Ionizing radiation, radiation protection

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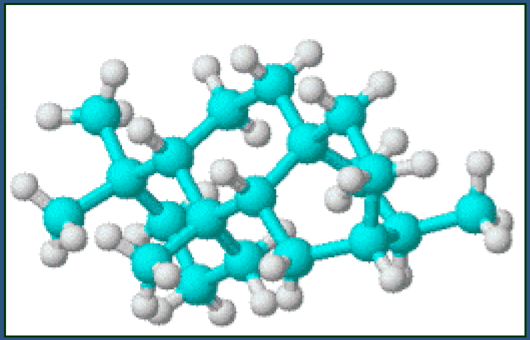
Ionizing radiation (IR):

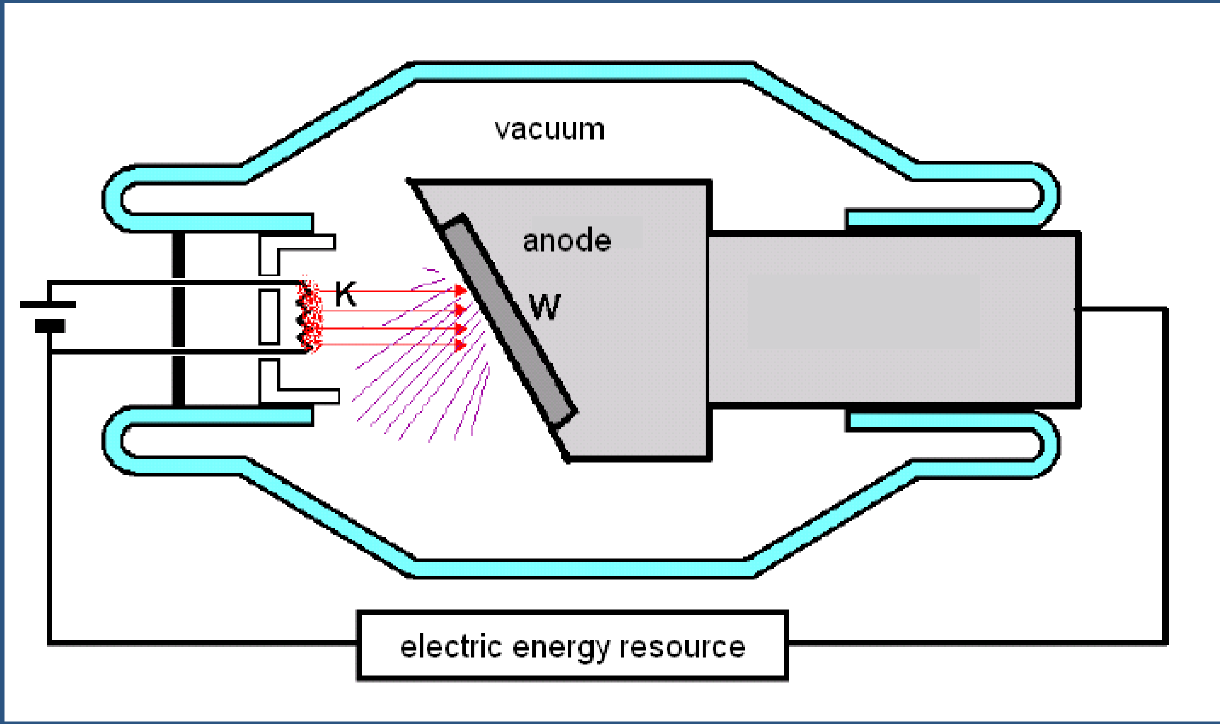
- is caused by the energetic particles or waves that have the potential to ionize an atom or molecule through atomic interactions



X-ray tube:

low energy radiation - low voltage - long w.
high energy radiation - high voltage - short w.

heat 98-99%
energy 1-2%



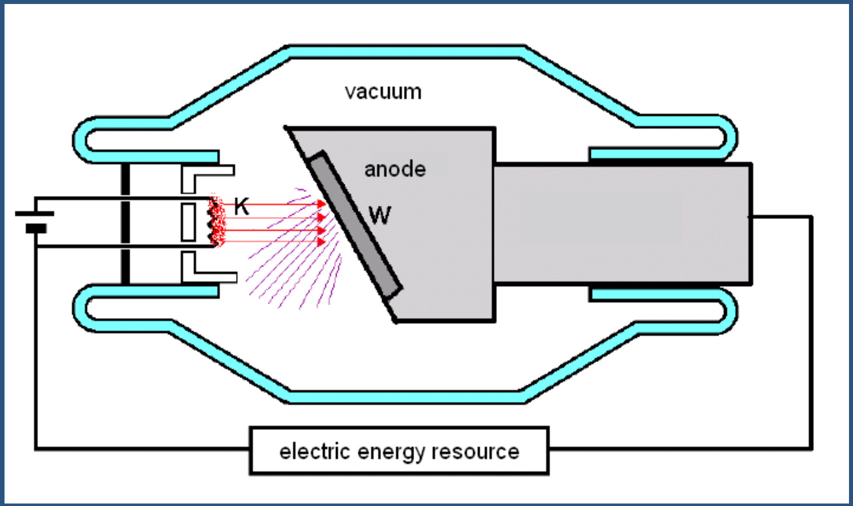
- high energy electrons are emited from catode and strike on the metalic anode

