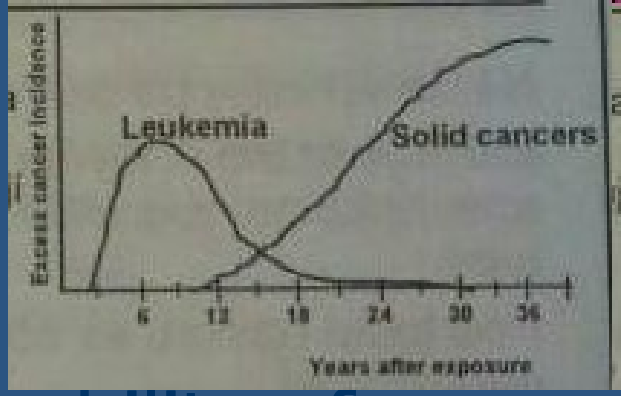


ionizing radiation - biological effect

stochastic

deterministic

stochastic effects:

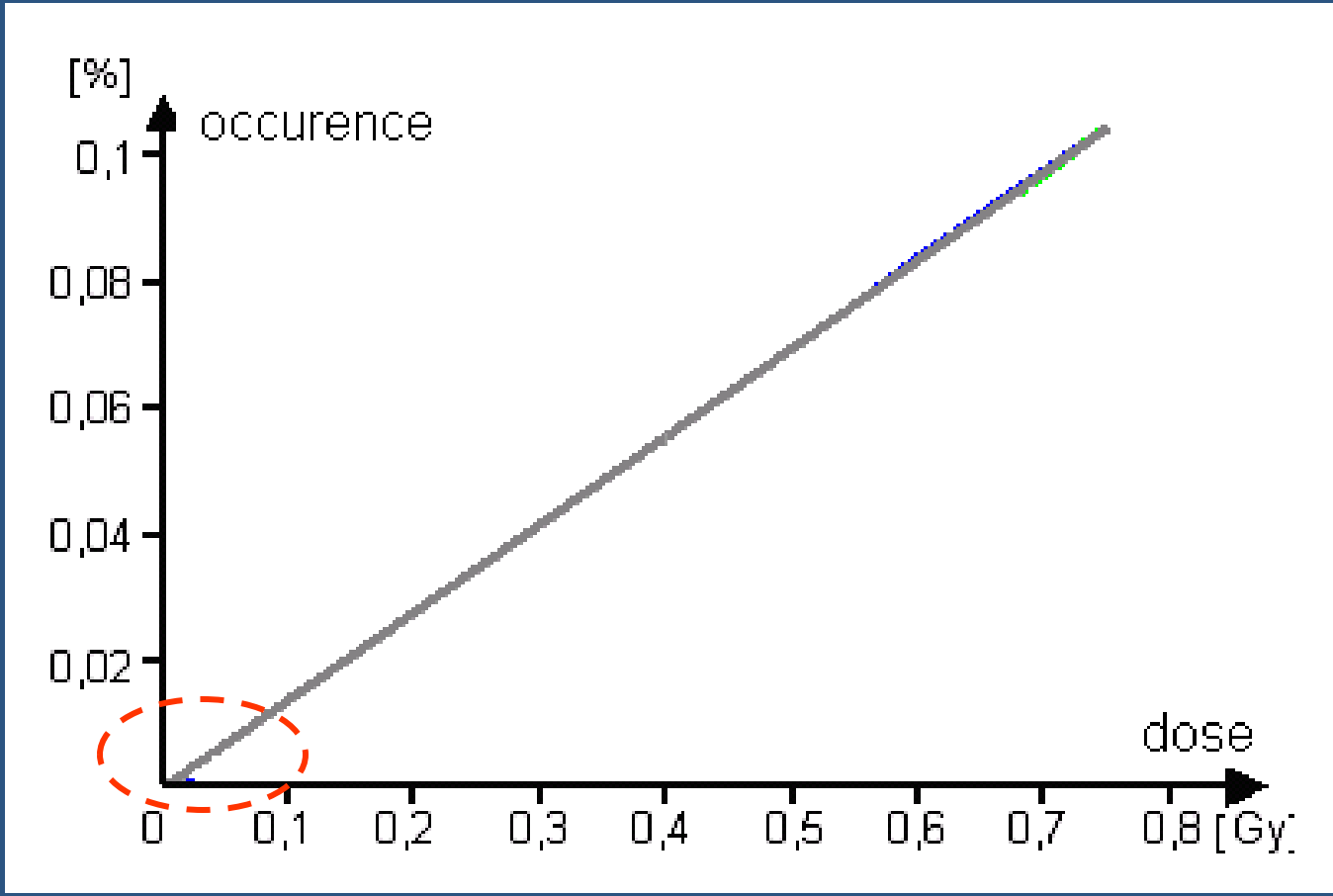


- no threshold
- increasing D_{ef} – increasing probability of stochastic effects
- magnitude of the effect do not dependent on the dose
- never effect immediately after irradiation (after several years)
- carcinogenic + genetic effects
- lesion may not occure in the irradiated spot

D_{ef} (Sv)

Latence: several years for cancer
100s years for genetic effects

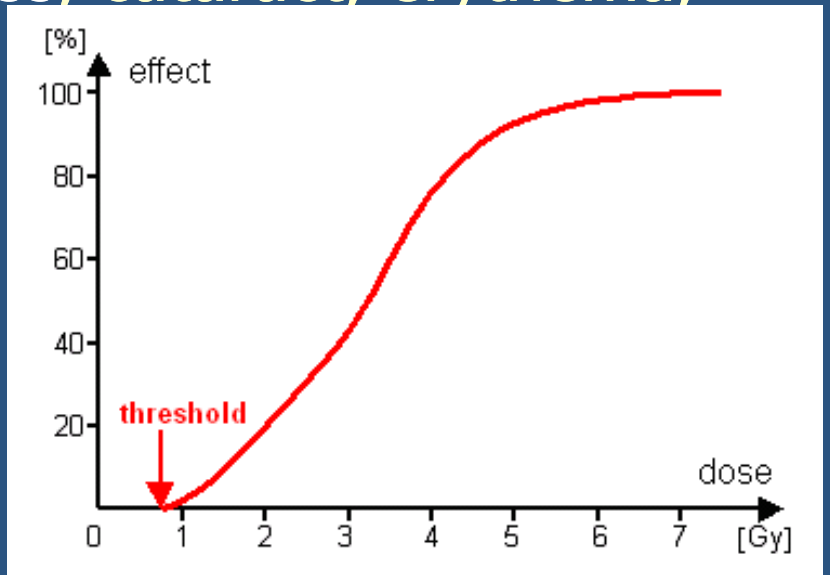
stochastic effects:



The graph of incidence of occurence at a dose

deterministic effects:

- threshold
- lesion depends on absorbed dose
