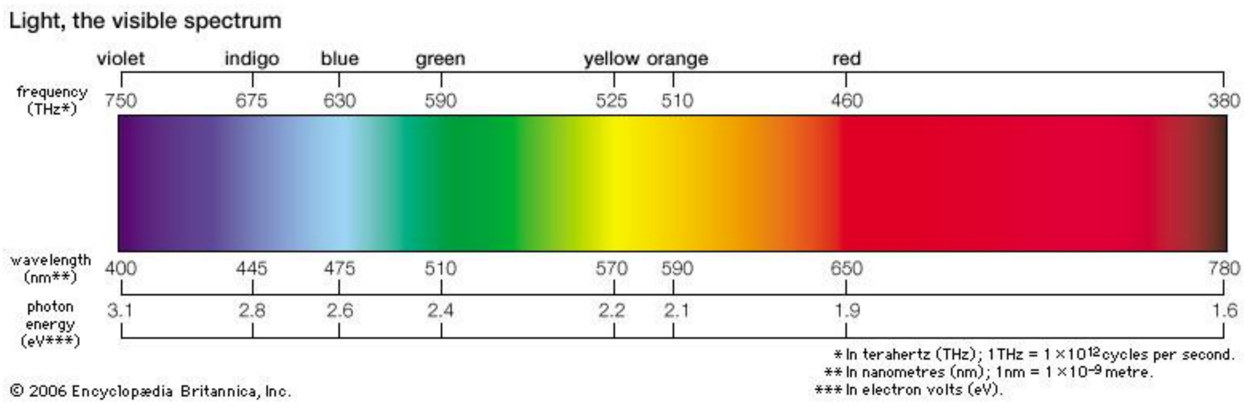
Presented by the Reno High Rollers
International Plastic Modelers Society affiliate
Reno, Nevada, U.S.A.

COLOR THEORY
for Figure Painters and Model Builders

The purpose of this paper is to define a core set of concepts used in the discussion of color and its application.

Color is the physical reaction of our optical sensing systems to a narrow range of electro-magnetic radiation. The frequency band we can see extends from wavelengths around 780 nanometers (red), to about 400 nanometers (violet); also called the visible spectrum.



The eyes (specifically the rods and cones of the retina) and visual cortex of the brain form our optical sensing system. This is important to the model builder because it is our goal to convince the brain that the miniature image we produce is an actual full-sized object. One of the tools we use to achieve this objective the manipulation of color.

There are three types of retinal cones, each of which is responsive to a narrow range of frequencies, centered on three colors. It is the relative amplitude of these three signals going to the brain that allow us to sense the full array of visible colors.

