Leadership program

Developing an expanded talent pool for the irradiation industry

Reims, France - April 26, 2023

More radiation biology…

Yves HENON

This is S1 E2

S1 E1 was:

iia INTERNATIONAL IRRADIATION ASSOCIATION

Leadership program

Developing an expanded talent pool for the irradiation industry

WEBINAR - March 31, 2023

Basics of radiation biology for radiation processing

Yves HENON

Contents

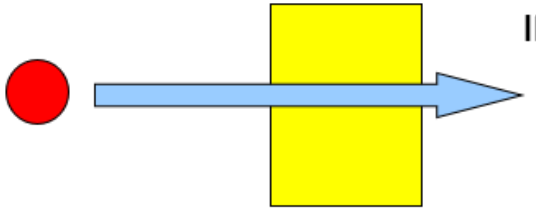
- Brief reminder of key concepts
- Radiation biology
  - DNA
  - Sensitivity to radiation
- Radiation safety
- Radiation biology in action
  - Plant mutation breeding
  - Sterilie insect technique
  - Phytosanitary irradiation
  - Pasteurisation and sterilisation

Note: Radiation biology is complex. In this presentation some notions have been simplified.

Radiation biology

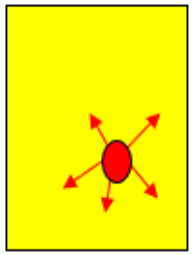
Branch of biology concerned with the effects of radiation on living systems

Irradiation but not only…



IRRADIATION

NO RADIOACTIVITY CREATED
Nucleus of atoms in product unchanged.
Only electrons are involved.

