

# Effects of Radiation on Human Health

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# 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**

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# Acute Effects

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

Dose (mSv)	Symptoms
250 or less	Almost no clinical symptoms
500	Temporary reduction of white blood cells (lymphocytes)
1,000	Nausea, vomiting, whole-body languor, substantial reduction of lymphocytes
1,500	Radiation sickness to 50%
1,000	Death to 5%
4,000	Death to 50% within 30 days
6,000	Death to 90% within 14 days
7,000	Death to 100%

# Late Effects

**Cataracts**: clouding of the lens of the eye

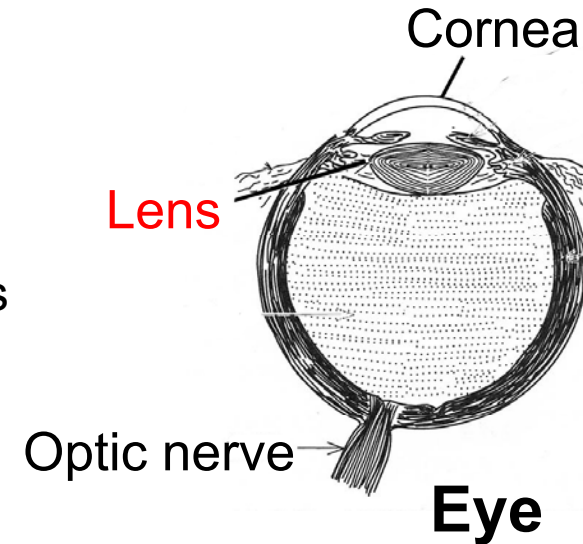
- Latent period: several years to a few decades
- Do not occur below a single exposure dose of 2,000 mSv

