

Effects of Radiation

on Human Health

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大学等放射線施設協議会

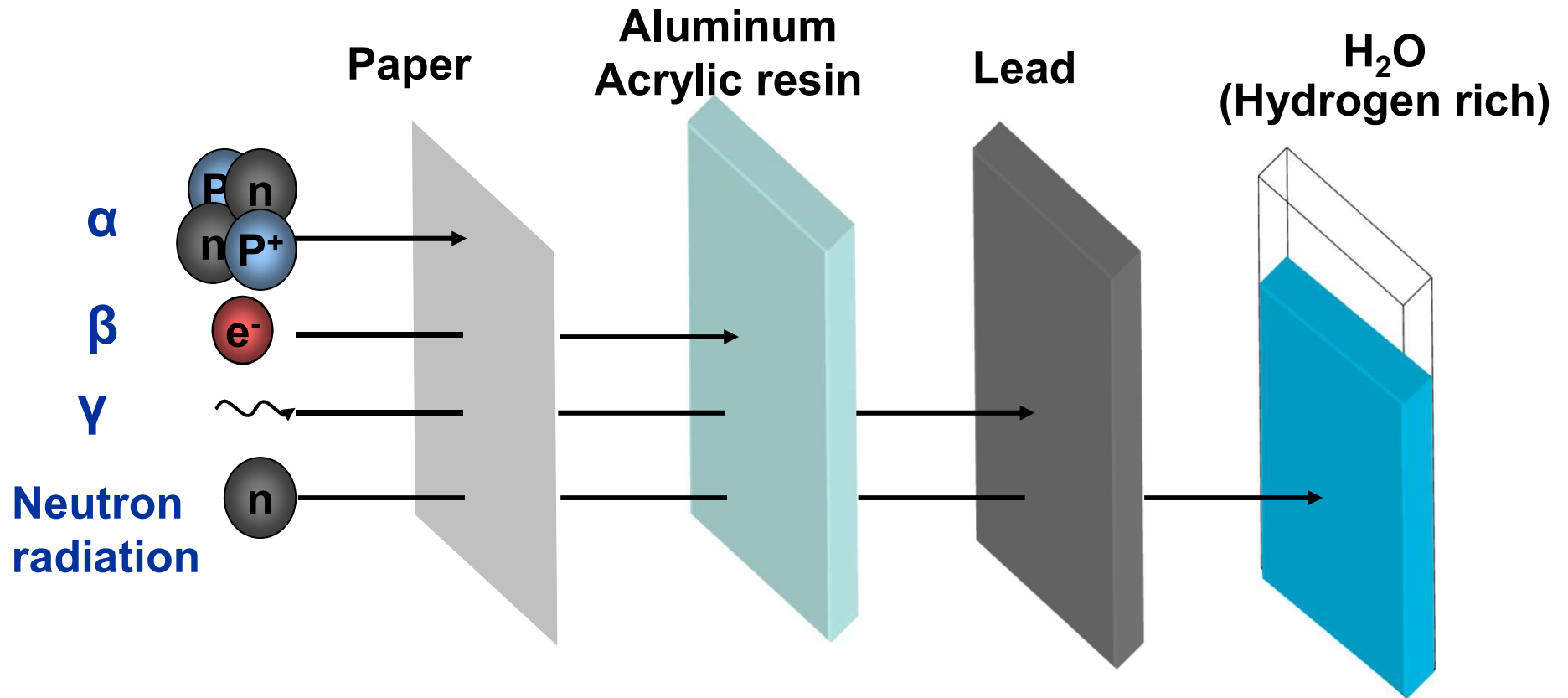
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Factors that relate to biological effects

