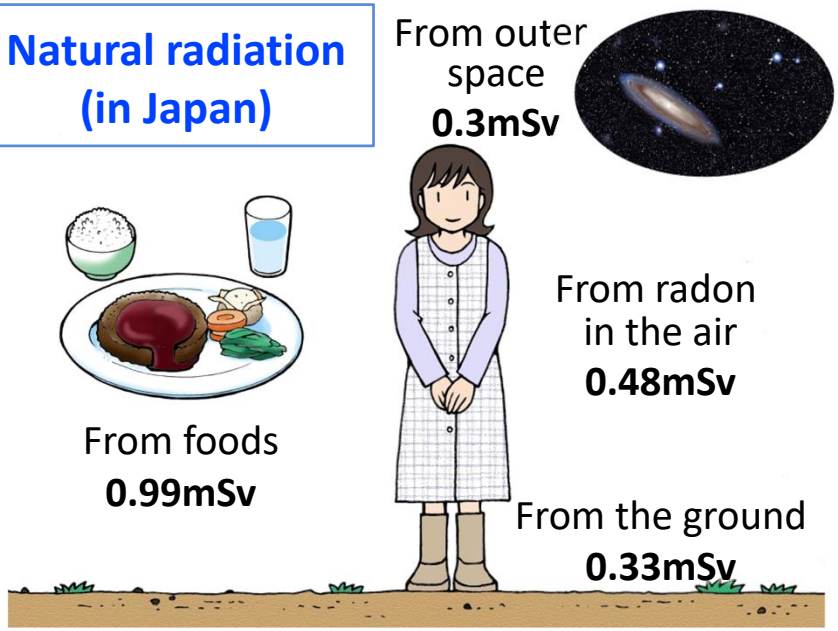
Radiation around Us

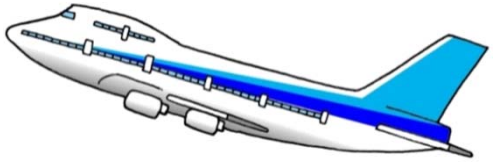
# Exposure Dose from Natural and Artificial Radiation

## Natural radiation (in Japan)




Annual dose from natural radiation (Japanese average): 2.1 mSv

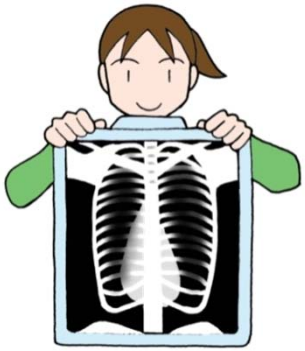
Annual dose from natural radiation (global average): 2.4 mSv



**Tokyo to New York Air travel (round trip)** **0.11～0.16mSv**

## Artificial radiation

**Chest CT scan (single scan)** **2.4～12.9mSv**



**Chest X-ray scan (single scan)** **0.06mSv**

mSv: millisieverts

Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; and "Environmental Radiation in Daily Life (2011)," new edition, Nuclear Safety Research Association; ICRP (International Commission on Radiological Protection) 103, etc.

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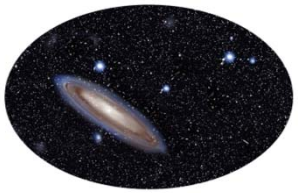
# Comparison of Exposure Doses per Hour

## Comparison of ambient dose rates



μSv/h

100

10

1

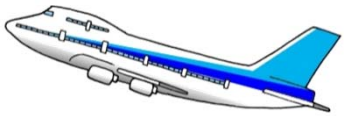
0.1

0.01

**20.8～41.6** In the International Space Station

**7.40** Aircraft (Tokyo ⇔ New York)

**1.05** Kerala (India)



**0.10** Top of Mt. Fuji

**0.11** Misasa Hot Spring

**0.057～0.110** Gifu Prefecture

**0.028～0.079** Tokyo

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)

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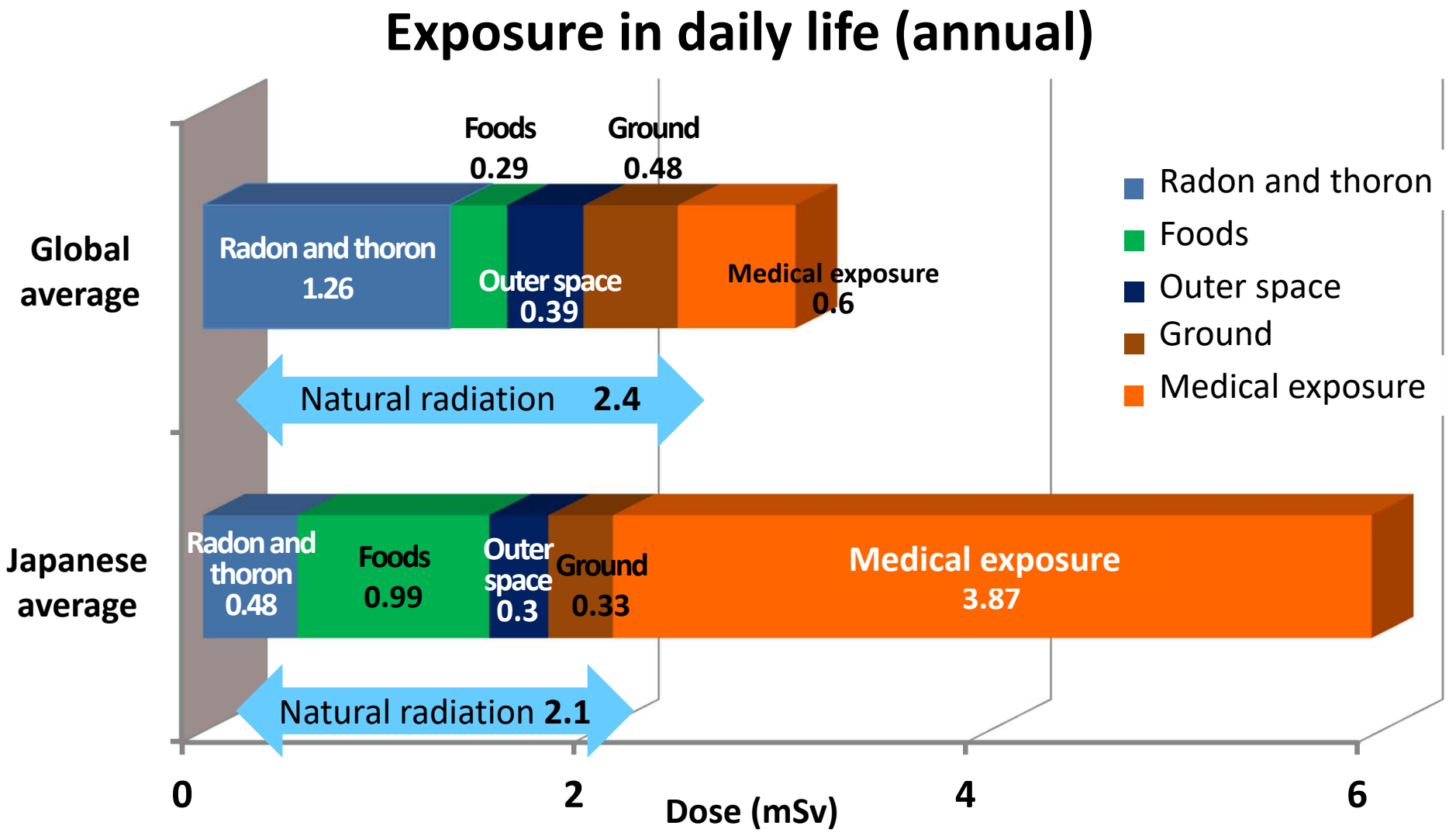
# Comparison of Exposure Doses per Year




Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; and "Environmental Radiation in Daily Life (2011)," Nuclear Safety Research Association

# Breakdown of Natural Exposure Doses (Japanese)

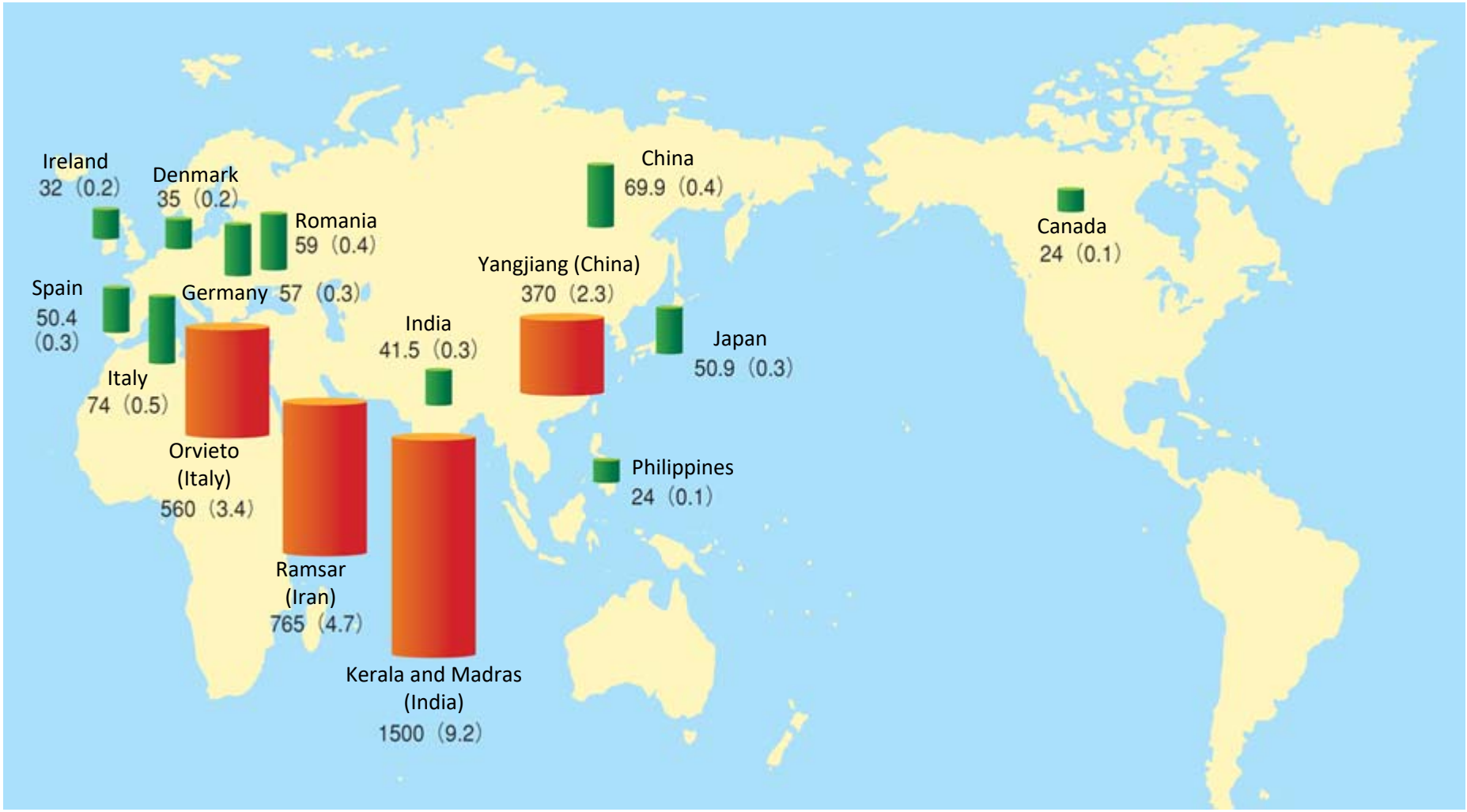
| Type of exposure | Breakdown of radiation sources | Effective dose (mSv/year) |
|---|---|---|
| External exposure | Cosmic rays | **0.3** |
| | Ground radiation | **0.33** |
| Internal exposure (inhalation) | Radon-222 (indoors and outdoors) | **0.37** |
| | Radon-220 (thoron) (indoors and outdoors) | **0.09** |
| | Smoking (Lead-210, Polonium-210, etc.) | **0.01** |
| | Others (uranium, etc.) | **0.006** |
| Internal exposure (ingestion) | Mainly Lead-210 and Polonium-210 | **0.80** |
| | Tritium | **0.0000082** |
| | Carbon-14 | **0.01** |
| | Potassium-40 | **0.18** |
| **Total** | | **2.1** |

Source: "Environmental Radiation in Daily Life (2011)," Nuclear Safety Research Association

# Ground Radiation (World)

Nanograys/h (mSv/y)

