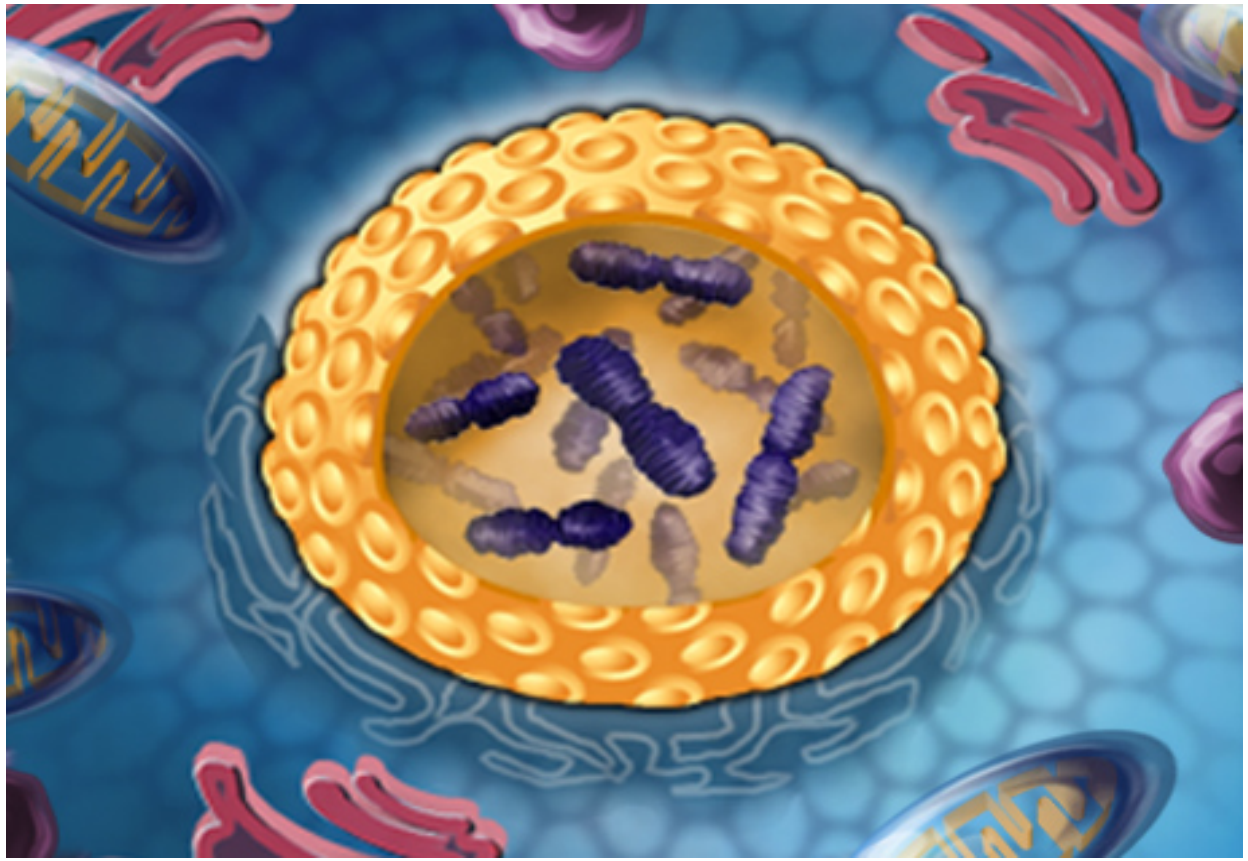
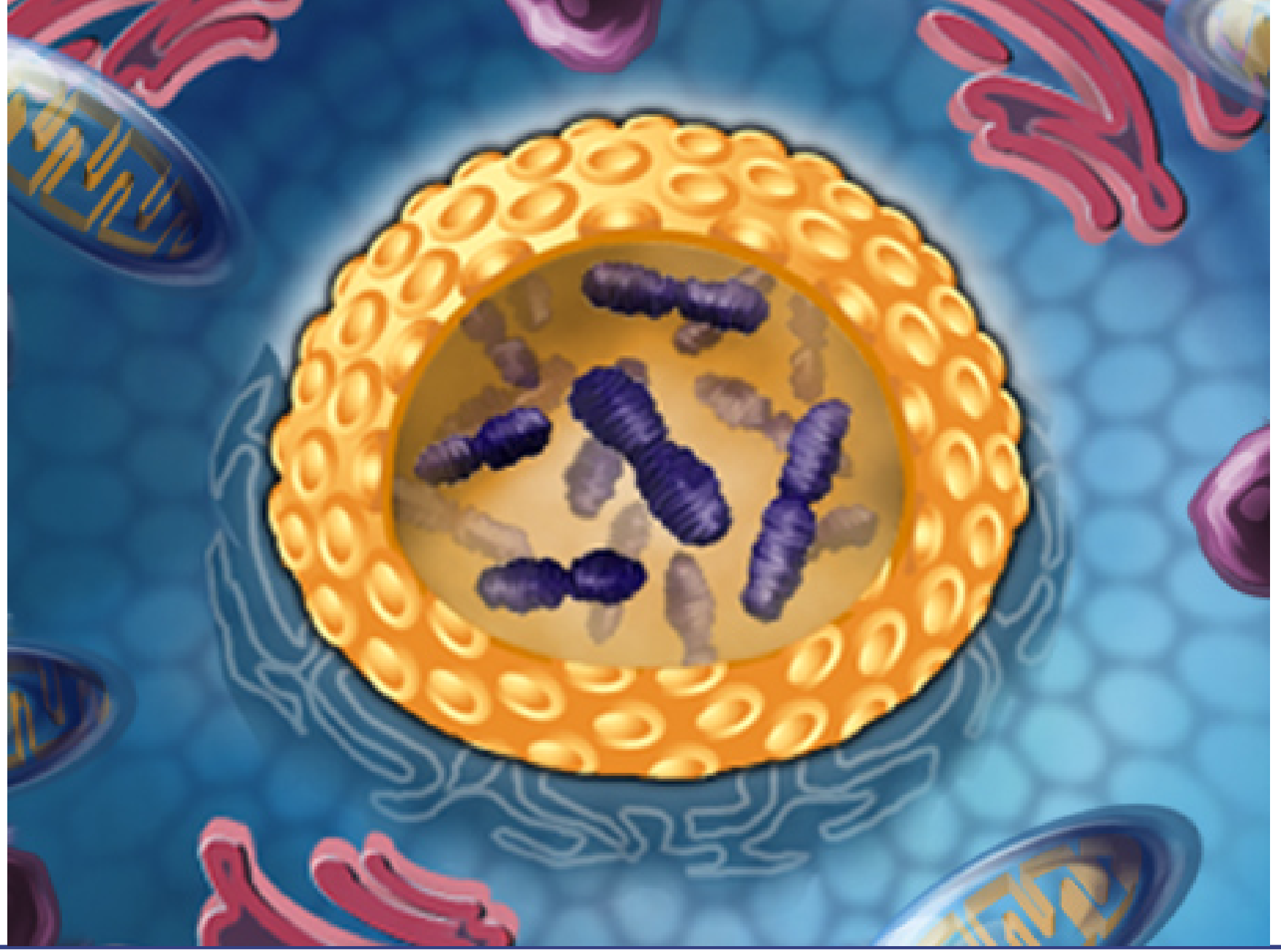
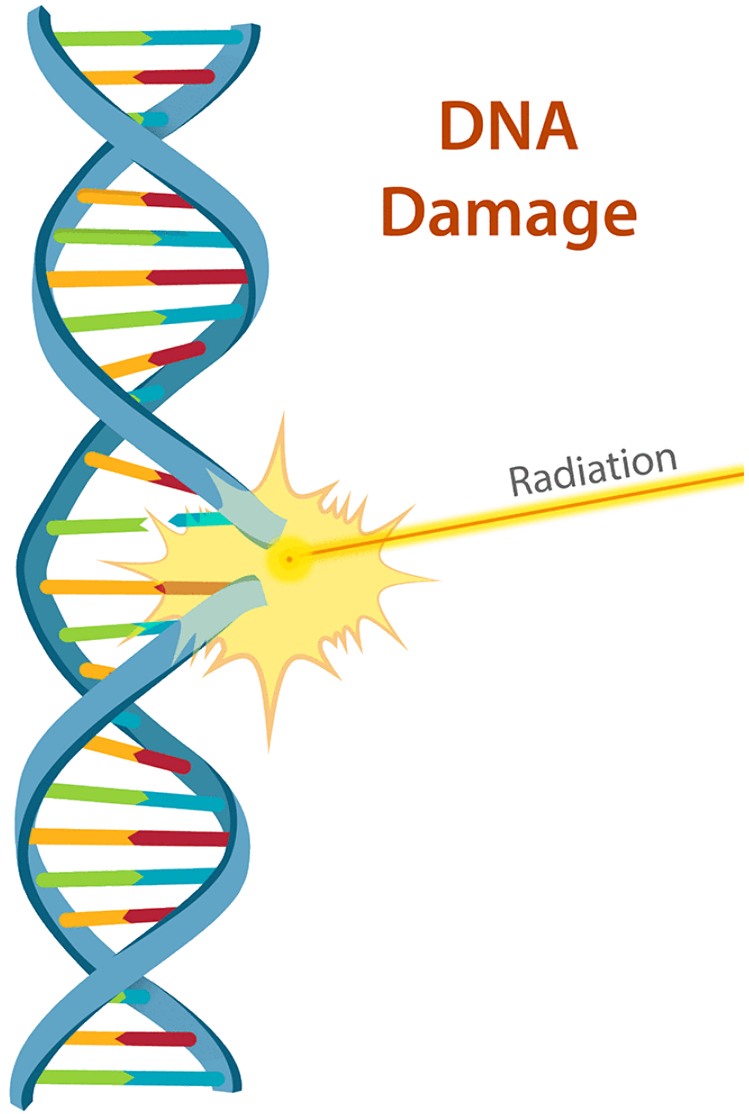
Biological effects in nuclear and radiological accidents

