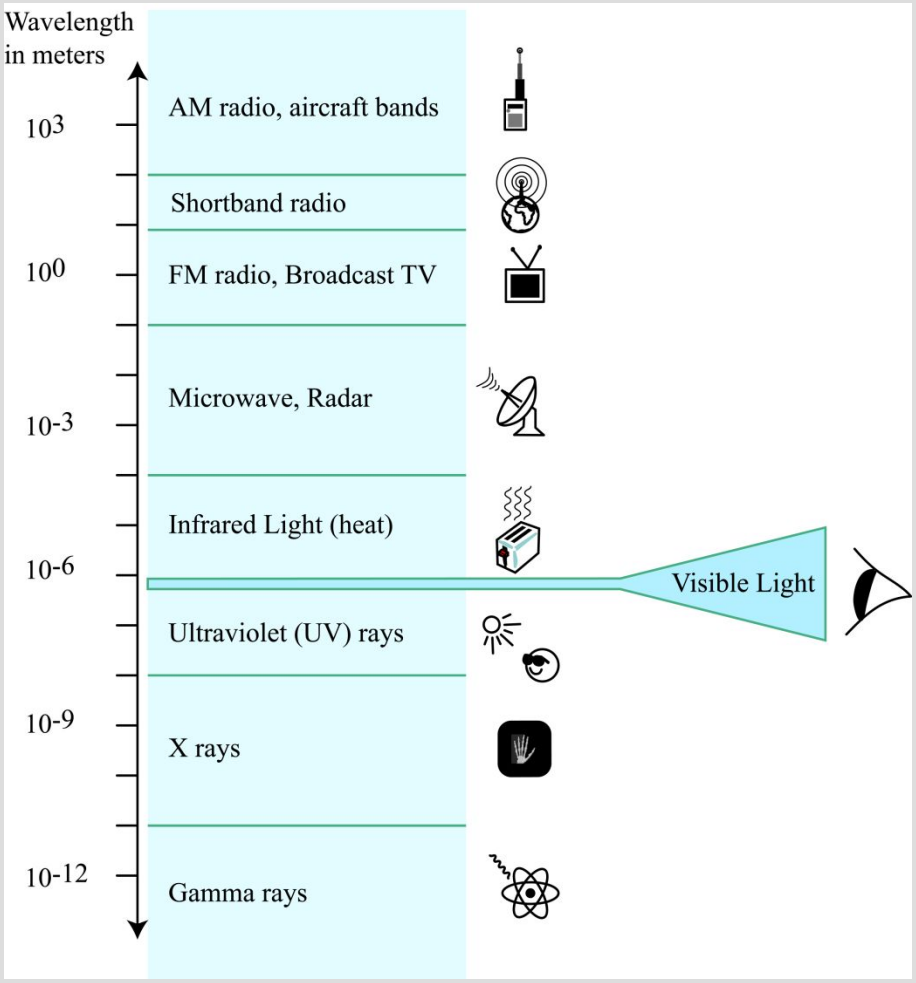
User-Centered Website Development: A Human-Computer Interaction Approach

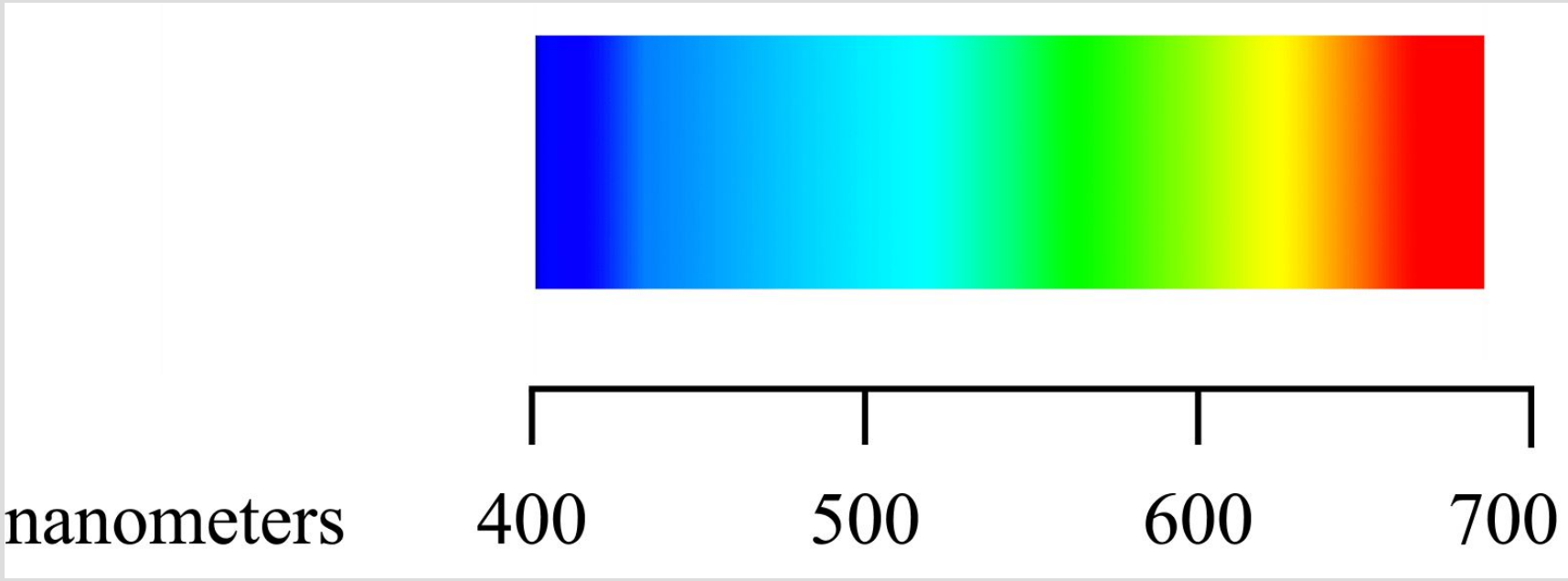
The Physics of Color

- Light with a wavelength between 400-700 nanometers is perceived by the human eye as a color

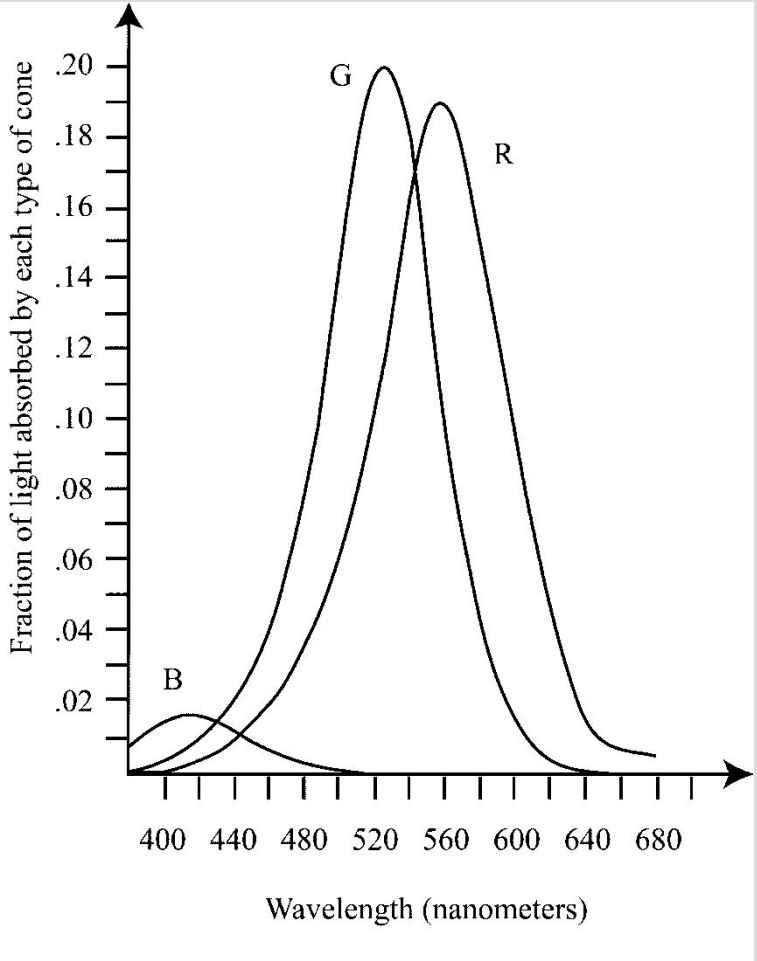
The electromagnetic spectrum, of which visible light is a very thin band

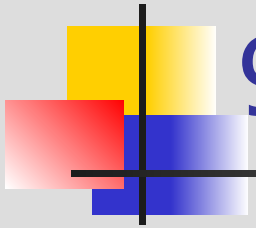


The spectrum of visible light



Human Response to Color (Weakness in seeing differences in blue)

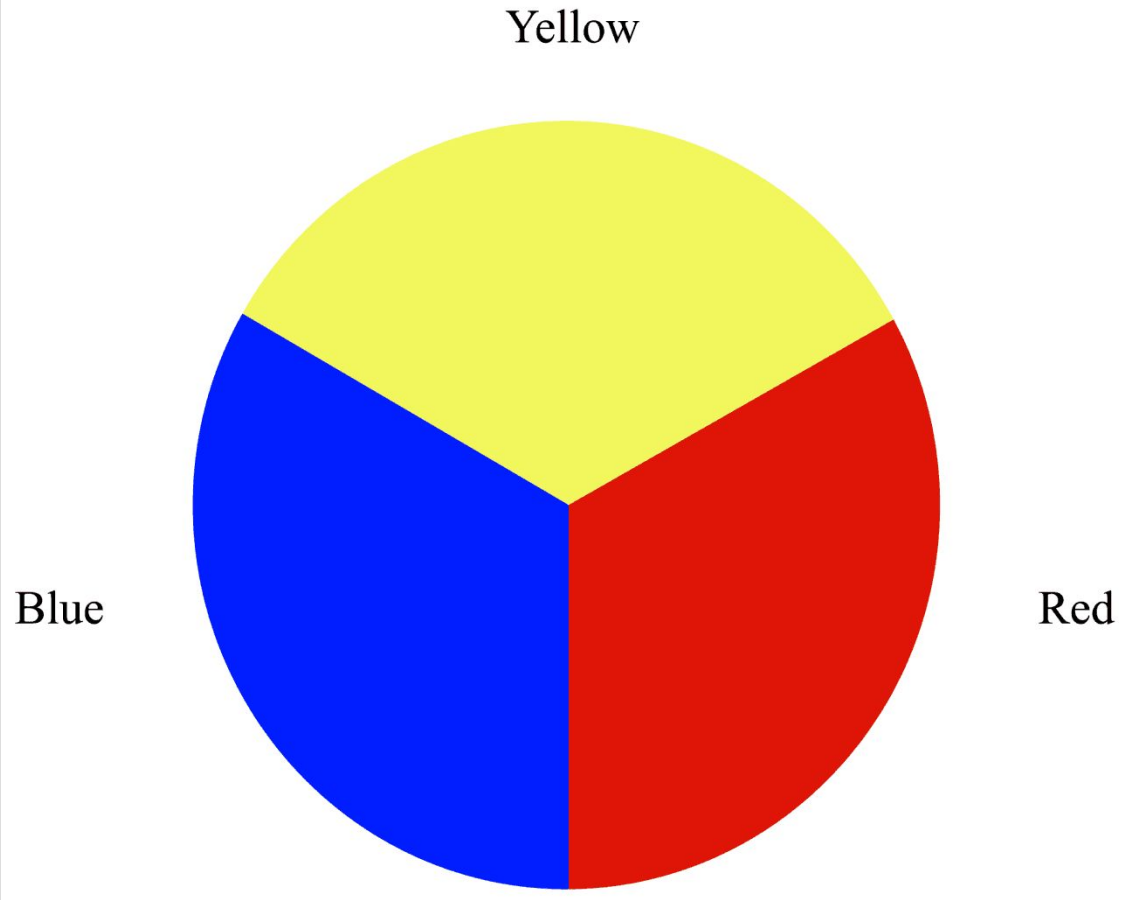




9.3 Color Models

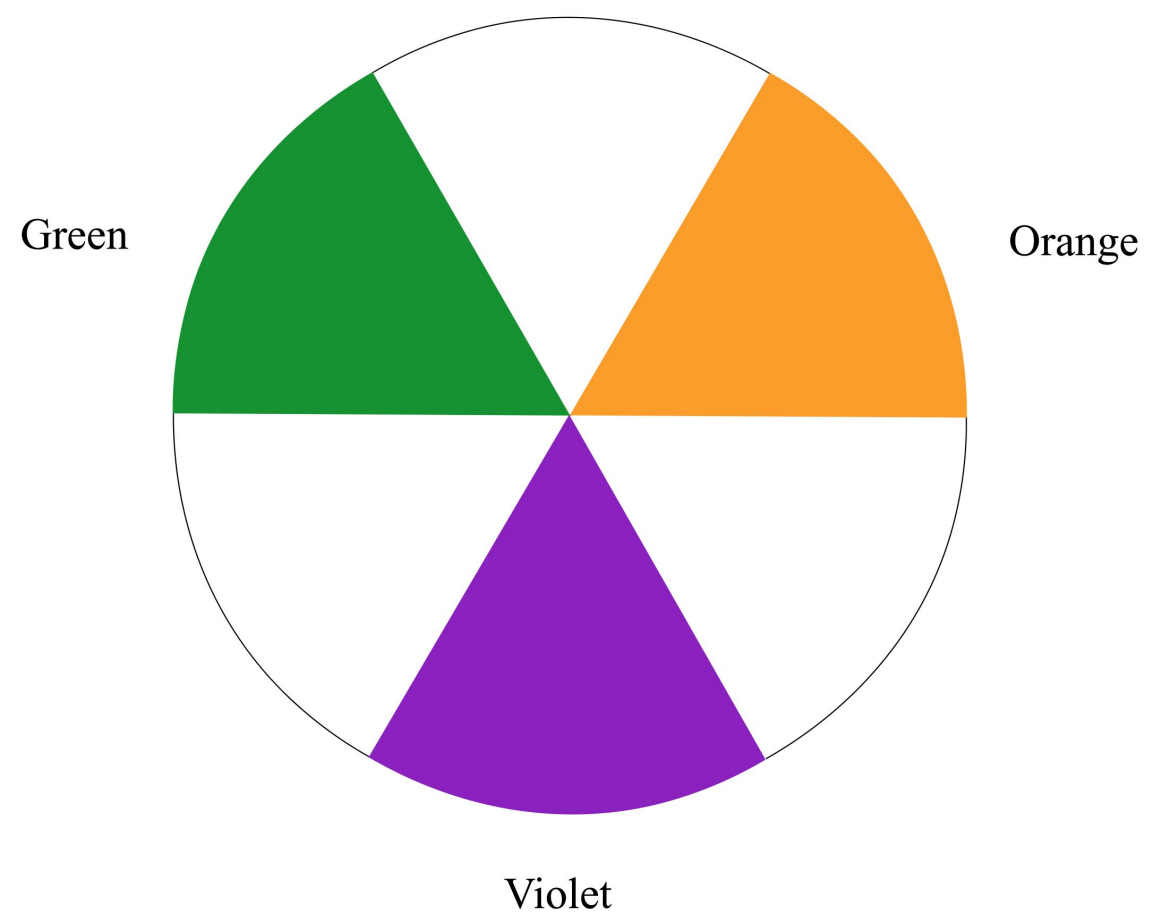
- An artist's color wheel: red, yellow, and blue (RYB)
- Additive color: red, green, blue (RGB)
- Subtractive color: cyan, magenta, yellow, and black (CMYK)
- Hue, saturation, and brightness (HSB)

