

Chapter 7

Color and Graphics

Increasingly, people access the Web with high quality color monitors. Therefore, colors and color graphics are an important dimensions of website design. Understanding colors and how they can be used to enhance visual communication is the first step in the effective use of color in site designs.

Color, like many other design factors, appears deceptively simple to use. Color options appear in numerous software packages on the market. Color can be selected, spilled, painted, air brushed, or filtered in virtually every shade. Conservative color, wild color, pattern and textured color—its everywhere, and most of us have been exposed to it since we were children. From chalk art, to crayons, to the craft project in junior high, to painting a room in our house, most of us have worked with color in one way or another.

When people declare that they are not artists, they often say, “I can’t even draw a stick figure.” No one ever says “I don’t really know anything about color.” This assumed knowledge can often lead to poor color choices by most novices. Designers, this odd breed of professionals who are often thrown into the general mix with other “artists,” such as sculptors or painters, are usually not born with an innate sense of color. Instead, most designers are formally trained to understand color and its meaning in communication. Aesthetics, combined with communication, is at the root of choosing color. Applying color for purely aesthetic reasons is a luxury awarded to actual artists, who do not necessarily have to answer

to the public, much less a paying client. Designers, on the other hand, have to do just that—articulate and defend their color choices and its merits.

Chapter 7 introduces basic color theories and relates them to digital images and Web design. The understanding is basic to creating and manipulating graphical images for your site. As you read through the sections, keep in mind that color is a highly subjective area for most clients, who have specific color preferences and find it difficult to compromise on this aspect of a project. You will have to give this matter careful consideration if you run into this problem—be prepared to negotiate tactfully.

7.1 A Historical Note on Color Theory

Over the years, scientists and artists have studied why human beings respond to some color combinations more favorably than others. Often, color preferences can be very subjective and personal. This adds a dimension of difficulty for formulating theories about color. Early work and experimentation began with the development of the color wheel (Section 7.2). These theories continued to evolve over decades to explain particular patterns and behaviors. Distinguished colorists include Newton, Goethe, Holze and Albers who explained both measurable color attributes (colorimetry) and subjective color choices.

Fundamental to any color theory is the ability to distinguish colors and give them precise names. Let's say you selected a yellow. Is it a brown mustard yellow or a bright sunshine yellow? Even those are imprecise descriptions subject to interpretation by individuals. How would you actually pinpoint any particular color without ambiguity?

In the 1990s, Albert Henry Munsell, an art professor in Boston (USA), developed one of the most influential color-modeling systems and a notation for precisely naming colors. Munsell's system identified three independent components of color:

- *Hue*—According to Munsell, hue is “the quality by which we distinguish one color from another.” Light with different hues have different wavelengths. The terms *hue* and *color* are often used interchangeably in common language. But we will try to avoid

that here.

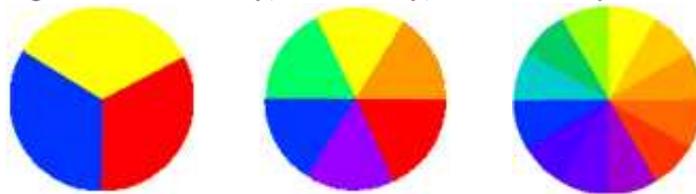
- *Value*—“The quality by which we distinguish a light color from a dark one.” It measures how *bright* or *dark* a color is. At full value (brightness) a color of any hue appears white. At zero value (no brightness), any color appears black.
- *Chroma*—The richness of hue. It differentiates deep blue from pale blue, for example. Chroma is also known as the color’s *saturation*. Adding white paint to red reduces its saturation or chroma making it paler. A color at full saturation is a pure hue. A color at zero saturation is a shade of gray.

Munsell also developed a system to quantify Hue, Value, and Chroma making it possible to precisely specify colors. His system has been adapted by Pantone in their color matching system as well as by TRUEMATCH or CIE systems and others.

Johathan Itten is the first to realize the harmony in color pairs according to their spatial relationships. He defined and identified strategies for successful color combinations.

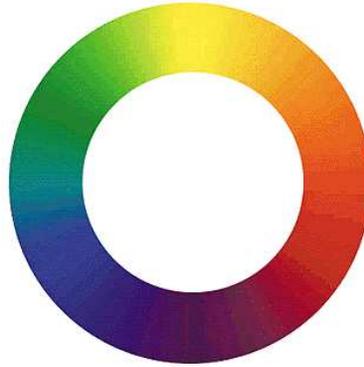
7.2 The Color Wheel

Figure 7.1: Primary, Secondary, and Tertiary Colors



As most of us remember from early childhood, there are three *primary hues* red, yellow and blue (Figure 7.1) that can combine to obtain all other color hues. For example, green = yellow + blue, orange = yellow + red, and purple = blue + red. These are the *Secondary hues* (Figure 7.1). *Tertiary colors* are yellow-orange, red-orange, red-purple, blue-purple, blue-green and yellow-green. These colors are created by mixing secondary colors (Figure 7.1).

Figure 7.2: Color Wheel



In 1666, Sir Isaac Newton developed the first circular color diagram, and since that time, the traditional color wheel have evolved many variations (Figure 7.2). Generally, a color wheel is a diagram that represents color hues and their interrelationships in a circular pattern. Most color wheels begin with the primary and secondary hues, then show a chromatic relationship between analogous colors.

