LOW DOSE RADIATION IN RADIOLOGY:

Consultancy Meeting on Science and Technology and Society Perspectives on Nuclear Science, Radiation and Human Health: The International Perspective
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RADIATION EFFECTS

Measurements in millisieverts (mSv). Exposure is cumulative.

HIGH RISK

Potentially fatal radiation sickness. Much higher risk of cancer later in life.

10,000 mSv: Fatal within days.

5,000 mSv: Would kill half of those exposed within one month.

2,000 mSv: Acute radiation sickness.

MODERATE RISK

No immediate symptoms. Increased risk of serious illness later in life.

1,000 mSv: 5% higher chance of cancer.

400 mSv: Highest hourly radiation recorded at Fukushima. Four hour exposure would cause radiation sickness.

100 mSv: Level at which higher risk of cancer is first noticeable

TOLERABLE LEVELS

No symptoms. No detectable increased risk of cancer.

20 mSv: Yearly limit for nuclear workers.

10 mSv: Average dose from a full body CT scan

9 mSv: Yearly dose for airline crews.

3 mSv: Single mammogram

2 mSv: Average yearly background radiation dose in UK

0.1 mSv: Single chest x-ray

How is Radiation Delivered?

EYES High doses can trigger cataracts months later.

THYROID Hormone glands vulnerable to cancer. Radioactive iodine builds up in thyroid. Children most at risk.

LUNGS Vulnerable to DNA damage when radioactive material is breathed in.

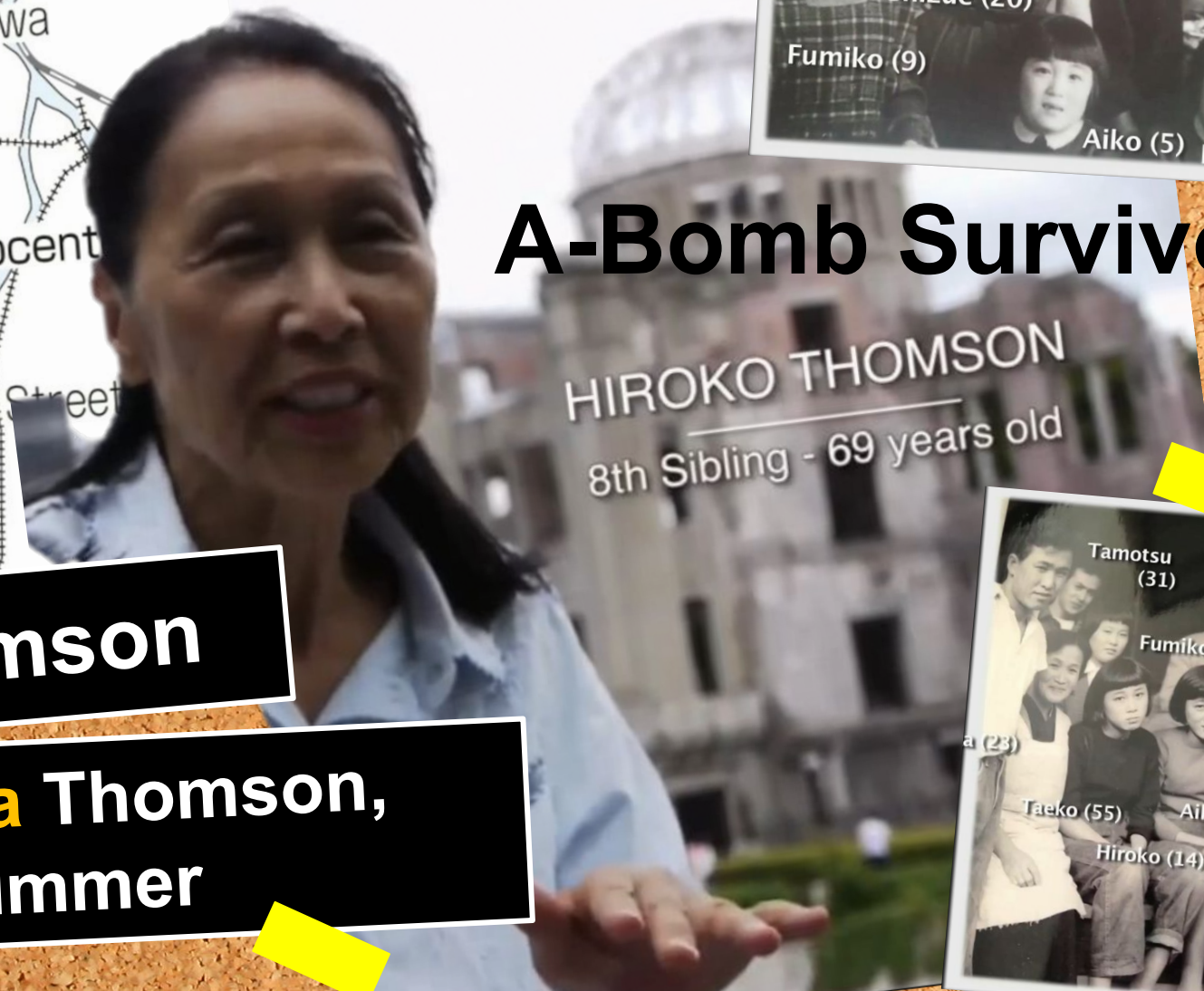
STOMACH Vulnerable if radioactive material is swallowed.

REPRODUCTIVE ORGANS High doses can cause sterility.

SKIN High doses cause redness and burning.

BONE MARROW Produces red and white blood cells. Radiation can lead to leukaemia and other immune system diseases.

NAKAMURA Family Story

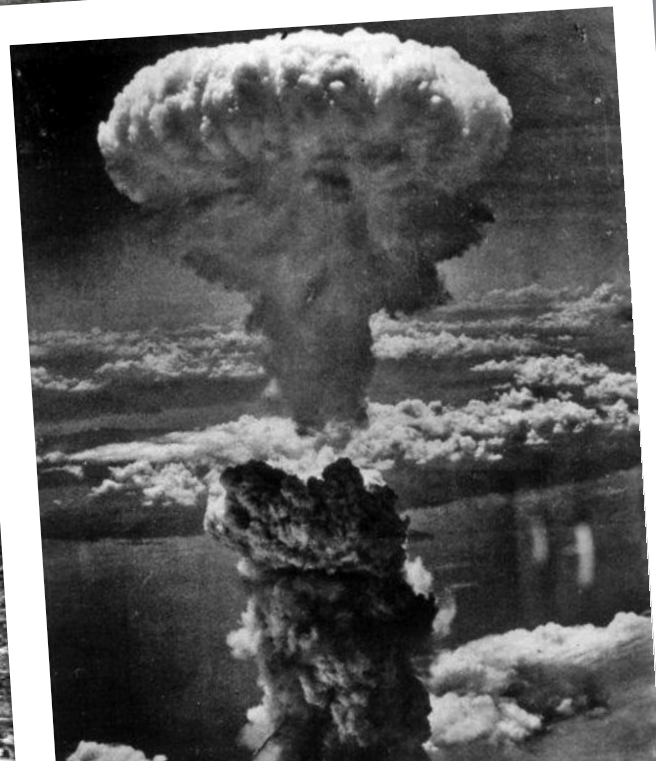


A-Bomb Survivors

Hiroko Nakamura Thomson

Mother of Akiko Nakamura Thomson, Filipino Olympic Swimmer

A-Bomb Survivor



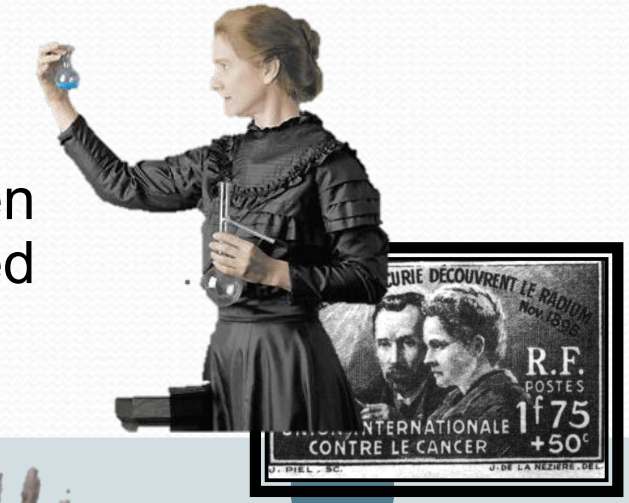
LECTURE OUTLINE

- Definition of Radiation
- Low Dose Radiation
- Natural and Background Exposure
- Low Dose Radiation in Medicine
- Radiation Protection

Definition of Radiation

HISTORICAL PERSPECTIVE:

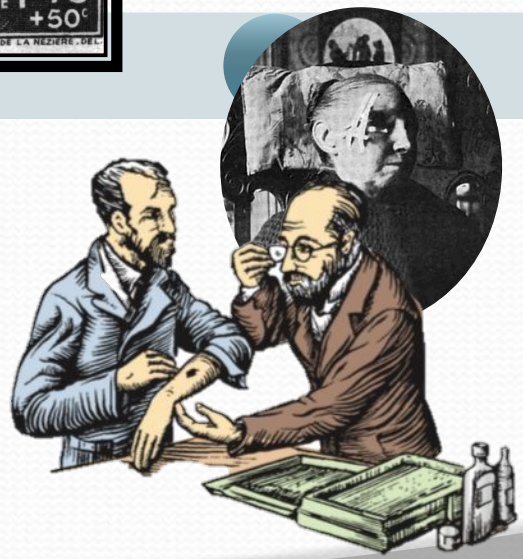
1895: Roentgen described X-rays



1899: 1st patient CURED with radiotherapy (RT)

