RGB COLORS

In the early days of the Web, many computers used 8 bit colors. Old computer screens could display at most 256 different colors. As shown in the top of Figure 1, one byte of memory is needed to store 256 different colors. Newer computers use 24-bit Red-Green-Blue (RGB) colors. That's 3 bytes. The first byte can store 256 shades of red, the second byte 256 shades of green, and the third byte 256 shades of blue. That gives almost 17 million different color combinations.

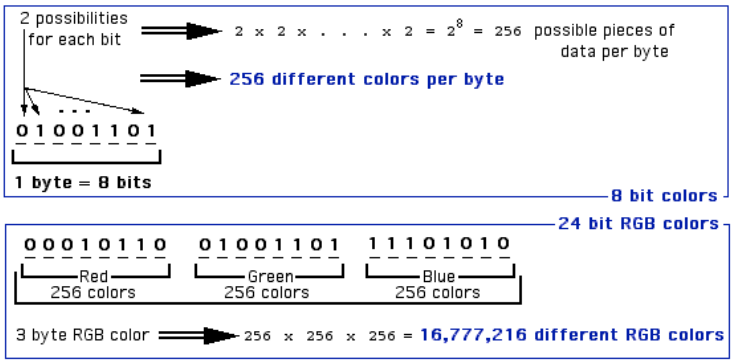


Figure 1 – 3 byte RGB color storage in computers

The 256 shades of each color can be represented using standard numbering for a byte - from 0 to 255. Figure 2 lists a few shades, out of the 256 total. Figure 2 can represent shades of Red, Green, or Blue since each color component is given a byte of memory.

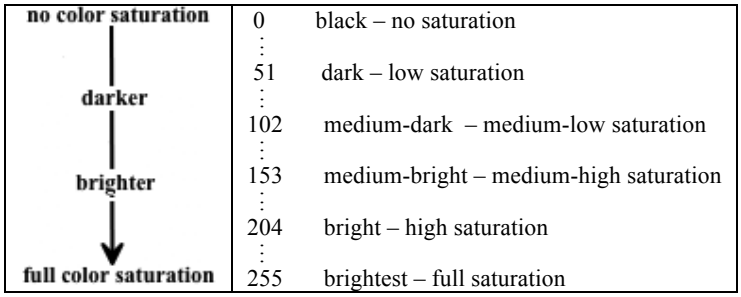


Figure 2 – One byte (0-255) is used for the different shades of a color.

The absence of color is represented by 0. As the shades move upward from 0 to 255, the color saturation (amount of color) increases. Finally at shade 255, full saturation (brightest possible) is attained. An RGB color has 256 possible shades (levels of saturation) of each of Red, Green, and Blue, and the three color components are always listed in that order. Standard notation for an RGB color is as follows.

```
rgb(255,0,0)
```

This stands for 255 of Red, 0 of Blue, and 0 of Green. Said in words, that's a full saturation of Red, but no saturation of Blue and Green. That is the brightest possible "pure red".

Figure 3 lists several RGB values to give you a feel for how this works. The "pure colors" only contain saturation of one color. Not all mixed colors are easy to understand, but purple and grey are. Purple shades are made with equal saturations of Red and Blue, but no Green. Different grey shades are made with equal saturations of all three color components. But it can be hard for humans to understand other mixtures of RGB colors without experimenting with a visual color tool as suggested below Figure 3.

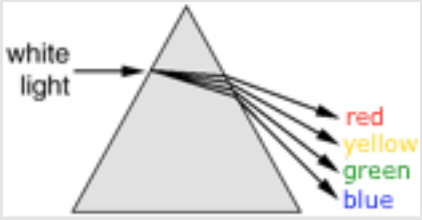
Pure Colors			Mixed Colors	
Red	Green	Blue	Grey	Purple
			rgb(0,0,0)	
rgb(1,0,0)	rgb(0,1,0)	rgb(0,0,1)	rgb(1,1,1)	rgb(1,0,1)
rgb(51,0,0)	rgb(0,51,0)	rgb(0,0,51)	rgb(51,51,51)	rgb(51,0,51)
rgb(102,0,0)	rgb(0,102,0)	rgb(0,0,102)	rgb(102,102,102)	rgb(102,0,102)
rgb(153,0,0)	rgb(0,153,0)	rgb(0,0,153)	rgb(153,153,153)	rgb(153,0,153)
rgb(204,0,0)	rgb(0,204,0)	rgb(0,0,204)	rgb(204,204,204)	rgb(204,0,204)
rgb(255,0,0)	rgb(0,255,0)	rgb(0,0,255)	**rgb(255,255,255)**	rgb(255,0,255)

