Sometimes it helps to revisit the basics. Here we present a condensed excerpt from Andrew Rodney's forthcoming book, "Color Management for Photographers."

Playing with prisms

Nature and nature's laws lay hid in night:/ God said, "Let Newton be!" and all was light." —Alexander Pope

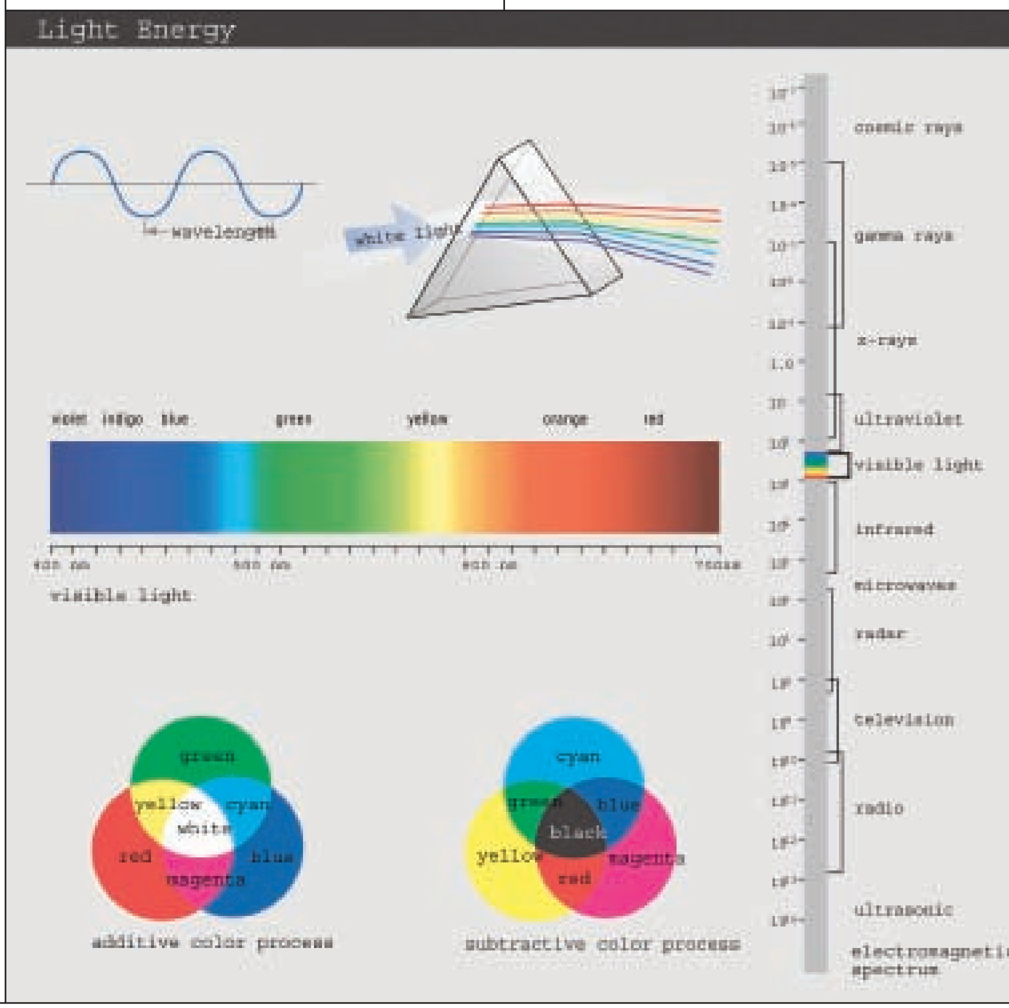
In order to perceive the color of an object, we need light to illuminate that object. It may seem rhetorical, but imagine how the color of a red apple would appear in a pitch-black room. Light and color are important ingredients of photography, color management, and color theory. It's worth discussing in detail and, forgive me for saying it, looking at in a new light.

Light is a form of energy, electromagnetic radiation. One way to picture electromagnetic energy is as a wave. The wave's *frequency* can be measured from crest to crest, in nanometers (nm; one billionth of a meter). Our illustration *(direction)* shows a range of visible frequencies from about 400nm to 700nm. There are many other forms of electromagnetic radiation that exhibit wavelengths on either side of this range of visible energy, including infrared, microwave, and radio on one end the scale, and ultraviolet, x-ray and gamma-ray on the other.

