With Solar Cycle 25 gearing up over the next few years, you may want to think about upgrading your license, your radio, and your antenna. On that last matter, here's a primer on gain, that explains how certain antennas can concentrate energy right where you want it.

Antenna Gain

Imagine standing in a field on an autumn afternoon. The sky is utterly cloudless, and the sun is shining brightly, warming you and everything else with its evenly distributed light.

You spot a brown, desiccated leaf at your feet. To get a closer look, you reach into your pocket and produce a magnifying glass. As you hold the glass and examine the leaf, you suddenly notice a dazzling spot of light on the leaf's surface. Wisps of smoke appear at the spot and, seconds later, the leaf erupts into flames!

What just happened? In your eagerness to get a better glimpse of the leaf, you forgot that your magnifying glass would focus the sunlight, greatly concentrating its power in a small area. The sunlight that a moment ago offered only gentle warmth quickly became much hotter and brighter at the point where the magnifying glass focused it on the leaf.

When you concentrate electromagnetic radiation at a particular location, you effectively concentrate at least a portion of its power at that location as well. Light energy is a type of electromagnetic radiation; so is radio energy. And just as a magnifying glass can concentrate light, antennas can concentrate radio waves.

It All Comes Down to Gain

The concept of *gain* can be a little confusing. You'll hear hams speak of gain when they are talking about amplifiers, and they express this gain in numbers known as *decibels*, or dB. For example, if you have an amplifier that takes 100 watts of radio frequency (RF) energy and turns it into 200 watts, that amplifier is said to have a gain of 3 dB. Let's not get into the mathematics of why this is so, but if you'd like to dive deeper into decibels, you'll find an online tutorial at www.animations.physics.unsw.edu.au/jw/dB.htm.

In the world of antennas, however, we use the concept of gain a little differently. Unlike amplifiers, antennas can't *produce* more RF energy than what is already present. However, they can *concentrate* RF energy to varying degrees, and we also refer their ability to do this in terms of gain expressed in decibels.

This is why you'll also hear amateurs talking about how much gain an antenna has — or doesn't have. ("My antenna has more than 5 dB of gain!") Most people assume that more antenna gain is always good. As you're about to see, this assumption isn't always true.

Fired-up Frequencies

The frequencies of light are much higher than the frequencies of radio signals. The higher the frequency, the more energy is carried in the radiation. That's why sunlight from 93 million miles away can be concentrated by a magnifying glass and ignite a fire. Focused radio frequency radiation could start fires too, but you'd need a lot of concentrated power from a source much closer to the target.

Example 1: A Mobile Antenna

In Figure 1 you see a simple mobile antenna installed on the roof of a car. The odd-shaped bubble surrounding the antenna represents the pattern of RF energy sent and received. Notice that the bubble has a dimple directly over the top of the antenna. Engineers refer to this as *null* in the pattern. This is where energy is at its weakest.

A pattern like this is considered to have low gain because it isn't very concentrated — it is sending and receiving in nearly all directions at the same time, and at the same strength. Does this mean that this low-gain design is a poor antenna?

Not at all. When you are operating from a moving car, the distances and headings between you and the other stations are constantly changing. In this environment, you want to create patterns that give you the broadest coverage in as many directions as possible, and that's exactly what this low-gain antenna is intended to do.

Example 2: A Yagi Antenna

In Figure 2 we have a type of antenna known as a *Yagi* installed on a tower in someone's yard. A Yagi is a type of *directional* antenna. Rather than sending and receiving signals in many directions at once, like the mobile antenna in the previous example, a Yagi concentrates sending and receiving in a single direction. Notice how its radiation pattern is long and narrow, reaching outward from the antenna.

A directional antenna works more like a magnifying glass, focusing power in a relatively tight beam. This allows for much greater communication range than you could enjoy with a mobile antenna. (In fact, many hams refer to directional antennas as *beams*.) The tighter the focus of a directional antenna, the greater its gain will be in the direction you're aiming it.

Higher antenna gain has obvious benefits, but there is a downside as well. Unless you only care about communicating in a single direction at all times, you're going to have to invest in a device called an *antenna rotator* that will allow you to turn the antenna to new positions. Also, directional antennas increase in physical size as their gain increases.

The Greatest Gain for the Greatest Need

If your goal is long-distance communication, look for a higher-gain directional antenna. But if your goal is to radiate signals in all directions for broader coverage, a lower-gain antenna is a better choice.

Some antenna designs offer a mix of higher and lower gains with radiation patterns that are concentrated in some directions, but not others. Sometimes this mix of patterns is intentional, but often not. For instance, a multiband HF dipole antenna may generate different gain patterns depending on the frequencies in question. This is why you may hear a ham refer to his dipole antenna performance by saying, "On 20 meters I can contact stations almost anywhere, but when I switch to 15 meters, most of my contacts are either southwest or northeast of me." Chances are his antenna has an evenly distributed pattern when he is using it on 20 meters, but on 15 meters, it concentrates energy to the southwest and northeast.

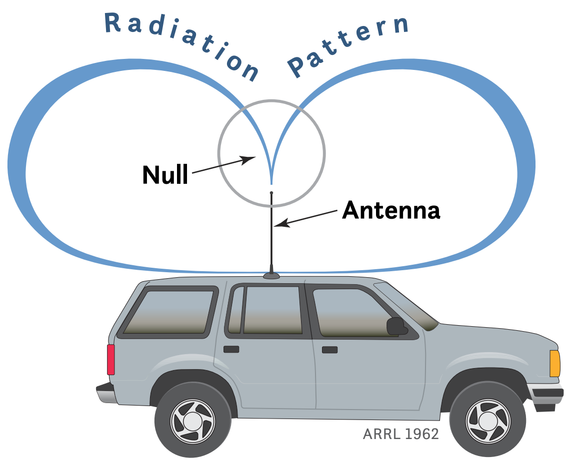

Figure 1: Most mobile antennas are "low-gain" designs for good reasons. A low-gain antenna sends and receives energy in a broader pattern that is better suited to communicating with stations that may lie at different distances and directions from the car.

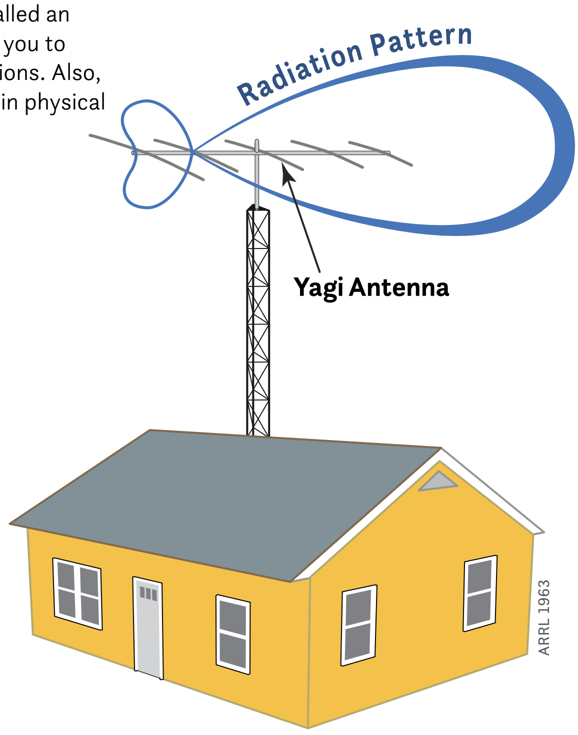

Figure 2: A high-gain directional antenna, like this Yagi, concentrates power in a particular direction, creating the pattern shown here. As a result, this type of antenna is ideal for communicating with stations that may be far away.