UNDERSTANDING COLOR

imaging

WHAT IS COLOR?

Imagine a world without color – for that is what really exists. All the objects that surround us have no color. Color exists only in our minds. Color is a visual sensation that involves three elements – a light source, an object and a viewer. Light from the sun or another light source strikes objects around us, is reflected and modified by the objects, then reaches the receptors in our eyes and is interpreted by our brains into something we call color.

Since color only exists in our minds, explaining the physical aspects of color is just part of the story. The way objects appear to us and the judgments we make about color are determined by a combination of many factors.

Some of these factors are easy to measure and some are not. Individual perceptual differences, eye fatigue and mood of the viewer are as important to a discussion about color as are the properties of light sources and objects.

Color as perceived by the human eye cannot be simulated by any instrument, nor can it be reproduced by any printing process. Light is essential for vision. Light causes color. Without light color would not exist. Light that appears white to us, such as light from the sun, is actually composed of many colors.

Each color has its own measurable wavelength or combination of wavelengths. (Light travels in waves much like waves produced by dropping a pebble in a pond, except light waves are extremely small.)

The wavelengths of light are not colored, but produced the sensation of color.

Light is a form of energy. All wavelen gths of light are part of the electromagnetic energy spectrum. The spectrum is a continuous sequence of energy waves that vary in lengths from short to long.

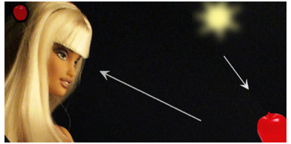
Visible light – the wavelengths our eyes can detect – is a small portion of the entire spectrum.

At one end of the visible spectrum are the short wavelengths of light was perceive as blue. At the other end of the visible spectrum are the longer wavelengths of light we perceive as red. All the other color we can see in nature are found somewhere along the spectrum between blue and red. Beyond the limits at each end of the visible spectrum are the short wavelengths of ultraviolet light and X-rays and the long wavelengths of infrared radiation and radio waves which are not visible to the human eye.

We can separate a beam of white light into its component colors by passing it through a glass prism which causes the light beam to bend. Each wavelength, or color, bends at a slightly different angle which separates the white light into an array of colors. When the sun comes out after a rainstorm, water droplets in the air can act as prisms and display the arc of colors in the sky we see as a rainbow.

The visible portion of the spectrum is divided into thirds, the predominant colors are blue, green and red. These are primary colors of light. Visible colors can be arranged in a circle, commonly known as the color wheel. Blue, green and red form a triangle on the color wheel. In between the primary colors are the secondary colors, cyan, magenta and yellow which form another triangle.

HOW IS COLOR PERCEIVED?



Objects in nature derive their color from colorants they process that absorb or subtract certain wavelengths of light while reflecting other wavelengths back to the viewer. For example, a red apple really has no color, it merely reflects the wavelengths of white light that cause us to see red and absorbs most of the other wavelengths. The viewer (or detector) can be the human eye, film in a camera or a light sensing instrument.

The human eye contains two basic types of light receptors, rods and cones. The rods are sensitive only to the presence of light, not color. The cones are sensitive to color. During normal daytime vision, it is the cones, not the rods that actively contribute to vision. At night, the more sensitive rods take over and give us “night vision.” There are three groups of cones, each sensitive to a portion of the visible color spectrum– red light, green light and blue light. The brain receives signals from the cones, processes them, then evokes the sensation of color. Various combinations of light waves evoke the sensation of other colors.

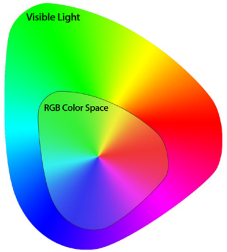
Color perception varies form person to person. Perception is a subjective phenomenon influenced by many variables including the light source, surrounding colors, mood of the viewer and the individual variations in our visual systems. A small number of people have color-deficient vision.

The most common form is the inability to distinguish between reds and greens. These people are considered color-blind. This phenomenon may result from one type of cone missing or a defect that affects analysis in the brain. Color blindness affects 8% of mend and less than 0.5% of women.

HOW IS COLOR REPRODUCED?

Throughout history, reproducing the colors we see in nature has taken many forms. The media and methods used to reproduce color include paintings, printing presses, color file, color monitors, color printers, etc. There are only two basic was, however, of reproducing color – additive and subtractive.

ADDIVTIVE COLOR SYSTEM — RGB



The additive color system involves light light emitted directly from a source, before it is reflected by an object. Light of a specific color, or wavelength (for example, a theatrical spotlight), can be
produced by directing white light through a special filter that allows the desired wavelength to pass blocks others.
The additive reproduction process mixes various amounts of red, green and blue light to produce other colors. Combining one of the additive primary colors with another produces the additive secondary colors cyan, magenta, and yellow.

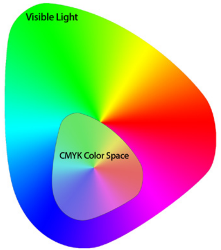
To illustrate this, imagine three spotlights, one red, one green and one blue focused from the back of an ice arena on skates in an ice show. Where the blue and green spotlights overlap, the color cyan is produced; where the blue and red spotlights overlap, the color magenta is produced; where the red and green spotlights overlap the color yellow is produced.

When added together, red, green and blue lights produce what we perceive as white light.