Innovations in Technologies in the use of radiation

1898: the Curies discovered radium

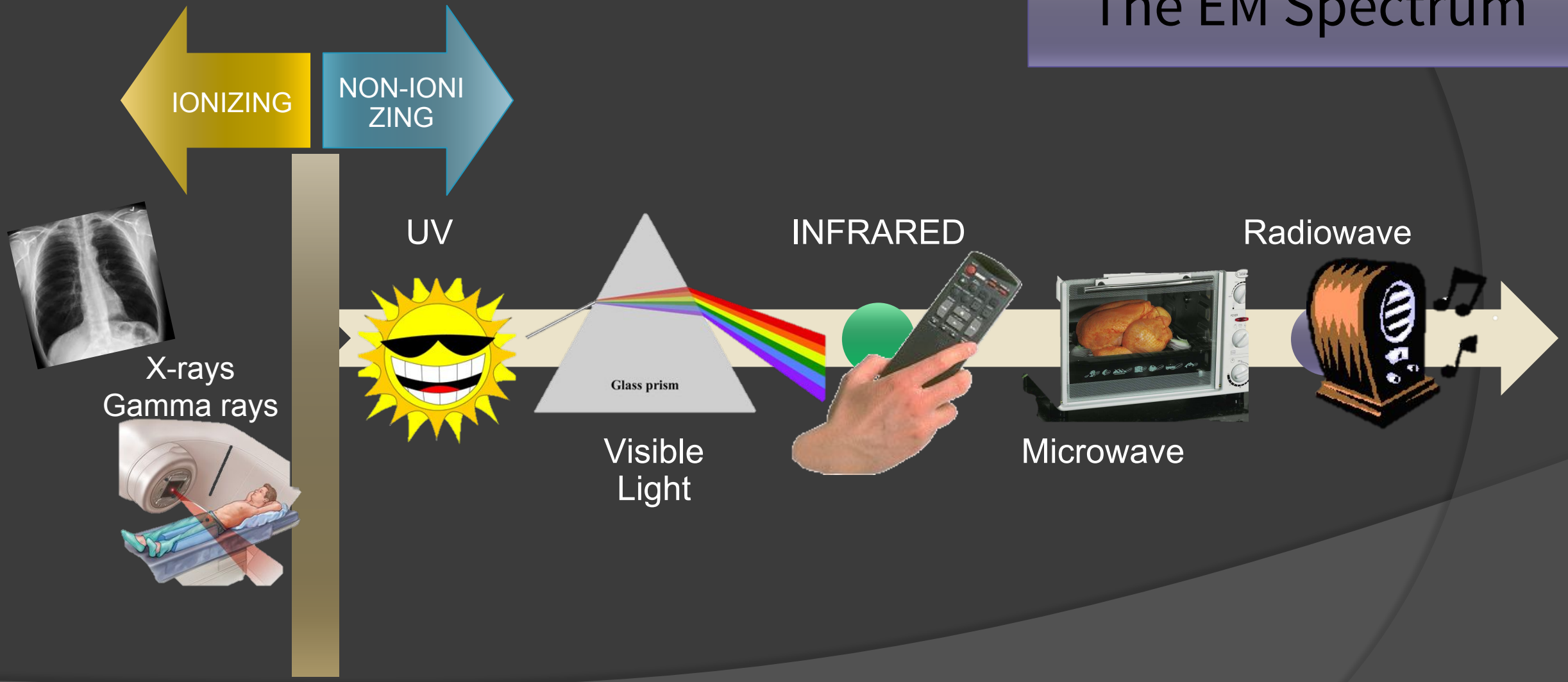


up to 1920's, GROWTH period of clinical radiology

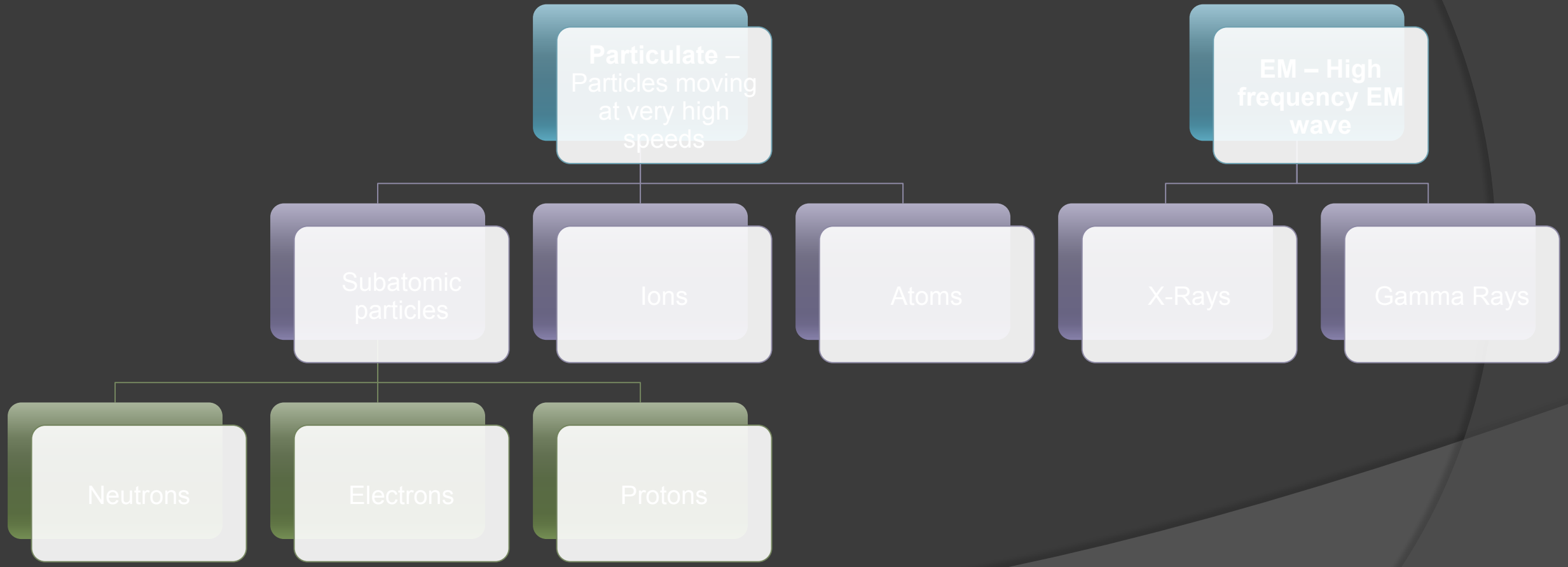
Definition of Radiation

- “Radiation is an energy in the form of
  - Electro-magnetic waves or particulate matter
  - Traveling in the air

The EM Spectrum



Ionizing Radiation: Particulate VS E.M.

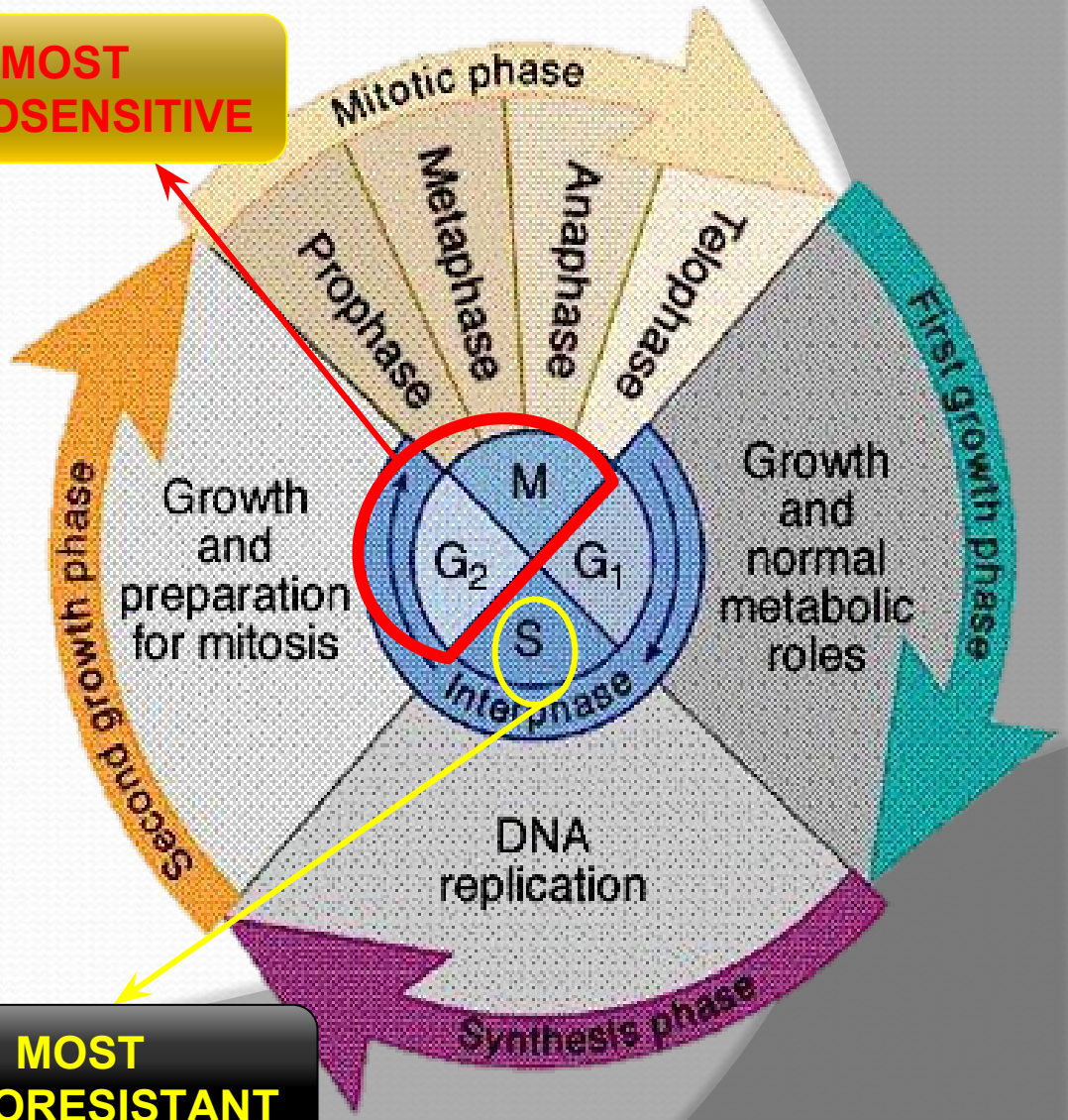


RADIOBIOLOGY

RADIATION

- USE of high-energy x-rays
  - To KILL cancer cells
- DESTROY their ability to
  - Grow
  - Multiply
  - Spread
- Affect ALL cells
  - Normal cells: Better RECOVERY
  - Cancer cells: More sensitive to DAMAGE