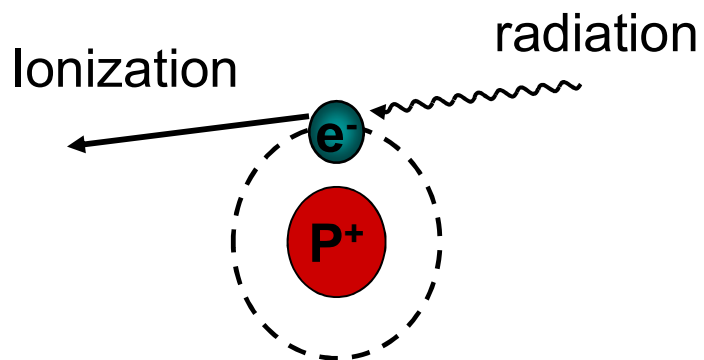
1. Penetrating ability

2. Linear Energy Transfer (LET)

1. Penetrating Ability of Radiations



2. Linear Energy Transfer (LET)

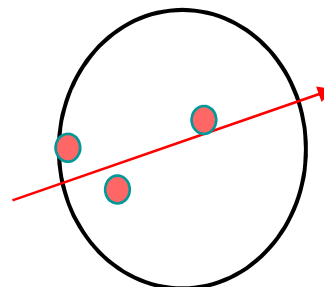


The energy transferred per given distance of track

||

**Linear Energy Transfer
(LET)**

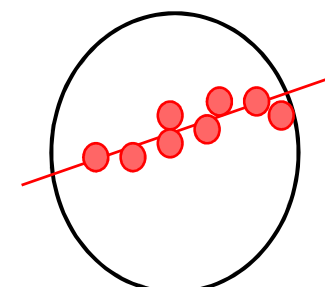
Low LET
radiations
(X, γ, β)



Sparsely ionizing

Less biological effect

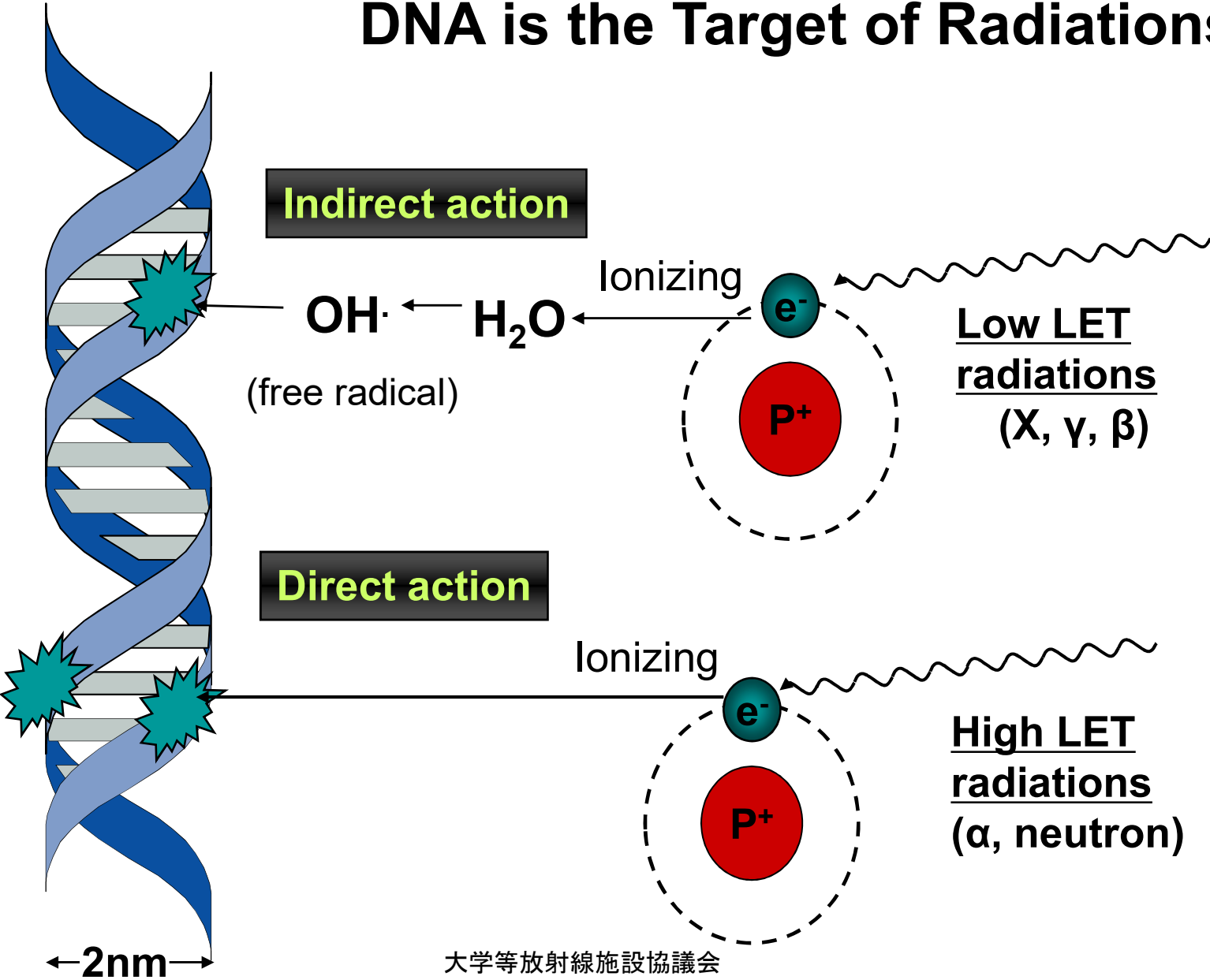
High LET
radiations
(α , neutron)