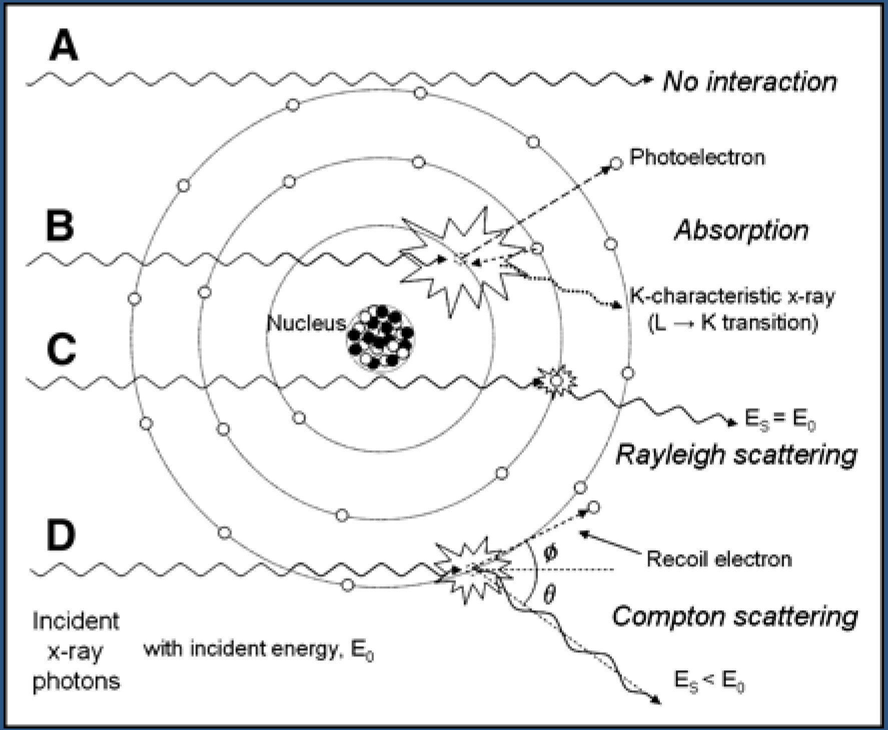
- electromagic radiation
- photon
- short wavelength 10 - 0,001 nm

- cathode (Wolfram fibre)
  - emits electrons
  - voltage 10-500 kV accelerate el.
- anode (Wolfram, Molybden)

speed of electrons - 165 000 km/s

X-ray:

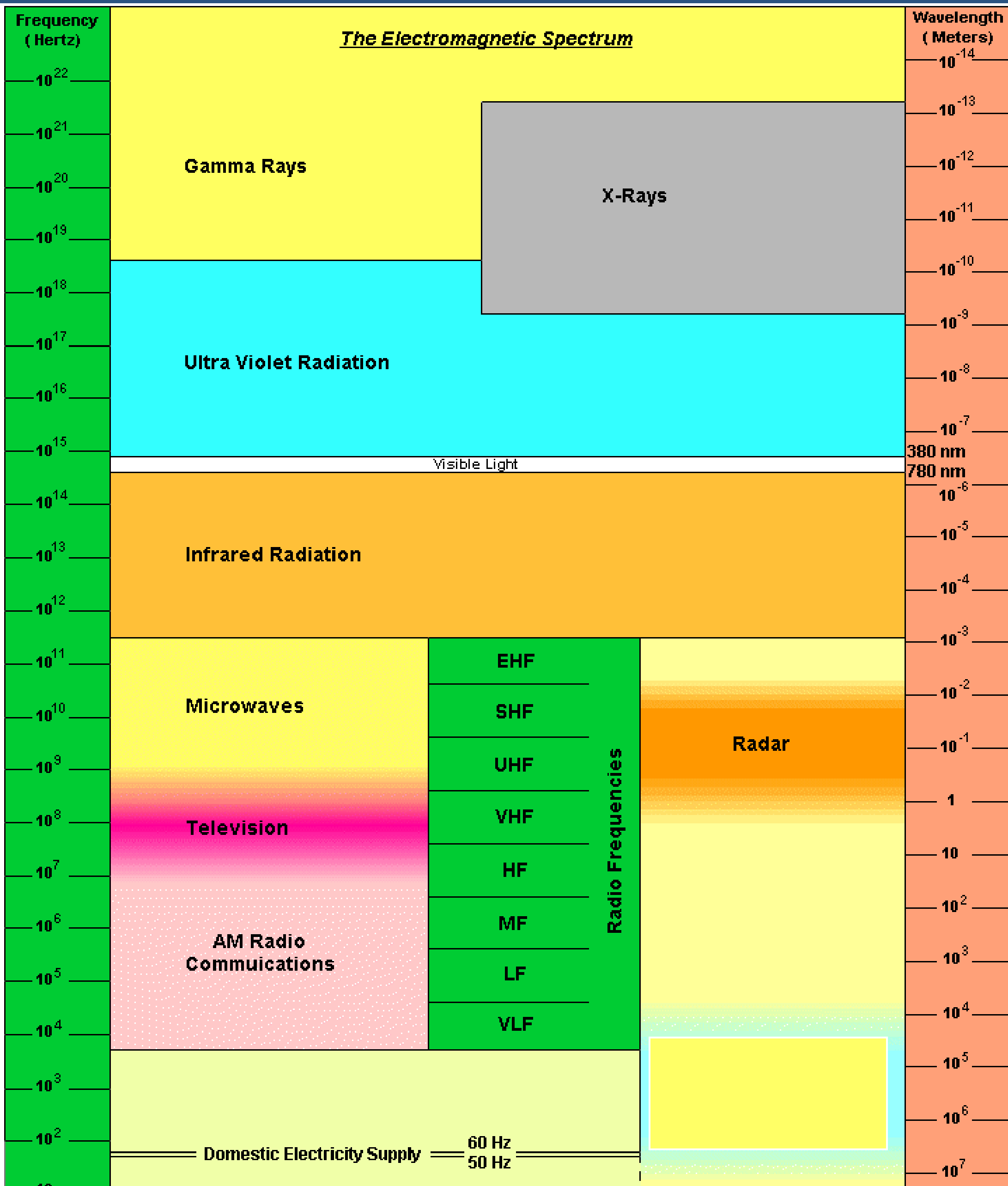




Bremsstrahlung radiation (braking radiation) – electrons are stopped by repulsive force of electrons in electron shell. Kinetic energy of electons is changed into energy of X-ray photons

Characteristic X-ray – electrons dash out the electrons of K or L shells. Than the vacant site is filled by electrons from a higher energy shell.

The Electromagnetic spectrum:

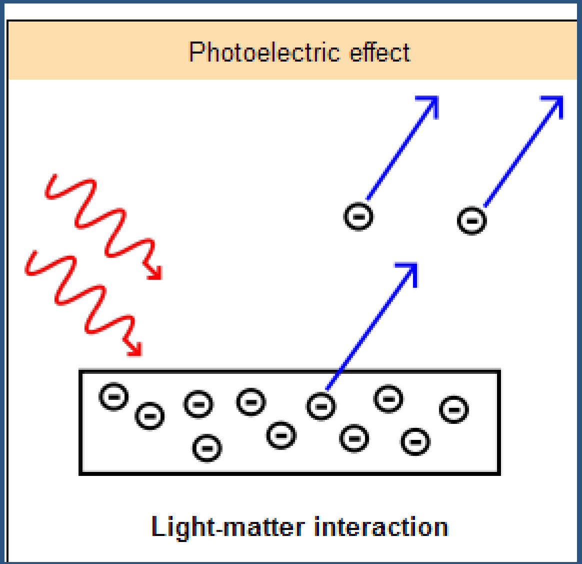


- x-rays wavelength 10 - 0,001 nm

Interaction of IR with matter:

- Gamma (X-) rays – ionize by secondary electrons which are caused by this processes:

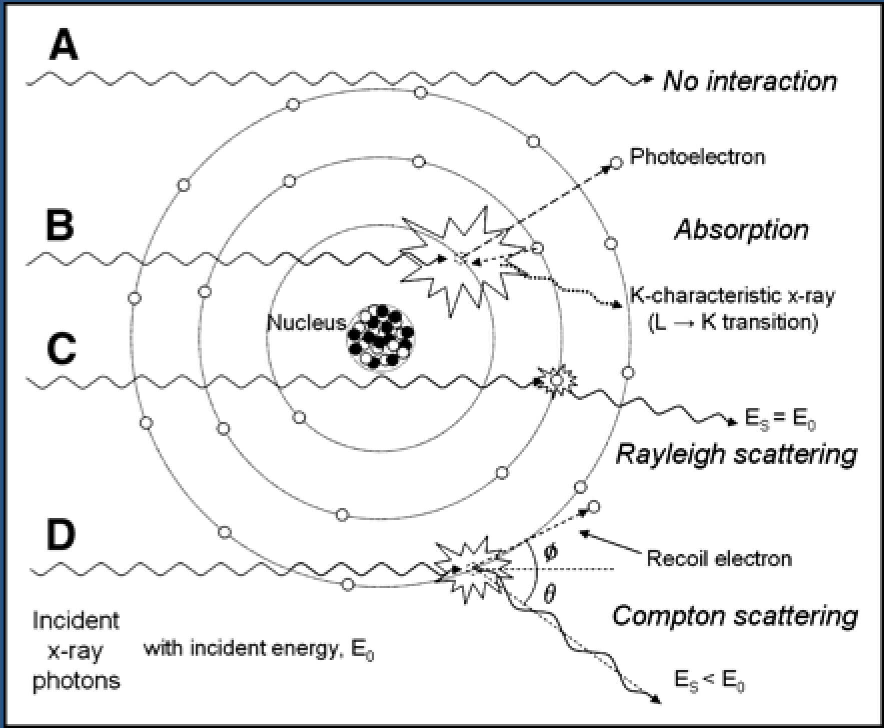
Photoelectric effect – electrons are emitted from the atom after the absorption of energy from X-ray