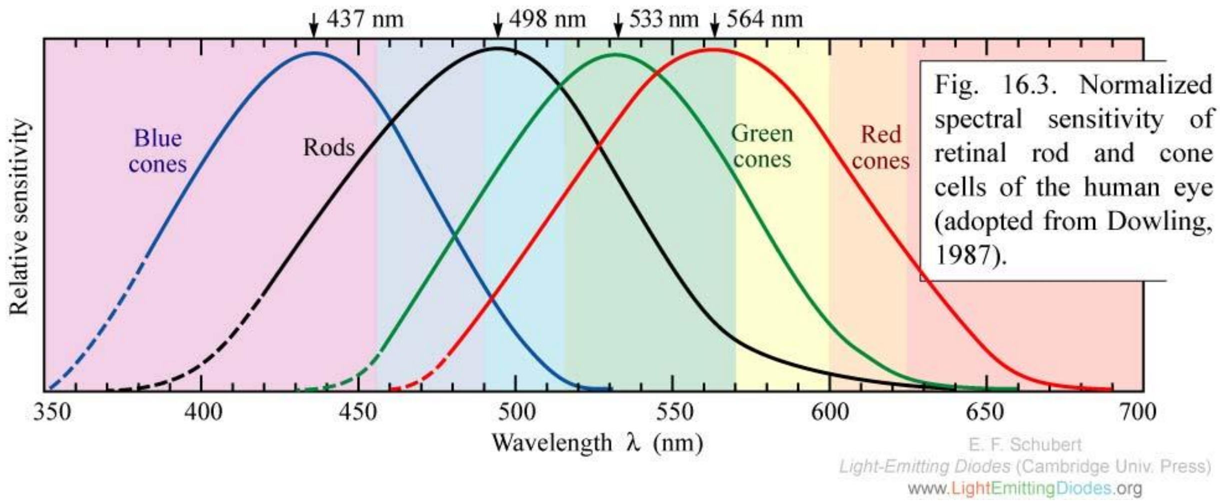
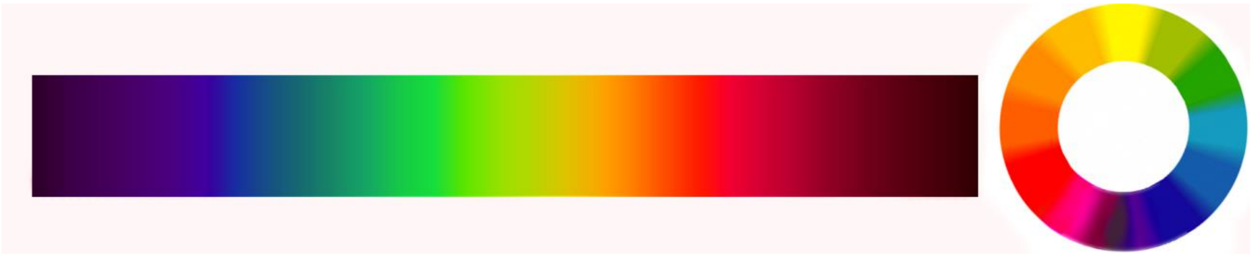


Fig. 16.3. Normalized spectral sensitivity of retinal rod and cone cells of the human eye (adopted from Dowling, 1987).

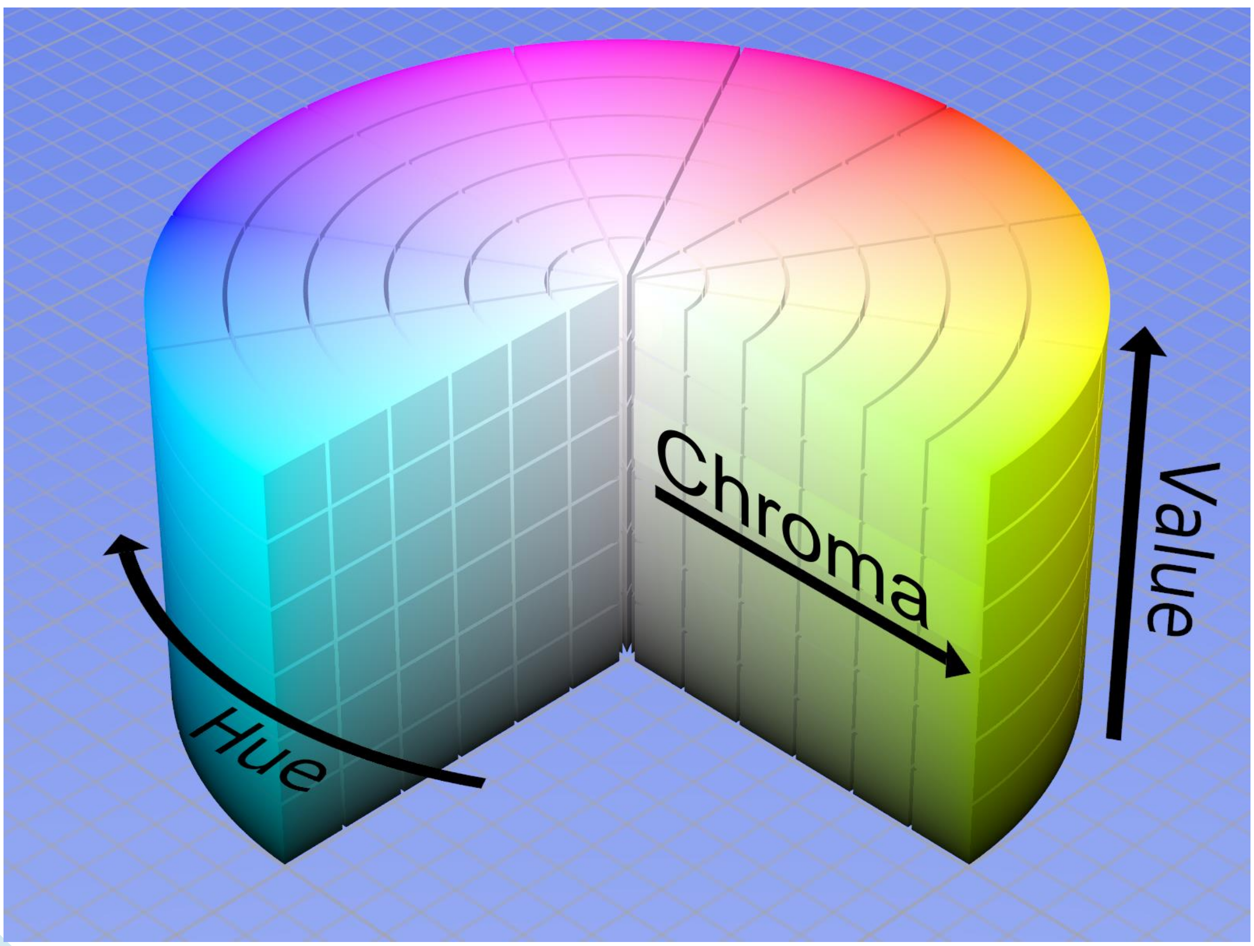
The rods of the retina do not impart any color information, but provide the light/dark contrast information that allows us to determine shape and texture.

