PrePress Today

The Digital Darkroom

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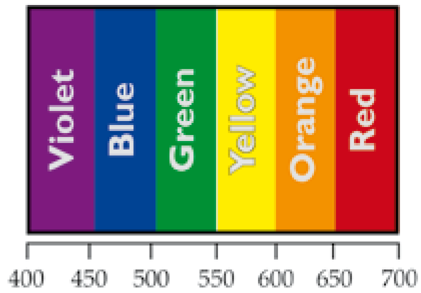
The Mystery of Color

The Mystery of Color

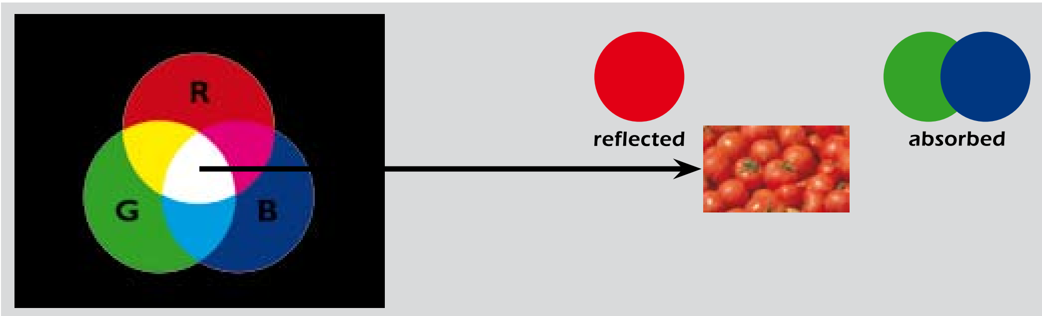
Color is not only a psychological sensation, which is caused by light entering the human eye it is also a miracle.



We all know electromagnetic waves like radio waves, X-Ray, Microwaves and the dangerous gamma waves. The electromagnetic spectrum measures approximately eleven kilometers. As higher the spectrum, as shorter are the wavelength. Within this spectrum between Infrared light (IR) at 350 nm and Ultraviolet light (UV) at 700 nm is very small a space of roughly 350 nm called the Visible Light Spectrum. We have to understand that 1 nm (Nanometer) is equal to a 1 billionth of a meter. So the light spectrum we are talking about takes 350 billionth of a meter. Within this spectrum millions and millions of colors are produced out of the prime colors RED – GREEN and BLUE also called the RGB spectrum.
All other electromagnetic waves are not visible for the human eye but there are animals with a different visible light spectrum for instance some insects, which are blind in the Infrared light but can see the Ultraviolet light.

But how do we see the color?

The sun sending electromagnetic waves to the earth produces our daylight. These waves hit all objects in their range with all the millions of colors of the RGB color spectrum. The object surface itself reflects parts of the colors. What is not reflected will be absorbed and converted into energy. For instance, when we see a red tomato, only the red is reflected. Most of the green and blue parts will be absorbed and converted into energy. A white car in the sun reflects about 90% of the RGB colors; a black car absorbs 90% of the color and converts it into energy. So the black car will be much more heated in the sun than a white car.



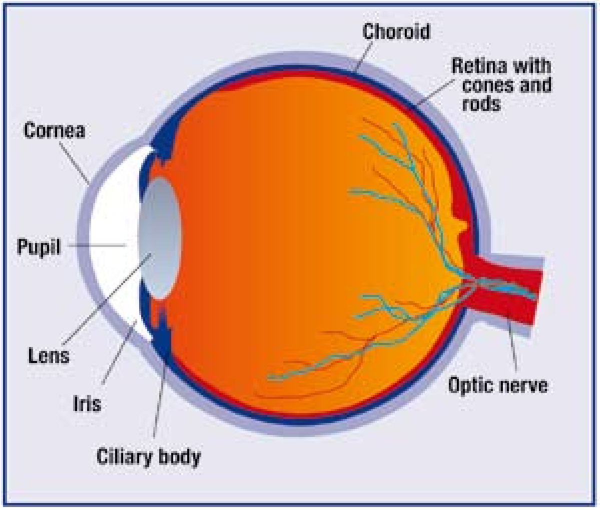
How does the Human Eye respond to colors?

The structure of the human eye can be divided into three main layers or tunics whose names reflect their basic functions: the fibrous tunic, the vascular tunic, and the nervous tunic.

