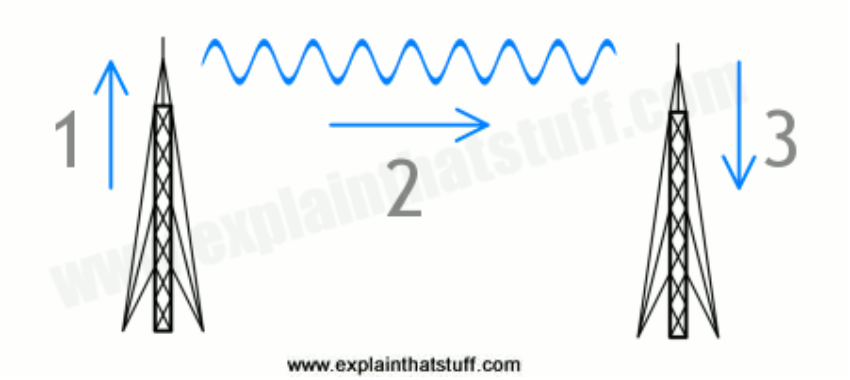
3. Antennas and transmitters

Imagine holding out your hand and catching words, pictures, and information passing by. That's more or less what an **antenna** (sometimes called an aerial) does: it's the metal rod or dish that catches radio waves and turns them into electrical signals feeding into something like a radio or television or a telephone system. Antennas like this are sometimes called receivers. A transmitter is a different kind of antenna that does the opposite job to a receiver: it turns electrical signals into radio waves so they can travel sometimes thousands of kilometers around the Earth or even into space and back. Antennas and transmitters are the key to virtually all forms of modern telecommunication. Let's take a closer look at what they are and how they work!

How antennas work

Suppose you're the boss of a radio station and you want to transmit your programs to the wider world. How do you go about it? You use microphones to capture the sounds of people's voices and turn them into electrical energy. You take that electricity and, loosely speaking, make it flow along a tall metal antenna (boosting it in power many times so it will travel just as far as you need into the world). As the electrons (tiny particles inside atoms) in the electric current wiggle back and forth along the antenna, they create invisible electromagnetic radiation in the form of radio waves. These waves, partly electric and partly magnetic, travel out at the speed of light, taking your radio program with them. What happens when I turn on my radio in my home a few miles away? The radio waves you sent flow through the metal antenna and cause electrons to wiggle back and forth. That generates an electric current—a signal that the electroniccomponents inside my radio turn back into sound I can hear.



Artwork: How a transmitter sends radio waves to a receiver. 1) Electricity flowing into the transmitter antenna makes electrons vibrate up and down it, producing radio waves. 2) The radio waves travel through the air at the speed of light. 3) When the waves arrive at the receiver antenna, they make electrons vibrate inside it. This produces an electric current that recreates the original signal.

Transmitter and receiver antennas are often very similar in design. For example, if you're using something like a satellite phone that can send and receive a video-telephone call to any other place on Earth using space satellites, the signals you transmit and receive all pass through a single satellite dish—a special kind of antenna shaped like a bowl (and technically known as a **parabolic reflector**, because the dish curves in the shape of a graph called a parabola). Often, though, transmitters and receivers look very different. TV or radio broadcasting antennas are huge masts sometimes stretching hundreds of meters/feet into the air, because they have to send powerful signals over long distances. (One of the ones I tune into regularly, at Sutton Coldfield in England, has a mast 270.5 metres or 887ft high, which is something like 150 tall people standing on top of one another.) But you don't need anything that big on your TV or radio at home: a much smaller antenna will do the job fine.

Important properties of antennas

Three features of antennas are particularly important, namely their directionality, gain, and bandwidth.

Directionality

Dipoles are very **directional**: they pick up incoming radio waves traveling at right angles to them. That's why a TV antenna has to be properly mounted on your home, and facing the correct way, if you're going to get a clear picture. The telescopic antenna on an FM radio is less obviously directional, especially if the signal is strong: if you have it pointed straight upward, it will capture good signals from virtually any direction. The ferrite AM antenna inside a radio is much more directional. Listening to AM, you'll find you need to swivel your radio around until it picks up a really strong signal. (Once you've found the best signal, try turning your radio through exactly 90 degrees and notice how the signal often falls off almost to nothing.)

Although highly directional antennas may seem like a pain, when they're properly aligned, they help to reduce interference from unwanted stations or signals close to the one you're trying to detect. But directionality isn't always a good thing. Think about your cellphone. You want it to be able to receive calls wherever it is in relation to the nearest phone mast, or pick up messages whichever way it happens to be pointing when it's lying in your bag, so a highly directional antenna isn't much good. Similarly for a GPS receiver that tells you where you are using signals from multiple space satellites. Since the signals come from different satellites, in different places in the sky, it follows that they come from different directions, so, again, a highly directional antenna wouldn't be that helpful.

Gain

The **gain** of an antenna is a very technical measurement but, broadly speaking, boils down to the amount by which it boosts the signal. TVs will often pick up a poor, ghostly signal even without an antenna plugged in. That's because the metal case and other components act as a basic antenna, not focused in any particular direction, and pick up some kind of signal by default. Add a proper directional antenna and you'll *gain* a much better signal. Gain is measured in decibels (dB), and (as a broad rule of thumb) the bigger the gain the better your reception. In the case of TVs, you get much more gain from a complex outdoor antenna (one with, say, 10–12 dipoles in a parallel "array") than from a simple dipole. All outdoor antennas work better than indoor ones, and window and set-mounted antennas have higher gain and work better than built-in ones.

Bandwidth

An antenna's **bandwidth** is the range of frequencies (or wavelengths, if you prefer) over which it works effectively. The broader the bandwidth, the greater the range of different radio waves you can pick up. That's helpful for something like television, where you might need to pick up many different channels, but much less useful for telephone, cellphone, or satellite communications where all you're interested in is a very specific radio wave transmission on a fairly narrow frequency band.