0.7 Sv/gray is used in conversion to effective doses.

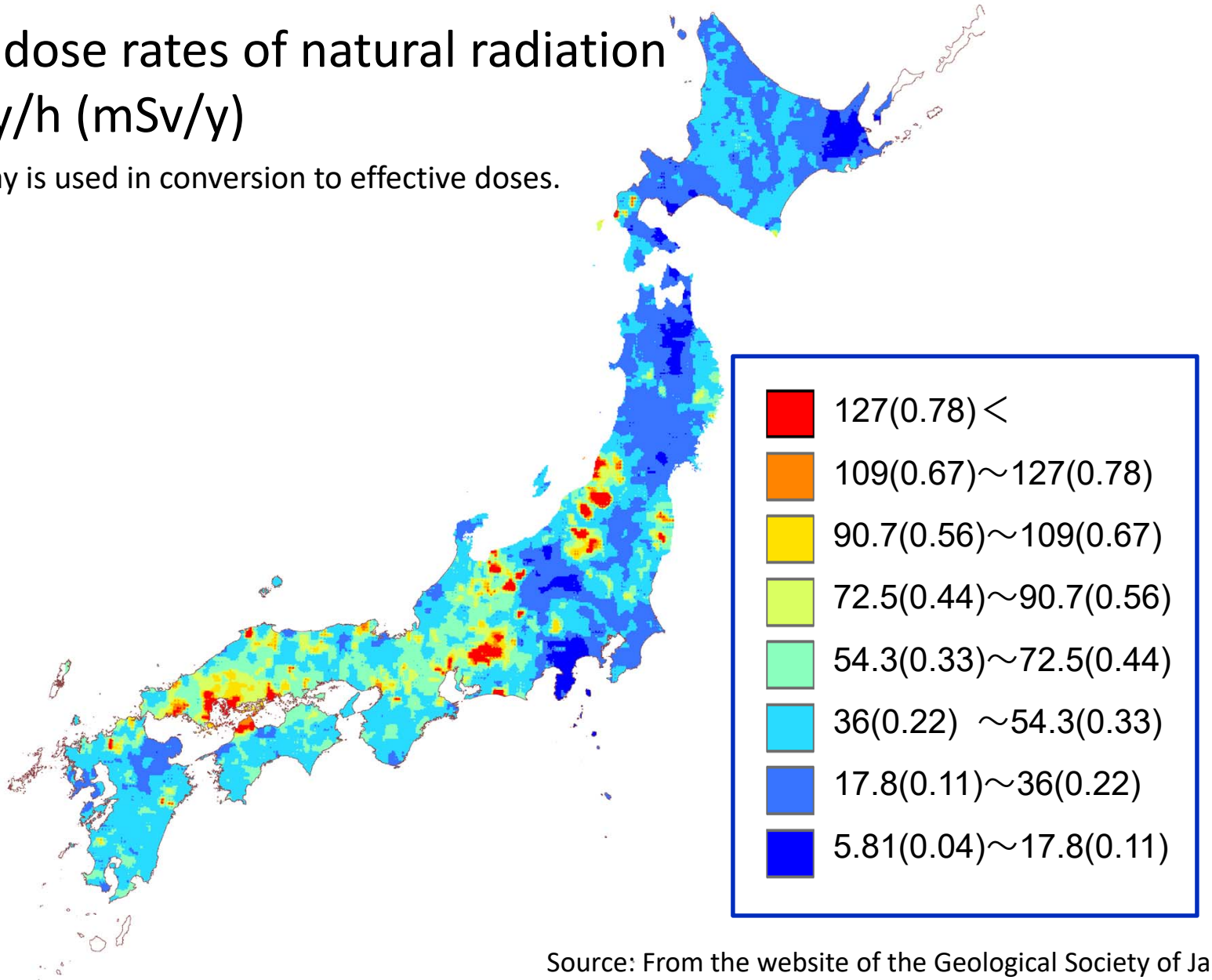



Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; and "Environmental Radiation in Daily Life (2011)," Nuclear Safety Research Association

# Ground Radiation (Japan)

## Ambient dose rates of natural radiation Nanogray/h (mSv/y)

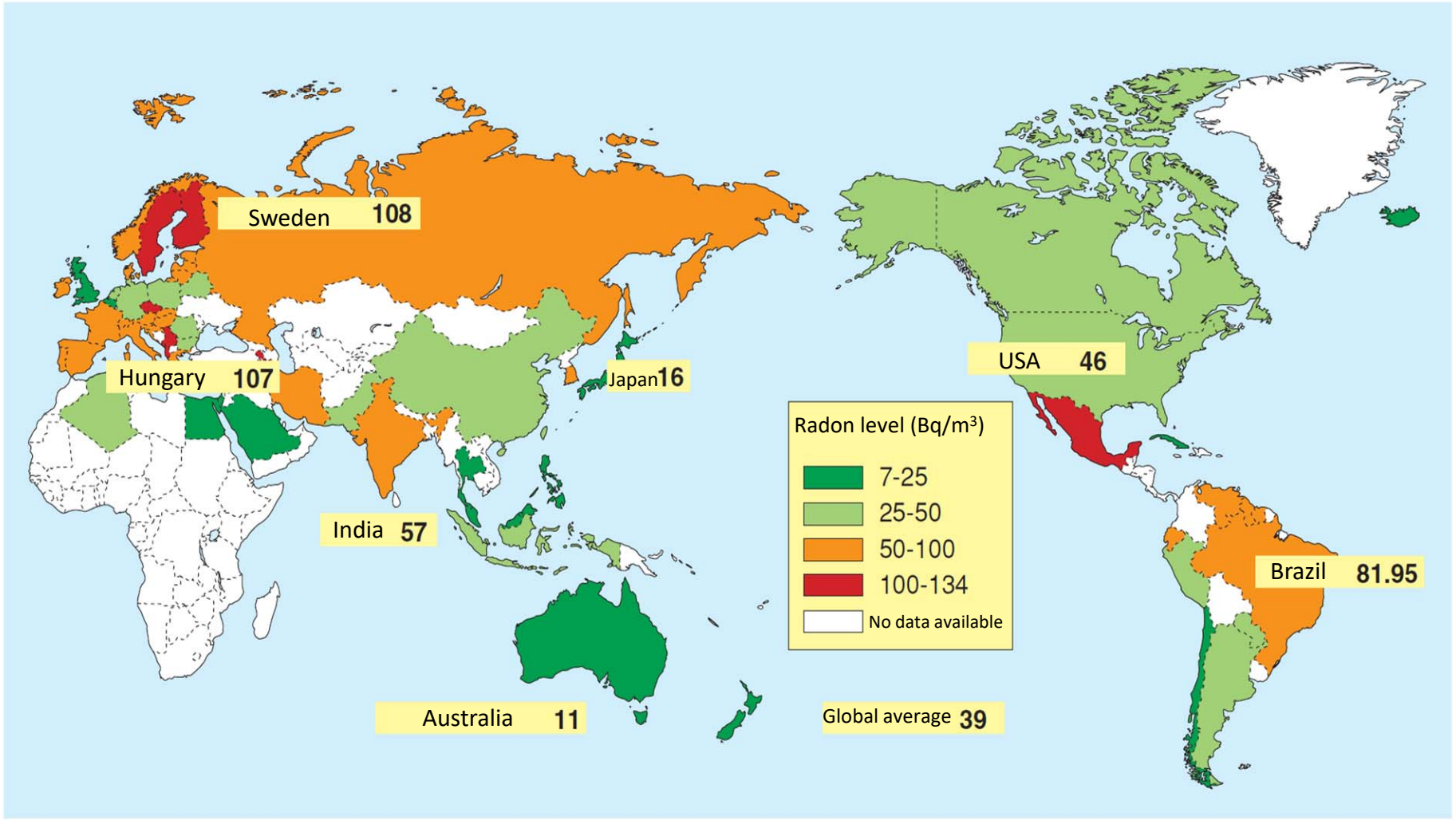
- 0.7 Sv/gray is used in conversion to effective doses.