  - after crossing the threshold dosis - increases damage in certain organs
- local effects
- radiation damage is clinical provable
- example: acute radiation sickness, cataract, erythema, infertility etc
- D_{ekv} (Sv)



The graph of incidence of effect at a dose

radiosensitivity

- active bone marrow, lymphoid organs, gonads, GIT
- skin epithelium, epithelium of esophagus, stomach, bladder), lens
- vessels, growing cartilage, bone growth
- mature cartilage, mature bone, respiratory tract, endocrine system
- muscles, CNS

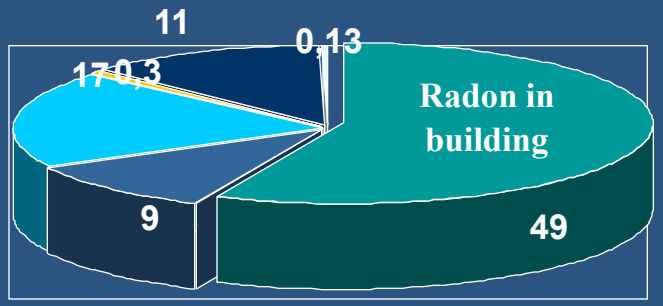
embryo

- 2 weeks – „everything or nothing“
- 3.–8. w – organogenesis, risk of malformations
- 8.–15. w – risk of mental handicap
- after 15. w – the same resistance as born child

