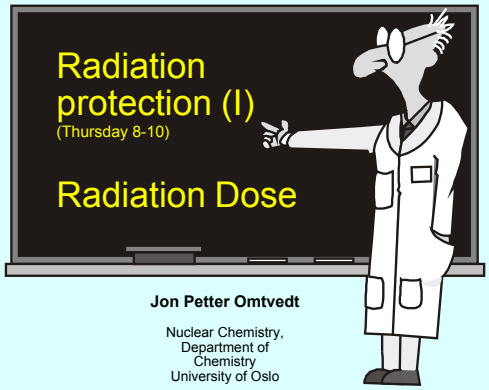
Radiation protection (I)

(Thursday 8-10)

Radiation Dose



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Radiation Dose

- **Radiation dose**, D, is a measure of how much energy is deposited per mass unit in the material hit by the radiation.
- **Dose rate**, R_D, is radiation dose per unit of time.
- The unit for radiation dose is **gray** (Gy).
  - It's defined as: 1 Gy = 1 J / kg.

$$Radiation\ Dose = \frac{energy}{mass}; \qquad D = \frac{E}{m}$$

Radiation dose = Stråledose
Dose rate = dosehastighet

The Biological Dose Equivalent

- Different types of radiation has different biological effects, even if the absorbed dose is equal.
- The dose is therefore multiplied with a factor, Q, ("quality factor") which compensates for this.
- Q is characteristic for each type of radiation.
- For our purpose we use N = 1.
- The unit for the biological dose equivalent is Sievert (Sv).

$$H = D \cdot Q \cdot N$$

Strålingstype	Kvalitetsfaktor
200-250 keV røntgen	1
γ-kvant, β-partikler og elektroner	1
Termaliserte nøytroner (< 0.8 MeV)	3
Hurtige nøytroner (>0.8 MeV), protoner og α-partikler	10
Tunge ioner	20

The Effective Dose Equivalent

- There is large differences between how sensitive the body's organs are to radiation.
- Therefore we introduce a *weight factor* which take the radiation sensitivity of each organ into account.
- Thus, the *effective dose equivalent* is defined equal to the *biological dose equivalent* H multiplied with the organs weight factor, f.
- The factors is scaled in such a way that when all the organs in the body is added together, the sum equals 1.00.
  - Thus, for a whole body radiation, the weight factor equals 1.00.
- The effective dose equivalent is measured in units of Sievert (Sv) (the weight factor is dimension less).

$$H_{eff} = f \cdot H$$

Summary & Norwegian Terms

$$Radiation\ Dose = \frac{energy}{mass}; \qquad D = \frac{E}{m}$$

Unit gray (Gy), 1 Gy = 1 J / kg.

The Biological Dose Equivalent $H = D \cdot Q \cdot N$

The Effective Dose Equivalent $H_{eff} = f \cdot H$

Unit Sievert (Sv).

Radiation dose = Stråledose
Dose rate = dosehastighet
Biological Dose Equivalent
= Biologisk doseekvivalent
Effective Dose Equivalent
= Effektiv doseeqvivalent
Quality factor = Kvalitetsfaktor

Internal radiation - ALI values

- It is difficult to calculate doses, in particular for internal sources.
- ALI = *Annual Limit on Intake*.
- ALI is defined as the amount of a given type of nuclide (in Becquerel) which if swallowed, inhaled or by some other means entered the body, will inflict a 20 mSv dose.

Source for ALI values

- ICRP has made tables with ALI values which makes it much easier to estimate internal doses.
- The ALI tables are easy to use, but based on sofisticated and complex calculations.

ICRP = International Commission on Radiological Protection

ALI - example

Strålingstype	ALI-verdi (Bq)	
	Ved svelg:	innpusting:
Tritium (^{3}H)	$1 \cdot 10^{9}$	$1 \cdot 10^{9}$
Karbon-14 (^{14}C)	$4 \cdot 10^{7}$	$4 \cdot 10^{7}$
Fosfor-32 (^{32}P)	$1 \cdot 10^{7}$	$8 \cdot 10^{6}$
Svovel-35 (^{35}S)	$2 \cdot 10^{8}$	$1 \cdot 10^{8}$
131-Jod (^{131}I)	$1 \cdot 10^{6}$	$8 \cdot 10^{5}$

It is a good idea to not eat or breathe radioactivity....!