Densely ionizing

More biological effect

DNA is the Target of Radiations



Classification of Biological effects of Radiations on the Human Body

- **Acute Effects vs. Late Effects**
- **Deterministic Effects vs. Stochastic Effects**
- **Somatic Effects vs. Genetic Effects**

Classification of Biological effects of Radiation on the Human Body

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Acute Effects

Symptoms of acute effects and dose delivered
(Whole body, single exposure to gamma rays (or X-rays))

Dose (Gy)	Symptoms
0.25 or less	Almost no clinical symptoms
0.5	Temporary reduction of white blood cells (lymphocytes)
1	Nausea, vomiting, whole-body languor, substantial reduction of lymphocytes
1.5	Radiation sickness to 50%
1	Death to 5%
4	Death to 50% within 30 days
6	Death to 90% within 14 days
7	Death to 100%

Late Effects

Cataracts: clouding of the lens of the eye

- Latent period: several years to a few decades
- Do not occur below a single exposure dose of 2 Sv

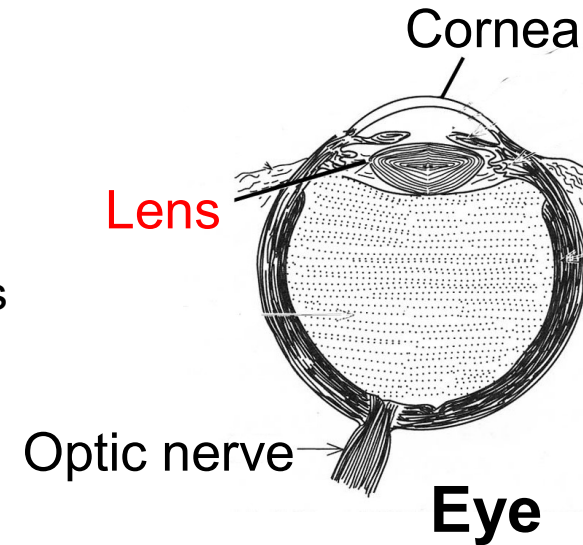
Cancers

- Latent period: several years to a few decades

Genetic effects

- Could be
- But not verified in human beings so far

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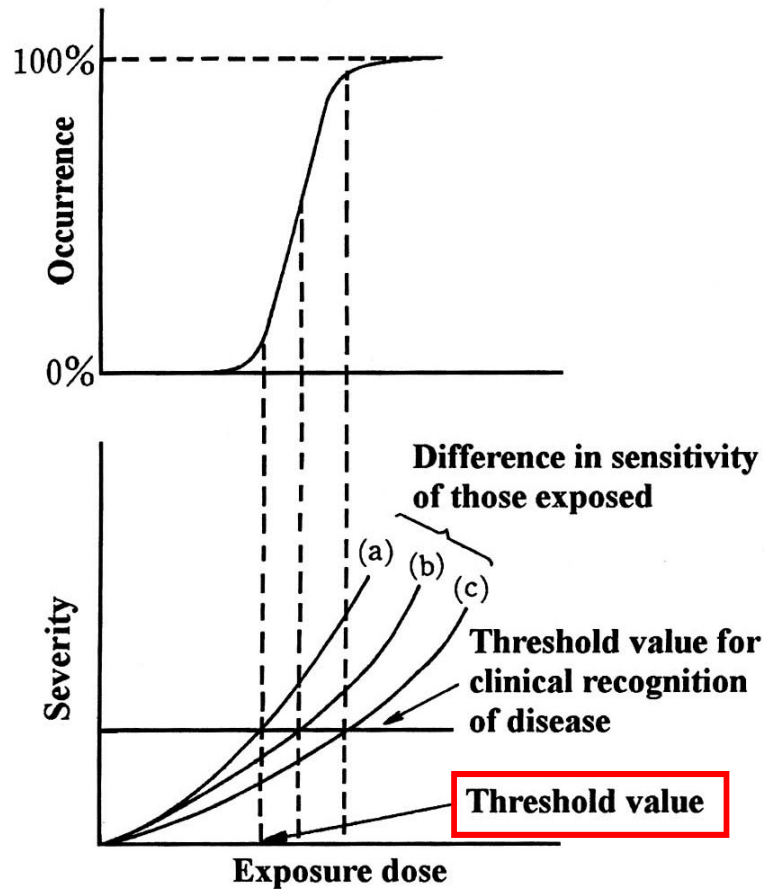