The highest radiosensitivity – 1. third of gravidity!

ionizing radiation - etiology:

- natural : artificial = 5:1
- 54 % Radon (Rn)
- 16 % cosmic radiation
- 19 % gama radiation
- 11 % inner radiation, radionuclid
  - ^{40}K, ^{14}C
- 93 % medical irradiation
- 1 % nuclear energy
- 2 % professional irradiation
- 2 % nuclear fall-out

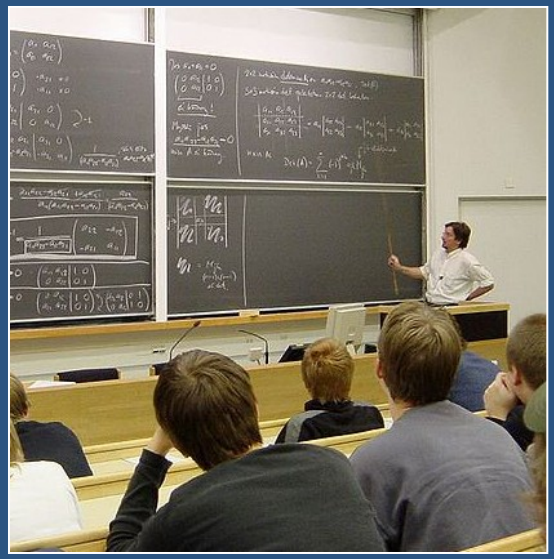


- Radon in building
- Natural radionuclid in humans
- Gama from Earth surfice
- Nuclear fall-out
- Medical irradiation
- The rest

units

absorbed dosis (D)	Gray (Gy)
ekvivalent dosis (D_{evk})	Sievert (Sv)
efective dosis (D_{ef})	Sievert
collective dosis (D_{ef})	manSv

limits:



- Radiation employee
- D_{ef} - 5 y - 100 mSv
- D_{ef} - 1 y - 50 mSv
- D_{ekv} – 1 y - lens - 150 mSv

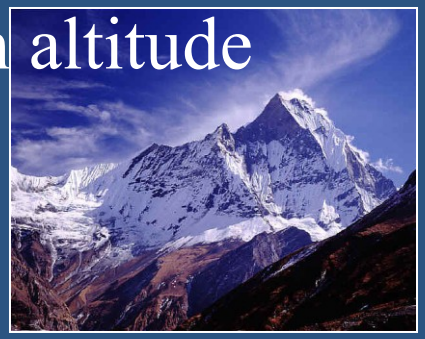
- Students
- 6 mSv
- 50 mSv

A pregnant woman – during whole pregnancy - 1 mSv

D_{ef} – 1 mSv

- **several years** – external irradiation from nature sources
- **several years** – internal irradiation from potassium in body
- **< 1 year** – internal irradiation from **Radon** in buildings

- **severals months** – external irradiation in high altitude



- **100-1000 hours** – external irradiation during long flight

1 mSv – 1 year limit for irradiation for person in population.

probability of death – 50 mSv:

- irradiation of **50 mSv**
- 1 year work in **„industry“**
- smoke **10 packs of cigaret**
- 15 years in household with smoker
- drink **50 bottle of good wine**
- 1500 km tour on the **bicycle**
- 45 000 km travel by car

death probability - **1:10000**

exposure from artificial sources

Source	**basis of comparison**	**The period of exposure from natural sources**
Medicine irradiation	year experience	90 days
Nuclear weapons	yet all	2,3 years
Nuclear energy	1 year of operation	1 day
Major accidents	per all the time	20 days
Exposure at work	per year	8 hours
Exposure from natural sources		1 year

effective dosis – x-ray, CT

Modality	Effective dose (mSv)	Number of x-ray pictures *	Ekvivalent radiation dose **
limbs, joints	less than 0,01	less than 0,5	1,5 day
teeth	**0,02**	**1**	**3**
lung	0,02	1	3
skull	0,07	3,5	11 days
mammography	0,1	5	15 days
pelvis	0,7	35	7 weeks
thoracic spine	0,7	35	7 weeks
lumbar spine	1,3	65	7 months
enteroklysis	3	150	16 months
irrigography	7	350	3,2 years
chest CT	8	400	3,6 years
abdominal CT	10	500	4,5 years