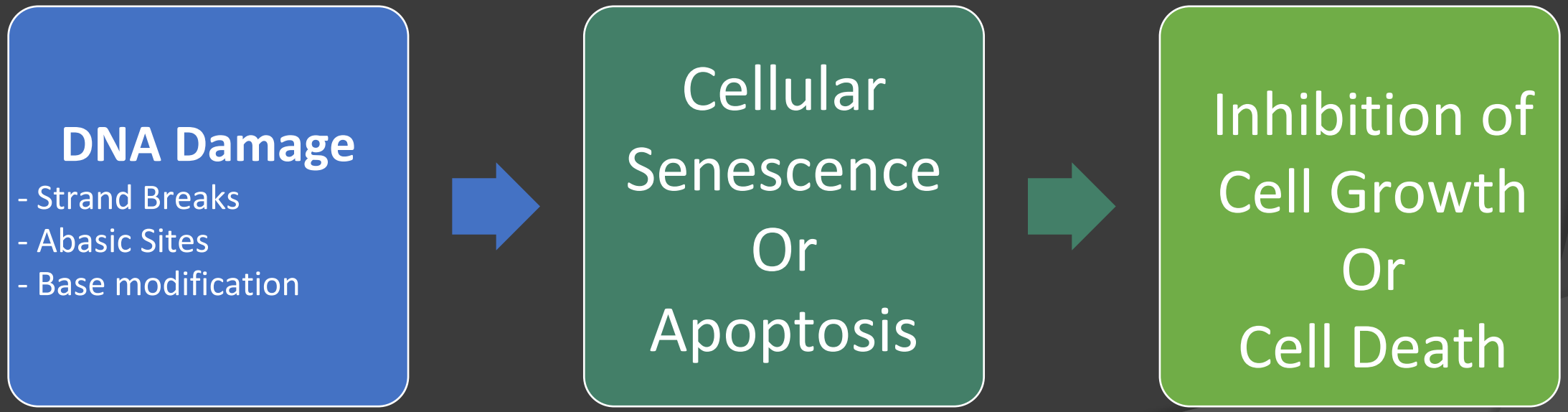
MOST RADIOSENSITIVE



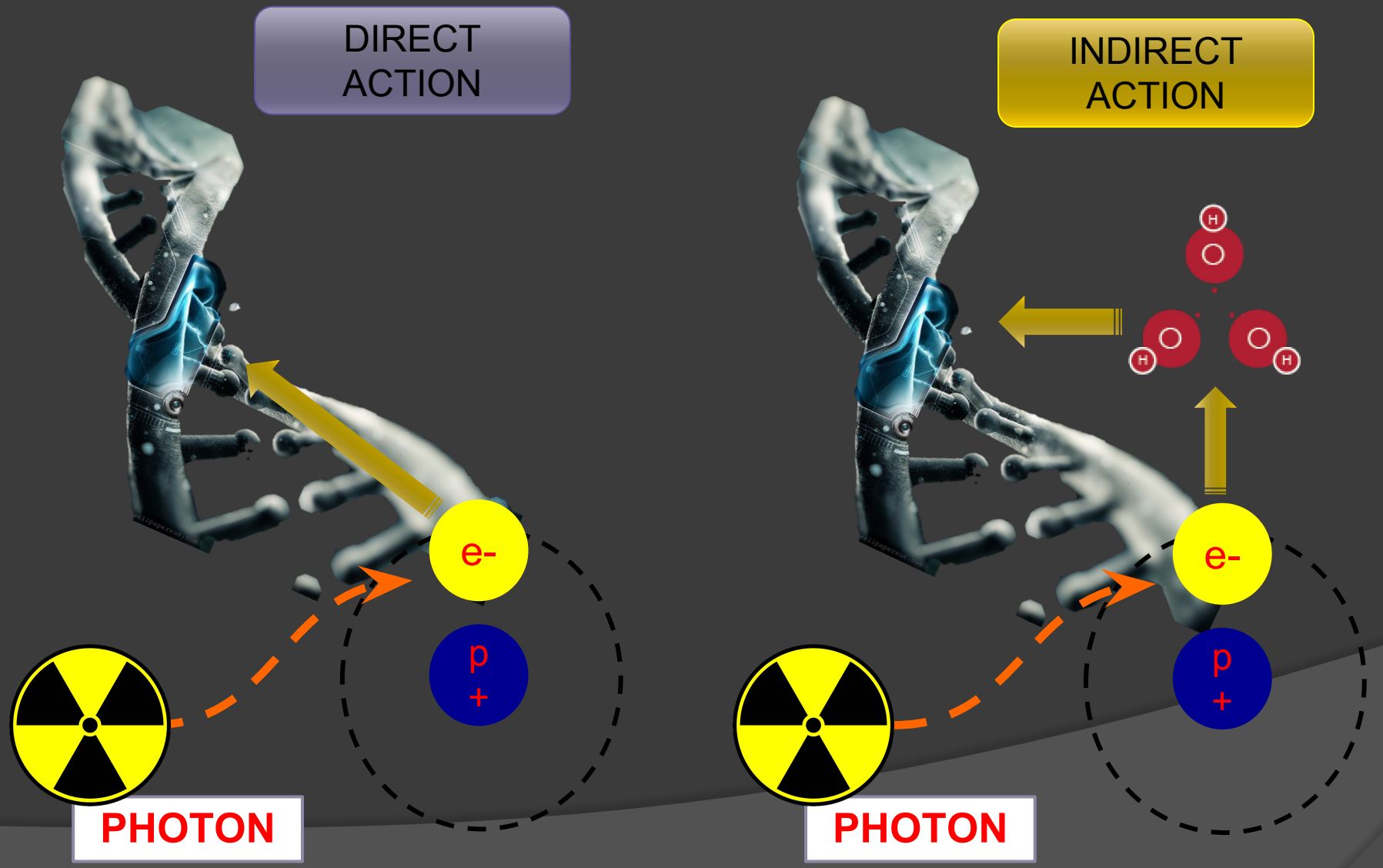
MOST RADIORESISTANT

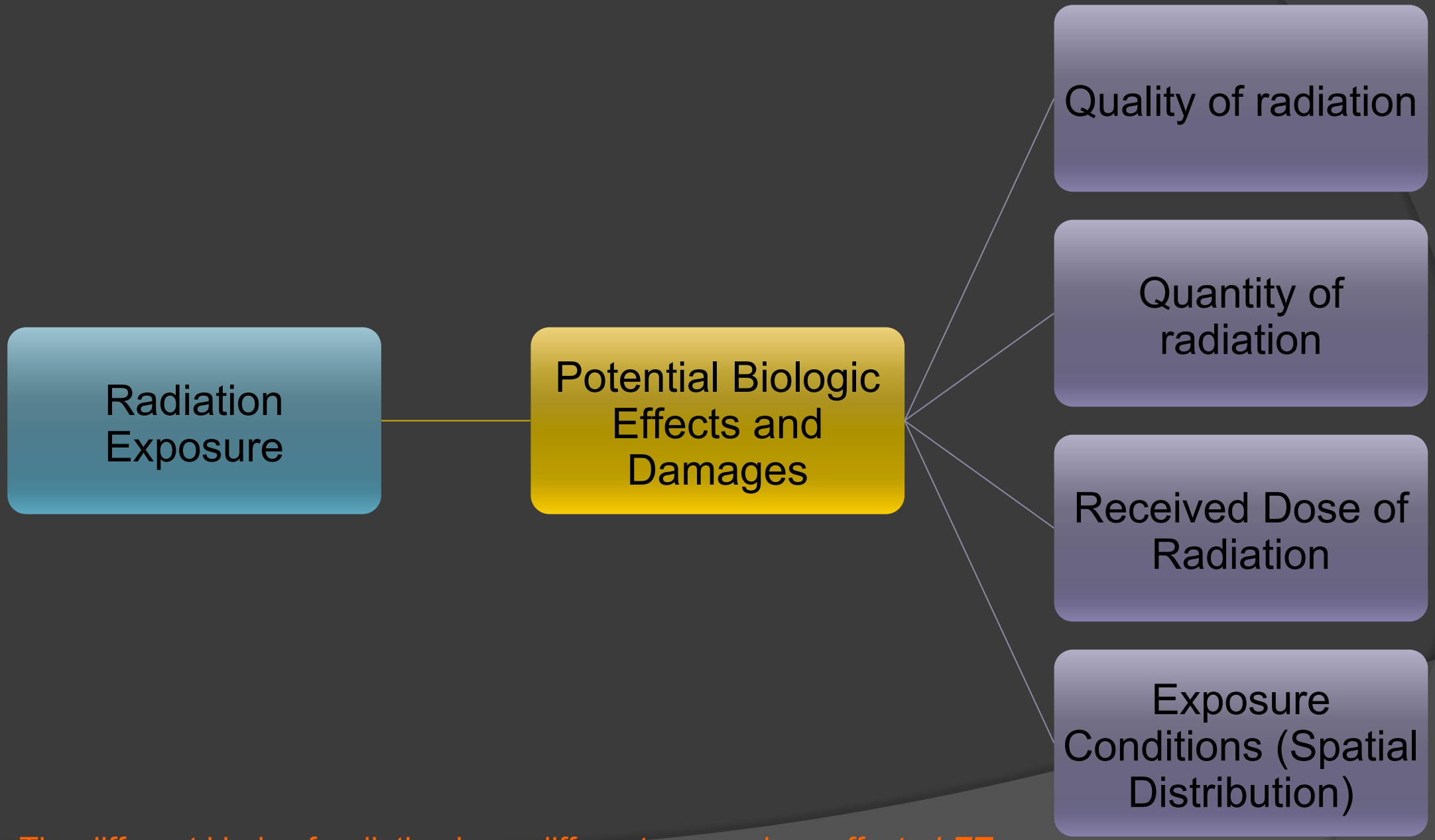
Radiation induced DNA damage

Primary Target of Radiation: **DNA**



Direct and Indirect Action of Ionizing Radiation





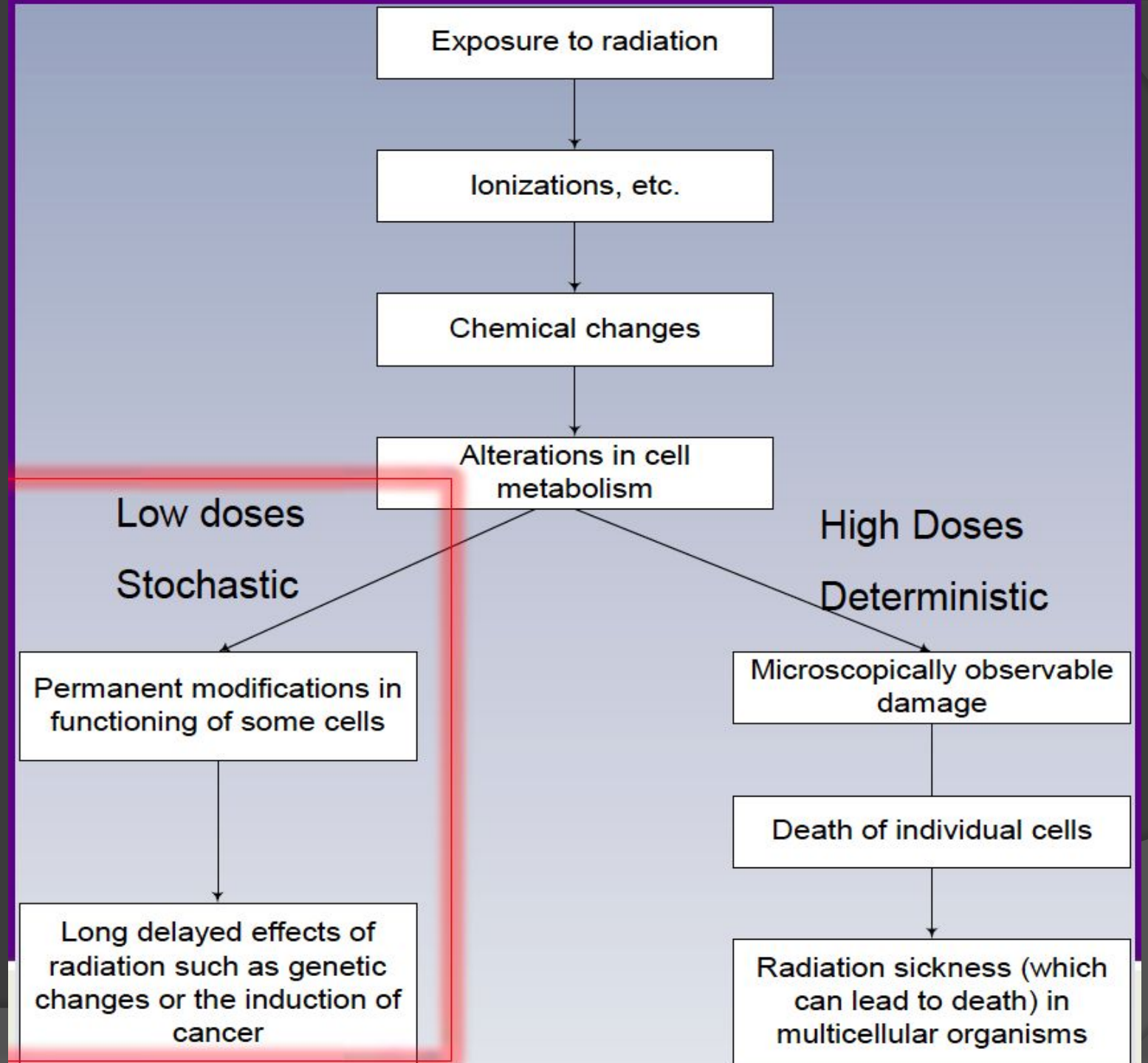