Source: From the website of the Geological Society of Japan

# Indoor Radon

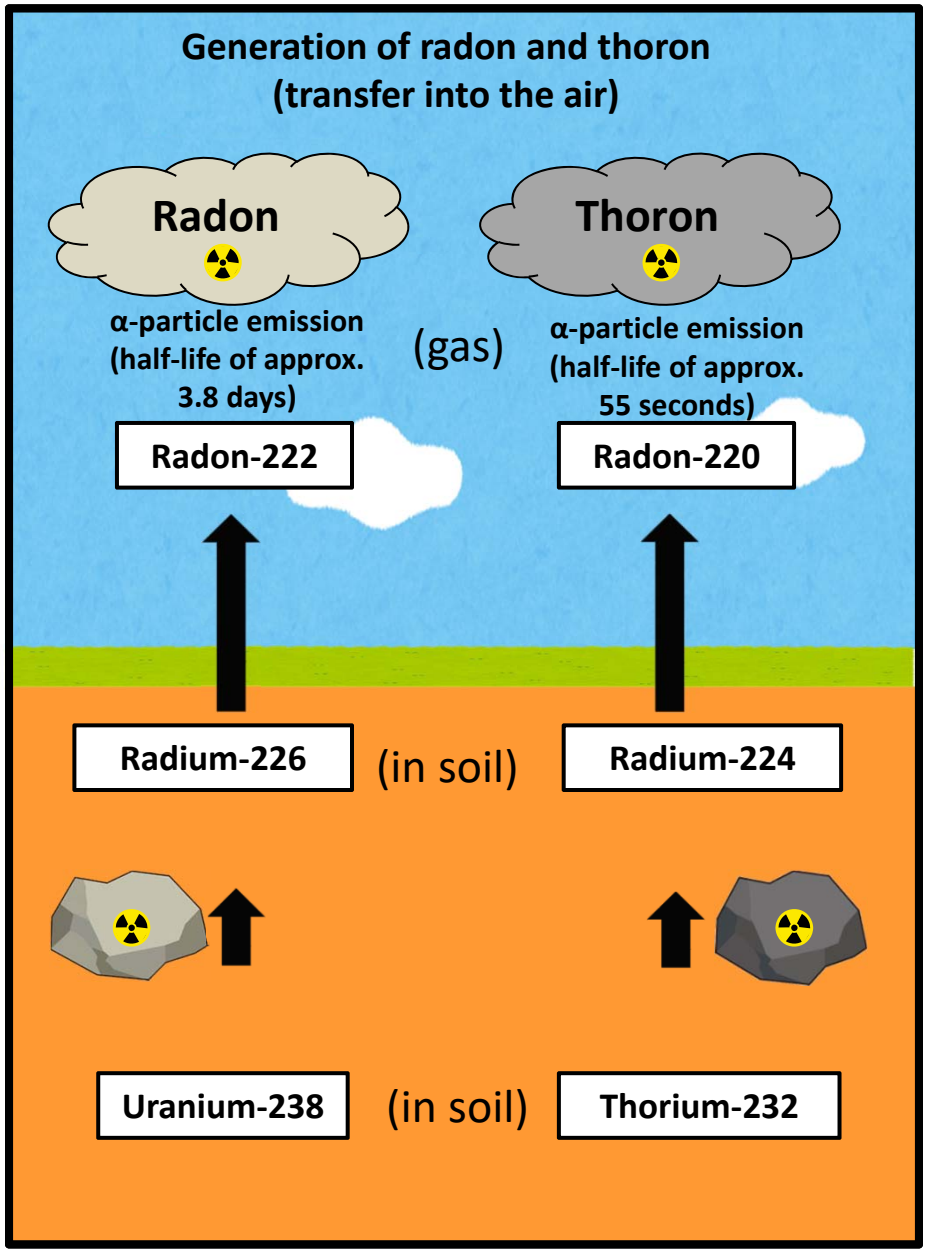
Regional differences in exposure from indoor radon (arithmetic average: **Bq/m3**)

