radiation
questions & answers

Presented by the Florida Department of Health,
and the Agency for Toxic Substances and Disease Registry

Preface

The Booklet

This booklet was developed by the Florida Department of Health (DOH) to answer questions about radiation. It is intended to provide basic education for the general public concerning radiation. An electronic version of the booklet was update in October 2012 for use on the internet.

It is adapted from a booklet developed by the Florida DOH and the Agency for Toxic Substances and Disease Registry (ATSDR) for a community in Tarpon Springs. However, it has been modified for use in any community.

The Questions

Most of the questions are worded just as they were asked. Some questions came from letters and e-mails from local community members and during meetings.

Many of the questions are about radiation in general. A few extra questions were added to provide more information about radiation.

The Answers

Answers to the questions were provided by a panel of government experts on radiation whose credentials are provided in a brief biographical sketch at the end of the booklet.

Review of the Booklet

Prior to general distribution, a draft of the booklet was the subject of public comment. Changes related to technical comments were incorporated in this version of the booklet.

Additional Information Sources

About radiation

Florida Department of Health,
Bureau of Radiation Control
Call: (850) 245-4266

About radiological emergencies
(24 hours a day)
Florida Department of Health,
Bureau of Radiation Control,
Call: (407) 297-2095

About radon

Florida Department of Health
Call toll free: (800) 543-8279

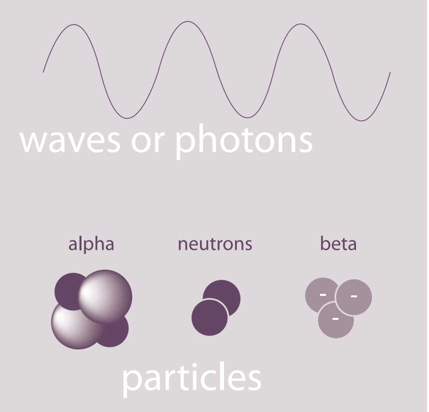
About this booklet

Florida Department of Health,
Health Assessment Team,
Call toll-free (in the state of
Florida): (877) 798-2772

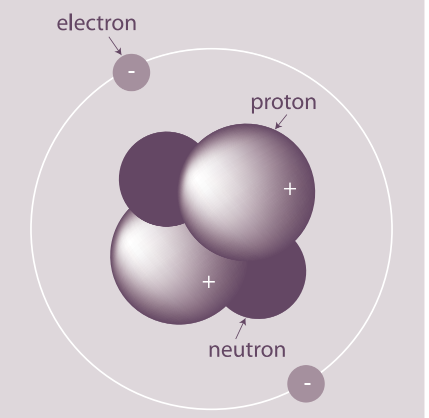
Your Questions

1. What is radiation?

Radiation is energy traveling in the form of particles or waves. Three common types of particles are alpha, beta, or neutrons. Waves are bundles of energy called photons. Some examples include microwaves used to cook food, the radio waves for radio and television, light, and gamma rays and x-rays, both used in medicine.



types of radiation



atomic structure

2. What are atoms made of?

An atom consists of a central nucleus. The nucleus is made up of neutrons and protons. The electrons orbit, or go around the nucleus. Each proton carries a positive charge. Neutrons are electrically neutral; they have no charge. Each electron carries a negative charge. Most atoms in nature are electrically neutral. Therefore, the number of electrons that surround the nucleus is the same as the number of protons in the nucleus.

Atoms with different numbers of protons are called elements. The number of protons in a nucleus determines the element of the atom. For example, the number of protons in neon is 10 and the number in uranium is 92.

Neutrons provide a way to "glue" the protons in place.

Without neutrons, the nucleus would split apart because the positive protons would repel each other. Elements can have different numbers of neutrons in them. For example hydrogen, which normally has only one proton in the nucleus, can have a neutron added to its nucleus to form deuterium, or have two neutrons added to create tritium, which is radioactive. Atoms of the same element, which vary in neutron number, are called isotopes. Some elements have many stable isotopes (tin has 10) while others have only one or two. Radioactive isotopes are called radioisotopes or radionuclides.

