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## Cellular (Cell) Phones

Cellular (cell or mobile) phones first became widely available in the United States in the 1990s. Since then, along with the large and still growing number of cell phone users (both adults and children), the amount of time people spend on their phones has also risen sharply.

Cell phones give off a form of energy known as [radiofrequency \(RF\) waves](#)<sup>1</sup>, so the safety of cell phone use has raised some concerns. The main concerns have focused on whether cell phones might increase the risk of brain tumors or other tumors in the head and neck area, as these areas are closest to where the phone is usually held while talking or listening on a call.

### How do cell phones work?

Cell phones send signals to (and receive them from) nearby [cell towers](#)<sup>2</sup> (base stations) using RF waves. This is a form of energy in the electromagnetic spectrum that falls between FM radio waves and microwaves. Like FM radio waves, microwaves, visible light, and heat, RF waves are a form of **non-ionizing radiation**. They don't have enough energy to cause cancer by directly damaging the DNA (genes) inside cells. RF waves are different from stronger (**ionizing**) types of radiation such as [x-rays](#), [gamma rays](#)<sup>3</sup>, and [ultraviolet \(UV\) rays](#)<sup>4</sup>. Ionizing radiation can break the chemical bonds in DNA, which might lead to cancer.

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

# ELECTROMAGNETIC SPECTRUM

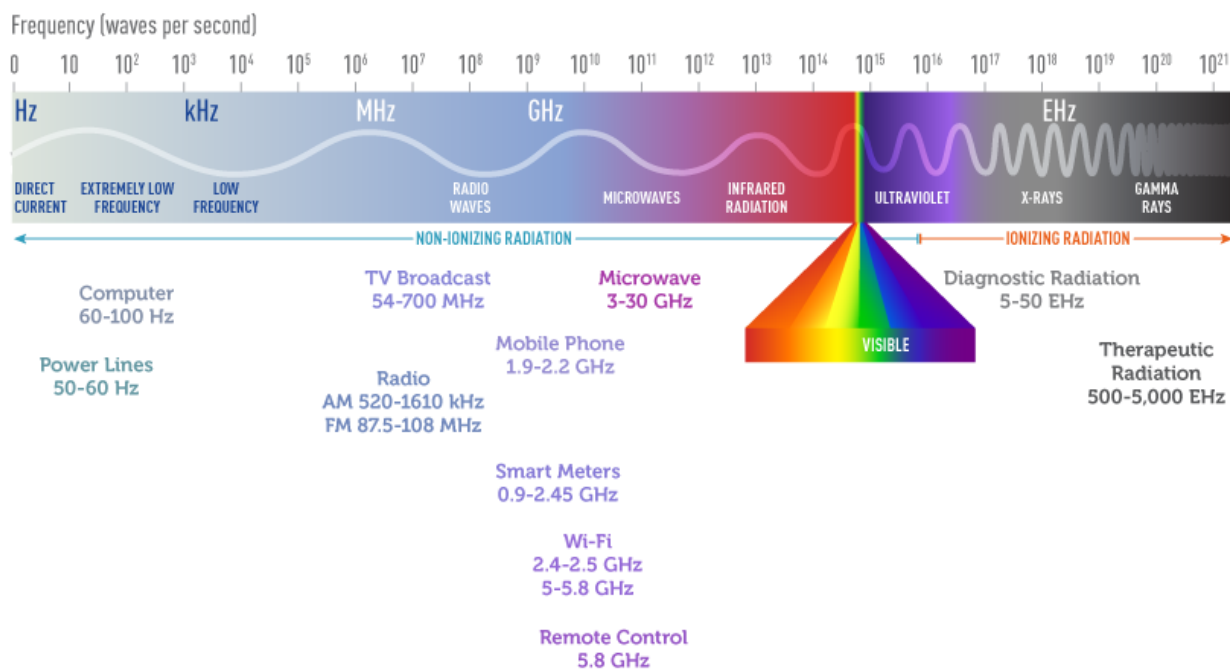


Image credit: National Cancer Institute

At very high levels, RF waves can heat up body tissues. But the levels of energy given off by cell phones are much lower, and are not enough to raise temperatures in the body.

