Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Basic Radiation Physics

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Basic Radiation

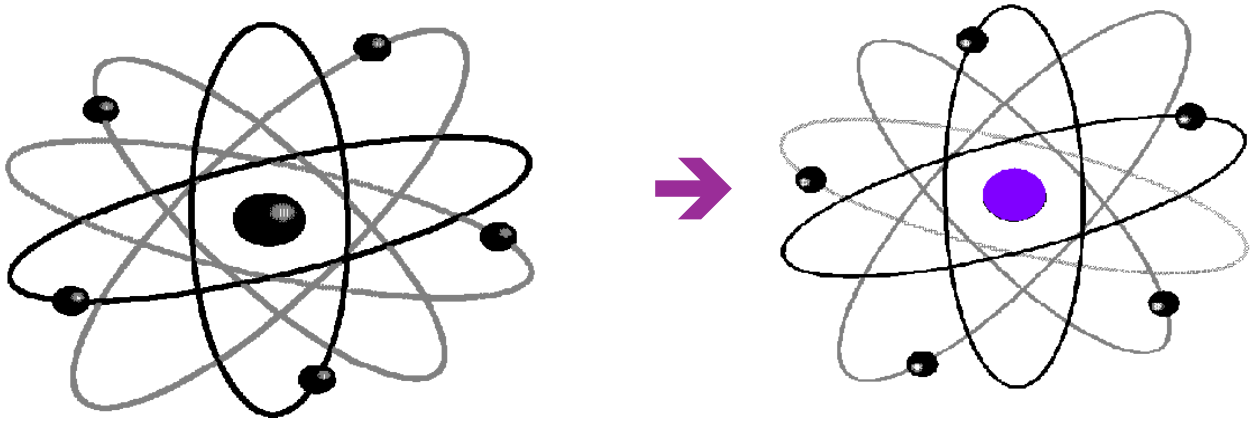
- ➔ Basic terminology
- ➔ Quantities and units
- ➔ Characteristics of different radiation

Biological effects

- ➔ DNA damage
- ➔ Acute and stochastic effects
- ➔ Levels; How much is much, how little is little?

Radioactivity

Spontaneous disintegration **(decay)**, of unstable atoms



+ Energy
(α, β, γ)

Radioactivity

It’s impossible to foresee when individual atoms will decay

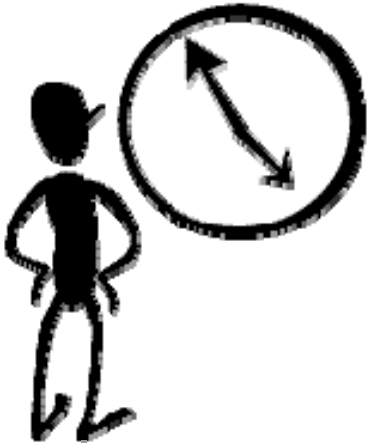
”Chance” seems to decide together with the degree of instability

Radioactivity

For a certain time period, we know:

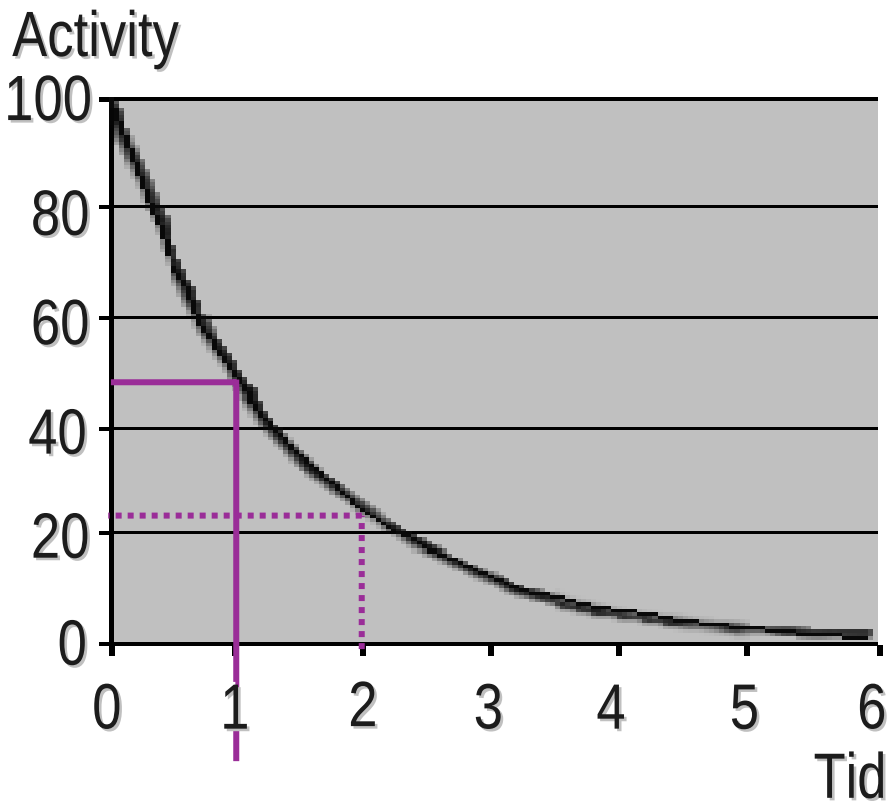
1) the probability for disintegration of individual atoms in a substance

and, consequently,



2) the fraction of a large amount of atoms that will disintegrate

Half time



One half time will decrease the number radioactive atoms to 50 %, two half times to a 25 % etc.

Half time

Only time can “destroy” radioactive substances

Each radioactive substance has a specific half time than can not be changed

Examples:

- Iodine-131 8 d
- Cobolt-60 5,3 y
- Sr-90 29 y
- Cs-137 30 y

Minced meat → meat ball: Reduction of 40-50 % *

*Private study. Reproducibility not tested

Radioactivity

Definition and units

Activity

Is the <u>number of disintegrations per time unit</u>

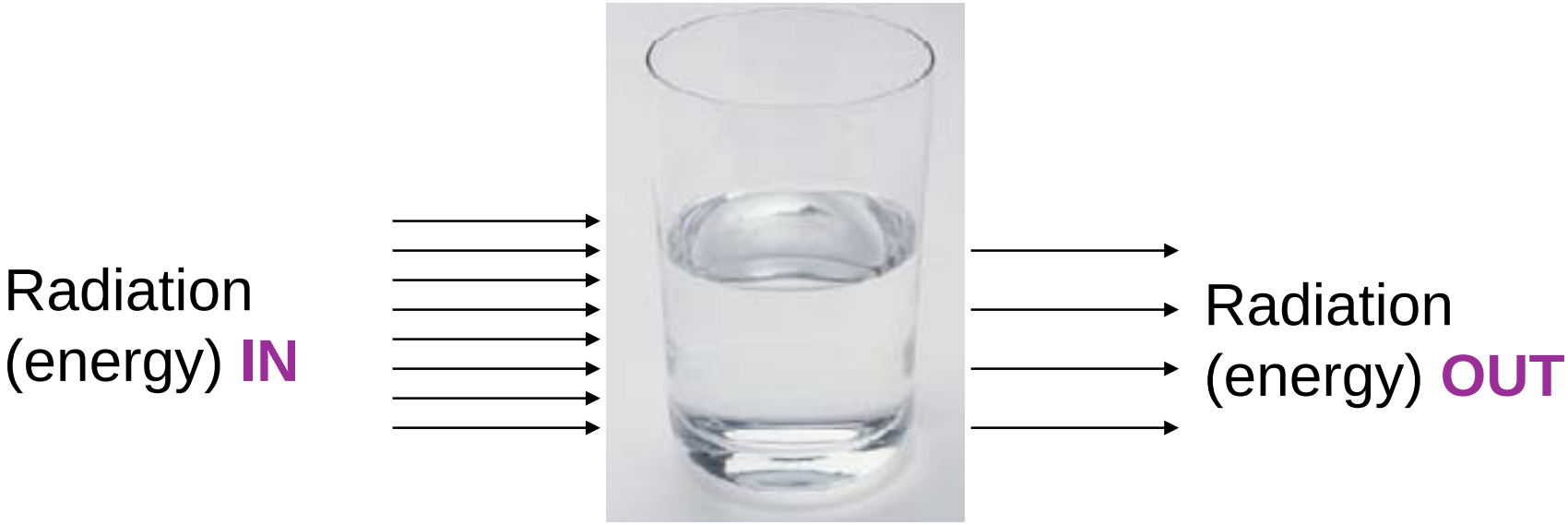
Becquerel [Bq]

where <u>one disintegration / s = 1 Bq</u>

Curie [Ci]:

1 Ci = 37 000 000 000 Bq (37 GBq)

Absorbed dose



$$\text{Dose} : \frac{\text{absorbed energy}}{\text{mass}}$$

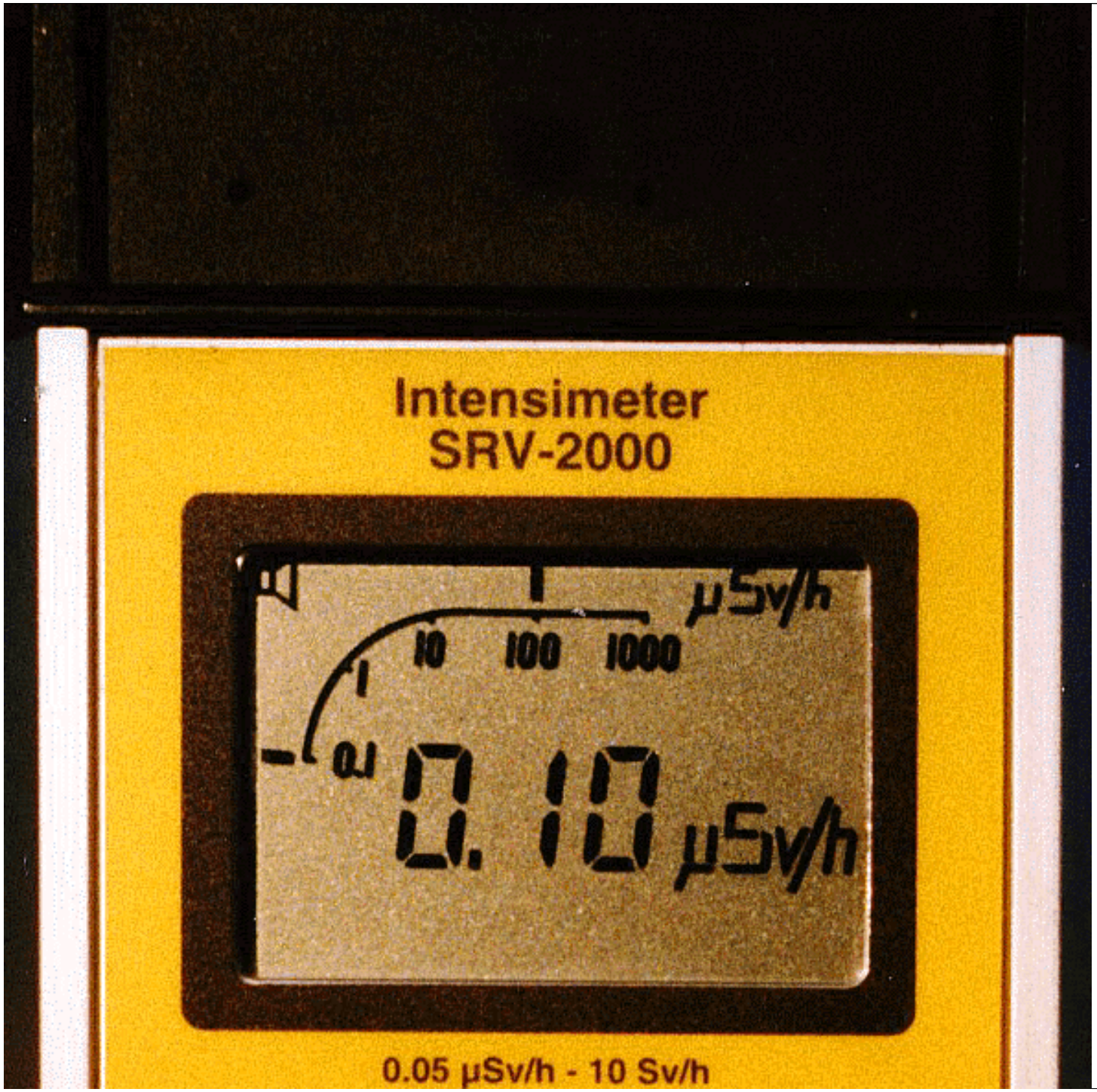
absorbed energy = energy $_{\text{IN}}$ – energy $_{\text{OUT}}$

Dose – Quantifies and units

Absorbed dose
Gray [Gy] (=J/kg)
1 Gy = 100 rad
1 rad ≈ 1 Roentgen [R]

Equivalent dose
Sievert (Sv)
1 Sv = 100 rem

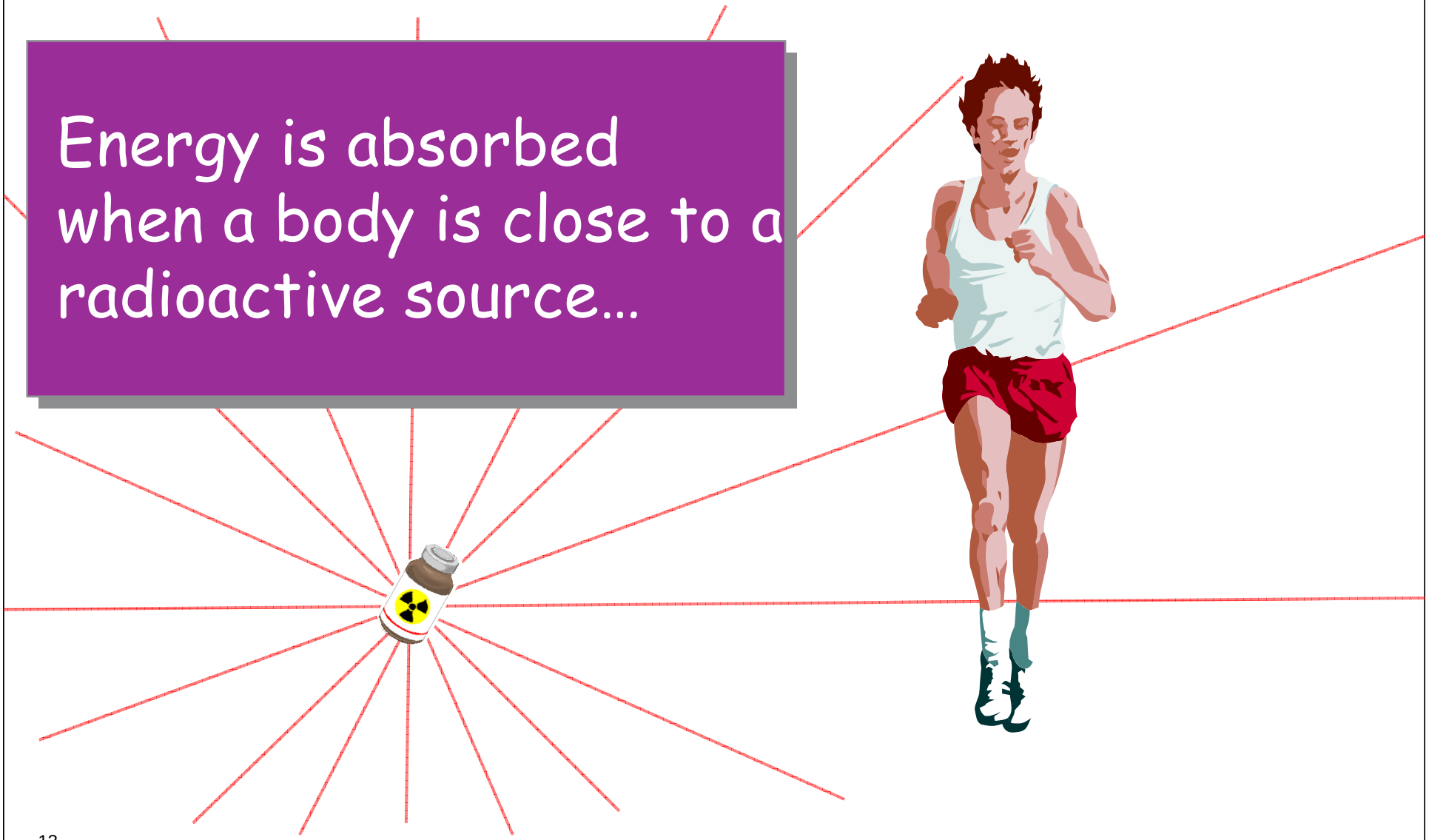
Effective dose
Sievert (Sv)


Intensimeter
SRV-2000
µSv/h
10
100
1000
0.1
0.10 µSv/h
0.05 µSv/h - 10 Sv/h

Dose rate

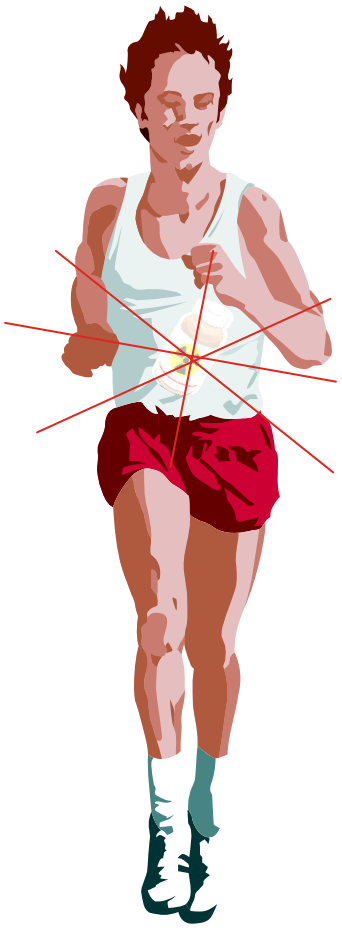
Absorbed dose

Energy is absorbed when a body is close to a radioactive source…



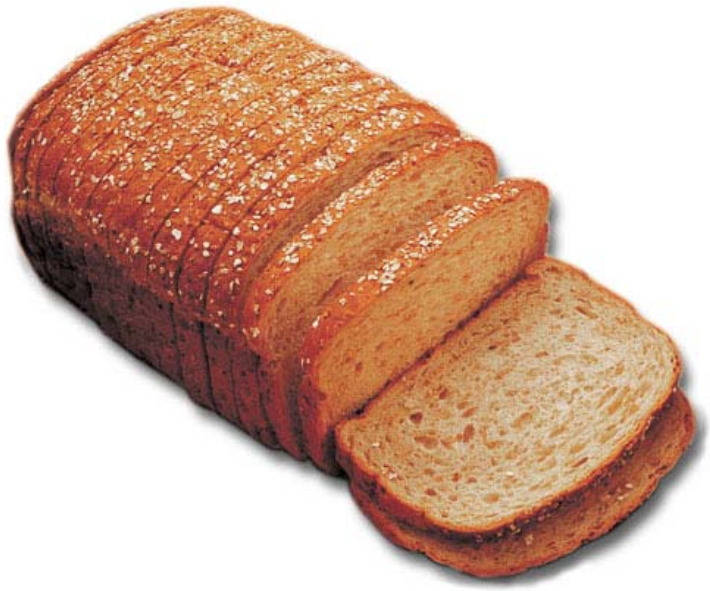
Absorbed dose

…or when the source is inside the body



Calculation example

Intern contamination



Milk:
500 Bq I-131 ➔ 7 µSv
1000 Bq Cs-137 ➔15 µSv

Meat / bread:
1000 Bq Cs-137 ➔16 µSv

Calculus example

Ground deposition

Normal background is 0.1 µSv/h

(large variations)