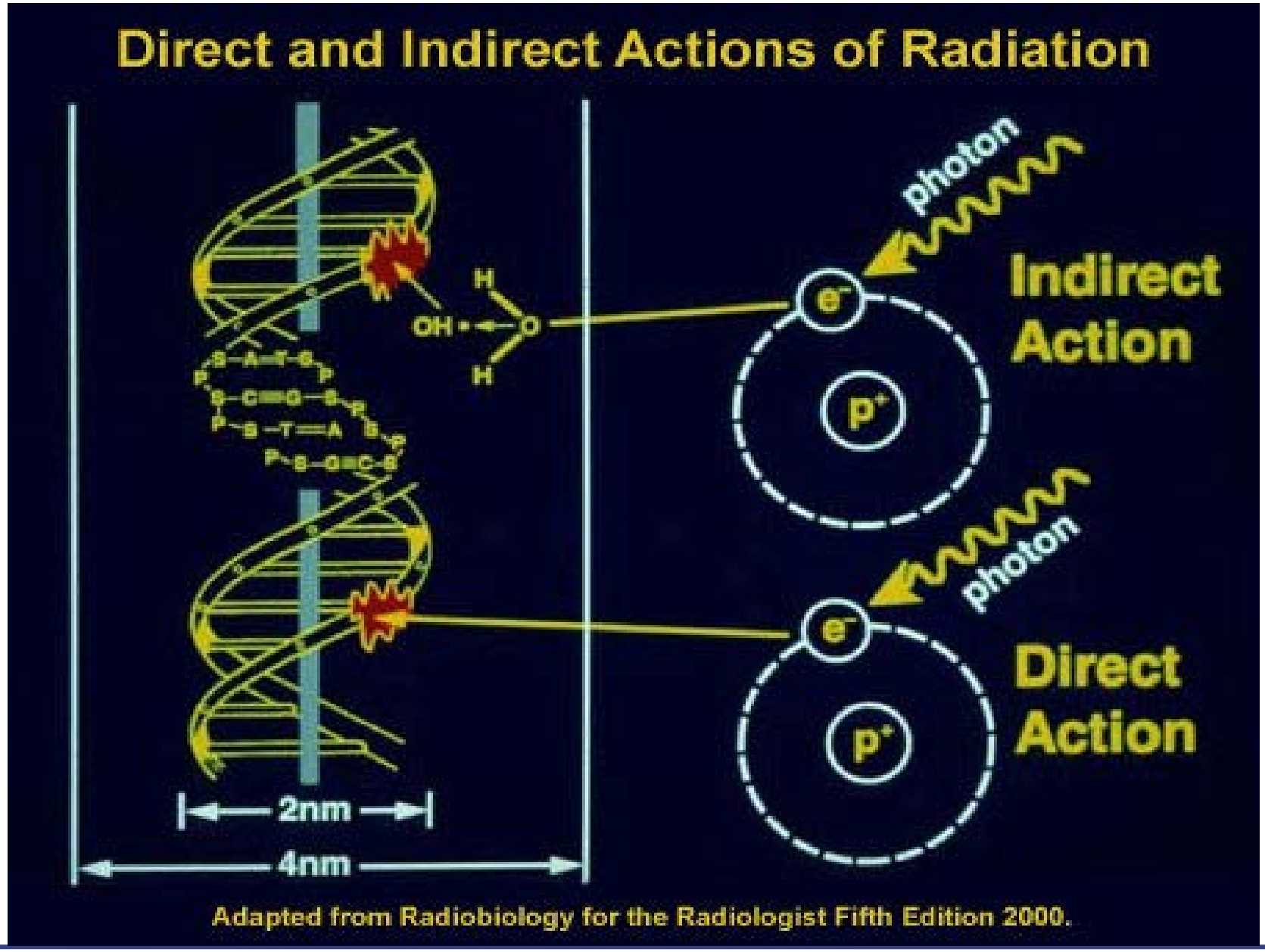


Isabel Bravo

June 15, 2023
EURADOS Annual Meeting
Porto, Portugal

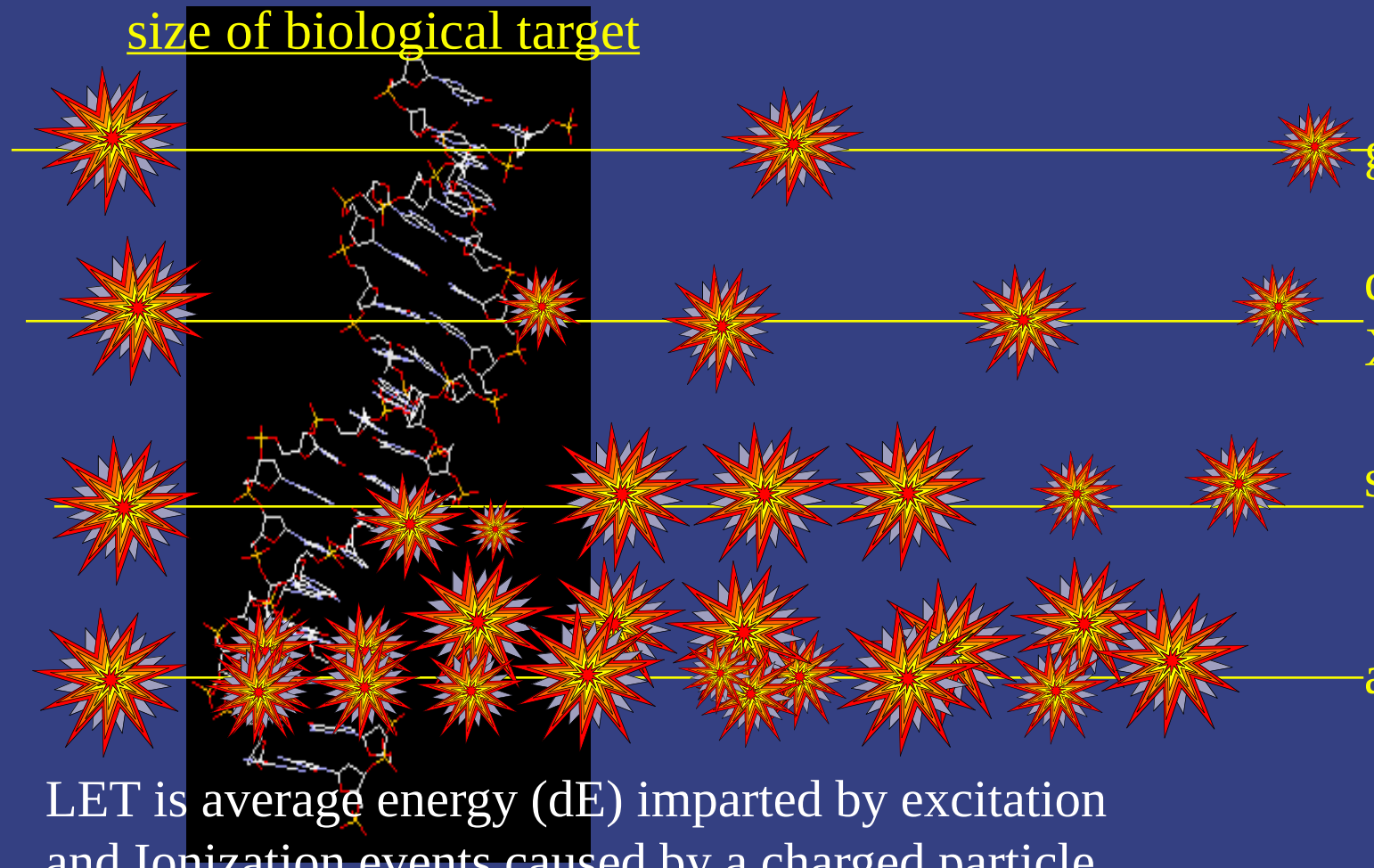



DNA
Damage
Radiation


Direct and Indirect Actions of Radiation
photon
Indirect Action
photon
Direct Action
2nm
4nm
Adapted from Radiobiology for the Radiologist Fifth Edition 2000.

LINEAR ENERGY TRANSFER