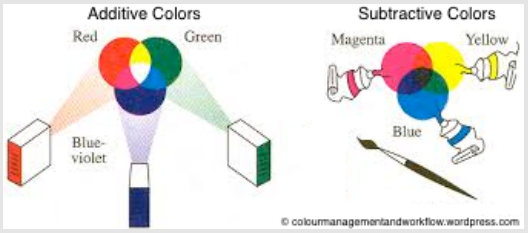
Figure 3 – A few easily understood RGB colors, out of almost 17 million total.
To visualize this, see the RGB Sliders tool at http://www.cknuckles.com/rgbsliders.html

Notice the boldfaced colors at the top and bottom of the Grey column in Figure 3.

```
rgb(0,0,0)        black – absence of color
rgb(255,255,255)  white – full saturation of all colors
```

That may surprise you, but you have to think of RGB colors as mixing colors of visible light. The complete absence of light is black. Think of the pure blackness of inter-stellar space where there is no light. On the other hand, think of the light that comes from the sun, which we often call *white light*. White light contains a full saturation of all colors, which is easily demonstrated when white light passes through a glass prism or when you see a rainbow in the sky.





Like visible light, mixing RGB colors is called *additive*. The more colors you mix together, the brighter the resulting color. Mix full saturations of all colors, and you get white. This is the opposite of what happens when you mix colors of paint, which is called *subtractive*. The more colors of paint you add together, the darker the mixture gets, effectively subtracting brightness.

You may wonder why Red, Green, and Blue are the primary colors for RGB, rather than Red, Yellow, Blue as you learned in school as primary colors. As discussed above, mixing paint is much different than combining different wavelengths (colors) of light. Human eyes, whose job is to process light, are even in tune to RGB. You've probably heard of the rods and cones in eyes. The cones process color and have peak sensitivities near to the wavelengths of red, green, and blue light. Even nature knows RGB!

In CSS (Cascading Style Sheets), there are two main notations for RGB colors. One uses the `rgb()` notation we have been using above. The other uses *Hexadecimal* numbers (base 16) as shown below.

`rgb(204,204,204)` <------ both represent the same light grey ------> **`#CCCCCC`**

Above, CC in Hex is equivalent 204, which is why the two colors are the same. Most developers use the Hexadecimal (or simply *Hex*) notation rather than the `rgb()` notation, although you will see them both used in practice.

The concept of base 16 Hex numbers is no different from binary (base 2) or the base 10 numbers you use everyday. Binary uses only two digits (0,1). Base 10 uses ten digits (0,1,2,3,4,5,6,7,8,9). Similarly Hex uses sixteen digits (0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F), where the A represents 10, the B represents 11, and so forth, up to F representing 15. Each place requires a single digit, so you can't use 11, for example, because that's 2 digits.

The reason Hex is useful in computing is that a byte can always be represented as a two-digit Hex number. Internally, computers use binary where a byte is 8 bits like 10110110. But for humans the most

convenient ways to represent bytes is either to associate each byte with a base 10 number (0 to 255), or to associate each byte with a Hex number (00 to FF). Figure 4 lists some Hex numbers and their base 10 equivalents.

Hex	Base 10
00	**0**
1A	26
2F	47
33	**51**
4C	76
55	85
66	**102**
7D	125
81	129
99	**153**
A1	161
B2	178
CC	**204**
DD	221
E8	232
FF	**255**

Figure 4 – Each shade of Red, Green, or Blue can be given as a Hex number or a Base 10 number. This is a small sample of the 256 total shades for each RGB color component.

Figure 4 only lists a few select values, but *ascii-code.com* lists all 256 two-digit Hex numbers along with the base 10 equivalents. That Web site is discussing storing characters as bytes, but storing 256 different shades of a color in a byte is similar in concept.

