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Radiofrequency (RF) Radiation

Radiation is the emission (sending out) of energy from any source. X-rays are an example of radiation, but so is the light that comes from the sun and the heat that is constantly coming off our bodies.

When talking about radiation and cancer, many people think of specific kinds of radiation such as x-rays or the radiation made by nuclear reactors. But there are other types of radiation that act differently.

Radiation exists across a spectrum from very low-energy (low-frequency) radiation to very high-energy (high-frequency) radiation. This is sometimes referred to as the **electromagnetic spectrum**.

The electromagnetic spectrum illustration below shows all of the possible frequencies of electromagnetic energy. It ranges from extremely low frequencies (such as those from power lines) to extremely high frequencies (x-rays and gamma rays), and includes both non-ionizing and ionizing radiation.

Examples of high-energy radiation include [x-rays and gamma rays](#)¹. These rays, as well as some higher energy [UV radiation](#)², are forms of **ionizing radiation**, which means they have enough energy to remove an electron from (ionize) an atom. This can damage the DNA (genes) inside of cells, which can sometimes result in cancer.

ELECTROMAGNETIC SPECTRUM

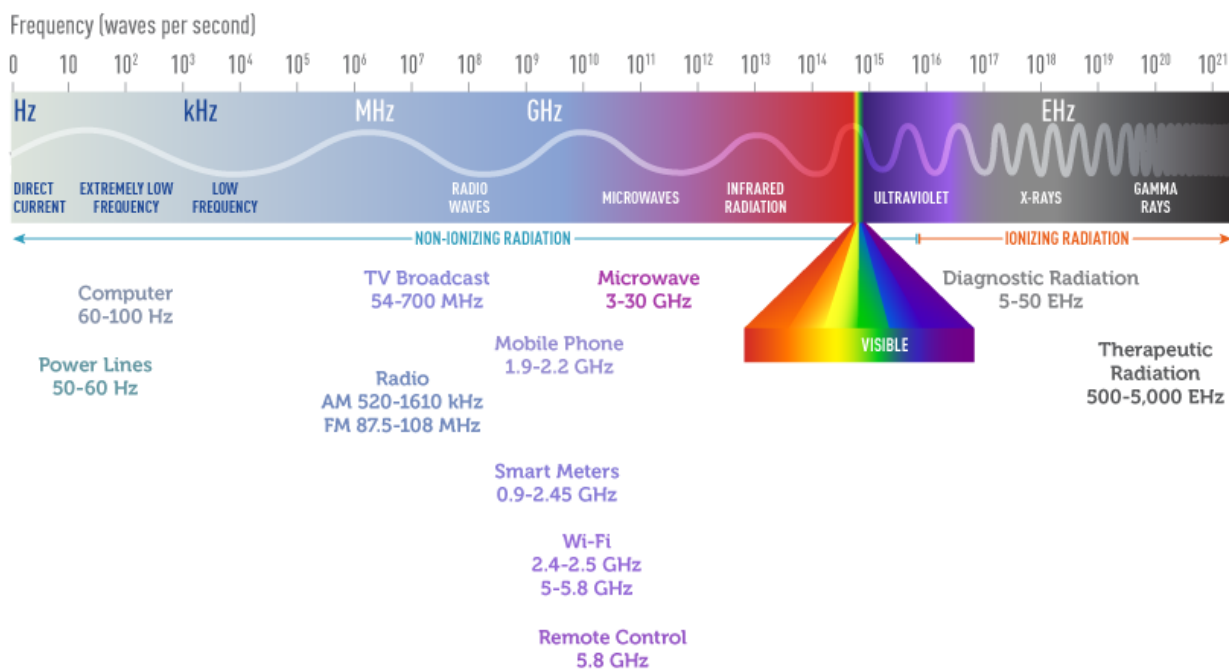


Image credit: National Cancer Institute

What is radiofrequency (RF) radiation?

Radiofrequency (RF) radiation, which includes radio waves and microwaves, is at the low-energy end of the electromagnetic spectrum. It is a type of **non-ionizing radiation**. Non-ionizing radiation does not have enough energy to remove electrons from an atom. Visible light is another type of non-ionizing radiation. RF radiation has lower energy than some other types of non-ionizing radiation, like visible light and infrared, but it has higher energy than [extremely low-frequency \(ELF\) radiation](#)³.

If RF radiation is absorbed by the body in large enough amounts, it can produce heat. This can lead to burns and body tissue damage. Although RF radiation is not thought to cause cancer by damaging the DNA in cells the way ionizing radiation does, there has been concern that in some circumstances, some forms of non-ionizing radiation might still have other effects on cells that might somehow result in cancer.

How are people exposed to RF radiation?

