

## Answers to frequently asked questions relating to the accident at the Fukushima Daiichi nuclear power plant

### 1. Questions about radiation and radioactivity

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**Q1** What types of radiation are there?

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**A1** There are two main types of radiation:

- Radiation with same properties as those of light: X-rays and gamma rays
- Radiation in particles: Alpha, beta, and neutrons
- X-rays are electromagnetic waves (same properties as those of light) that are generated using high-voltage X-ray generators. The penetrating power of such rays is relatively strong.
- Gamma rays are electromagnetic waves produced in a process of “radioactive decay” of radioactive isotopes (radioactive materials). They are electromagnetic waves like X-rays, and their penetrating power is strong.
- Alpha particles are emitted by radioactive nuclei such as uranium or plutonium in a process known as “atomic decay.” An alpha particle is composed of two neutrons and two protons (a helium nucleus). The penetrating power of alpha rays is so weak that they can be stopped with one sheet of paper. Concern regarding external exposure to alpha particles is unnecessary.
- Beta particles are electrons emitted in the process of “atomic decay” of radioactive isotopes. In general, most beta particles cannot reach a depth exceeding 1 cm.
- Neutrons are emitted in a process of “nuclear fission” of uranium and plutonium. The uncharged nature of the neutron contributes to their high penetrating power, but water can stop neutron penetration. (A neutron is the same weight as a proton in the hydrogen nucleus, and hence it can be stopped by the principle of billiard-ball motion.)

(Note)

Atomic decay: An isotope is defined as an atom with the same number of protons but a different number of neutrons. (For example, there are three types of hydrogen atoms: the most common form of hydrogen with one neutron, deuterium with two neutrons, and tritium with three neutrons. Only tritium is radioactive.) Some isotopes will release extra energy in the form of radiation and decay into stable atoms (frequently accompanied by an increase or decrease in atomic number). This is what is called “atomic decay.”  
Nuclear fission: The splitting of the nucleus of an atom such as uranium and plutonium resulting from collision with neutrons.

**Q2** What does 1,000  $\mu\text{Sv/h}$  mean?

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**A2** “1,000  $\mu\text{Sv/h}$ ” indicates that one is exposed to 1,000 microsieverts of radiation per hour. Total annual natural radiation dose for people living in Japan is estimated to be about 1,000 microsieverts (i.e., 1 millisievert, excluding radiation from radon), and hence the figure indicates that you would be exposed to the typical total annual radiation dose in one hour.

**Q3** What is meant by internal exposure?

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**A3** Ingestion or inhalation into the body of radioactive substances leads to internal exposure. The speed of excretion of the radioactive substance from the body depends on the type of radioactive element involved.

**Q4** What is half-life?

**A4** Half-life is a term used to express the amount of time required for a substance's radioactivity to decay by half. When two times this half-life period elapses, the radioactive intensity does not equal zero—rather it becomes one-quarter of the original quantity, due to the formula  $1/2 \times 1/2 = 1/4$ .

**Q5** I hear that radioactive cesium emitted in the accident turns into barium-137 through beta decay. Does this reaction occur even when radioactive cesium turns into compounds such as oxides or chlorides?

**A5** Decay (disintegration) of an atomic nucleus is not affected whatsoever by the molecular form of the compound. Therefore, the speed and the products of decay are the same regardless of whether the compound is cesium chloride or cesium hydroxide. However, cesium-137 emits strong gamma rays after beta decay and is therefore a gamma emitter as well as a beta emitter.

**Q6** Is it radiation or radioactivity that is leaking from the power plant? And, into where is it leaking?

**A6** Both radiation and radioactivity (radioactive substances, i.e., radioisotopes) leaked from the plant. Due to the hydrogen explosions at that time, radioactive substances were released into the surrounding environment all at once, and these substances are now emitting radiation. Please refer to the easy-to-understand explanation on the difference between radiation and radioactivity on the RERF website at <http://www.rerf.jp/general/whatis/index.html>. Radioactive substances (radioisotopes) released into the environment due to the hydrogen explosions were derived from nuclear fission products when nuclear energy was produced at the power plant. Various radioisotopes were generated, and there have been particular concerns about effects of radiation emitted from iodine and cesium radioisotopes. Such radioisotopes did leak from the destroyed nuclear reactors, but as far as we know, leaks of the sort that could cause problems have already stopped. Unless there is another serious accident, there is no need to worry about such leaks. The present issues are the levels of radiation doses emitted by the radioactive substances (radioactivity) released into the environment at the time of the hydrogen explosions and the degree of their effects on human health.

