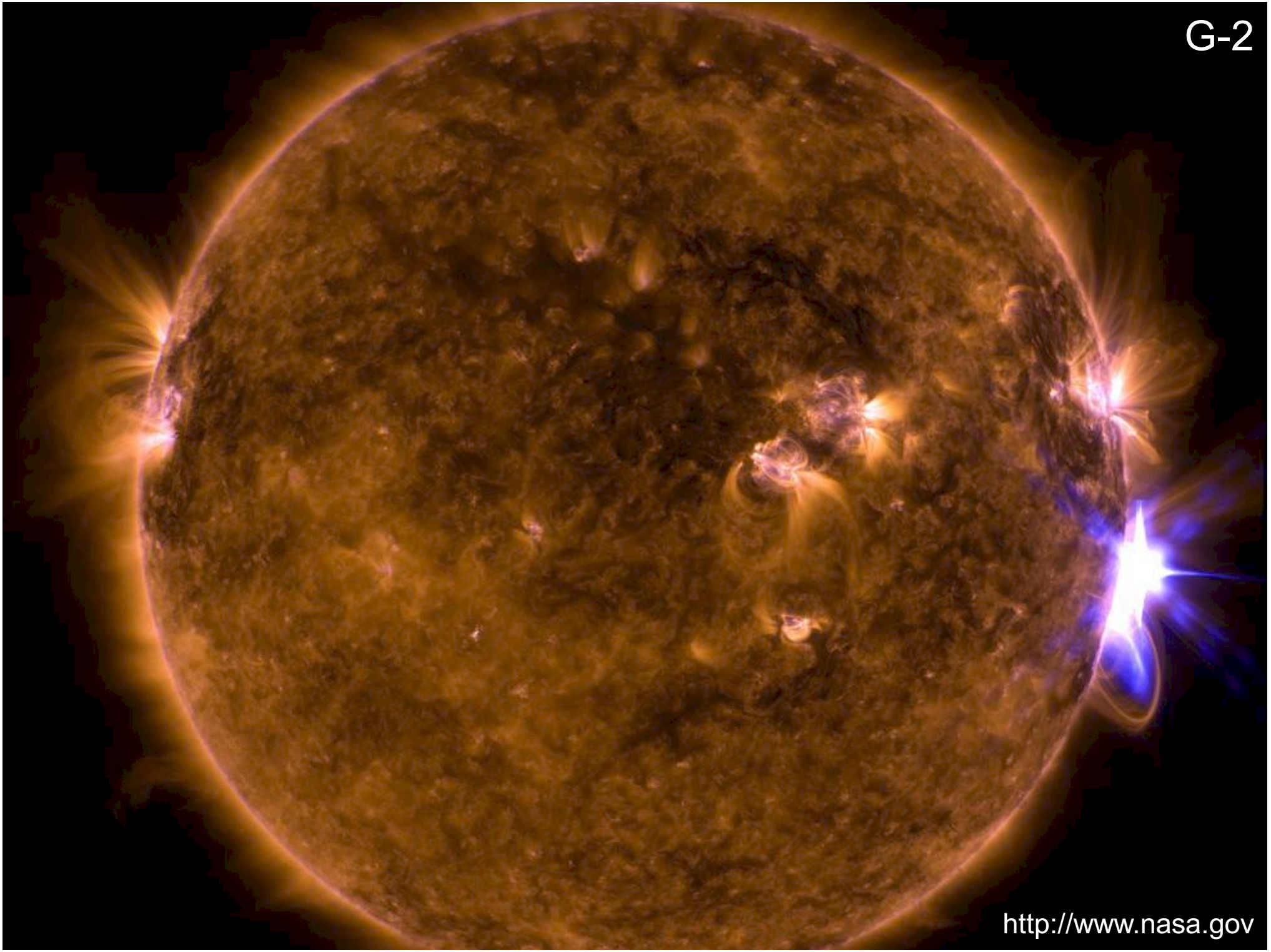
Radiation Safety Course

(School of Science, University of Tokyo)

Biological Effects of Radiation to Human Body

Autumn-Winter 2020


G-2
http://www.nasa.gov

G-3

SOLAR PHYSICS

A physics-based method that can predict imminent large solar flares

Kanya Kusano[1]*, Tomoya Iju[2], Yumi Bamba[1,3], Satoshi Inoue[1]

Solar flares are highly energetic events in the Sun's corona that affect Earth's space weather. The mechanism that drives the onset of solar flares is unknown, hampering efforts to forecast them, which mostly rely on empirical methods. We present the κ-scheme, a physics-based model to predict large solar flares through a critical condition of magnetohydrodynamic instability, triggered by magnetic reconnection. Analysis of the largest (X-class) flares from 2008 to 2019 (during solar cycle 24) shows that the κ-scheme predicts most imminent large solar flares, with a small number of exceptions for confined flares. We conclude that magnetic twist flux density, close to a magnetic polarity inversion line on the solar surface, determines when and where solar flares may occur and how large they can be.