The different kinds of radiation have different energy loss effects *LET*.

Low Dose Radiation

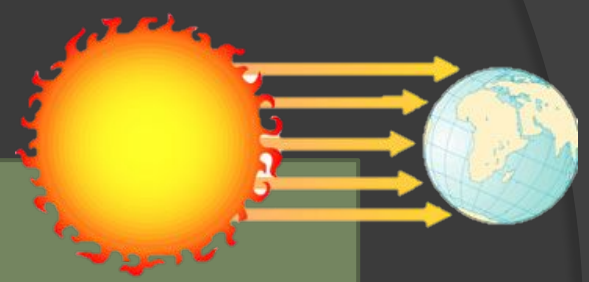
Low Dose Radiation Exposure

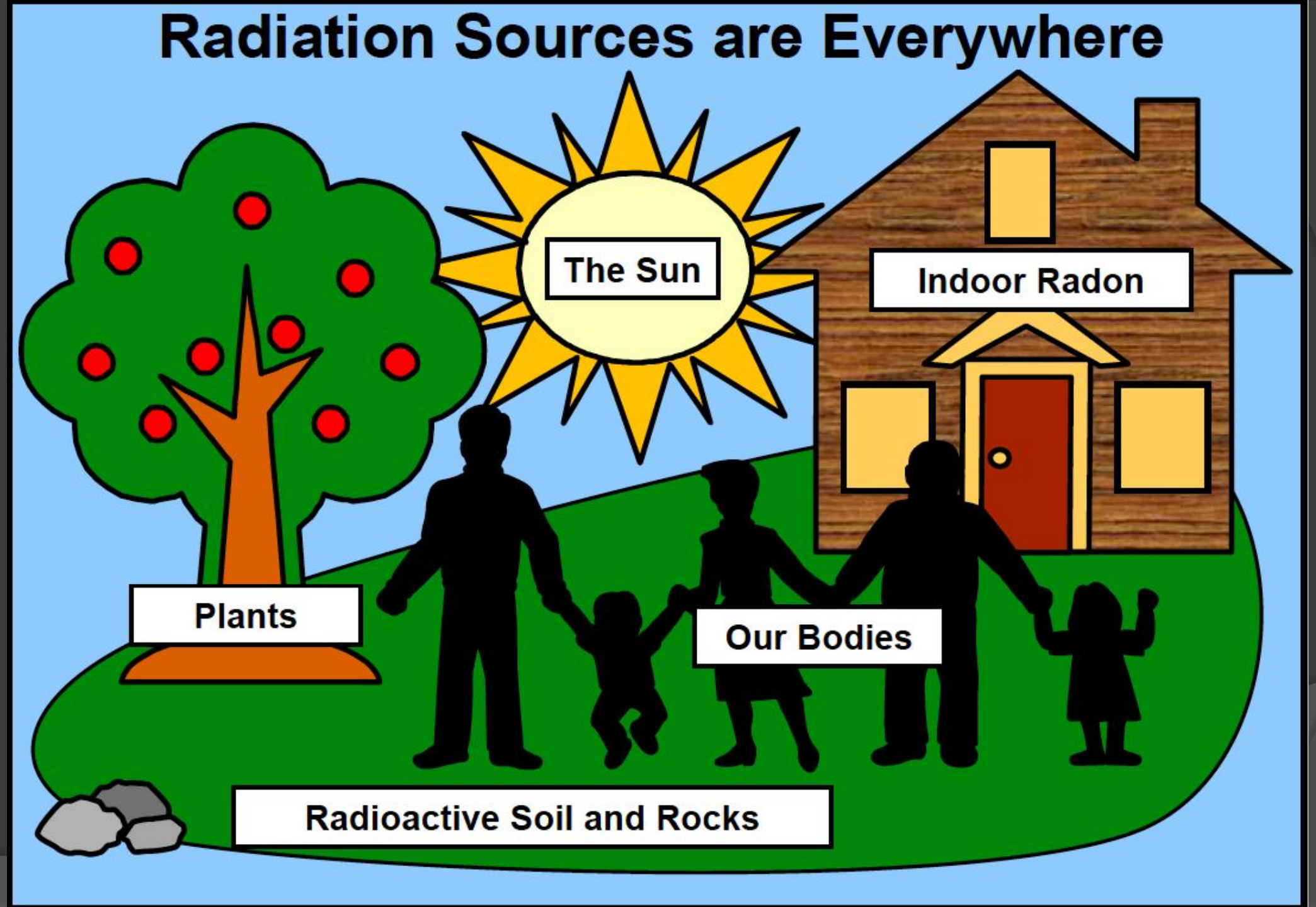
- Dose up to **100 mSv**
  - United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2012 report

Low-dose Radiation Exposure and Carcinogenesis. 2012
Keiji Suzuki1 and Shunichi Yamashita1,2