People can be exposed to RF radiation from both natural and man-made sources.

Natural sources include:

- Outer space and the sun
- The sky – including lightning strikes
- The earth itself – most radiation from the earth is infrared, but a tiny fraction is RF

Man-made RF radiation sources include:

- Broadcasting radio and television signals
- Transmitting signals from cordless telephones, [cell phones](#)⁴ and [cell phone towers](#)⁵, satellite phones, and 2-way radios
- Radar
- WiFi, Bluetooth[®] devices, and [smart meters](#)⁶
- The heating of body tissues to destroy them in medical procedures
- “Welding” pieces of polyvinyl chloride (PVC) using certain machines
- Millimeter wave scanners (a type of full body scanner used for security screening)

Some people can have significant RF exposure as part of their jobs. This includes people who maintain antenna towers that broadcast communication signals and people who use or maintain radar equipment.

Most people are exposed to much lower levels of man-made RF radiation every day due to the presence of RF signals all around us. They come from radio and television broadcasts, WiFi and Bluetooth devices, cell phones (and cell phone towers), and other sources.

Some common uses of RF radiation

Microwave ovens

Microwave ovens work by using very high levels of a certain frequency of RF radiation (in the microwave spectrum) to heat foods. When food absorbs microwaves, it causes the water molecules in the food to vibrate, which produces heat. Microwaves do not use x-rays or gamma rays, and they do not make food radioactive.

Microwave ovens are designed so that the microwaves are contained within the oven itself. The oven only makes microwaves when the door is shut and the oven is turned

on. When microwave ovens are used according to instructions, there is no evidence that they pose a health risk to people. In the US, federal standards limit the amount of RF radiation that can leak from a microwave oven to a level far below what would harm people. Ovens that are damaged or modified, however, could allow microwaves to leak out, and so could pose a hazard to people nearby by potentially causing burns.

Full-body security scanners

In many airports in the United States, the Transportation Security Administration (TSA) uses full body scanners to screen passengers. The scanners currently used by the TSA use **millimeter wave imaging**. These scanners send out a small amount of millimeter wave radiation (a type of RF radiation) toward the person in the scanner. The RF radiation passes through clothing and bounces off the person's skin, as well as any objects under the clothes. Receivers sense the radiation and create an image of the outline of the person.

Millimeter wave scanners do not use x-rays (or any other kind of high-energy radiation), and the amount of RF radiation used is very low. According to the US Food and Drug Administration (FDA), these scanners have no known health effects. However, TSA often allows people to be screened in a different way if they object to screening with these scanners.

Cell phones and cell phone towers

Cell phones and cell phone towers (base stations) use RF radiation to transmit and receive signals. Some concerns have been raised that these signals might increase the risk of cancer, and research in this area continues. For more information, see [Cellular Phones](#)⁷ and [Cell Phone Towers](#)⁸.

Does RF radiation cause cancer?

Researchers use 2 main types of studies to try to determine if something might cause cancer:

- **Studies done in the lab studies**
- **Studies looking at groups of people**

Often neither type of study provides enough evidence on its own, so researchers usually look at both lab-based and human studies when trying to figure out if something causes cancer.

The following is a brief summary of some of the major studies that have looked at this issue to date. However, this is not a comprehensive review of all studies that have been done.

Studies done in the lab

RF waves don't have enough energy to damage DNA directly. Because of this, it's not clear how RF radiation might be able to cause cancer. Some studies have found possible increased rates of certain types of tumors in lab animals exposed to RF radiation, but overall, the results of these types of studies have not provided clear answers so far.

A few studies have reported evidence of biological effects that could be linked to cancer, but this is still an area of research.

In large studies published in 2018 by the US National Toxicology Program (NTP) and by the Ramazzini Institute in Italy, researchers exposed groups of lab rats (as well as mice, in the case of the NTP study) to RF waves over their entire bodies for many hours a day, starting before birth and continuing for at least most of their natural lives. Both studies found an increased risk of uncommon heart tumors called malignant schwannomas in male rats, but not in female rats (nor in male or female mice, in the NTP study). The NTP study also reported possible increased risks of certain types of tumors in the brain and in the adrenal glands.

While both of these studies had strengths, they also had limitations that make it hard to know how they might apply to humans being exposed to RF radiation. A 2019 review of these two studies by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) determined that the limitations of the studies didn't allow conclusions to be drawn regarding the ability of RF energy to cause cancer.

Still, the results of these studies do not rule out the possibility that RF radiation might somehow be able to impact human health.

Studies in people

Studies of people who may have been exposed to RF radiation at their jobs (such as people who work around or with radar equipment, those who service communication antennae, and radio operators) have found no clear increase in cancer risk.