* equivalent number of the X-ray chest examination

** approximate period at which the person received the equivalent radiation dose from natural sources

effective dosis – nuclear medicine

Modality	Typical effective doses (mSv)	Number of x-ray pictures *	Ekvivalent radiation dose **
pulmonary ventilation (Xe-133)	0,3	15	7 weeks
pulmonary perfusion	**1**	**50**	6 month
kidneys (Tc-99m)	1	50	6 month
thyroid gland (Tc-99m)	1	50	6 month
bones (Tc-99m)	4	200	1,8 year
PET head (F-18 FDG	5	250	2,3 year
dynamic myocard scintigraphy (Tc-99m)	6	300	2,7 year

* equivalent number of the X-ray chest examination
** approximate period at which the person received the equivalent radiation dose from natural sources

optimalization

- It had been examinated?
  - The physician should make every effort to reduce repetition of already examinated examinations (at another hospital, etc.).
- Do I need it really?
  - doctor should avoid unnecessary examination, which do not affect treating (for example – degenerative diseases spine….etc.)

optimalization

- Do I need it now?
  - the doctor should not require too often the examinations. For example before the disease could further develop or retreat, or before results may affect treatment.
- Is it best examination (modality)?
  - doctor should consider to discuss the method of examination with a radiologist before sending the patient to

optimalization

- Did I explaned the problem?
  - the doctor should obtain all relevant clinical informations and determine the questions which is interested in.
- Not too many x-ray, CT (and other examinations)?
  - Some clinicians tend to rely on (X-ray) examinations more than others. Some patients like this investigation.

categorization of workplaces

- I. category - small sources, densitometry, **dental X-ray**
- II. category - radiodiagnostics / therapy
- III. category - particle accelerators, sealed radionuclide sources (radiotherapy, brachytherapy)
- IV. category - nuclear facilities, radioactive waste repository

protective equipment

- distance
- time
- shielding (alpha, beta, X-ray)
  - aprons, collars, shields, covers the gonads and thyroid
- Children – the fuser equipment

Questions

My wife recently underwent a dental x-ray examination. We found that at that time she was in the third week of pregnancy. How big is the risk?

Complete ortopantomogram of pregnant patients - the

dose receiving by embryo is around 0.001 mGy.

In comparison with the average natural background which makes 3 mGy - the dose in such tests is less than the dose from natural exposure for one day.

Cases were shown that such small doses pose none risk.

Of course, this is not conclusive evidence of absolute safety company, but provides assurance that if any risk arises as extremely small.

Questions

I am already three months working with a panoramic and intraoral X-rays devices. I missed one menstrual cycle and I believe that I was pregnant - approximately five to six weeks. I wonder if my child is in any danger of radiation, which I was exposed at the work.

- It is very unlikely that you and your unborn child are suffered any harm because of your professional exposure and have any significant risk. Available data indicate that a typical dose of irradiation on professional dental work is about 0.7 mSv per year. For comparison - the average natural radiation, which is exposed to each of us - is 3.5 mSv per year. Limits for workers with x-ray is 100 mSv in five consecutive years, but one year shall not be exceeded value of 50 mSv. Pregnant women must not received a dose greater than 1 mSv. The limits are chosen to avoid deterministic effects and did not lead to a significant increase in the likelihood of late effects such as cancer and genetic changes.
- Pregnant women should follow all steps to minimize their own irradiation. During the scan, they should be separated from the X-ray by shielding layer, preferably a wall. If this is not possible in their workplace they may stand for photographing away from the device. Discuss with your employer use of a personal dosimeter with a monthly deduction of benefits received. It should be emphasized that there is no reason to panic.

Thank you

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