**Cancers**

- Latent period: several years to a few decades

**Genetic effects**

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

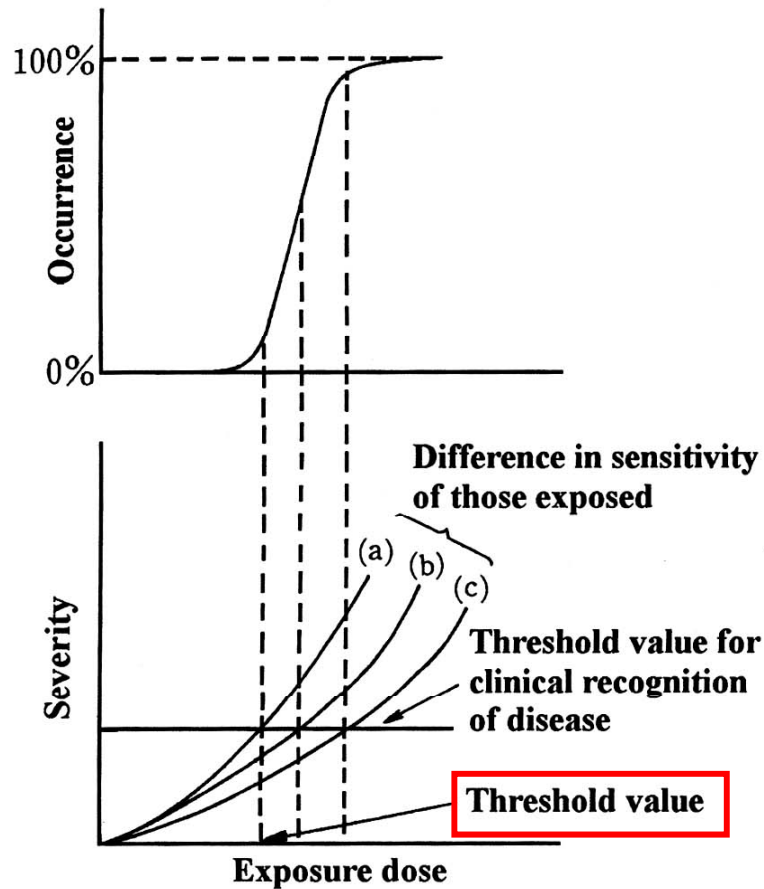


Use a appropriate shield  
in front of your eyes

# Classification of Biological effects of Radiation on the Human Body

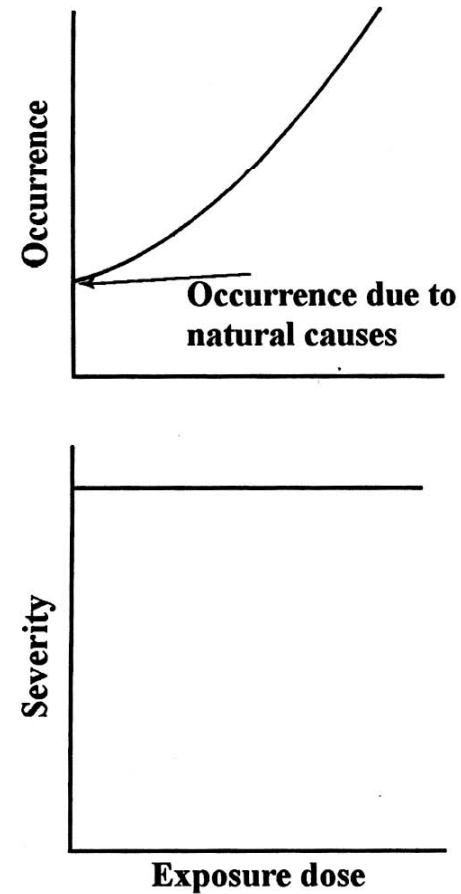
- Acute Effects vs. Late Effects