By a delightful coincidence, the two extremes of the visible spectrum yield nearly identical color sensations. This allows us to wrap the linear spectrum into a color wheel, giving us our most important tool for understanding how colors work.



THE COLOR SOLID

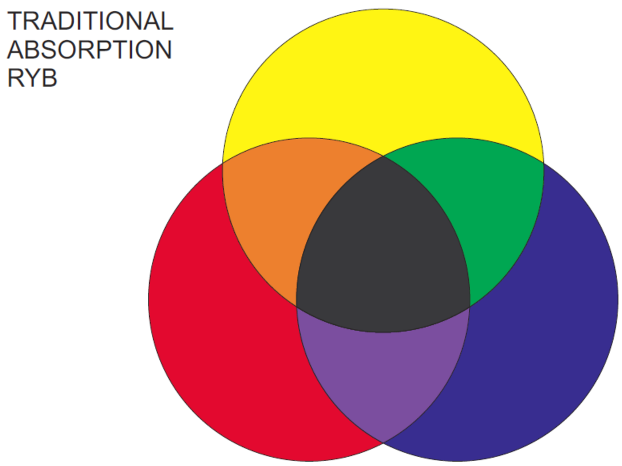
Stacking color wheels in order from the lowest value (most highly saturated) to the highest value (least saturated) creates a second important tool for looking at color, the color solid:



HUE and CHROMA

The hue is the family to which a color belongs. The color wheel displays the various hues, longer wavelengths moving toward shorter wavelengths, arrayed around the periphery. As a convention, yellow is traditionally displayed at the top, with the junction between long-wavelength red and short-wavelength violet at the bottom.