The color wheel groups *active* and *passive* colors. Often, warm, high-saturation, bright colors appear to come forward and are said to be active. Cool, low-saturation, dark colors appear to visually recede and are said to be passive. Some colors appear to be neutral.

7.3 Color Harmony

In general, human beings respond strongly to colors. People often have strong likes and dislikes when it comes to color. Whatever their preferences, most people respond positively to the harmonious use of color. Harmony may be defined as a pleasing arrangement of parts such as in music. Harmonious color creates an inner sense of order, a visual balance, which engages the viewer. Color harmony implies that color scene is neither boring nor chaotic. As indicated by the principle of unity and variety (Section 4.5), it is important to know how much and what colors to include in a design. If you don't include enough color, you run the risk of boring the viewer. On the other hand, if you overwhelm the viewer with too much color, the visuals may not make any sense. The idea that more color is better isn't

a good one since color, like any other element in design, has to be used for a reason, and it has to make sense in the overall composition. The human brain tends to reject what it doesn't understand. Like much of design, harmonious color is subjective and in the final analysis, color choices sometimes come down to what the client likes or dislikes. Despite its subjectivity, there are some general principles for using color or achieving color harmony. These have to do with understanding color contrast, complement, analogy, and context.

7.4 Color Contrast

Figure 7.3: Hue Contrast-Value Contrast



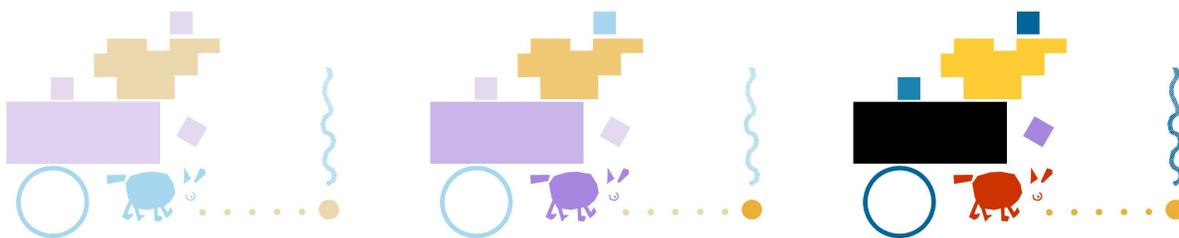
Just like for contrast of forms (Section 4.7), the figure-ground relationship is important for contrast in color. The color difference between a subject (or figure) and its surrounding field (ground) creates contrast—the more contrast between a figure and the ground, the more visible it becomes.

Contrast of color comes in two basic varieties, *value contrast* (light vs. dark color) and *hue contrast* (difference in color hue). But there is more to color contrasts. In his two well-known books, “The Art of Color” and “The Elements of Color,” Itten writes about the effectiveness of color relationships with respect to seven distinct color contrasts as we’ll see next.

Itten’s Color Contrasts

1. **Contrast of hue**—Difference between hues such as yellow, blue and red (Figure 7.3).

Figure 7.4: Low, Moderate, and High Hue Contrasts



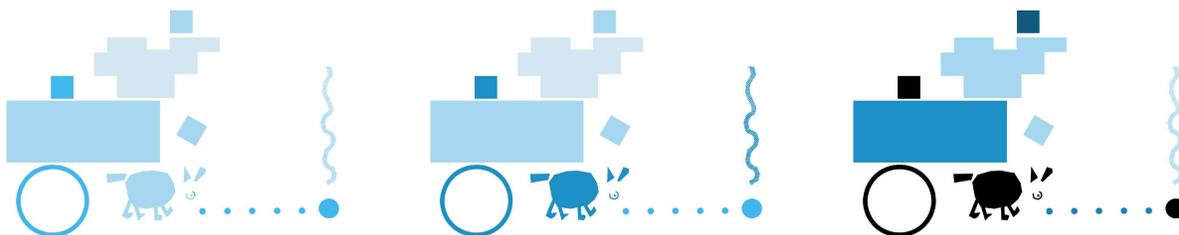
The contrast is formed by the juxtaposition of different hues. The greater the distance between hues on a color wheel, the greater the contrast. Figure 7.4 shows low, moderate and high hue contrasts.

Figure 7.5: Contrast: Warmth, Saturation, and Extension



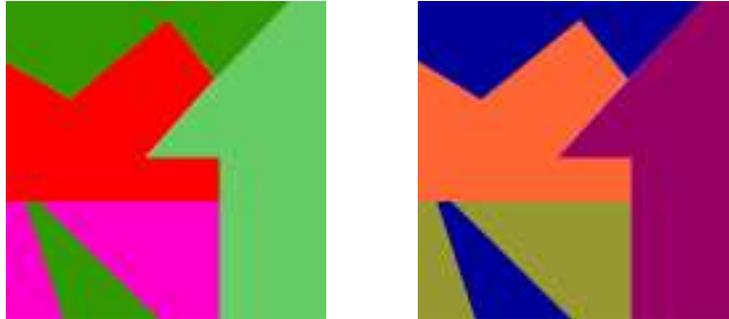
2. **Light-dark contrast**—black and white, night and day, dark gray and light gray. The contrast is formed by the juxtaposition of light and dark values. Also effective as a monochromatic composition. Figure 7.6 shows different value contrasts.