Much of what we know about light, a critical factor in seeing color, dates back to Sir Isaac Newton and his fondness for prisms. When white light passes through a prism, the rainbow of colors we see are individual frequencies of light. Newton's prism sorted light rays by wavelength, as shorter wavelengths are more bent (refracted) than longer wavelengths. My dad taught me this mnemonic for the order of the colors in the spectrum: ROY-G-BIV, for red, orange, yellow, green, blue, indigo, and violet. Between any two of these colors lies the continuum of the pure spectral colors of the rainbow, the *hues*.

We see these pure spectral colors only rarely, produced by devices such as lasers. Most colors we see are a mixture of many wavelengths at different intensities. A very important term to understand in discussing color is *illuminant*. An illuminant is a description of a real or imaginary light source as described by a *spectral power distribution* curve (SPD), a graph showing the intensity of each wavelength in the visible spectrum. Defined this way, illuminants are an absolute, unambiguous measurement of a light source.

Another important term is *spectrophotometry*. When you shine an illuminant on a patch of color then measure the



Light is a form of electromagnetic radiation. After passing through a prism, white light displays its components, the visible spectrum of light, ranging from violet (400nm) to red (700nm). This illustration also shows how both additive and subtractive primaries can produce white or black, and many other colors. (Illustration Courtesy of GretagMacbeth)

light reflected back, you get an exact map of the color in the form of a curve. Often referred to as *spectral data*, this spectrophotometric data is important in color management. The device used to take this measurement of reflected light is called a *spectrophotometer*.

The phenomenon of "color" exists only inside our brain, as a sensation created by various frequencies of light falling upon the retina. A red apple does not emit red light. Rather, the apple's color absorbs the shorter wavelengths of light shining on it and reflects the longer wavelengths. Our retinas have a receptor that is sensitive to longer wavelengths; when stimulated, it sends a signal to the visual cortex. (The retinal receptors for shorter wavelength do not send a signal.) The visual cortex processes this signal and associates its pattern with a sensation of color. Another part of the brain associates that sensation with the word "red," and now you are able to describe the color with language.

Due to the primitive nature of our visual system (we have only three color receptors), many very different mixes of frequencies produce the exact same sensation in the brain. Two colors with very different spectral properties may look identical. This is what allows us to simulate colors on a printed page or computer screen using very different methods.

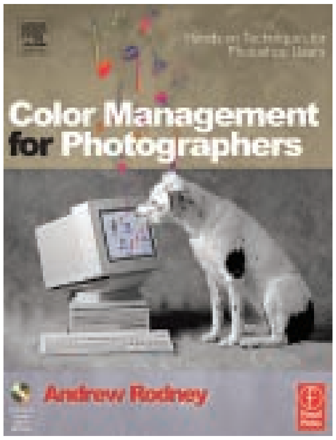
Many years after Sir Isaac, other scientists discovered that they could simulate an array of colors from a combination of only three *primary colors*, red, green, and blue (RGB). These are known as *additive primaries* of light. When none of these colors is present, we have no light, and thus black. As we begin adding red, green, and blue light in various proportions, we can simulate most colors. When the three are present in equal amounts, we perceive *neutral* colors from dark gray to white.

Another common primary system of colors is based on *subtractive primaries*, cyan, magenta, and yellow (CMY). With pigments, each primary color subtracts one of the additive primaries from white light. Not all color systems are based on red, green, and blue as primary colors. For example, green is not a primary color when mixing paint, but yellow, red, and blue are.

With CMY, we start with white, perhaps white paper, and add density, using CMY colorant—inks, dyes, toner, or pigments—until we reach black, as in the illustration. This is the opposite of the additive RGB process. We are actually subtracting red, green, and blue from the white light striking the paper.

When white light strikes cyan pigment, green and blue are reflected and red is absorbed. When white light strikes magenta pigment, red and blue are reflected and green is absorbed. When white light strikes yellow pigment, red and green are reflected and blue is absorbed. This CMY model is how color printing works.

Printing the maximum of all three colors subtracts all light, thus we get black—at least in theory. The inverse of red is cyan. The opposite of green is magenta, and the opposite of blue is yellow. (You can see how CMY/RGB have a bit of a yin-yang relationship.) In most real-world printing processes, however, the result is not black but muddy brown. This is due to the impurity of CMY colorants. For this reason we need to add a black colorant, or *key color* (K), so named, perhaps, to avoid confusing it with the primary color blue. CMYK is the color process used in offset printing and usually referred to as four-color process. ■



To order "Color Management for Photographers: Hands-on Techniques for Photoshop Users" by Andrew Rodney (Focal Press, $44.95), please call 800-545-2522 or visit www.focalpress.com .