**Q7** Is it radiation or radioactivity that leaked into the soil and water? If it is radiation, how long will restoration to the original condition take?

**A7** What remain in soil are radioisotopes. These radioisotopes emit radiation during the process of decay of atomic nuclei. To determine how long restoration of the environment will take, the physical half-lives of such radioisotopes must be taken into account. Further, it is necessary to consider how these elements behave (how they spread) in the environment.

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## 2. Questions about radioactive contamination

**Q8** What is meant by radioactive contamination?

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**A8** Radioactive contamination means a state in which radioactive substances are not safely managed and therefore may cause radiation exposure on the human body, including when radioactive substances are attached to clothes and skin.

**Q9** What should we do if we are contaminated? What is decontamination? Where can we be decontaminated?

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**A9** Decontamination needs to be performed if we become contaminated. Decontamination means elimination of radioactive materials from clothes and skin. Washing any exposed clothes and skin with soap would be best. However, when washing skin, don't rub too hard. If you scratch your skin, radioactive materials could infiltrate the body through such openings. It is impossible to accurately determine the need for decontamination without measurements using a radiation measurement device. For more information about measurement of radiation doses, please refer to **Q24**.

**Q10** What should one do in the case of rain?

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**A10** The radioactive substances suspended in the atmosphere can be absorbed by rain and fall to earth in that form. Therefore, it would be prudent for people in the vicinity of the nuclear power plants and areas with high radiation levels to avoid being rained on, although getting wet in the rain would not necessarily pose a threat to health.

**Q11** Are Hiroshima and Nagasaki still radioactive?

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**A11** The practical answer is, "No."  
There are two ways residual radioactivity is produced from an atomic blast. The first is due to fallout of the fission products or the nuclear material itself—uranium or plutonium (uranium was used for the Hiroshima bomb whereas plutonium was used for the Nagasaki bomb)—that contaminate the ground. Similar ground contamination occurred as a consequence of the Chernobyl accident, but on a much larger scale. The second way for residual radioactivity to be produced is by neutron irradiation of soil or buildings (neutron activation), causing non-radioactive materials to become radioactive.

Fallout

The Hiroshima and Nagasaki bombs exploded at altitudes of 600 meters and 503 meters, respectively, then formed huge fireballs that rose with the ascending air currents. About 10% of the nuclear material in the bombs underwent fission; the remaining 90% rose to 10-50 km in the sky with the fireball.

Subsequently, the material cooled down and some of it started to fall with rain (black rain) in the Hiroshima and Nagasaki areas, but probably most of the remaining uranium or plutonium was dispersed widely in the atmosphere. Because of the wind, the rain did not fall directly on the hypocenters but rather in the northwest region (Koi, Takasu areas) of Hiroshima and the eastern region (Nishiyama area) of Nagasaki.

The maximum estimates of dose due to fallout are 10–30 mSv in Hiroshima and 200–400 mSv in Nagasaki. The corresponding doses at the hypocenters are believed to be 1 mSv or lower in Hiroshima and 50 mSv in Nagasaki.

Nowadays, the radioactivity is so miniscule that it is difficult to distinguish from trace amounts (including plutonium) of radioactivity caused by worldwide

fallout from atmospheric (as opposed to underground) atomic-bomb tests that were conducted around the world in past decades, particularly in the 1950s and 1960s.

#### Neutron activation

Neutrons comprised 10% or less of the A-bomb radiation, whereas gamma rays comprised the majority of A-bomb radiation. Neutrons cause ordinary, non-radioactive materials to become radioactive, but gamma rays do not. The bombs were detonated far above ground, so neutron induction of radioactivity on the ground did not produce the degree of contamination people associate with nuclear test sites (Nevada test site in southwestern U.S., Maralinga test site in South Australia, Bikini and Mururoa Atolls, etc.).