Figure 7.6: Light, Medium, and Dark Values



3. **Cool-warm contrast**—red, orange yellow (warm) contrasted with blue, green and brown (cool). See Figure 7.5.
4. **Complementary contrast**—opposing colors on the color wheel which create maximum contrast; yellow, violet, blue, orange, red, green (Figure 7.7).

Figure 7.7: Contrast: Simultaneous and Complementary



5. **Simultaneous contrast**—contrast when the boundaries between colors perceptually vibrate sometimes creating interesting illusions (Figure 7.7). This is an effect that occurs when two adjacent colors enhance or reduce their optic saturation:
 - White looks whiter when surrounded by darker value.
 - Gray appears more intense when surrounded by lighter value.
 - Colors can appear lighter or darker depending on their surrounding value and hue.
6. **Contrast of saturation**—contrast between pure, intense colors and more neutral, pale colors.
7. **Contrast of extension**—involves assigning numeric properties to color and then using them in weighing proportional amounts next to one another. See Figure 7.5.

Analogous Colors

Analogous colors are any three colors which are side-by-side on a 12-part color wheel such as green, yellow-green and yellow. This type of color is often found in nature and it tends to be pleasing to the eye (Figure 7.8).

Figure 7.8: Analogous and Complementary Colors



Complementary Colors

Figure 7.9: Complementary Color Example in Painting



Complementary colors are two colors that are directly opposite to each other on the color wheel, such as red and green and orange and blue (Figure 7.8). Complementary colors generally look very well together in a design. These opposing colors create maximum contrast which can be a powerful tool in a composition. However, be careful when using

Figure 7.10: Value vs. Color Contrast

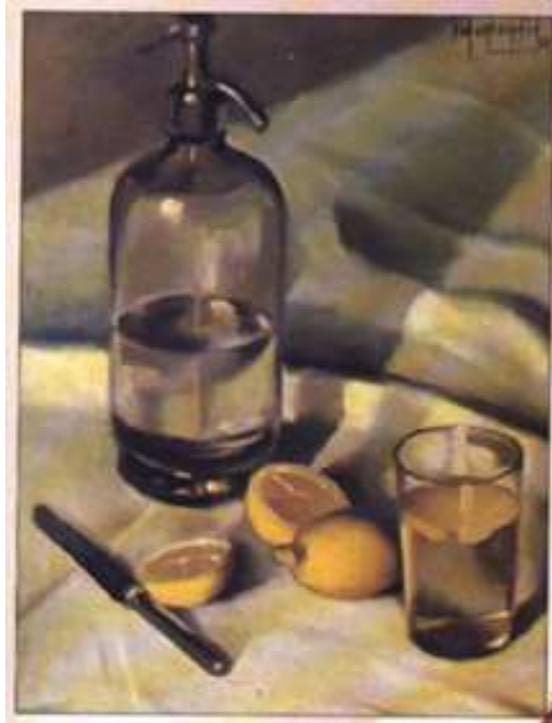


complementary colors. Green and red tend to vibrate when used next to each other. It is also not advisable to use them in many cases, especially for text. An important point to keep in mind about complementary colors is that they do not necessarily give you contrast of value (Figure 7.10). Take red and green for example. Just because this combination provides maximum “hue” contrast, that doesn’t mean that the same combination creates the same “value” contrast. This is a very important point to keep in mind when designing pages which will be printed on a black and white printer.

Use of complementary colors is significant in print. Painters especially work with complementary color beautifully. For example, mix red and green paints together in unequal parts. This will create a dull red or a grayish green, depending on the prominence of the color you added. Then tone down both colors with white and mix them together. This combination will yield a superior range of neutralized grays. Next time you’re at a museum and you see a classic painting by Renoir or Monet, notice how the shadows were created. Figure 7.11 (J. M. Parramon, Lemonade, private collection) shows such gray shadows. The richness of tone may have been created using this technique. According to Jose M. Parramon who wrote “Color Theory,” this combination creates a range of neutralized complementary colors and it is where you’ll find harmony.

A final word on complementary colors is this. Strive to create contrast of value as well as contrast of color. If both are not possible, value is a more critical factor when you’re designing Web pages.

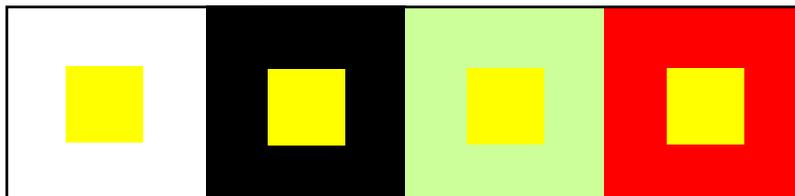
Figure 7.11: Complementary Colors Mixed to Obtain Gray for Shows



Color Context

Color context refers to the environment in which colors are seen. Color context has to do with surrounding colors and how they impact the use of color. In Figure 7.12, we can see that yellow the square looks more brilliant against a black background and very pale and dull against the white background. The yellow square also looks bigger against the black background, than against the other three backgrounds. Also, the yellow square begins to “vibrate” against the light green, almost producing a blurring effect on the yellow.