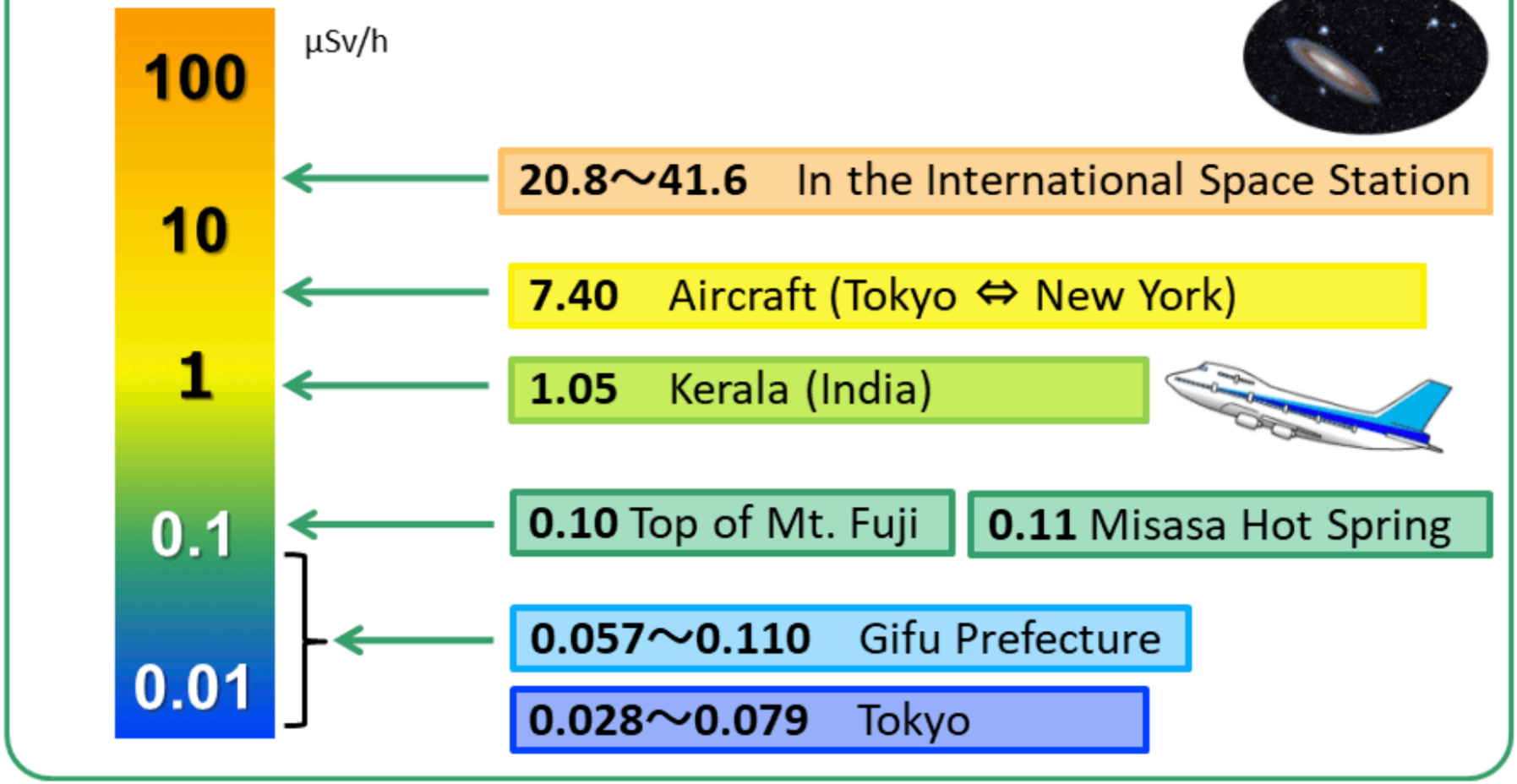
Emissions and Effects by Solar Flares

Emissions	Field	Main effects
Electromagnetic radiations	Earth's ionosphere	X-ray causes an increase of electron density in D-layer and short-wave fadeout.
High-energy particles	Outer space, Earth's ionosphere in the high latitudes and polar regions	Protons and electrons captured in the Earth's magnetosphere cause an increase of radiation dose in the radiation belts and may damage astronauts in space, aircrafts flying at high altitude and satellites. In high latitudes and polar regions, precipitation of protons and electrons into the atmosphere causes an increase of electron density in D-layer and a disturbance of HF radio communications.
Plasmas	Earth's magnetosphere	Inflow of plasmas by the interaction with the magnetosphere causes auroras, geomagnetic storms and network disturbance by ionospheric storm.