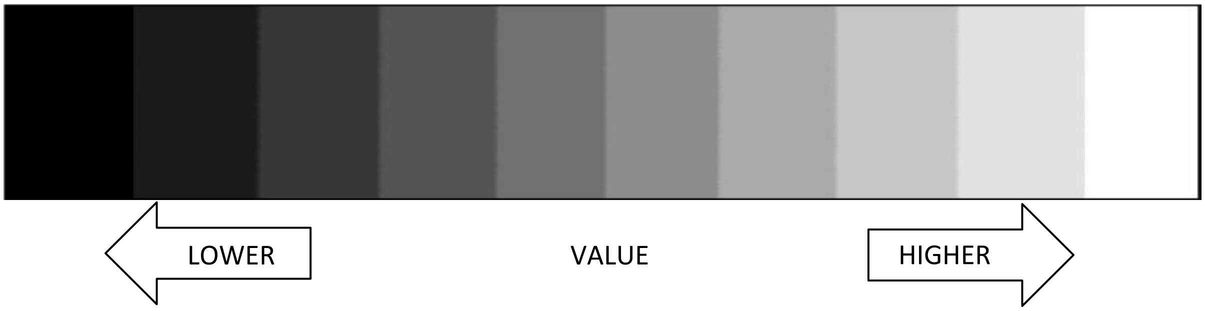
For paints, the three hues red, yellow and blue are known as primary colors. Mixing equal portions of two primary pigments yield the secondary hues orange, green and violet. Mixing various proportions of primary color pigments yield all of the other hues on the color wheel. Mixing equal portions of all three primary hues results in a color with no hue (gray).



Hues directly across from each other are known as “complimentary” colors. Red and green, orange and blue, yellow and purple are complimentary pairs. Mixing increasing amounts of a complimentary hue into a pure hue proportionately decreases its purity, or chroma, from a pure hue, to some sort of gray. Low chroma examples of various hues are root beer (red), rust (orange), tan (yellow), olive (green), denim (blue) and mauve (violet).

VALUE, SHADES and TINTS

The lightness or darkness of a color is described by its value. For pigments, darker values absorb more of the reflected light than do lighter colors. A “pure” black would absorb all light (equally), and be described as a very low value; while a “pure” white would reflect all light(equally), and be described as a very high value.

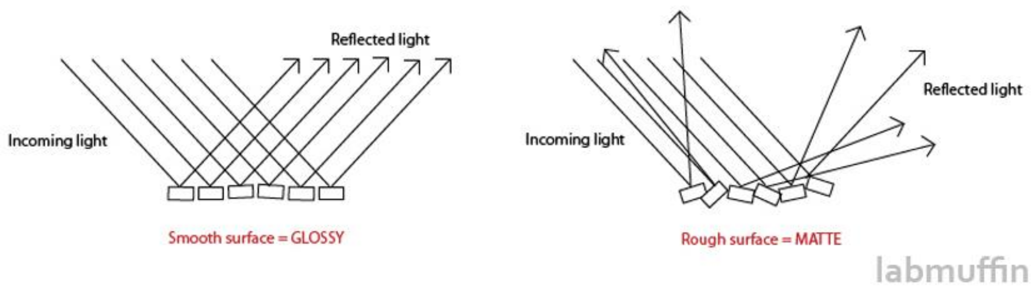


Shading is the addition of black to a color to lessen its value. For the purposes of mixing colors, the pigment described as “black” can be any hue but of a very low value. Also, black pigments are usually of low chroma. Lamp black is actually blue, while ivory black is a shade of yellow. This becomes a concern (either an opportunity or a problem, depending on the desired effect) when attempting to shade colors. Adding lamp black to a brown not only makes it darker, but also decreases its chroma. Ivory black would be a better choice for shading brown if the desire is to preserve the chroma of the color.

Tinting is the addition of white to a color to increase its value. Similar to blacks, whites are very high value, and can represent nearly any hue. White pigments are nearly always of very low chroma, so that dding white to a color almost always decreases its chroma.