## How are people exposed?

The RF waves come from the cell phone's antenna, which is part of the body of a hand-held phone. The waves are strongest at the antenna and lose energy quickly as they travel away from the phone. The phone is often held against the head when a person is on a call. The closer the antenna is to a user's head, the greater their expected exposure to RF waves. The body tissues closest to the phone absorb more energy from RF waves than tissues farther away.

Many factors can affect the amount of energy from RF waves that a person is exposed to, including:

- **The amount of time the person is on the phone.**

- **Whether the person is holding the phone close to the head, or is instead using the speaker mode or a hands-free device.** The farther away from a person's body the phone is, the less they are exposed.
- **The distance and path to the nearest cell phone tower.** Cell phones adjust their power to use the minimum amount for a good signal. Being farther away from the tower requires more energy to get a good signal, as does being inside a building.
- **The amount of cell phone traffic in the area at the time.** Higher traffic (from many people using cell phones) may require more energy to get a good signal.
- **The model of phone being used.** Different phones give off different amounts of energy.

## Cell phone specific absorption rate (SAR)

The specific absorption rate (SAR) is the amount of RF energy from the phone absorbed by the user's body. Different cell phones have different SAR levels. Cell phone makers are required to report the maximum SAR level of their product to the US Federal Communications Commission (FCC). This information can often be found on the manufacturer's website or in the user manual for the phone. The upper limit of SAR allowed in the United States according to FCC safety guidelines is 1.6 watts per kilogram (W/kg) of body weight.

But according to the FCC, comparing SAR values between phones can be misleading. The listed SAR value is based only on the phone operating at its highest power, not on what users would typically be exposed to with normal phone use. The actual SAR during use varies based on a number of factors, so it's possible that a phone with a lower listed SAR value might sometimes expose a person to more energy from RF waves than one with a higher listed SAR value.

## Do cell phones cause tumors?

Because cell phones usually are held near the head when a person is on a call, the main concern has been whether the phones might cause or contribute to tumors in this area, including:

- Malignant (cancerous) [brain tumors](#),<sup>5</sup> such as gliomas
- Non-cancerous tumors of the brain, such as meningiomas
- Non-cancerous tumors of the nerve connecting the brain to the ear (vestibular schwannomas, also known as acoustic neuromas)

- Tumors of the salivary glands

A few studies have also looked at possible links to other types of cancer.

### **What do studies show?**

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

- **Studies done in the lab (using lab animals or cell cultures)**
- **Studies looking at groups of people**

In most cases neither type of study provides enough evidence on its own to show if something causes cancer in people, so researchers usually look at both lab-based and human studies.

*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.*

### **Lab studies of RF waves**

As noted above, the RF waves given off by cell phones don't have enough energy to damage DNA directly or to heat body tissues. Because of this, it's not clear how cell phones 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.

Large studies published in 2018 by the US National Toxicology Program (NTP) and by the Ramazzini Institute in Italy 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 most or all 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 waves from cell phones. 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 waves from cell phones might somehow impact human health.

## **Studies in people**

Several dozen studies have looked at possible links between cell phone use and tumors. Most of these studies have focused on brain tumors. Many of these have been case-control studies, in which patients with brain tumors (cases) were compared to people who didn't have brain tumors (controls), in terms of their past cell phone use.

These studies have had mixed results. Some studies have found a possible link between cell phone use and brain tumors, while others have not. For example, several studies published by the same research group in Sweden have reported an increased risk of brain tumors in people using cell phones. However, there was no apparent overall increase in brain tumors in Sweden during the years that correspond to these reports.