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# Deterministic Effects vs. Stochastic Effects



## Deterministic Effects

- Acute effects
- Cataract



## Stochastic Effects

- Cancer, leukemia
- Genetic effects

# Deterministic effects

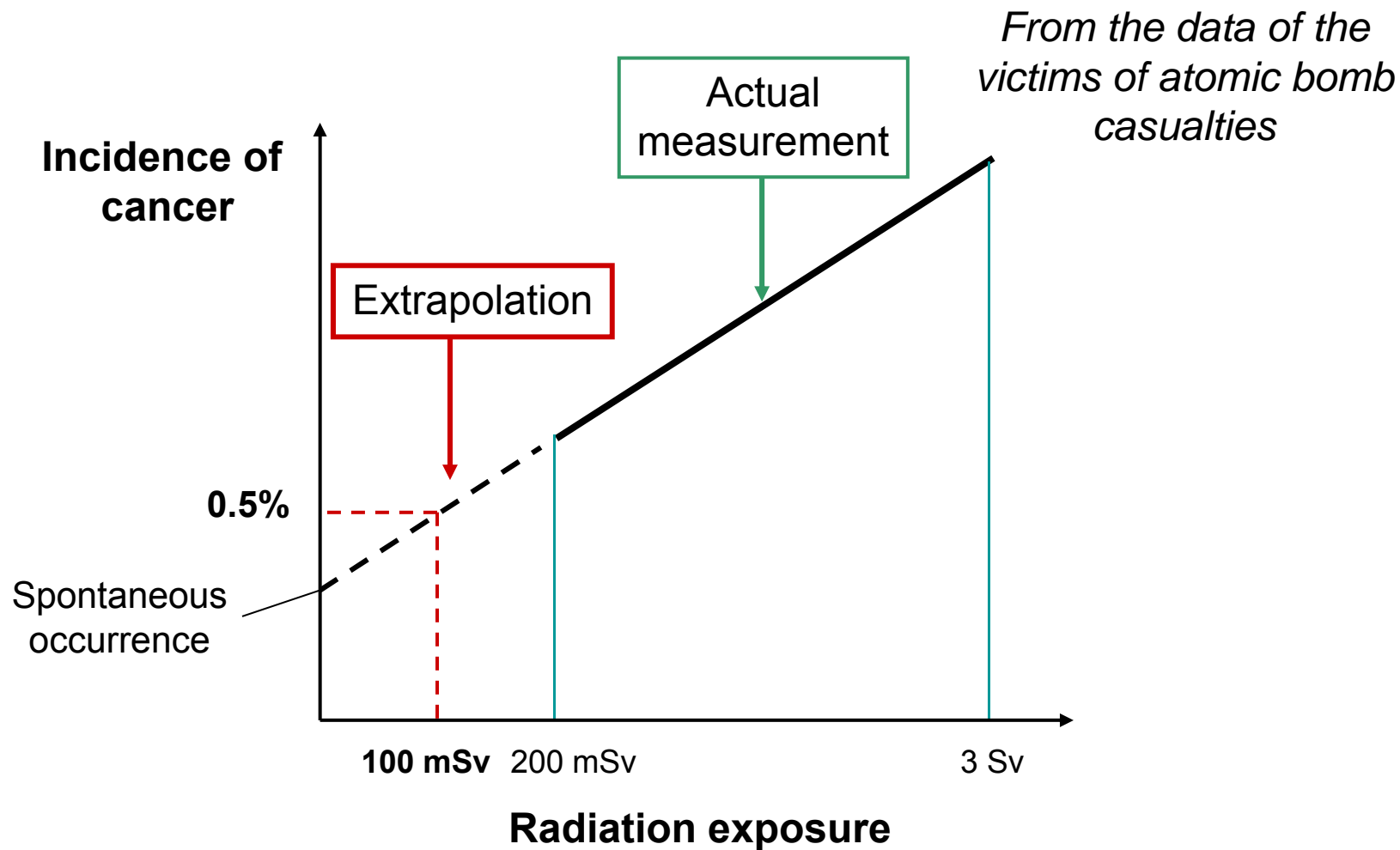
Projected threshold estimates of the acute absorbed dose for 1% morbidity after whole body gamma ray exposures