The artist's model: red, yellow, and blue

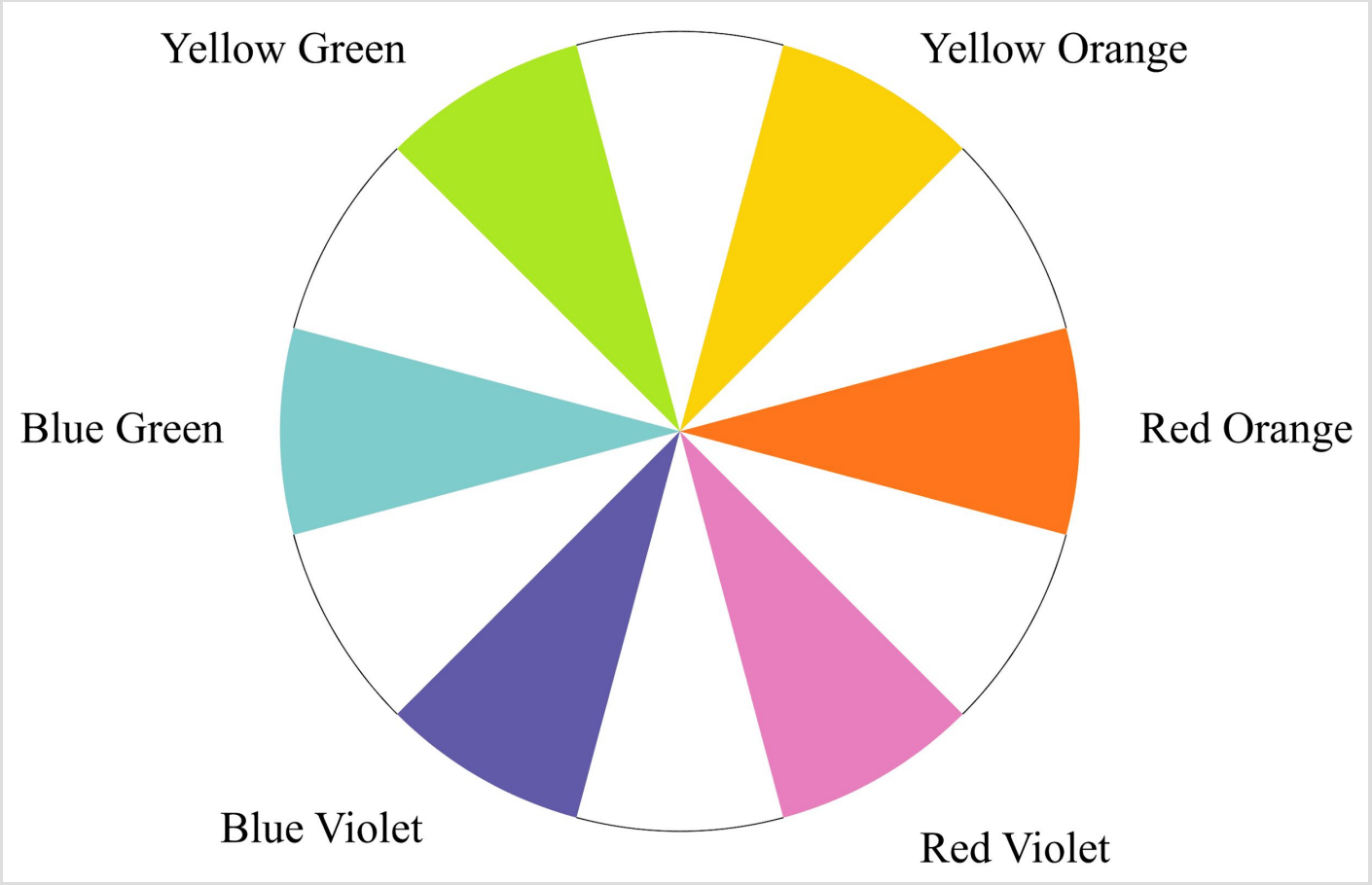


An artist's color wheel

The secondary colors



The tertiary colors



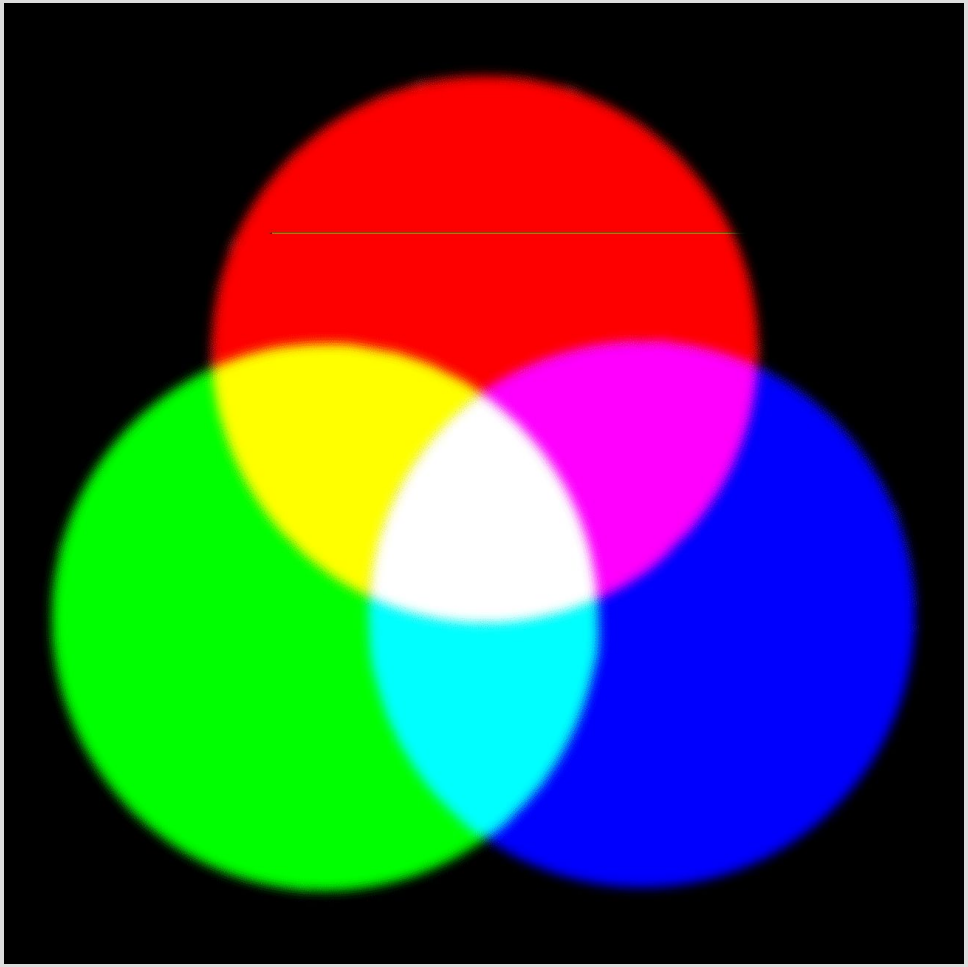
In additive color (RGB)

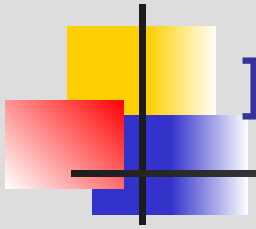
- Red + Green = Yellow

- Red + Blue = Magenta

- Green + Blue = Cyan

Additive color: things that emit light, especially monitors (RGB)

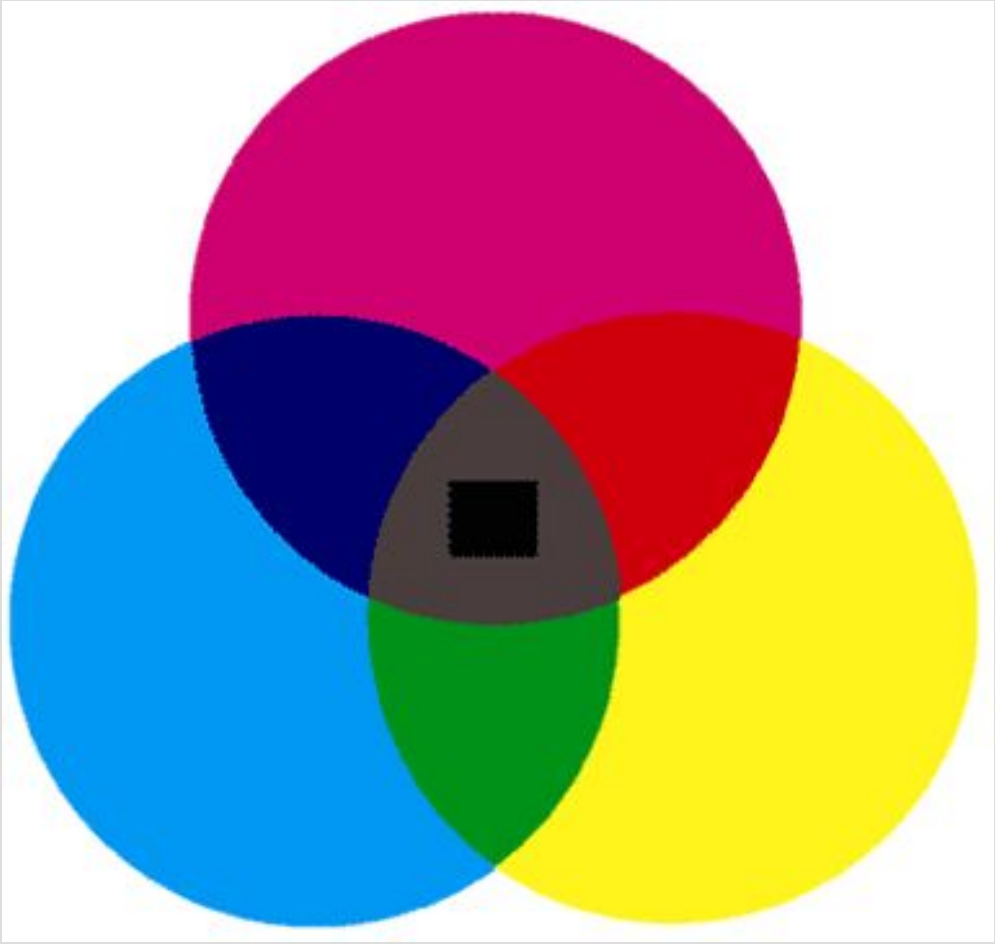


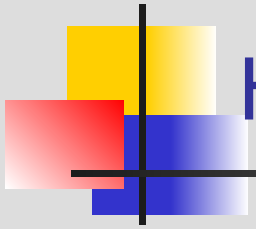


In subtractive color . . .

- Cyan subtracts Red (Green+Blue-Red)
- Magenta subtracts Green (Red+Blue-Green)
- Yellow subtracts Blue (Red+Green-Blue)
- In photography, that's it: all three together subtract all light, giving black
- In print, the dyes aren't that good, and we need black ink too
- Hence, four-color printing: CMYK
- K from blacK; B already means Blue

Subtractive color: things that reflect (and selectively absorb) light (CMYK)

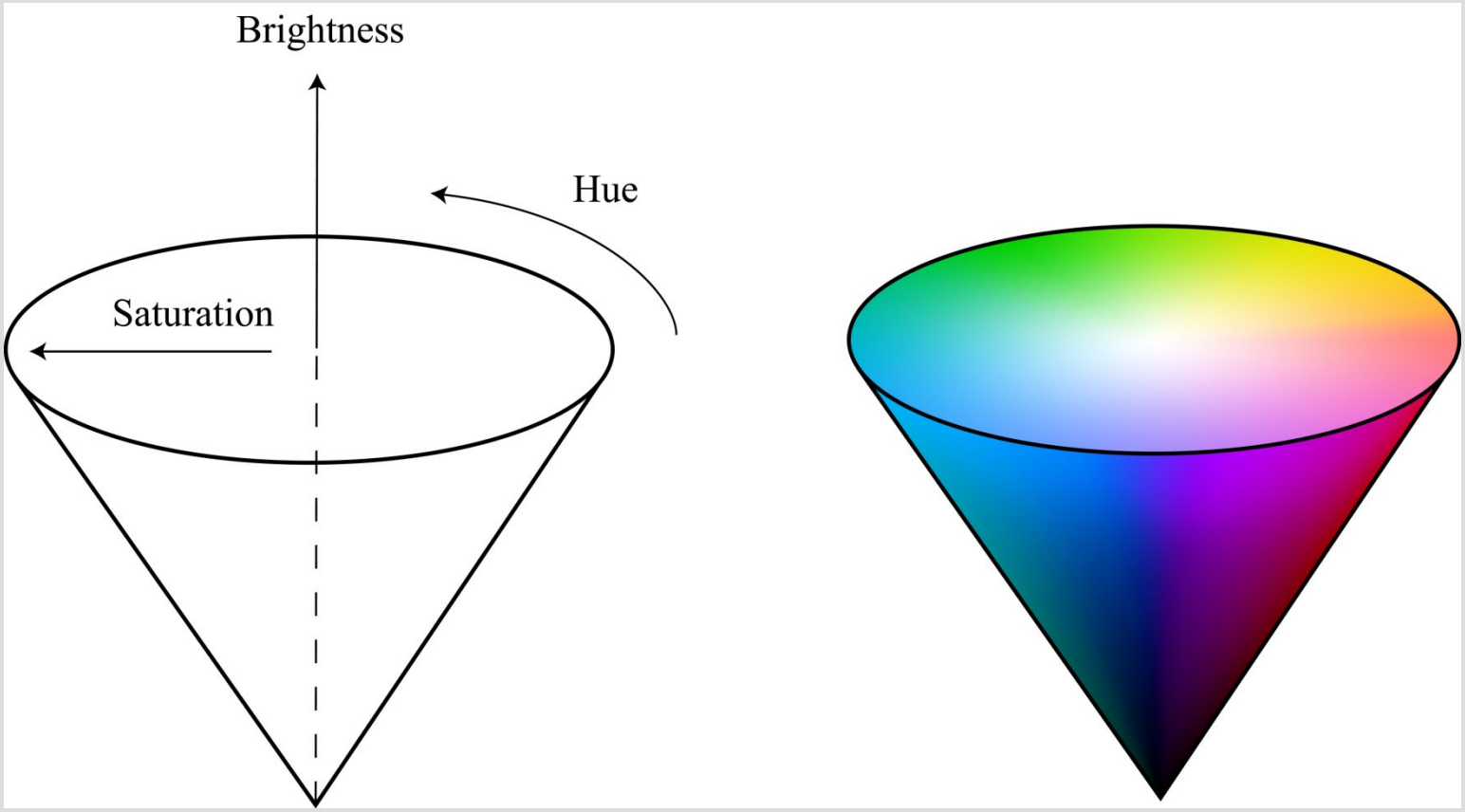


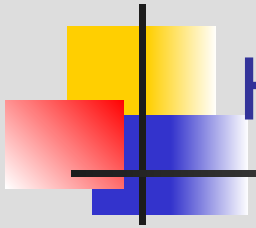


HSB: Hue, Saturation, and Brightness

- Hue: where a color lies around a color wheel: red, green, yellow, blue-green, etc.
- Saturation: the "purity" of a color; a fully-saturated color has no white mixed with it, in paint terms
- Brightness: light, dark, or in between?
- In everyday use, most people probably are thinking of hue when they speak of color

The color cone: hue, saturation, and brightness in relation to each other

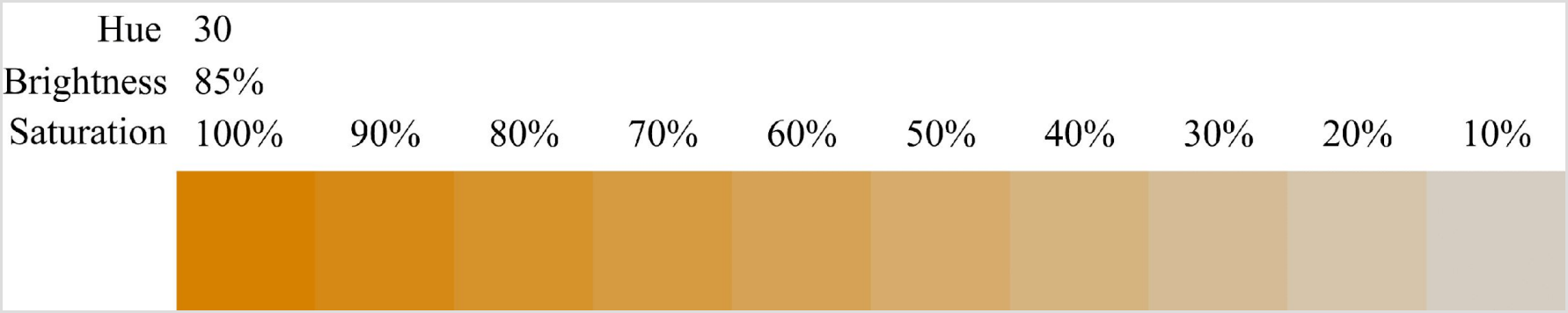




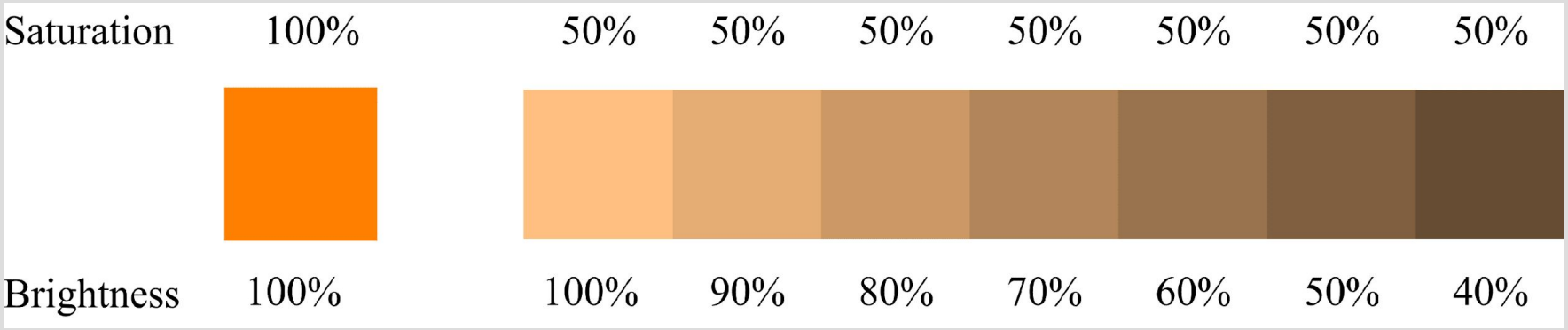
HSB: Hue, Saturation, and Brightness

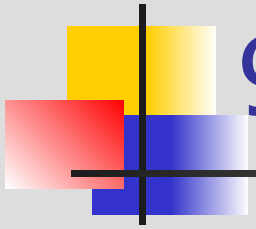
COLOR	Hue	Saturation	Brightness
Red	0°	100%	100%
Yellow	60°	100%	100%
Green	120°	100%	100%
Cyan	180°	100%	100%
Blue	240°	100%	100%
Magenta	300°	100%	100%
White	0°	0%	100%
Black	0°	0%	0%