Three large studies deserve special mention:

### ***The INTERPHONE study***

The 13-country INTERPHONE study, the largest case-control study done to date, looked at cell phone use among more than 5,000 people who developed brain tumors (gliomas or meningiomas) and a similar group of people without tumors. Overall, the study found no link between brain tumor risk and the frequency of calls, longer call time, or cell phone use for 10 or more years. There was a suggestion of a possible increased risk of glioma, and a smaller suggestion of an increased risk of meningioma, in the 10% of people who used their cell phones the most. But this finding was hard to interpret because some people in the study reported implausibly high cell phone use. The researchers noted that the shortcomings of the study prevented them from drawing any firm conclusions, and that more research was needed.

Another part of the INTERPHONE study compared more than 1,000 people with acoustic neuromas to more than 2,000 people without tumors, who served as matched controls. As with gliomas and meningiomas, there was no overall link between cell phone use and acoustic neuromas. There was again a suggestion of a possible increased risk in the 10% of people who used their cell phones the most, but this finding was hard to interpret because some people reported implausibly high cell phone use.

### ***The Danish cohort study***

A large, long-term study has been comparing all of the people in Denmark who had a cell phone subscription between 1982 and 1995 (about 400,000 people) to those without a subscription to look for a possible increase in brain tumors. The most recent update of the study followed people through 2007. Cell phone use, even for more than 13 years, was not linked with an increased risk of brain tumors, salivary gland tumors, or cancer overall, nor was there a link with any brain tumor subtypes or with tumors in any location within the brain.

This type of study (following a large group of people going forward in time and not relying on people's memories about cell phone use) is generally thought to provide stronger evidence than a case-control study.

But this study also has some drawbacks. First, it is based only on whether or not people had a cell phone subscription at the time. It didn't measure how often these people used their phones (if at all), or if people who didn't have a subscription used someone else's phone. There are also limits as to how well this study might apply to people using cell phones today. For example, while the cell phones used at the time of the study tended to emit higher levels of RF waves than modern cell phones do, people also probably used their phones quite a bit less than people use their phones today.

### ***The Million Women Study***

A large prospective (forward-looking) study of nearly 800,000 women in the UK examined the risk of developing brain tumors over a 7-year period in relation to self-reported cell phone use at the start of the study. This study found no link between cell phone use and brain tumors overall or several common brain tumor subtypes, but it did find a possible link between long-term cell phone use and acoustic neuromas. The authors of this study, however, did note the possibility that this link might have been due to more intensive medical investigation in long-term cell phone users because of media coverage at the time.

### ***All studies done so far have limitations***

In summary, studies of people published so far have not established a clear link between cell phone use and the development of tumors. However, these studies have had some important limitations that make them unlikely to end the controversy about whether cell phone use affects cancer risk.

First, studies have not yet been able to follow people for very long periods of time. After

a known cancer-causing exposure, it often takes decades for tumors to develop. Because cell phones have been widely used for only about 20 years in most countries, it is not possible to rule out possible future health effects.

Second, cell phone usage is constantly changing. People are using their cell phones much more than they were even 10 years ago, and the phones themselves are very different from what was used in the past. This makes it hard to know if the results of studies looking at cell phone use in years past still apply today.

Third, most of the studies published so far have focused on adults, rather than children. (One case-control study looking at children and teens did not find a significant link to brain tumors, but the small size of the study limited its power to detect modest risks.) Cell phone use is now widespread even among younger children. It is possible that if there are health effects, they might be more pronounced in children because their bodies might be more sensitive to RF energy. Another concern is that children's lifetime exposure to RF waves from cell phones will be greater than adults', who started using cell phones when they were older.

Finally, the measurement of cell phone use in most studies has been crude. Most have been case-control studies, which have relied on people's memories about their past cell phone use. In these types of studies, it can be hard to interpret any possible link between cancer and an exposure. People with cancer are often thinking about possible reasons for it, so they may sometimes recall their phone usage differently from people without cancer.

With these limitations in mind, it is important to continue to study the possible risk of cell phone exposure, especially with regard to use by children and longer-term use.

### What do expert agencies say?

**The American Cancer Society (ACS) does not have any official position or statement on whether or not radiofrequency (RF) radiation from cell phones, cell phone 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 also sometimes comment on the ability of certain exposures (such as cell phone use) 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](#)<sup>6</sup>.)