Radiation Dose Effects

- Strong radiation doses will result in almost immediate illness symptoms. This we call deterministic effects.
- For both weak and strong radiation doses there is a certain likelihood of developing illnesses at a later stage (in particular different types of cancer). This is called stochastic effects.
- For radiation doses of the same order of magni-tude as the background radiation, the likelihood of developing any illness is most likely zero.

Many such reports in the press about radiation effects of small doses have created a largely unjustified fear of everything nuclear.

Large doses

- Doses around 0,25 Sv will give measurable changes in the blood.
- In spite of this, doses up to 1 Sv do not give any immediate illness.
- Doses above 1 Sv leads to signs of radiation illness, which are:
  - Nausea.
  - Vomiting.
  - Head ache.
  - Loss of the white blood cells.

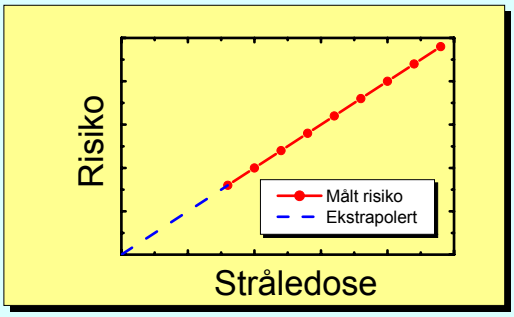
Really large doses

- Doses of more than 3 Sv causes temporarily hair loss, but also mer serious internal damage.
- Examples of such internal damage are damaged nerve cells and a serious loss of white blood cells.
- The reduction of the amount of white blood cells leads to a much higher likelihood of infections, etc.
- Radiation also reduces the production of blood plates, which helps the blood coagulate. Therefore, people having received high doses will easily bleed.

Deadly Doses

- 50 % of people having received a dose of 4.5 Sv will die.
- Doses above 8 Sv always leads to death There is no treatment for the effects of such radiation doses. The patient will die within 2 to 14 days.
- Those surviving large doses will with high likelihood develop cancers.

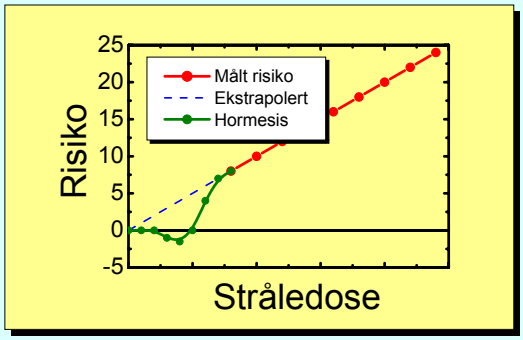
Estimate of Dose Effects



Hormesis?

- All living organisms have been developed in a milieu in which radioactivity (background) has been a part of the surroundings.
- There are results indicate that small doses of ionising radiation do not have any negative effects at all.
  - On the contrary, there is indications which points to certain positive effects on e.g. the immune system.
- A "healthy" effect of low radiation doses is commonly referred to as "hormesis".
  - Hormesis comes from the Greek word "hormaein", which means "to excite". I.e. low doses have a stimulating effect.

Hormesis?



Loss of expected life time

Årsak/kilde:	Gjennomsnittlig livslengde tap (dager):
Helserisiko:	
Røke 20 sigaretter pr. dag	2370
20% overvekt	985
Alle slags ulykker	435
Alkohol (gjennomsnitt for USA)	130
Drukning	41
Naturlig bakgrunnsstråling	8
Katastrofer (jordskjelv, osv.)	3,5
Yrkesrisiko:	
Gruvedrift	328
Bygg og anlegg	302
Jordbruk	277
Transportsektoren	164
Service næringer	47
All slags industri (gjennomsnitt)	74
Strålingsrelatert:	
Medisinsk røntgendiagnostikk (gjennomsnitt)	6
0,01 Sv yrkesrelatert stråledose (enkelt dose)	1
0.01 Sv/år stråledose i 30 år	30