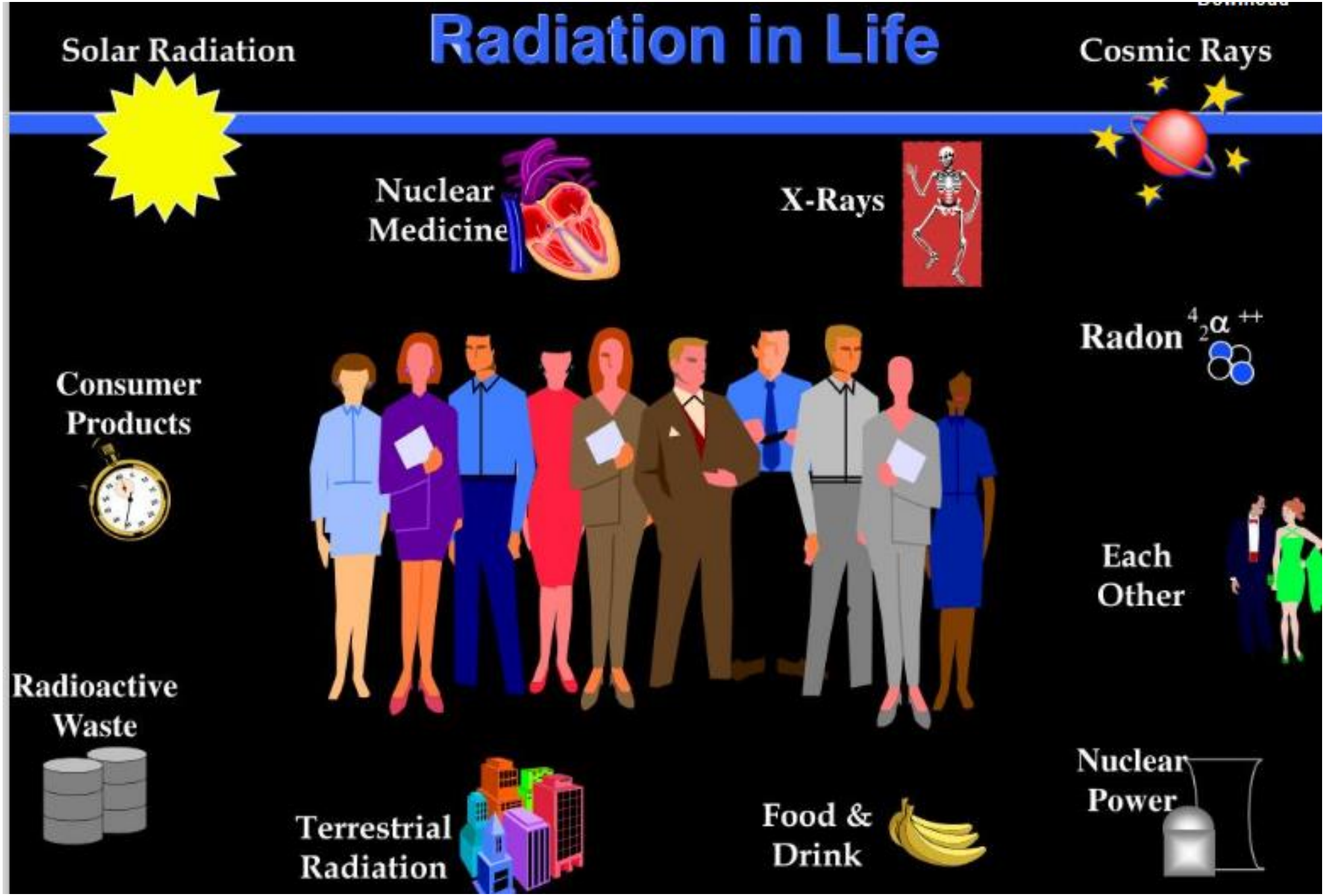


CONTAMINATION = RADIOACTIVE POLLUTION

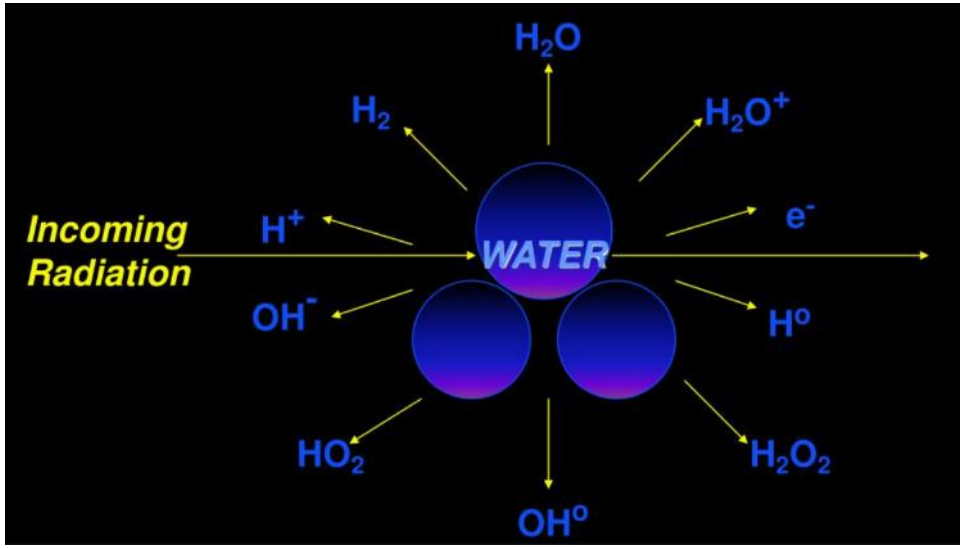
Presence of radioactiity within a medium
Radiation emitted within the medium