Lower intervention level for pasture restriction
10000 Bq/m
Results in a dose rate

0.02 µSv/h
for I-131

0.03 µSv/h
for Cs-137

Ionisation radiation can not be registered by our senses

0.1° C ~ 400 Sv

- Can't be seen
- Can't be heard
- Can't be felt
- Doesn't smell
- Doesn't taste

Indication

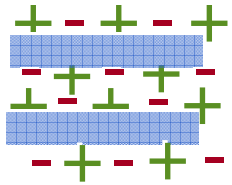
In order to detect ionising radiation you need to use **radiation detectors**

Different types of radiation and different purposes requires different types of detectors

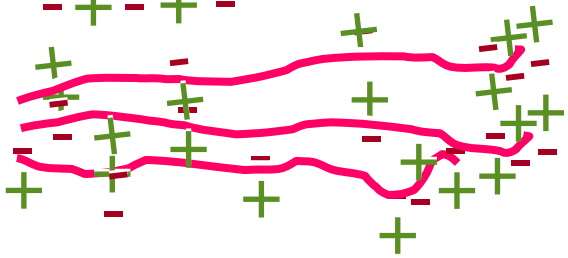
Different types of ionising radiation

Particular radiation

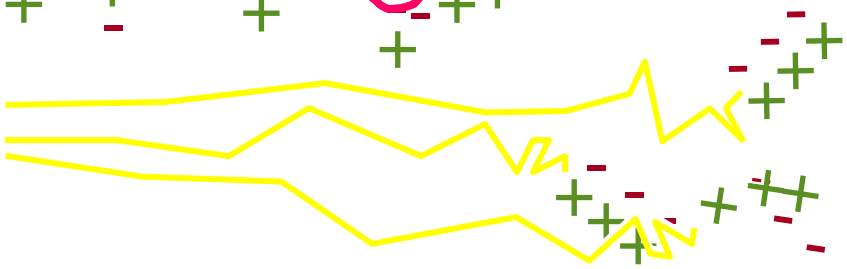
Alpha



Beta



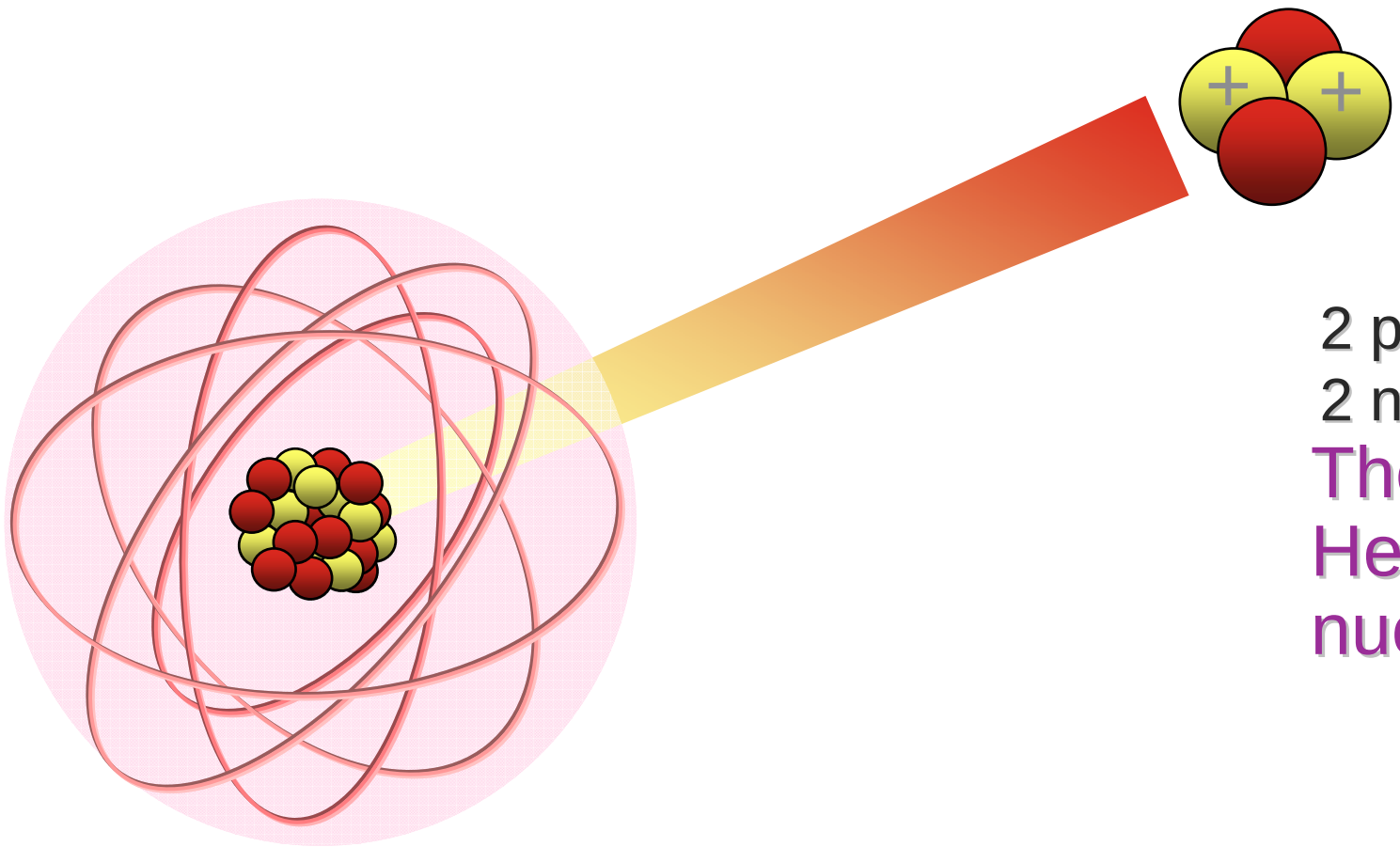
Neutrons



Electromagnetic radiation

Gamma

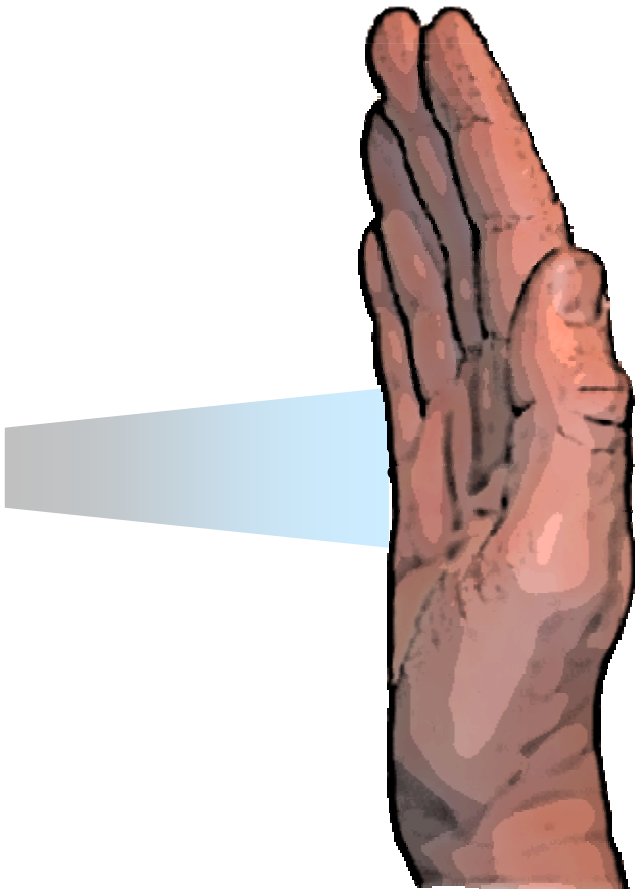
Alpha radiation



2 protons
2 neutrons
The Helium nucleus

Emitted by heavy radioative atoms eg:
radon-222, radium-226, uranium-238, plutonium-239, americium-241