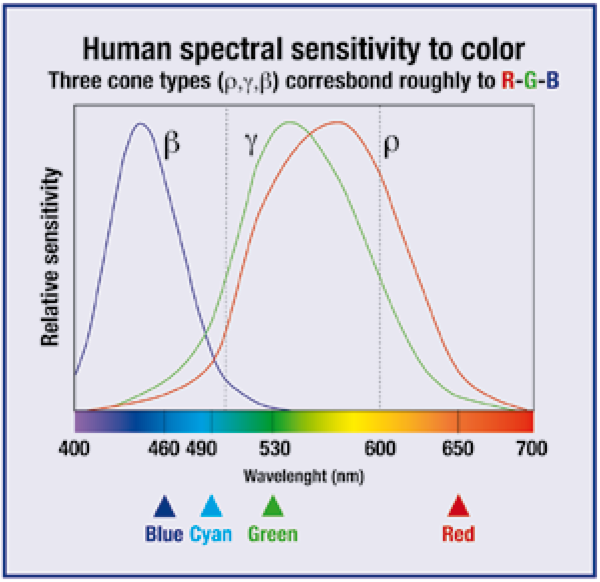
The fibrous tunic is the outer layer of the eyeball consisting of the cornea and sclera. The sclera gives the eye most of its white color. It consists of dense connective tissue filled with the protein collagen to both protect the inner components of the eye and maintain its shape.

The vascular tunic is the middle vascularized layer, which includes the iris, ciliary body, and choroid. The choroid contains blood vessels that supply the retinal cells with necessary oxygen and remove the waste products of respiration. The choroid gives the inner eye a dark color, which prevents disruptive reflections within the eye.

The nervous tunic is the inner sensory which includes the retina. The retina contains the photosensitive rod and cone cells and associated neurons. To maximize vision and light absorption, the retina is a relatively smooth, but curved, layer. It does have two points at which it is different, the fovea and optic disc. The fovea is a dip in the retina directly opposite the lens, which is densely packed with cone cells. It is largely responsible for color vision in humans, and enables high acuity, such as is necessary in reading. The optic disc, sometimes referred to as the anatomical blind spot, is a point on the retina where the optic nerve pierces the retina to connect to the nerve cells on its inside. No photosensitive cells whatsoever exist at this point, it is thus “blind”.



The human eye has two categories of light receptors: rods, which are active in dim light and have no color sensibility, and cones, which are active in bright light and provide us with our ability to see colors. There are three different cone receptors sensitive for red, green, and blue colors. Scientifically these receptors are named in

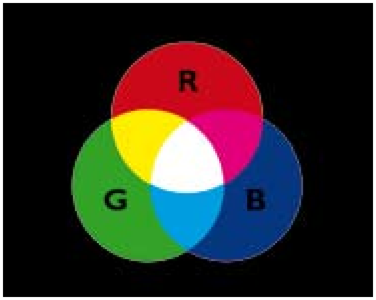


Greek letters: Rho (r) for red, Gamma (g) for Green and Beta for Blue (b).
In our drawing we show how the cones of the human eye react on the visible light. We can see that the Beta and Gamma curves are quiet close to the blue and green spectrum. But the Rho sensor is not even close to red but to a color close to yellow-orange.
The mystery here is that with our eyes we can recognize the colors but as a matter of fact, they are build in our brain.
This makes things sometimes quite difficult, especially in the printing business, where two, three or more persons see the same color different. So, which one is the right one?
For people with color blindness, or color vision deficiency, having problems dividing green from red or yellow from blue even if it is only partly it will be difficult to adjust the colors in printing. An important part of color adjustment is the light source. Normally it should be similar to sunlight, which is approximately 5500 k (Kelvin).
Color temperatures below 4000 K appear reddish whereas those above about 7500 K appear bluish. Color temperature is important in the fields of image projection and photography where a color temperature of approximately 5500 K is required to match “daylight” film emulsions. The Sun for instance, has an effective photosphere temperature of 5778 K.

Also during a pressrun the operator can see color differently. This normally ends in color variations and will cause problems with the customer. The reason is that we tend to moods and in different moods we see color differently. It is almost better not to rely on the human eye, when it comes to colors. Densitometers and photo-spectrometers will provide us with much better and constant results.

The RBG Color Space

All the light produced by a light source is RGB. Sunlight, light bulbs, tube lights, beamers, monitors for TV and computer, scanner, and digital cameras are all made up of three luminous or glowing colors: RED, GREEN, and BLUE.



When these colors are projected on top of each other we will get white. When the colors lit up next to each other in different intensities, we can see millions of different colors.

Understanding the RGB color space is important to printing because it is the native color space of compu-ters and monitors. As long as we design for the Internet, RGB is the right color space. But we do not print in RGB. Here we use the CMYK color space. So RGB is totally incompatible with any printer, plotter and printing press.

Also known as “Luminous” or “Additive” colors, RGB behaves just the opposite of printing inks. For example, black is displayed on a TV by removing all three sources of colors and white is displayed by adding maximum amounts of all three colors.

It is the opposite way from the printing process, where (on a white piece of paper) black is displayed by adding color and white by removing, or not printing it.