Separation of ion clusters in relation to size of biological target



LOW LET Radiation

gamma rays

deep therapy X-rays

soft X-rays

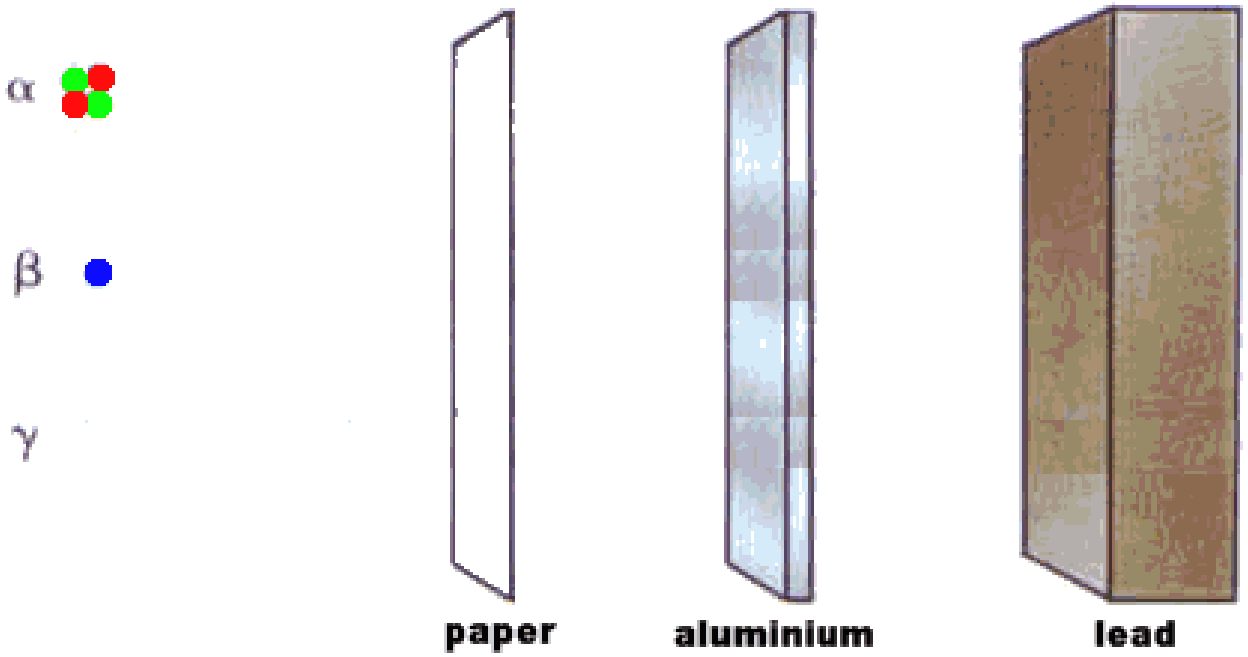
alpha-particle

HIGH LET Radiation

LET is average energy (dE) imparted by excitation and Ionization events caused by a charged particle traveling a set distance (dl) - LET = dE/dl (keV/ μm)