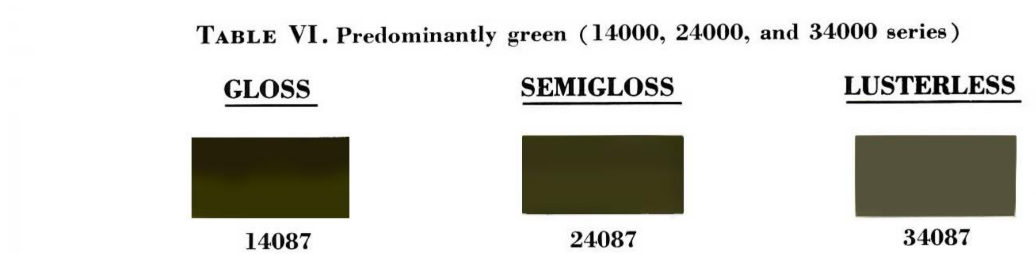
How the Beam Bounces

Much of the information contained in an image depends on how light is reflected from the object. The amount of reflected light is given by its value. The way in which the light is reflected is determined by the smoothness of the surface; also known as gloss or luster. Light follows the “angle of incidence equals angle of reflection” formula. At the molecular level, glossy surfaces are smooth and even so that light is evenly reflected. Matt surfaces are very uneven causing incoming light to be randomly scattered.



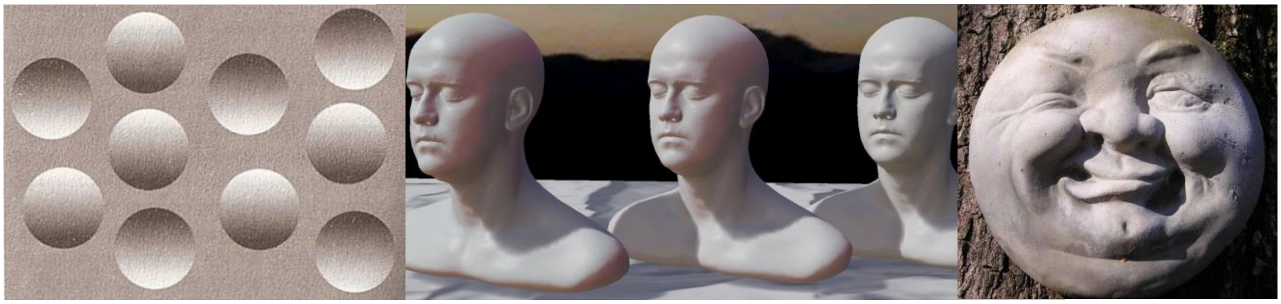
Very glossy surfaces reflect nearly all light in a single direction. A mirror, for instance, produces an image with all of the detail of the original. A less polished surface will appear hazy as some of the information is lost due to scattering. A dead flat surface displays none of the information contained in the original.

Compared to a hue with a semi-glossy finish, glossy colors appear darker (lower value) and display a higher chroma. Flat colors appear lighter and display a lower chroma.



In Between the Dark and the Light

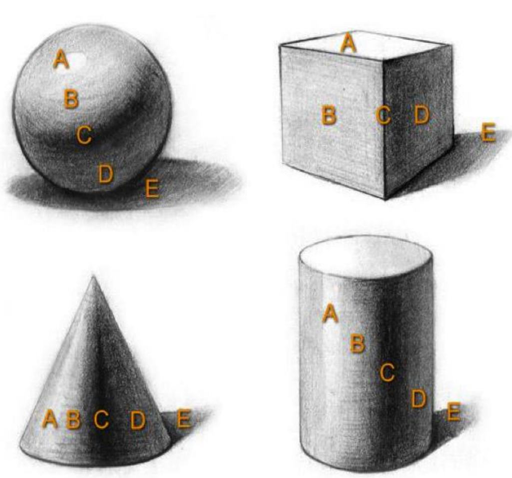
Shadows and highlights allow us to construct a mental picture of the shape and texture of an object.