Use a appropriate shield in front of your eyes

Classification of Biological effects of Radiation on the Human Body

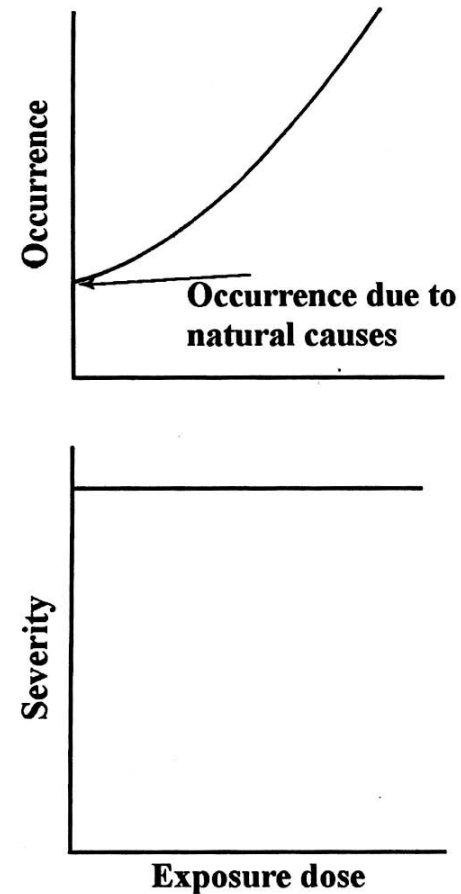
- Acute Effects vs. Late Effects
- **Deterministic Effects vs. Stochastic Effects**
- Somatic Effects vs. Genetic Effects

Deterministic Effects vs. Stochastic Effects



Deterministic Effects

- Acute effects
- Cataract



Stochastic Effects

- Cancer, leukemia
- Genetic effects

Deterministic effects

Projected threshold estimates of the acute absorbed dose for 1% morbidity after whole body gamma ray exposures

Effect	Organ/Tissue	Time to develop effect	Absorbed dose (Gy)
Temporary sterility	Testes	3-9 weeks	~ 0.1
Permanent sterility	Testes	3 weeks	~ 6
	Ovaries	< 1 week	~ 3
Depression of blood forming process	Bone marrow	3-7 days	~ 0.5
Skin reddening	Skin (large areas)	1-4 weeks	< 3-6
Skin burns	Skin (large areas)	2-3 weeks	5-10
Temporary hair loss	Skin	2-3 weeks	~ 4
Cataract (visual impairment)	Eye	Several years	~ 1.5

ICRP publication 103, pp168, Table A.3.4, 2007

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Deterministic effects

Projected threshold estimates of the acute absorbed dose for 1% mortality after whole body gamma ray exposures

Exposed population	Organ/Tissue	Time to develop effect	Absorbed dose (Gy)
Bone marrow syndrome			
without medical care	Bone marrow	30-60 days	~ 1
with good medical care	Bone marrow	30-60 days	2-3
Gastro-intestinal syndrome			
without medical care	Small intestine	6-9 days	~ 6
with good medical care	Small intestine	6-9 days	> 6
Pneumonitis	Lung	1-7 months	6