Interaction of IR with matter:

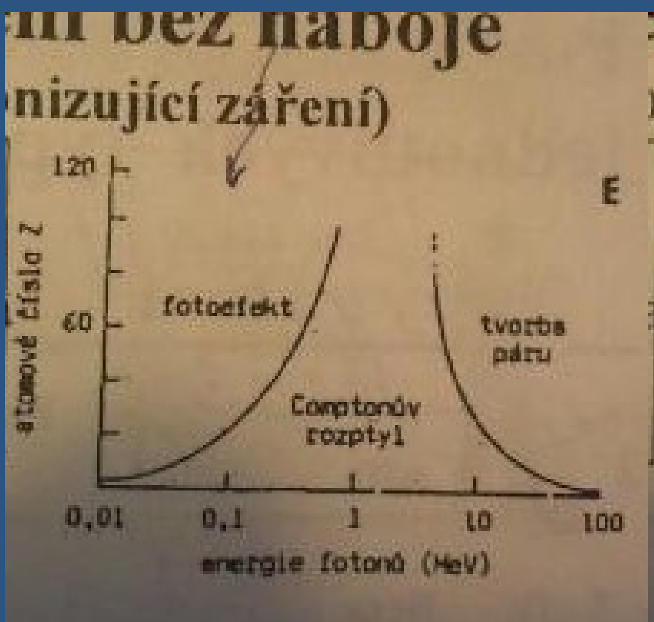
Compton effect – in the electron being given part of the energy and a photon containing the remaining energy being emitted in a different direction from the original.

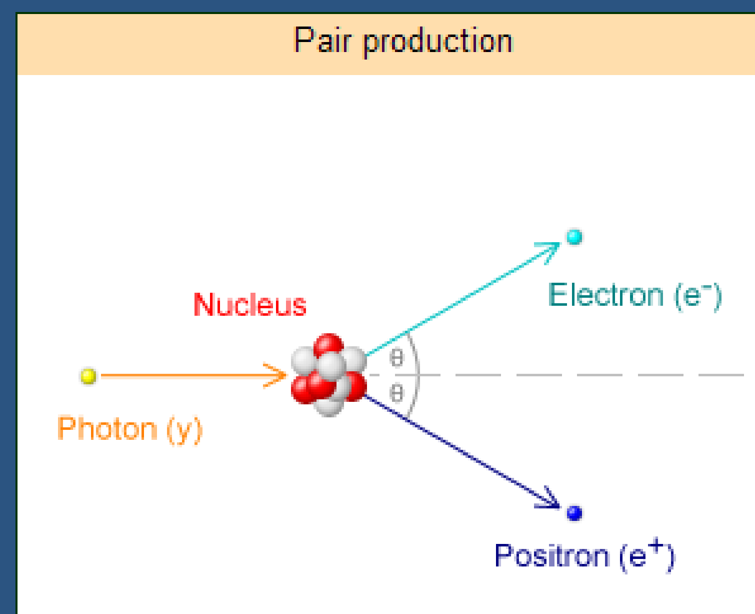
If the photon still has enough energy, the process may be repeated. If the photon has sufficient energy it can even eject an electron from its host atom entirely (Photoelectric effect).



Interaction of IR with matter:

Pair production - a high-energy photon interacts with an atomic nucleus, allowing it to produce an electron and a positron





Interaction of IR with matter:

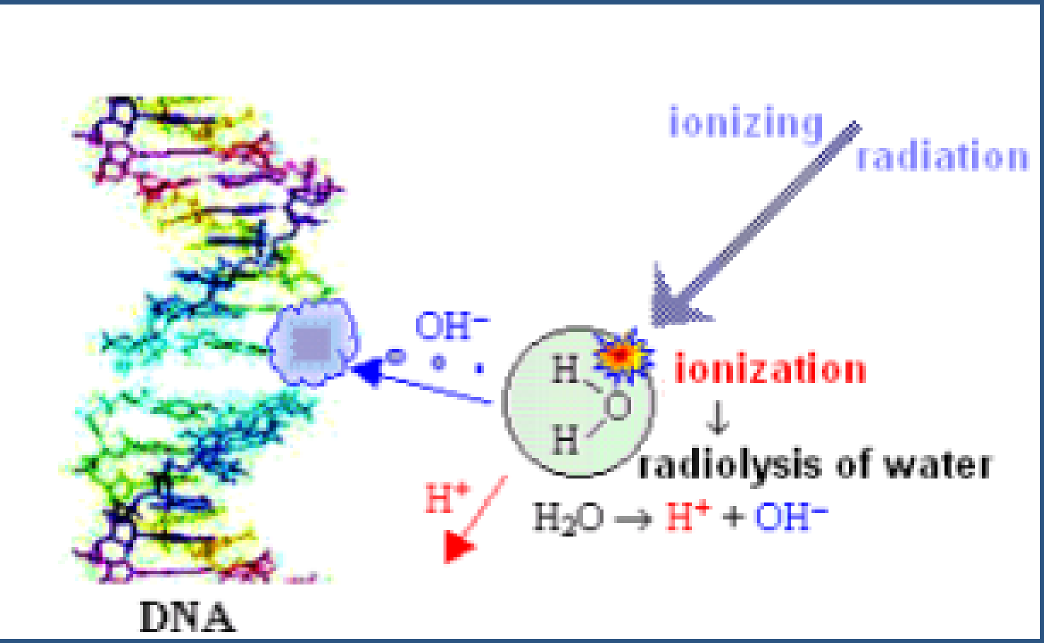
photon

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

ionisation

chemical changes

biological effect



Biological effects of IR:

chemical – takes 0,001 – 1 s

- interaction of ions, radicals, excited atoms with biological organic molecules (DNA, proteins)

biological – takes a few minutes – tens years

- functional and morfological changes in cells, organs and whole organism

X-ray apparatus:

Therapy

skiagraphy

skiagraphy-fluoroscopy

angiography

mammography

fluoroscopy

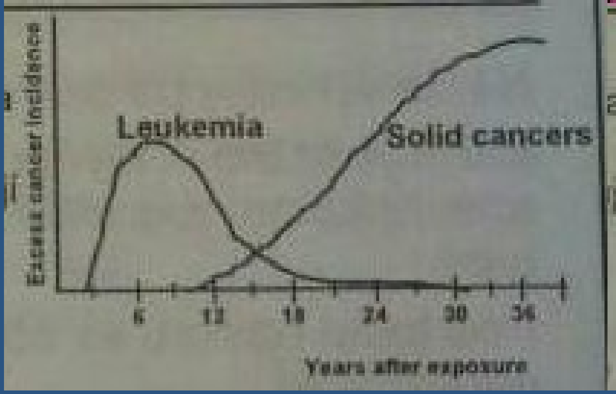
CT

Biological effects of IR:

stochastic

deterministic

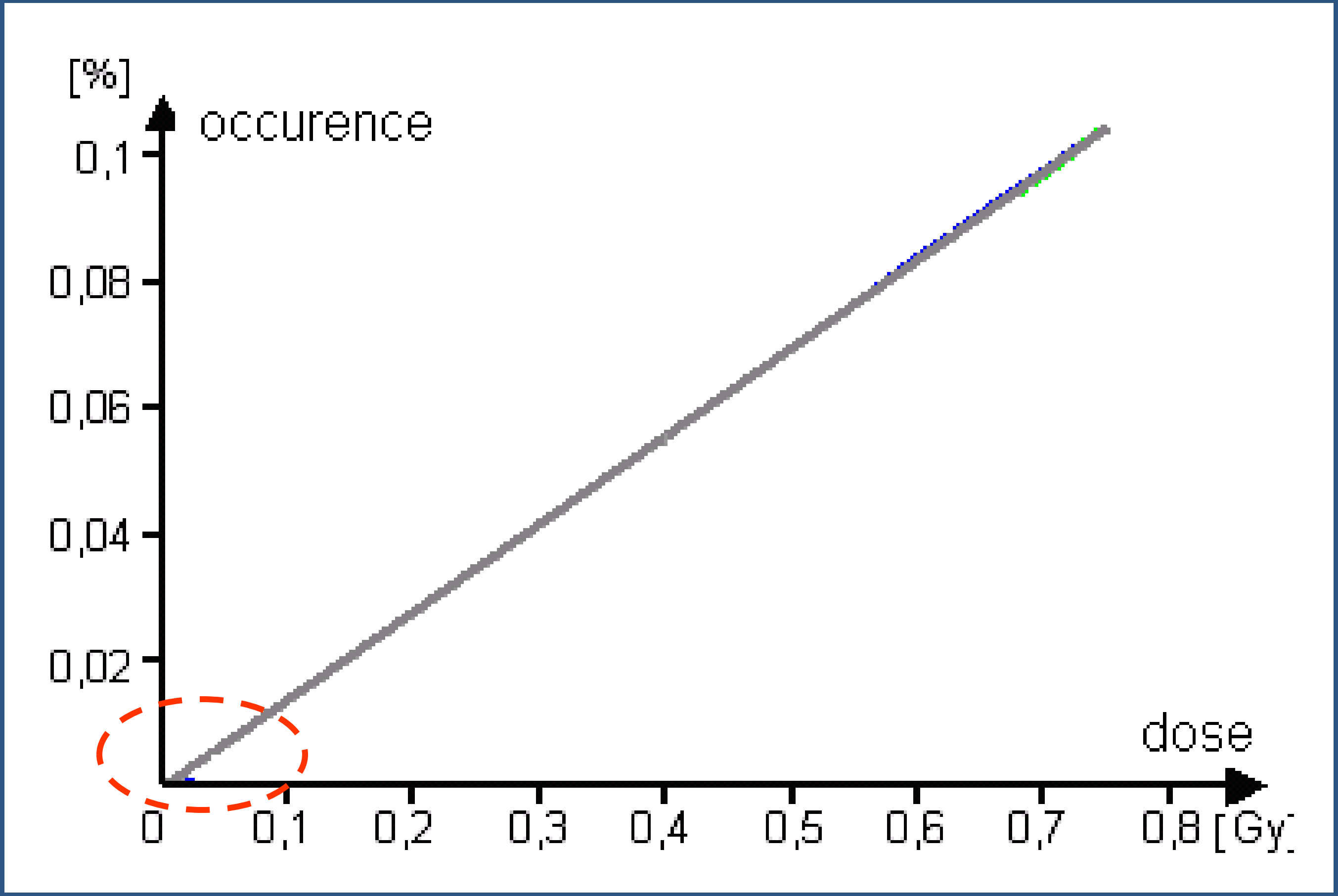
Stochastic effects:



- no threshold
- increasing D_{ef} – increasing probability of stochastic effects
- effect intesity do not dependent on the dose
- no effect immediately after irradiation (after several years)
- carcinoma + genetic effects
- lesion is not related to place of irradiation
- D_{ef} (Sv)

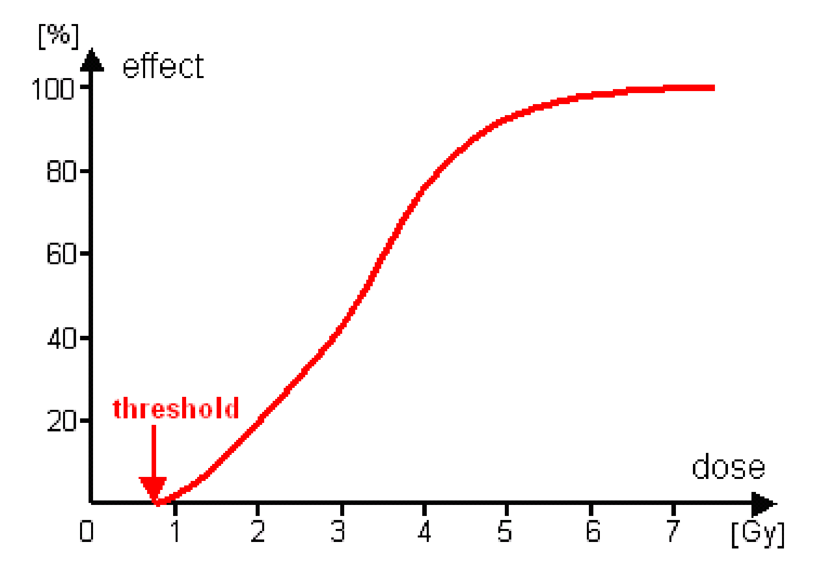
Latence: several years for cancer
100s years for genetic effects

Stochastic effects:



Deterministic effects:

- threshold
- lesion depends on absorbed dose
- local effects
- radiation damage is clinical provable
- example: cataract, erythema, infertility etc
- D_{ekv} (Sv)



Deterministic effects:

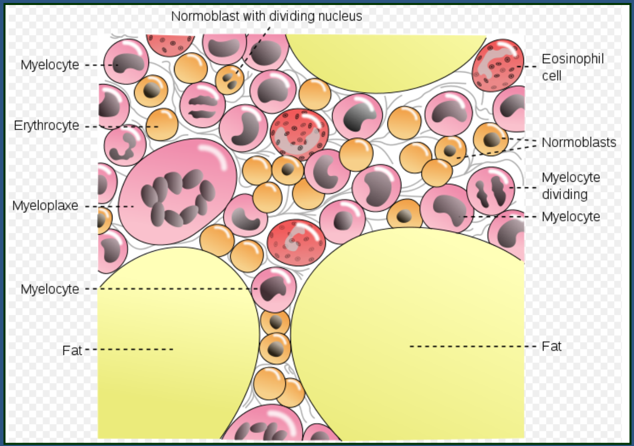
- accute radiation syndrome

bone marrow form - threshold 1-2Gy (typical 3-6Gy)
- massive loss of leukocytes, greatly increasing the risk of infection
- uncontrollable bleeding in the mouth, under the skin and in the kidneys
- bone marrow is nearly or completely destroyed, so a bone marrow transplant is required

gastric form – dose 6-10Gy
- gastric and intestinal tissue are severely damaged
- nausea, vomiting, diarrhoea (loss of minerals and water)