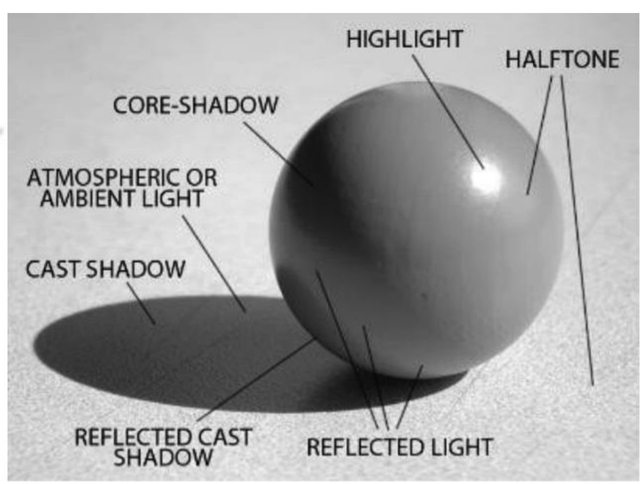


The rods of the retina transmit information about the intensity of the light, and do not provide any actual color information. It is the combination of information from rods (dark and light) and cones (color variations) that allow us to see the entire shape of an object:

From **http://www.colorclarity.net**

The portion of a shape most nearly perpendicular to a light source will exhibit a highlight. As portions are turned away from the light source they display increasingly dark halftones; Those portions that are blocked from direct contact with the light source will display shadows.





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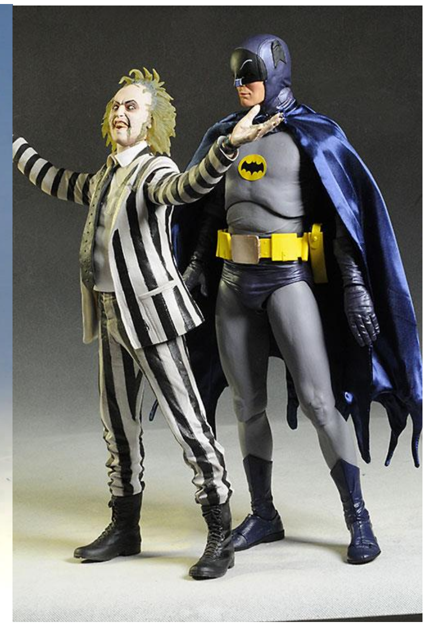
In nature, the interplay of light and shadow helps our optical system determine shape. In miniature, it is necessary to enhance this effect with chroma adjustment, shading and tinting in order to simulate the natural distribution of light and shadow.

For figure painters, the normal convention is an overhead light source such as the sun or a chandelier. Unless there is some other dramatic or artistic element the painter is attempting to portray, the virtual light source should considered to be overhead, probably no more than 15° from the zenith.

While two-dimensional paintings have the luxury of fixing the virtual light source, painting a three dimensional figure means that the actual light source can come from any direction, usually beyond the control of the painter. Thus, the figure painter must supply the virtual highlights and shadows in order for the figure to give the illusion of full-size reality. The smaller the scale of the figure, the more dramatic becomes the need for this treatment.

25mm (1/72 scale) figures by James Wappel via **http://**wappellious.blogspot.com**/**
Painted highlights and shading

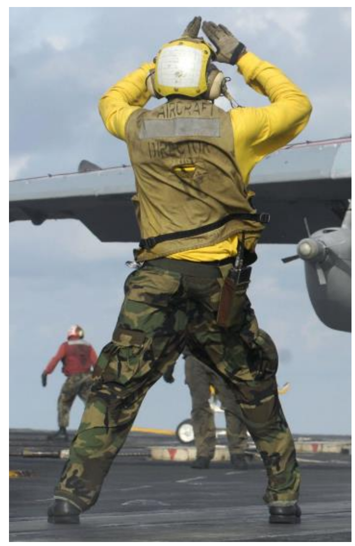


1/4 Scale NECA from http://www. mwctoys.com
Mostly natural highlights and shading

For figure painters, understanding the nature of highlights and shadows is an important skill in creating a believable presentation. In general, colors exposed to bright sunlight exhibit a higher value and chroma (lighter tint and grayer hue). Colors in shade display a lower value and the same or increased chroma (darker shade and purer hue).