Adapted from Wikipedia

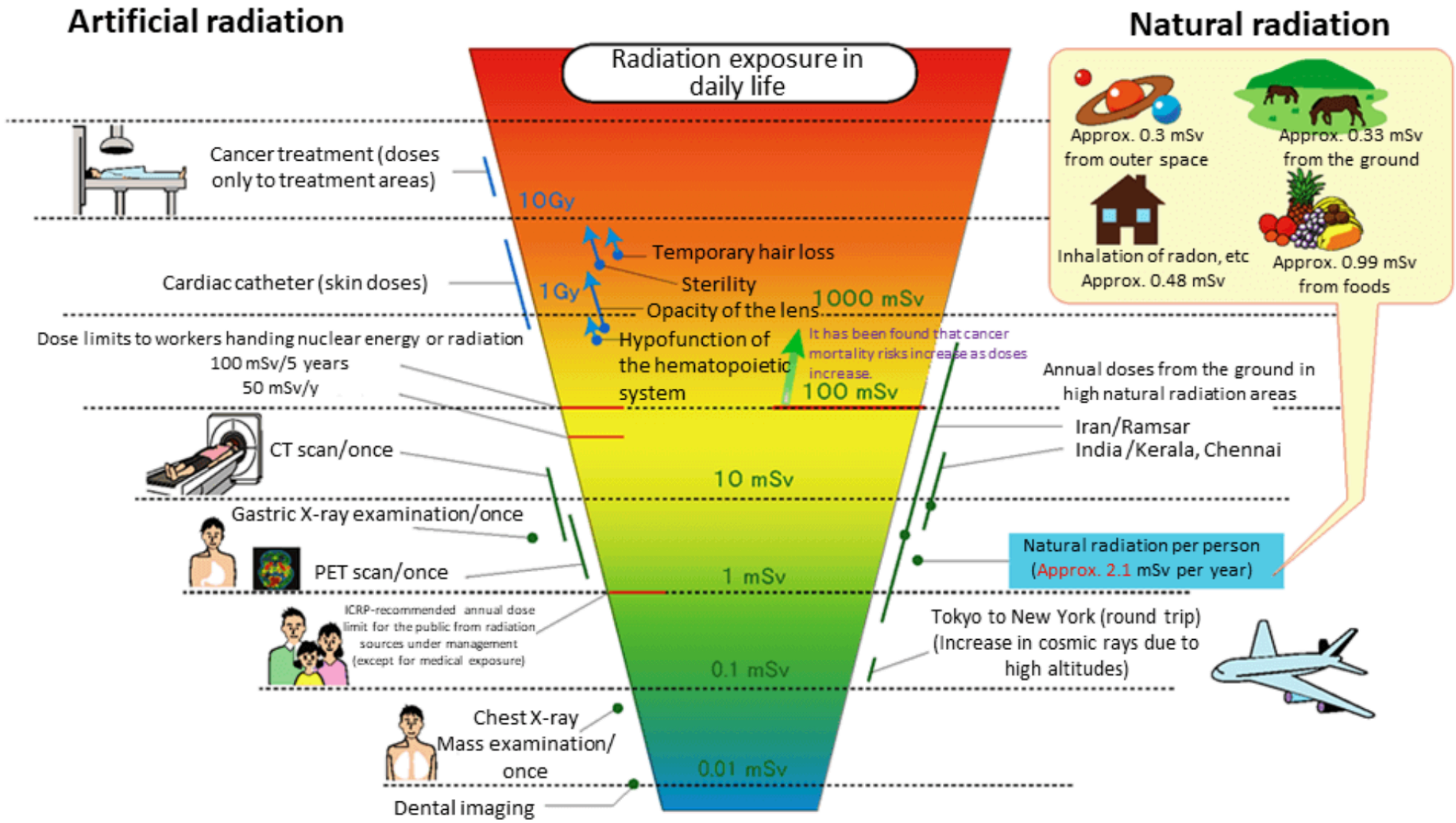
Radiation around Us Comparison of Exposure Doses per Hour