A number of studies have looked for a possible link between cell phones and cancer. Although some studies have shown a possible link, many others have not. For many

reasons, it is hard to study if there might be a link between cell phones and cancer, including the relatively short time that cell phones have been in widespread use, changes in the technology over time, and difficulty in estimating each person's exposure. The topic of cell phones and cancer risk is discussed in detail in [Cellular \(Cell\) Phones](#)⁹.

What do expert agencies say?

The American Cancer Society (ACS) does not have any official position or statement on whether or not radiofrequency radiation from cell phones, cell phones towers, or other sources is a cause of cancer. ACS generally looks to other expert organizations to determine if something causes cancer (that is, if it is a carcinogen), including:

- The **International Agency for Research on Cancer (IARC)**, which is part of the World Health Organization (WHO)
- The **US National Toxicology Program (NTP)**, which is formed from parts of several different government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA)

Other major organizations might also comment on the ability of certain exposures to cause cancer.

Based on a review of studies published up until 2011, the **International Agency for Research on Cancer (IARC)** has classified RF radiation as “possibly carcinogenic to humans,” based on limited evidence of a possible increase in risk for brain tumors among cell phone users, and inadequate evidence for other types of cancer. (For more information on the IARC classification system, see [Known and Probable Human Carcinogens](#)¹⁰.)

More recently, the **US Food and Drug Administration (FDA)** issued a technical report based on results of studies published between 2008 and 2018, as well as national trends in cancer rates. The report concluded: “Based on the studies that are described in detail in this report, there is insufficient evidence to support a causal association between radiofrequency radiation (RFR) exposure and [tumor formation].”

So far, the **National Toxicology Program (NTP)** has not included RF radiation in its *Report on Carcinogens*, which lists exposures that are known to be or reasonably anticipated to be human carcinogens. (For more on this report, see [Known and Probable Human Carcinogens](#)¹¹.)

According to the **US Federal Communications Commission (FCC)**:

“[C]urrently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses. Those evaluating the potential risks of using wireless devices agree that more and longer-term studies should explore whether there is a better basis for RF safety standards than is currently used.”

How can I avoid exposure to RF radiation?

Because sources of RF radiation are so common in the modern world, there is no way to completely avoid exposure to it. There are some ways you can lower your exposure to RF radiation, such as:

- Avoiding jobs with increased RF exposure
- Limiting the time you spend near appliances, equipment, and other devices (such as WiFi routers) that give off RF radiation
- Limiting the time you spend with a cell (mobile) phone placed against your ear (or close to another part of your body)

Still, it isn't clear that doing these things will be helpful in terms of health risks.

Hyperlinks

1. www.cancer.org/cancer/cancer-causes/radiation-exposure/x-rays-gamma-rays.html
2. www.cancer.org/cancer/cancer-causes/radiation-exposure/uv-radiation.html
3. www.cancer.org/cancer/cancer-causes/radiation-exposure/extremely-low-frequency-radiation.html
4. www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phones.html
5. www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html
6. www.cancer.org/cancer/cancer-causes/radiation-exposure/smart-meters.html
7. www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phones.html
8. www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html
9. www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phones.html
10. www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html

11. www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html
12. <http://www.cdc.gov/>
13. <http://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns>
14. <http://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety>
15. <http://www.cancer.gov/>
16. <http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>
17. <http://www.niehs.nih.gov/>
18. <http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>
19. <http://www.cdc.gov/>
20. <http://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns>
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22. <http://www.cancer.gov/>
23. <http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>
24. <http://www.niehs.nih.gov/>
25. <http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>

Additional resources

Along with the American Cancer Society, other sources of information include:

Centers for Disease Control and Prevention (CDC) Toll-free number: 1-800-232-4636 (1-800-CDC-INFO) Website: www.cdc.gov (<http://www.cdc.gov/>)¹²

Federal Communications Commission (FCC) Wireless Devices and Health Concerns: www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns (<http://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns>)¹³ RF Safety FAQ: www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety (<http://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety>)¹⁴

National Cancer Institute (NCI) Toll-free number: 1-800-422-6237 (1-800-4-CANCER) Website: www.cancer.gov (<http://www.cancer.gov/>)¹⁵ Electromagnetic Fields and Cancer: www.cancer.gov/about-cancer/causes-

prevention/risk/radiation/electromagnetic-fields-fact-sheet (<http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>)¹⁶

National Institute of Environmental Health Sciences (NIEHS)

Website: www.niehs.nih.gov (<http://www.niehs.nih.gov/>)¹⁷ Electric and Magnetic Fields: www.niehs.nih.gov/health/topics/agents/emf/index.cfm (<http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>)¹⁸

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

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