3. What is radioactivity?

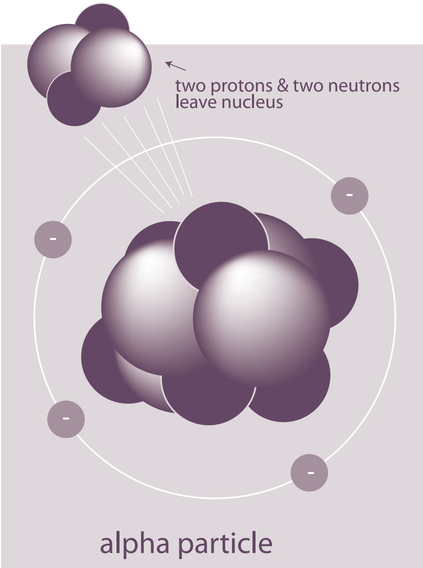
Radioactivity is a natural and spontaneous process. Unstable atoms of an element release or radiate excess energy in the form of particles or waves. These emissions are collectively called ionizing radiation. Depending on how the nucleus loses this excess energy, either a lower energy atom of the same form will result, or a completely different nucleus and atom will be formed. Radioactivity can be natural. An example of this would be uranium. It can also be man-made. An example would be the radionuclides produced by fission of uranium in nuclear reactors.

4. What is ionizing radiation?

Radioactive elements produce energetic radiation capable of removing electrons from atoms or molecules or ionizing them. Such radiation is called ionizing radiation. This type of radiation is of very high energy. When this energy interacts with materials, it can remove electrons from the atoms in the material. This effect is the reason why ionizing radiation is hazardous to health. This effect also provides the means by which radiation can be detected. X-rays, gamma rays, and alpha and beta particles are all forms of ionizing radiation. Non-ionizing radiation, such as radio waves, lack the energy to ionize atoms.

5. What are alpha particles?

Alpha particles are made up of two neutrons and two protons that have been ejected from the nucleus of a decaying radioactive atom. Alpha decay only occurs in very heavy elements such as uranium, thorium, and radium. These atoms have a lot more neutrons in their nucleus than protons. Having more neutrons than protons in their nucleus makes emission of the alpha particle possible. After an atom ejects an alpha particle, a new daughter atom is formed. The daughter atom has two less neutrons and two less protons. This creates a new element. Thus, when uranium-238 (which has 92

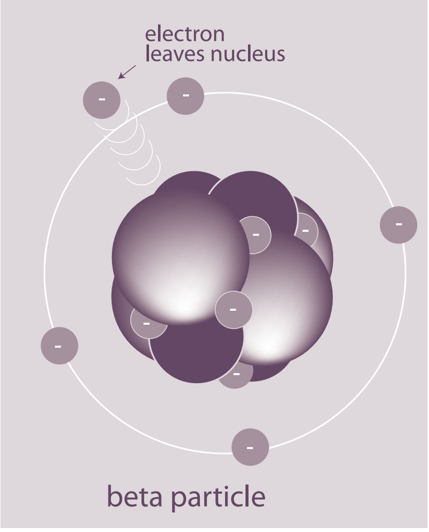


protons and 146 neutrons) decays, thorium-234 is created. Thorium-234 has 90 protons and 144 neutrons. Alpha particles are the heaviest radiation and very energetic. The two protons mean the particle carries two positive charges that interact strongly with electrons in the material. Such interaction causes much ionization in a very short distance. Because of the many interactions in a short distance, typical alpha particles will travel no more than a few centimeters in air. A sheet of paper can stop alpha particles. The outer layer of skin can also stop alpha particles. This means that alpha particles are not harmful unless they get inside the body by eating or breathing or through a wound.

To cause harm inside the body, alpha emitting radioactive material must be in a chemical form that allows the material to be carried to and concentrated in critical radiosensitive tissues of the human body (such as bone marrow). Many alpha emitting radionuclides have radioactive decay daughters that also emit or release alpha particles during radioactive decay.

6. What are beta particles?

Beta particles are electrons emitted or released from the nucleus of a radioactive atom. Because this electron is from the nucleus of the atom, it is called a beta particle. This is the only thing that distinguishes it from the electrons that orbit the atom. Like alpha decay, beta decay occurs in isotopes that have more neutrons in their nucleus than they do protons. When a nucleus ejects a beta particle, one of the neutrons in the nucleus is transformed into a proton. Since the number of protons in the nucleus has changed, a new daughter element is formed. The new daughter element has one less neutron but one more proton than the parent. Beta particles have a negative charge. They weigh only a small fraction of a neutron or proton. As a result, beta particles interact less readily with material than alpha particles. Depending on the beta particle's energy (which depends on the radioactive atom), they will travel up to several meters in air. Thin layers of metal or plastic stop beta particles. The more energetic beta particles can cause burns if beta emitting materials remain on the skin. They can also cause harmful effects if they are taken into the body and concentrated in a sensitive organ (such as Iodine 131 in the thyroid).