More recently, the **US Food and Drug Administration (FDA)** issued a technical report based on 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](#)<sup>7</sup>.)

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.”

According to the **US Centers for Disease Control and Prevention (CDC)**:

“At this time we do not have the science to link health problems to cell phone use. Scientific studies are underway to determine whether cell phone use may cause health effects.”

## How can I lower my exposure to RF waves from cell phones?

It is not clear at this time that RF waves from cell phones cause harmful health effects in people, but studies now being done should give a clearer picture of the possible health effects in the future. Until more is known, there are several things that people who are



concerned about RF waves can do to limit their exposure.

**Use the speaker mode or video chat feature on the phone, or a hands-free device such as a corded or cordless earpiece.** This moves the antenna away from your head, which decreases the amount of RF waves that reach the head. Corded earpieces emit virtually no RF waves (although the phone itself still emits small amounts of RF waves that can reach parts of the body if close enough, such as on the waist or in a pocket). Bluetooth<sup>®</sup> earpieces typically transmit RF waves at much lower power levels than cell phones themselves (see below).

**Texting instead of talking on the phone may be another way to reduce your exposure.** But it may not be a good option in some situations, especially if you are driving. For safety reasons, it is especially important to limit or avoid the use of cell phones (especially texting) while driving.

**Limit your (and your children's) cell phone use.** This is one of the most obvious ways to limit your exposure to RF waves from cell phones. For example, you may want to limit the amount of time you spend talking on the phone (at least with your phone up to your ear). Parents who are concerned about their children's exposure can limit how much time they spend talking on the phone.

**Consider choosing a phone with a low SAR value.** Different models of phones can give off different levels of RF waves. But as noted above, according to the FCC the SAR value is not always a good indicator of a person's exposure to RF waves during normal cell phone use. One way to get information on the SAR level for a specific phone model is to visit the phone maker's website. The FCC has links to some of these sites here: [www.fcc.gov/general<sup>8</sup>/specific-absorption-rate-sar-cellular-telephones<sup>9</sup>](http://www.fcc.gov/general<sup>8</sup>/specific-absorption-rate-sar-cellular-telephones<sup>9</sup>). If you know the FCC identification (ID) number for your phone model (which can often be found somewhere on the phone or in the user manual), you can also go to the following web address: [www.fcc.gov/oet/ea/fccid<sup>10</sup>](http://www.fcc.gov/oet/ea/fccid<sup>10</sup>). On this page, you will see instructions for entering the FCC ID number.

## Are phones on 5G networks any different?

Fifth generation (5G) cellular networks are now being rolled out in many parts of the United States and in other countries. 5G networks are capable of transmitting much larger amounts of data over shorter periods of time than previous generations (4G, 3G, etc.).

5G networks (and the phones that use them) operate on some higher frequency (higher energy) RF wavelengths than older generation networks (although newer phones can

typically still use the older networks as well). But the newer 5G signals still use RF waves, so they are still forms of **non-ionizing** radiation, which is not thought to have the ability to directly damage DNA.

The studies that have been done so far to look at possible links between cell phone use and cancer have focused on older generation (mainly 2G and 3G) signals. At this time, there has been very little research showing that the RF waves used in 5G networks are any more (or less) of a concern than the other RF wavelengths used in cellular communication. For more on 5G networks, see [Cell Phone Towers](#)<sup>11</sup>.

## What about cordless phones?

Cordless phones, commonly used in homes, have base units that are plugged into telephone jacks and wired to a local telephone service. They are not considered cell phones. Cordless phones operate at about 1/600 the power of cell phones, so they are much less likely to be a concern in terms of health effects.

## What about Bluetooth<sup>®</sup> devices (including earbuds)?

Many wireless devices now communicate over shorter distances using Bluetooth technology. For example, many phones now have the option of using wireless (Bluetooth) earbuds. Phones can also connect to other devices (tablets, laptops, car dashboard computers, etc.) using Bluetooth.