Properties of alpha radiation

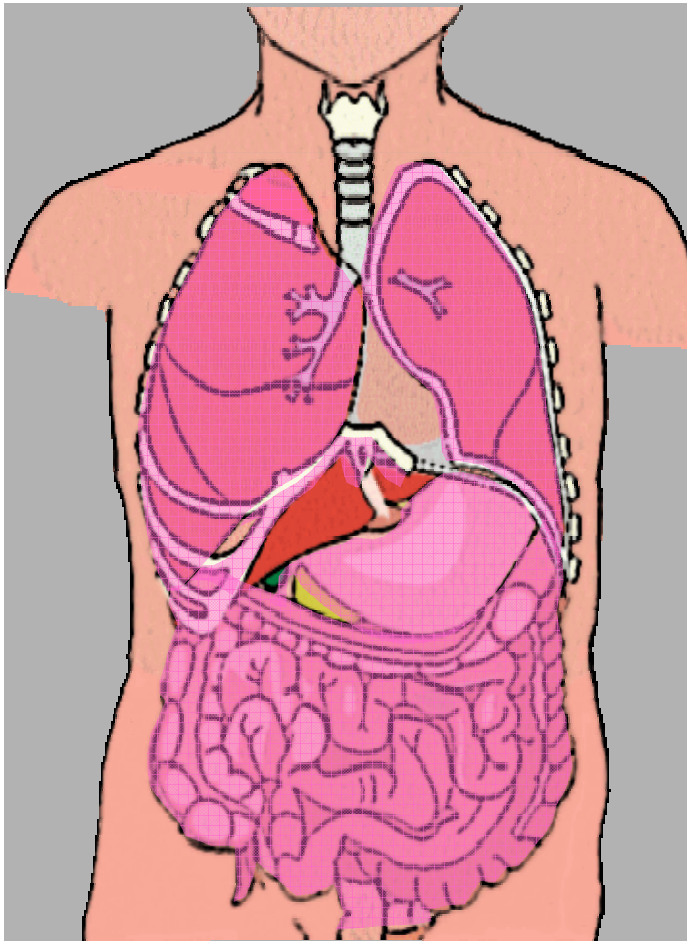


Range no more than about a cm in air

The radiation can not penetrate the skin

The radiation is stopped by clothes, equipment or the protection around radiation detectors

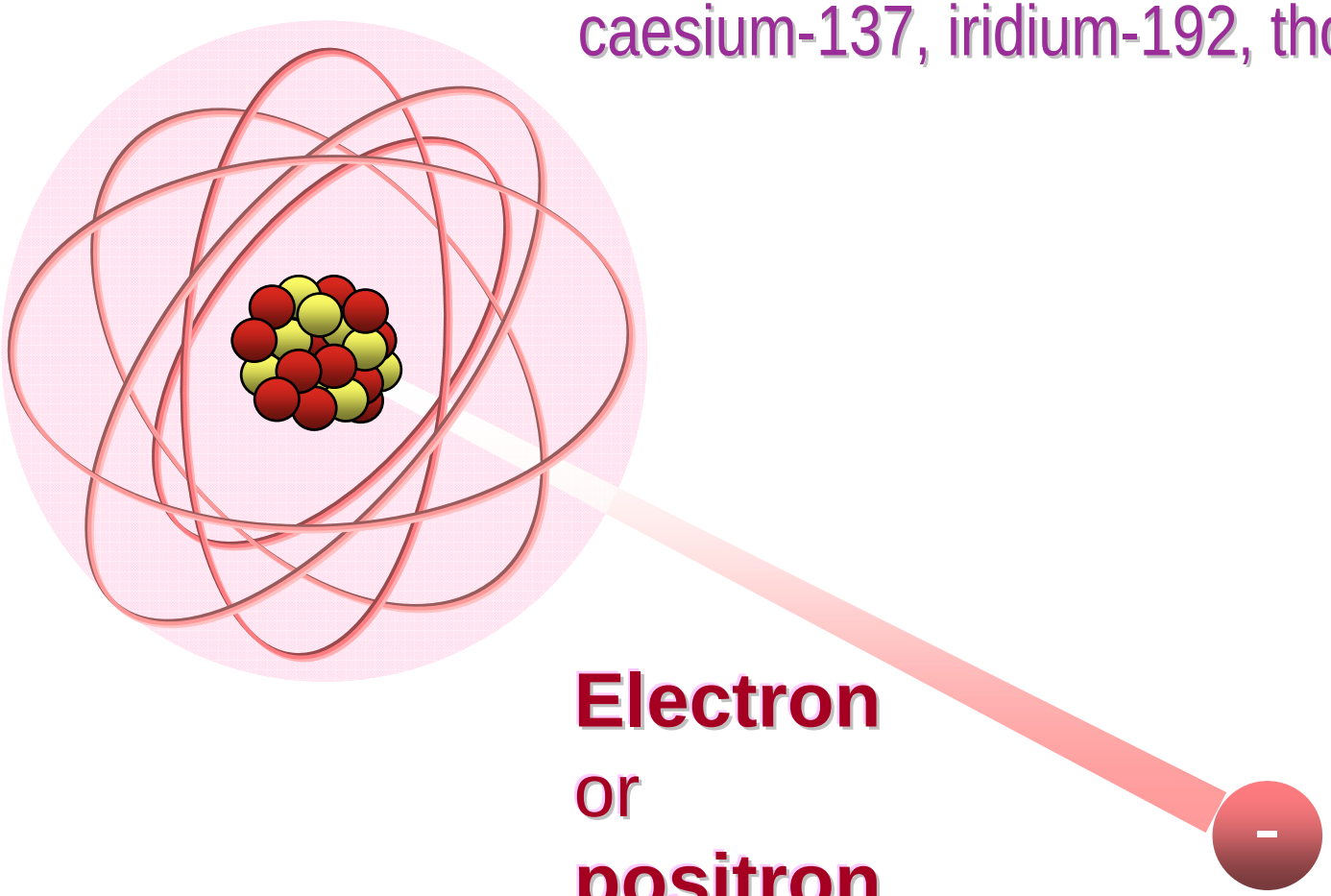
Alpha radiation in the body



Alpha radiation can only cause damage if the source gets inside the body; Either orally, by inhalation or through open wounds

Beta radiation

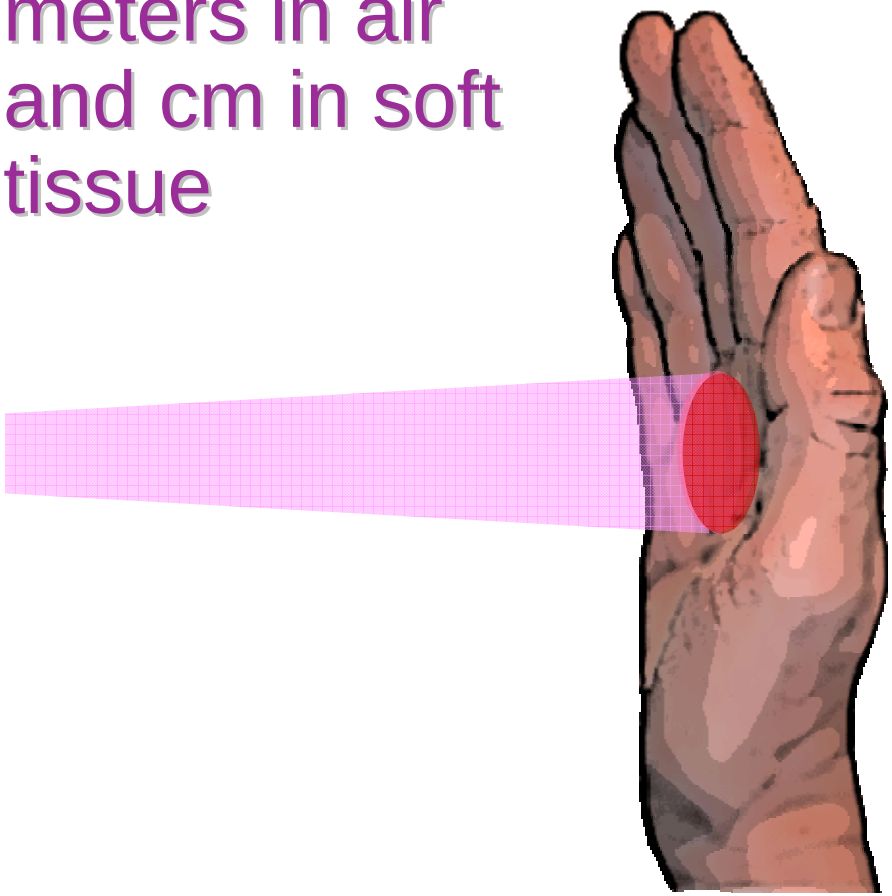
Emitted by many radioactive substances. Eg :
phosforous-32, cobalt-60, strontium-90, caesium-137, iridium-192, thorium-234