Past investigations suggested that the maximum cumulative dose at the hypocenter from immediately after the bombing until today is 800 mSv in Hiroshima and 300–400 mSv in Nagasaki. When the distance is 0.5 km or 1.0 km from the hypocenter, the estimates are about 1/10 and 1/100 of the value at the hypocenter, respectively. The induced radioactivity decayed very quickly with time. In fact, nearly 80% of the above-mentioned doses were released within a day, about 10% between days 2 and 5, and the remaining 10% from day 6 afterward. Considering the extensive fires near the hypocenters that prevented people from entering until the following day, it seems unlikely that any person received over 20% of the above-mentioned doses, i.e., 160 mSv in Hiroshima and 60–80 mSv in Nagasaki.

**Q12** Aren't volatile radioactive substances gases? If they are, do these gases contaminate soil? Please tell me about the mechanisms by which gases contaminate soil. Do non-volatile substances spread in the form of fine particles?

**A12** Volatile radioisotopes, such as radioactive iodine, turn into gases and float in the air. There also is the possibility that such gases adhere to soil or dissolve in water, contaminating the environment. Non-volatile metallic radioisotopes also spread, and some of them are thought to dissolve in water and turn into ions.

**Q13** This is a question about the series of nuclear power plant accidents. Using numbers that have been published as examples in order to compare contamination levels by atomic bombs and the accidents in Chernobyl and Fukushima, what would be the contamination levels for the Fukushima and Chernobyl accidents if the level for Hiroshima is assumed to be 1?

**A13** Contamination levels can be calculated by multiplying the radiation per unit area by the total area of the contaminated zone. Typically, however, adequate information is lacking on low-level contamination, even though information is often available on measurements of areas that are contaminated so heavily as to make it impossible for people to live there. Moreover, in Hiroshima and Nagasaki, because the temperatures when the bombs exploded were as high as 10,000 °C, all the nuclear substances and nuclear fission products were vaporized and spread widely due to the updrafts that produced the mushroom clouds. Therefore, the ground surfaces nearby were not substantially contaminated (radioactive substances were contained in the rain that fell in some parts of the suburbs, however). Thus, there are no definitive answers to this question.

**Q14** I have heard that, according to some calculations, the level of radiation emitted in Chernobyl was reported to be 8,000 times higher than that in Fukushima. Is that true?

**A14** Both nuclear power plants and atomic bombs use energy from nuclear fission, but nuclear power plants have a much larger amount of nuclear substances

(fuel). The longer the period during which fuel is burned, the more radioactive products accumulate. One site on the internet indicates that a 1,000,000-kilowatt nuclear power plant produces as much death ash (radioactive products) a day as 6 Hiroshima-type atomic bombs (according to the Wikipedia page on atomic bombs). However, it is unknown how much radioactive material was released from the accident of the Fukushima nuclear power plant.

**Q15** I hear that there should be no concerns any longer about soil contamination in Hiroshima and Nagasaki. If radioactive contamination in Fukushima were to stop now, how long would it take for the effects on human health to disappear?

**A15** It is difficult to answer the question because the minimum radiation level that can cause effects is unclear. Because the half-life of cesium-137 is 30 years, the effects may persist unless those radioisotopes are washed away (the radioactivity will only decrease to one-half in 30 years and to one-quarter of the total amount in 60 years). However, research aiming at reducing contamination will apparently be initiated, so some measures definitely will be taken. If a house is contaminated, there are two options: having it decontaminated or moving out. One would have to decide which option to choose, taking necessary costs into consideration. Even if decontamination is carried out, however, dose levels would probably not fall to zero, so some compromise would be necessary. In that case, one cannot avoid the issue of how much contamination one can put up with. It would be difficult to solve this problem by simply drawing a line someplace, because people have different opinions on this matter.

**Q16** I plan to purchase secondhand a piece of heavy machinery that had been used in Fukushima. If I were to use such equipment over the long term, would my health be affected?

**A16** It cannot be denied that heavy machinery used close to the nuclear power plant might have been contaminated with radioactivity. It is advisable to have the contamination level of the equipment tested before purchase. Generally speaking, however, because contamination levels were very low, most of the contamination could probably be washed away with water. Except for equipment used on site at the nuclear power plant, there have been no reports of high-level contamination that may cause health effects.