EURADOS

IPOPORTO



radiação α – high ionization,
low penetration

radiação β – low ionization,
average penetration

radiação γ – indirect inization, high penetration

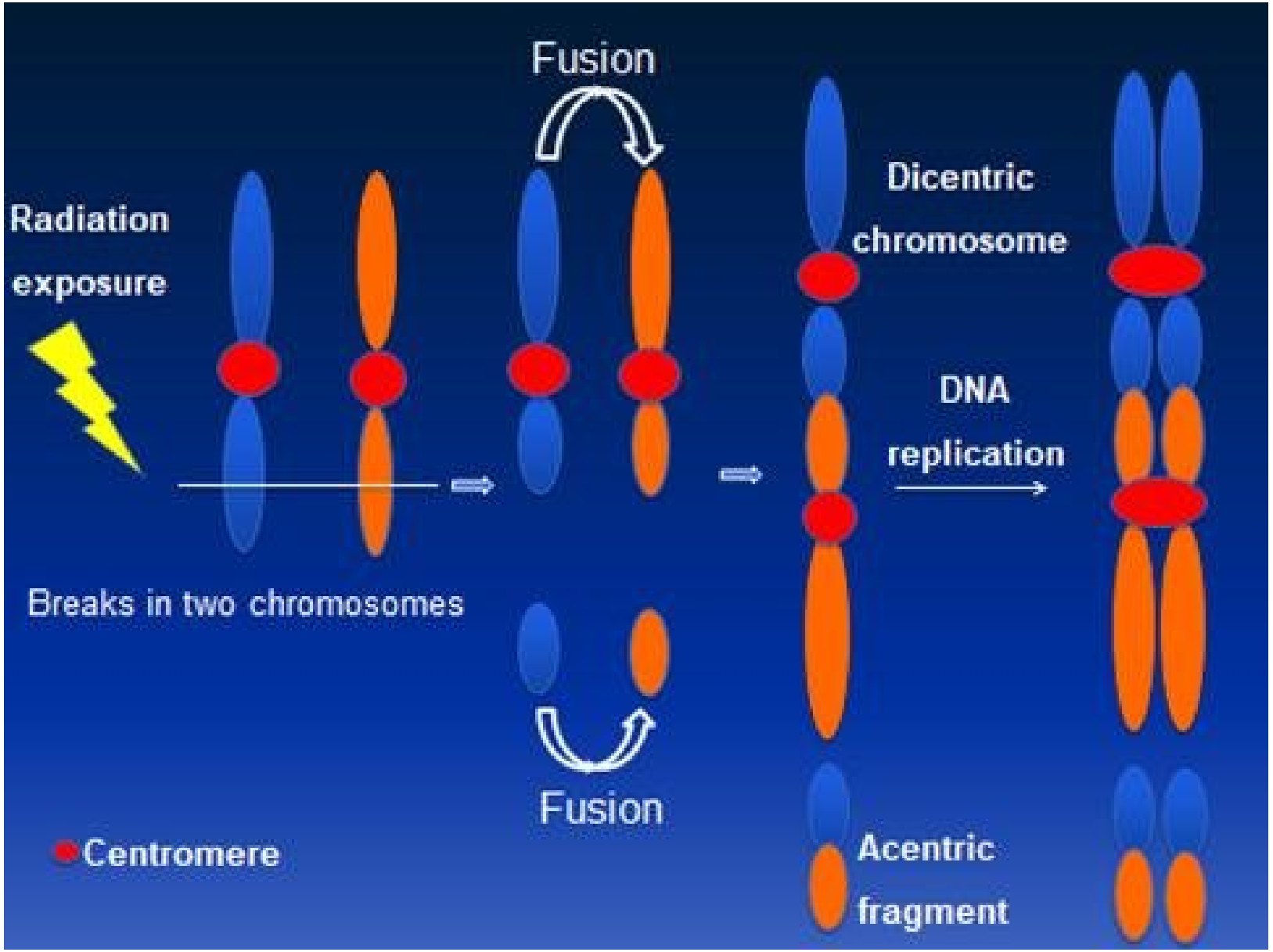
Stages of radiation effects

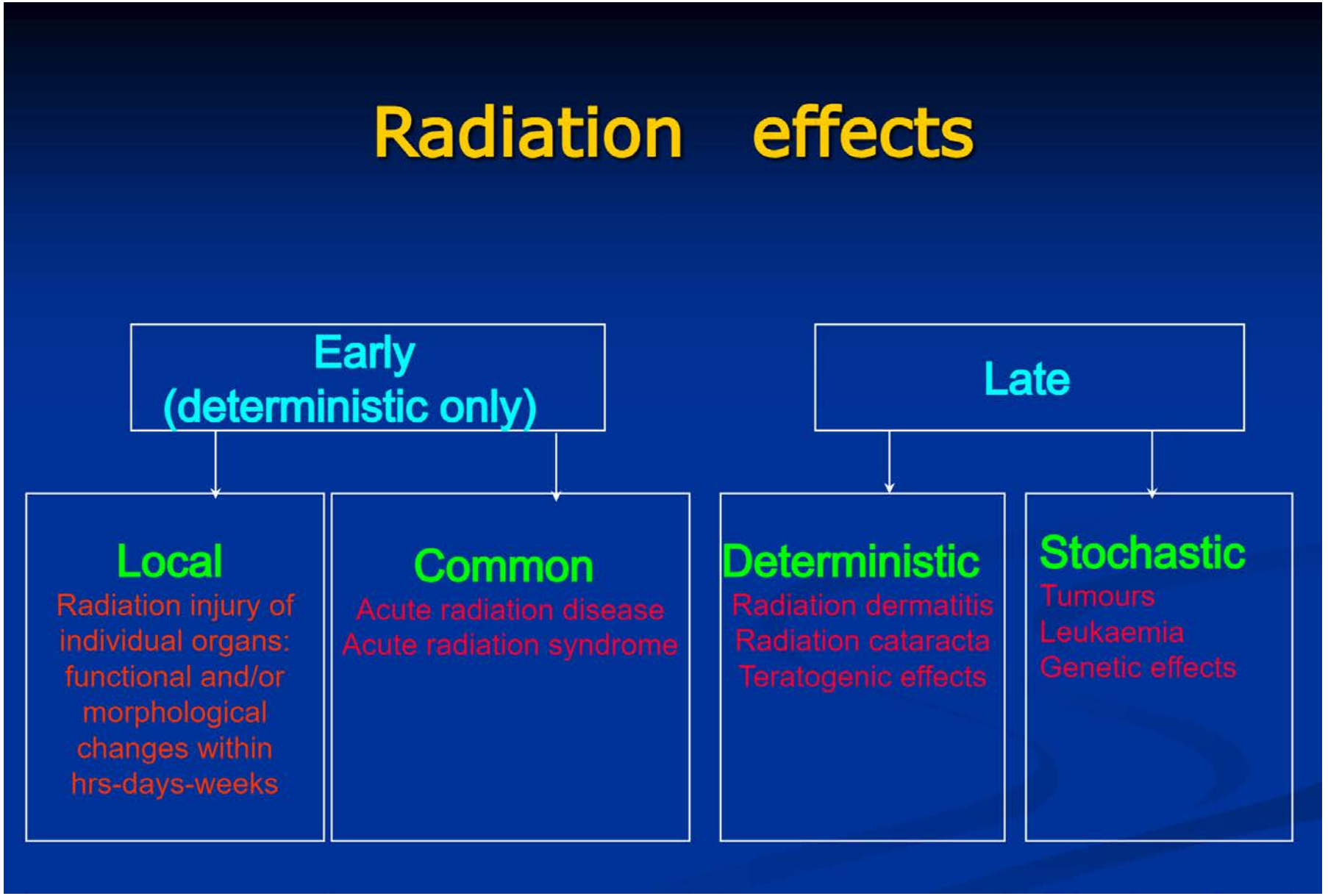
Physical stage: production of ionised molecules 10^{-18} sec