Comparison of ambient dose rates



Sources: Prepared based on "Radiation Exposure Management," the website of the JAXA Space Station Kibo PR Center, 2013; "Japanese Internet System for Calculation of Aviation Route Doses (JISCARD)," the website of the National Institute of Radiological Sciences; "Research on Ambient Gamma-ray Doses in the Environment," the website of the National Institute of Radiological Sciences; Furuno, p.25-33 of the 51st report of the Balneological Laboratory, Okayama University, 1981; and Nuclear Regulation Authority Radiation Monitoring Information (range of previous average values at monitoring posts)

Comparison of Exposure Doses (Simplified Chart)



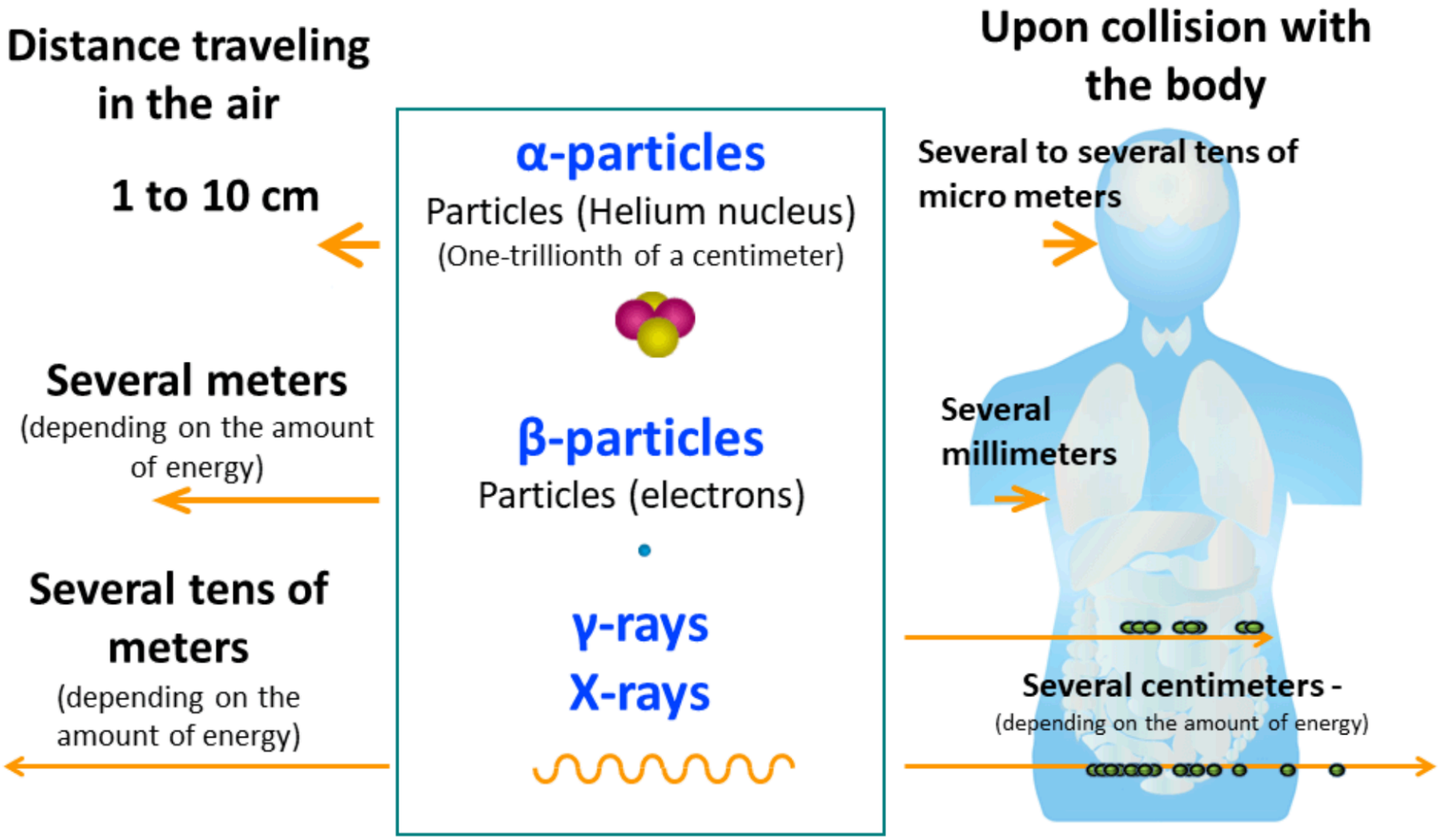
Sources:

- The 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report
- The 2007 ICRP (International Commission on Radiological Protection) Report
- The exposure guideline of the Japan Association of Radiological Technologists
- "Life Environmental Radiation (Calculation of the National Dose)," new edition

Prepared by the National Institute of Radiological Sciences based on the sources above (May 2013)

mSv: millisieverts

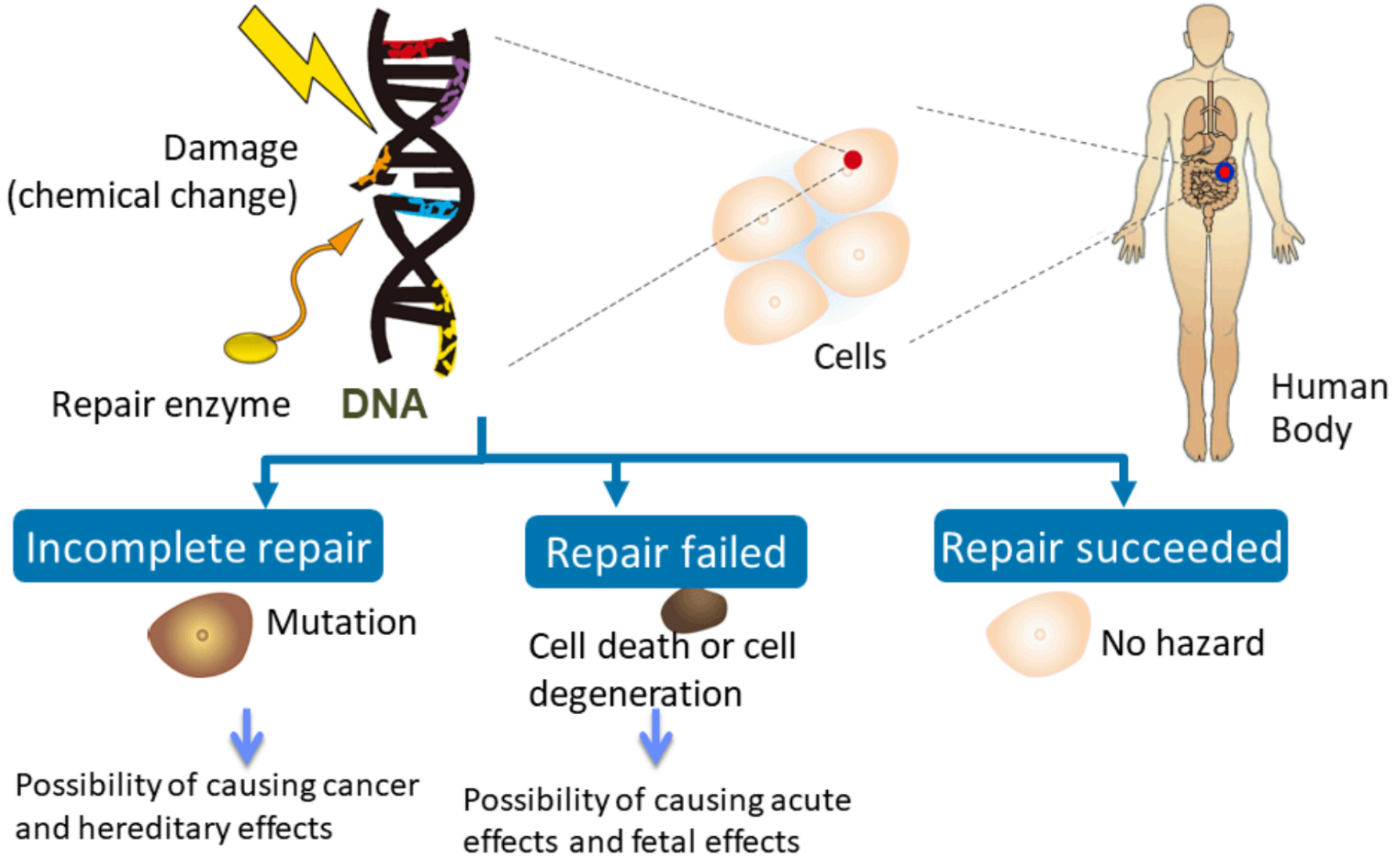
Radiation Penetrating Power of Radiation within the Body



Source: BOOKLET to Provide Basic Information Regarding Health Effects of Radiation
https://www.env.go.jp/en/chemi/rhm/basic-info/