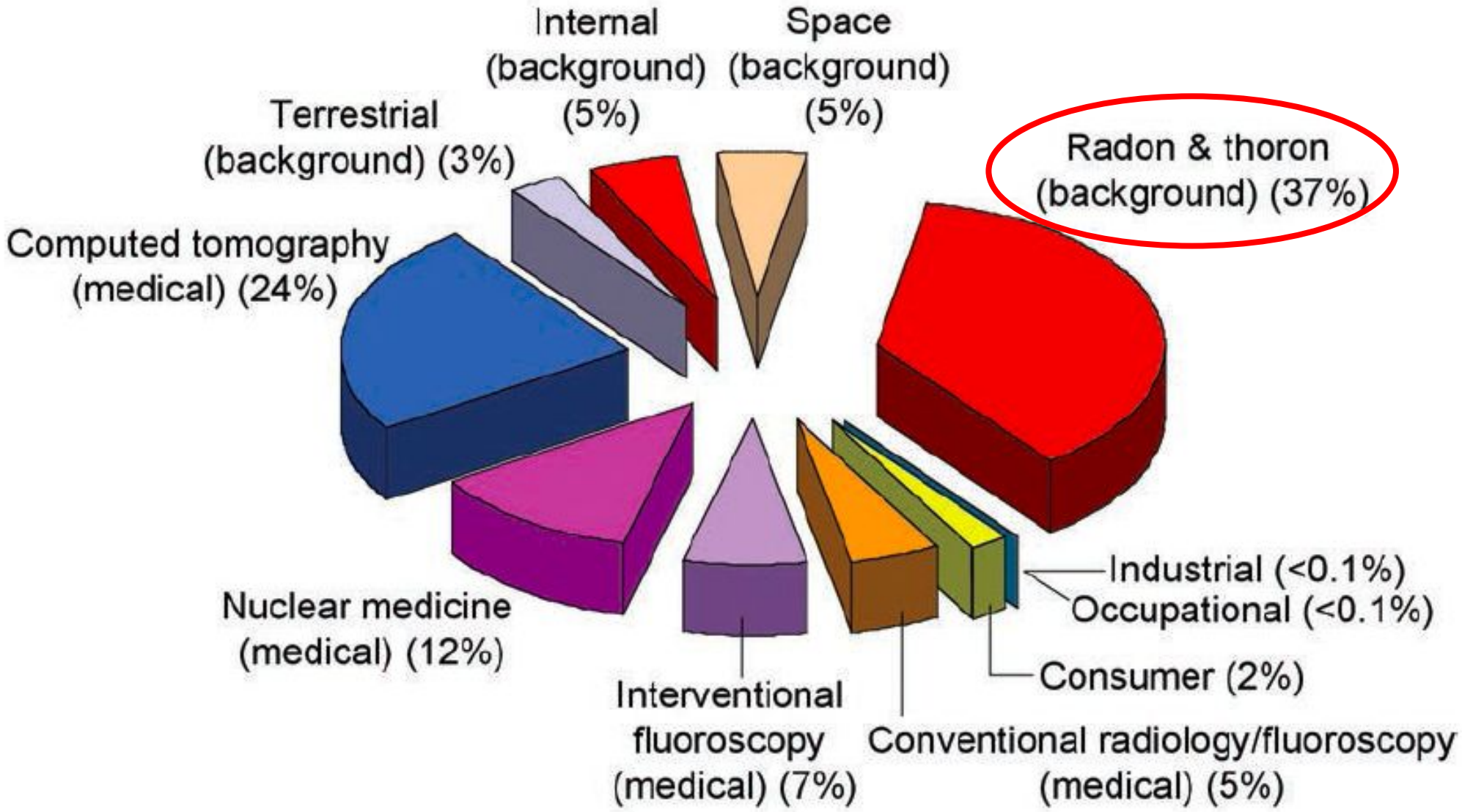

Exposure to radiation
Ionizations, etc.
Chemical changes
Alterations in cell metabolism
Low doses
Stochastic
High Doses
Deterministic
Permanent modifications in functioning of some cells
Long delayed effects of radiation such as genetic changes or the induction of cancer
Microscopically observable damage
Death of individual cells
Radiation sickness (which can lead to death) in multicellular organisms

Natural and Background Exposure



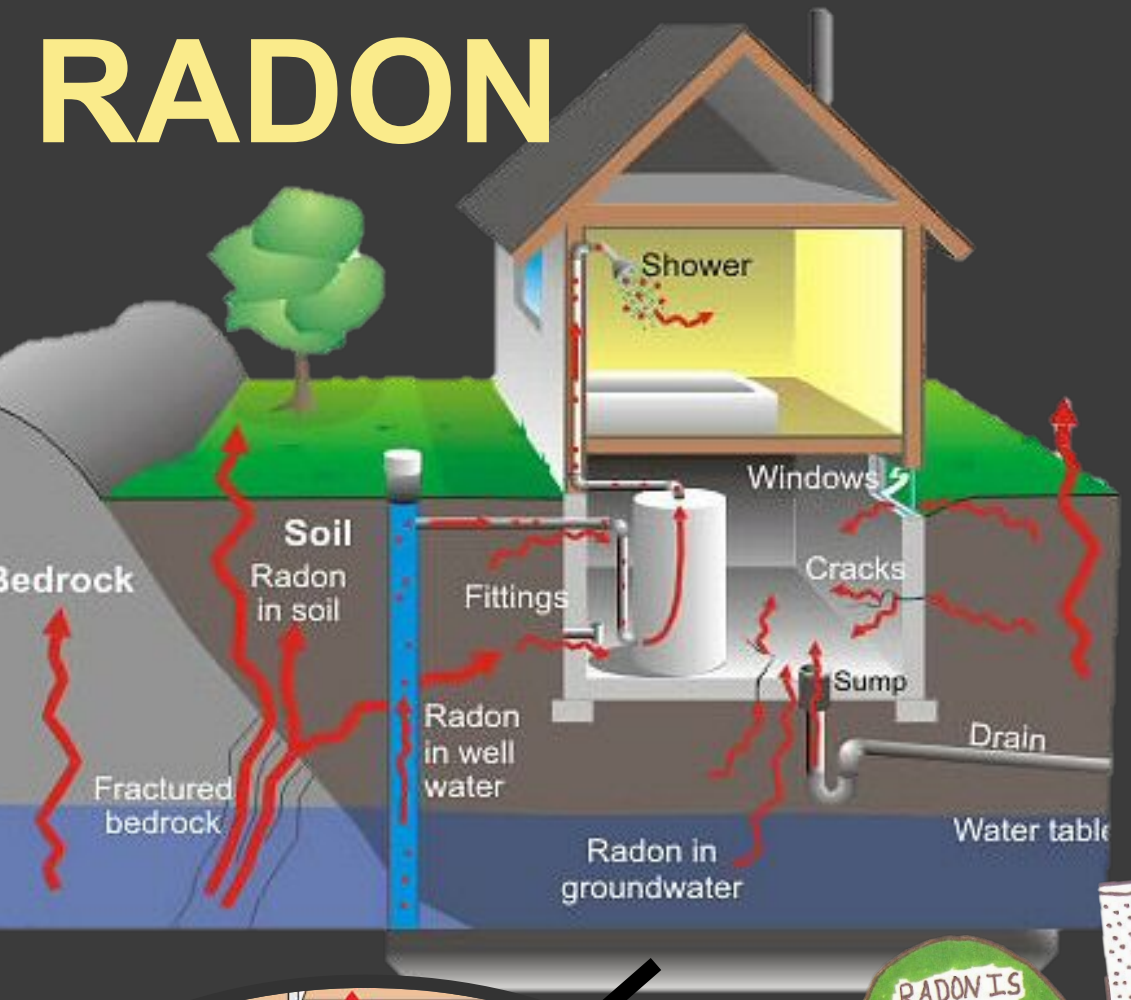

Radiation Sources are Everywhere
The Sun
Indoor Radon
Plants
Our Bodies
Radioactive Soil and Rocks

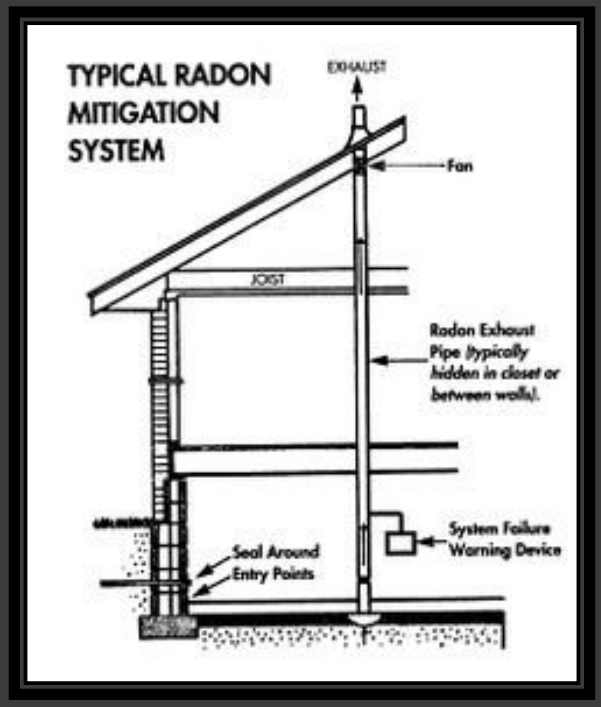
% Contribution of Sources of Exposures



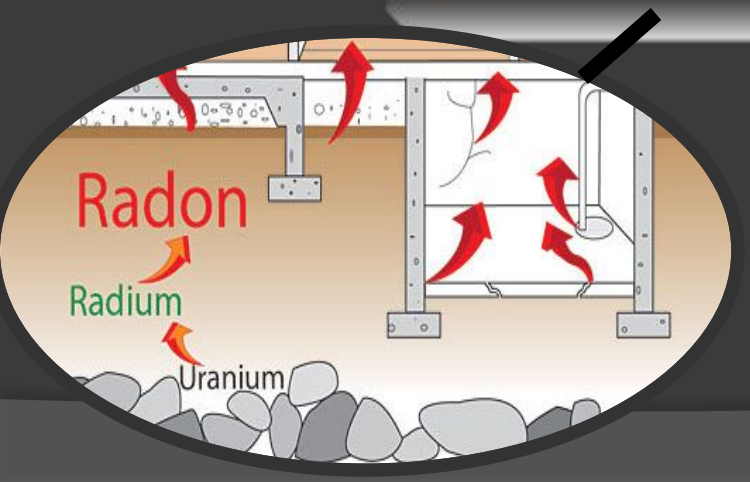
Hall and A.J. Giaccia, Radiobiology for the Radiologist, Seventh Ed., Lippincott, Williams and Wilkins, 2012