Varying saturation, with brightness held constant



Varying brightness, with saturation held constant

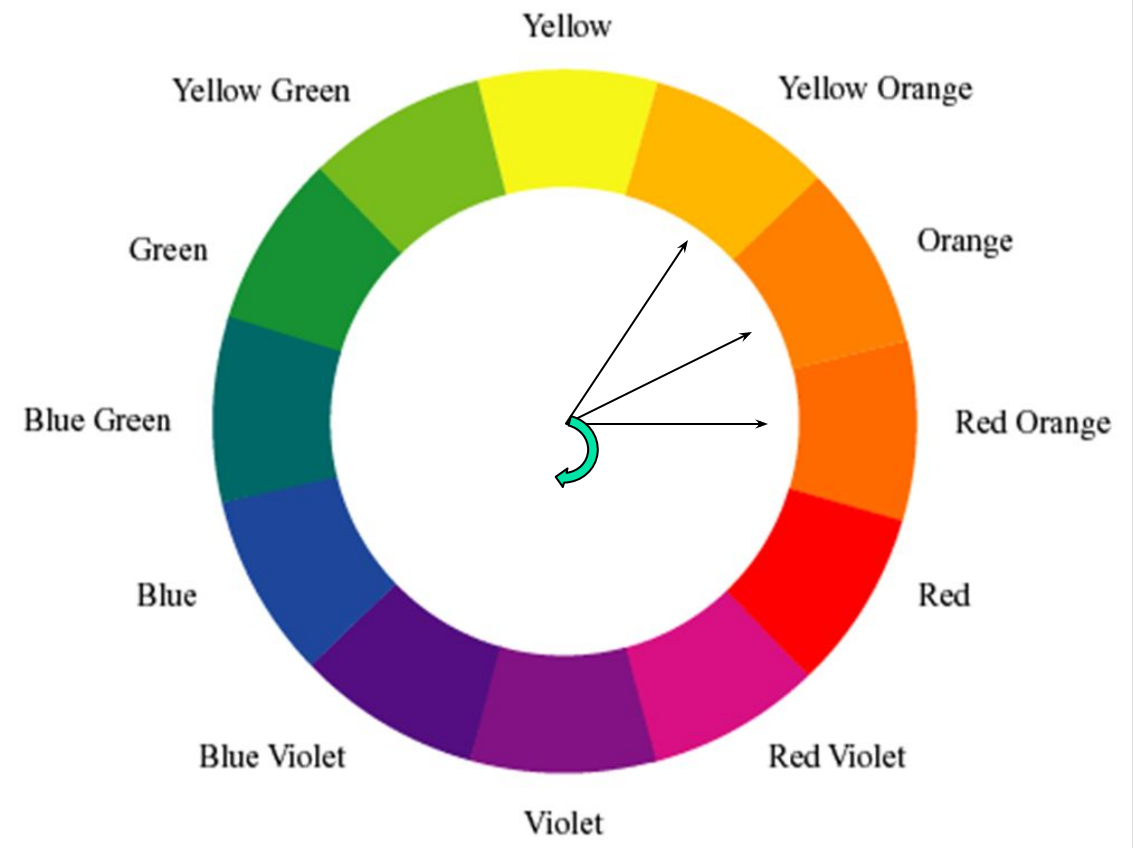




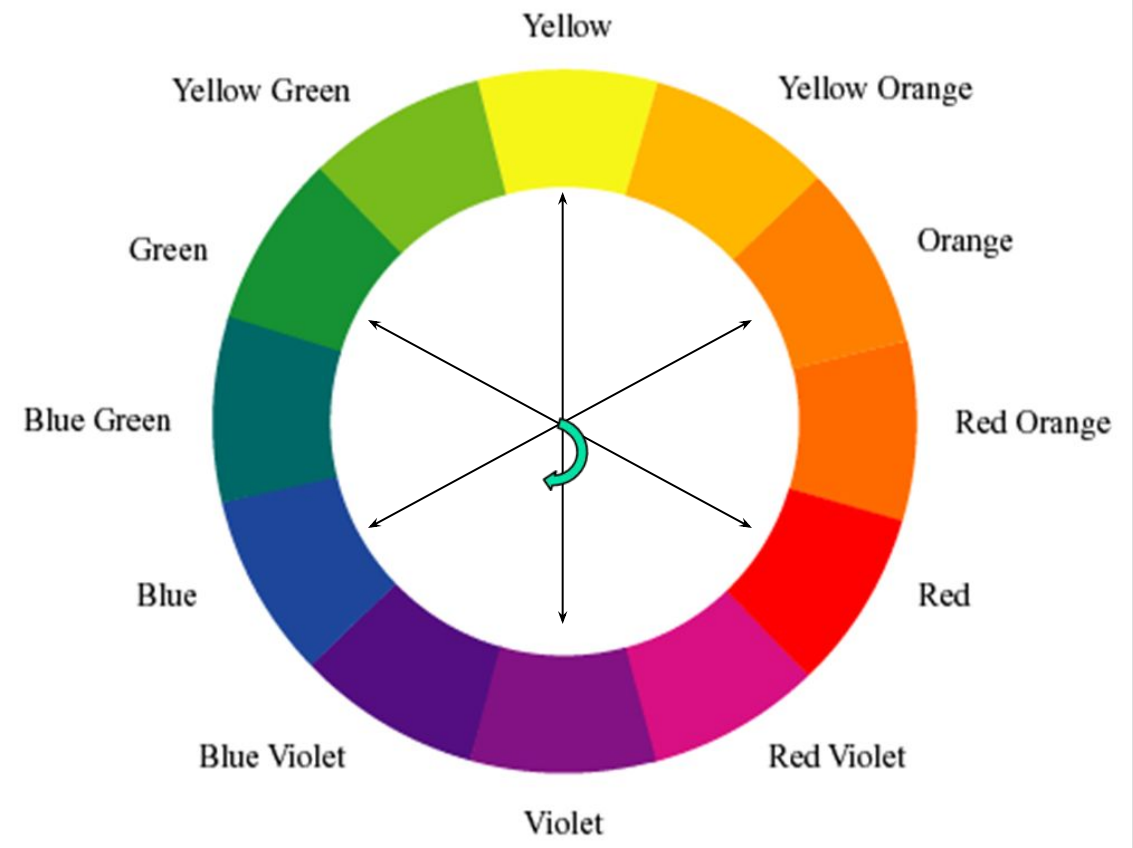
9.4 Four Color-Harmony Schemes

- Monochromatic: colors of same or similar hue, differing in brightness and/or saturation
- Complementary: colors approximately opposite each other on a color wheel
- Analogous: colors adjacent to each other, from any segment of a color wheel
- Triadic: three colors approximately equally spaced around a color wheel

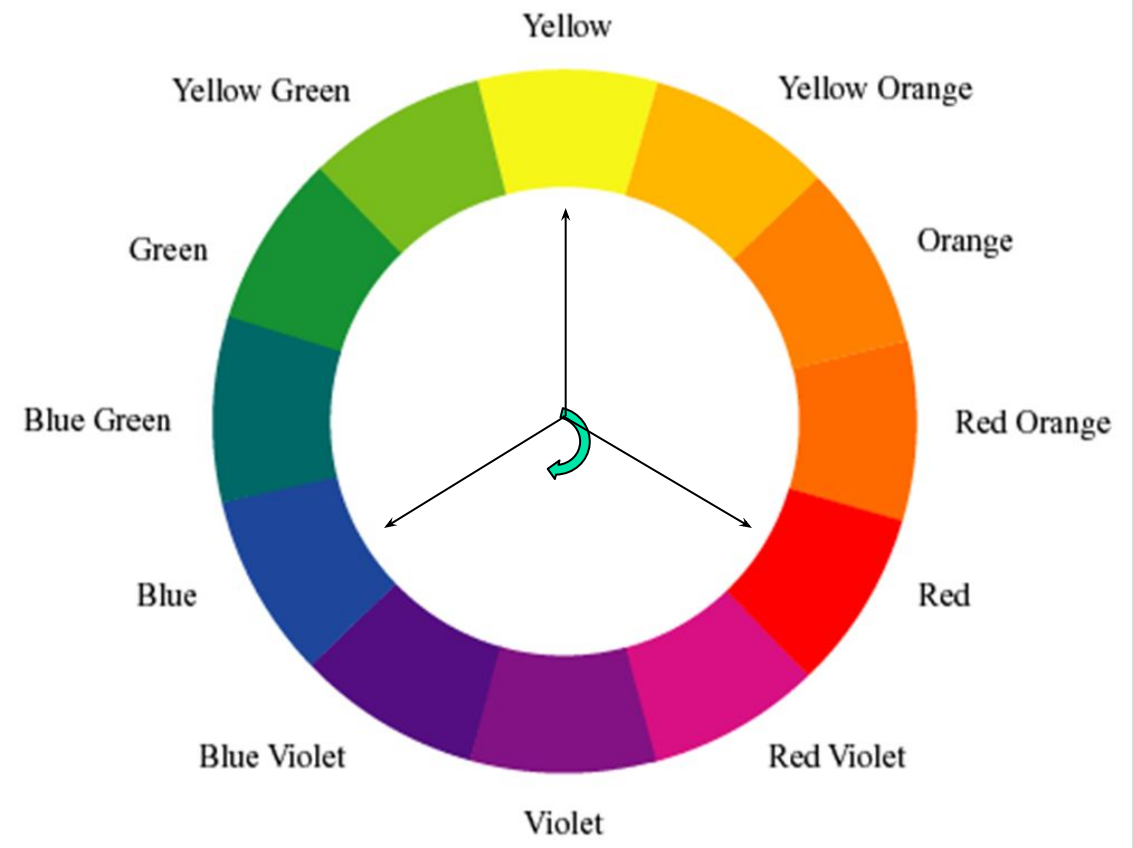
Analogous Colors



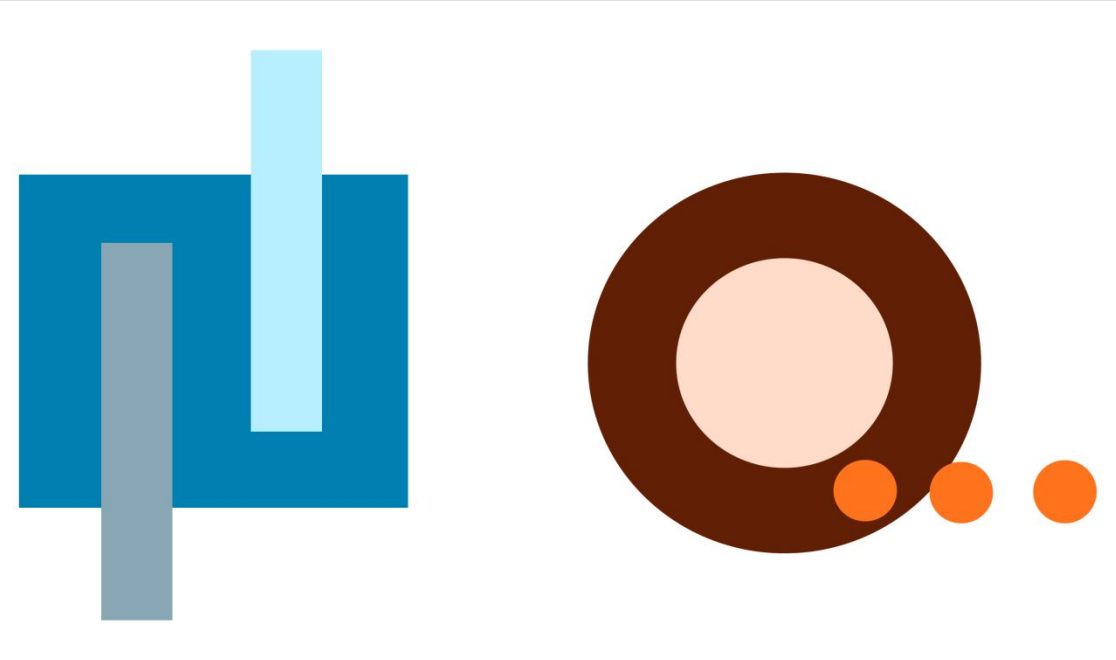
Complementary Colors



Triadic Colors



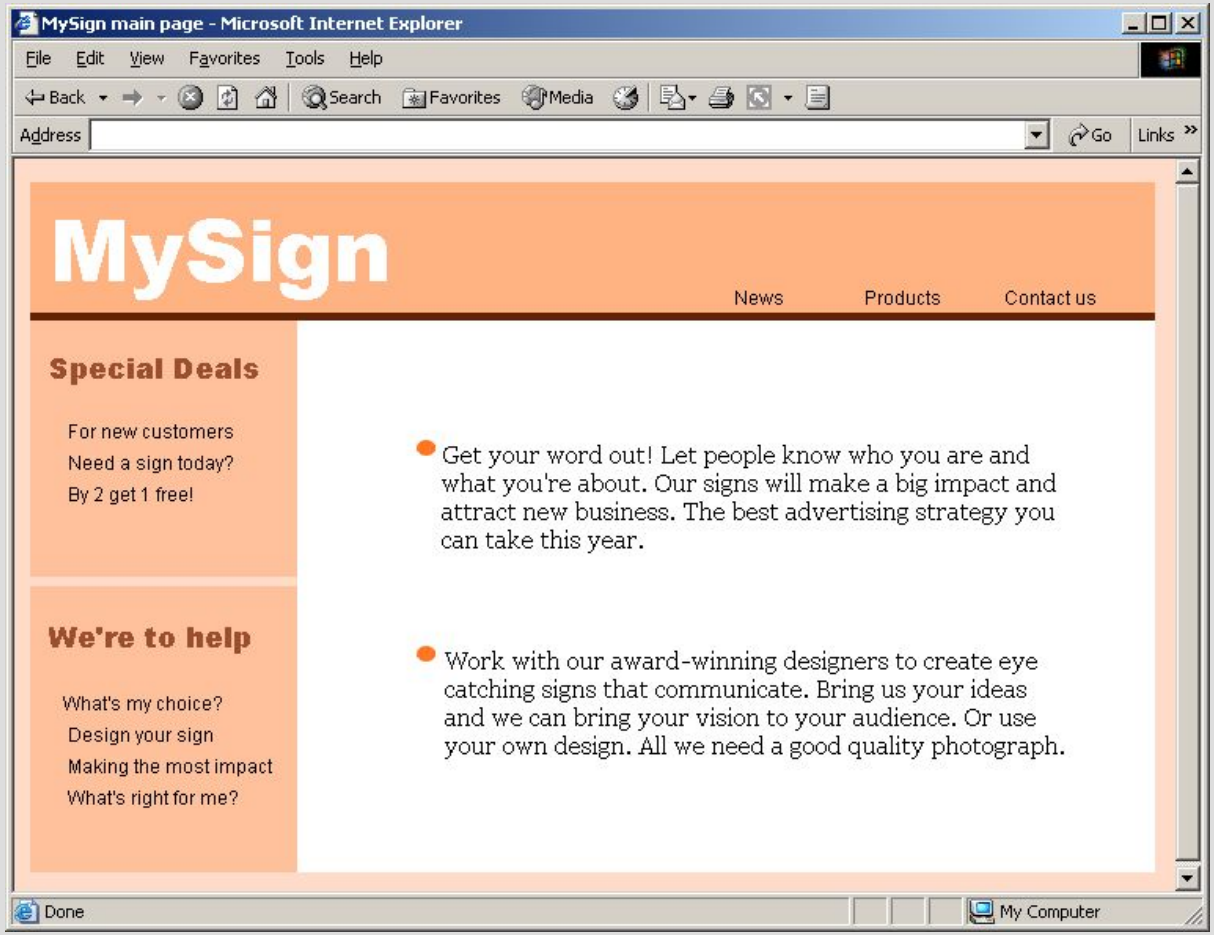
Monochromatic color harmony: colors of same hue, differing in brightness and/or saturation