Electron
or
positron

Properties of beta radiation

Range: several meters in air and cm in soft tissue

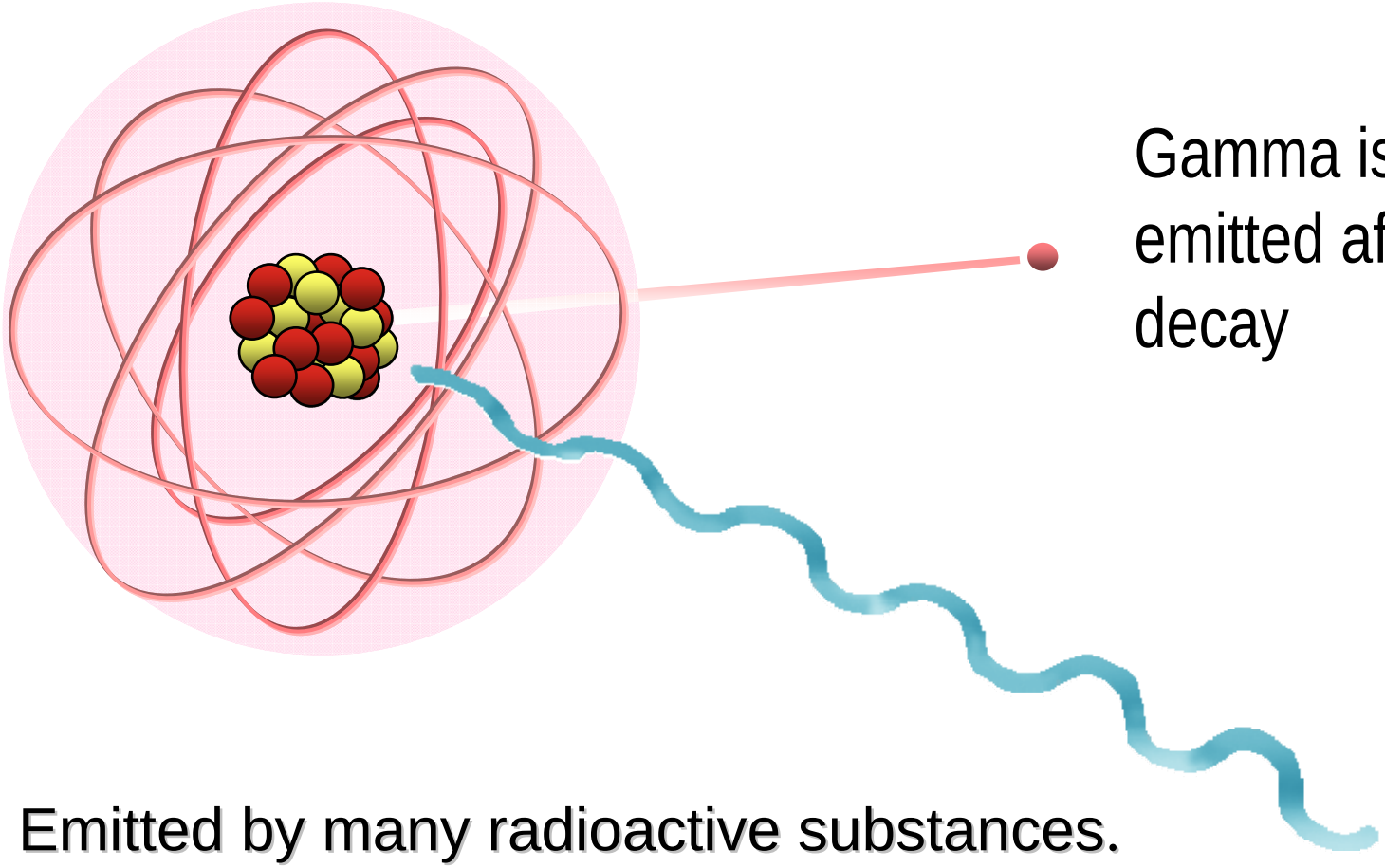


Can penetrate skin

If contamination is left on skin it can cause burn injuries

Clothing give some protection and prevent skin contamination

Gamma radiation



Gamma is often emitted after a beta decay

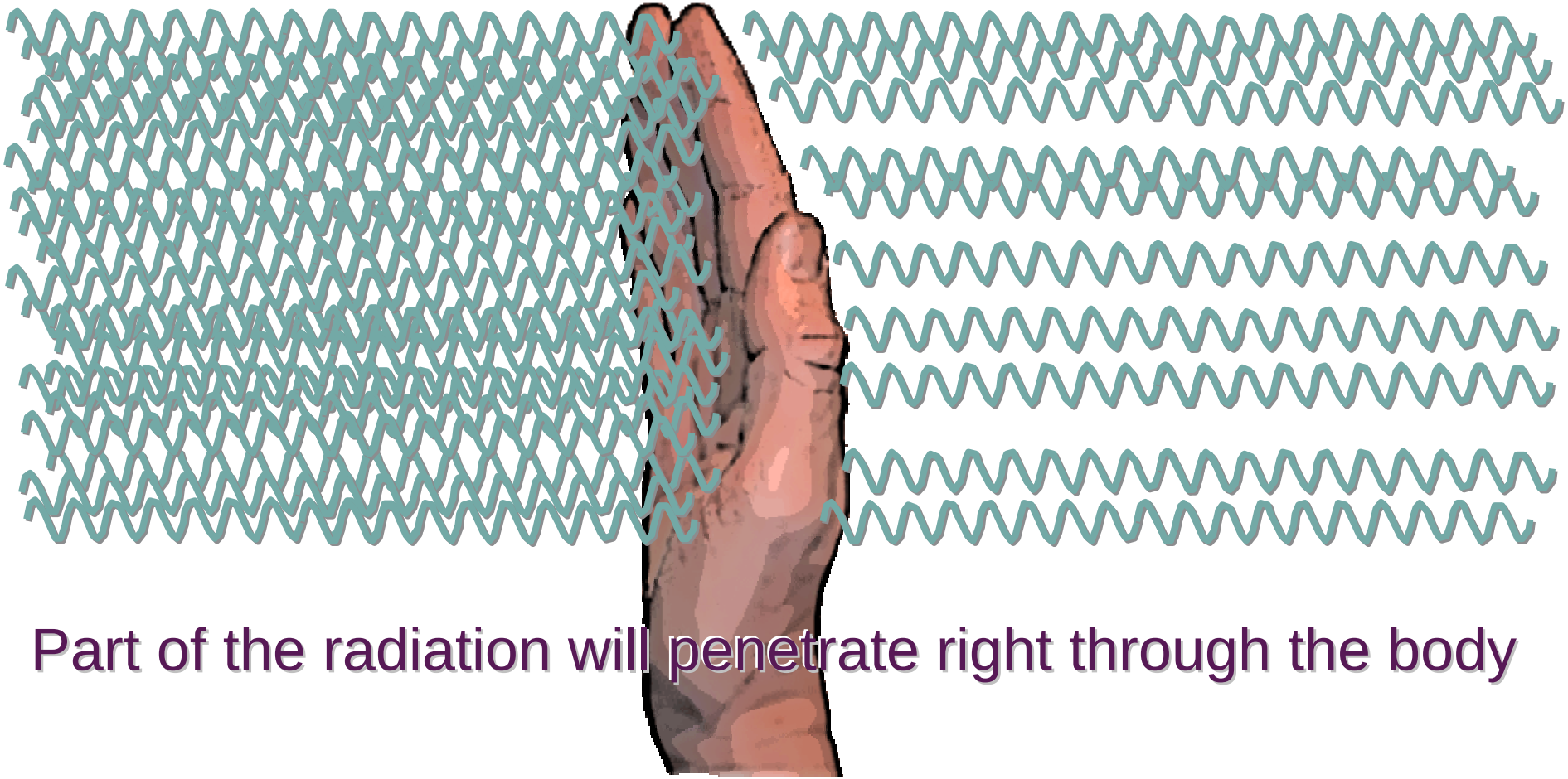
Electro magnetic radiation

Photon

Emitted by many radioactive substances.
kobalt-60, molybden-99, iodine-131, caesium-137, iridium-192, lead-214 (radium-B), vismuth-214 (radium-C)

Properties of gamma radiation

Range: hundreds of meters in air, decimetres in soft tissue



Part of the radiation will penetrate right through the body

Radio active substance are not contagious but could be spread as a pollution

An exposed person is not contagious.

Radio active substances can not proliferate like bacteria or viruses

A contaminated person can contaminate others

Basic Radiation

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Effects on humans of ionising radiation