**Q17** After I bought seedlings (roots) of “myoga” (Japanese ginger) the other day, I noticed that they were harvested in November or thereafter in an area designated as “contaminated” according to maps showing radioactive contamination distributions. Because I was concerned, I inquired by telephone and got a response indicating that although the farm had not been decontaminated, contamination levels of its products had been measured, and that products had been shipped only after it was confirmed that no contamination was detected. This response makes me wonder, though; aren’t all the products shipped from areas designated as contaminated according to the radioactivity maps affected by radioactivity?

**A17** Because contamination released into the air due to the hydrogen explosions of the nuclear reactors was carried away by the wind and fell to the ground, they have been detected at distant locations. Fallout was scattered over long distances, and that is why so few contaminated farms have been found. There should be no problem with the farm products that you bought.

### **3. Questions about radiation measurements and radiation doses**

**Q18** How would one find out his or her level of radiation exposure?

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**A18** The estimate from the perspective of the physics field would be: “The hourly radiation dose rate at the location of exposure” × “the number of hours present at that site.”

Biological estimates are arrived at in the following two ways, with the estimation methods requiring significant time and money and lacking a large number of experts to carry them out. For those reasons, the measurements that can be carried out are limited in number and unavailable even in the case of requests from individuals.

- One method involves investigation of chromosomes in blood lymphocytes after two-day cultures (this method requires at least 2 cc of blood).
- The other method of deriving such estimates involves investigation of tooth enamel through the use of the electron spin resonance technique. The method is problematic as it can result in inaccurate assessment if the teeth used are not molars. Such measurement typically requires a pulled tooth, and therefore the method is not useful at times of emergency when time is short.

Such measurement methods are applicable for cases in which radiation exposure is at a level of at least 300 millisieverts (or 300,000 microsieverts).

**Q19** We often see on TV people using plastic-wrapped measurement devices, but does such protection do anything? Those who are measuring look like they are wearing normal clothes. Do such devices wrapped in plastic measure accurately?

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**A19** Measurement equipment is usually wrapped in plastic because it does not give accurate results when contaminated with radioactive materials. The plastic is replaced when it is dirty. It measures high levels of radiation, which may have adverse effects on human health, and therefore it does not pose any problem in measurements since radiation of such levels will penetrate plastic.

**Q20** I recently read an article that indicated cesium and plutonium were detected on the air-conditioner filters of cars. Can we consider that such materials were stopped by the filters and did not enter the cars by passing through the filters? Also, I measured radiation doses in my car using a dosimeter for X-rays and gamma-rays and obtained a value of 0.06. I do not consider the number to be very high, but is there any way to determine, based on this value, whether any plutonium is present?

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**A20** In the case of Fukushima, cesium was probably released in the form of gas, so there is a possibility that cesium gas was not stopped by the filters. However, even if cesium atoms had been released in the form of gas, they might subsequently have become compounds through chemical reactions. In that case, they may have been large enough to have been stopped by the filters.

It is not clear in what kind of compound plutonium was released, but it is said that, in the case of radioactive fallout from nuclear tests, plutonium was released in the form of small particles (‘hot’ particles). If that was the case with Fukushima, it is highly likely that plutonium was captured by filters.

The value 0.06 microsievert measured inside the car (per hour) is considered to be normal in terms of natural radiation levels (that figure can be converted to an annual level of 0.53 millisievert). However, it cannot be determined based on this value alone whether a minute amount of plutonium was included.

**Q21** If radiation doses at point X from radiation sources A and B (which is not on line X-A) are a and b (sievert/h), respectively, can we consider that the total radiation dose at point X is  $a + b$ ?

**A21** Yes,  $a + b$  is correct because there is no interaction between different forms of radiation.

**Q22** I measured radiation by placing a scintillation counter directly on the ground. The value fluctuated between 0.09–0.10 microsievert/h. Is this radiation-dose fluctuation due to sine waves produced when cesium and other atoms in the ground radiate electromagnetic waves?