Since each Hex byte is exactly 2 digits, a Hex color like #A12F99 is completely well-defined, listing the #RedGreenBlue color components in that order. In contrast, the equivalent color in base 10 is written as rgb(161,47,153). The `rgb()` notation is used, because leaving out the commas leaves 16147153 which is not well-defined and also hard to read.

The 6 highlighted values in Figure 4 are historically called the *Web Safe* color shades. A Hex color constructed from the Web safe shades is called a *Web Safe Color*. For example, #CC33FF is a web safe color, whereas #CCB2FF is not a Web safe color because the Green part is B2. If you look back at Figures 2 and 3, you can now see why those color shade values were listed out of the 256 possible for each color. Those were mostly Web safe values.

The good news is that you can freely use any of the almost 17 million RGB colors. In the early years of the Web, most computer monitors had limited color capabilities. The Web safe colors were the only ones guaranteed to look the same (or even exist) on everyone's computer screen. With only 6 Web safe shades for each of Red, Green, and Blue, that gave developers only 6x6x6=216 colors with which to work. But now virtually all computer screens display the full RGB color spectrum, so Web developers can now design with many millions of colors.

Some developers still stick to mostly Web safe colors. The Web safe shades (00,33,66,99,CC,FF) are easy to remember and work with. These shades are also good for beginners because of the simplicity. Figure 5 lists the exact same colors as did Figure 3, but using Hex this time. White (#FFFFFFF) and black (#000000) are again highlighted in the table.

Pure Colors			Mixed Colors	
Red	Green	Blue	Grey	Purple
			#000000 (black)	
#010000	#000100	#000001	#010101	#010001
#330000	#003300	#000033	#333333	#330033
#660000	#006600	#000066	#666666	#660066
#990000	#009900	#000099	#999999	#990099
#CC0000	#00CC00	#0000CC	#CCCCCC	#CC00CC
#FF0000	#00FF00	#0000FF	**#FFFFFF (white)**	#FF00FF

Figure 5 – The same colors listed in Figure 3 (mostly Web Safe), but in Hex this time.

As you do more Web design, you will get accustomed to Hex colors. Soon, ones like those in Figure 5 will seem obvious to you. Even other color variations will start to make sense. For example, consider #9999CC, which is a soft medium blue. It's almost like medium gray (#999999) but with the blue component turned up a bit. Starting with a gray and tweaking one color component tends to create a soft color. But beyond that type of basic understanding, dealing with almost 17 million RGB colors gets difficult, even for experienced designers. That's where color picker utilities come in handy. If you search for such terms, you will find pages of links to utilities like the ones listed below.

http://www.w3schools.com/colors/colors_picker.asp
http://colorschemedesigner.com/

Colors for Web pages can be given as names (e.g. CornflowerBlue), but most designers do not use named colors. W3Schools lists 140 named colors that all browsers are supposed to render the same (http://www.w3schools.com/colors/colors_names.asp), but color picker utilities that can generate almost 17 million Hex colors offer much more flexibility. CornflowerBlue is actually on the W3Schools list of named colors, but if you use a named color with a crazy name such as you find on a box of crayons, a browser probably won't even recognize the color.

There are some other notations for colors that you will run across, so you at least need to be aware of them. One is RGBA, which is just RGB + A, where the A represents an additional *Alpha Channel*. The Alpha channel specifies the opacity (level of opaque). Opacity of 0.0 is fully transparent, meaning it's invisible whereas opacity of 1.0 is fully opaque. An intermediate value such as 0.5 would mean that you can halfway see through it (like a ghost) .

The notation used for RGBA is `rgba()`. For example, `rgba(51,0,0,1.0)` (dark red, fully opaque) is exactly the same as `rgb(51,0,0)` since the default for RGB is fully opaque (1.0 alpha). But for example, `rgba(51,0,0,0.5)` is dark red but semi transparent meaning stuff behind it would partially show through it. Explaining why this is sometimes useful in Web design is beyond the scope of this discussion.

Another color format you sometimes see is called HSL (Hue, Saturation, Lightness). This is an entirely different scheme for representing colors than RGB and further elaboration is also beyond the scope of this discussion. You can see what this is about using a HSL color slider utility such as http://www.w3schools.com/colors/colors_hsl.asp