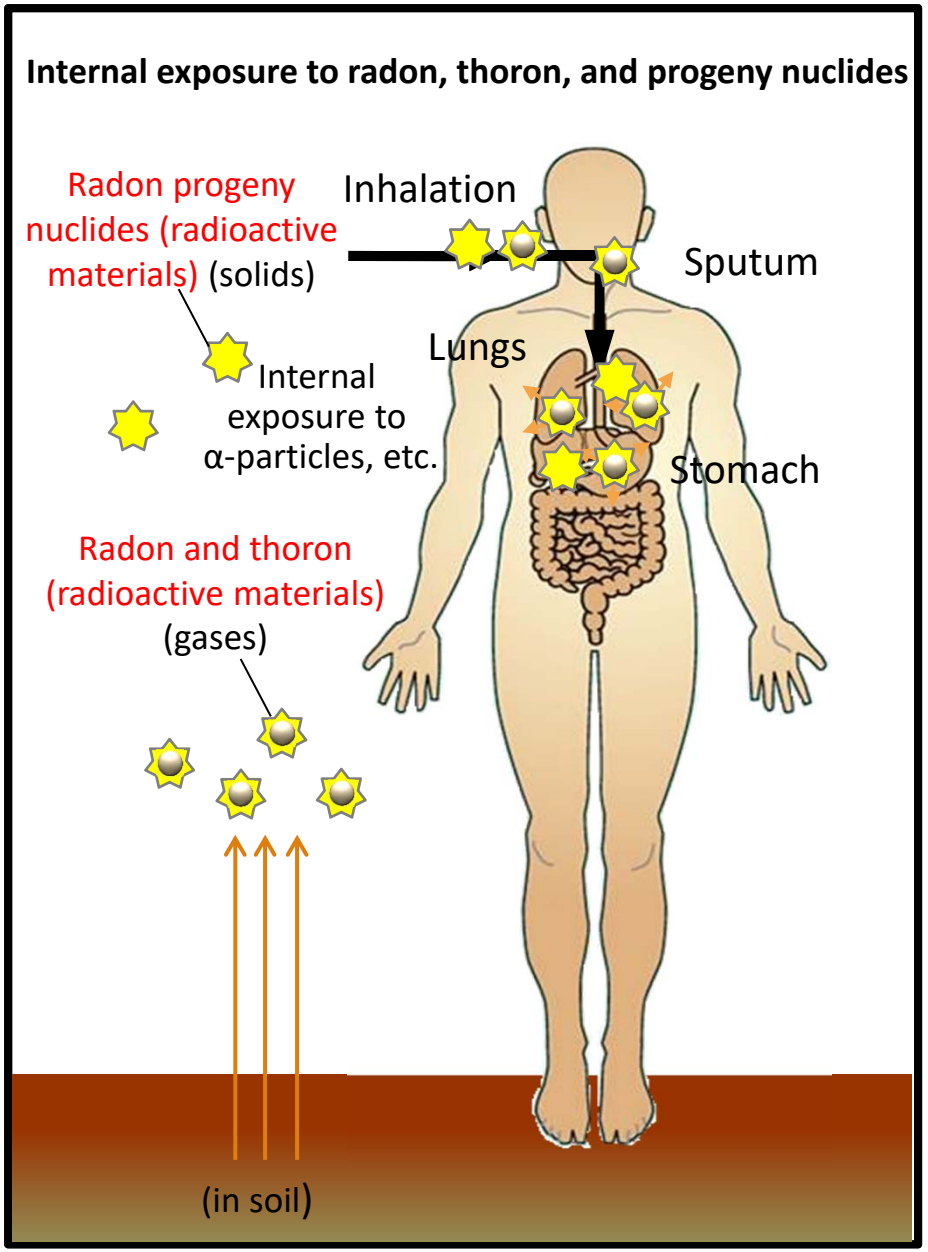



Bq/m3: becquerels/cubic meter

Source: Prepared based on the 2006 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report

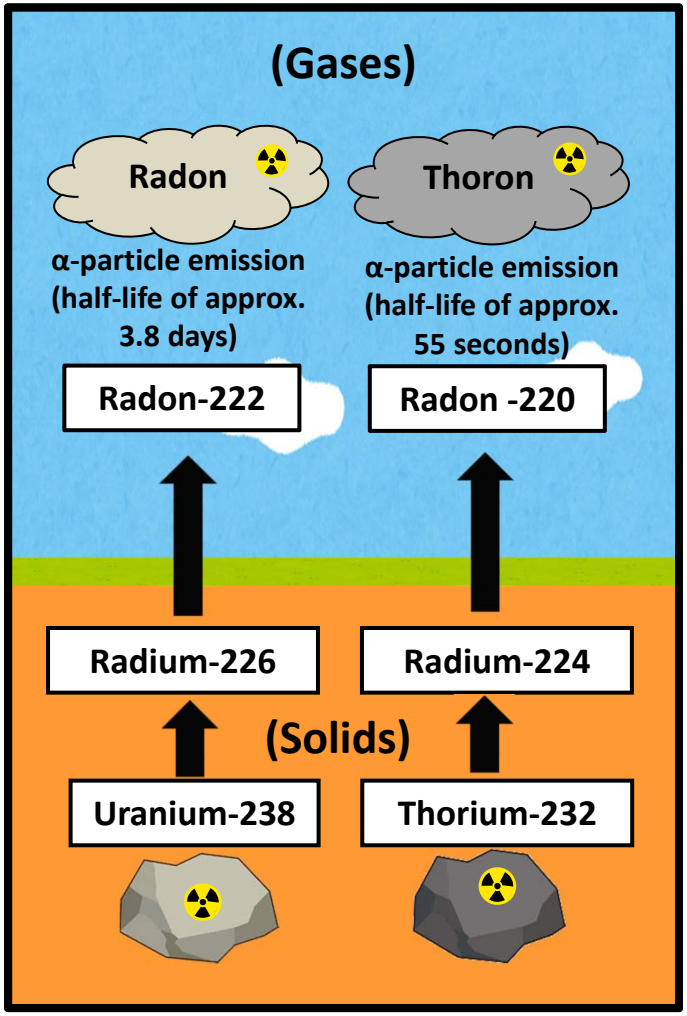
# Internal Exposure to Radon and Thoron through Inhalation



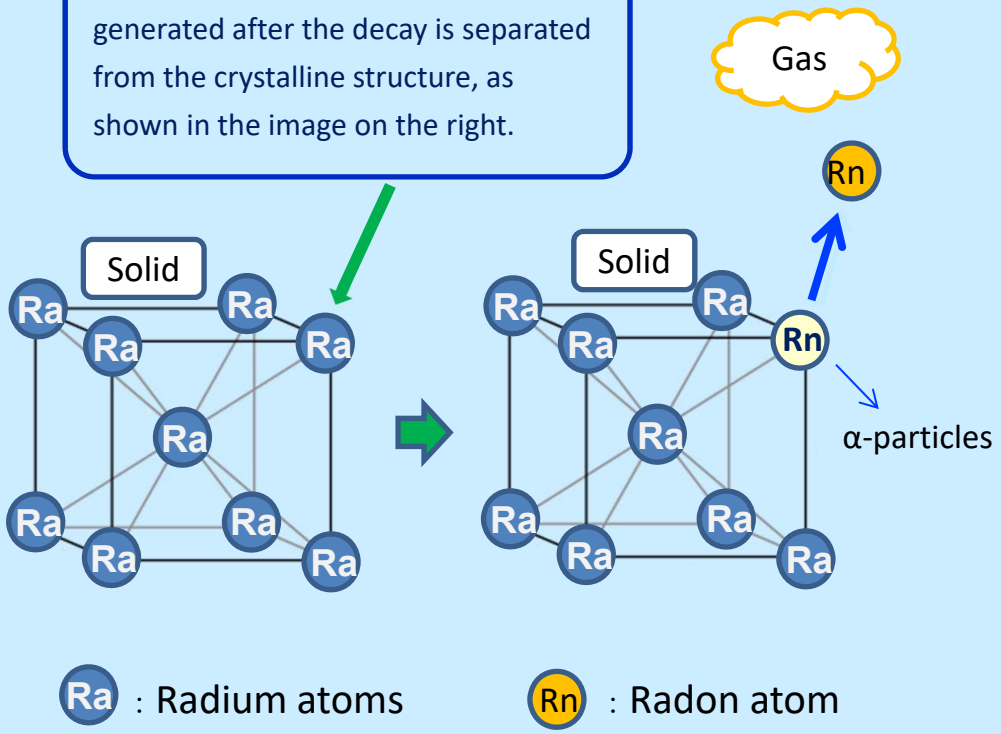



# Generation of Radon Gas from Solid Radium

It may seem strange that solid radium directly turns into radon gas.
This is caused by radioactive decay that causes atoms to change.




When this radium atom decays, radon generated after the decay is separated from the crystalline structure, as shown in the image on the right.