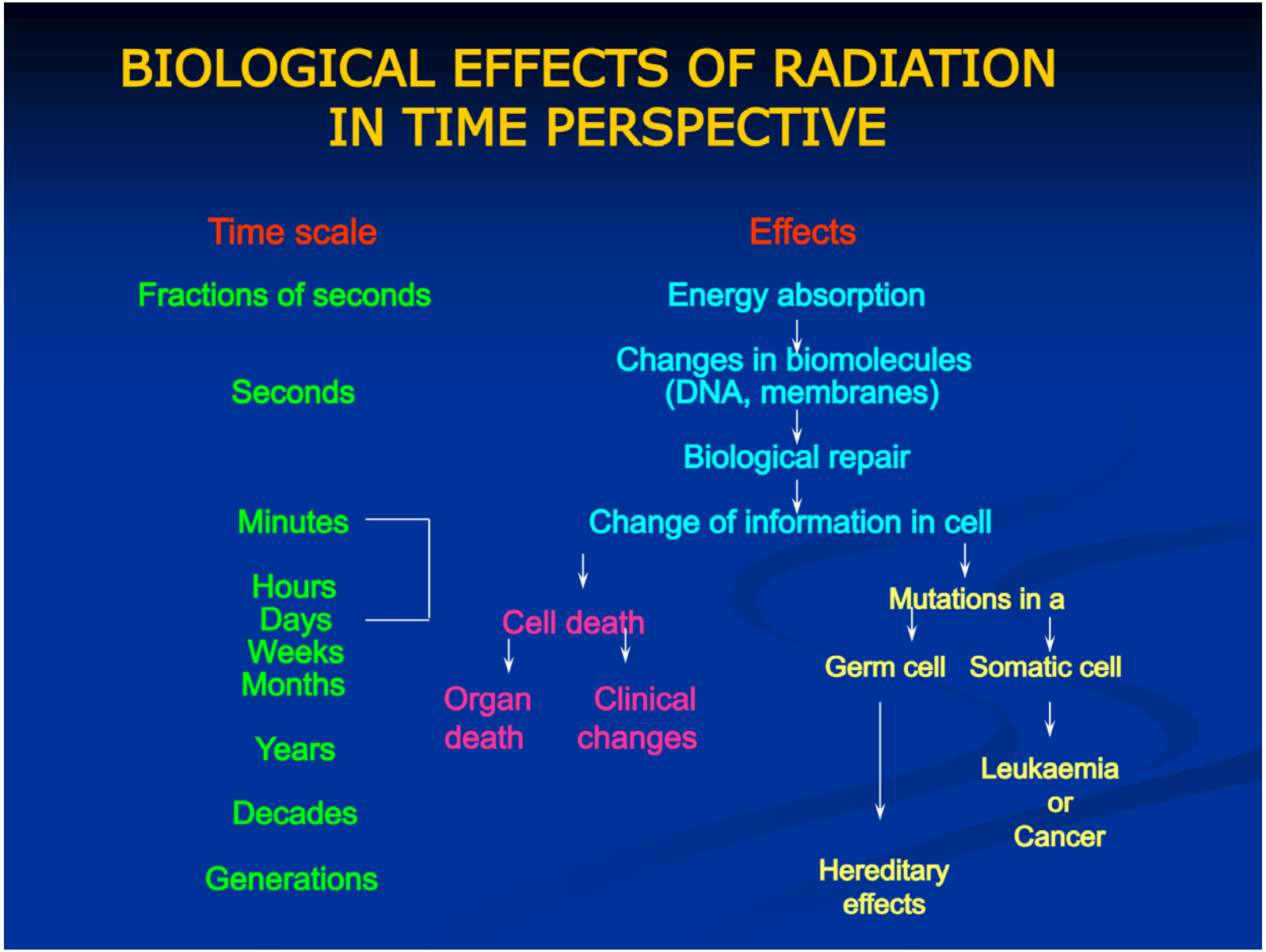
Phys/chemical stage: production of free radicals 10^{-13} sec

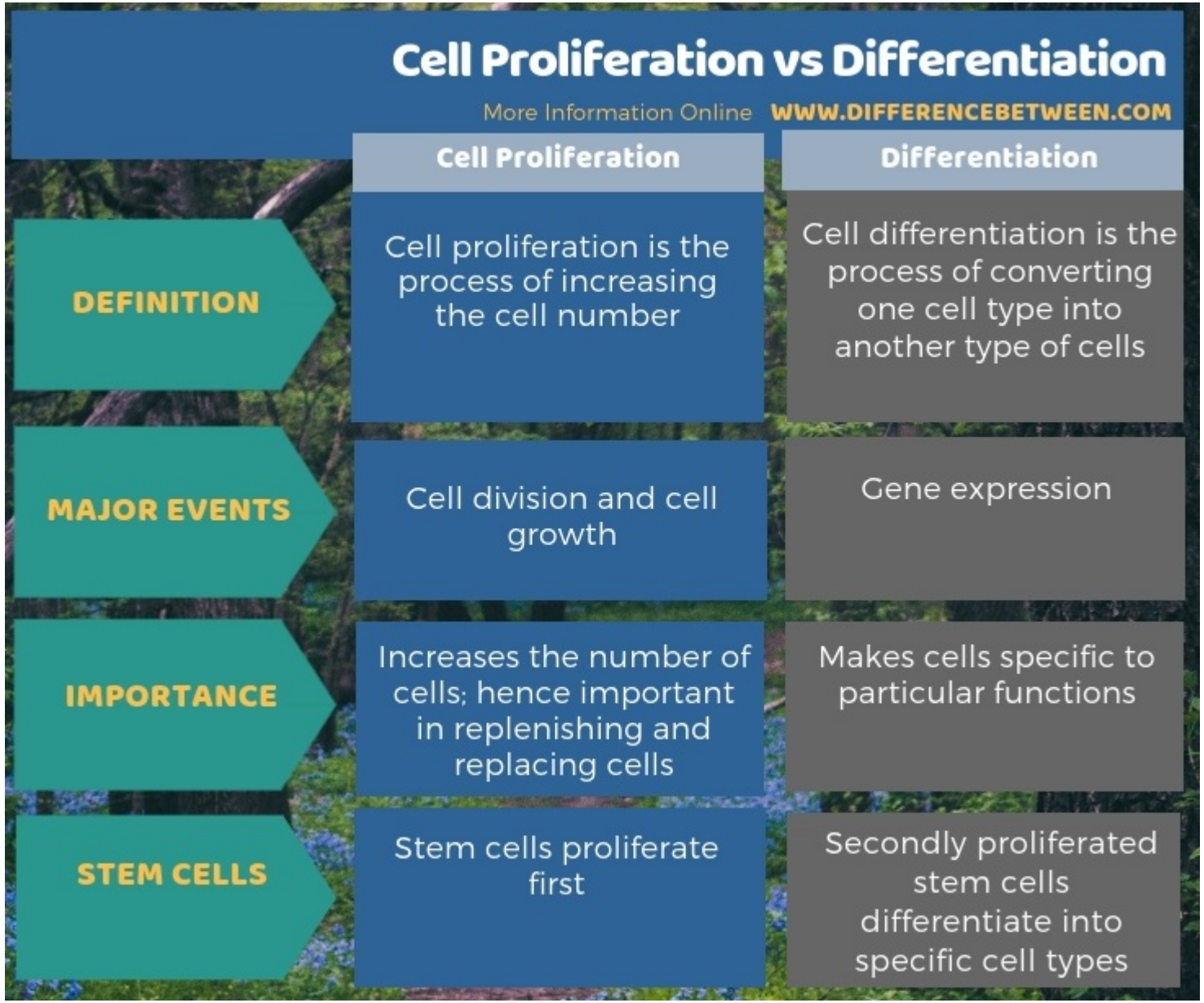
Chemical stage: interaction of rective species with orgs 10^{-6} sec

Biological stage: sequencial response to the chemical products of radiation. from 10^{-6} sec until many years.