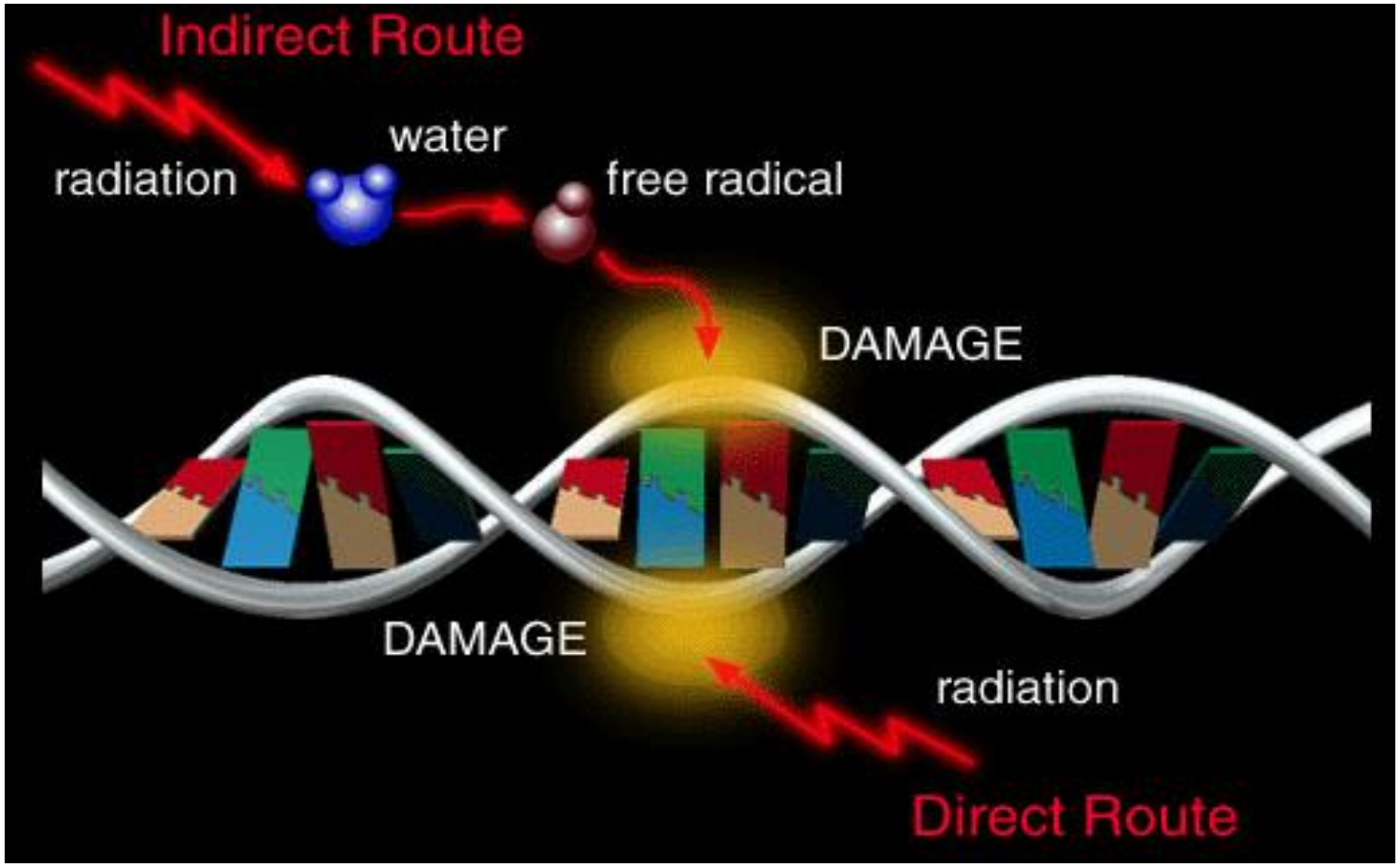
(RADIO)ACTIVATION

Product becomes radioactive after exposure to radiation
Nucleus of atoms in products changed
Requires particular types of sources

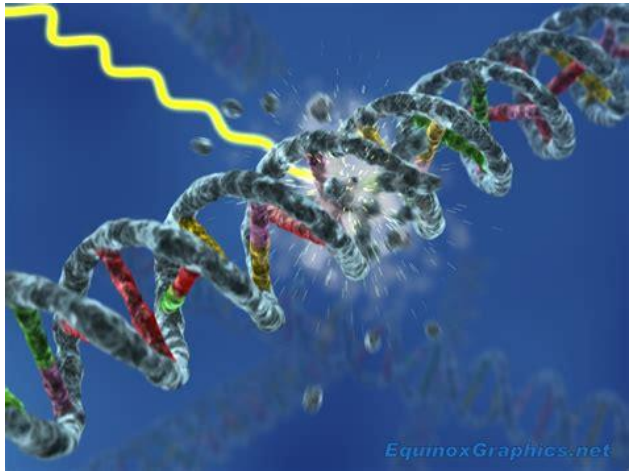

Radiation in Life
Solar Radiation
Cosmic Rays
Nuclear Medicine
X-Rays
Radon $^{4}_{2}\alpha^{++}$
Consumer Products
Each Other
Radioactive Waste
Terrestrial Radiation
Food & Drink
Nuclear Power

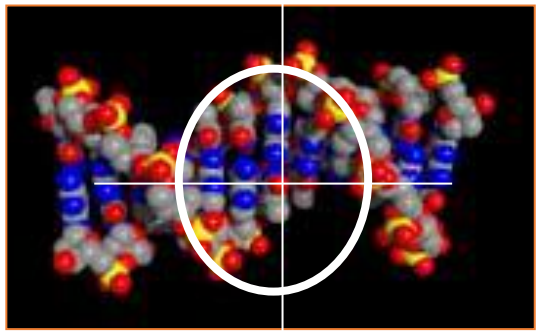
Lethality of ionizing radiation stems from effects on DNA





Sensitivity of living organisms





DNA TARGET SIZE

HUMANS PROTOZOA BACTERIA VEGETATIVE SPORES FUNGI BACTERIA VIRUS PRION

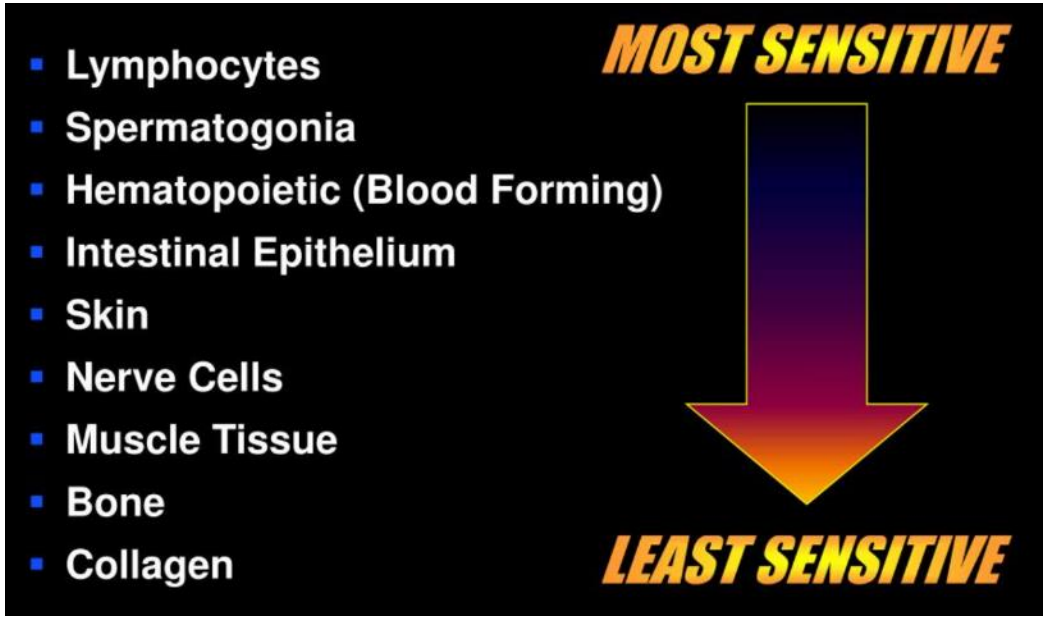
MOST SENSITIVE **MOST RESISTANT**

Sensitivity to ionizing radiation

Theory of Bergonie and Tribondeau (1906):