ICRP publication 103, pp168, Table A.3.4, 2007

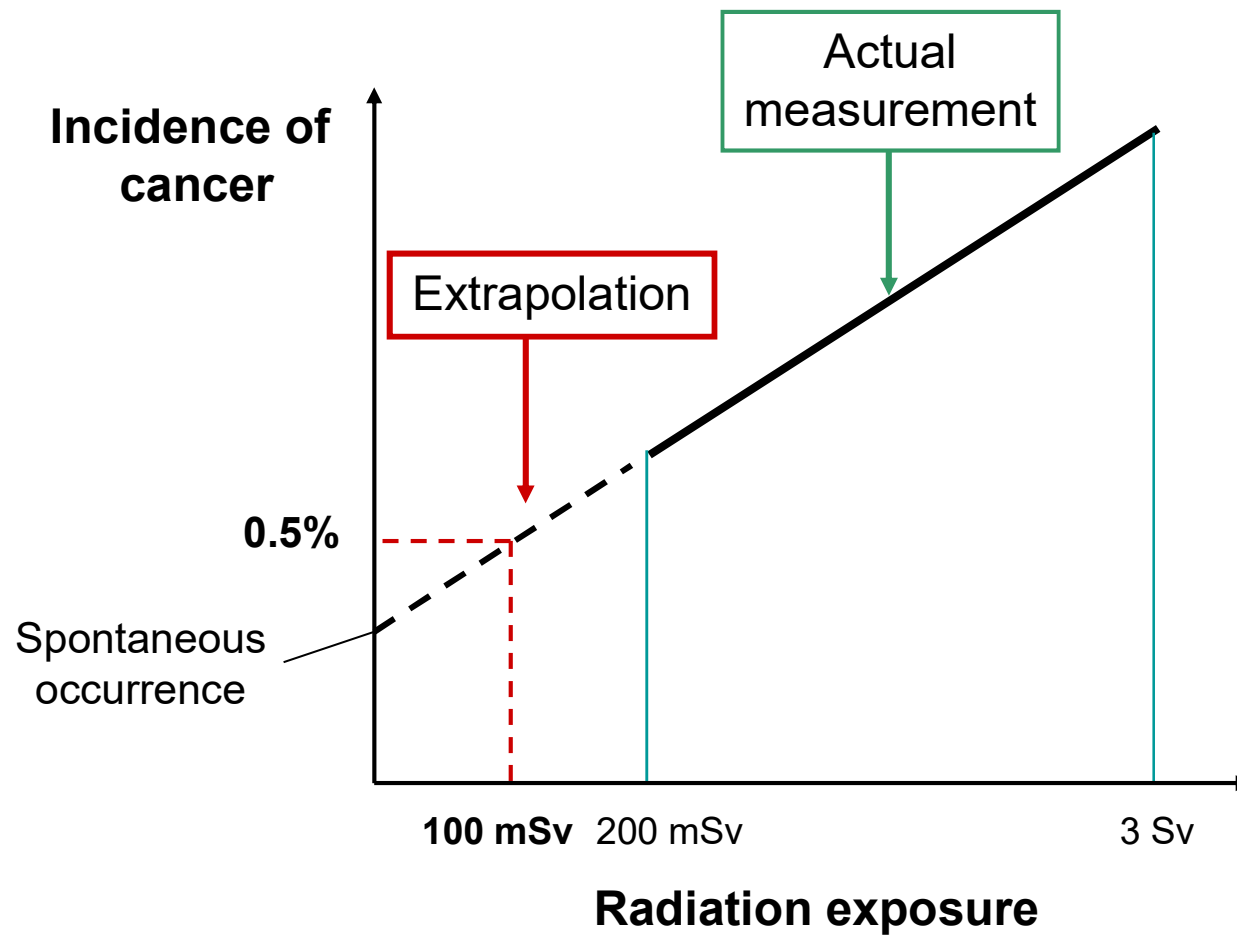
Stochastic effects

Detriment-adjusted nominal risk coefficients after exposure to radiation at low dose rate

Exposed population	Cancer	Heritable effects	Total
Whole population	$5.5 \times 10^{-2}/\text{Sv}$	$0.2 \times 10^{-2}/\text{Sv}$	$5.7 \times 10^{-2}/\text{Sv}$
Adult workers	$4.1 \times 10^{-2}/\text{Sv}$	$0.1 \times 10^{-2}/\text{Sv}$	$4.2 \times 10^{-2}/\text{Sv}$

ICRP publication 103, pp53, Table 1, 2007

Risk Estimate for Cancers (Stochastic Effect)



Classification of Biological effects of Radiation on the Human Body

- Acute Effects vs. Late Effects
- Deterministic Effects vs. Stochastic Effects
- Somatic Effects vs. Genetic Effects

Somatic Effects

Effects of radiation limited to the exposed individual, as distinguished from genetic effects, that may also affect subsequent unexposed generations.

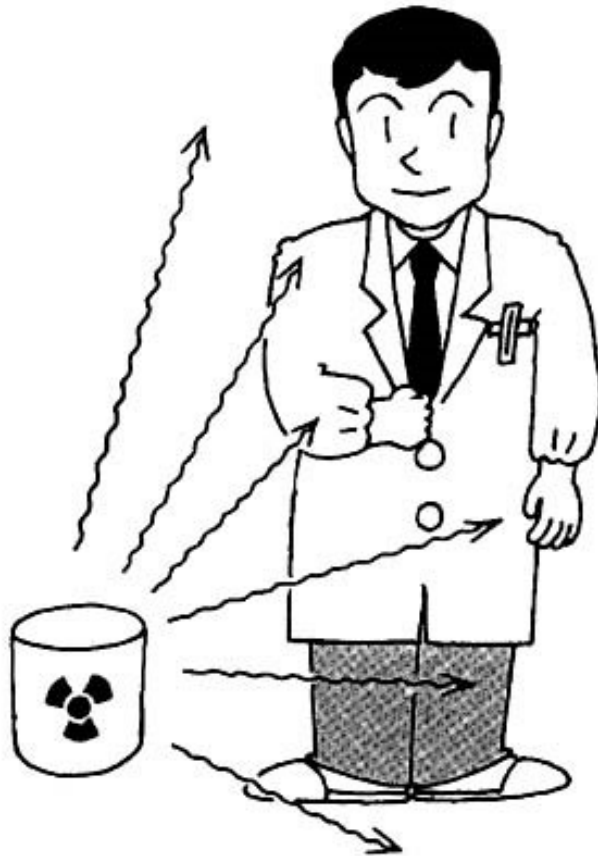
Genetic Effects

The radiation induced change in the DNA of germ cells resulting in the passing of the altered genetic information to future generations.