Effect	Organ/Tissue	Time to develop effect	Absorbed dose (mSv)
Temporary sterility	Testes	3-9 weeks	~ 100
Permanent sterility	Testes	3 weeks	~ 6,000
	Ovaries	< 1 week	~ 3,000
Depression of blood forming process	Bone marrow	3-7 days	~ 500
Skin reddening	Skin (large areas)	1-4 weeks	< 3,000-6,000
Skin burns	Skin (large areas)	2-3 weeks	5,000-10,000
Temporary hair loss	Skin	2-3 weeks	~ 4,000
Cataract (visual impairment)	Eye	Several years	~ 1,500

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



# Risk Estimate for Cancers (Stochastic Effect)



# Classification of Biological effects of Radiation on the Human Body

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## **Somatic Effects**

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

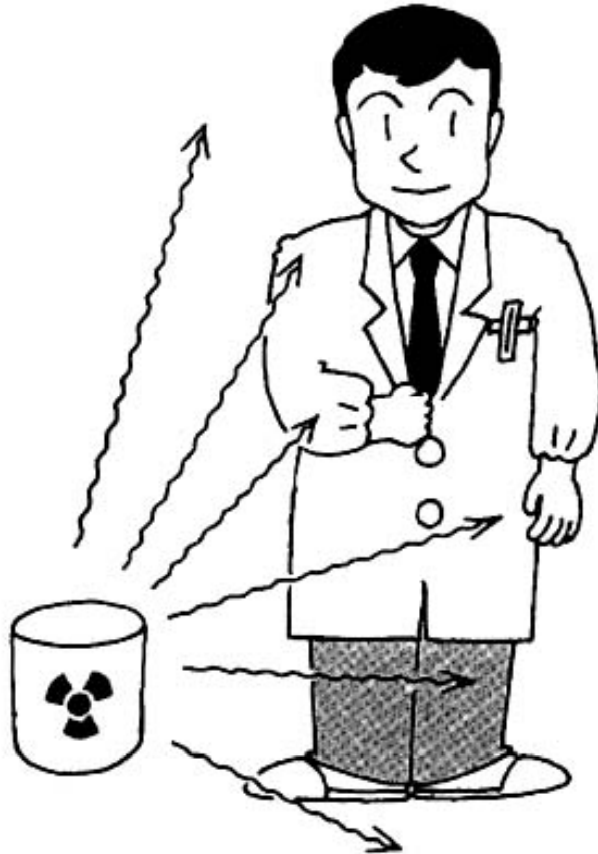
## **Genetic Effects**

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

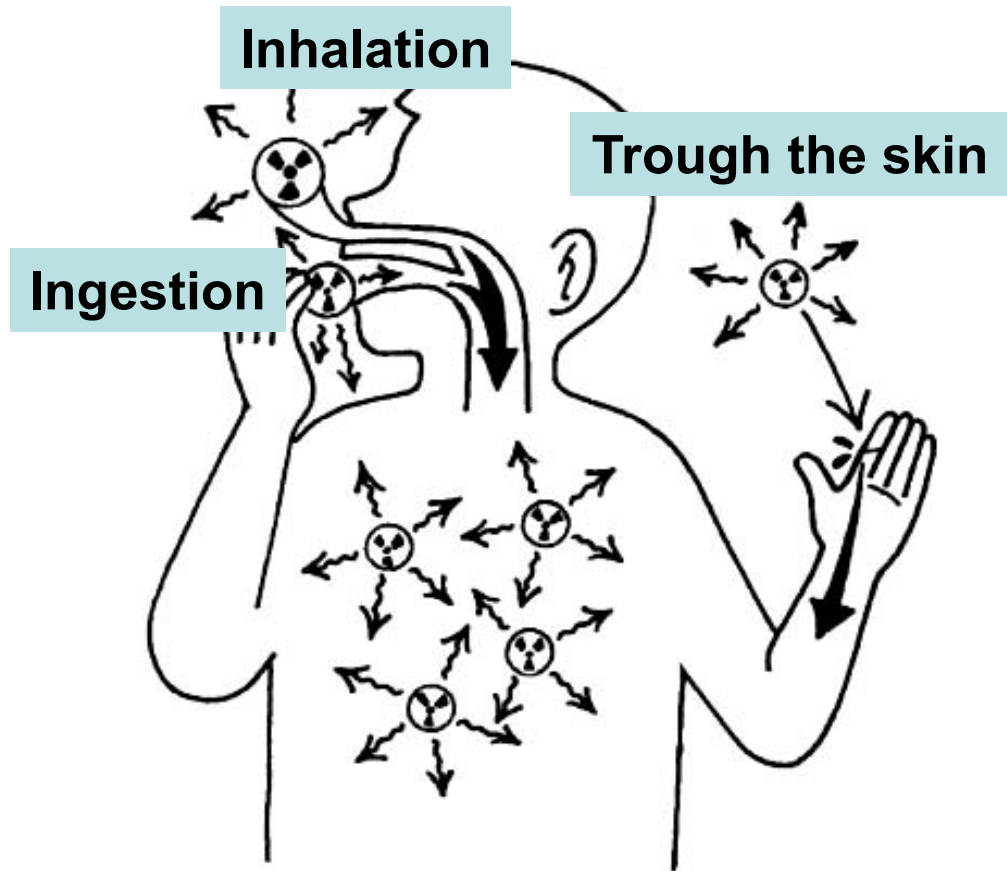
**External Exposures**

vs.

**Internal Exposures**



**External exposure**



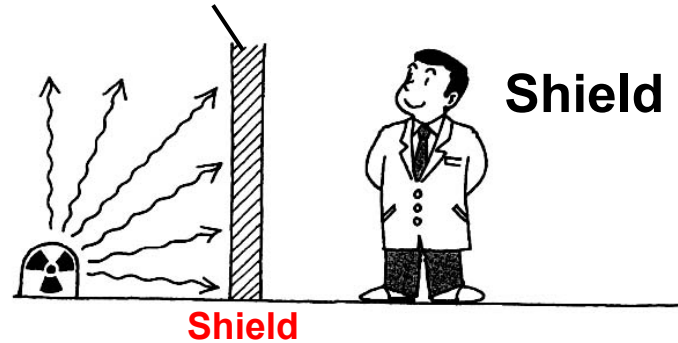
**Internal exposure**

# Protecting Against External Exposure

## 3 principles

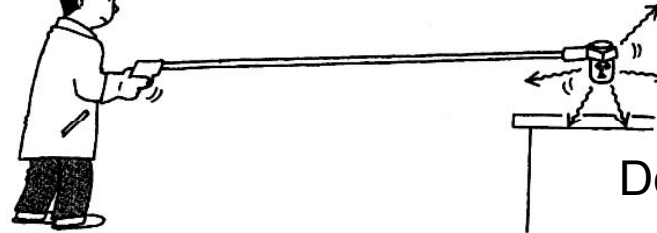
### Shielding

As near to the radiation source as possible



### Distance

Stay as far away as possible.