# Natural Radioactive Materials in the Body and Foods

## Radioactive materials in the body

| When body weight is 60kg | | |
|---|---|---|
| Potassium-40 | ※1 | 4,000Bq |
| Carbon-14 | ※2 | 2,500Bq |
| Rubidium-87 | ※1 | 500Bq |
| Tritium | ※2 | 100Bq |
| Lead and polonium | ※3 | 20Bq |

※1 Nuclides originating from the Earth
※2 Nuclides derived from N-14 originating from cosmic rays
※3 Nuclides of the uranium series originating from the Earth

## Radioactivity concentrations (Potassium-40) in foods


Rice: **30**; Milk: **50**; Beef: **100**; Fish: **100**; Dry milk: **200**; Spinach: **200**;
Potato chips: **400**; Green tea: **600**; Dried *shiitake*: **700**; Dried kelp: **2,000** (Bq/kg)

Bq: becquerels Bq/kg: becquerels/kilogram

Source: Prepared based on "Research on Data about Living Environment Radiation (1983)," Nuclear Safety Research Association

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# Radiation Doses from Medical Diagnosis

| Type of examination | Diagnostic reference levels*1 | Actual exposure dose*2 | |
|---|---|---|---|
| | | Dose | Type of dose |
| General imaging: Front chest | 0.3mGy | 0.06mSv | Effective dose |
| Mammography (mean glandular dose) | 2.4mGy | Around 2 mGy | Equivalent dose (Mean glandular dose) |
| Fluoroscopy | IVR (InterVentional Radiology): Fluoroscopic dose rate 20 mGy/sec | Gastric fluoroscopy Around 4.2-32 mSv*3 (varies depending on operators and subjects) | Effective dose |
| Dental imaging | From 1.1 mGy at the frontal teeth of the mandible to 2.3 mGy at the molar teeth of the maxilla | Around 2-10 μSv | Effective dose |
| X-ray CT scan | Adult head simple routine: 85 mGy | Around 5-30mSv | Effective dose |
| | Child (age 6-10), head: 60mGy | | |
| Nuclear scanning | Value for each radioactive medicine | Around 0.5-15mSv | Effective dose |
| PET scan | Value for each radioactive medicine | Around 2-20mSv | Effective dose |

* 1 : "Diagnostic Reference Levels based on the Latest Survey within Japan," J-RIME, etc., June 7, 2015 (partially updated on August 11, 2015) (http://www.radher.jp/J-RIME/)

* 2 : "Q&A on Medical Exposure Risks and Protection Regarding Medical Exposure from CT Scans, etc.," National Institutes for Quantum and Radiological Science and Technology (http://www.nirs.qst.go.jp/rd/faq/medical.html)

* 3 : Prepared based on "Gastric Fluoroscopy" in "X-ray Medical Checkup" in "Basic Knowledge on Medical Radiation," (http://www.khp.kitasato-u.ac.jp/hoshasen/iryo/), Kitazato University Hospital, Radiology Department

Prepared based on materials *1, *2 and *3 above

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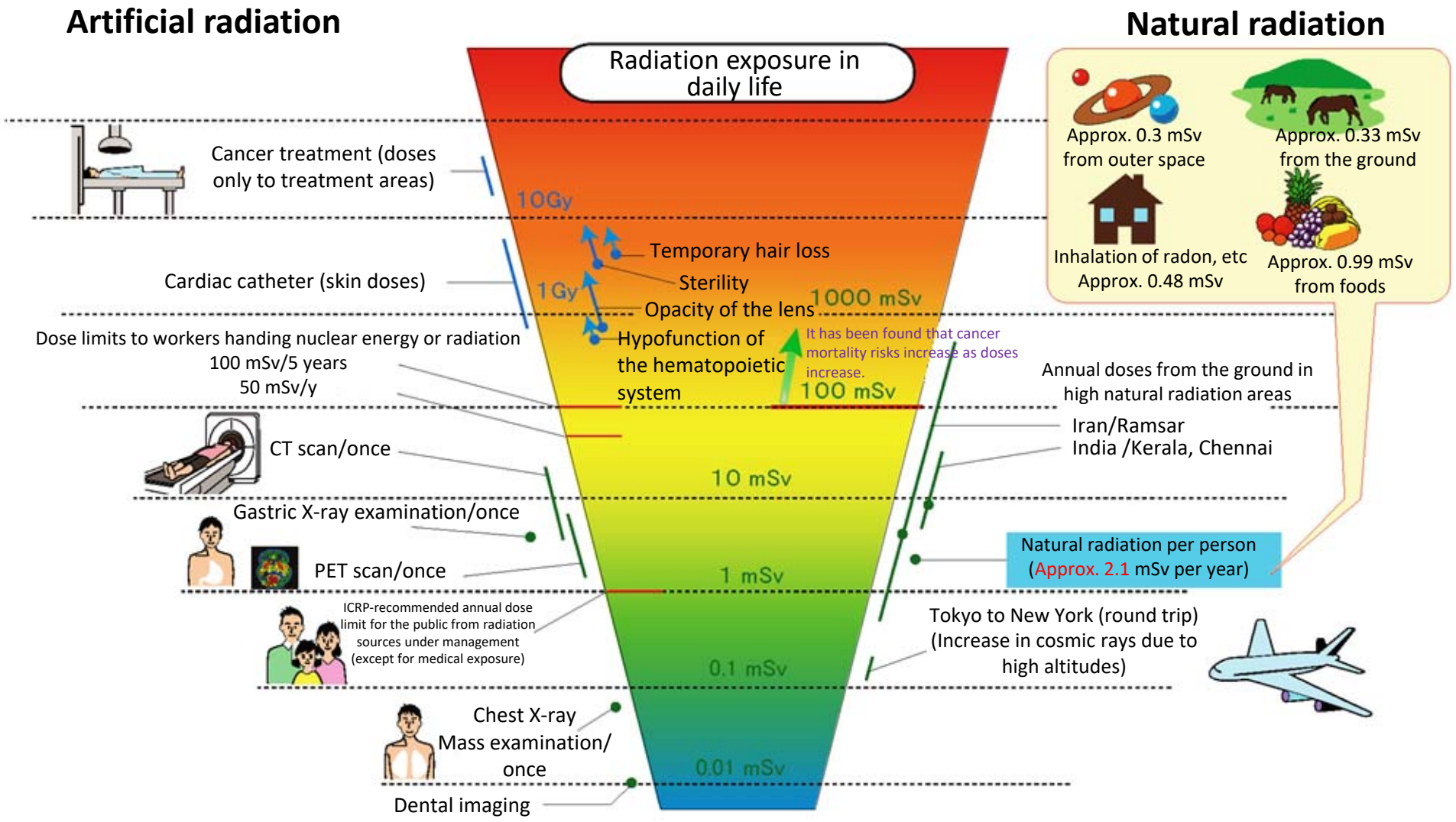
# Comparison of Exposure Doses (Simplified Chart)