Experiences from

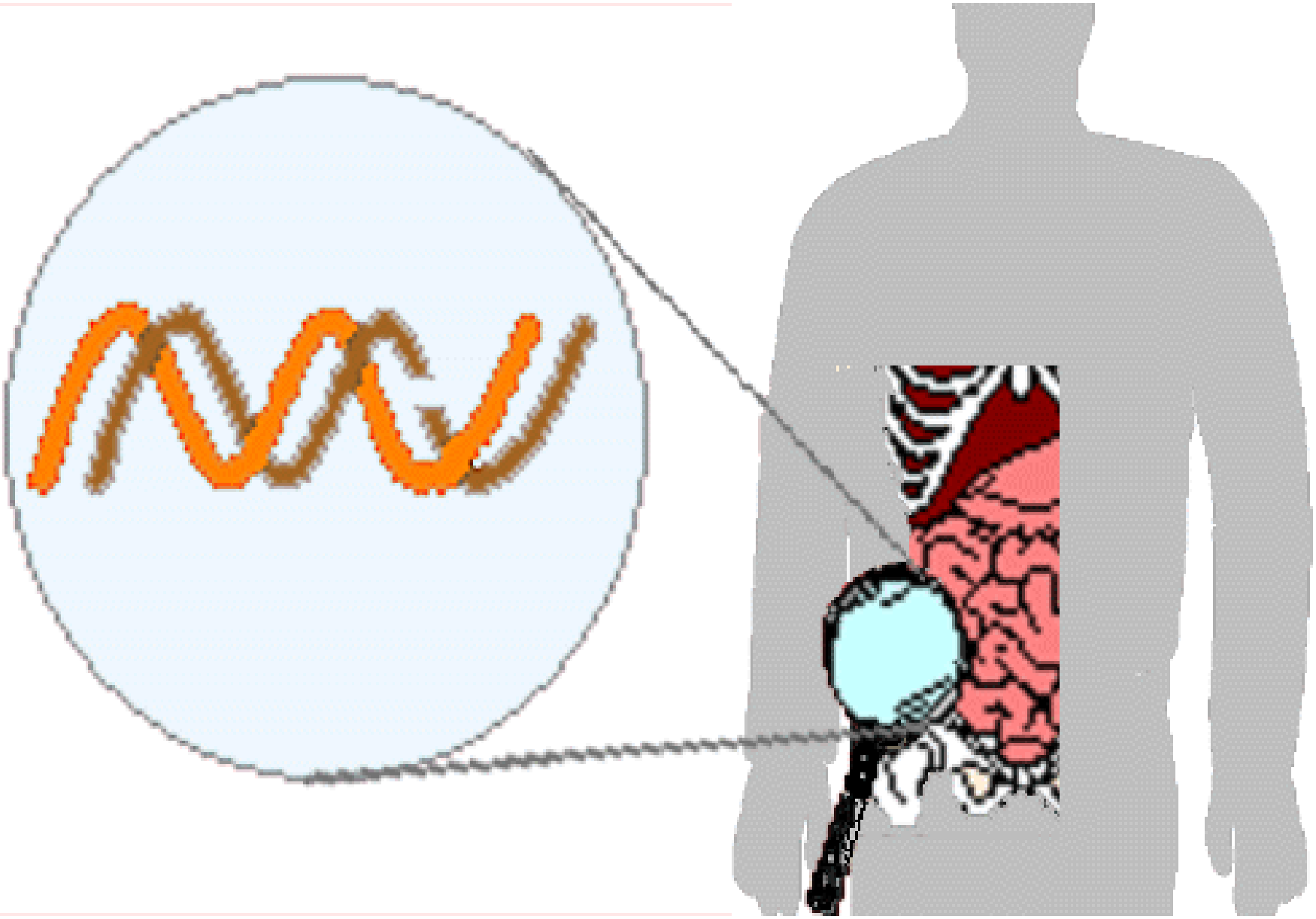
Radiation injuries during early use of radiation

Side effects during cancer therapy

Nuclear and radiological incidents and accidents

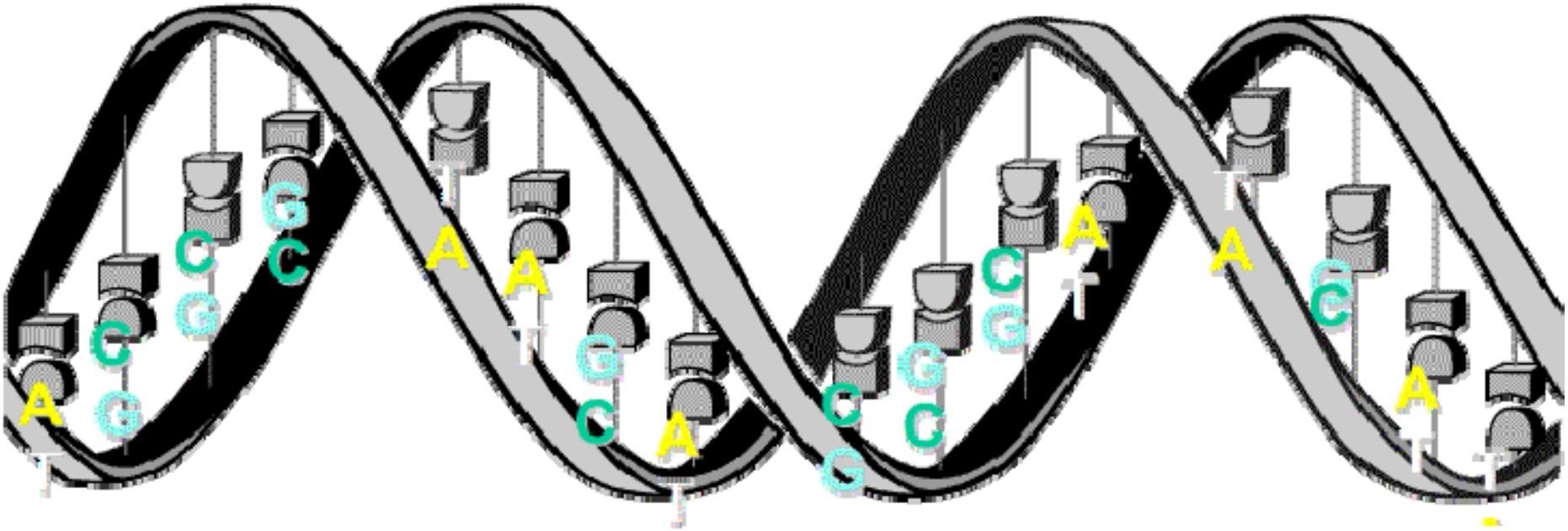
Hiroshima and Nagasaki

- **The radiation damages the arvsmassa of the cells, DNA-molecule**



DNA-molecule

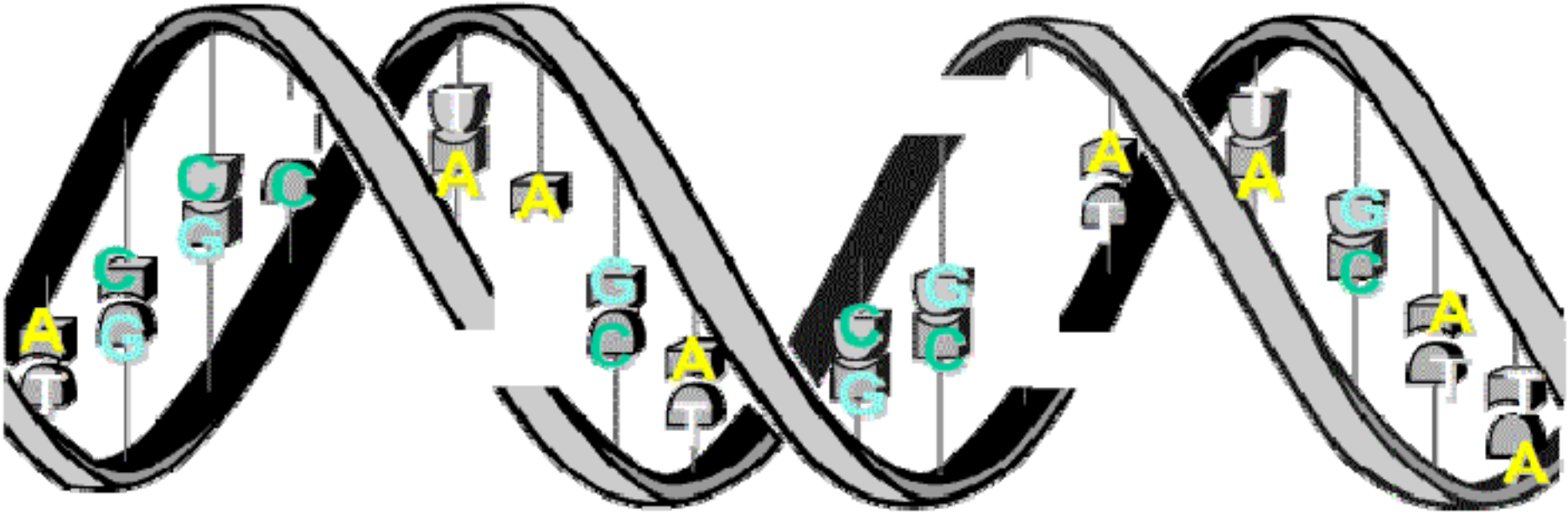
contains the genetic code



... A C C G T A C T T A G G C A T ...
... T G G C A T G A A T C C G T A ...

DNA-molecule

is damaged by the radiation

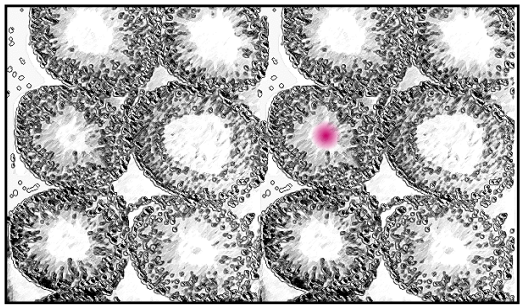


Singel sting break

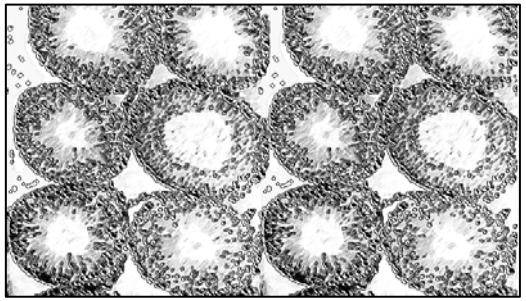
Double sting break

...ACC TACTTAGG AT...
...TGGCATGAATCC TA...

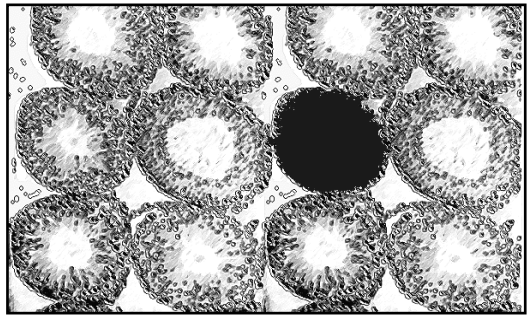
When DNA is damaged
Alternative 1



The damage is repaired and the cell proliferates normally



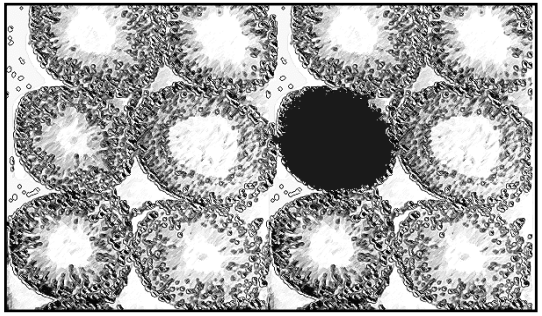
Low dos rate, long time. Good chances for repair.