Radiosensitivity of tissues:

- activ bone marrow, lymphoid organs, sex gland, gastrointestinal system
- skin, mucous membrane (oesophagus, stomach, urinary bladder), lens
- blood vessel, growing cartilage, growing bone
- completed cartilage and bone, lungs, endocrinal system
- muscle, central nerve system



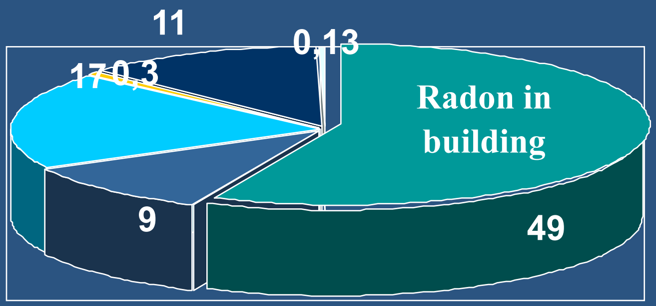
Embryo

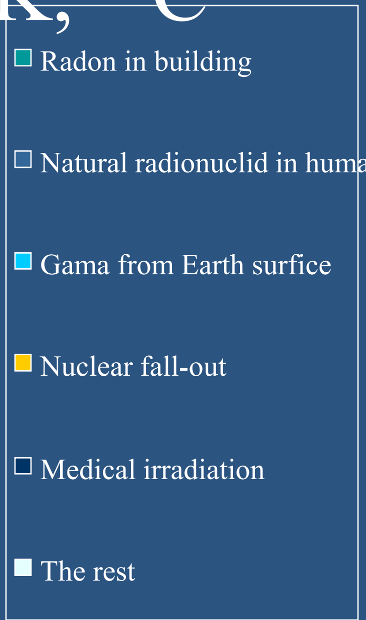
- 2 weeks – „everything or nothing“
- 3.–8. w – organogenesis, risk of malformations
- 8.–15. w – risk of mental handicap
- after 15. w – the same resistance as born child

The highest radiosensitivity – 1. third of gravidity!

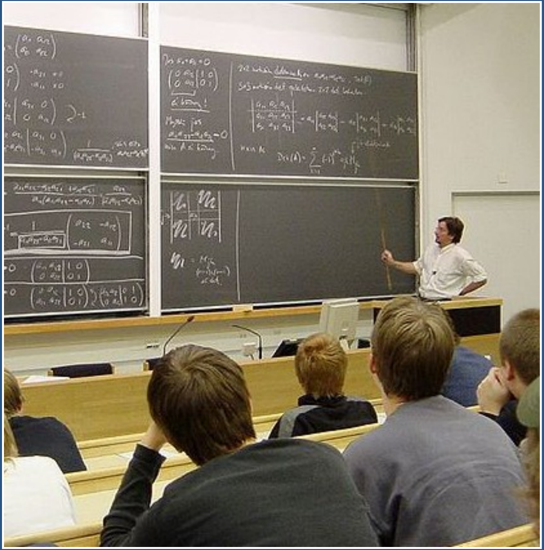
Ionizing radiation - etiology:

- 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





Limits:



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

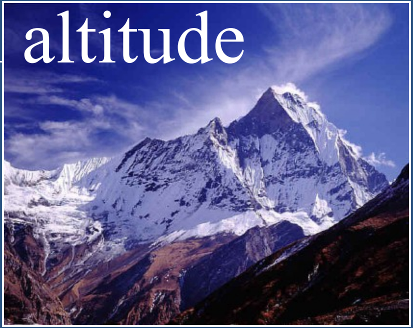
- Students
- 6 mSv
- 50 mSv

A pregnant woman – during whole pregnancy - 1 mSv

D_{ef} – 1 mSv

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

- <u>**severals months**</u> – external irradiation in high altitude



- <u>**100-1000 hours**</u> – 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

Effective doses of X-ray examinations:

Type of examination	Typical effective dose (mSv)		Time to stay in natural background radiation
R. of hands, joints	less 0,01	0,5	1,5 day
R. of chest	**0,02**	**1**	**3 days**
Radiogram of skull	0,07	3,5	10 days
R. of Th spine	0,7	35	3,5 months
R. of pelvis	0,7	35	3,5 months
R. of abdomen	1	50	5 months
R. of hip joint	0,3	15	1,5 months
R. of L spine	1,3	65	6 months
urography	2,5	125	1 year
Fluoroscopy of stomach	3	150	1,2 years
Fluoroscopy of small intestinum (enteroclysis)	3	150	1,2 years
irrigoscopy	7	350	2,8 years
CT of head	2,3	150	11 months
CT of chest	8	400	3,2 years
CT of abdomen or pelvis	10	500	4 years