$$\text{Dose rate} = K / R^2$$

K: constant

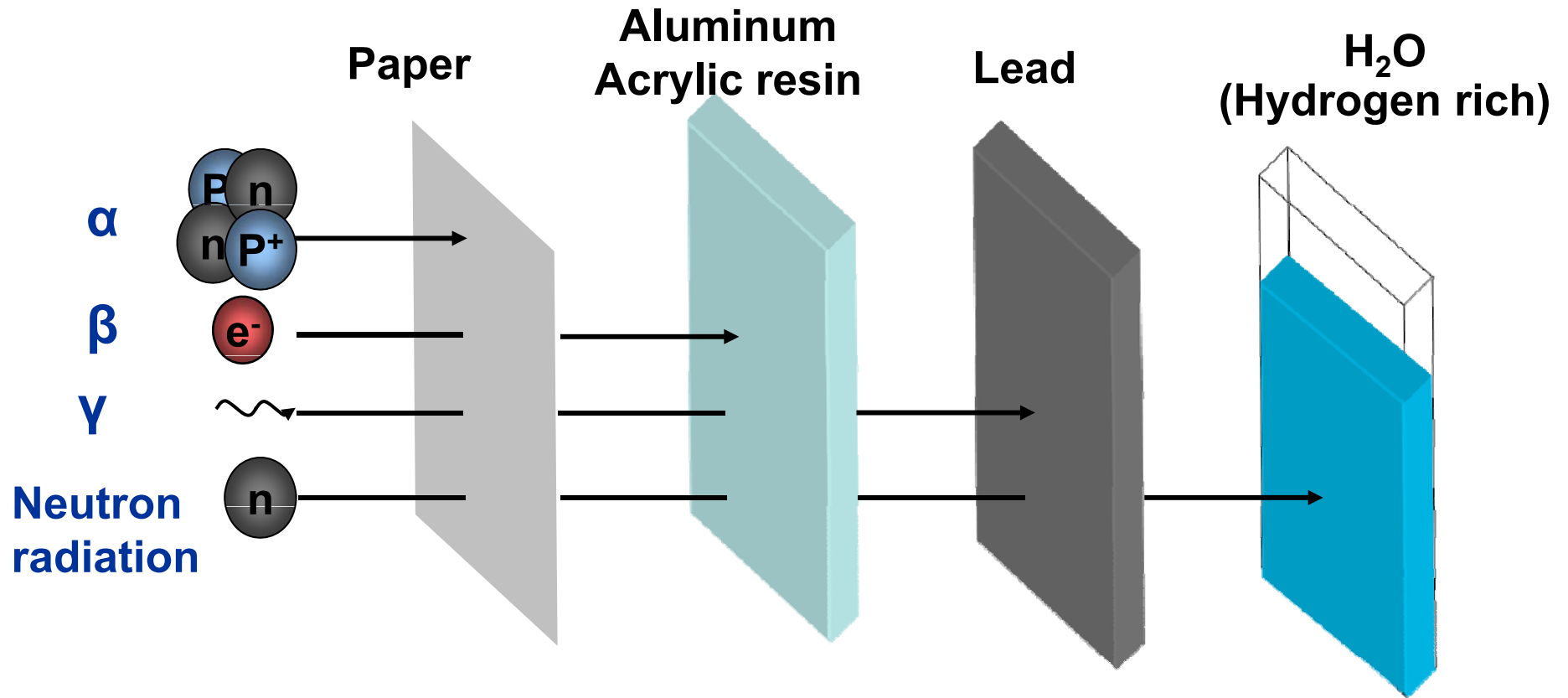
R: distance

### Time



Keep exposure time short !

# 1. Penetrating Ability of Radiations



# Protecting Against Internal Exposure

## Intake routes of radioisotopes



(1)

**Inhalation**



(2)

**Ingestion**



(3)

**Through the skin  
(wound)**

# 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
$\gamma$ rays & X rays	1
Beta rays	1
Proton	2
$\alpha$ 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