Cells are radiosensitive when they:

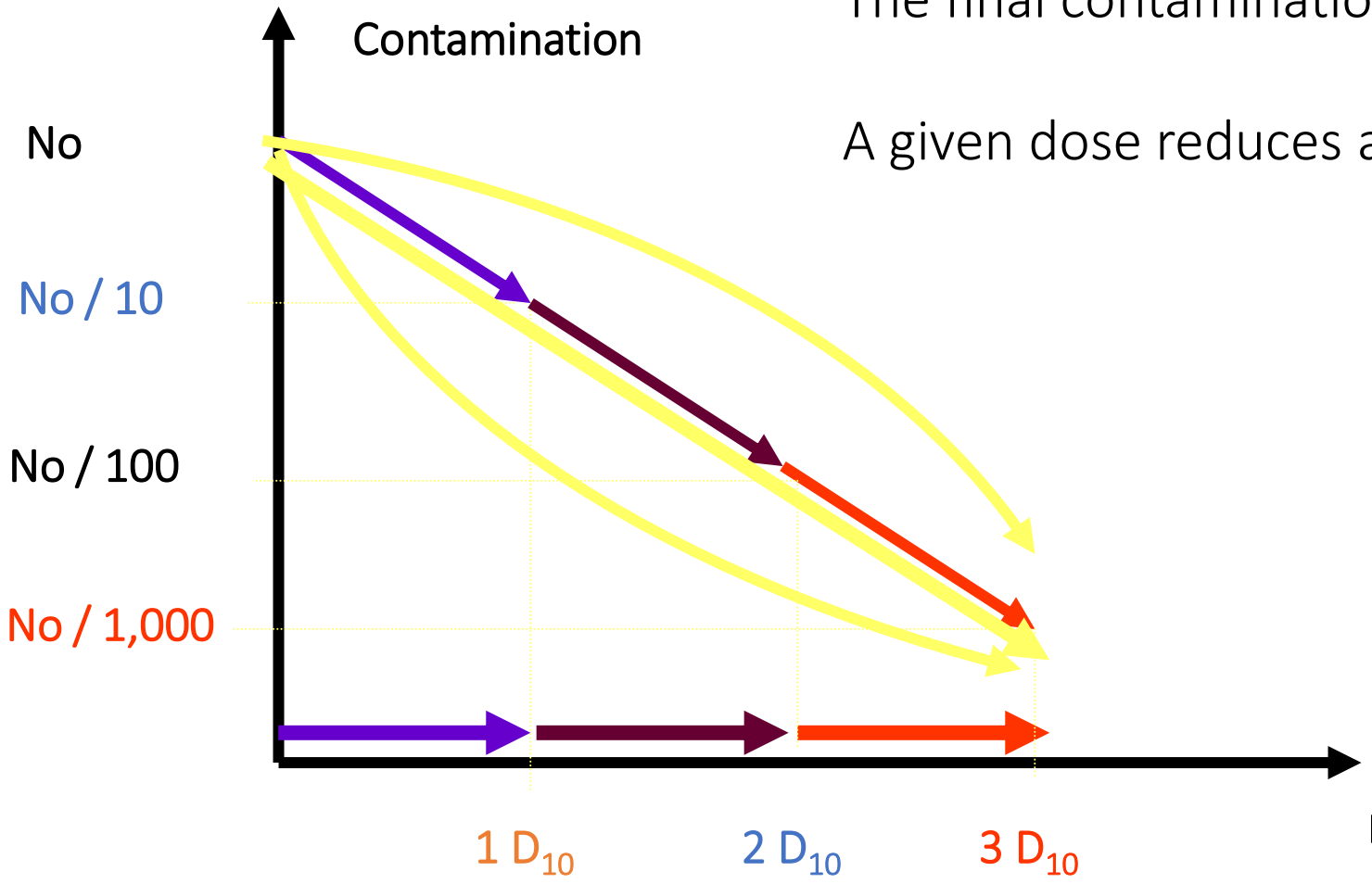
- Have a high division rate
- Have a long dividing future
- Are of an unspecialized type



Relative sensitivity of human cells and tissue types

STERILISATION – PASTEURISATION (FOOD, COSMETIC, PHARMA, INGREDIENTS)