Television screens and computer monitors are examples of systems that use additive color. A mosaic of thousands of red, green and blue phosphor dots make up the images on video monitors. The phosphor dots emit light when activated electronically. It is the combination of different intensities of red, green and blue light that produces all the colors on a video monitor. Because the dots are so small and close together, we do not see them individually, but see the colors formed by the mixture of light.

Colors often vary from one monitor to another. This is not now information to anyone who has visited an electronics store with various brands of televisions on display. Also, colors on monitors change over time. Currently, there are no colors standards for the
phosphors used in manufacturing monitors for the graphics arts industry.
When added together, red, green and blue lights produce what we perceive as white light.

SUBTRACTIVE COLOR SYSTEM (CMY)



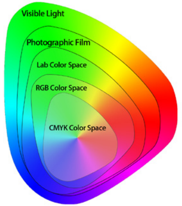
The Subtractive color system involves colorants and reflected light. Subtractive color stars with an object (often a substrate such as paper of canvas) that reflects light and uses colorants (such as pigments or dyes) to subtract portions of the white light illuminating an object to produce other colors. If an object reflects all the white light back to the viewer, it appears white. If an object absorbs (subtracts) all the light illuminating it, no light is reflected back to the viewer and it appears black. It is the subtractive process that allows everyday objects around us to show color. Remember the example of the red apple? The apple really has not color. It has no light energy of its own. Colorants in the apple's skin absorb the green and blue wavelengths of white light and reflect the red wavelengths back to the viewer, which evokes the sensation of red.

THE LIMITATIONS OF COLOR REPRODUCTION

The colors we see in nature represent an extremely wide range of colors. When it comes to reproducing color, however, we run into limitations. No color reproduction system (color film, color monitors, printing presses, etc.) can reproduce the entire range of colors we see in nature.

- Color Gamuts

Color gamma is another term for “range of colors.” Each color reproduction system has its own color gamut.
For example, the gamut of colors that can be reproduced on photographic film is greater than the gamut of colors that can be produced
with process color inks on paper using the offset printing process. Computer screens
display more – and different – colors than can be produced on color film or
most color printing devices.



How many colors are there?

If you are a human eye - billions
If you are a computer screen - 16 million
If you are a photographic film - 10 to 15 thousand
If you are a printing press - 5 to 6 thousand

- Additive Color vs. Subtractive Color

Video monitors use the additive color system. Offset printing uses the subtractive color system. Computer screens display a larger gamut of colors than can be produced on press and by most color printing devices. This is important to know when using the computer as a design tool. The color you see on your computer monitor is probably not what you will get when the job is printed.

The limitations of the offset printing (subtractive) process are due in part to the image screening process and in part to the type of paper used to print the image. The screening process converts an original continuous-tone image, such as a color photograph, into a pattern of small dots for each process color so the image can be printed with a pigment (wax, toner, ink) or dye on paper. A continuous-tone image shows a
continuous density range between lighter and darker areas. An ink-printable image (screened image) is made up of small dots which creates the illusion of lighter and darker tones. A screened image can be produced using a fixed grid pattern of
different-sided dots, or by varying the number of randomly placed, same-sized dots – or a combination of the two.

- Paper Base

Another factor that affects the amount of colors reproducible by the subtractive process s the type of substrate – usually paper – used to print the image. As discussed earlier, offset printing uses transparent color inks that act as filters an subtract portions of the white light striking the image on paper to produce other colors.
It is the paper that reflects any unabsorbed light back to the viewer. Paper stocks vary in color, gloss, brightness, texture and absorbency. A press that prints on coated paper produces a wider range of colors than a press that prints on uncoated paper.

This is because the rougher surface of the uncoated paper scatters the light and reduces the amount of light reflected back to the viewer. Smooth, glossy white paper returns more light back to the viewer. The range of colors on a substrate such as newsprint, which is usually rough, uncoated and yellowish, is more limited. A paper with a bluish cast will absorb some red and green wavelengths and cause colors to appear grayer than if printed on white paper. The effect of the paper base is so important to the appearance of a printed sheet that it can be considered a fifth color.

SUMMERY

Many involved in the color reproduction process are learning about color the hard way, through trail and error – often at great expense. The information in this book is intended to provide an understanding of basic color principles essential for making informed decisions during the color reproduction process.

It is important to know what color is a visual sensation that involves three elements – a light source, an object and a viewer. Without light, color would not exist. Light that appears white to us, such as light from the sun, is actually composed of many colors. If visible light is divided into thirds, the predominant colors are red, green and blue, which are the primary colors of light.

There are only two ways of reproducing color – additive and subtractive. Additive color involves the use of colored lights. It starts with darkness and mixes red, green and blue light together to produced other colors. When combined in equal amounts, the additive primary colors produce the appearance of white. Subtractive color involves colorants and reflected light. It uses cyan, magenta and yellow pigments or dyes to subtract portions of white light illuminating an object to produce other colors. When combined in equal amounts, pure subtractive primary colors produce the appearance of black.

It is the subtractive process that allows everyday objects around us to show color. For example, a red apple really has no color. Colorants in the apple's skin absorb the green and blue wavelengths of white light and reflect the red wavelengths back to the viewer, which evokes the sensation of red. All color printing processes use the subtractive process to reproduce color. Printing presses use transparent color inks that act as filters and subtract portions of the white light striking the image on paper to produce other colors.