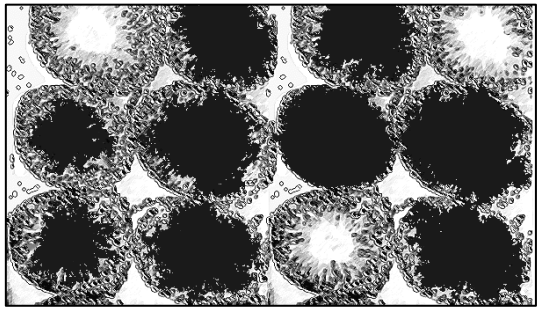
High dose rate, short time. Limited time for repair.

When DNA is damaged
Alternative 2

The cell dies



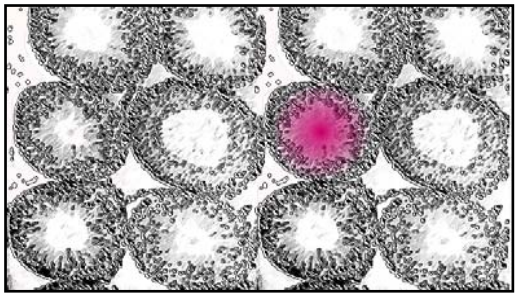
Death of a small amount cells is not a problem. The body takes care of the dead cells



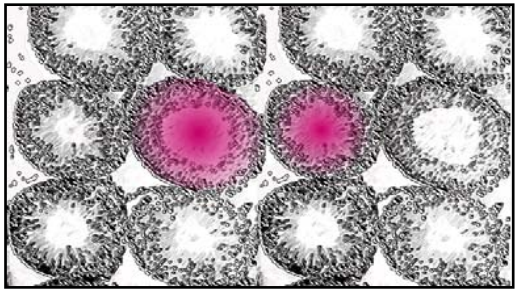
If many cells dies, <u>the function of the organ in question is jeopardised and life of the individual is threatened</u>

It takes many dead cells for the injury to be manifested – the dose need to exceed a threshold

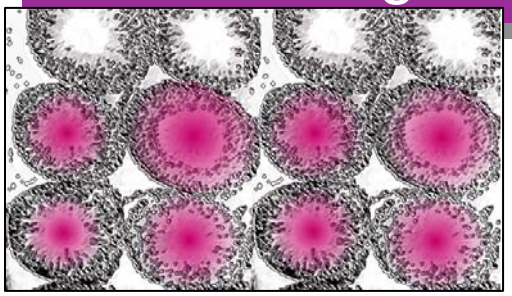
When DNA is damaged
Alternative 3



The cell survives but the damage is transferred to the dautgher cells

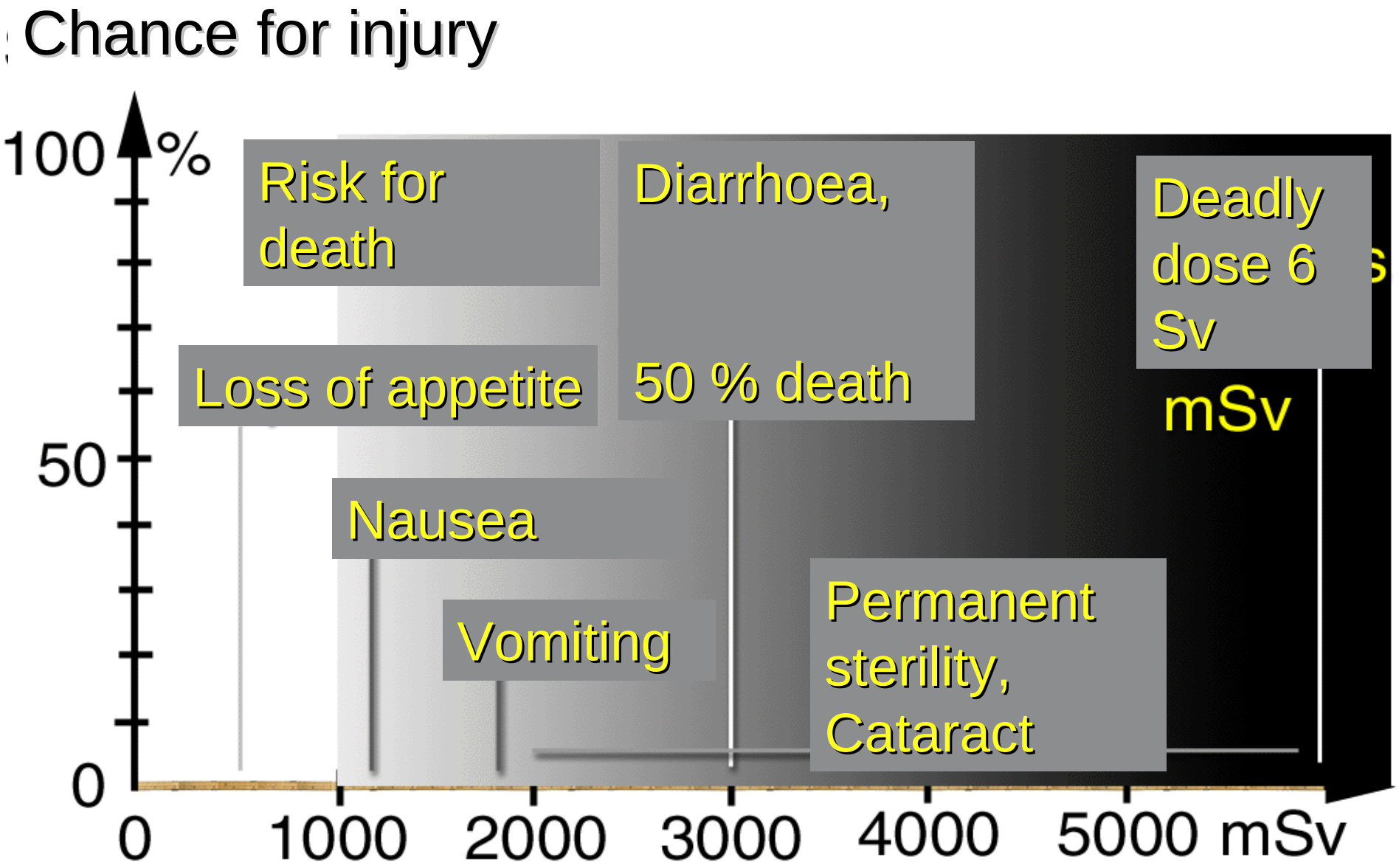


In general – **tumour disease**
In sex cells – **hereditary damages**
to the next generation