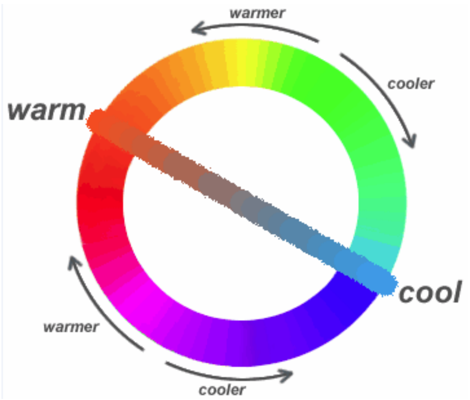
Highlights are opaque. Details at the highest points are washed out as colors become less saturated (lower chroma) and achieve higher values. This lessens contrasts so that variations are more difficult to see.

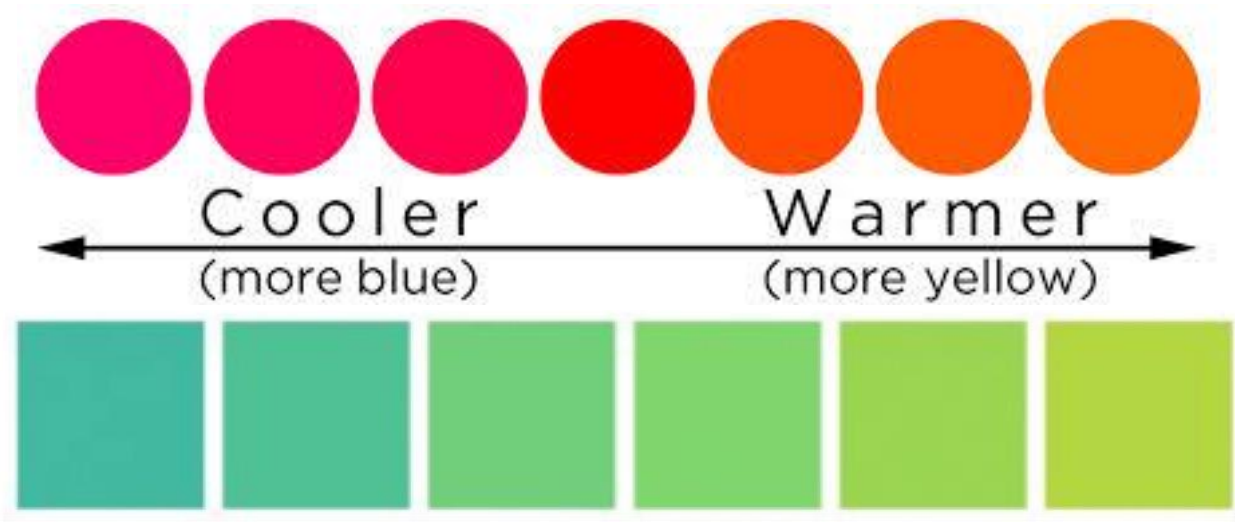
Shadows are transparent. Colors decrease in value, but retain or marginally increase their chroma. Details can increase as contrast increases in the midrange, but only to the point that decreasing values in deep shadow limit the effect.



Warm/Cool Color Effects

Colors have certain psychological effects, based on their perceived temperature. Colors on the right/upper side of the wheel (green, blue, violet) are known as “cool” colors, while those on the left/lower (red, orange and yellow) are the “warm” colors. Be aware that every hue can have a warmer or cooler version. The exceptions are blue and orange, but even these can have versions with characteristics of the adjacent hues.





In art, considered use of warm and cool colors can be used to dramatic effect. Depending upon context, warm colors can appear comforting (sandy beach), alarming (muzzle flash) or even slightly sick (yellow green). Cool colors can appear calming (the dark greens of a forrest) and soothing (blue skies and calm waters), but can be equally disturbing (green cheese) or even frightening (blue flesh).