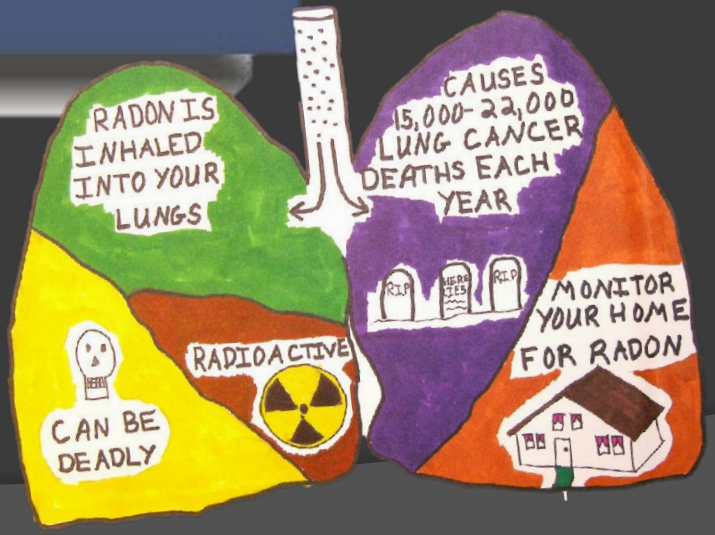
RADON


Shower
Windows
Soil
Radon in soil
Bedrock
Fittings
Cracks
Sump
Radon in well water
Drain
Fractured bedrock
Water table
Radon in groundwater


TYPICAL RADON MITIGATION SYSTEM
EXHAUST
Fan
JOIST
Radon Exhaust Pipe (typically hidden in closet or between walls).
System Failure Warning Device
Seal Around Entry Points


SafetySiren
PRO SERIES 3
Radon
Gas Detector
Concentration Level
pCi / liter
Menu


Radon
Radium
Uranium


RADON IS INHALED INTO YOUR LUNGS
CAUSES 15,000-22,000 LUNG CANCER DEATHS EACH YEAR
MONITOR YOUR HOME FOR RADON
RADIOACTIVE
CAN BE DEADLY
RIP
RIP
HERE LIES

Radiation in Daily-life

※Unit : μSv

Background 2.4 mSv/yr

CT Scan 7 mSv

Chest X-rays 0.05 mSv

Radiation dose (microsievert: μSv)

250,000

50,000

10,000

1,000

100

10

Upper limit of radiation dose permitted for people who engage in emergency work.

[250,000 μSv/year]

Upper limit of radiation dose permitted for radiation workers, police , and firefighters who engage in disaster prevention.

[50,000 μSv/year]

[~10,000 μSv/year]

Radiation dose in Guarapari(Brazil) per year.

Chest CT scan

[6,900 μSv/each time]

[~2,400 μSv/year]

Space 0.39 Ingestion 0.29 Earth 0.48 Radon absorbed in air 1.26

Natural radiation dose per year.

Global average

Dose limit for public per year (except for medical care).

[1,000 μSv/year]

Gifu ⟷ Kanagawa

Maximum difference of the average of natural radiation dose in each prefecture.

[~400 μSv/year]

gastrointestinal X-ray examinati

[600 μSv/each time]

An air travel between Tokyo and New York (RT).

(Increased cosmic radiation at high altitude.)

[~200 μSv/round trip]

[50 μSv/each time]

Chest X-ray examination.

[22 μSv/year]

Evaluated dose of radiation from radioactive substance emitted from the nuclear fuel reprocessing plant per year.

[50 μSv/year]

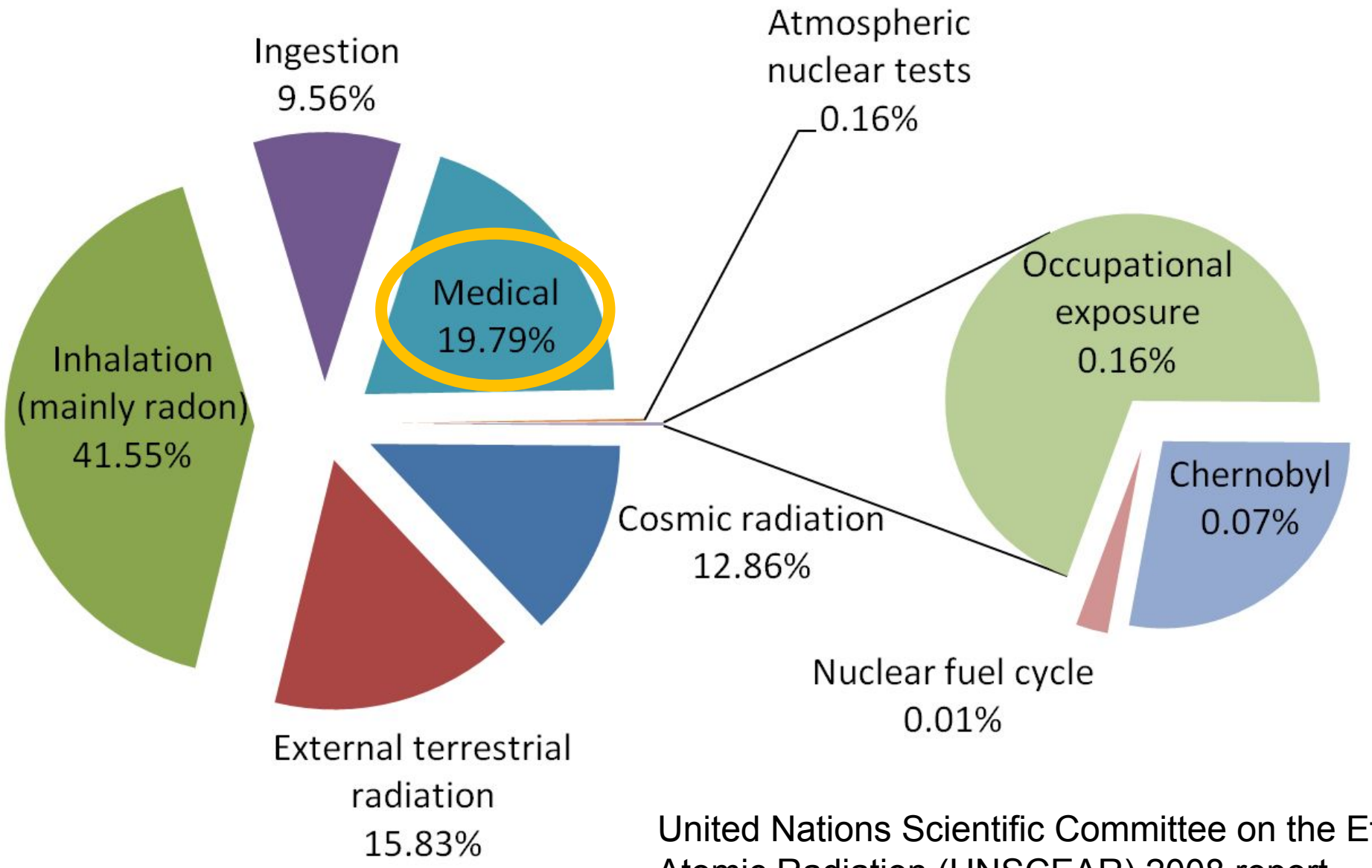
Standard dose of radiation around a nuclear plant (light water reactor).

(Actual result is far below the value.)

[10 μSv/year]

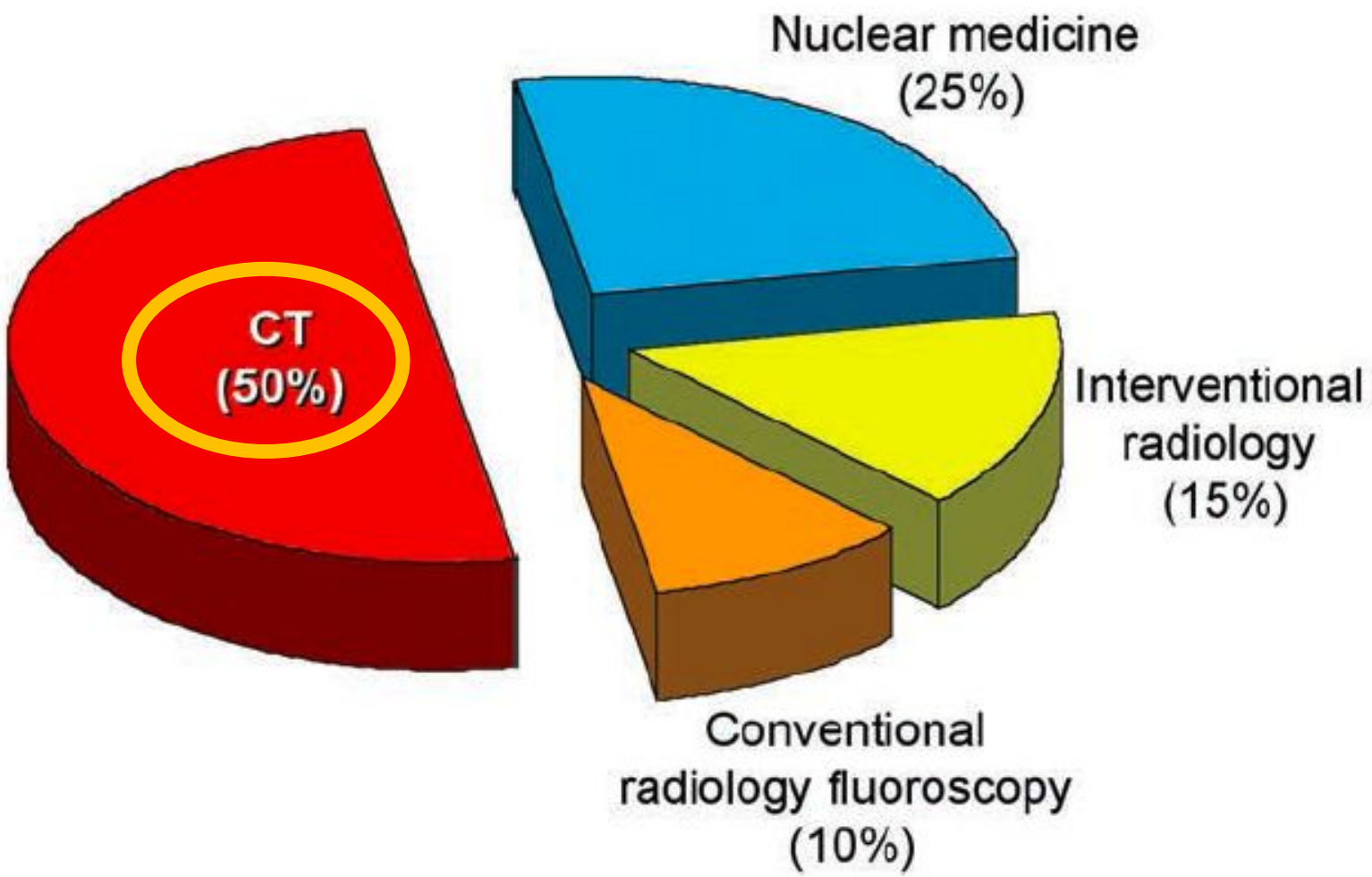
Standard radiation dose from Clearance level.