Mechanism of Causing Effects on Human Body

DNA→Cells→Human Body



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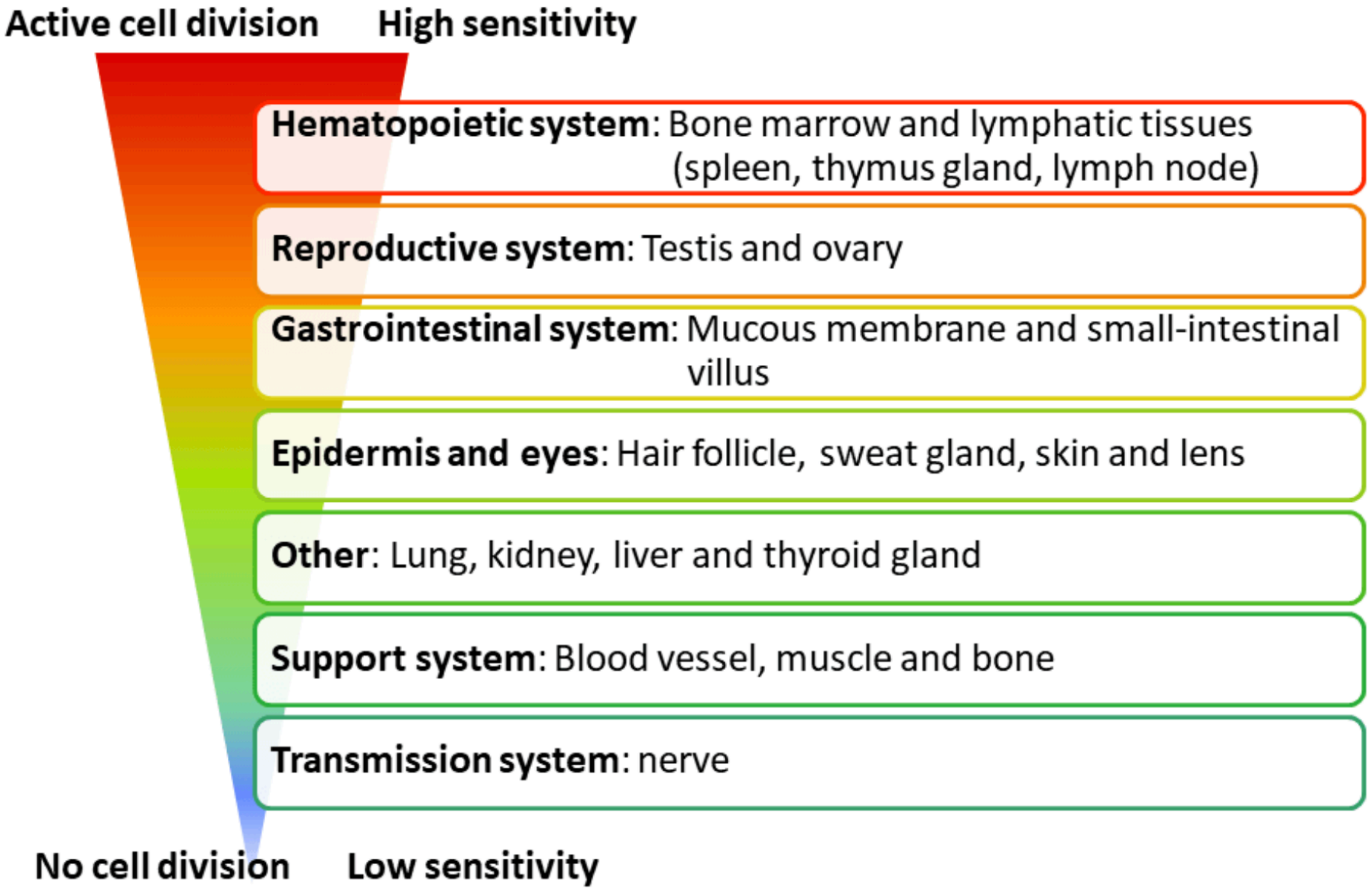
Mechanism of Causing Effects on Human Body

Radiosensitivity of Organs and Tissues



Source: BOOKLET to Provide Basic Information Regarding Health Effects of Radiation
https://www.env.go.jp/en/chemi/rhm/basic-info/