Figure 7.12: Color Context



Warm and Cool Colors

Figure 7.13: Warm and Cool Colors



Warm colors are associated with sunlight and fire while cool colors are associated with water and moonlight. Warm colors are said to appear closer proximity and cool colors tend to create a sensation of distance. As you develop your own layouts, this is a good rule of thumb to keep in mind when you begin choosing your background and foreground colors. An example of warm colors are red, orange and related hues. Green, violet and ultramarine are cool colors. Except for orange-red, all hues can be made warmer by mixing in a little yellow or red. For example, if you add a little red to purple, it will become red-violet. The same can be done to make colors cooler. If you were to add a blue, blue-green or white to a color, you will cool it down. Green can be both cool or warm, depending on whether yellow or cyan is the dominant color in the mix. Yellow can also be both cool and warm. All colors, warm and cool may appear warmer or cooler depending on their placement. In case of Figure 7.13, we see that the grapes on the left look warm and the ones on the right look cool.

Saturation

Saturation is a term used to describe the state of absolute purity in color. In painting, this term remains a hypothesis, and it means something a little different on the computers. This will be discussed later in the chapter. For now, we need to say that pure colors mixed with black, gray or white difference diminish in color or hue. They become pale or dull and the

Figure 7.14: Example of Saturation



color always appears less bright than the original color. When mixed with other hues, pure colors become transformed into either reddish or bluish or greenish tones. Colors created with these mixtures are called “unsaturated” colors. In fact, if you mix equal part of two complementary colors, you will get the lowest level of saturation.

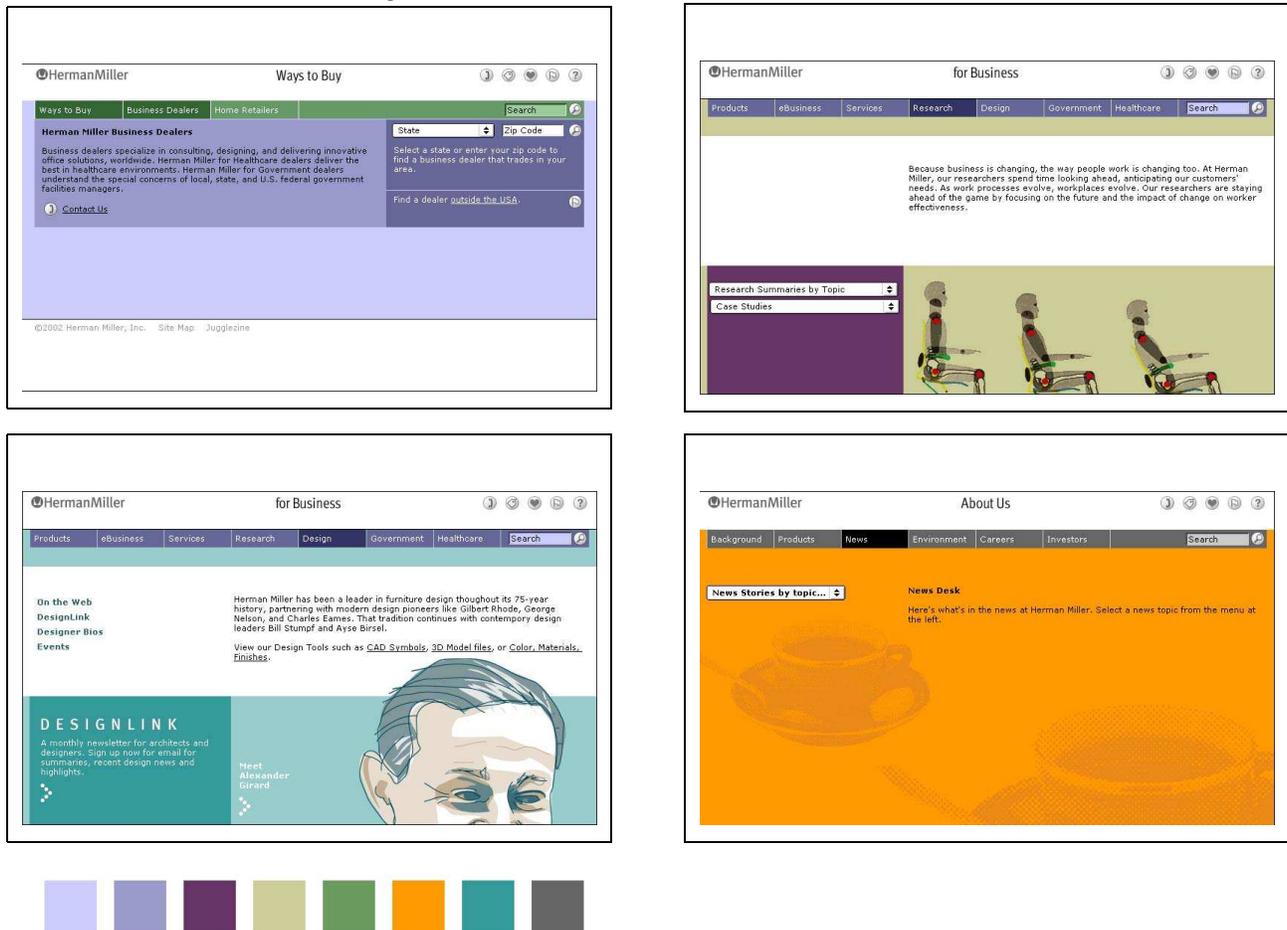
7.5 Color for the Web

Knowing why some color combinations work better than others will improve your ability to make color choices. With the color concepts and theories discussed so far, let’s see how actual websites put them to use.