MICROBIAL INACTIVATION KINETICS



The final contamination depends on the initial contamination

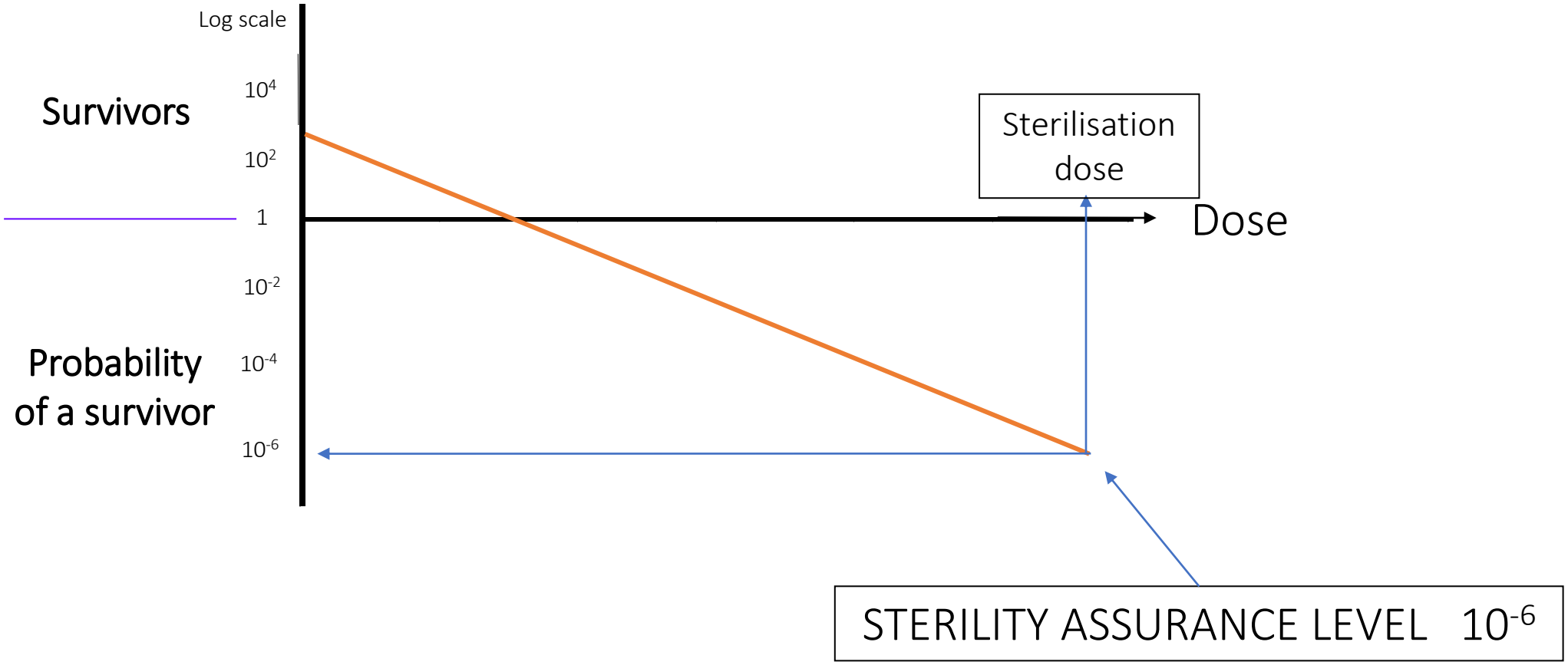
A given dose reduces a given <u>proportion</u> of the contamination

D_{10}

SENSITIVITY OF VARIOUS MICROORGANISMS

Microorganism	D_{10} (kGy)
Staphyloccoccus spp	*0.2 – 1.7*
Streptococcus spp	*0.1 – 1.0*
Bacillus sphaericus	*0.5 – 9.0*
Pseudomonas aeruginosa	*0.1 – 0.7*
Salmonella typhi	*0.1 – 0.8*
Candida albicans	*0.2 – 0.4*
Aspergillus fumigatus	*1.4 – 3.8*
Enterovirus polio	*0.3 – 4.5*
Prions	*> 15*

RADIATION STERILISATION OF MEDICAL DEVICES



FACTORS OF INFLUENCE

At a given dose:

FACTORS	MICROBIAL SENSITIVITY	PRODUCT STABILITY
Water ⇧	⬆	⬇
Temperature ⇧	⬆	⬇
Oxygen ⇧	⬆	⬇
Substrate	⬆⬇	⬆⬇

IN COMMERCIAL PRACTISE, THE CHOICE OF A DOSE RANGE IS OFTEN A COMPROMISE

Radiation safety

In an irradiation facility, a lethal dose may be delivered within seconds, depending on distance to source and duration of exposure

Anyone working with ionising radiation **must** be aware of the hazards and receive training in radiation safety

70 years of radiation processing industry: outstanding safety record

Very few accidents that could have been avoided, all due to the "human factor": safety procedures not followed or safety system circumvented

IAEA / ISO sign (since 2007)

Accidental exposures to radiation

Nezvizh, Belarus 1991
Gamma irradiator – Operator received whole body dose : 11Gy - 18Gy