Deterministic Effects

Threshold Values for Various Effects

Threshold acute absorbed doses of γ-rays

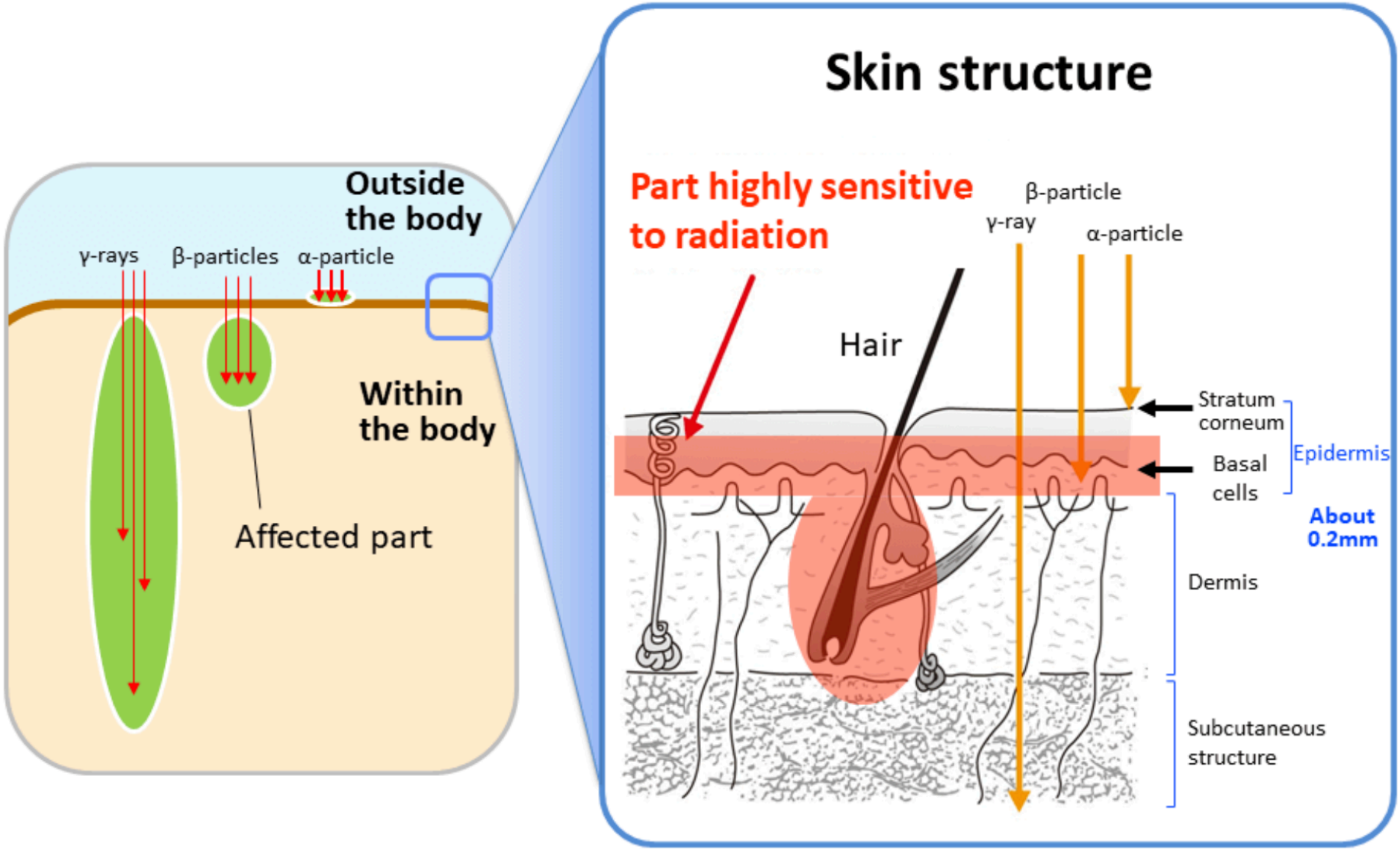
Disorders	Organs/Tissues	Incubation period	Threshold value (Gy)*
Temporary sterility	Testis	3 to 9 weeks	Approx. 0.1
Permanent sterility	Testis	3 weeks	Approx. 6
	Ovary	Within 1 week	Approx. 3
Deterioration of hemopoietic capacity	Bone marrow	3 to 7 days	Approx. 0.5
Skin rubor	Skin (large area)	1 to 4 weeks	3 to 6 or lower
Skin burn	Skin (large area)	2 to 3 weeks	5 to 10
Temporary hair loss	Skin	2 to 3 weeks	Approx. 4
Cataract (failing vision)	Eyes	20 years or longer	Approx. 0.5

* Threshold doses for symptoms with clear clinical abnormalities (doses causing effects on 1% of people)

Source: 2007 Recommendations of the International Commission on Radiological Protection (ICRP), and ICRP Report 118 (2012)