Low Dose Radiation in Medicine



United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2008 report

Contributions to the Effective Dose from Radiology



E.J. Hall and A.J. Giaccia, Radiobiology for the Radiologiist, Seventh Ed. Lippincott, Williams and Wilkins, 2012

TYPICAL DOSES

Source or mode	Typical dose (mSv)
10 hour aeroplane flight	0.03
Chest x-ray	0.05
CT scan	10
Annual dose from natural background	2.4
Annual dose to nuclear worker	1
Annual cosmic radiation at sea level	0.4
Annual cosmic radiation Mexico City (2 300m)	0.8
Chernobyl recovery workers in 1986	150

m = milli = 1 thousandth

IAEA

Source: UNSCEAR

Ionizing Radiation

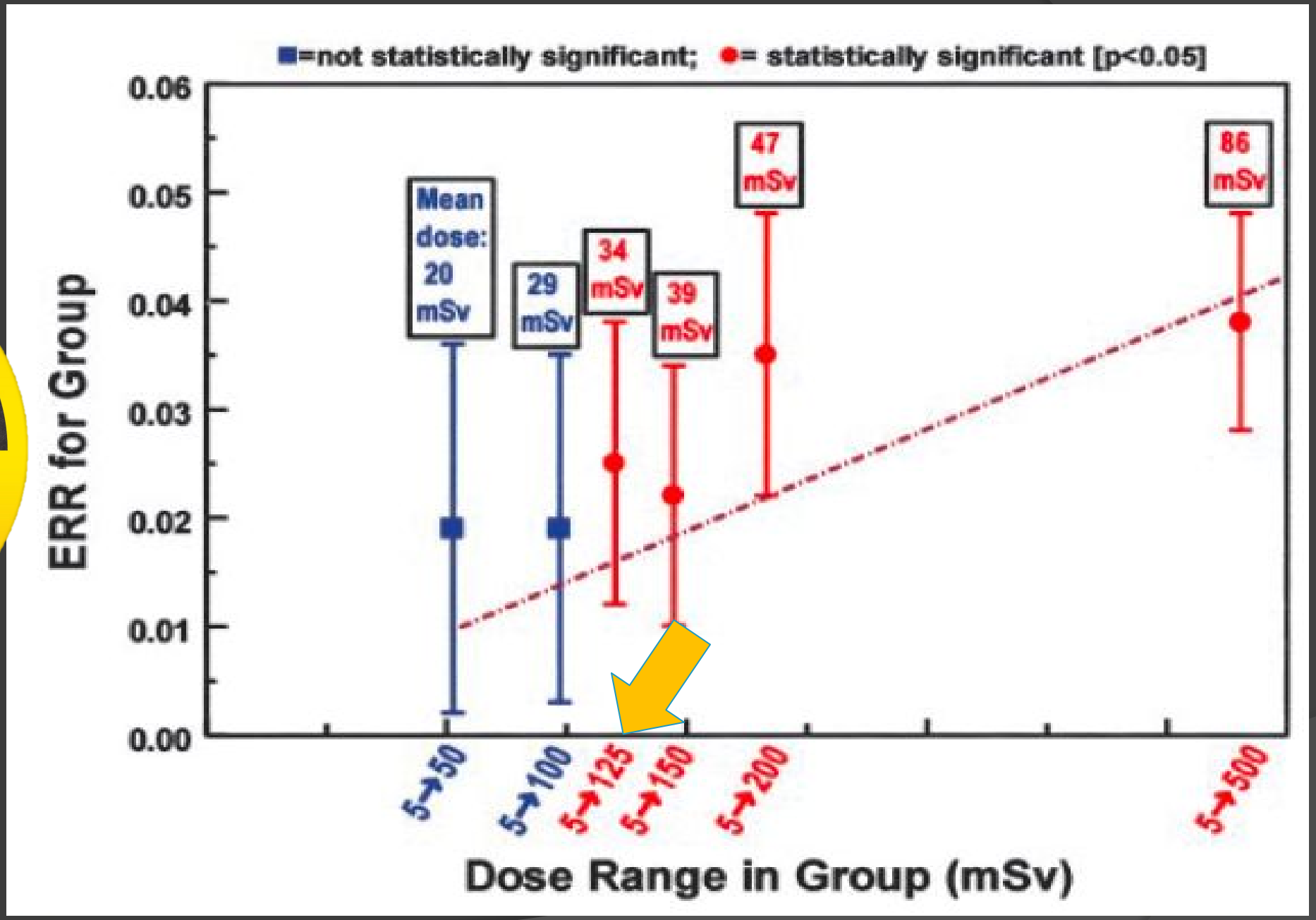
	Dose in mGy or mSv
Conventional X-rays	0.02-10
Conventional Complex X-rays	3-10
CT	5-15
Spiral CT	10-20
Angiography	10-200
Interventional	10-300
Nuclear imaging	3-14
Annual background radiation	2.4mSv

Health Risks From Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 2006.

Cancer Risks from Diagnostic Radiology

Procedure	Typical Effective Dose (mSv)	Equivalent # of Chest x rays	Equivalent Background Radiation (@2.4mSv/yr)	**Added Lifetime Cancer Risk (@0.005%/mSv)**
Chest x ray	0.05	1	1 week	**0.00025 %**
Mammography	0.4	8	2 months	**0.002 %**
Barium x ray (enema)	8.0	160	3.3 years	**0.04 %**
CT Scan Abdomen	7.0	140	3.0 years	**0.035 %**
Cardiac Fluoro	10.0…	200…	4.2 years…	**0.05… %**

NOTE : Natural mortality 0.25 % per year (Ontario)



Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know by Brenner et al (2003)

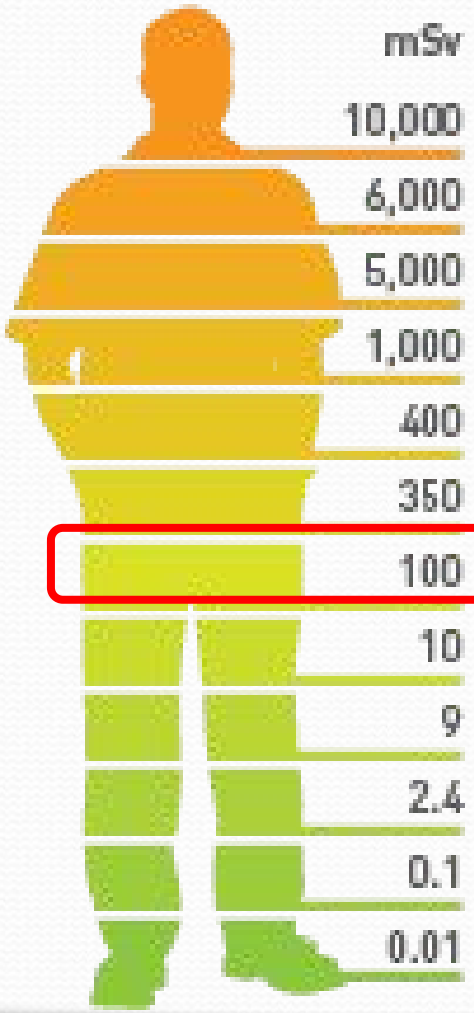
Table 1. Excess lifetime risk of mortality (averaged over both sexes)[a]

Acute dose (Gy)	Solid cancers combined (percentage at specified dose)	Leukaemia (percentage at specified dose)
0.1	0.36-0.77	0.03-0.05
1.0	4.3-7.2	0.6-1.0

Source: Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation — 2006 Report to the General Assembly, with Scientific Annexes A and B, vol. I (United Nations publication, Sales No. E.08.IX.6 and corrigendum), annex A, para. 593.

[a]An excess lifetime risk of 1.0 per cent equates to 1 additional case per 100 people.