Herman Miller site (hermanmiller.com) uses a very nice, soft palette of colors. See Figure 7.15. Numerous colors throughout the site identify different sections. As a an example, we’ve included just eight section colors to show why they work well together. The eight color sample uses complimentary colors from the secondary and tertiary palette (Figure 7.15). Purple and green are complimentary because they appear apposite each other on the color wheel, creating dynamic hue contrast. Orange and blue-green also work nicely for

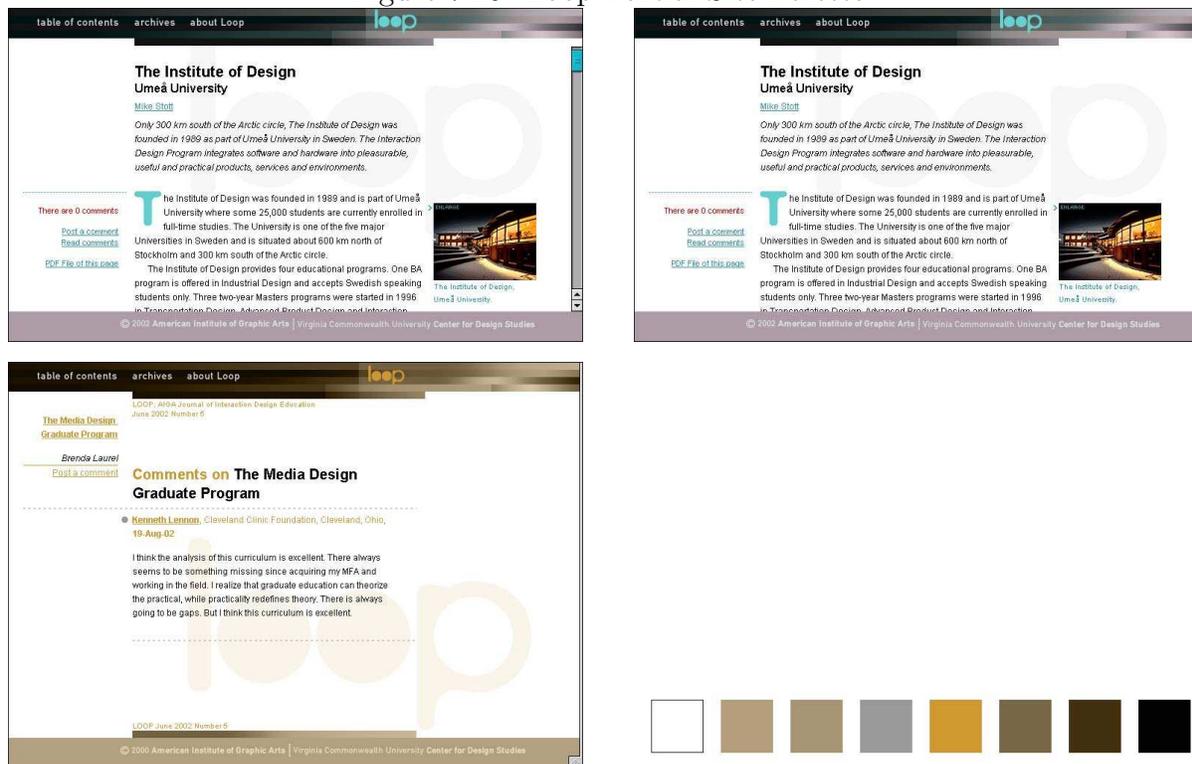
Brooks/Cole book/January 28, 2003

Figure 7.15: Herman Miller Website Colors



the same reason. Light and dark lavender, derivative of dark purple, provide a necessary value shift, creating contrast of value. Warm orange and soft yellow-green contrast effectively with the cool dark green, blue-green, purple, lavender and cool gray. Dark gray appears as an accent color for typography and rules providing good value for readability, while black rollovers indicate activity on the buttons. Black, in this case, is neutral as to not interfere with the overall diverse color palette. Many sites limit their colors to 4 or 6 choices. This can be both effective and smart in terms of unifying the site. Remember, more color isn't necessarily better. In case of Herman Miller, the site contains diverse information, so the multi-color palette makes sense. Color choices support the message and support aesthetics in the overall design.