7. What are gamma rays?

After a decay reaction, the nucleus is often in an excited state. This means that the decay has produced a nucleus that still has excess energy to get rid of. Rather than releasing another beta or alpha particle, this energy is lost by emitting a pulse of electromagnetic radiation called a gamma ray. The gamma ray is identical in nature to light waves or microwaves. However, it is of very high energy. Like all forms of electromagnetic radiation, a gamma ray has no mass and no charge. Gamma rays interact with material by colliding with the electrons in the shells of atoms. Because the collisions are rare, they are able to travel great distances before stopping. Depending on their initial energy, gamma rays can travel from one to hundreds of meters in air. Gamma rays can easily go right through people. It is important to note that most alpha and beta emitters also emit or release gamma rays as part of their decay process. However, there is no such thing as a "pure" gamma emitter. Because of their high energy, gamma rays are easy to detect. An important gamma emitter is technetium-99m, which is widely used in nuclear medicine.

8. What are x-rays?

X-rays are identical to gamma rays except they have slightly lower energies and are produced by machines. X-ray production occurs when high-energy electrons strike a heavy metal target such as tungsten or molybdenum. When electrons hit this material, some of the electrons will approach the nucleus of the metal atoms. At that point they are deflected since they have opposite charges. That means the electrons are negative and the nucleus is positive. This causes the electrons to be attracted to the nucleus. This deflection causes the energy of the electron to decrease. This decrease in energy then results in formation of an x-ray. X-ray machines are important diagnostic tools in the medical field and also have many industrial applications.

9. How do we measure radioactive material?

When given a certain amount of radioactive material, it is common to refer to the quantity based on its activity. The activity is based on the number of disintegrations or transformations the quantity of material undergoes in a given period of time. A common unit of activity is the curie. The curie is a very large amount of activity, so we often talk in terms of millicuries, microcuries and picocuries. A curie is equal to 37,000,000,000 disintegrations per second. A millicurie is equal to 37,000,000 disintegrations per second. A microcurie is equal to 37,000 disintegrations per second.

10. What units do we use to measure radiation levels?

Different units are used to measure radiation levels; a common unit is the rem. A rem measures the biological damage from ionizing radiation. Like the curie, a rem is a large amount, so we often talk in terms of millirem and microrem. For example, the average background radiation in Florida ranges from 6 to 12 microrem per hour (see question 12). Background radiation is in the air, soil, and water; it is all around us.

11. What is half -life?

Half-life is the time required for the quantity of a material to be reduced to one-half its original value. All radioisotopes have a particular half-life. In some cases, a half-life can be very long. Others are extremely short. For example, uranium-238 has such a long half-life, 4.5 billion years, that only a small fraction has decayed since the earth was formed. In contrast, carbon-11 has a half-life of only 20 minutes.

12. What is background radiation?

Background radiation is produced from naturally occurring radiation that has been present since the formation of the earth. It also includes any fallout from nuclear weapons testing over the past 50 years. Fallout is radioactive debris from a nuclear detonation. This type of debris can be either airborne or deposited on soil. On average, Americans receive about 360 millirem (mrem) annually from all sources of ionizing radiation. Of that amount, 82 percent (300 millirem) results from radon and other natural radiation

Sources	Average annual effective dose equivalent (mrem)
Natural Sources:	
Inhaled (Radon and Decay Products)	200
Other Internally Deposited Radionuclides	39
Terrestrial Radiation	28
Cosmic Radiation	27
Cosmogenic Radioactivity	1
Rounded total from natural sources	300
Artificial Sources:	
Medical X-ray	39
Nuclear medicine	14
Consumer products	10
Total	363 rounded off to 360

sources. A major source (about 40 millirem per year) of naturally occurring radiation comes from inside our bodies—in the form of potassium-40, a radioisotope of potassium. A breakdown of the sources of typical radiation exposure for the average individual per year is shown in the chart above.

13. How are we exposed to radiation?

Exposure to radiation can occur in three ways: by (1) contamination, (2) irradiation, or (3) a combination of both.