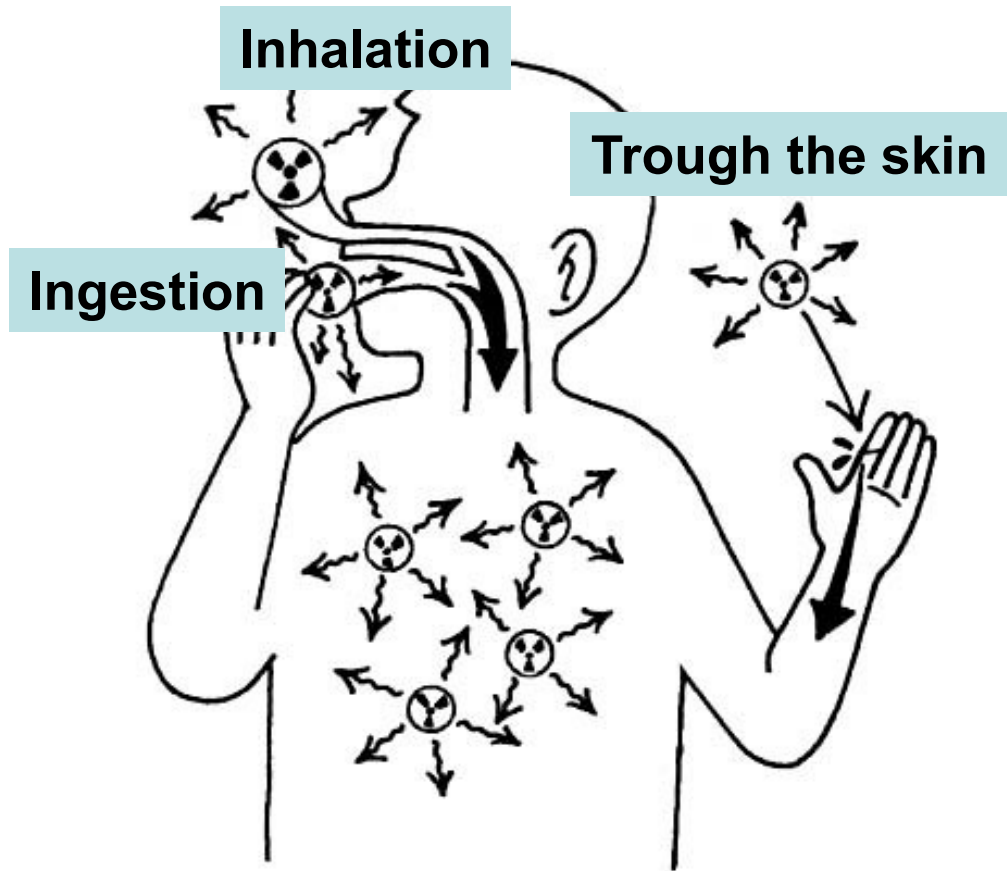
External Exposures

vs.

Internal Exposures



External exposure



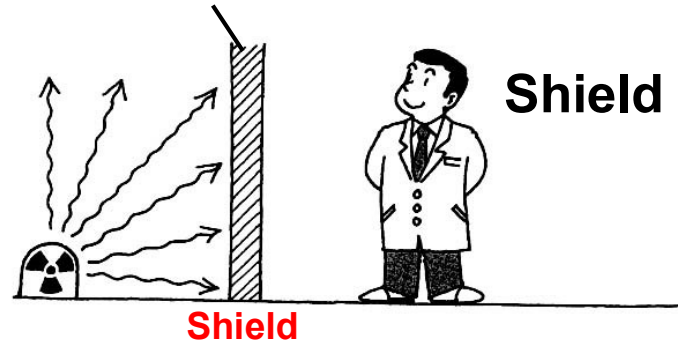
Internal exposure

Protecting Against External Exposure

3 principles

Shielding

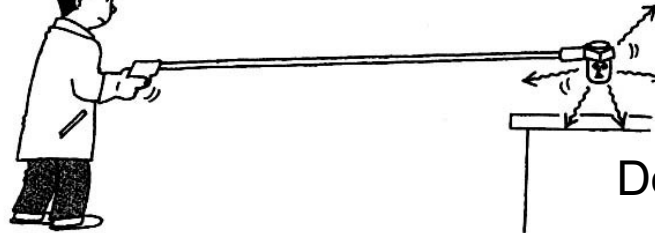
As near to the radiation source as possible



Shield radiation sources.

Distance

Stay as far away as possible.



Dose rate = K/R^2

K: constant

R: distance

Time



Keep exposure time short !