Figure 7.16: Loop Partial Site Palette

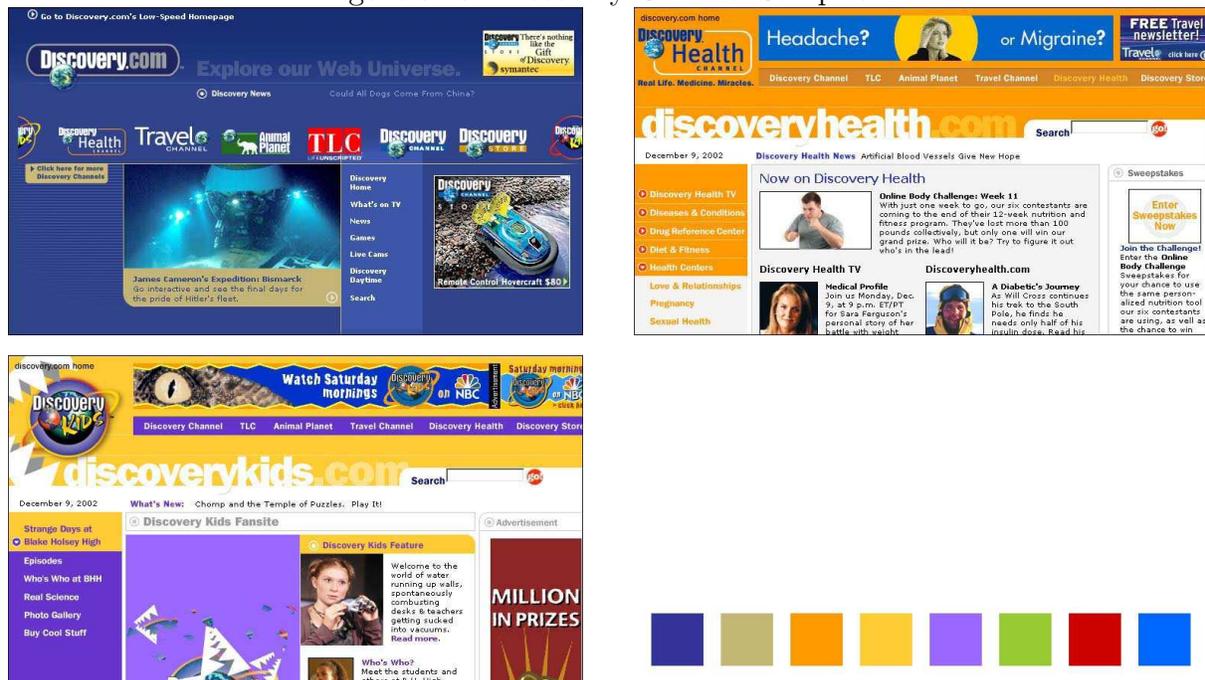


AIGA (American Institute of Graphic Arts) Journal of Interaction Design (loop.aiga.org) uses a limited color palette on their site. The site, is relatively small and the nature of their information is not as complex as on the Herman Miller site. Loop does a good job of stretching one hue, such as brown and blue, with various values of the same hue. For example, the bands of colors at the top all contain the same hue only with different values. This effect is sometimes used because it provides variety and depth without complicating the design with another color. The word loop appears in the lightest value on top of the vertical bands in both the blue and brown pages. Another nice feature of this palette is the sensitivity used in arranging typography. The levels of information such as headlines, subheads, body copy and links copy are organized with meaning, employing the same kind of value discretion found in the graphics. Notice that Figure 7.16 has a full-color photograph at the bottom right corner which stands out dramatically against the simple colors used in the rest of the layout. This is another good reason to use a simple color palette—it allows the reader to focus on

Brooks/Cole book/January 28, 2003

the photographs and not be confused by color on every part of the page. Finally, we need to point out the color inside the photograph. Sensitivity to color includes choosing colors in photographs used on the site. In this case, the yellow is a compliment to blue, providing a single, dynamic accent on the page. These simple yet often overlooked choices play a vital role in the overall success of your design.

Figure 7.17: Discovery Channel Samples 1



The amount of information on the site does not correlate to the amount of colors used. There are large sites which use very limited palettes, while others use extensive color palettes. Color is not a random choice. As stated previously in this chapter, color is just one part of design and it has to work in tandem with type, layout, space and concept. Discovery Channel site (discovery.com) is quite large. It has many distinctly different sections all with varying subsections—all which have to work together in one site. The major sections have to have their own identity, but remain true to the parent site. The following six examples illustrate many of the main sections and show both the simplicity and diversity of color.

The homepage for discovery.com (Figure 7.17) uses a simple navy blue background contrasted with white and warm, tan color. This conservative layout and color allow for the

many featured logos on the page such as Discovery Channel, Animal Planet, Travel Channel, etc. all in different shapes, sizes, and colors. All of the samples shown have consistently placed elements which adds to the unity of the site:

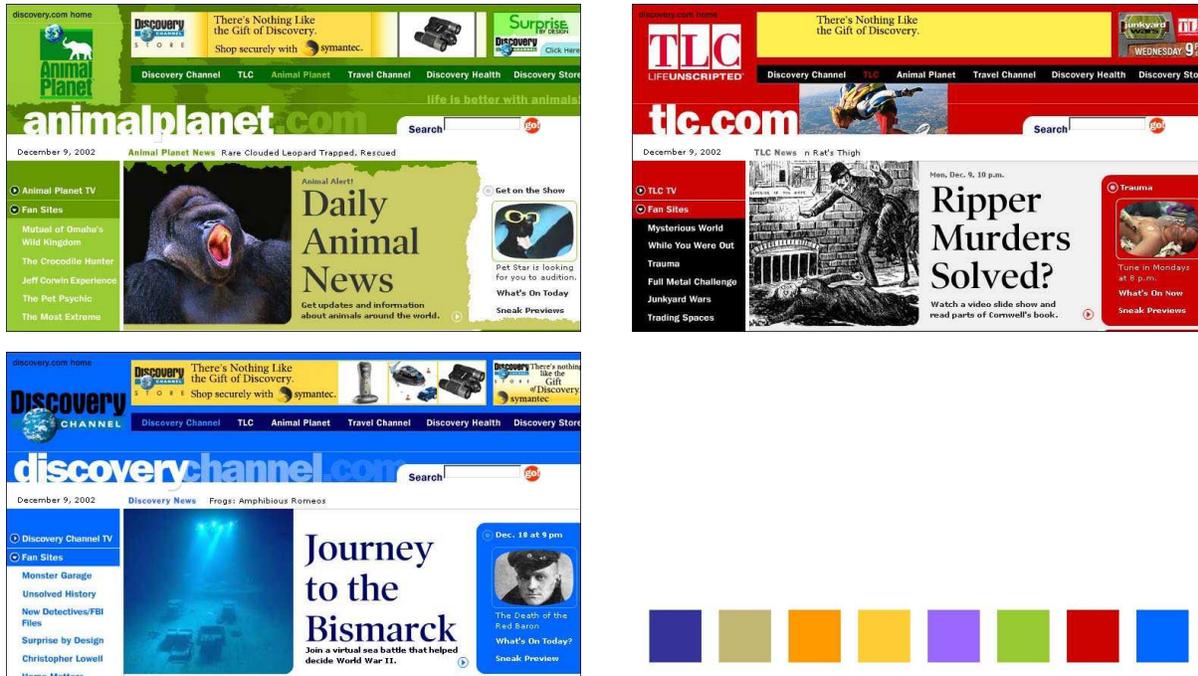
- logo appears in the upper left hand corner
- channel name, all in lower case appears with no breaks
- banner ads, appear immediately to the right of the logo
- global navigation bar is at the bottom of the banner ad
- local navigation is always on the left
- featured topic, with a large photo is prominently placed in the center
- large headline is placed to the right of the photo
- sneak previews located to the right of the featured topic