14. What is contamination?

Contamination means that radioactive material in the form of gases, liquids, or solids, is emitted or released into the environment. This radioactive material may be unwanted in the particular location. These materials contaminate people externally, internally, or both. The external surface of the body can become contaminated if someone comes into contact with radioactive material. If the radioactive material gets inside the body through the lungs (by breathing), stomach (by ingesting), or through open wounds, it can become deposited internally. Internal contamination will cause absorption of some of the radioactive material into the body's cells, tissues, and organs, including bone, liver, thyroid, or kidneys. If radioactive material gets inside a person, it is distributed throughout the body according to its chemical properties. For example, carbon (C) and potassium (K) atoms are found naturally throughout the human body. A very small number of these atoms are naturally radioactive. That means that these naturally occurring radioactive materials (C-14 and K-40) are incorporated into cells, tissues, and organs throughout the body. On the other hand, radioactive strontium (Sr-90) has chemical properties similar to calcium (Ca). If radioactive strontium is taken into the body, the bones absorb most of it much in the same manner as calcium from milk. Similarly, the thyroid gland needs iodine (I) to function properly. That is why iodine is added to salt. The thyroid will also absorb radioactive iodine (I-123, I-125, or I-131). When a person's thyroid is not working correctly, radioactive forms of iodine might be used to identify (I-123) or treat (I-131) the problem.

15. What is irradiation?

Irradiation can be external, internal, or both. External irradiation occurs when all or part of the body is exposed to ionizing radiation from an external source. During an exposure, the body can absorb this radiation, or the radiation can pass completely through the body. A similar thing occurs during an ordinary chest x-ray. Following external exposure, an individual does not become radioactive. Internal irradiation results from internal contamination. When radioactive material gets inside the body, it irradiates the surrounding cells, tissue, and organs and will continue to do so as long as the material remains in the body.

16. What is the difference between radiation and chemicals?

A chemical is a substance made up of atoms or molecules. Radiation is energy. More about radiation is discussed in this booklet in questions 1 through 12.

17. What is the potential for cumulative effects from multiple radiation exposures?

The potential for multiple radiation exposures posing an increased risk for adverse health effects depends on four things:

- the exposure level or dose,
- the type of radiation,
- the exposure pathway (external or internal), and
- the time between exposures.

When someone is repeatedly exposed to radiation, it can cause cumulative effects (also known as additive effects) to a person's body.

These are effects that build up over time. The main adverse effect of radiation to the human body is damage to the DNA, the genetic recipe for a cell. Minor damage to DNA can be repaired. However, the damage also can be serious enough to cause cell death. Between these two extremes, a mutation, or permanent change in the DNA, can occur. The change is the result of a DNA repair that has gone wrong. This is called incorrect repair. Mutations can be passed on to offspring. These changes in the DNA might not kill someone, but mutations might build up in cells. This build-up can increase the chance the person may become ill. Cell mutations in the human body have been linked to an increased risk for developing cancer. Mutations in reproductive cells might also occur; this type of mutation has been linked to some diseases, which can be passed on from parents to offspring. The chance for this type of mutation increases with each exposure to radiation.

Because cancer cells divide more rapidly and are more sensitive to radiation than healthy cells, radiation is used to treat cancer. Other rapidly growing cells that are likely to react to radiation are the cells that make blood and skin. Cells in the stomach, intestines, eyes, ovaries, and testes are also more likely to be affected by radiation than other cells.

Cells can repair damage caused by radiation. However, being exposed to radiation time and time again before the body can repair itself may result in more damage. Effects may build up and can increase the chance for illness.

18. What is a total body burden test? When is a total body burden test for radiation appropriate? Are most doctors aware of this type of test?

A total body burden test measures levels of radioactive material inside the body. The levels of radioactivity are measured using external detectors or by analyzing biological samples, such as urine or blood. It is rare that a person will be exposed to radioactive materials at levels that require a total body burden test.

This test can be used when radioactive material has entered someone's body by inhalation, ingestion, or when it enters the body through the skin or by other means. It is not a way to measure radiation exposure from sources outside the body. It is not appropriate following external exposure to x-ray or gamma radiation. After such exposures, no radiation remains in the body. However, while radiation does not remain in the body following an exposure, effects from the radiation exposure may remain.

This test might not be one a general practice physician would know about. However, if someone has been exposed to excessive amounts of radioactive materials, a doctor can refer a patient to a specialist for such a test.

19. What is the difference between long-term versus short-term radiation exposure?

Being exposed at a certain level for a long period of time produces a greater dose than exposure to the same level for a short period of time. Dose refers to the amount of radiation absorbed. However, usually we think of long-term exposure as occurring at lower levels. With radiation, an example of a typical long-term exposure is the background radiation to which a person is exposed. This includes how much radiation someone is exposed to during his or her entire life. An example of a short-term exposure is the dose received during an airplane flight. This is due to greater cosmic radiation at higher altitudes. Other short-term exposure examples are dental or chest x-rays. It should be noted that the total dose of radiation received over a long period of time, such as a year or years, may produce no health effects; however, the same total dose received in a short period of time, such as minutes, may be harmful.