**A22** There may not be a clear answer to this question, but this fluctuation is a very common phenomenon. The range of 0.09–0.10 represents a normal measurement fluctuation. It can be caused by detection sensitivity of the counter (in other words, signal pulse resolving time); it can also be measurement fluctuation due to radiation randomly entering the detector. At these low radiation doses, which are within the range of environmental background levels, measurements can fluctuate to some extent.

**Q23** Concentration and accumulation of radioactive fallout in soil must have begun a long time ago. There are data (Meteorological Research Institute) showing that several thousand times more radioactive substances (such as Cs-137 and Sr-90) than usual continued to fall for about 20 years between 1955 and 1975, when atomic and hydrogen bombs were tested frequently. There was a large amount of fallout from the accident of the Fukushima nuclear power plant, but at the same time, there must have been a large amount of radioactive substances that fell and accumulated during that 20-year period, with such substances emitting substantial levels of radiation. Is it possible to take measurements, conduct analysis, and make categorizations to determine when radioactive substances emitting the radiation measured currently in hot spots were produced (whether they originated from the past accumulations or from the Fukushima accident)?

**A23** Some of the radioactive substances falling on the ground are washed away with rain, and so on, with time, and the remaining substances seep into the ground. An inexpensive mobile radiation counter only counts the total level, but an expensive counter (not mobile) can measure the energy of gamma rays as well as beta rays. Types of released energy differ by nuclide of radioactive substances, so there is a possibility that recent contamination (mainly cesium-137) and past contamination can be distinguished. An easier way to handle this issue is to assume that contamination due to past nuclear tests is spread almost uniformly throughout the country and then subtract those doses from the calculation of the doses from the accident.

**Q24** What should one do if potentially exposed to radiation?

**A24** Radiation dose will be estimated based on behavior records. Please refer to **Q18** for estimation methods.

You would be advised to go to a location where radiation measurement devices are being used for detection of radiation contamination, and undergo measurement for detection of any radiation.

Radiation can be measured at the following sites:

- [Hiroshima University Radiation Emergency Medicine Promotion Center](#)
- [Institutes related to health care for the radiation-exposed \(eastern Japan\) \(primary and secondary\)](#)

- [Institutes related to health care for the radiation-exposed \(western Japan\) \(primary and secondary\)](#)

Those at locations distant from the nuclear power plant need not be overly concerned.

#### 4. Questions about radiation risk and radiation protection

**Q25** How do you protect yourself from radiation leaks?

**A25** The best way to protect yourself from radiation is to keep away from radiation sources or minimize the time spent around them. It is recommended that everyone stay clear of nuclear power plants releasing radioactive substances and any other areas with high radiation levels, and that you minimize the time of your stay around such areas. If you have passed by the power plant, measurement of radiation levels with a survey meter would help you feel reassured. For more information on such measurement, please refer to **Q24**.

**Q26** How far should I stay away from the power plant? Is there any association with length of stay in the affected area?

**A26** Radiation has the same properties as light, and radiation dose therefore is in inverse proportion to the square of distance from the source of radiation (amount of radiation decreases to one-fourth when distance is doubled), as long as radiation is released from one source.  
Radiation dose rate (in units of microsievert per hour), which has been touched on in the news, indicates the amount of radiation that someone will receive based on the assumption that s/he remains at the same location for an hour. The total amount of radiation dose is calculated by multiplying the radiation dose rate by the length of stay in the affected area.  
Radioactive materials released from the nuclear power plant will be spread by the wind. The wind blowing to the east will likely spread most radioactive materials over the Pacific Ocean.

**Q27** Is it possible to prevent disease after one has been exposed to radiation?

**A27** Once you are exposed to radiation, the effects cannot be reversed. The development of sickness due to radiation exposure (in this case, "acute radiation sickness") happens when the level of exposure exceeds 1 sievert (1 sievert = 1,000 millisieverts = 1 million microsieverts). For ordinary citizens to reach this level of exposure is very unlikely.  
When radiation enters the body through food and the like (internal exposure), there are very few methods established for the prevention of sickness (except for cases of prevention of thyroid exposure by taking iodine prior to/immediately after exposure). Medical procedures would be undertaken for treatment of any specific symptoms that arise.