RADIATION DOSES AND EFFECTS



mSv	EFFECT
10,000	Fatal within weeks
6,000	Typical dosage recorded in those Chernobyl workers who died within a month
5,000	Single dose which would kill half of those exposed to it within a month
1,000	Single dose which would cause radiation sickness, nausea, but not death
400	Maximum radiation levels recorded at the Fukushima plant on March 14, per hour
350	Exposure of Chernobyl residents who were relocated
100	Lowest level linked to increased cancer risk
10	Full-body CT scan
9	Exposure of airline crew travelling the polar route from NYC to Tokyo, per year
2.4	Natural radiation to which we are all exposed, per year
0.1	Chest x-ray
0.01	Dental x-ray

https://cna.ca/issues-policy/radiation/quantifying-radiation/

Table 1. Fatal cancer risk coefficients at low doses or dose rates as a function of age at exposure, from Goodenough (2001) [10]

Age (years)	0–20	21–40	41–60	61–80	>80
Lifetime probability of fatal cancer (% Sv^{-1})	11.5	5.5	2.5	1.2	0.2

Low dose radiation risks by Dendy et. al. The British Journal of Radiology, 76 (2003), 674–677

Radiation Protection and Safety

Low Dose Radiation: LONG TERM Effects

RERF A-Bomb Cohorts

Cohort	Size
Life Span Study	**120,000** Allows an estimate of cancer incidence and mortality
In-Utero Cohort	**3,600** Allows estimates of mental retardation, microcephaly, etc.
Children of exposed individuals	**77,000** Allows estimate of heritable effects

Carcinogenesis
5%/Sv

Mental Retardation
40%/Sv

Hereditary effects
0.2%/Sv

Health Risks From Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 2006.

Nominal risk coefficients for cancer and heritable effects (% per Sv).						
Exposed Population	Cancer		Heritable effects		Total	
	ICRP 1990	ICRP 2007	ICRP 1990	ICRP 2007	ICRP 1990	ICRP 2007
Whole population	6.0	5.5	1.3	0.2	7.3	5.7
Adults	4.8	4.1	0.8	0.1	5.6	4.2

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 2007 Recommendations of the ICRP, Publication 103, Pergamon Press, Oxford (2007).

General Principles

International

Philippines

Jose R. Reyes Memorial Medical Center

Department Of Radiotherapy

Authorized staff

Individual

Radiation Protection Principles

Dose limitation

- Members of the Public =1mSv/y
- Occupationally exposed personnel = 20mSv/y

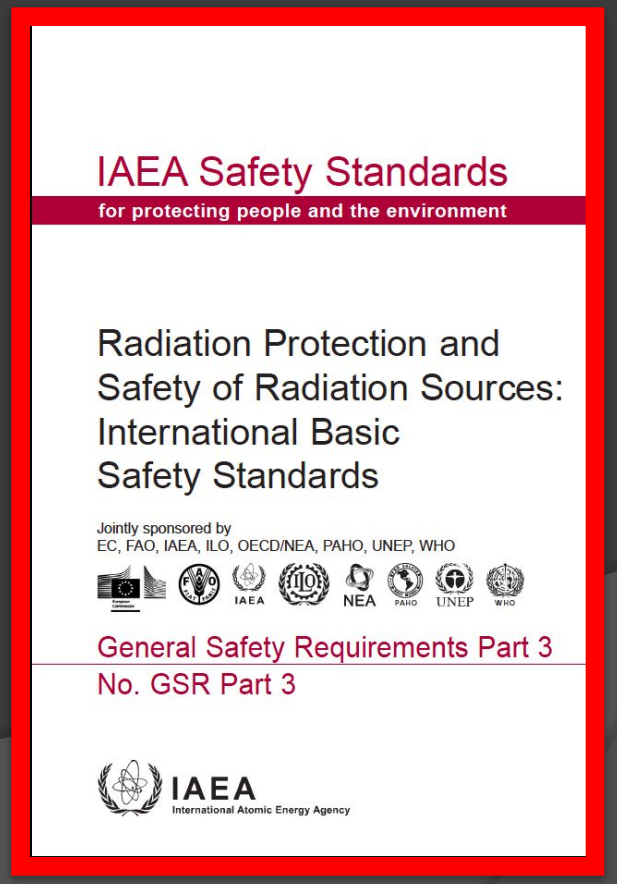
Justification

Optimization

Guidance levels

Categories of Exposures

- International Basic Safety Standards
  - Medical
  - Occupational
  - Public



Medical Exposure

Patients as part medical or dental diagnosis and treatment

Relatives, friends, individuals (non-staff) who voluntarily help in support and comfort of patients

Volunteers in a program of biomedical research

Public

People living around a radiotherapy facility

Visitors to the department

Relatives, friends and other persons who may be in contact with patients

Not necessarily: Partners and non-occupational persons who are involved in care or comforting the patient

Means t event

Types of Monitoring

Area monitoring

- Survey meters

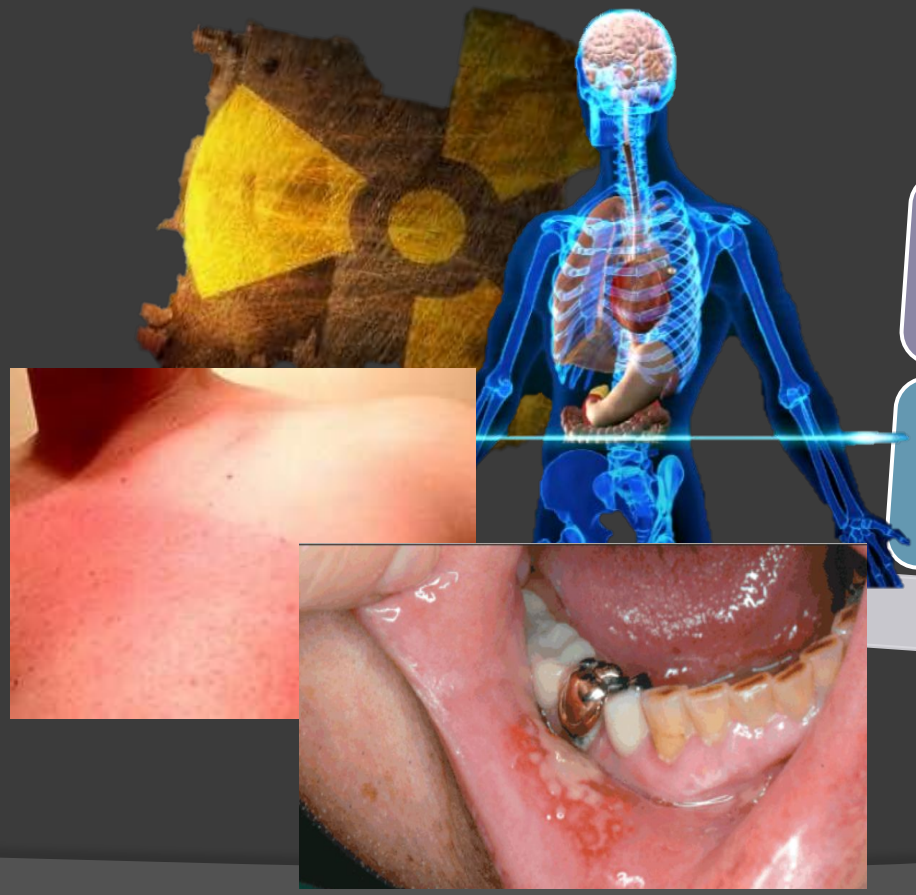
Personnel monitoring

- Personal dosimeters

CONCLUSION

Risks

Benefits



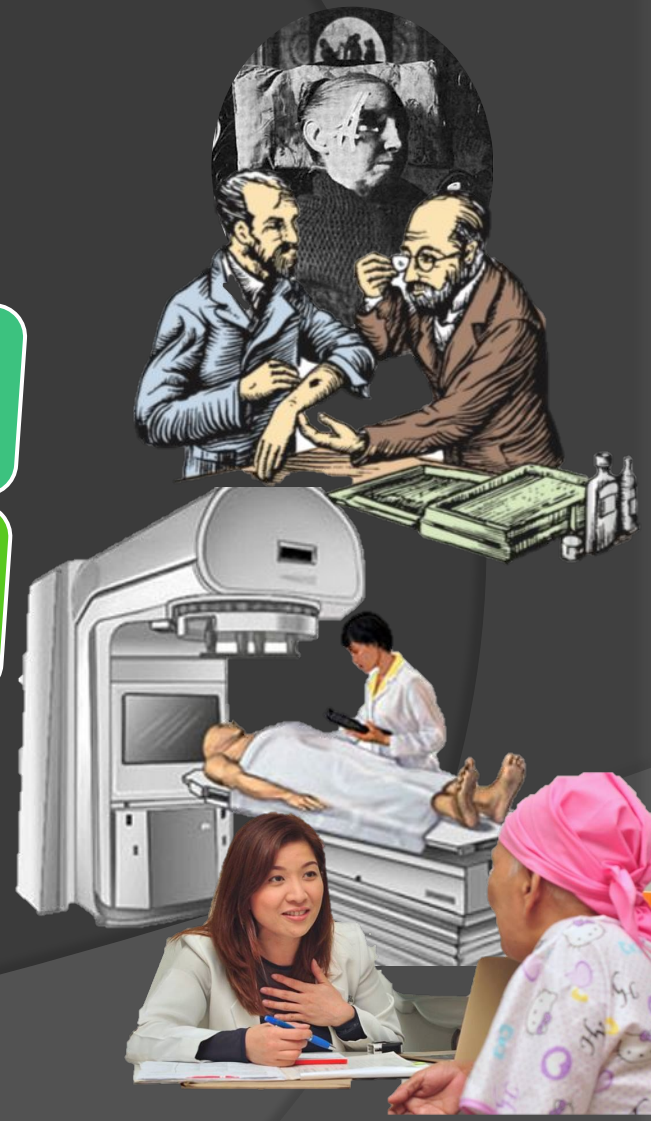
Toxicities

Radiation Carcinogenesis

Diagnostic

Therapeutic

Quality of Life



Underground River, Palawan

Mt. Pinatubo

MARAMING SALAMAT PO!

Boracay beach

Manila Bay Sunset