20. What is a dosimeter? Is it more appropriate to use a dosimeter to measure personal, actual exposures, rather than estimating exposures based on mathematical projections?

A dosimeter is an instrument used to measure radiation dose. When properly used, dosimeters can provide accurate information about most types of radiation exposure for the period of time that they are used. However, mathematical projections are good tools that can be very useful when dosimeters cannot be (or were not) used.

In most cases, it is best to have an exact way of measuring the actual exposure a person receives. A dosimeter can do this. However, care is needed to make sure that it is used correctly. It is also important to be sure that it can accurately measure the person's dose. This is even truer if the levels of radiation are low. In many radiation exposure situations in the past, dosimeters were not used because the exposure was not expected or was thought to be too low for concern. Therefore, mathematical projections were and still are being used to estimate low-dose exposures and exposures where dosimeters were not used. These are estimates that use a formula to figure out a dose. Conservatively, they tend to overestimate the actual dose to help protect human health.

21. How can people limit or avoid exposures to radiation?

It is impossible to completely avoid radiation exposure because everyone is exposed to background levels. (Please see Questions 10 and 12 for more information about background radiation.) Individuals can limit their exposure to other sources of radiation by using the three basic principles of radiation protection. The principles are time, distance and shielding. You can limit the time you are near a source, you can increase the distance you are from the source, and you can place a shield, such as a concrete wall, between you and the source. These steps will help reduce your exposure.

The easiest way to reduce exposure is to test your home for radon and if levels are too high, steps can be taken to reduce them.

The DOH Bureau of Community Environmental Health's Radon section provides information about radon, its health effects, as well as information about how to test for and reduce levels of radon. The owner or resident usually pays for testing of homes. Call (800) 543-8279 for information on how to test for radon, where to get test kits, or details on testing companies.

22. Why are there different ways to measure radiation levels? What do the different ways mean? What is a safe level?

Each of the three types of radiation (alpha, beta, and gamma, described above) requires a different instrument to measure it. One survey instrument cannot accurately measure all types of radiation. A survey instrument only measures whether radiation is detected and its levels. A portable ion chamber measures ionization that can be converted to dose. ATSDR's Minimum Risk Level (MRL) for ionizing radiation is 100 millirem per year above background. (Note: background includes the dose from building materials.) The MRL is an estimate of human exposure—by a specified route and length of time—to a dose of chemical or other agent that is likely to be without measurable risk of adverse, non-cancerous effects. An MRL should not be used as a predictor of adverse health effects. An MRL is used only as a guideline.

It was previously stated that the average American receives an annual radiation exposure of 360 millirem per year. But what does an exposure of 360 millirem per year mean? Radiation is harmful and sometimes fatal. Measurable harmful effects occur at doses of about 100,000 millirem or more. The residents of Hiroshima and Nagasaki received such levels at the close of World War II from atomic bombs. But scientists disagree about the risks of lower levels of radiation. Some scientists assume that the exposure risk from radiation is in proportion to the dose. They assume that the exposure risk from each millirem is just 1/100,000 of the known exposure risk from 100,000 millirem. According to this theory, called the linear no threshold (LNT) hypothesis, no amount of radiation is safe. This position is the most conservative. It is the hypothesis that is used by government agencies to set standards, as it provides the greatest margin of safety. It is also the easiest to use in calculating exposure risks at low levels. No one has ever been able to demonstrate harmful effects at levels below 10,000 millirem. At such low exposure levels, the exposure risk becomes statistical, based on projections of what happens at higher doses. Many reputable scientists and physicians reject the LNT hypothesis as unscientific for calculating harmful effects from low doses of radiation. They argue that radiation is the only thing we assume has no safe dose. But after more than 40 years of research, science still cannot prove or disprove the existence of radiation-induced heath effects in humans from low-level exposures. Since a clear consensus on the question of safe radiation exposure levels does not exist, most agencies continue to regulate ionizing radiation from a conservative position. These agencies, including ATSDR, assume that there may be a risk associated with low-level radiation exposures. This is the basis for the ALARA philosophy. This philosophy says that facilities that have and use radiation must maintain radiation exposures as low as reasonably achievable (ALARA). The concept balances the costs of controlling doses against the many benefits we get from radiation.