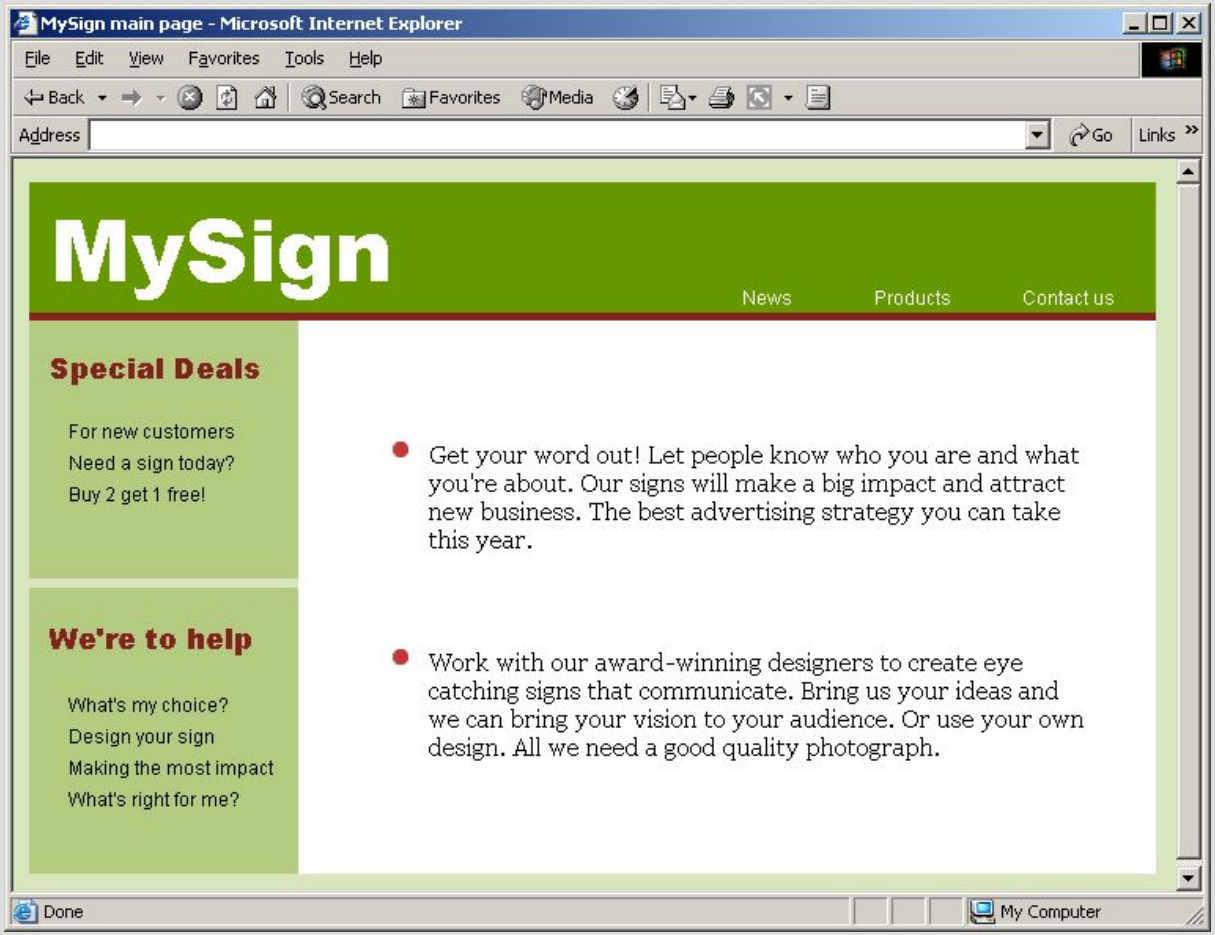
All blue

All orange

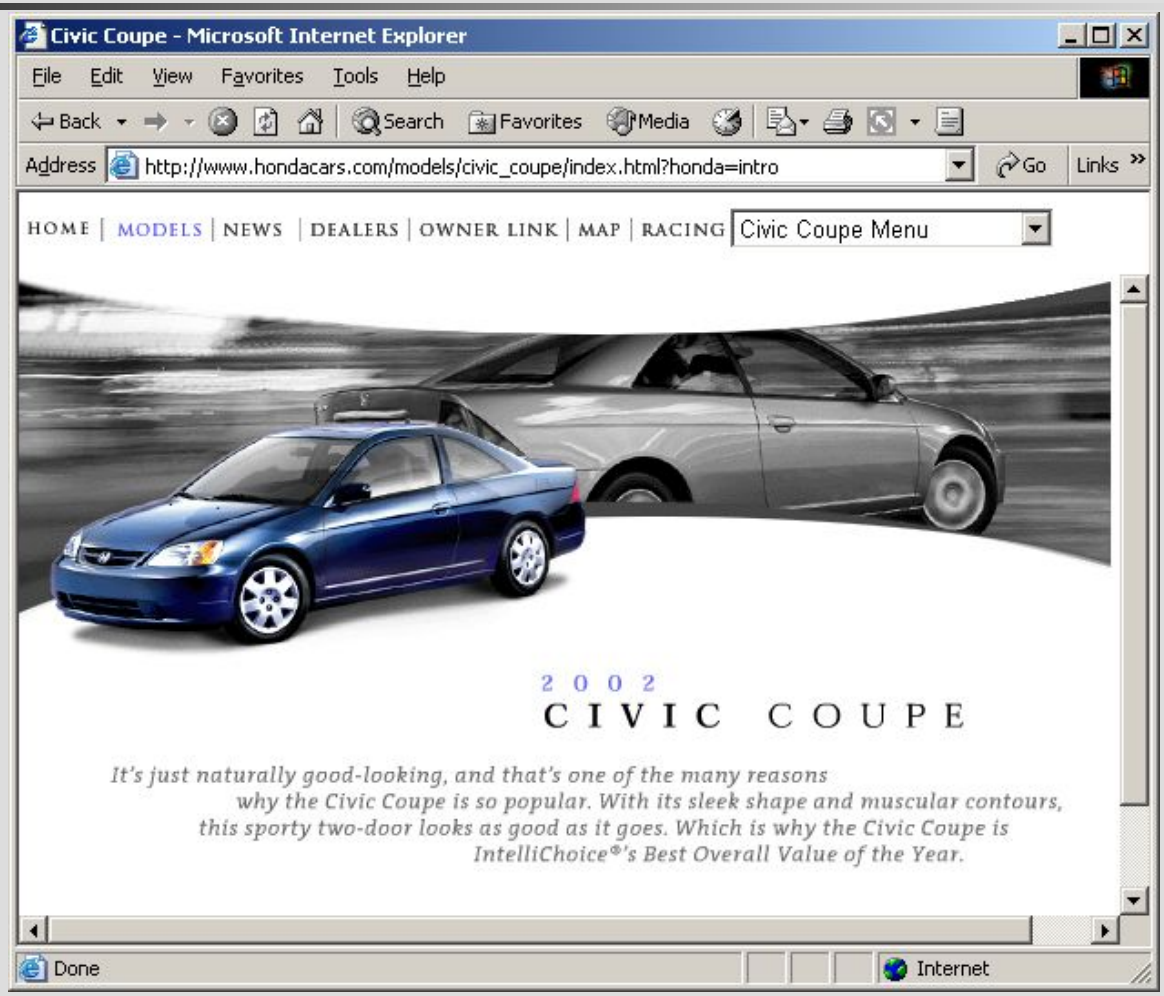
Monochromatic example: orange, with variation in brightness and saturation



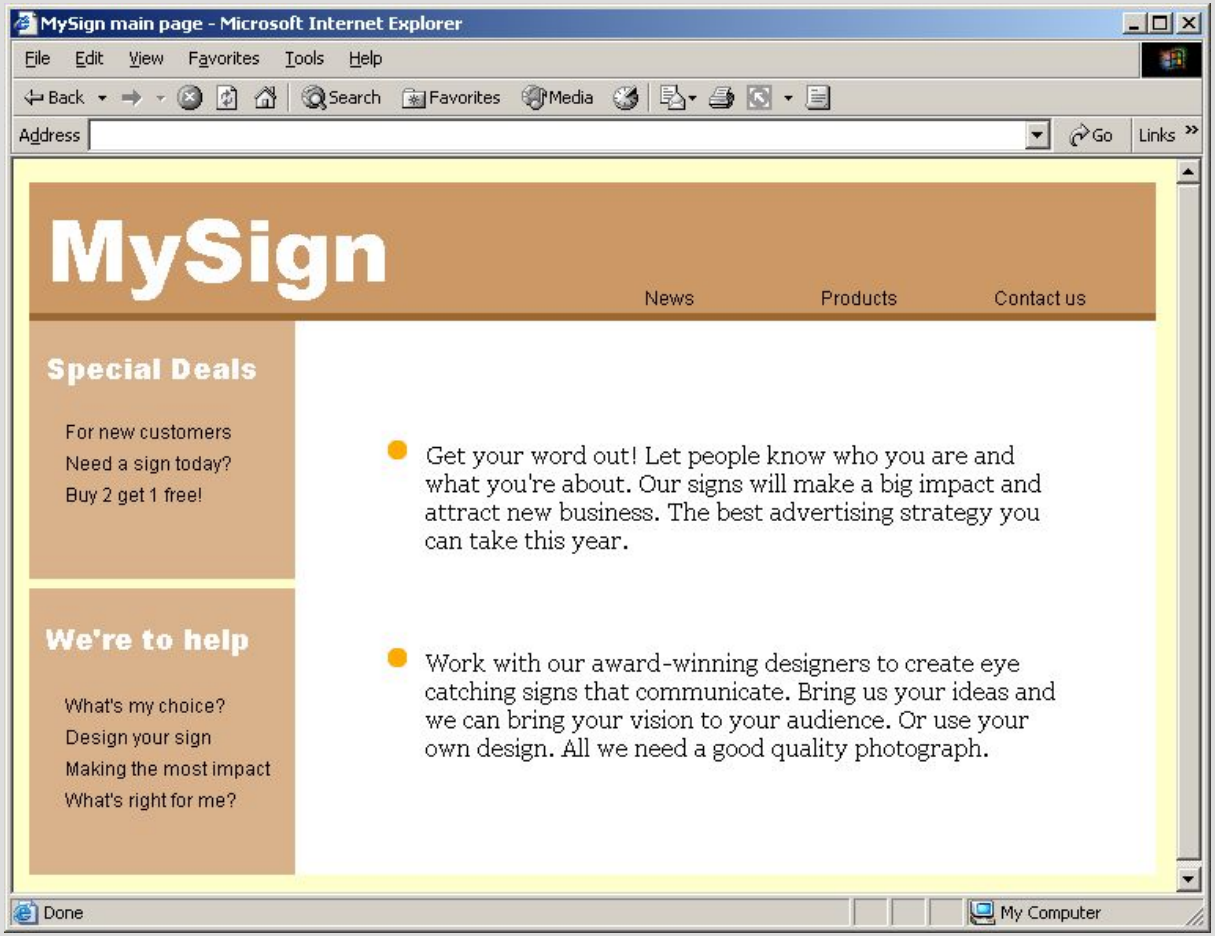
Complementary: red and green



Complementary: various blues, with red-orange highlights

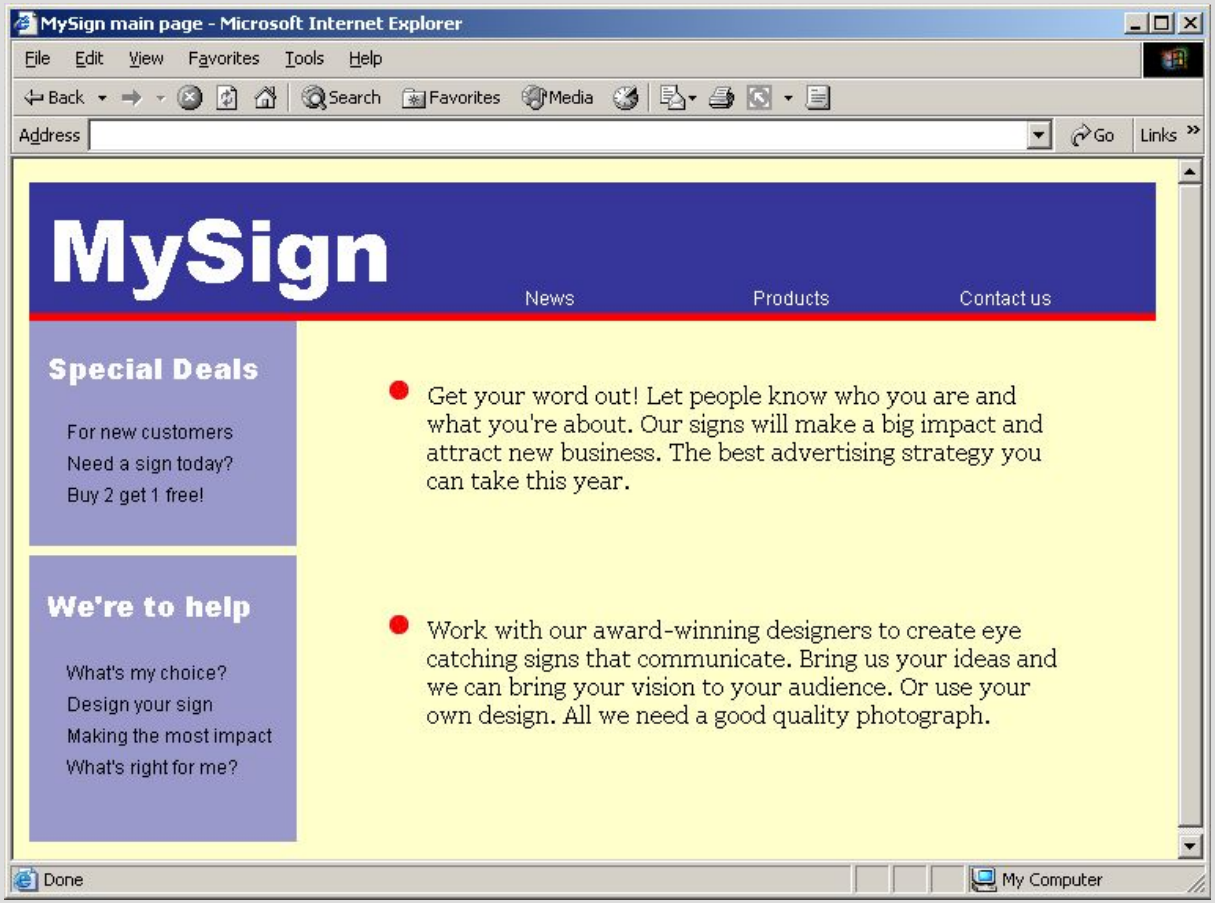


Analogous: bright orange, darker yellow-orange, light yellow



Analogous: red-orange through yellow-green

Triadic: red, yellow, blue

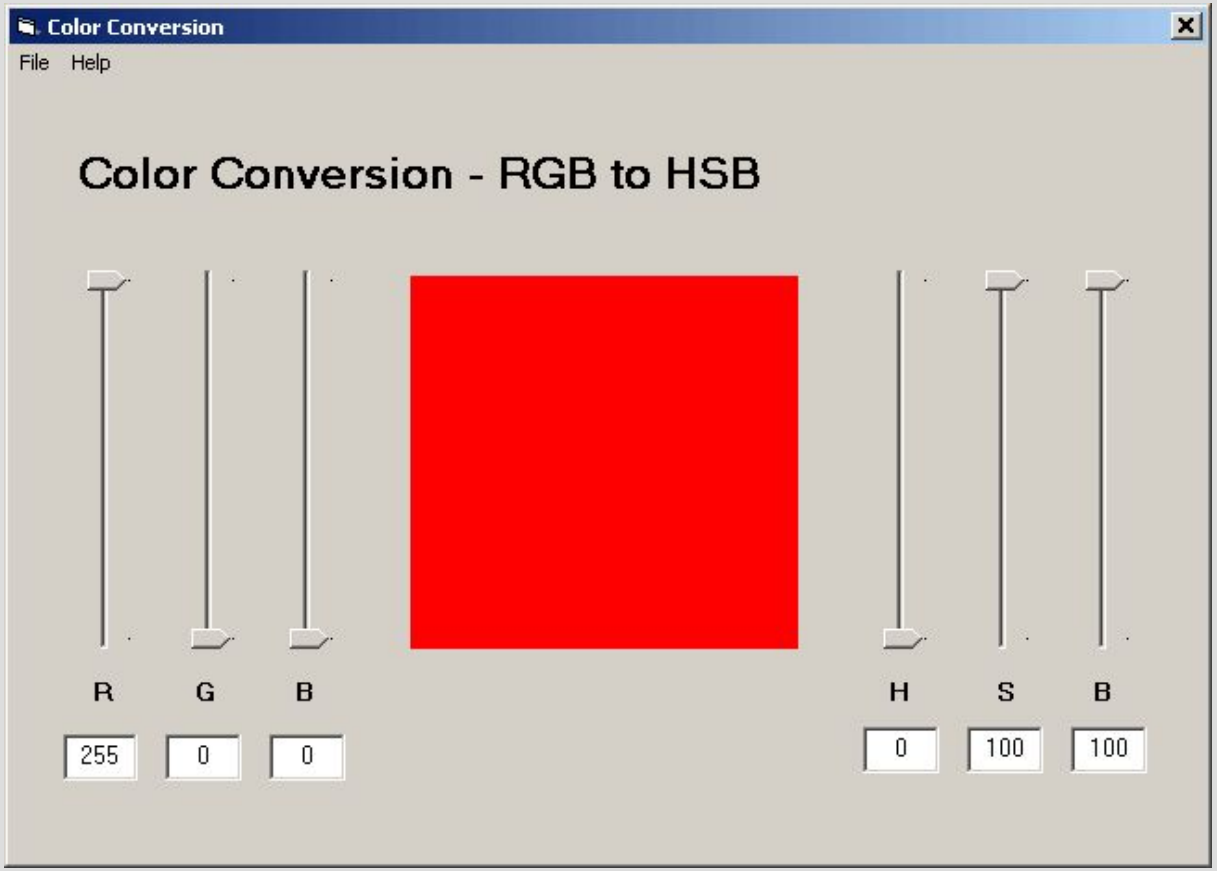


Triadic: red, yellow, blue

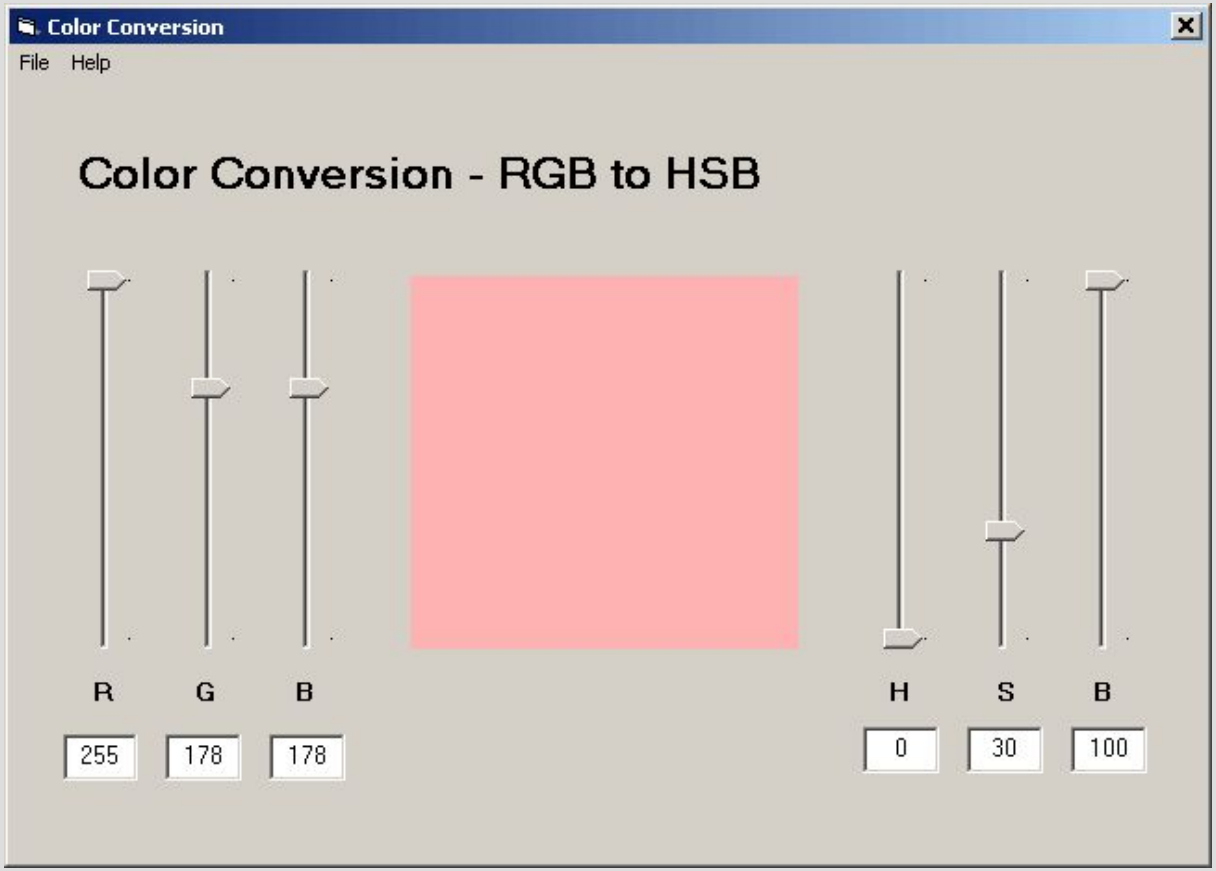
The color software at the companion Web site is a great way to learn