**Q28** When is iodine used? Where can it be obtained?

**A28** Radioactive iodine is an element created in great quantities through the process of nuclear fission of uranium. This radioactive iodine is characterized by its propensity to accumulate in the thyroid gland once it is ingested in the body. Therefore, by taking non-radioactive iodine in tablet form ahead of time, in the case of potential contamination by nuclear fission products, the iodine would compete with the uptake of the radioactive form of iodine from entering

the thyroid gland on the off chance that it entered the body, and thereby reduce exposures.

In the case of a radiation accident, iodine is administered on the basis of a determination made by the office in charge of responding to the accident. Besides such cases, a physician's prescription is necessary, and therefore nonprofessionals should not be taking iodine on their own.

**Q29** What differences are observed in health effects between short-term and long-term exposures to radiation, when total exposure doses are the same?

**A29** Generally, when doses of radiation exposure (in terms of total exposure dose resulting from multiplication of radiation dose per hour by exposure time) are the same, health effects decrease as exposure time is prolonged. However, it is highly likely that the degree of decrease in such effects differs depending on the radiation dose (the degree of decrease is more significant for high levels of radiation exposure). Therefore, at low doses (e.g., 100 millisieverts or less), there may be only slight differences in health effects between long-term and short-term exposures. Expert opinions differ with regard to this matter.

**Q30** Would there be any effects on fetuses (pregnant women), and babies to be born?

**A30** It is believed that radiation exposure of a fetus during the period of organogenesis (2-8 weeks after fertilization) poses risk of congenital anomaly (deformation), although there is no such data for A-bomb survivors. A fetus is very vulnerable to radiation during the fetal period of 8-15 weeks after fertilization when brain cells are actively dividing. The data of A-bomb survivors indicates that the rate of microcephaly (involving intellectual impairment) increased. However, such effects are unlikely to emerge at a level of less than 100 millisieverts.

**Q31** Are there any health effects from radioactive cesium?

**A31** Radioactive cesium (cesium-137 or 134) is a strong emitter of gamma (and beta) radiation, and hence it is easy to measure. It is a type of atom produced as a result of nuclear fission of uranium and plutonium, and the half-life of cesium-137 and cesium-134 are 30 years and 2 years, respectively. Greater health effects are expected with increases in radiation dose.

**Q32** Please tell me about the effects of radioactivity on surfers in the ocean off the coast of that part of Japan.

**A32** Please refer to radiation doses published on the website of the Ministry of Education, Culture, Sports, Science and Technology. Please ask the department of health and welfare of the coastline prefectures if radiation doses listed on the website are safe both on the shore and in the ocean. It is also recommended to call the Health Consultation Hotline (0120-755-199) of the said ministry.

**Q33** Would 0.12 Bq of urinary cesium compared with ordinary levels increase the risk of cancer?

**A33** It is difficult to answer the question directly because there is no description of the volume of urine measured. However, if the measured volume were 100 cc, it means that the level was 1.2 Bq per liter, and if that is the case, there should be

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no problem at all.

Even if the measured volume were 50 cc, it means that the level was 2.4 Bq per liter, which was the average among Japanese during the time when atmospheric nuclear tests were being conducted frequently.

Reference-information websites:

Atomic encyclopedia ATOMICA

<http://www.rist.or.jp/atomica/data/pict/09/09010411/03.gif>

[http://www.rist.or.jp/atomica/data/dat\\_detail.php?Title\\_Key=09-01-04-11](http://www.rist.or.jp/atomica/data/dat_detail.php?Title_Key=09-01-04-11)

**Q34** Isn't it virtually unnecessary to worry about effects of low-dose exposure? People of the generation who were born and brought up in the days when nuclear weapons were tested frequently (people around 40 now; several thousand times more radioactive substances than usual continued to fall and accumulate for about 20 years, starting in around 1955, according to the data of the Meteorological Research Institute) must have been exposed repeatedly to low-dose radiation (both internally and externally) for a long time since they were infants. However, rates of abnormalities and health issues in this generation are not considered to be high. Doesn't this mean that people of this generation and their parents prove, through their own experience, that there shouldn't be any serious concerns about low-dose exposure?