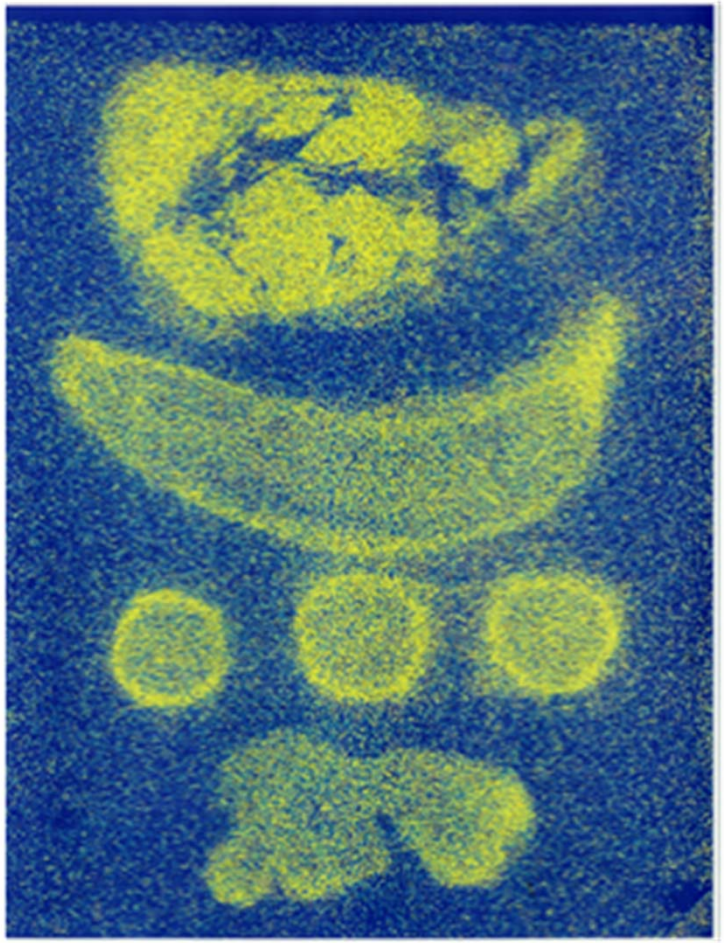

Sources:

- 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

# Visualized Radiation



Radiographs of pork meat, banana (cut vertically and horizontally), and ginger

## Radiation from foods

- Mostly β-particles from Potassium-40
- The natural abundance ratio of Potassium-40* is **0.012%**.
- Potassium-40 has a half-life of **$1.26 \times 10^9$** years.

*Percentage of Potassium-40 relative to the total amount of potassium found in nature

Source: Applied Physics Vol.67, No.6, 1998

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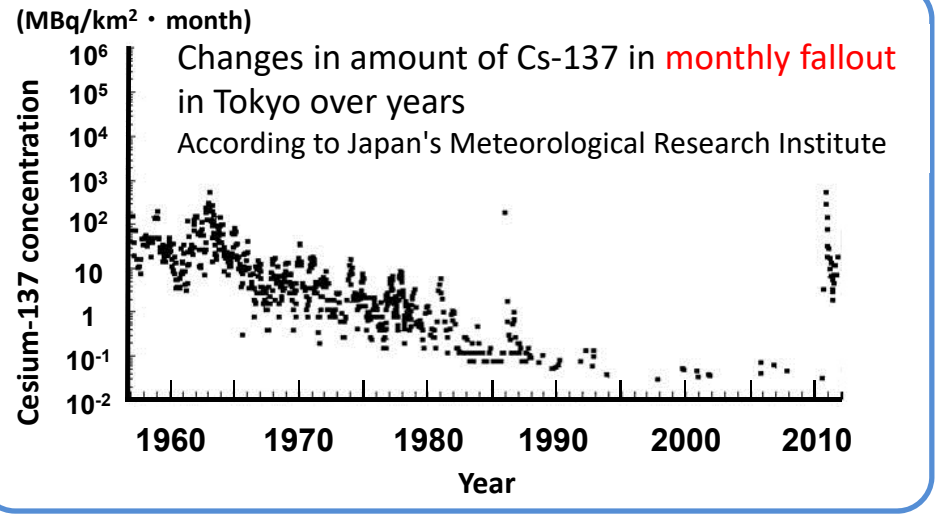
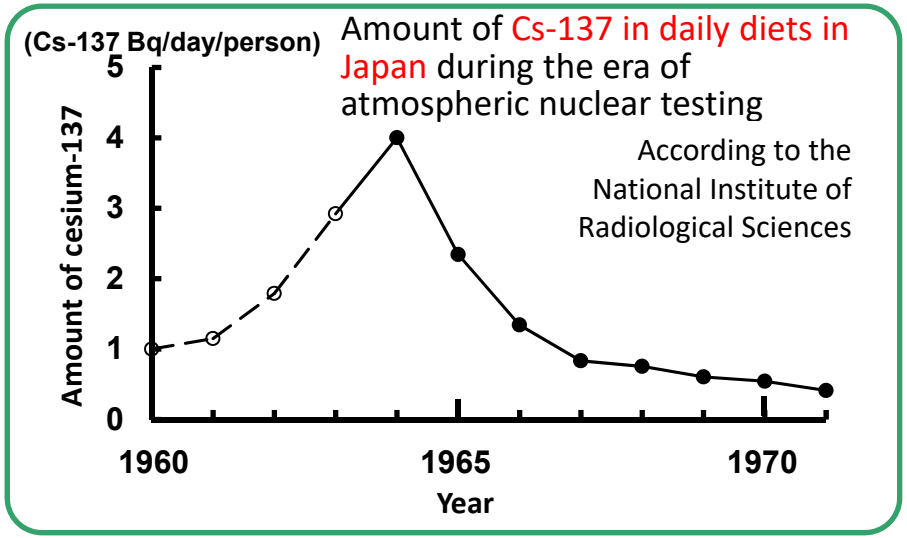
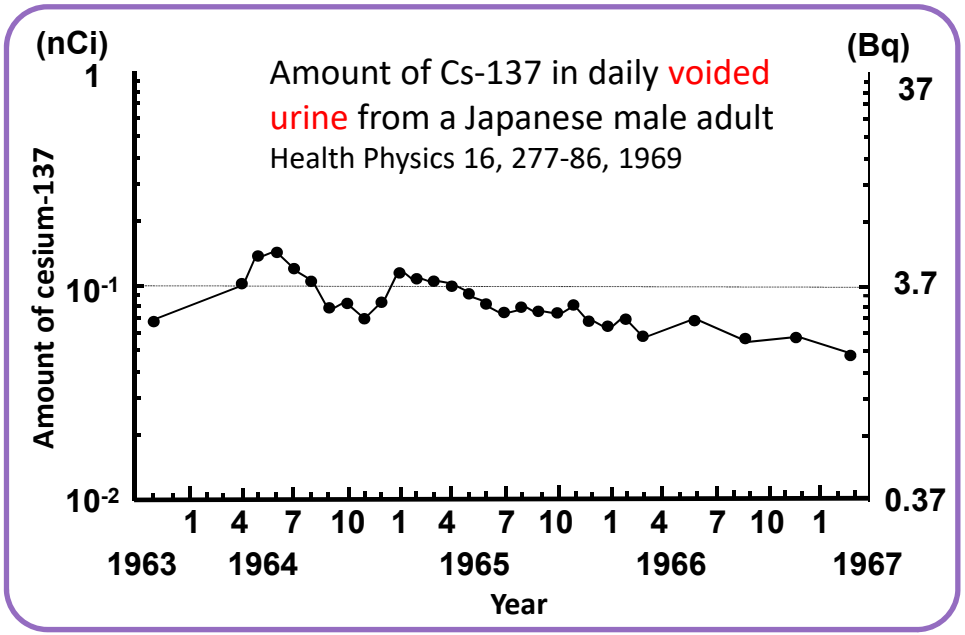
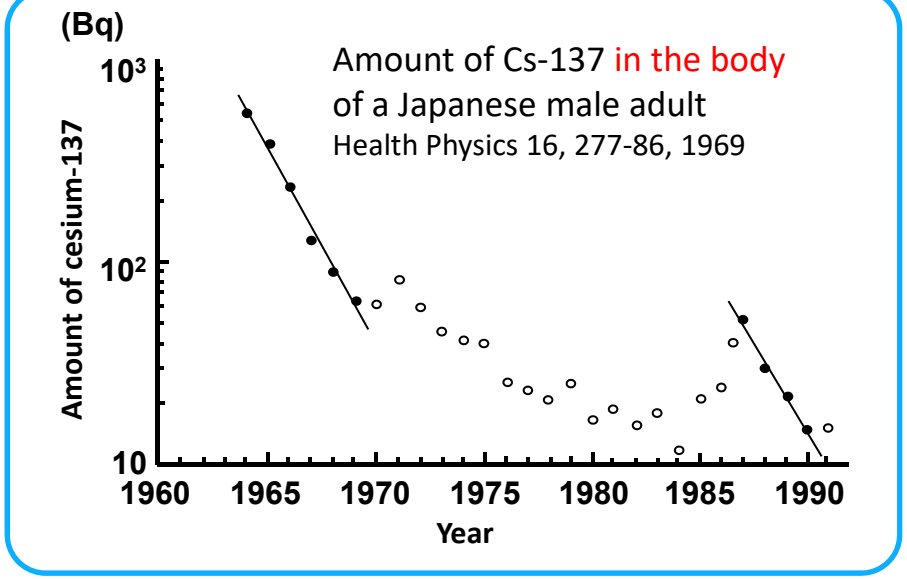
# Effects of Radioactive Fallout due to Atmospheric Nuclear Testing