- Permits simple experimentation with the concepts, e.g.:
  - What is pink? (Desaturated red)
  - Can a dark color be saturated? (Yes)
  - Does adding red and green really give yellow? (Yes)
  - Is gray ever saturated? (No)
  - What does saturation mean at low brightness levels? (Not much)
  - In RGB, how do you "add white" to red? (Increase the amounts of green and blue)
  - **http://www.prenhall.com/mccracken/**

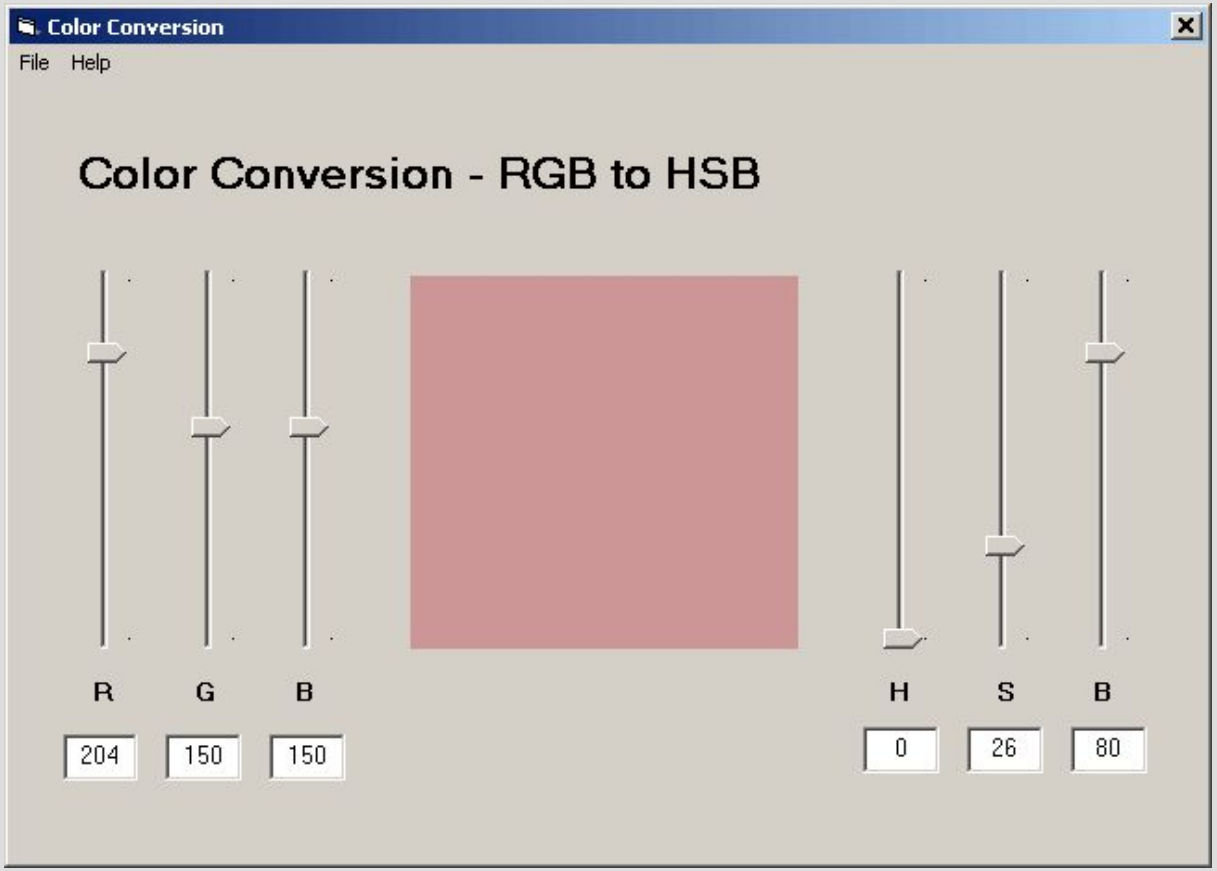
Here is pure red; what would we have to do to make pink?



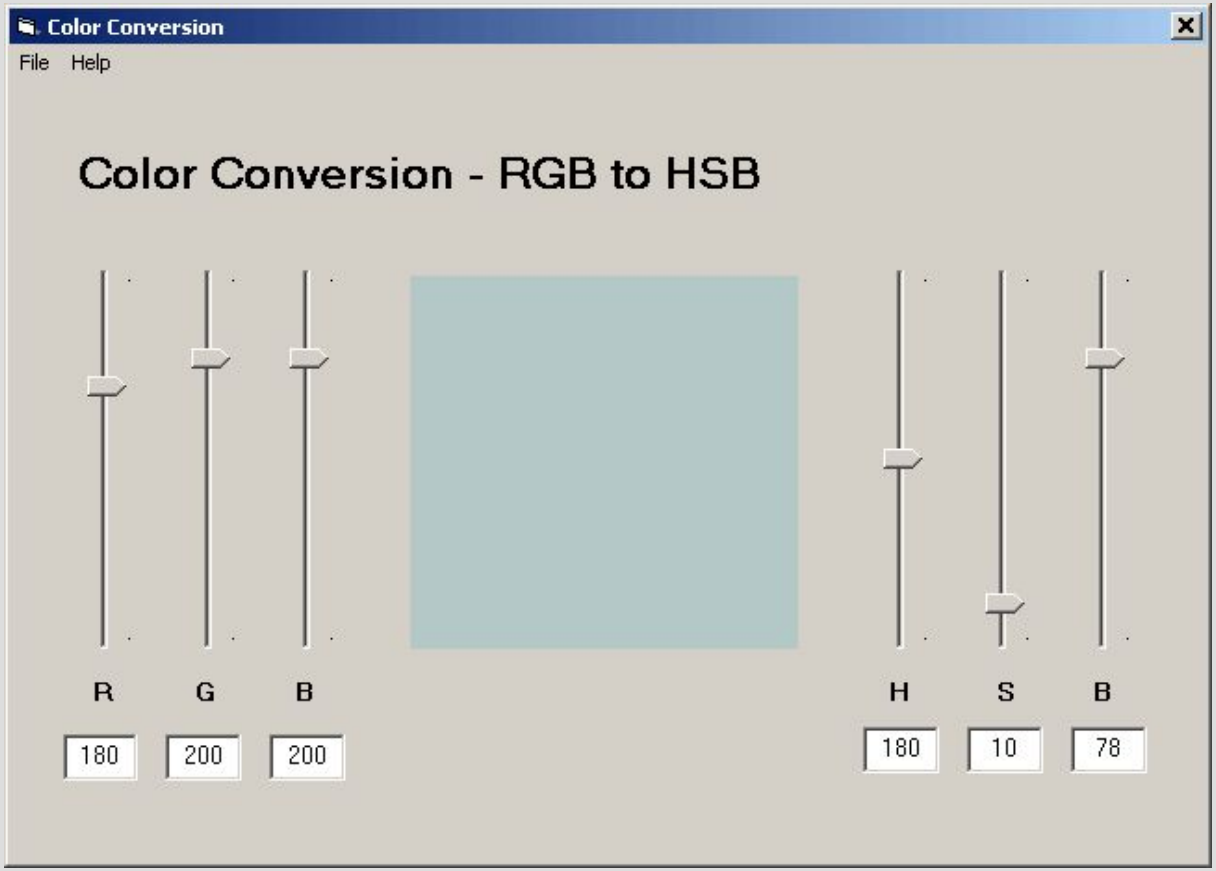
Answer: add green and blue



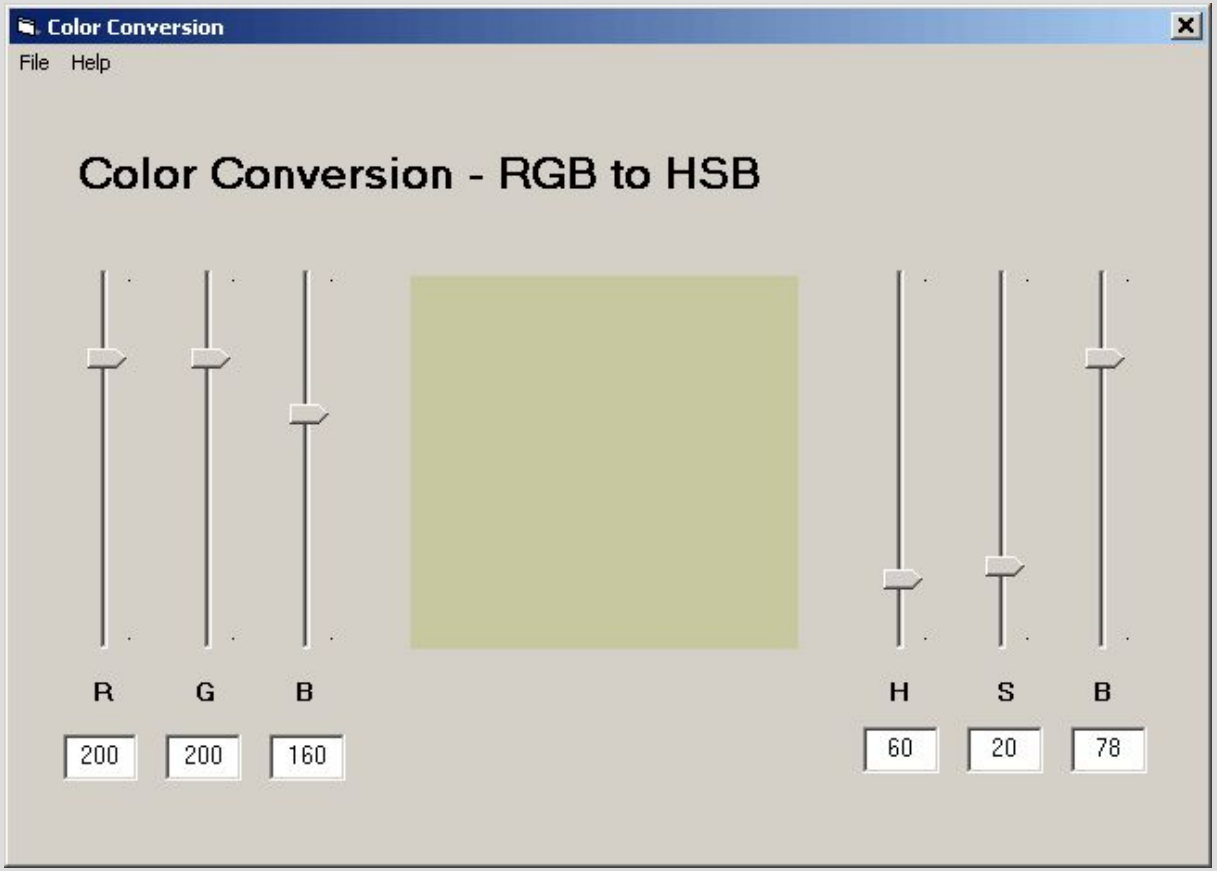
Lower all three, to get "dusty red," maybe, although we don't often use the language of fashion or interior decoration



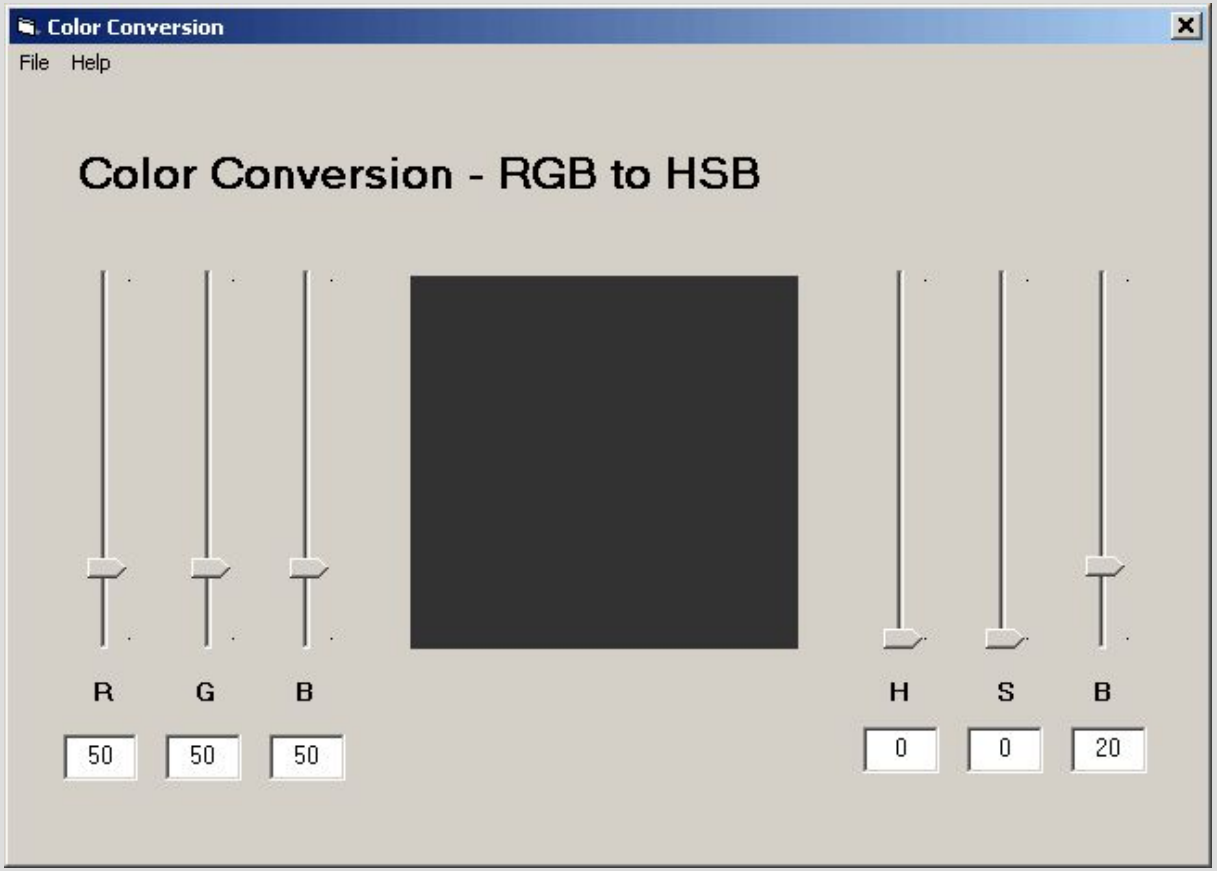
This is a cool gray: less red than green and blue