Protecting Against Internal Exposure

Intake routes of radioisotopes



(1)

Inhalation



(2)

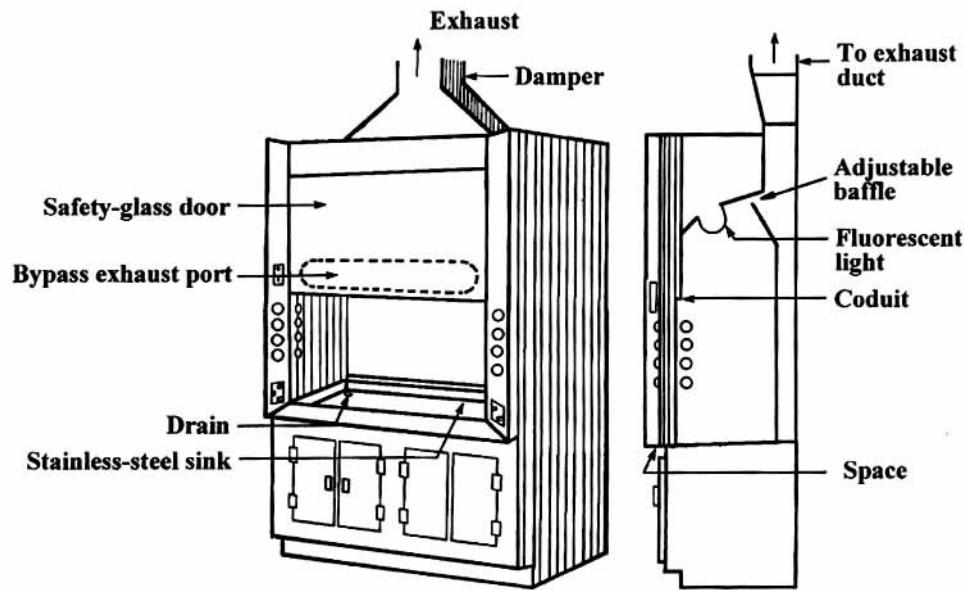
Ingestion



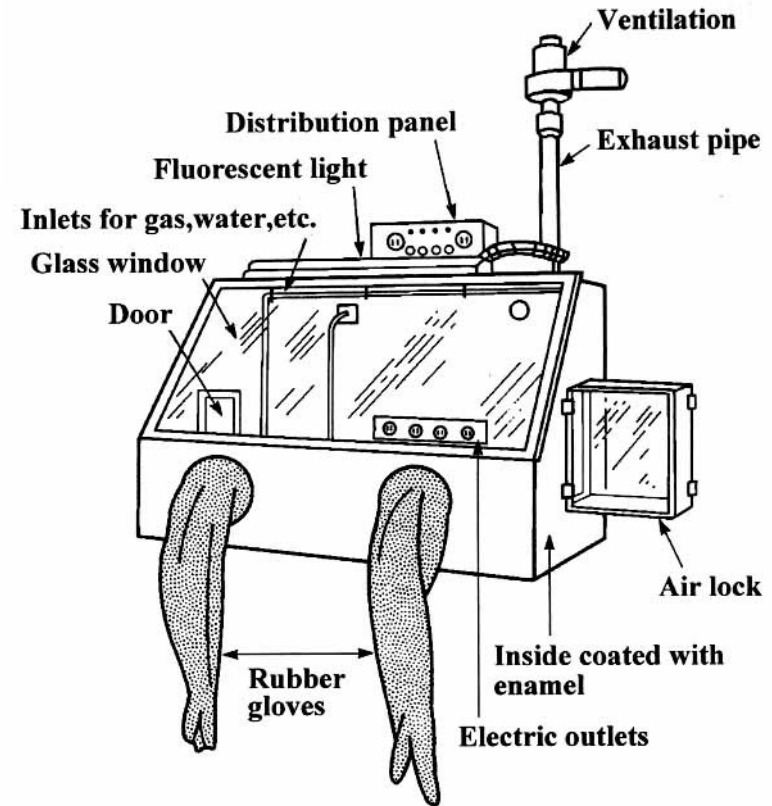
(3)

**Through the skin
(wound)**

To Prevent the inhalation of radioisotopes



Oak Ridge-type hood



Glove box

Prohibited Matters

Eating or drinking



Smoking



Wearing make-up

Radiation-Related Quantities and Units

Absorbed Dose : Gray (Gy)

- The energy absorbed per unit mass of the material
- A fundamental dosimetric quantity (physical unit)
- Regardless of the kind of radiation
- $1 \text{ Gy} = 1 \text{ J/ kg}$
- Dose not reflect the degree of biological effects