Fusion
Radiation exposure
Dicentric chromosome
DNA replication
Breaks in two chromosomes
Fusion
Centromere
Acentric fragment


Radiation effects
Early (deterministic only)
Late
Local
Radiation injury of individual organs: functional and/or morphological changes within hrs-days-weeks
Common
Acute radiation disease
Acute radiation syndrome
Deterministic
Radiation dermatitis
Radiation cataracta
Teratogenic effects
Stochastic
Tumours
Leukaemia
Genetic effects


BIOLOGICAL EFFECTS OF RADIATION
IN TIME PERSPECTIVE
Time scale
Effects
Fractions of seconds
Energy absorption
Changes in biomolecules
(DNA, membranes)
Seconds
Biological repair
Minutes
Change of information in cell
Hours
Days
Weeks
Months
Cell death
Mutations in a
Germ cell
Somatic cell
Organ
death
Clinical
changes
Years
Leukaemia
or
Cancer
Decades
Hereditary
effects
Generations


Cell Proliferation vs Differentiation
More Information Online WWW.DIFFERENCEBETWEEN.COM
Cell Proliferation
Differentiation
DEFINITION
Cell proliferation is the process of increasing the cell number
Cell differentiation is the process of converting one cell type into another type of cells
MAJOR EVENTS
Cell division and cell growth
Gene expression
IMPORTANCE
Increases the number of cells; hence important in replenishing and replacing cells
Makes cells specific to particular functions
STEM CELLS
Stem cells proliferate first
Secondly proliferated stem cells differentiate into specific cell types

Tissue Sensitivity

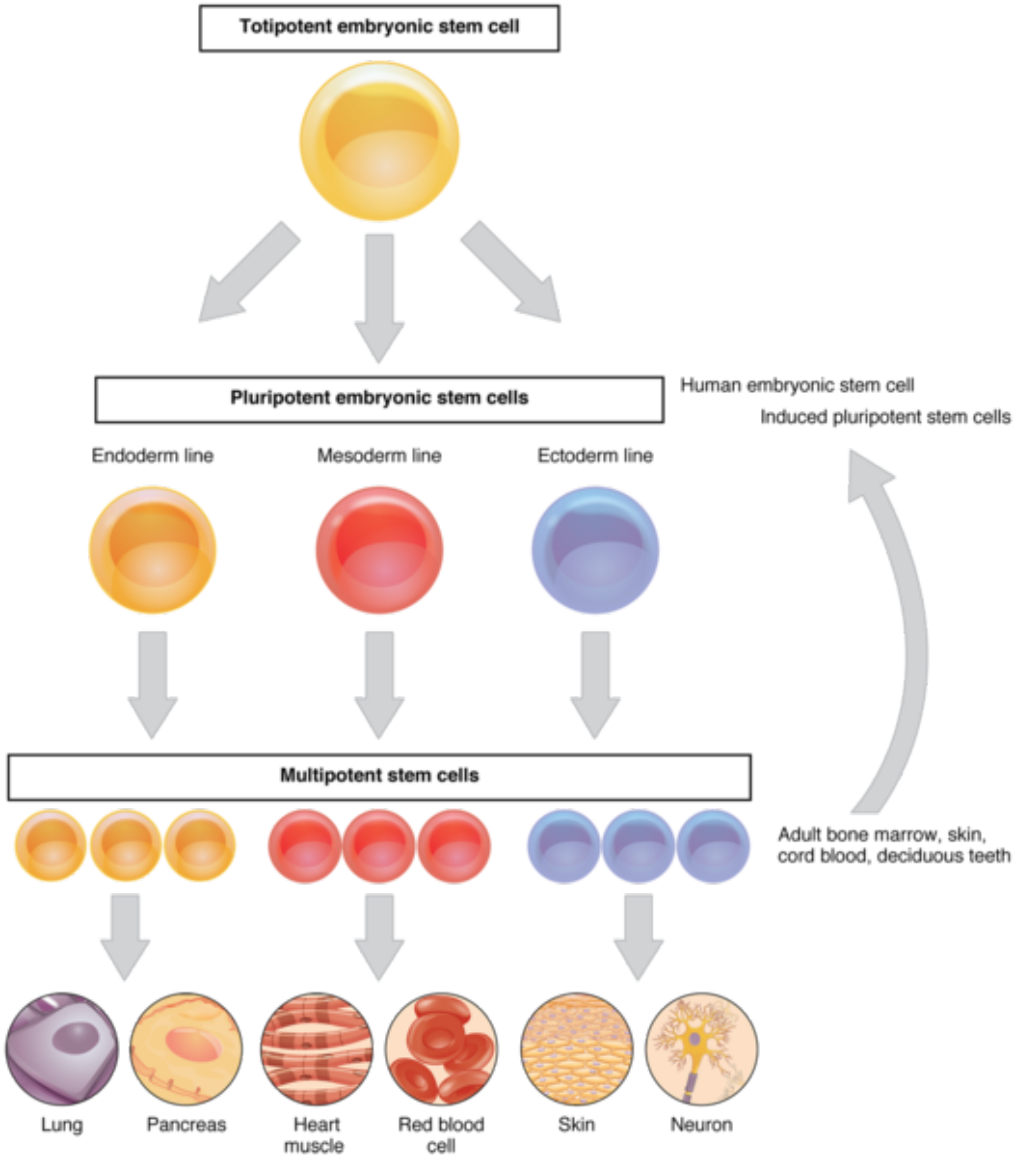
In general, the radiation sensitivity of a tissue is:

- proportional to the rate of proliferation of its cells

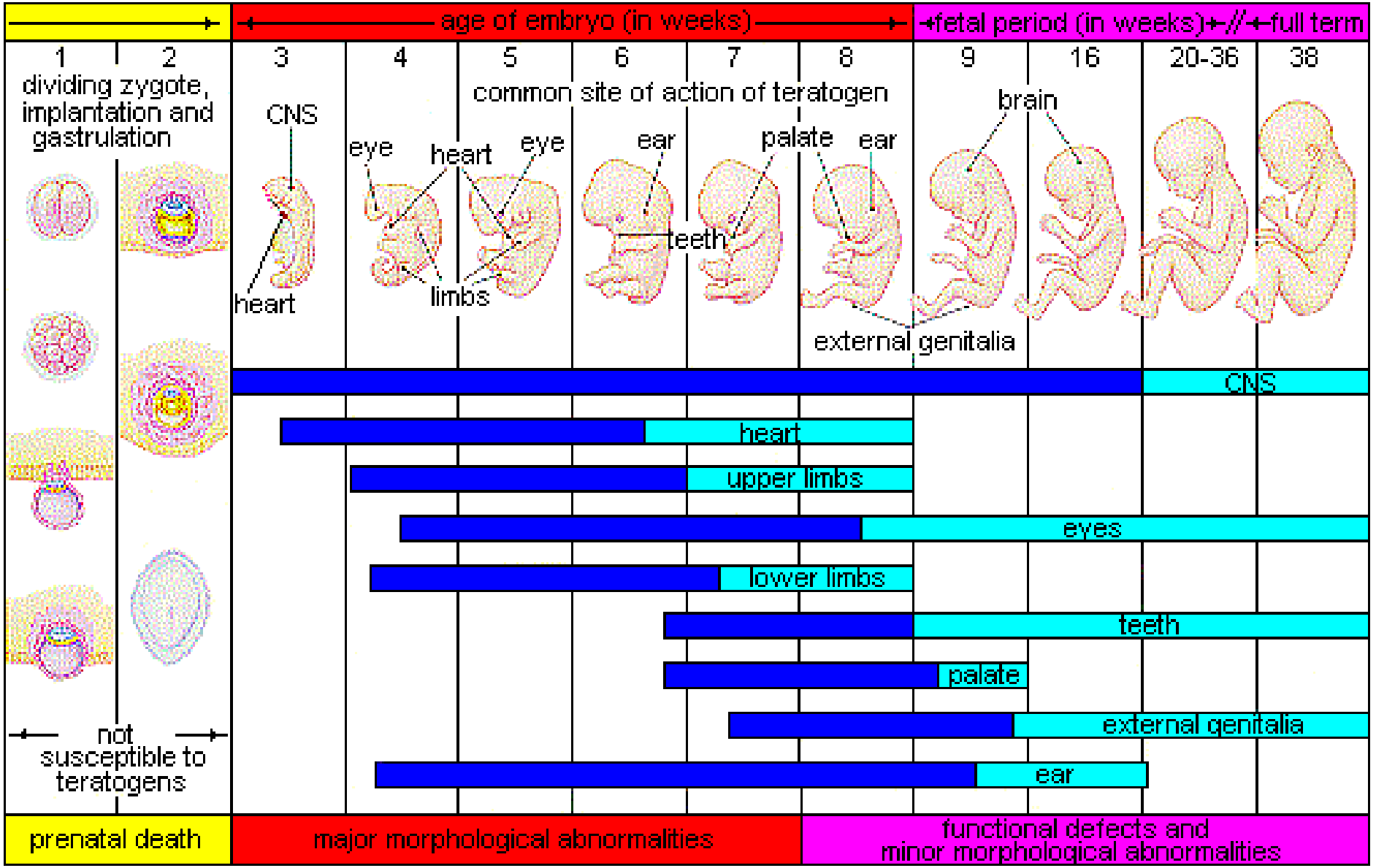
inversely proportional to the degree of cell differentiation

Most Sensitive: Blood-forming organs

- Reproductive organs
- Skin
- Bone and teeth
- Muscle
- **Least sensitive:** Nervous system



Pathology: From the Tissue Level to Clinical Manifestations and Inter-professional Care, Jennifer Kong and Helen Dyck, 2022
https://doi.org/https://doi.org/10.14288/7710-8833



http://dept.clcillinois.edu/psy/LifespanDevelopment.pdf

At the Thyroid Center in Minsk, Belarus, patients get treatment for the destructive effects of radiation to the thyroid gland after being exposed to fallout from the Chernobyl nuclear accident in 1986.

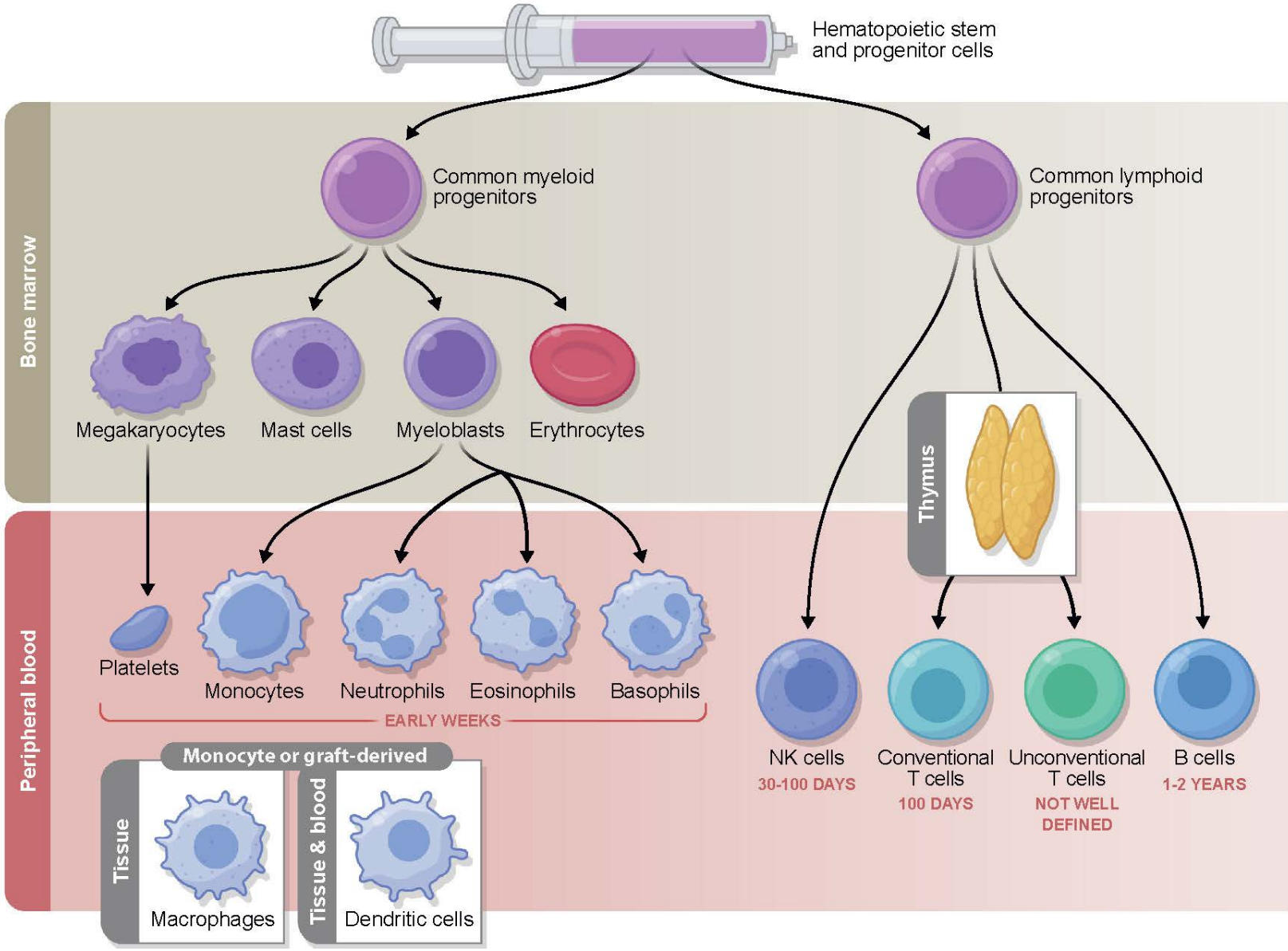
PHOTOGRAPH BY GERD LUDWIG, NAT GEO IMAGE COLLECTION