**A34** Because contamination spread nationwide during the days when nuclear weapons were tested frequently, no control group for comparison exists in the country. Therefore, all we can say is that no effects could be detected, even though there might actually have been some effects. There is the possibility that the economic growth and the increase in average lifespan experienced during this period might have offset any detrimental effects.

**Q35** I am looking for data and materials concerning results of thyroid examinations conducted as part of the "Fukushima Residents Health Management Study" to determine the effects of the accident at the Fukushima nuclear power plant. From a layperson's perspective, the percentage of people who were diagnosed with health issues according to the website

<http://www.pref.fukushima.jp/imu/kenkoukanri/240426shiryou.pdf>

seems high, but I am having difficulty in interpreting the information because there are no numbers that can be used for comparison purposes. If a similar examination were to be conducted on the general population of people not affected by the Fukushima accident, what would be the percentage of those with health effects? It would be appreciated if you could inform me of any past information, including research data, showing such percentages.

**A35** Unfortunately, there have been no reports on results of the frequency of nodules based on thyroid examinations of a large number of children among the general population.

Several reports were published on the frequency of nodules detected by ultrasonography among adults, and a comprehensive report summarizing these findings was published in English in 1996.<sup>1)</sup> "Guidelines Concerning Thyroid Tumor Therapy, 2010,"<sup>2)</sup> published in Japanese, introduces the content of the said report, and states that thyroid nodules were found in 17–64% of the subjects in four prospective studies using ultrasonography. These studies, which show frequencies that vary substantially, were conducted before 1996, and the performance of ultrasonography machines used in these studies was quite different from that of machines used today. With improved performance, current machines can detect very small nodules of 1–2 mm. Therefore, if examinations were to be conducted with modern equipment, the frequency should be even higher. Usually, secondary examinations are conducted when a nodule of 10 mm or larger is found in an adult. In Fukushima, stricter criteria are used, with

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secondary examinations being conducted when a nodule of 5.1 mm or larger is found.

1) Tan G, Gharib H. Thyroid incidentalomas: management approaches to non palpable nodules discovered incidentally on thyroid imaging. *Ann Int Med* 1997; 126: 226-231

2) Guidelines Concerning Thyroid Tumor Therapy, 2010, edited by the Japan Association of Endocrine Surgeons and the Japan Thyroid Association, published by Kanehara & Co., Ltd.

## 5. Other questions

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**Q36** Are experiments using animals, such as mice, being conducted to study the degree of effects of radiation exposure?

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**A36** Various experimental animals, plants, and cultured cells are being used.

**Q37** Culling of livestock

(1) Are animals destroyed because they were exposed to radiation or because radioactivity was taken up into their bodies internally?

(2) If one were to eat such culled livestock, what detrimental effects would there be on one's health?

(3) Does radiation continue to remain in the bodies of animals exposed to radiation?

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**A37** (1) It is virtually impossible to measure how much radiation farm animals were exposed to, i.e., their radiation doses. Radiation does not remain in the body after exposure (only neutrons activate substances, but no neutrons were emitted from the accident). The issue is, therefore, what quantities of radioactive substances were taken up internally into the bodies of animals.

(2) As to mechanisms of possible detrimental effects of eating such culled livestock, there is a concern that radioisotopes with long half-lives, such as cesium-137, may be taken up into the human body and cause internal exposure. Even in such cases, however, careful consideration should be given to internal exposure doses. Serious questions should be raised about the argument that such animals are dangerous simply because they were contaminated, if the argument is not based on any discussion of radiation doses.

(3) Needless to say, radioactive substances entering the bodies of animals and humans decay in accordance with their half-lives. In the case of radioactive iodine, which has a half-life of 8 days, for example, radioactivity will decrease to one-half after 8 days and to one-quarter of the original amount after 16 days. In addition, radioactive substances in the body are excreted from the body through natural biological processes. Thus, together with the substantial contribution of biological half-life, such processes aid in the reduction in amount of radioactive substances in the body. However, some radioisotopes are absorbed into bone and organs, and thereby remain in the body for long periods of time. To understand this idea, it would be helpful to look at the periodic table that we all studied in chemistry class, and imagine that atoms similar to the molecules and atoms that make up bone and muscle become radioactive (for example, please compare the molecular structures of calcium, an element that constitutes bone, and strontium).