Bluetooth devices use RF waves in a similar wavelength range as those used for cell phones. But because the signals only need to travel a short distance (such as from the phone to a person's ears), they can operate at much lower power levels than those used by phones, which in theory might make them less of a health concern. But as with other devices that give off RF waves, possible health effects from these devices cannot be ruled out completely at this time.

## Hyperlinks

1. [www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html](http://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html)
2. [www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html](http://www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html)
3. [www.cancer.org/cancer/cancer-causes/radiation-exposure/x-rays-gamma-rays.html](http://www.cancer.org/cancer/cancer-causes/radiation-exposure/x-rays-gamma-rays.html)
4. [www.cancer.org/cancer/cancer-causes/radiation-exposure/uv-radiation.html](http://www.cancer.org/cancer/cancer-causes/radiation-exposure/uv-radiation.html)

5. [www.cancer.org/cancer/brain-spinal-cord-tumors-adults.html](http://www.cancer.org/cancer/brain-spinal-cord-tumors-adults.html)
6. [www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html](http://www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html)
7. [www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html](http://www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html)
8. [www.fcc.gov/general/specific-absorption-rate-sar-cellular-telephones](http://www.fcc.gov/general/specific-absorption-rate-sar-cellular-telephones)
9. [www.fcc.gov/general/specific-absorption-rate-sar-cellular-telephones](http://www.fcc.gov/general/specific-absorption-rate-sar-cellular-telephones)
10. [www.fcc.gov/](http://www.fcc.gov/)
11. [www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html](http://www.cancer.org/cancer/cancer-causes/radiation-exposure/cellular-phone-towers.html)
12. [www.cdc.gov/nceh/radiation/cell\\_phones\\_FAQ.html](http://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html)
13. [www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns](http://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns)
14. [www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones](http://www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones)
15. [www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet](http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet)
16. [www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm](http://www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm)
17. [www.niehs.nih.gov/health/materials/cell\\_phone\\_radiofrequency\\_radiation\\_studies\\_508.pdf](http://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf)
18. [www.cdc.gov/nceh/radiation/cell\\_phones\\_FAQ.html](http://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html)
19. [www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns](http://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns)
20. [www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones](http://www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones)
21. [www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet](http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet)
22. [www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm](http://www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm)
23. [www.niehs.nih.gov/health/materials/cell\\_phone\\_radiofrequency\\_radiation\\_studies\\_508.pdf](http://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf)

## Additional resources

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

**Centers for Disease Control and Prevention (CDC)** Frequently Asked Questions about Cell Phones and Your Health

Website: [https://www.cdc.gov/nceh/radiation/cell\\_phones\\_FAQ.html](https://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html)  
([www.cdc.gov/nceh/radiation/cell\\_phones\\_FAQ.html](http://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html))<sup>12</sup>

**Federal Communications Commission (FCC)** Wireless Devices and Health Concerns  
Website: <https://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns>  
([www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns](https://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns))<sup>13</sup>

**Food and Drug Administration (FDA)** Cell Phones  
Website: <https://www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones>  
([www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones](https://www.fda.gov/radiation-emitting-products/home-business-and-entertainment-products/cell-phones))<sup>14</sup>

**National Cancer Institute (NCI)** Cell Phones and Cancer Risk  
Website: <https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet>  
([www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet](https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet))<sup>15</sup>

**National Institute of Environmental Health Sciences (NIEHS)** Cell Phone Radio Frequency Radiation:  
<https://www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm>  
([www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm](https://www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm))<sup>16</sup> Cell Phone Radio Frequency Radiation Studies:  
[https://www.niehs.nih.gov/health/materials/cell\\_phone\\_radiofrequency\\_radiation\\_studies\\_508.pdf](https://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf)  
([www.niehs.nih.gov/health/materials/cell\\_phone\\_radiofrequency\\_radiation\\_studies\\_508.pdf](https://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf))<sup>17</sup>

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

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