The RGB color space or “Gamut” is much bigger than the CMYK gamut. Here lies the danger for designers who use the RGB color space to create their artworks. Many of the colors, they like in the RGB mode cannot be printed on a printing press using process colors.

A color in the RGB color model can be described by indicating how much of the red, green and blue color is included and can vary between the minimum (no color) and maximum (full intensity). If all colors are at minimum the result is black. If all colors are at maximum the result is white. A confusing aspect of the RGB color model is that these colors can be written in several different ways.

For design purpose we normally use values between 0 and 255.

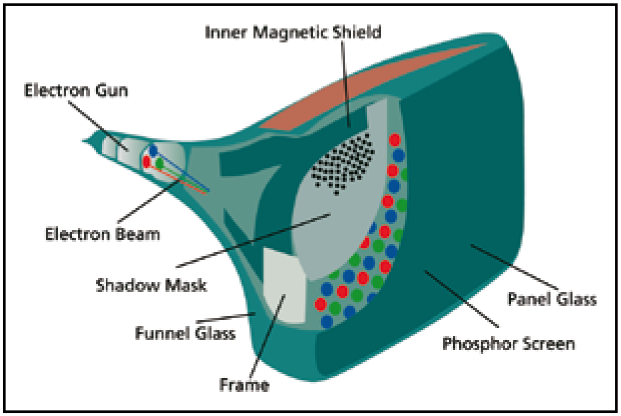
0,0,0	is black
255, 255, 255	is white
255,0,0	is red
0,255,0	is green
0,0,255	is blue
255,255,0	is yellow
0,255,255	is cyan
255,0,255	is magenta

The same range, 0 – 255, can be also written hexadecimal, sometimes with the prefix #. Because hexadecimal numbers in this range can be written with a fixed two digit format, the full intensity red #ff,#00,#00 might be contracted to #ff0000. This convention is widely used in web design.

Monitors

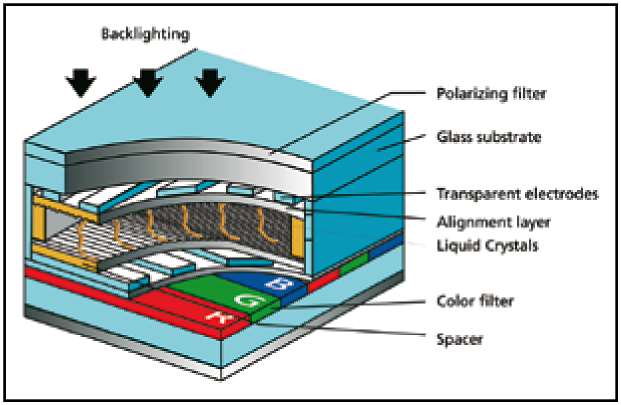
As we have already learned: all monitors produce colors in RGB. For design purpose we use two different type of monitors: CRT and LCD technology.

CRT monitors use an evacuated (vacuum) tube with an anode, a cathode, and an electron gun. This electron gun produces a beam at a layer of phosphors on the inside front face of the tube to produce images. The phosphors produce red, green, or blue light when exited by an energy source. The glowing red, green, and blue phosphors, grouped in RGB are called pixels. These pixels form the image on the screen. The number of pixels depend on the size of the monitor. A seventeen-inch monitor usually has 1024 x 768 pixels. This results in a total of 786,432 pixels.



Varying the brightness of the three phosphors can range from black, when the phosphors are switched of, to bright white, when the phosphors are at maximum intensity. The brightness of the three phosphors produces all the different colors.
These phosphors are very close together, so we cannot see them individual with our naked eye. We have to go very close to the monitor and we have to use a magnifying glass to see them differently. In normal they all blend together giving us, depending on the quality of the monitor, millions and millions of different colors. The blending of colors from a light source like the sun or a monitor is called “Additive” mixture.

LCD technology (LCD=Liquid Crystal Display) is used in the today’s flat-panel desktop monitors. All of them are based on active TFTs (Thin Film Transistors) to provide bright and sharp displays.
TFT LCDs are made out of several layers arranged as follows: polarizing filter, sheet



of glass, electrode, alignment layer, liquid crystals, alignment layer, electrode, sheet of glass, polarizing filter. Between the substrates are the thin film transistors and color filter panels, which provides the red, green, and blue primary colors, and the liquid crystal layer. The screen is illuminated from behind using fluorescent backlight.

Without electrical charge the liquid crystals are unstructured and no image will be visible. Using different amounts of electrical charges, the liquid crystal layer will allow light to pass through and the crystals orientate themselves according to the control center for the liquid crystals to illuminate either the red, green, or blue part of the pixel.

One pixel is made up by red, green, and blue chamber (one pixel element). Various degrees of electrical charge produce different colors. TFT screens are made up by grid of pixels. Each pixel is having a transistor for turning on or of the three colors. The number of transistors provides us the resolution for instance 1024 x 768 pixels.