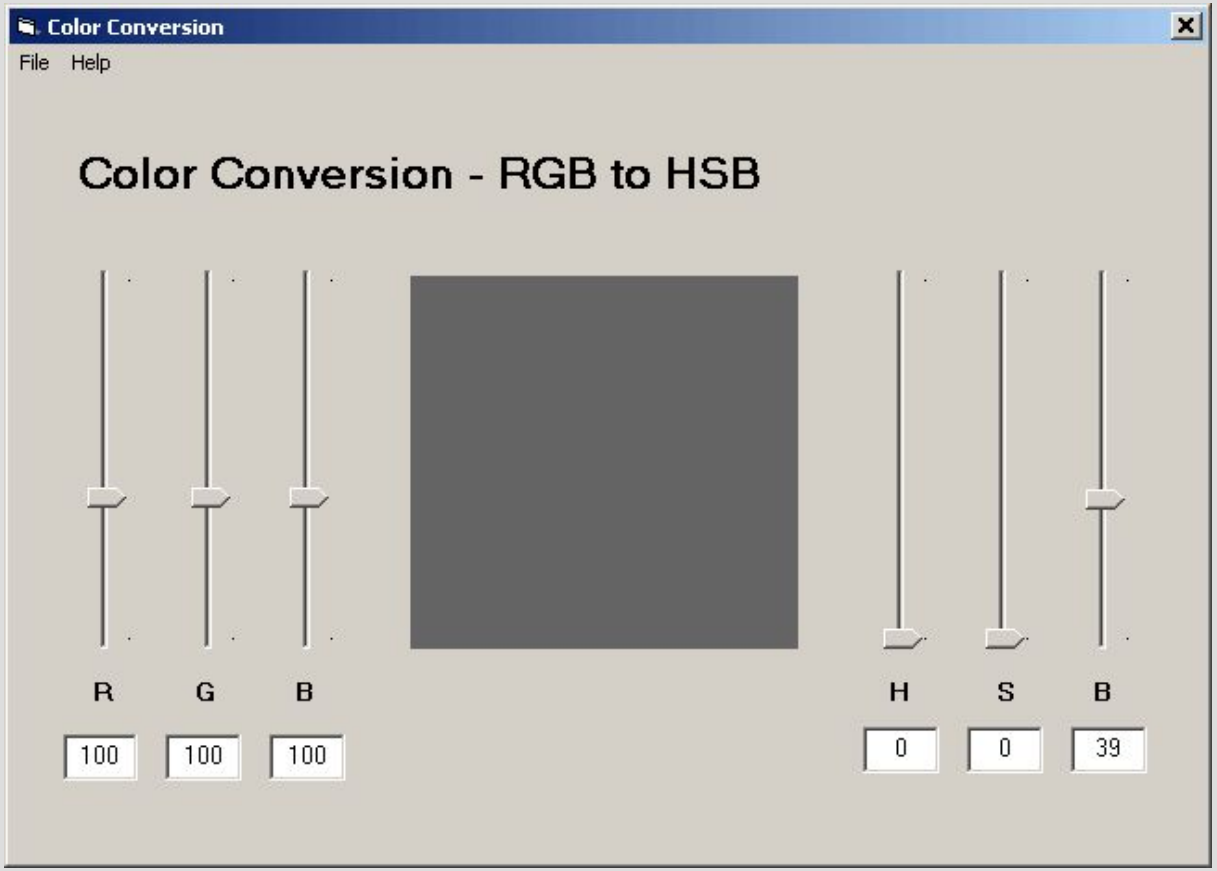
This is a warm gray: less blue than red and green



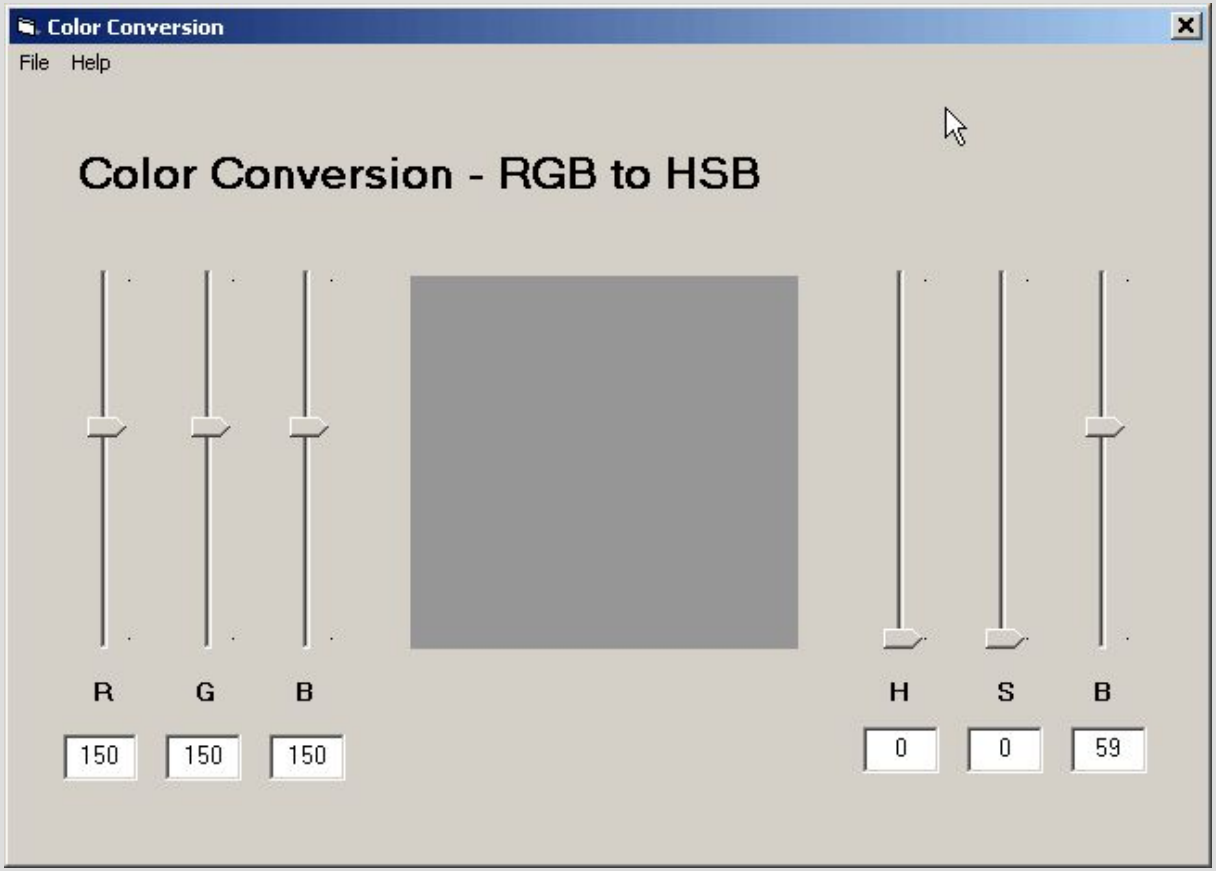
Is gray ever saturated? Let's try: this is so dark as to be almost black, depending on room lighting; zero saturation



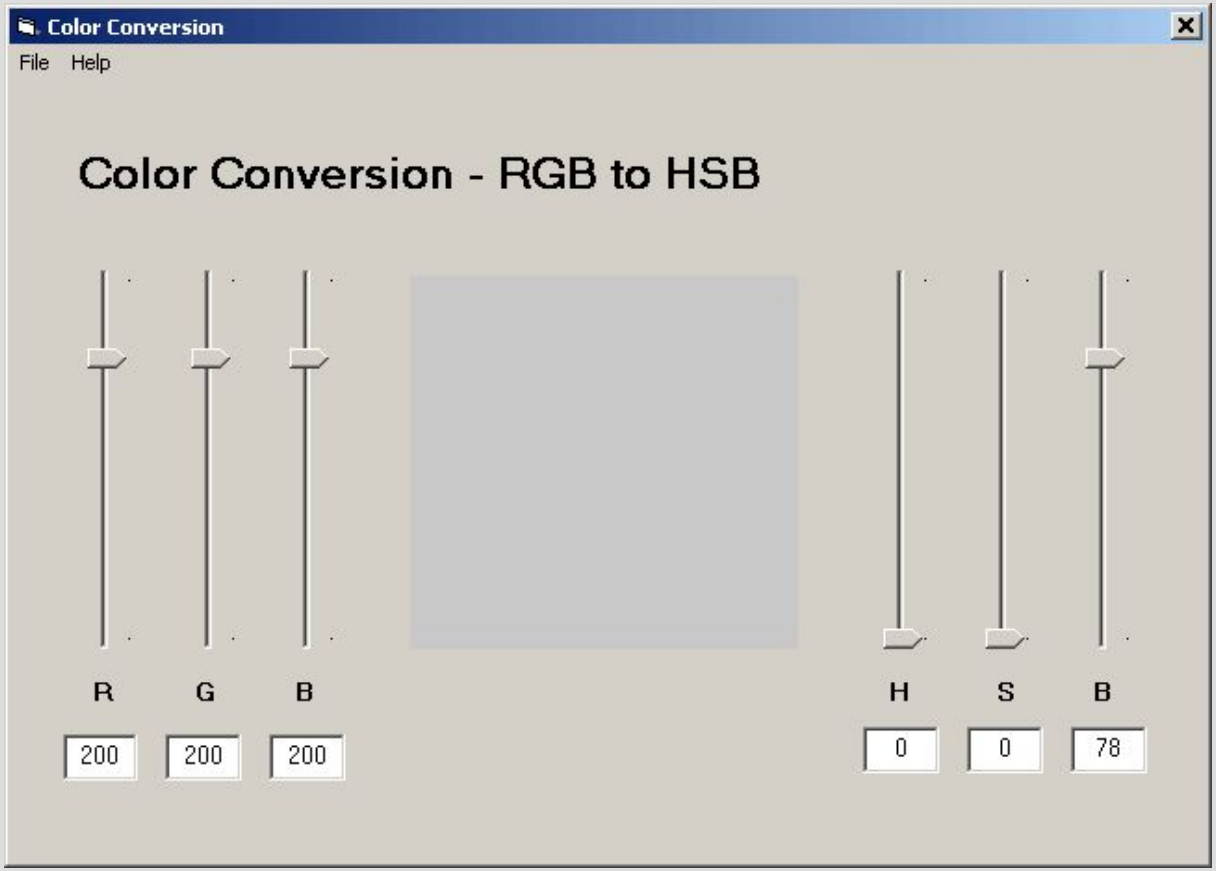
Another gray (same amount of R, G, and B); saturation still zero, brightness up



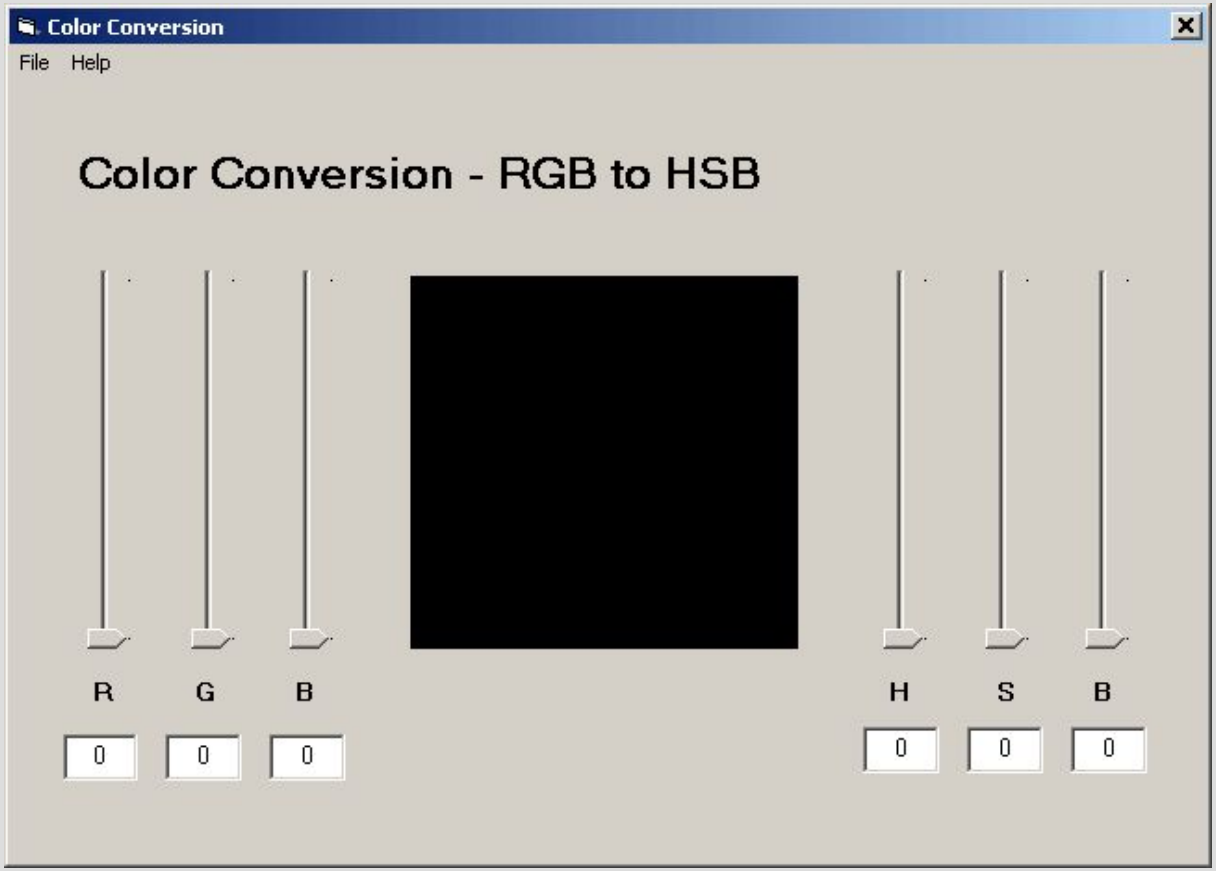
A lighter gray



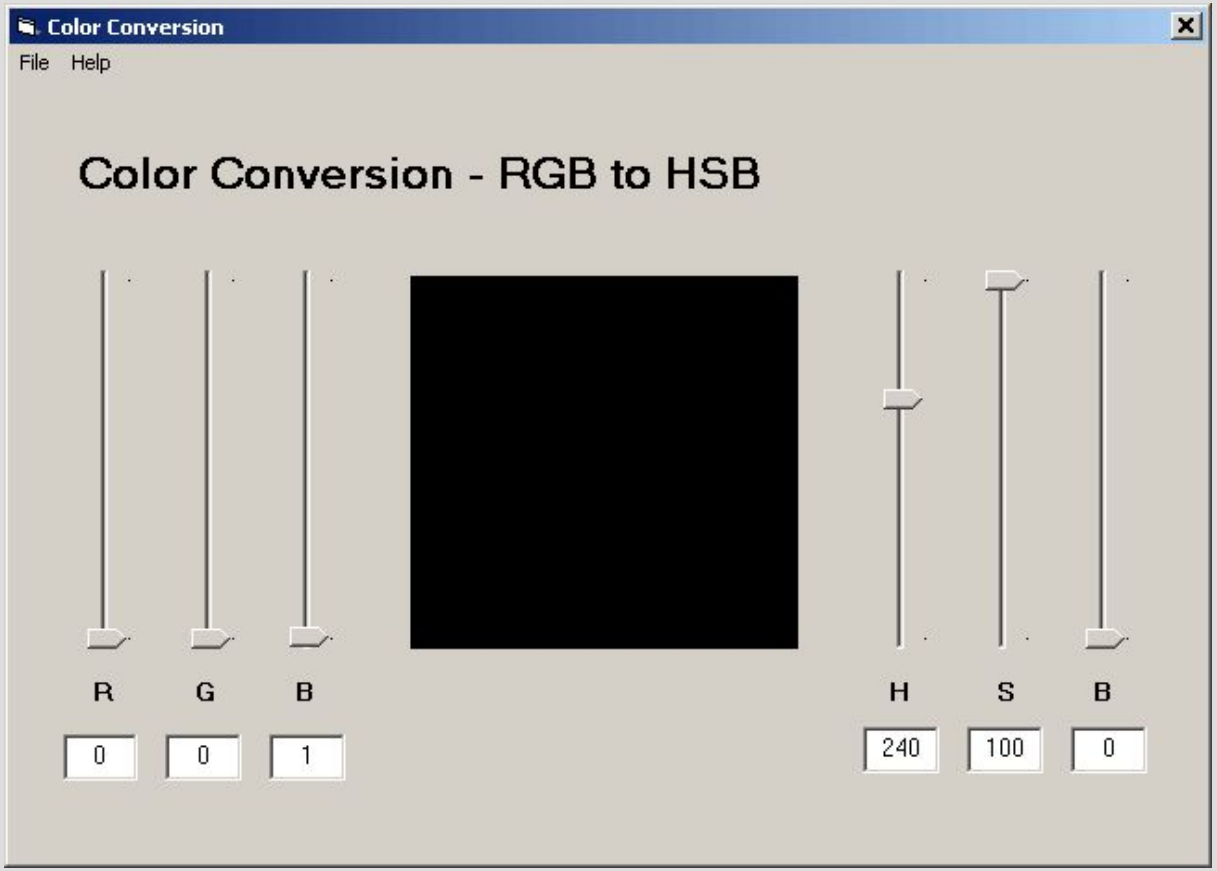
Gray getting toward white; still zero saturation



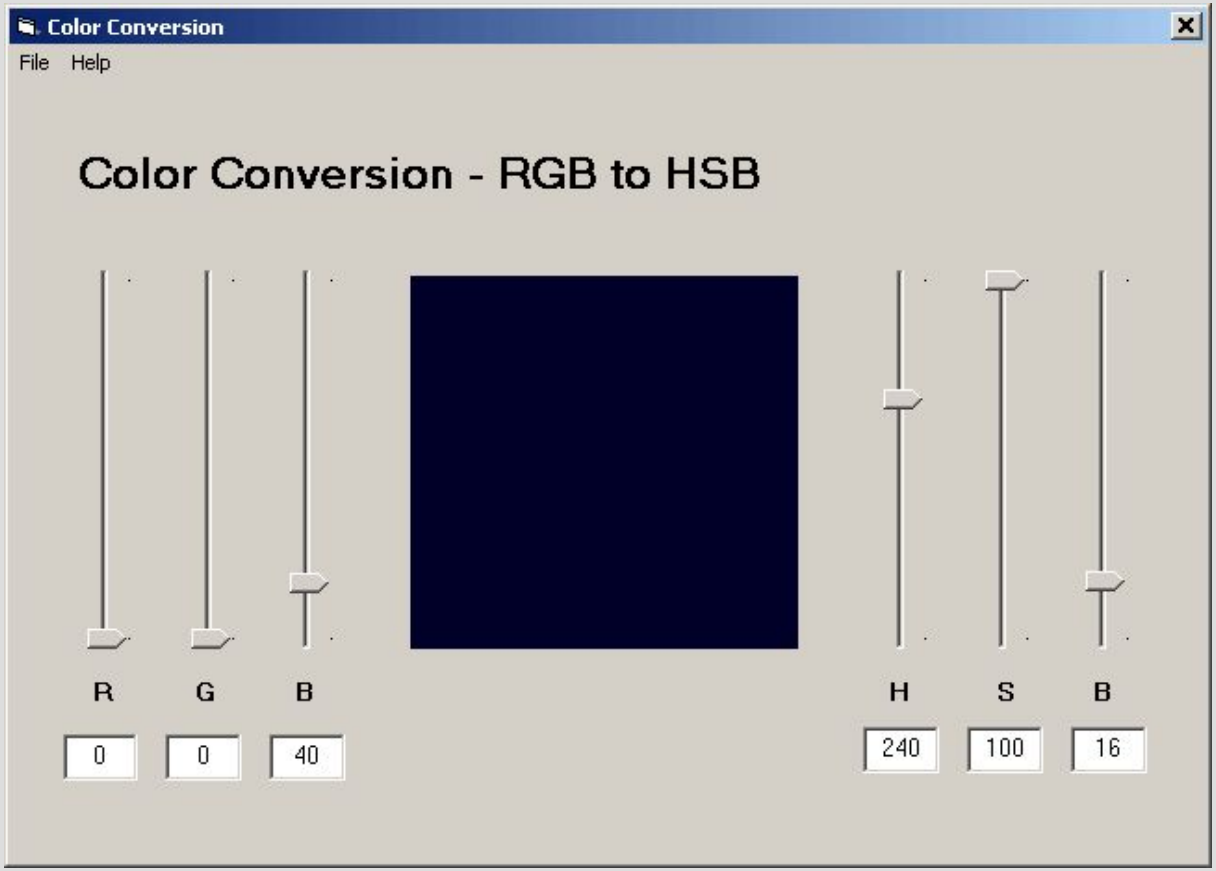
Black is completely unsaturated, right? Right.