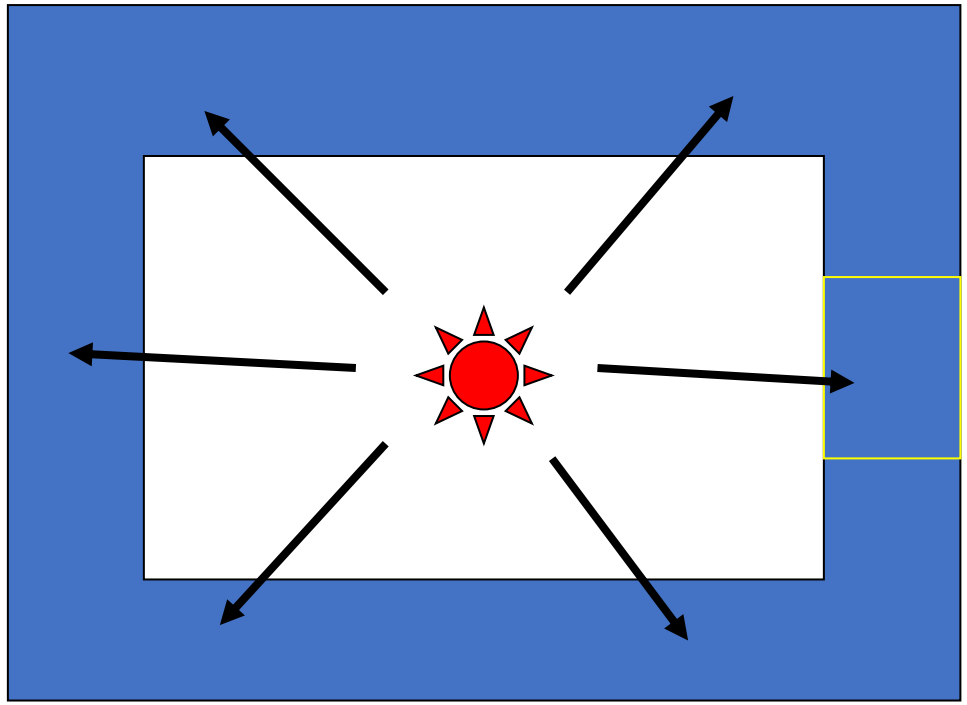
Died 113 days later

Maryland, USA, 1991
Electron Beam Accelerator – Operator received locally doses up to 13 Gy

Amputation of left hand and 3 right hand fingers 3 months later

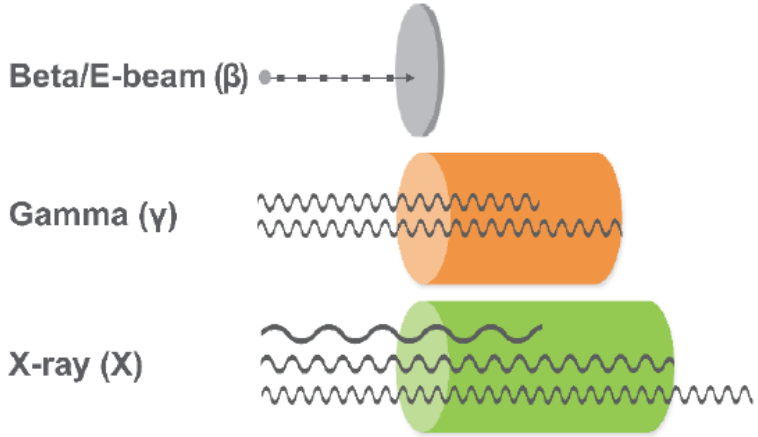
Preventing accidental exposure is mainly by design

To prevent exposure of humans outside the place where products are irradiated, sources of ionizing radiation are placed in a room with very thick concrete walls.



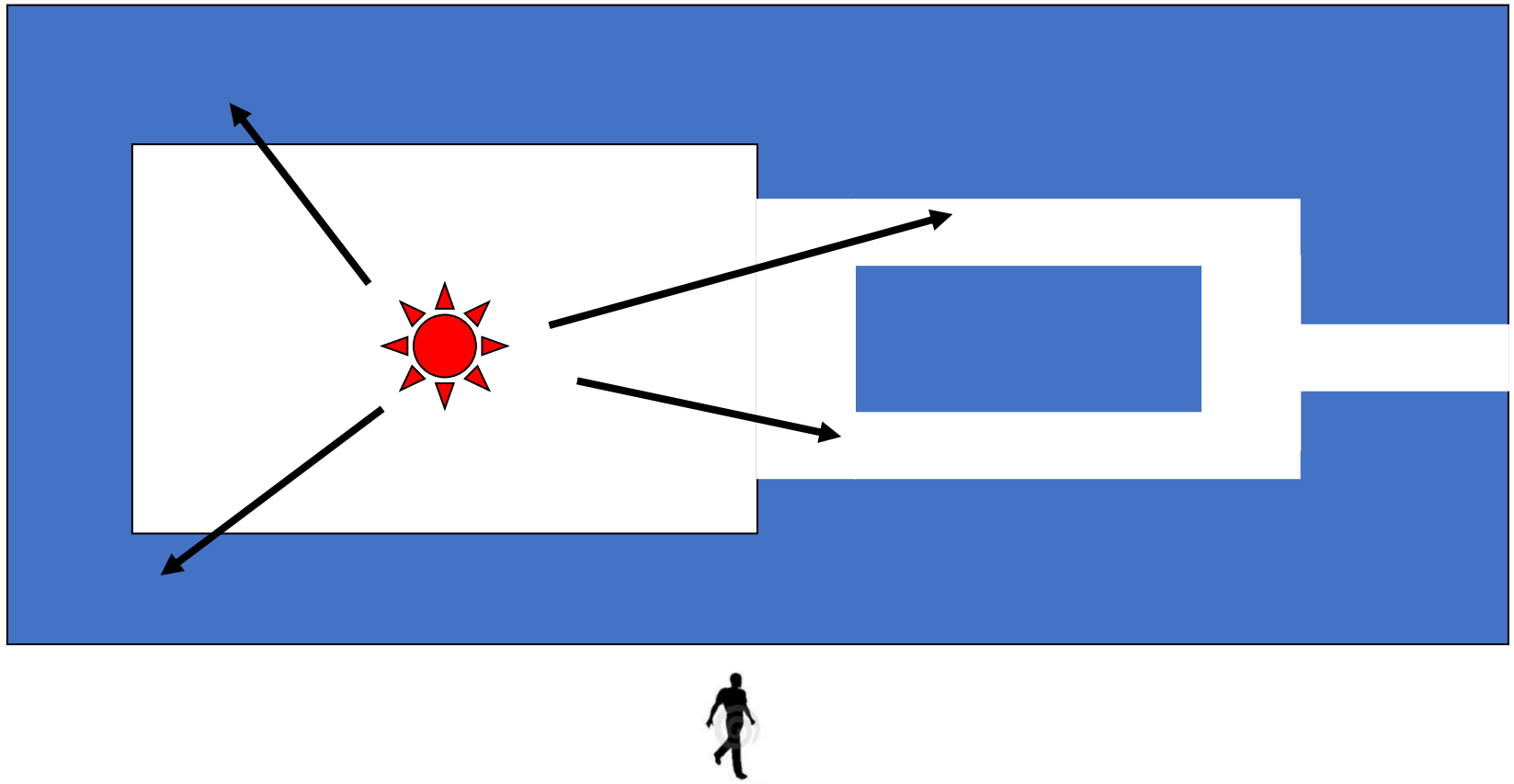
Nearly all radiation is absorbed in the walls.