The NEW ENGLAND JOURNAL of MEDICINE

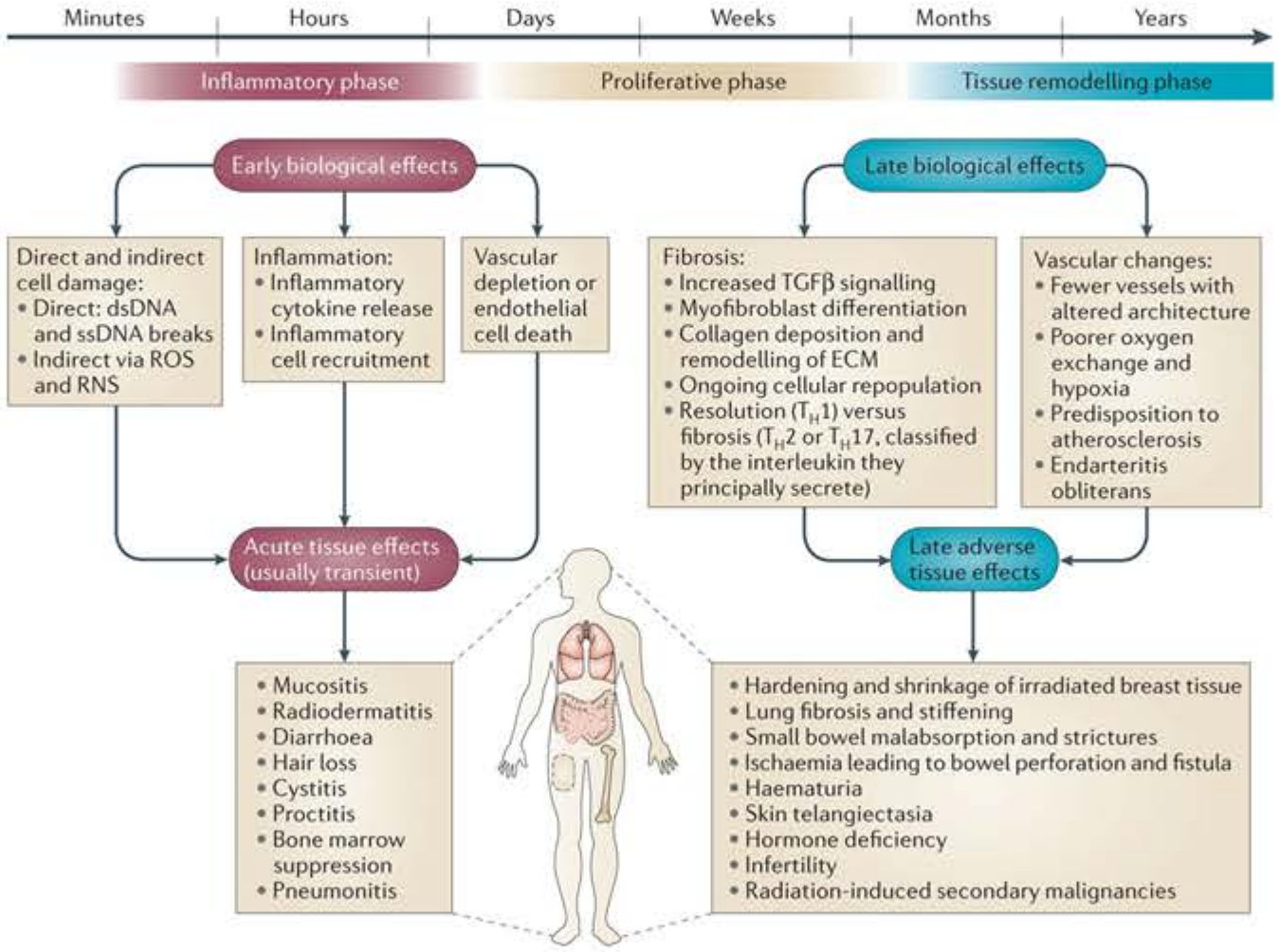
ORIGINAL ARTICLE ARCHIVE

Bone Marrow Transplantation after the Chernobyl Nuclear Accident

Alexandr Baranov, Robert Peter Gale, Angelina Guskova, Evgeny Piatkin, George Selidovkin, Ludmila Muravyova, Richard E. Champlin, Natalia Danilova, Leonora Yevseeva, Ludmila Petrosyan, Svetlana Pushkareva, Michail Konchalovsky, et al.



Andrlová H. *et al*, An Unconventional View of T Cell Reconstitution After Allogeneic Hematopoietic Cell Transplantation. Front Oncol. 2021 Feb 18;10:608923



Nature Reviews | Cancer

Radiation Dose to Adults From Common Imaging Examinations

Procedure		Approximate effective radiation dose (mSv)	Approximate comparable time of natural background radiation exposure
 ABDOMINAL REGION	Computed Tomography (CT) — Abdomen and Pelvis	7.7 mSv	2.6 years
	Computed Tomography (CT) — Abdomen and Pelvis, repeated with and without contrast material	15.4 mSv	5.1 years
	Computed Tomography (CT) — Colonography	6 mSv	2 years
	Intravenous Urogram (IVU))	3 mSv	1 year
	Barium Enema (Lower GI X-ray)	6 mSv	2 years
	Upper GI Study With Barium	6 mSv	2 years
 BONE	Lumbar Spine	1.4 mSv	6 months
	Extremity (hand, foot, etc.) X-ray	< 0.001 mSv	< 3 hours
 CENTRAL NERVOUS SYSTEM	Computed Tomography (CT) — Brain	1.6 mSv	7 months
	Computed Tomography (CT) — Brain, repeated with and without contrast material	3.2 mSv	13 months
	Computed Tomography (CT) — Head and Neck	1.2 mSv	5 months
	Computed Tomography (CT) — Spine	8.8 mSv	3 years

	CHEST	Computed Tomography (CT) — Chest	6.1 mSv	2 years
		Computed Tomography (CT) — Lung Cancer Screening	1.5 mSv	6 months
		Chest X-ray	0.1 mSv	10 days
	DENTAL	Dental X-ray	0.005 mSv	1 day
		Panoramic X-Ray	0.025 mSv	3 days
		Cone Beam CT	0.18 mSv	22 days
	HEART	Coronary Computed Tomography Angiography (CTA)	8.7 mSv	3 years
		Cardiac CT for Calcium Scoring	1.7 mSv	6 months
		Non-Cardiac Computed Tomography Angiography (CTA)	5.1 mSv	< 2 years
	MEN'S IMAGING	Bone Densitometry (DEXA)	0.001 mSv	3 hours
	NUCLEAR MEDICINE	Positron Emission Tomography — Computed Tomography (PET/CT) Whole body protocol	22.7 mSv	7.6 years
	WOMEN'S IMAGING	Bone Densitometry (DEXA)	0.001 mSv	3 hours
		Screening Digital Mammography	0.21 mSv	26 days
		Screening Digital Breast Tomosynthesis (3D Mammogram)	0.27 mSv	33 days

RSNA® Radiological Society of North America

ACR® American College of Radiology

IAEA International Atomic Energy Agency

INES

THE INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE

INES Level	People and Environment	
Major Accident Level 7	• Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures	
Serious Accident Level 6	• Significant release of radioactive material likely to require implementation of planned countermeasures	
Accident with Wider Consequences Level 5	• Limited release of radioactive material likely to require implementation of some planned countermeasures. • Several deaths from radiation	
Accident with Local Consequences Level 4	• Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. • At least one death from radiation.	
Serious Accident Level 3	• Exposure in excess of ten times the statutory annual limit for workers. • Non-lethal deterministic health effect (e.g., burns) from radiation.	
Incident Level 2	• Exposure of a member of the public in excess of 10 mSv. • Exposure of a worker in excess of the statutory annual limit	
Anomaly Level 1		
NO SAFETY SIGNIFICANCE (Below Scale/Level 0)		

www.iaea.org

www.icrp.org

www.unscear.org

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