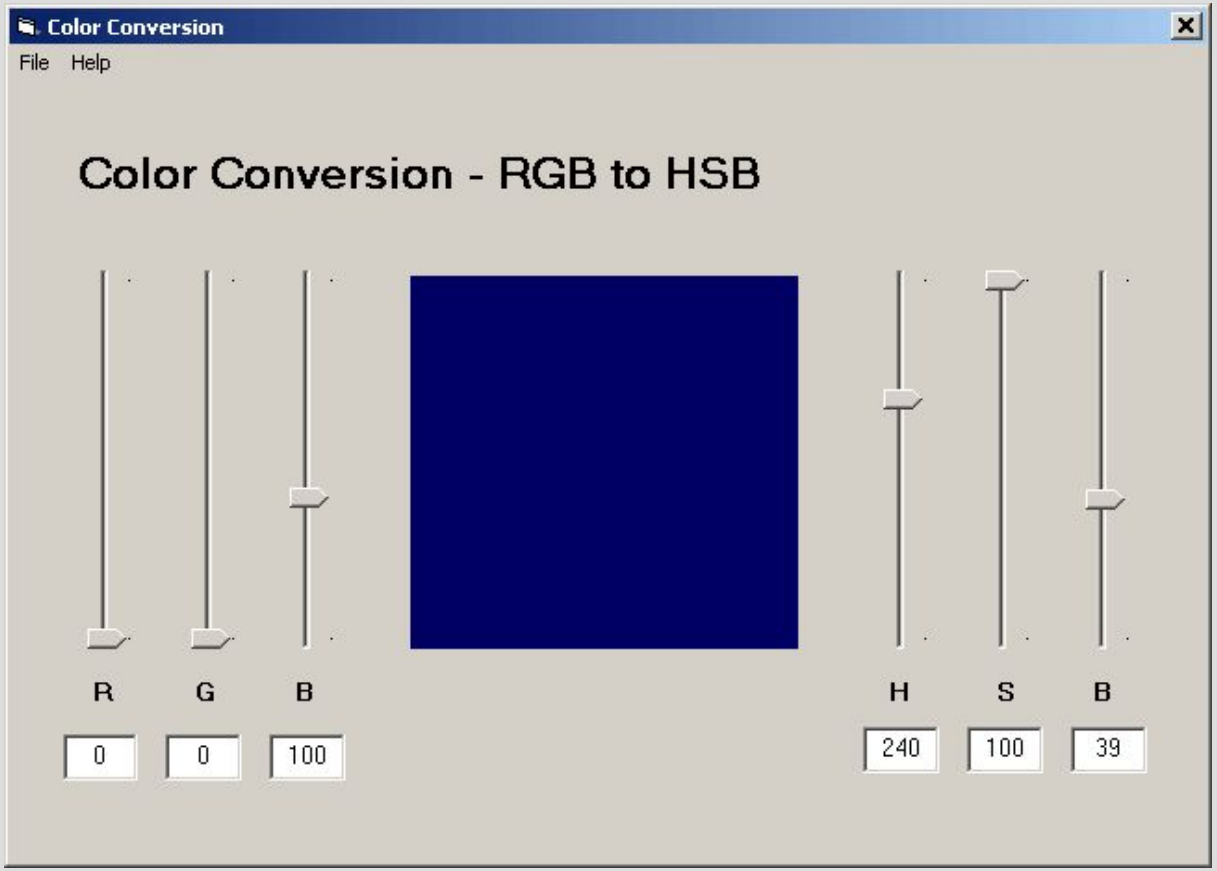
Change the amount of blue from zero to one: now 100% saturated (same result in Adobe and Microsoft software)



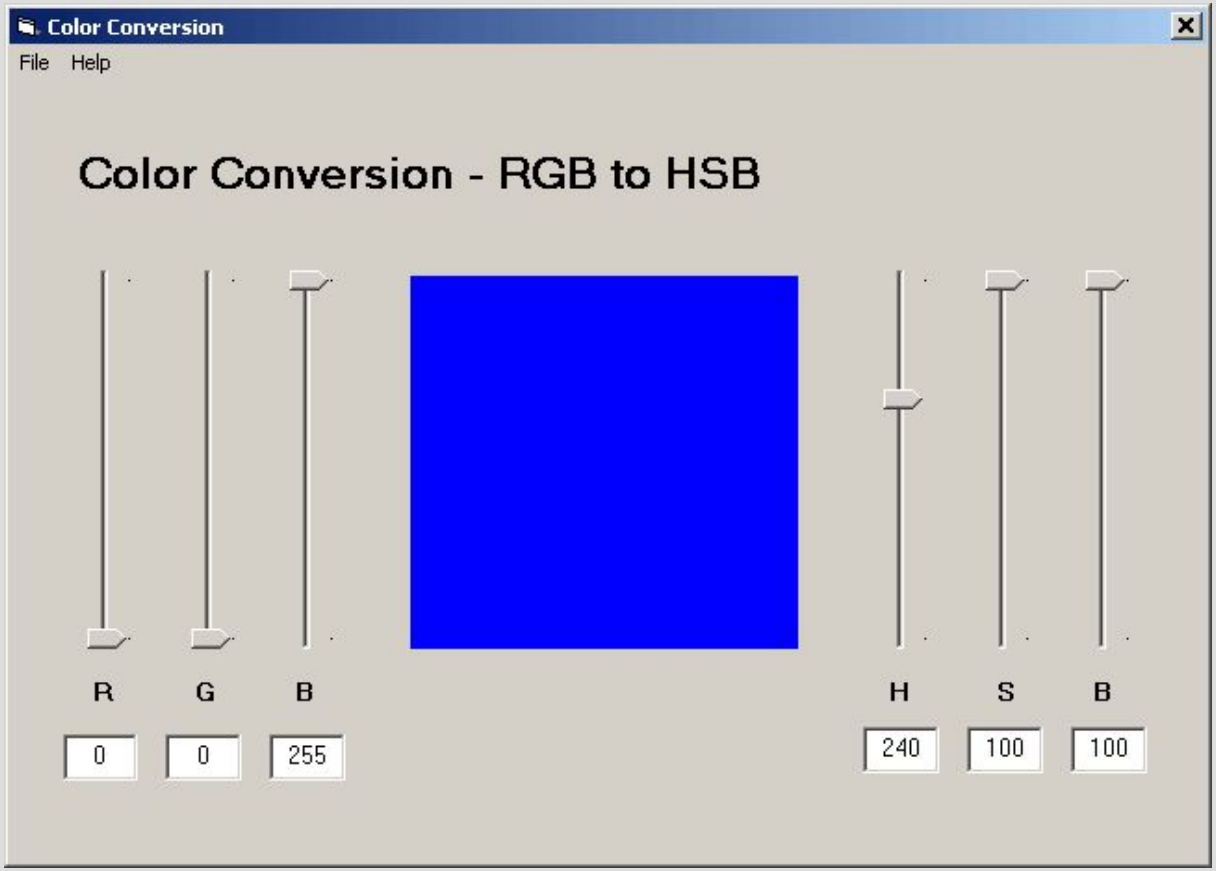
Now B = 40; can you distinguish from black? (Still 100% saturated)



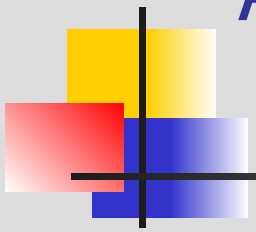
Now B = 100, and we have something like midnight blue; still 100% saturated—but now that begins to make sense



Pure blue; fully saturated by any definition

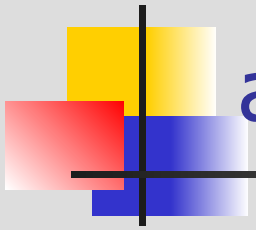


A little more on color harmony

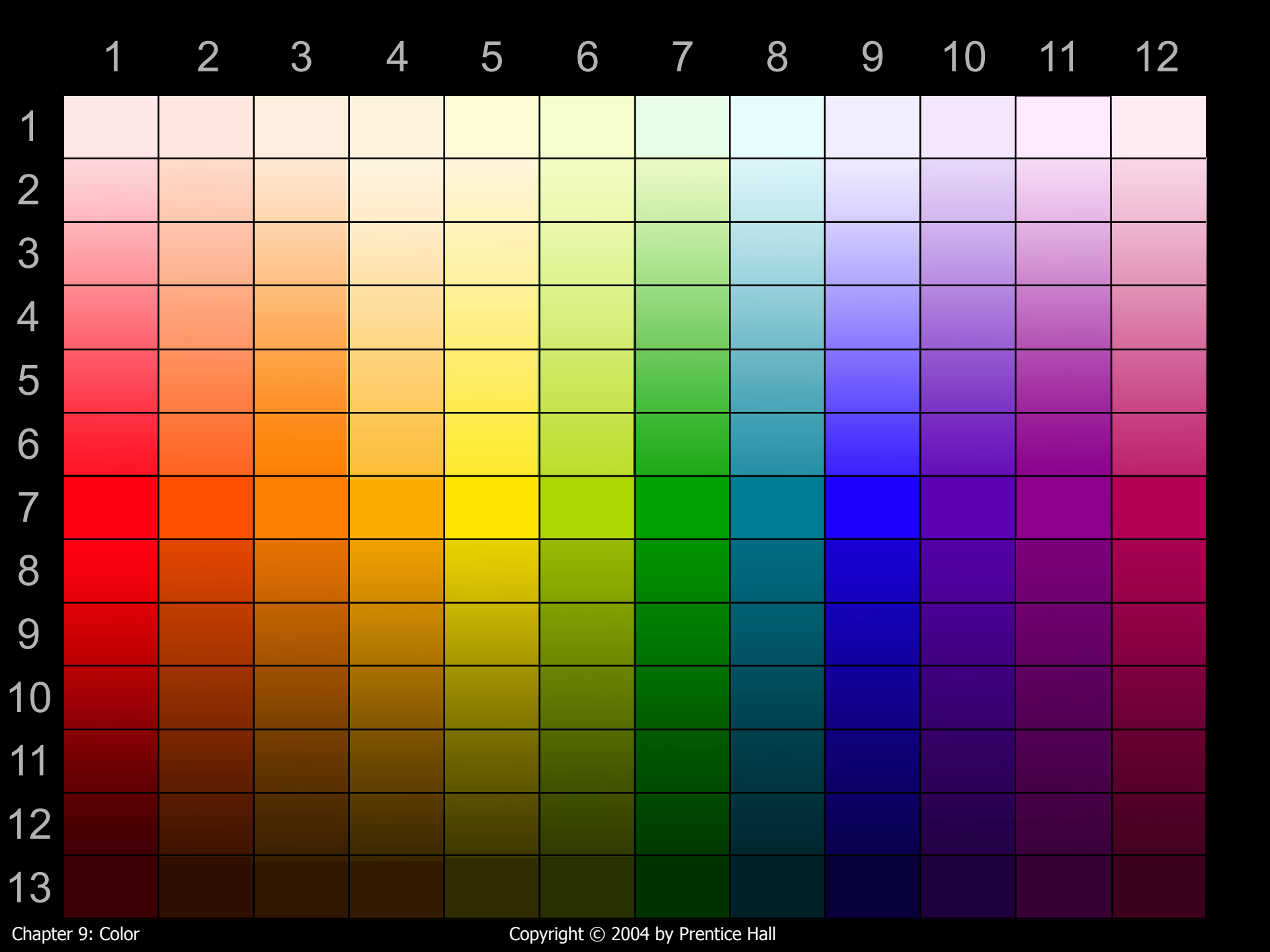


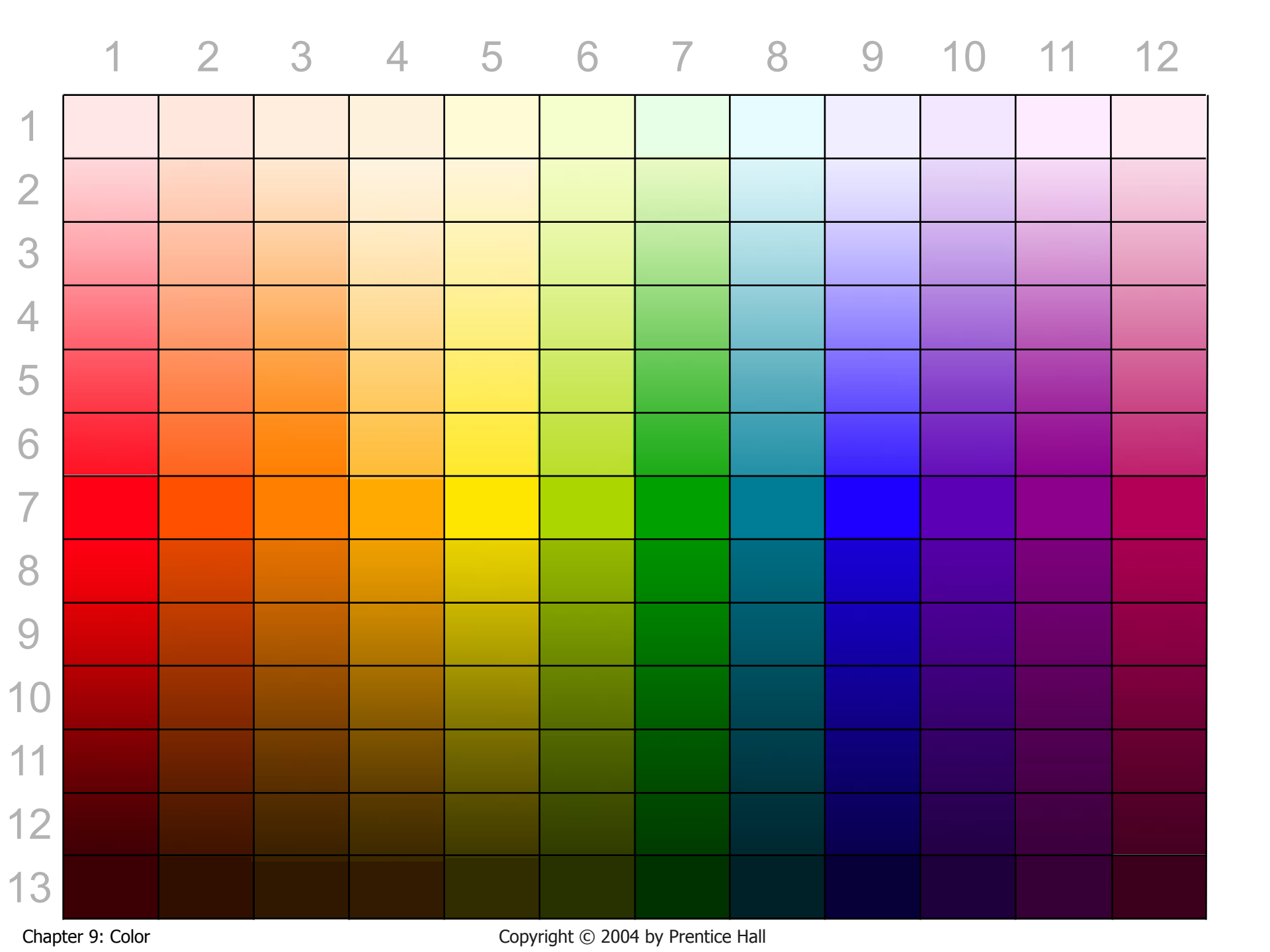
- In the text we were limited in the number of color pages we could use, so the examples of color harmony were necessarily restricted. With the luxury of more space here, we can add some additional material.
- In printing color in the book there is also the problem of *gamut*: many colors we can produce on the screen cannot be printed on a CMYK printer. Examples: red, green, and blue.