< 2.5 µSv / h



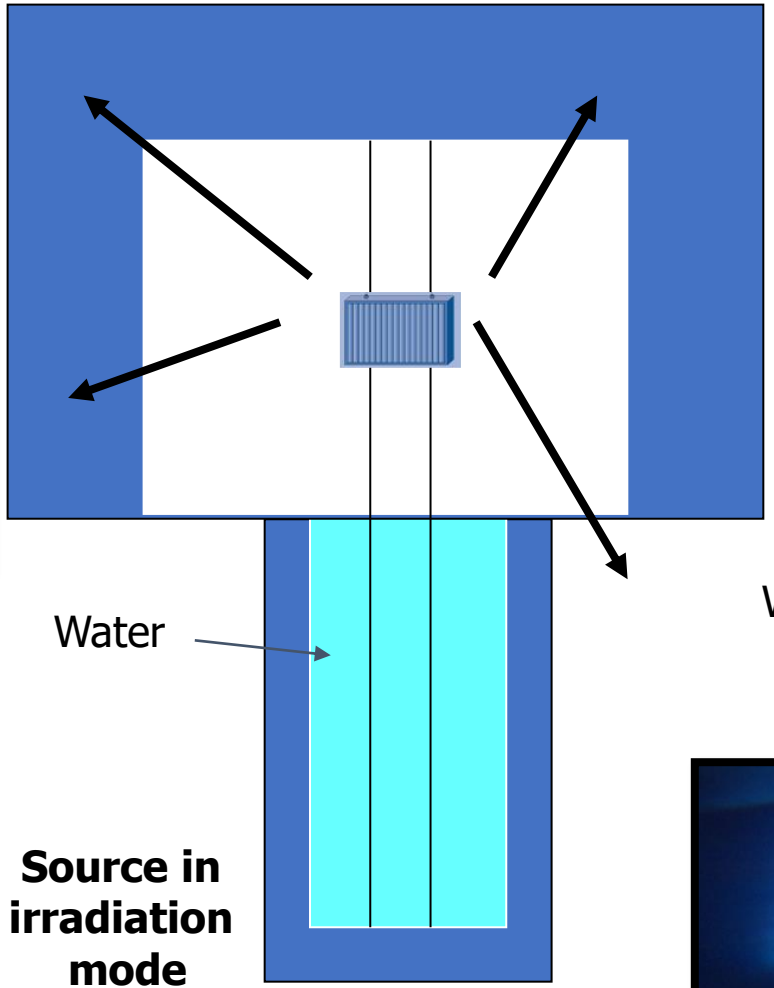
Preventing accidental exposure is mainly by design

To operate in continuous mode, a maze is necessary to prevent radiation from exiting.