Exposure Routes

External Exposure and Skin



Source: BOOKLET to Provide Basic Information Regarding Health Effects of Radiation
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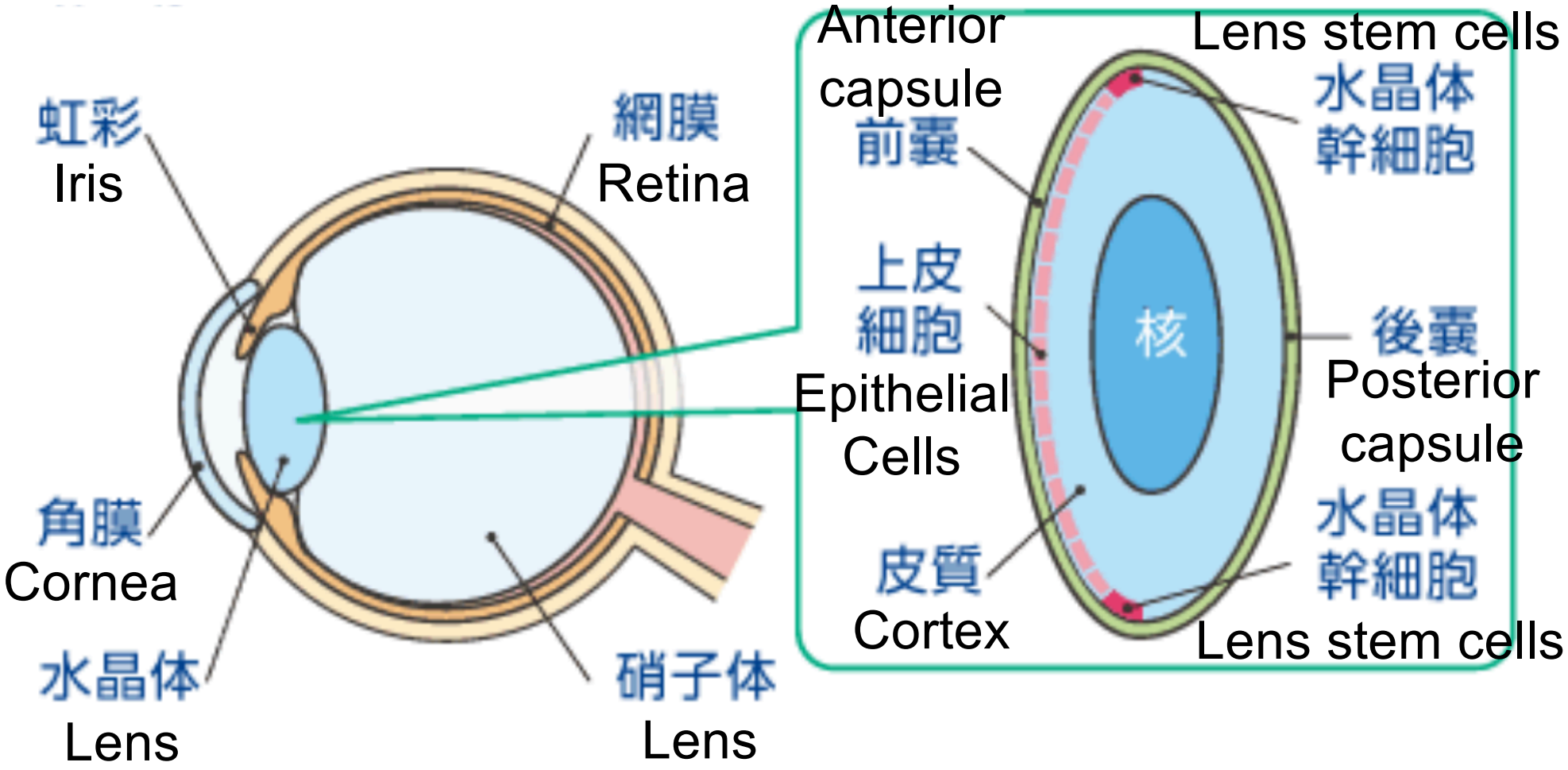
Structure of the Eyes and Lens



Adapted from Hoshina Corporation website
https://www.hoshina.co.jp

Equivalent Dose Limits to the Lens

Currently…

150 mSv/year
(Based on the ICRP 1990 Recommendations)

Up to 7.5 times

From next April…

Annual Average of 20 mSv for 5 years
（With no single year >50 mSv）
（ICRP Statement in 2011）

Question 2

From next April, the equivalent dose limits to the lens of the eye will be renewed to…

Annual average of ○○ mSv for 5 years
(With no single year >○○ mSv)