| Internal radioactivity: Body weight: 60 kg | Potassium-40: 4,000 Bq; Carbon-14: 2,500 Bq; Rubidium-87: 520 Bq; Tritium: 100 Bq |
|---|---|




MGq: megabecquerels, nCi: nanocuries※

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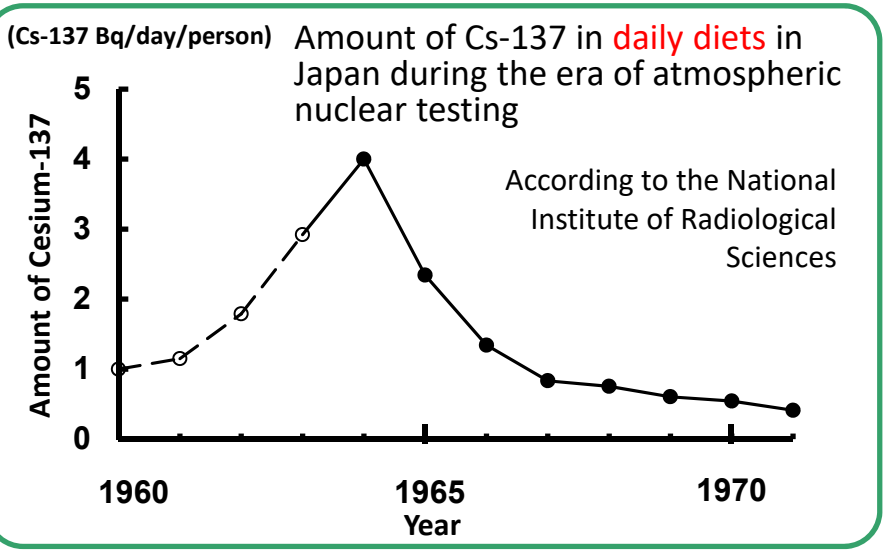
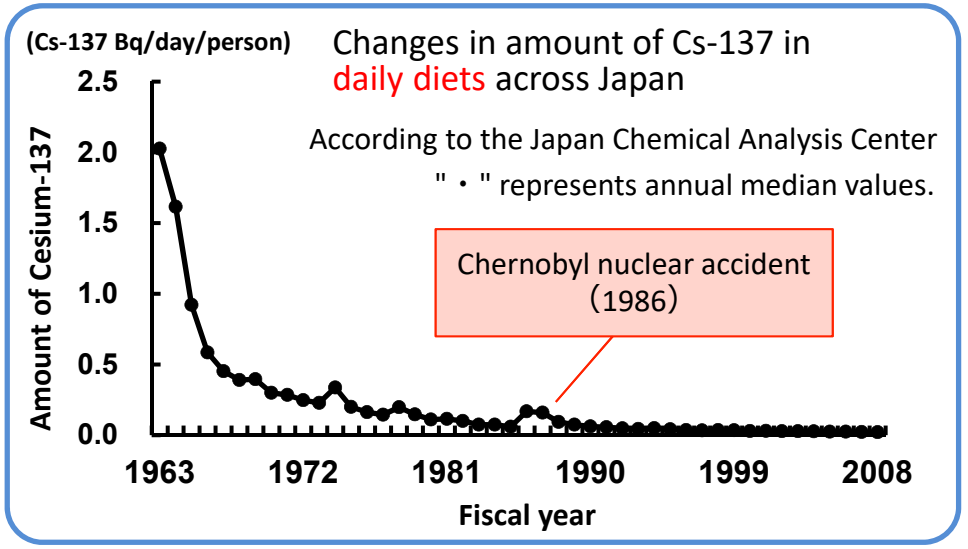
# Changes in Cesium-137 Concentrations in Foods over Time since before the Accident




*The two studies differ in sampling time and location.

- If an adult keeps consuming the typical diet of the 1960s for a year, internal radiation dose due to Cesium-137 is:

**4.0** (Bq/day) × **365** (day/year) × **0.013** (μSv/Bq) = **19 μSv/y**

= **<u>0.019 μSv/y</u>**

- (Japanese average)
  Annual internal exposure dose due to natural radiation in foods is:

**<u>0.99 mSv/y</u>***

Source: "Environmental Radiation in Daily Life (2011)," Nuclear Safety Research Association (2011)