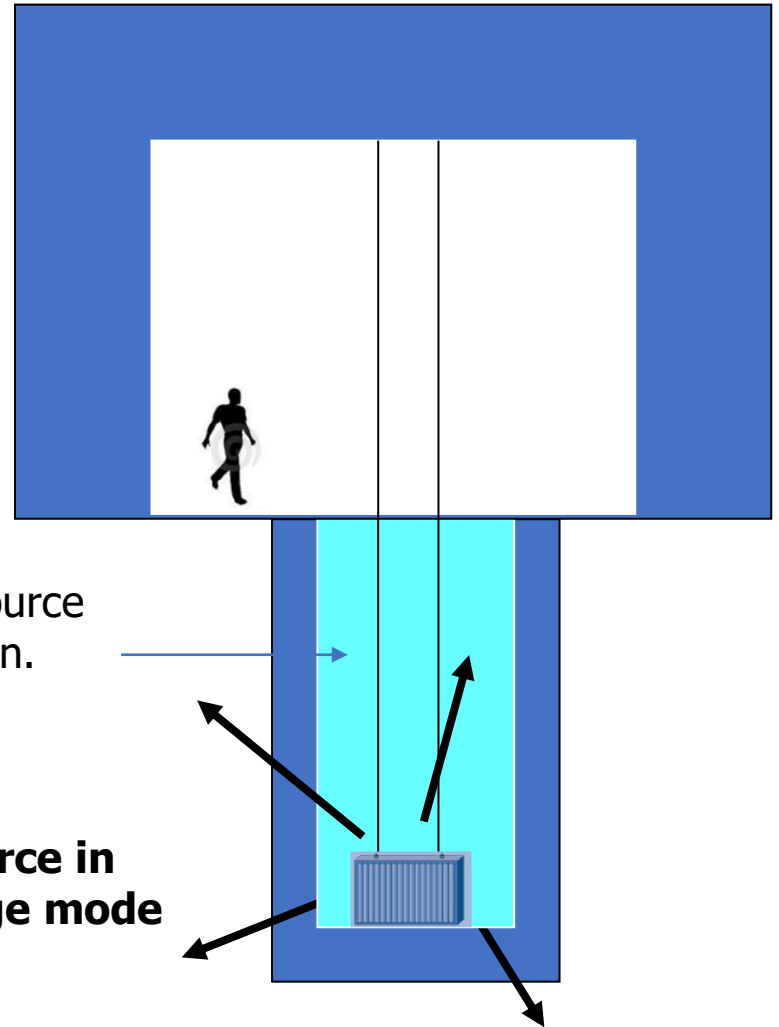


Preventing accidental exposure is mainly by design

In gamma irradiators, the emission of radiation cannot be paused.
A pool is built to store the source and allow entry in the irradiation room.



Water on top of source absorbs radiation.
Safe to enter.



Preventing accidental exposure is mainly by design

Safety systems have two purposes:

- Prevent entry in irradiation room when source in irradiation mode
- Prevent the source from moving to irradiation position when someon inside the irradiation room.

Achieved by using several different (redundant) systems such as:

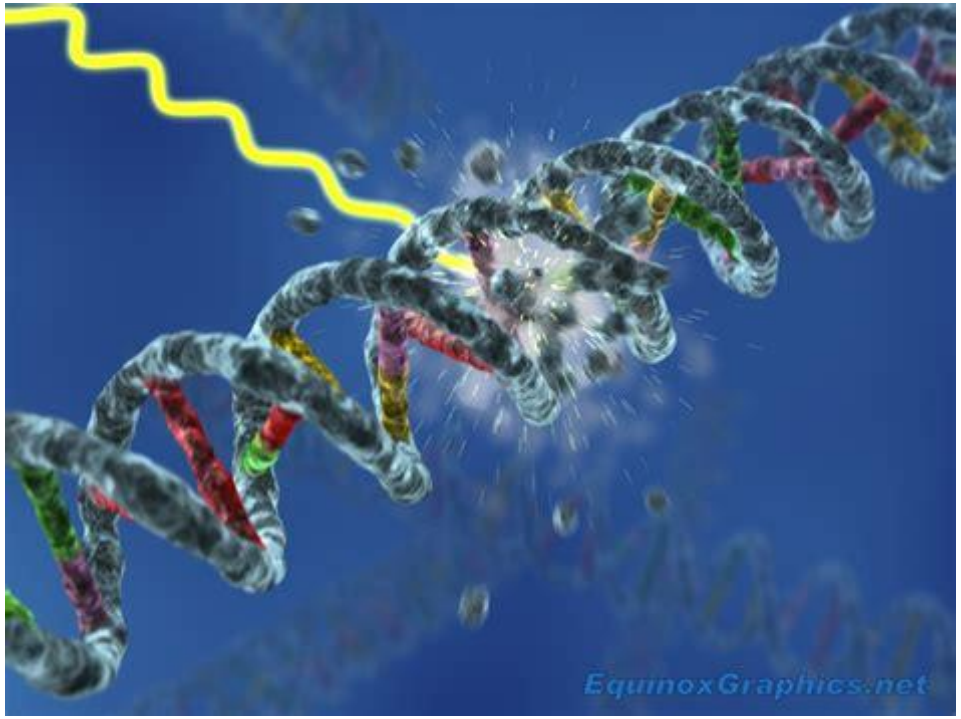
- Single key needed to start irradiation mode AND to open access door
- Entry door blocked when in irradiation mode or water level too low
- Photoelectric cells will stop irradiation mode if person detected at product maze entrance
- Cable running along inside of the irradiation room prevent going into irradiation mode when pulled

Radiation biology in action

Many applications of irradiation based on biological effects

Tool to modify the genetic material of living organisms

- To obtain new plant varieties with improved characteristics
- To render insects sterile



Tool to kill undesirable living organisms

- Microorganisms contaminating health care products, labware and packaging
- Insect pests and microorganisms in food

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THANK YOU