23. How is the possibility or probability of risk from radiation exposures assessed?

The public health risk from ionizing radiation is assumed to be directly proportional to dose. This is a relation based on a conservative assumption (meaning it errs on the side of caution to protect health). The International Council on Radiation Protection (ICRP) and the National Council on Radiation Protection and Measurement (NCRP) have both stated that an individual's risk cannot be calculated. However, an individual's exposures can be measured. But the measurement cannot be directly taken to mean specific health effects will occur. That is because other factors, such as heredity and lifestyle, must also be considered. Sometimes these factors may be unknown. We assume that any amount of radiation, no matter how little, causes some effect. However, the effect may be something that cannot be measured.

Science has studied groups of people who received a large radiation dose to provide the data that is used to figure risk. These groups include Japanese bombing survivors, radium dial painters, people exposed for medical purposes, and uranium miners.

24. To protect public health, is it necessary to clean up those areas identified as having the highest radiation levels in a community to reduce overall exposures and limit multiple exposures?

Yes, when the areas exceed health-based cleanup standards, it is necessary. The need to clean up an area should be determined considering the radiation dose for individuals with the highest exposures expected. The National Council on Radiation Protection and Measurement (NCRP) recommends a cleanup if the dose for that individual exceeds 500 millirem in a year. A cleanup should occur when it would limit someone's being exposed to high levels. For example, a cleanup should occur in areas where many people are likely to be exposed. Such areas may be cleaned up before other areas where levels are higher but it is unlikely anyone would be exposed.

25. How is background radiation considered in a measurement?

Any time radiation is measured; the background level is automatically included. A portion of the measurement is background radiation. How much of the measurement is from background is normally stated separately, unless the measurement is stated as being above background.

26. Why are there diverse references for how much radiation is allowable—OSHA, NIOSH, EPA, ATSDR?

The references vary because each agency provides different government services for different reasons. Therefore, each agency views radiation protection from different viewpoints. The Occupational Safety and Health Administration (OSHA) and the National Institute of Safety and Health (NIOSH) are both concerned with worker safety. The Environmental Protection Agency (EPA) is concerned about the environment and all living things, including one-celled animals and plants. The Agency for Toxic Substances and Disease Registry (ATSDR) looks at the effects of environmental exposures on human health issues. Discussions of radiation levels often refer to various standards in order to provide more information regarding radiation.

27. What is the difference between regulations and standards, and academic and governmental standards regarding radiation?

A regulation must be met. Law requires regulations. Standards are levels that government regulators aspire to meet. However, no law requires that standards be met. Standards are considered to be good practice. Standards and guidelines are the same thing. Both come from various sources, including government and academia.

28. How are standards set? Do standards imply safety?

Standards are set by agencies that regulate public health. That includes the EPA and the Florida Department of Environmental Protection (DEP). A give-and-take process that includes public input develops standards. Typical radiation standards relate to public health and safety. Standards do not imply that no risk exists.

Standards are established after:

- A health and safety need is shown,
- Research, including a great deal of testing, shows that the proposed level makes sense and is cost-effective,
- Public comment and hearings are conducted, and
- All necessary approvals are obtained.

29. What is the difference between radon in drinking water and radium in drinking water? Why are the acceptable levels different?

Radon and radium are both radioactive. However, they are two different radioisotopes. Both are taken into the body differently. Radon is a gas. As discussed in question 30, it escapes from water and primarily enters the body when it is breathed in. In the lung, radon emits alpha particles that could damage lung tissue. Radium is a solid at normal air temperatures. It is mostly dissolved or suspended in tap water. Radium can enter the body through drinking water with radium in it. Radium is absorbed like calcium. It can replace calcium in the body. In the bones, its decay results in emission of alpha particles that could damage bone cells.

30. What about radium in wells? What is the health risk of radium in drinking water?

As discussed in question 29, the risk of drinking radium in water is that it can replace calcium in the bone, which can slightly increase the risk of cancer over 70 years of consumption. It is unlikely that there are high enough levels present in most drinking water to cause this effect.

The Florida Department of Environmental Protection (DEP) regulates testing of public drinking water. There is a conservative health-based level for radium in water called an MCL, or Maximum Contaminant Level. MCLs are enforceable. If public water exceeds the MCLs, the public must be notified very soon after it is detected, and steps must be taken to correct it within a time frame that the utility company and DEP or the approved CHD (the regulator) agree upon.

Local County Health Departments may do some limited sampling of selected private drinking water wells for radionuclides. However, you may also want to consider paying for your private well to be tested by an independent laboratory if you are concerned about possible radium contamination. If testing shows radium in a private drinking water well, it can be easily removed by commonly available water treatment devices, such as water softeners or reverse osmosis filters.

31. Why would the contamination levels for radon in drinking water be handled differently from other radiation contamination in drinking water?