The colors, laid out linearly instead of around a circle

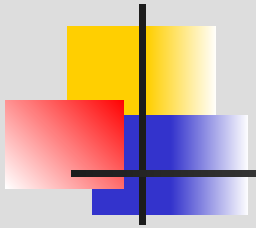


- On the next two slides we have the 12 colors of Slide 12, but shown in vertical bands
- In each band the colors range from quite light to quite dark
- Light colors may appear almost white—but that perception depends in part on background
- Dark colors may appear almost black—same comment
- So we show with a black background and then with a white background



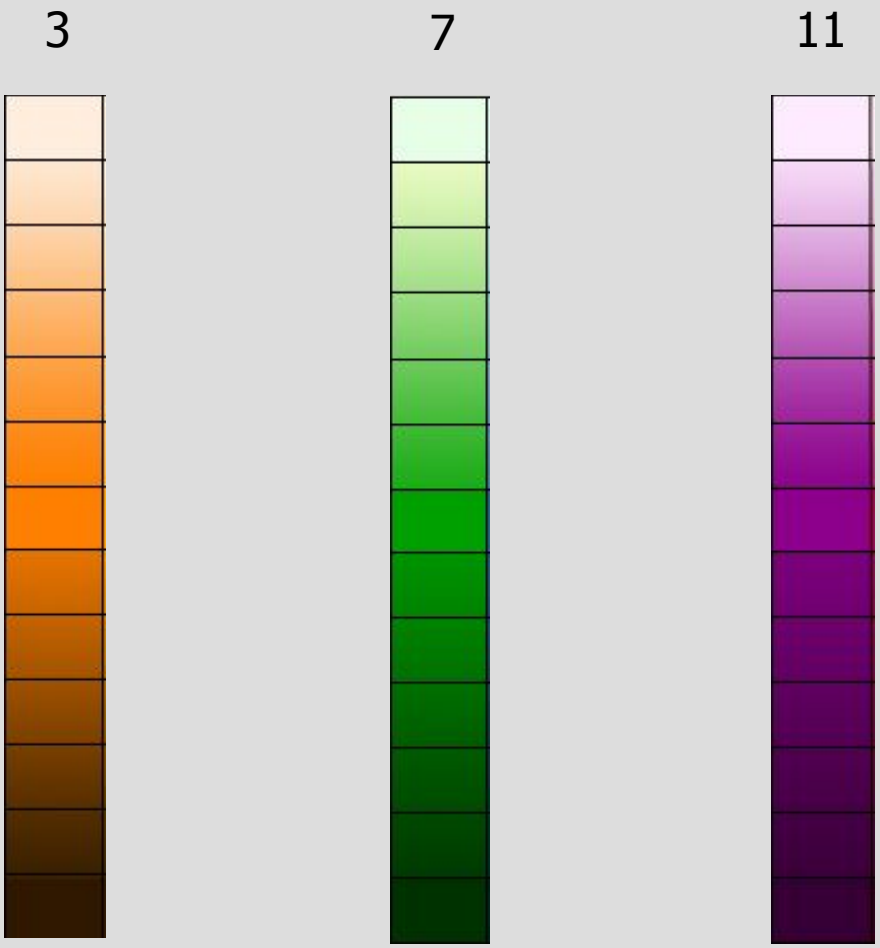


The four color-harmony schemes



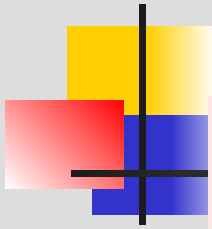
- Monochromatic: colors from one column
- Complementary: any two colors whose column numbers differ by 6
- Analogous: several colors from adjacent columns, with 12 considered next to 1
- Triadic: colors from columns:
  - 1, 5, and 9, or
  - 2, 6, and 10, or
  - 3, 7, and 11, or
  - 4, 8, and 12

Three columns for picking monochromatic schemes; these three make a triadic



Monochromatic: Column 8, rows 2, 7, 12

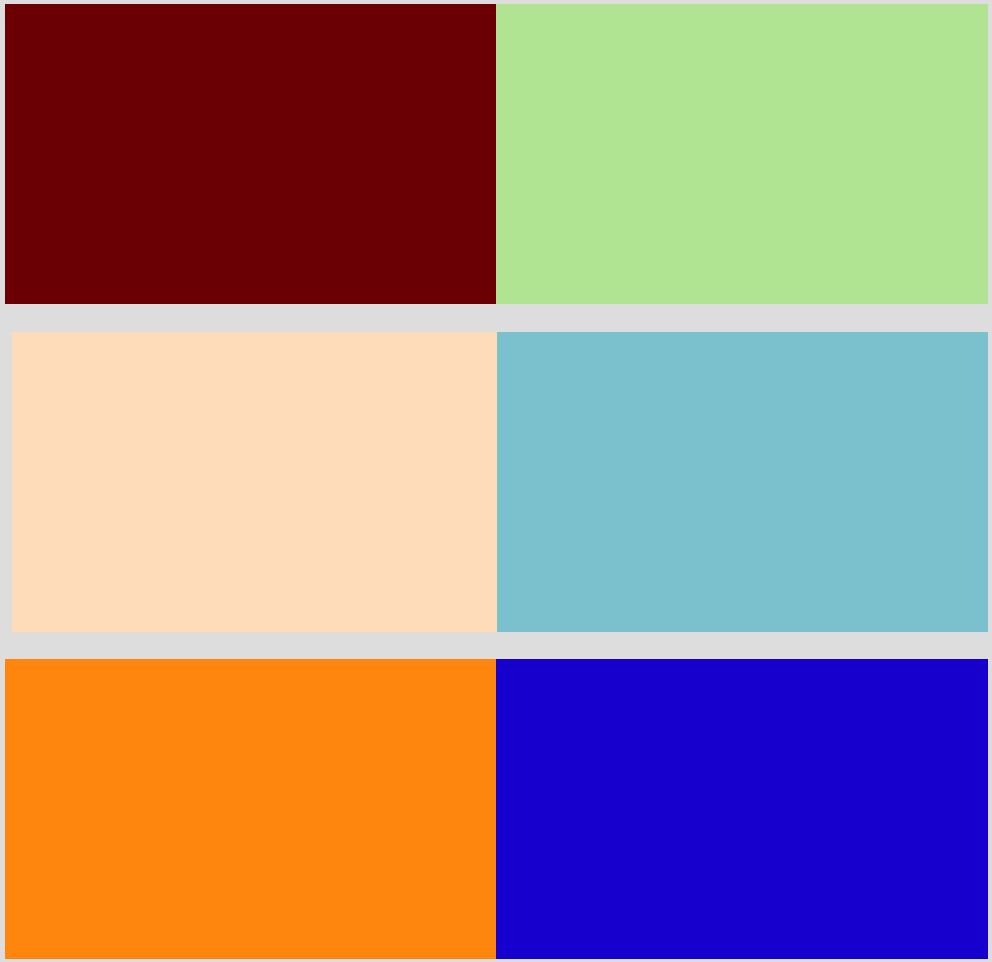
Monochromatic: Column 1, rows 1, 4, 10



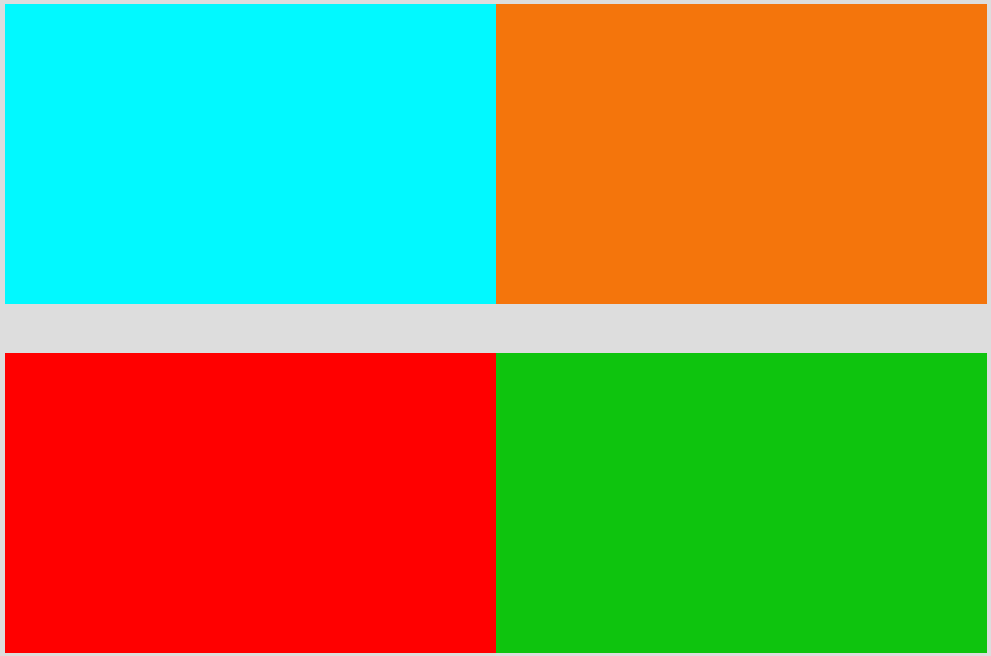
Words, words, words . . .

Show Me!

Three pairs of complementary colors (complements don't have to scream)



But they *can* scream, if you wish (It's called a *clash*—gets people's attention)



But don't do this casually—the clash can be almost painful; you need to have a reason to do it

A triadic can shout . . .

. . . or whisper . . .

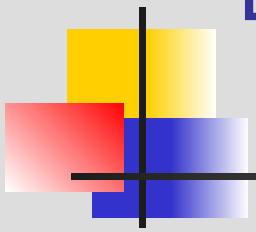
. . . or speak conversationally . . .

. . . or let others talk . . .

Big Important Words

Nice words, but not headline-type words. Text. The story, now that I have your attention.

End interlude



End of Interlude

And that is what we have time for, in exploring another way of looking at color harmony. Try it! Think about the color combinations that work, and experiment with variations of them.

Text and background colors for legibility

- Use combinations of dark text and light (high brightness, low saturation) background
- Avoid text and background colors that differ only in blue (Recall the "Human Response to Color" graph)

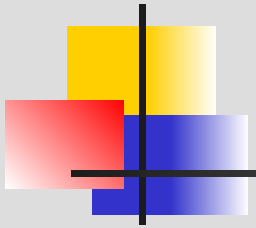
	R	G	B	Color
Text	255	255	0	Yellow
Background	255	255	255	White
Difference	No	No	**Yes**	

BAD CHOICE

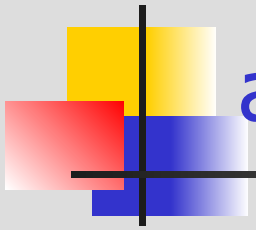
Text	255	255	0	Yellow
Background	0	0	80	Navy
Difference	**Yes**	**Yes**	**Yes**	

GOOD CHOICE

Text and background colors for legibility



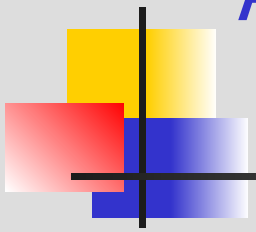
- Avoid combinations that use bright, saturated colors.
- Avoid combinations of red and blue, red and green and magenta and green because these can create a perception of vibration and can cause eye fatigue.



Text in a dark color on its complement in a light color works nicely

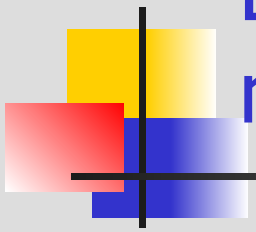
Color is one of the pleasurable aspects of eyesight and is an integral part of Web pages. Properly used, color makes a page both attractive and usable. It can provide cues that indicate a button's function or state. It can distinguish between navigational aids and content, unobtrusively guiding the user through a page. This chapter presents some color basics and design tips to enhance both the effectiveness and appeal of a Web site.

A great many combinations are possible



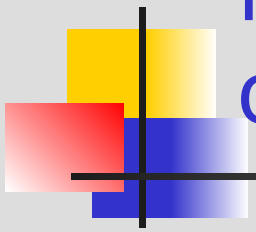
In this chapter you will do the following:

- understand physical and perceptual aspects of color
- become aware of several color models and learn the advantages of each
- learn to apply four different color harmony schemes
- explore how color can make Web pages pleasing and easy to read



Even a little color in the background makes text easier to read

It is rare that the color choices for Web pages are left entirely in the hands of a developer or designer. In most cases, the client will already have some colors in mind, based on a corporate logo, a school insignia or personal preference. Color harmonies provide options for choosing colors that are compatible with the client's wishes. Applying guidelines for text and background color will foster readability. Finally, using color to organize text and focus attention will result in easier navigation.



Now, for comparison, here is what black on white looks like

There is quite a bit of overlap in the response curves. The peak sensitivities for the first and second types are actually in the yellow range. There is a big disparity in the height of the three curves. This is due to the fact that human eyes are most sensitive in the green range of the spectrum and are dramatically less sensitive in the blue range.

Black on white may not look too bad here. But suppose you sat at a monitor six hours a day. Wouldn't you prefer a pastel background? And text that is dark but not black?

But do provide adequate contrast

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Always remember how we perceive blue vs. red and green

Below is the same text as on the previous slide, except pure blue instead of pure yellow. According to Adobe they both have 100% brightness, and according to Microsoft they both have luminance of 128. But that it not how we perceive them.

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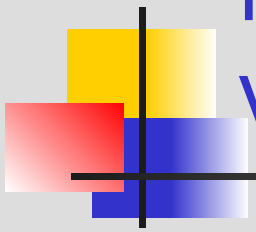
Don’t use red on blue or vice-versa

Blue has the shortest wavelength of visible light and red the longest. Blue is refracted more strongly than red in our lenses. (Compare with what a prism does to white light.) Result: our eyes can’t focus on red and blue at the same time, and the boundary seems to vibrate. It gets painful. Camera lenses deal with this by using lens components with different indexes of refraction, to produce an *achromatic* lens, so that red and blue both focus at the focal plane. Our eyes don’t work that way. This hurts.

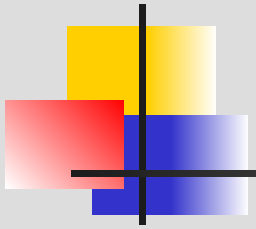
Never use bright red on bright green or vice-versa



Red on green also hurts the eyes. I refuse to show any more of it!

But change brightness and/or saturation . . .

But: same hues, except a very light green background and a very dark red text—different story. In fact, this is rather nice, so I'll show some more of it.
One reason this works is that there is adequate contrast between the text and the background. As noted, our low sensitivity to blue makes it hard to give rules on what the difference in brightness should be. Use judgment and common sense. And maybe do some user testing. ☺

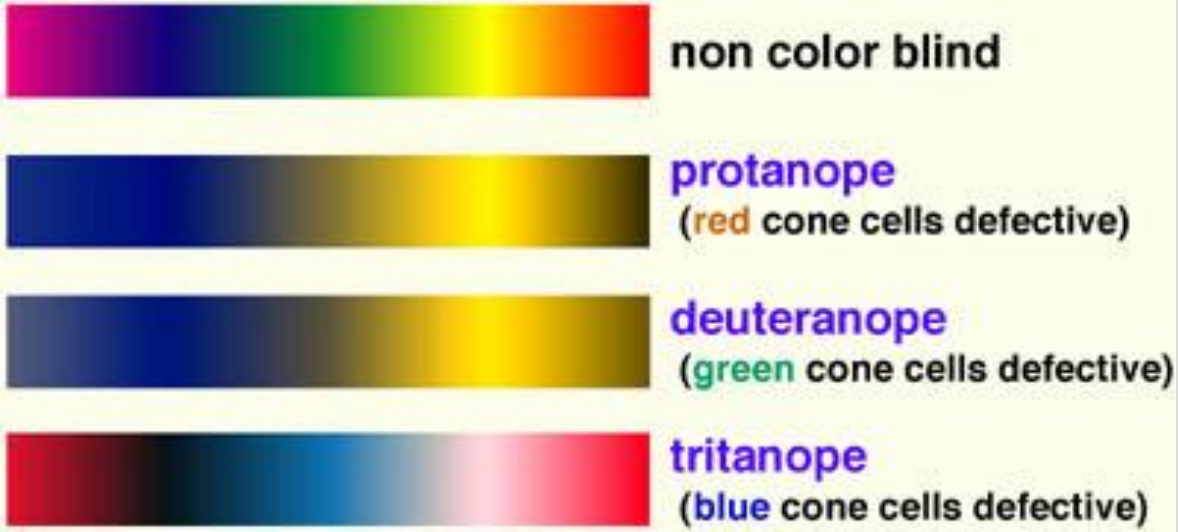


That's It For Text/Background

You have seen combinations that work and combinations that don't work. Be bold! Experiment! Just maintain adequate contrast.

Types of Color Blindness

- Protanopia – L-cone ("red weak")
- Deuteranopia – M-cone ("green weak")
- Tritanopia – S-cone (yellow/blue)



What Color Blindness Looks Like

Normal

Deuteranopia

Tritanopia

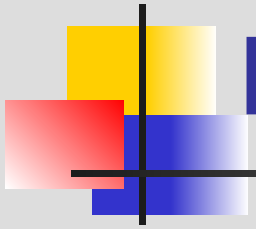
What Color Blindness Looks Like

Normal

Protanopia

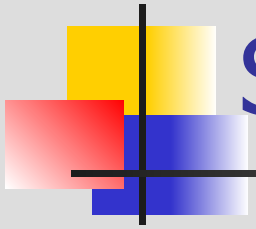
Deuteranopia

Tritanopia



Designing for Color Blindness

- Avoid red-on-green or green-on-red at all costs!
- Consider using magenta instead of red
  - Avoid using magenta with blue
- Use redundant coding of information
  - Use color and shape/location
- Avoid thin lines / small symbols
  - For color-coded text, use bold fonts



Summary

In this chapter you learned about:

- The color spectrum; our eyes' sensitivity to red, green, and blue
- Additive (RGB) and subtractive (CMYK) color models
- The hue, saturation, and brightness (HSB) color model
- Four color-harmony schemes: monochromatic, complementary, analogous, and triadic
- Text and background color combinations that are legible and easy on the eyes