Effective doses of examination in NM:

Type of examination	Typical effective dose (mSv)	Time to stay in natural background radiation
Static scitigraphy of kidneys	1,5	7 months
Dynamic scintigraphy of kidneys	2,2	10,5 months
Dynamic cholescintigraphy	2,3	11 months
Scintigraphy of skeleton	3,4	16 months
Perfused scintigraphy of lungs	1,2	6 months
Scintigraphy of thyroid	2,2	10,5 months
Scintigraphy of myocardium	7,5	3 years

Radiation protection

Protection of patients:

- Was the examination done?
- Is it the best type of examination?
- Explanation of problem?
- Do you necessary need this examinaton?
- Do you need the examination now?

Legislation:

- EUROATOM (law 18/1997)
  - aim of radiation protection (elimination of deterministic effects, minimalisation stochastic effects)
  - principle of working with IR (reasons for working, optimalisation, limitation)
- public notices of SÚJB (184/1997, 146/1997, 214/1997, 307/2002)

Categories of workplaces:

- 1st category – small sources, denzitometry, dental X-ray
- 2nd category – radiodiagnostics, therapy
- 3rd category – particle accelerators
- 4th category – nuclear power station, disposal site of nuslear waste

Filtration and shades:

Filtration – reduces intensity of low energy X-ray, reduces irradiation of skin and hypodermis

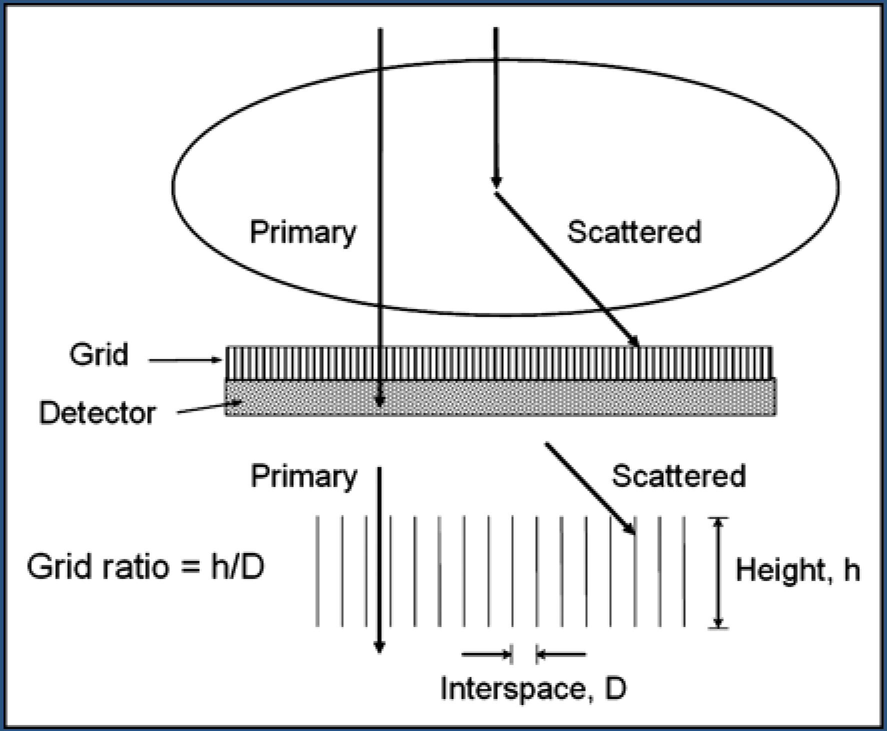
- $_{13}Al$, $_{29}Cu$ layer

Aluminium, Copper

Filtration and shades:

Secundary (Bucky s) shade – absorbs secundary and scattered radiation

- from lead belts



*Radiation protection:

- ✓ apron, collar
- ✓ diaphragm
- ✓ children – fixation equipment

- physical

  time - work as quickly as possible

  distance – by doubling the distance the dose rate is quartered

  shielding - α radiation - clothes, paper, plexiglass

  β radiation – plexiglass or aluminum

  γ rays – lead, steel, baryum concrete

  neutron radiation – materials containing a lot of hydrogen, cadmium and boron

- chemical - radioprotective substances

- biological – improving the immunity

Dosimetric magnitudes:

- express quantity of effects of ionizing radiation to matter (tissue, patient)

Protection of workers with IR:

- personal dosimetry

  - measure an absolute dose received over a period of time

  - by personal dosimetres

dozimetres: film, termoluminescent, scintilation, electrical, chemical

Protection of patients:

- Principle 1: reasons of medical irradiation

  - risk of the radiation damage must be less than a benefit for the patient

- Principle 2: optimalization

  - it is needed to aplicate the minimal necessary quantity of radiation which guarantees the quality of radiogram

Thank you