Layouts follows a specific template with little variation, yet each channel has its own unique color. Discovery Health (Figure 7.17), for example, uses bright, vibrant orange which contrasts nicely with complimentary blue used in the banner ad. The .com copy for the most part appears in the lighter value of the same color allowing it to be visible, but recedes back so the focus remains on the main title. This effect is used in Figure 7.17, and Figure 7.18.

The bright purple and yellow used for Discovery Kids (Figure 7.17) is appropriate for the topic. Purple and yellow are located apposite each other on the color wheel, which create maximum hue contrast. Again, we see the use of complimentary color used to create this strong visual impact.

Animal Planet (Figure 7.18) is all about animals and nature, so it makes good sense to use analogous colors, dark green, light green, yellow-green and yellow. Analogous colors, as you recall, are any three colors which appear next to one another on the color wheel. They

Figure 7.18: Discovery Channel Samples 2



are pleasing to the eye and often appear in nature. The soft, yellow green used behind the Daily Animal News seems appropriate and adds to the natural, jungle theme.

TLC.com (Figure 7.18) projects a dramatic, action-like urgency with its strong red and black. Contrasted with all white type, this approach is striking. Bright yellow, banner ad stands out well on this saturated, red background.

Discovery Channel (Figure 7.18) uses a deep water, royal blue, reminiscent of divers and deep sea adventures. Bright yellow, banner ad, again, contrasts nicely with the deep saturated blue both in value and hue.

7.6 Meaning of Color

Unlike any other language, color is immediate communication. It truly is the only language, other than music, that doesn't require any words. Is it any wonder that color is used in symbols and signs all over the world! You may not have to know how to read to see the red

stop sign or recognize a yellow caution sign in the United States. We can discuss light in many different aspects, it has its physics and mathematics manifestations. We can discuss color in terms of light and energy. By far the most meaningful discussion of color we can have is in the perception of color.

The Web is a global medium and as such, it requires us to consider the meaning of color in a much broader context. Color, like style, esthetics or even food preference is largely influenced by the culture we live in. In United States for example, red means danger; in China it means joy and festivities; in Japan, it means anger; in the Middle East, it means evil. Know your primary audience. Know how colors are perceived in each country and culture. Do your homework and research in that region of the world. This exercise will go a long way to ensure that your site truly caters to a global audience.

Here are some other examples of color and meaning in different parts of the world:

Figure 7.19: Color Meaning in Different Geographic Locations

COLOR	W. EUROPE & USA	CHINA	JAPAN	MIDDLE EAST
	danger, anger, stop	joy, festive	anger, danger	danger, evil
	caution, cowardice	honor, loyalty	grace, nobility, childish gaiety	happiness, prosperity
	sexual, safe, sour, go	youth, growth	future, youth, energy	fertility, strength
	purity, virtue	mourning, humility	death, mourning	purity, mourning
	masculinity, calm, authority	strength, power	villainy	
	death, evil	evil	evil	mystery, evil

Our color preferences are also rooted in the time period we live in. If you lived in ancient Egypt, you would associate black with seeds sprouting from the earth. Statues of Osiris

were painted black for that reason. Green herbs, in that same time period, were used to heal common ailments such as colds. Wooden statues painted in red were used as spiritual aides and buried with the mummified bodies in the Incas culture. Regardless of color's power to communicate non verbally, a person's language plays a significant role in color perception. Not all ideas can be expressed in some languages. According Benjamin Whorf's Linguistic Relativity Hypothesis, a language limitation can affect a person's color perception. An example of that would be the Shona language in Zimbabwe and the Boas a language in Liberia, both of whom have no words to distinguish red from orange. For them, there is only one color and they can't perceive the other. According to psychologist E. R. Jaensch, climate can also influence our color preferences. If you visit warmer climates, you will see that people there prefer to wear warm, bright colors. People living in less sunny climates prefer darker, cooler, more subdued colors.

Regardless of the culture, the time period, or the product that you're selling, color choices remain subjective. Color schemes are ultimately decided by designers and their clients, and sometimes the client's spouses. When defending your design choices, it is wise to know which battles you can win and which you can lose. Most people have very definite color dislikes and likes, and regardless of the color theory, market research or color's global meaning, the final deciding factors are often personal. As collaborators in the design process, it is a designer's job to advise clients on the most appropriate color choices based on what we know about color and meaning in the overall context of the design.