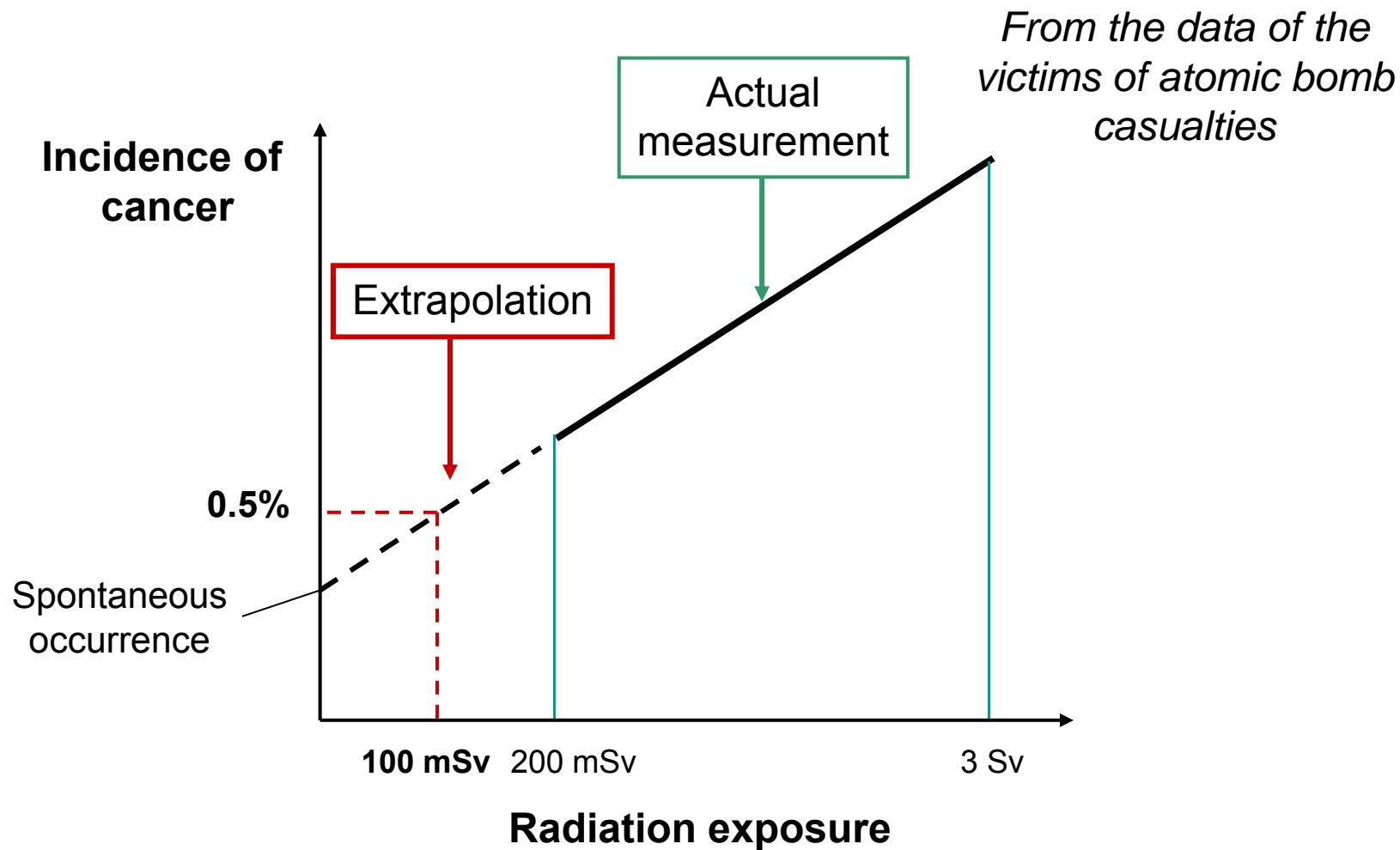
Tissue/Organ	Weighting factor
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Breast	0.12
Gonads	0.08
Bladder	0.04
Esophagus	0.04
Liver	0.04
Thyroid	0.04
Bone	0.01
Brain	0.01
Salivary gland	0.01
Skin	0.01
Others	0.12

## 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

(ICRP 2007)

# Risk Estimate for Cancers (Stochastic Effect)



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

<b>Effective dose limit</b>	50 mSv/year; 100 mSv/5years
Women	5 mSv/3 months
Pregnant women*	1 mSv as internal exposure
<b>Tissue equivalent dose limit</b>	
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

# Radiation burden in our life

- Natural radiation 3 mSv/year (average)  
(cosmic ray, earth, air, and food, etc)
- Medical diagnostic use 3 mSv/year (average)
  - chest X-ray 0.06~0.3 mSv
  - X-ray CT 10~50 mSv
  - Nuclear scan 2~15 mSv  
(I-131 thyroid scan 13 mSv)
- Cancer treatment
  - I-131 thyroid cancer treatment 2,000~4,000 mSv
  - Local radiation 40,000~60,000 mSv

**Benefit > Risk**

# Possible Biological Effect after Disaster of Fukushima Nuclear Power Plants

## Interim regulation

- Water and Milk: 300Bq/kg
- Vegetables (Spinach etc): 2,000Bq/kg

## Supporting data

- Water and Milk: 1L intake for a year = Absorbed dose 20.2mGy (20mSv): <<cancer risk
- Vegetables: Occasional intake  
Surface radiation may be minimized by washing

**These regulation has wide range of safety**  
(much less than the lower limits of possible harmful dose)

**The radiation is gradually decreasing**  
(half life of I-131: 8 days)

# Summary

- **The biological effects from this accident are very small for most of us, except those working in restricted areas (Fukushima power plants) at present.**
- **People in Hokkaido are quite safe with no radiation effect.**
- **Those escaped from the restricted areas around Fukushima nuclear power plants are also safe based on the results of radiation monitoring over 50,000 people.**
- **The water, milk, and, food (vegetables and fishes) are also safe under the government control. (The safely range is much less than the lower limits of possible harmful dose)**



Asahi Shinbun (Newspaper) Apr 12, 2011