Long latens time

Acute effects

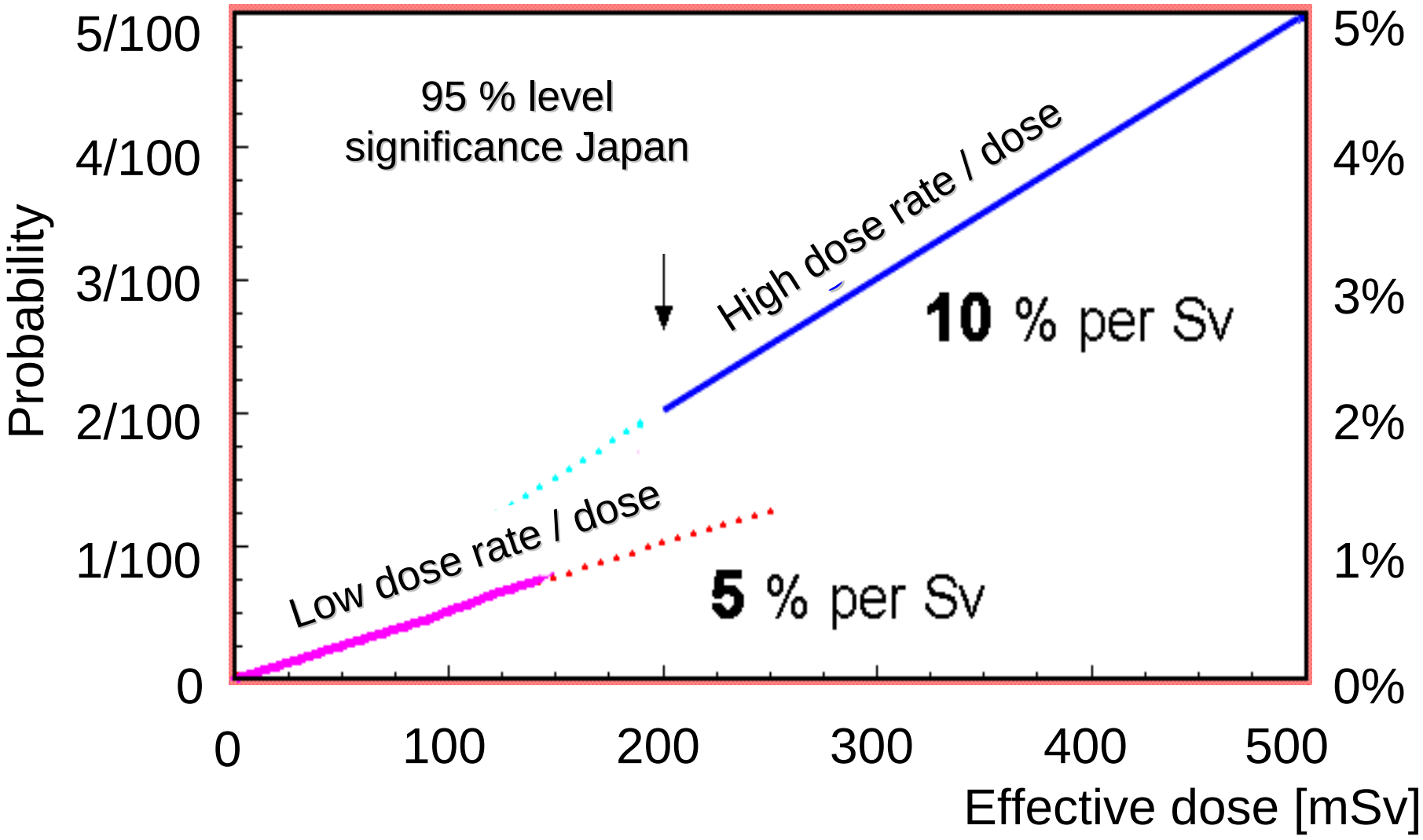


Radiation injury – Temporal development

Ir-192 source, 185 GBq kept in pocket for 1 ½ hour

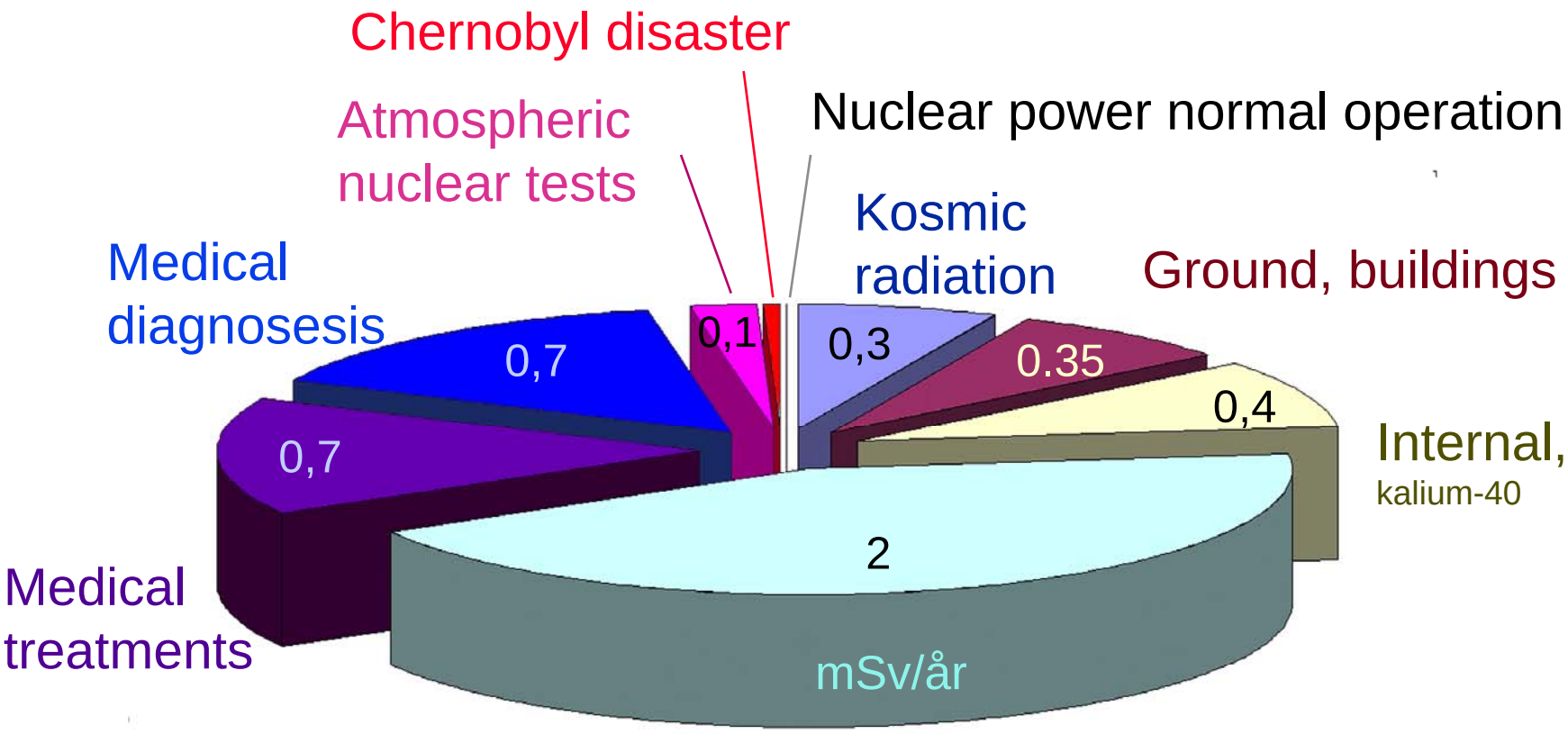
Radiation injury – Temporal development

Fatal cancer



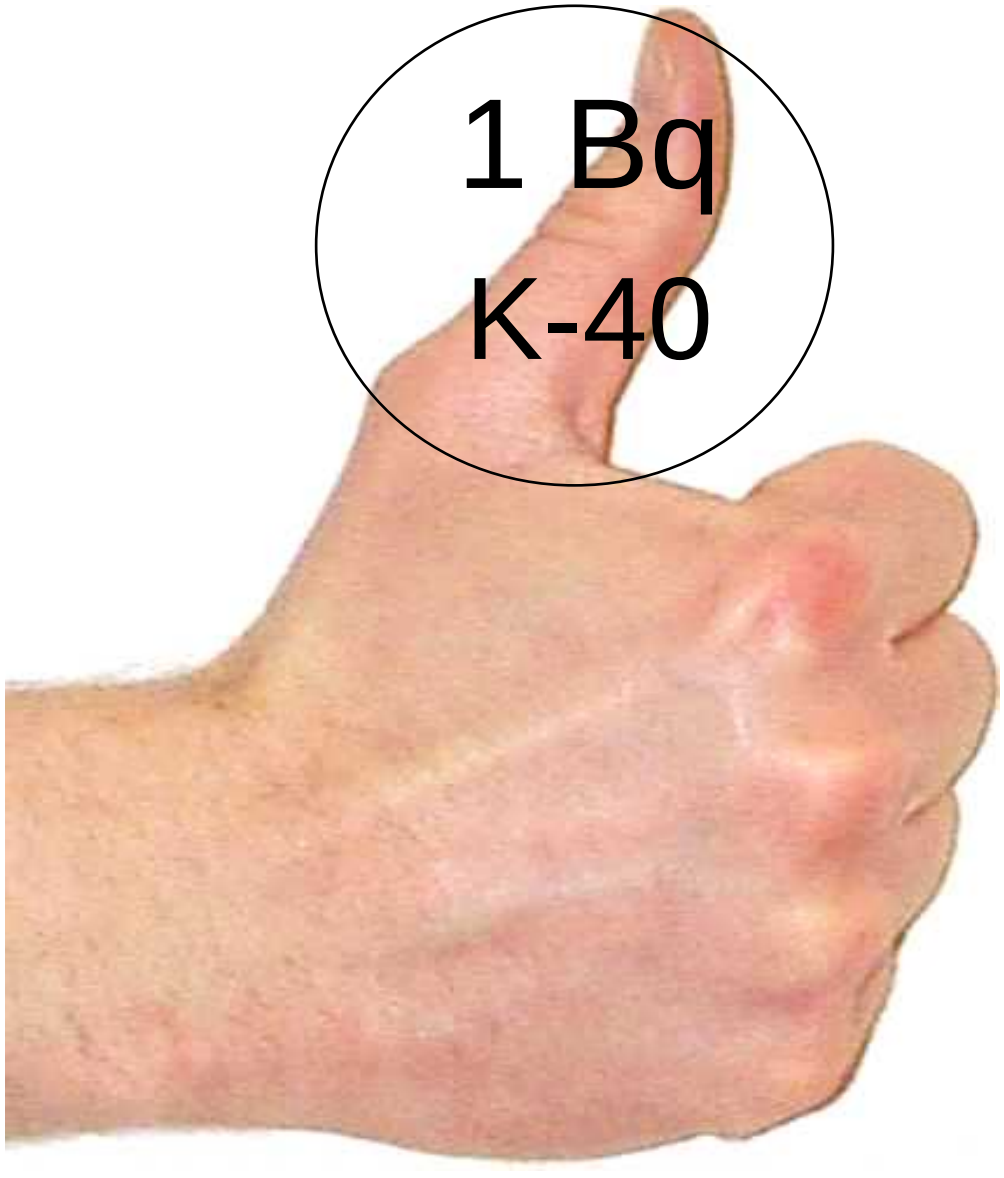
Radiation in every day life

Average in Sweden 1950-2000



approx 4 mSv/y

Rule of thumb



Tumme:
1/5000 of
bodymass

Thanks for your attention