Radon is an inert gas. That means radon in drinking water is not chemically bound to the water. Most of it escapes into the air as the water is used. Radon escapes as it passes through the aerator on the kitchen faucet. It also escapes when it sprays from the showerhead or into the dishwasher. Radon escapes when it agitates in the washing machine. Unlike some other radioisotopes that may be in drinking water, radon is an alpha emitter. Alpha emitters damage soft tissue, such as lung tissue. Because we breathe much more air than we drink water, our greatest soft tissue exposure pathway is through inhaling indoor air. If radon levels in a home are found to be high, a vent system that takes the indoor air outside helps to lower levels.

32. What is the MCL for radon in drinking/tap water?

The EPA has proposed a MCL (maximum contaminant level) for radon in drinking/tap water of 300 picocuries per liter. MCLs refer to the concentration of a chemical that cannot be legally exceeded in a public drinking water supply system. The MCL is devised and enforced by the EPA.

Radon is an alpha emitter. As mentioned in question 5, alpha emitters can damage lung tissue. Therefore, the main health concern for radon in tap water is that it may escape and enter indoor air. It can then be breathed into the body.

33. Can radon in drinking water be emitted during hot showers?

Yes, and during cold showers, too. Radon is released through any use of water. Aeration of the water or adding oxygen to the water through a device on the faucet allows the radon to escape. Radon is released from its physical combination with water during its first splash from a faucet just like carbonation is released when pouring a soft drink into a glass.

34. How do seasonal levels of radon vary?

Many of today's homes are tightly closed for heating or cooling. This can trap radon gas inside a home. Therefore, radon levels tend to be higher in summer and winter. Radon levels in homes also can vary depending on the outside barometric pressure. The indoor pressure of a home can affect radon levels. If the inside of the home is at a lower pressure than the outside, radon can be drawn out of the ground into living areas in the house. This occurs mostly in tightly insulated homes heated by gas or oil furnaces during the winter. Rain can also push radon gas from the ground into homes.

35. How do ventilation rates (i.e., in a closed room versus a room with cross-ventilation) affect radon concentrations?

Home ventilation with outdoor air dilutes the radon concentrations in indoor air. This assumes that outdoor levels are lower. A room with cross-ventilation allows radon gas to move outside. This reduces the radiation levels.

36. Where can people go to get resource information about radiation or ask for referrals?

General information about radiation can be found at the local public library. One can also request a copy of ATSDR's Toxicological Profile for Ionizing Radiation by faxing a request to (404) 639-6234 (Attention: Information Center). In addition, the Department of Health's Bureau of Radiation Control is a good source of information. They have area offices located around the state. The DOH Environmental Radiation Section and Lab is located in Orlando, (407) 297-2095. The main office is located in Tallahassee, (850) 245-4266.

You may also refer to the radiation websites listed in this booklet.

There are a number of websites that provide information on radiation-related issues. Here is a sampling of sites:

Agency for Toxic Substances and Disease Registry

Ionizing Radiation—Frequently Asked Questions (AKA ToxFAQs)
http://www.atsdr.cdc.gov/toxfaqs/tfacts149.pdf

American Lung Association

Radon Fact Sheet
www.lung.org/healthy-air/home/resources/radon.html

Baylor College of Medicine

Radiation Health Effects Research Resource
http://radefx.bcm.edu/chernobyl/default.htm

U.S. Environmental Protection Agency

Health Effects from Ionizing Radiation
www.epa.gov/radiation/understand/health_effects.html

U.S. Environmental Protection Agency

Ionizing Radiation Fact Sheet
www.epa.gov/radiation/understand/

U.S. Environmental Protection Agency

Radiation: Risks and Realities (Booklet)
www.epa.gov/radiation/docs/402-k-10-008.pdf

U.S. Environmental Protection Agency

Students and Teachers' Radiation Protection Pages
www.epa.gov/radiation/students.html

Idaho State University

What You Need to Know about Radiation (book), Lauriston S. Taylor
www.physics.isu.edu/radinf/lstintro.htm

Idaho State University

General Radiation Page
www.physics.isu.edu/radinf/

Nuclear Regulatory Commission

Biological Effects of Radiation
www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html

Radiation Websites

University of Michigan Student Chapter of the Health Physics Society

Radiation Information Page
http://www.umich.edu/~radinfo/introduction/index.htm

World Health Organization

Ionizing Radiation Web Page
http://www.who.int/ionizing_radiation/about/en/

Radiation Questions & Answers

Panel, Biographic Sketches

Michael D. Brooks, CHP, MSHP, Health Physicist, has been certified by the American Academy of Health Physics, and has been a Health Assessor with the Agency for Toxic Substance and Disease Registry (ATSDR) since July 1991. Previously he performed research and designed microwave components for aerospace applications. He also served 3.5 years as Reactor Controls Officer aboard a nuclear powered Fleet Ballistic Missile Submarine. He received his undergraduate degree in Physics, a MS in Physics, and a MS in Health Physics from the Georgia Institute of Technology, in Atlanta. He currently serves at ATSDR's Region 1 office in Boston.