To calculate the risk of irradiation to the human body

Equivalent Dose : Sievert (Sv)

Effective Dose : Sievert (Sv)

Equivalent Dose & Effective Dose

Equivalent Dose (H_T) : Sievert (Sv)

- a measure of biological effects on **a particular tissues or organs**

- $H_T = \sum_R w_R \cdot D_{T,R}$

w_R : Radiation weighting factor

$D_{T,R}$: Mean absorbed dose for a tissue or organ (Gy)

Radiation weighting factor (w_R)

Radiation	Weighting Factor
γ rays & X rays	1
Beta rays	1
Proton	2
α rays, fission fragments, heavy ion	20
Neutrons	Continuous function of the energy

(ICRP 2007)

Equivalent Dose & Effective Dose

Effective Dose (E) : Sievert (Sv)

Stochastic effects

- a measure of biological effects **throughout the body** (cancers or genetic effects)

$$E = \sum_T w_T \cdot H_T = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

H_T : Equivalent dose for tissues and organs

w_T : Weighting factor for organs or tissues

Tissue weighting factors

Tissue/Organ	Weighting factor
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Breast	0.12
Gonads	0.08
Bladder	0.04
Esophagus	0.04
Liver	0.04
Thyroid	0.04
Bone	0.01
Brain	0.01
Salivary gland	0.01
Skin	0.01
Others	0.12

Annual average dose per person

Doctors	0.24 mSv
Nurse	0.12 mSv
Radiotherapy technicians	0.68 mSv
Those engaged in research	0.01 mSv
Nuclear power plant worker	1.3 mSv

Effective Dose Limits and Tissue Equivalent Dose Limits for Radiation Workers (including Researchers)

Effective dose limit	50 mSv/year; 100 mSv/5years
Women	5 mSv/3 months
Pregnant women *	1 mSv as internal exposure
Tissue equivalent dose limit	
1) Lens of the eye	150 mSv/year
2) Skin	500 mSv/year
3) Abdomen of pregnant women *	2 mSv

*From the confirmation of pregnancy to delivery

Personal Radiation Monitoring

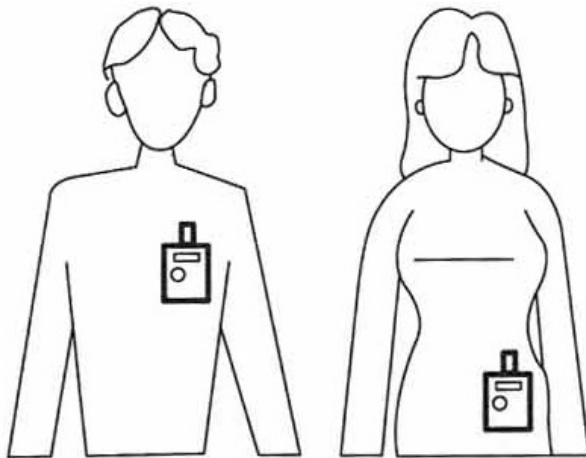
Personal monitoring instrument



Effective dose (実効線量)

Equivalent dose (等価線量)
for the lens, skin and abdomen

Where should a monitoring instrument be worn on?



Men

Women 大学等放射線施設協議会

Radiation exposure report

個人用報告書 個人用報告書 個人用報告書									
ご使用者名									
京大 太郎 殿			京大 太郎 殿			京大 太郎 殿			
個人コード									
30279640			30279640			30279640			
集計開始年月日									
07年03月01日			07年01月01日			06年04月01日			
集計終了年月日									
07年03月31日			07年03月31日			07年03月31日			
算定日									
07年04月13日			07年04月13日			07年04月13日			
測定方法									
放射線測定器使用			放射線測定器使用			放射線測定器使用			
胸									
モニタ名	ガラスバッジ	F S型	ガラスバッジ	F S型	ガラスバッジ	F S型	ガラスバッジ	F S型	
H1cm	0.1		0.2		0.1	0.2	0.1	0.2	05
H70um	0.1		0.2		0.1	0.2	0.1	0.2	10
モニタ名									
H1cm									
H70um									
モニタ名									
H1cm									
H70um									
モニタ名									
H1cm									
H70um									
測定結果									
2006年	0.20	10 ^x	0.20	10 ^x	0.20	10 ^x			
2007年		x		x		x			
2008年		x		x		x			
2009年		x		x		x			
2010年		x		x		x			
累積値	100	0.20 10 ^x	100	0.20 10 ^x	100	0.20 10 ^x			
調整・備考									
確認印									
測定機関名									
株式会社 千代田テクノル			株式会社 千代田テクノル			株式会社 千代田テクノル			
職員コード									
26-0515			7806			7806			7806
処理日									
070414			070414			070414			
B 01409									

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