Michael Gilley is an Environmental Administrator for the Florida Department of Health, Bureau of Community Environmental Health, in the Radon and Indoor Air Toxics section. His academic training is in industrial hygiene and health physics. He has been involved in research, evaluation, and mitigation strategy on environmental radiation and indoor air environmental issues for more than 25 years. Currently, he is a member of the Conference of Radiation Control Program Directors Incorporated, Committee on Radon and the American Water Works Association Research Project Foundation Advisory Committee. He retired from the Florida DOH in October 2010.

Wesley Nall has worked for the Polk County Health Department chiefly with the Radiological Health Section, where he supervises related activities. He has a BS degree in mathematics from Stetson University. His health physics training has been primarily through continuing education courses offered by the University of Florida, the Nuclear Regulatory Commission, and the Oak Ridge Associated Universities. The Polk County Health Department is one of two county health departments in the state with a Radiological Health Section. He retired from the Florida DOH in February 2010.

Bill Passetti is the Chief of the Bureau of Radiation Control in Florida's Department of Health. The bureau is responsible for several statewide radiation programs that include radioactive materials, x-ray machines, Radiological Technologists, emergency response, and environmental radiation monitoring. He received his BS degree in Radiologic Science from the Medical College of Georgia and has more than 20 years of experience in medical and regulatory radiation safety issues. He retired from the Florida DOH in May 2012.

Edward A. Tupin, MS, CHP Health Physicist, has over 30 years experience in the field of health physics. He was originally certified by the American Academy of Health Physics in 1982, and has been a health physicist with the Radiation Protection Division of the U.S. Environmental Protection Agency since 2002. He also spent four years as a Health Assessor with the Agency for Toxic Substance and Disease Registry (ATSDR) since July 1998. Previously he spent 13 years as a health physicist and radiation safety officer for the Center for Devices and Radiological Health, part of the Food and Drug Administration, working in the Office of Health Physics and the Division of Mammography Quality and Radiation Programs. Prior to that he was a nuclear medical science officer in the U.S. Army. His assignments included serving as radiation safety officer for the Enewetak Atoll Cleanup Project and army hospitals and health physics survey officer with the U.S. Army Environmental Hygiene Agency. He received his undergraduate degree in Biology from Wake Forest University, Winston-Salem, NC, and a MS in Pathology from Duke University.

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Name of Site:

Location:

Please complete the following that best describes your feelings for each statement:
Based on the information provided in this booklet:

I am more aware about radiation. ❑ Yes ❑ No ❑ Don't know

I understand radiation better. ❑ Yes ❑ No ❑ Don't know

I read the entire booklet. ❑ Yes ❑ No
If no, what parts did you read? (Please specify)

Were your health questions about radiation answered? ❑ Yes ❑ No
If no, what questions do you still have?

Is there information in the booklet you found confusing? If so, what area was confusing?

Is there any information you found unnecessary? If so, what information?

Which of these categories would best describe you?
❑ Community member ❑ A government employee ❑ Health Care professional
❑ Other (please specify)____

How did you get your copy of the booklet? (Check one)
❑ Mailed to me by Department of Health ❑ At a public meeting ❑ Received from friend
❑ Other (please specify)____

Any other comments?

If you would like someone to call you to discuss your concerns, please provide your name and telephone number:

Name:____

Phone #: (___) ______________________________

Please remove this survey from the booklet, fill out, stamp, and mail.

please remove this page and mail

Name

Address

City State Zip

Place stamp here

Florida Department of Health
Health Assessment Team
4052 Bald Cypress Way, Bin# A-08
Tallahassee, FL 32399-1712

fold here with address out and tape on open edge

The Department of Health's Hazardous Waste Site Health Assessment Team, would like to thank you for completing the attached questionnaire. In our efforts to prevent exposure and adverse health effects from radiation, we are concerned about the impact of our educational efforts.

To find out more about us, please call us toll free in the state of Florida at (877) 798-2772 or visit us online at www.doh.state.fl.us/environment/medicine/superfund.