7.7 Color and Readability

Much of what we have already discussed about color in this chapter can be applied to readability. For example, we know that contrast is critical to readability, so choose your color combinations wisely in order to provide a clear path to your message. *Type & Contrast*, by Alton Cook and Robert Fleury, is a good book to read if you would like more information on color and creative color combinations used for print; many of which may be applied to Web

design. Allan Haley is his essay on Effective Typography, found in the *Type & Contrast* is quoted as saying this about color and readability. “Good typography is not pretty design. Pretty design calls attention to the window, not the view. Pretty design is the designer’s fingerprints’ left on the window of communication. Good typographic communication is not pretty—it is smart. It helps the reader assimilate and understand the message.” Halley goes on to say that type needs to be readable and while competing for the viewer’s attention, a designer needs to create easy to use, inviting text. According to Halley, this ease of use will be the most valuable aspect of design to your viewers.

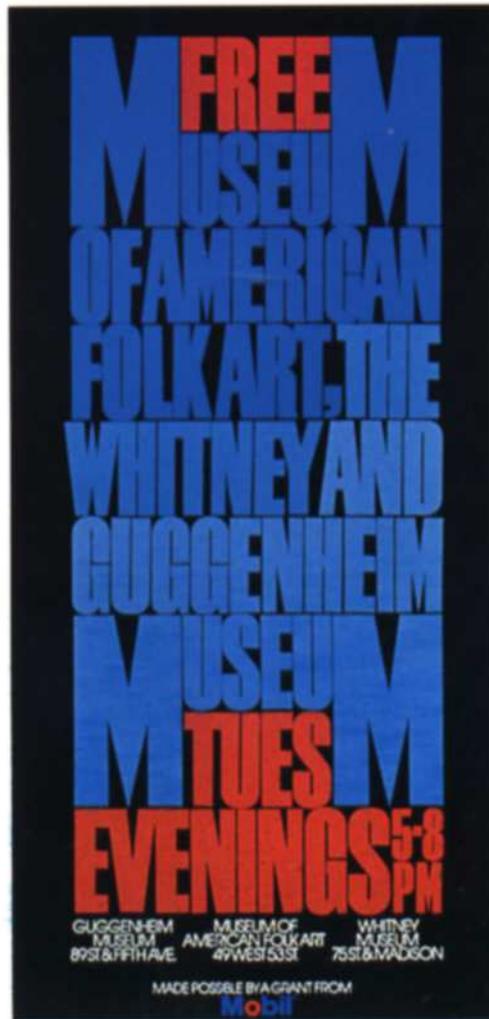
So, what else can we say about color and readability? Perhaps the most useful way of selecting color may be summarized by Alan Peckolick in his essay on Designing with Type and Color. (*Type & Contrast*, by Alton Cook and Robert Fleury). According to Peckolick, we should select color according to three key factors:

Intuition—Apply personal sensitivity to color selection. Trust that “gut” feeling, but don’t solely rely on it without considering other factors.

Knowledge—Color should be seen as another element in your design. It should simply not be used to “enhance” black and white forms. It should add something meaningful to your message such as setting the mood, introducing cultural meaning, or connecting through spontaneous associations with your viewers.

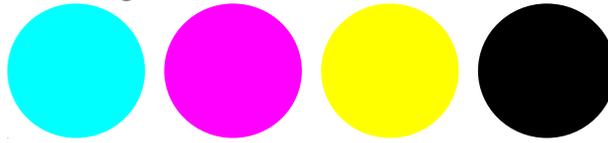
Experimentation—Experience can be the best teacher for knowing how to use color. In this case, you can benefit greatly from someone else’s experience by studying effective color applications which already exist on the Web.

Figure 7.20: Color with a purpose



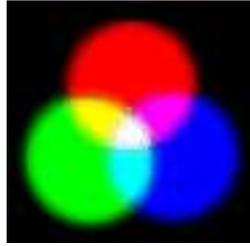
7.8 Color on Computers

Figure 7.21: CMYK color model



When preparing a document for printing, designers typically work with something called *CMYK* colors, (Cyan, Magenta, Yellow and Black) which combine to create a 4-color printing process. *CMYK* colors are *subtractive*. Each absorbs colors from incoming light (which is normally white) and let only Cyan, Magenta, Yellow, or nothing through.

Figure 7.22: RGB Color Model



Unlike *CMYK* printing, computers use the *RGB* (Red, Green and Blue) color model that works on the principle of *additive color*. Computers create colors through light emissions with a set of primary colors: red, green, and blue. And the primary colors combine to produce all different colors. Figure 7.22 shows how the primary colors add to form other colors.

The Web as a color display medium presents some unique problems. An obvious problem is the inability to control or predict the color characteristics of a viewer's computer platform or monitor. This is mostly due to the fact that different monitors have different *gamma values* (Section 7.9). Thus, when you design a light blue background on your computer, this same color may slip into dark violet or slimy green on different displays. Something to think about as you're designing backgrounds.

Fortunately, we can look forward to a few solutions to this problem in the near future.

One answer lies in embedding color and gamma information directly into images. Apple's ColorSync system (www.apple.com/colorsync/) is designed to place a filter inside GIF or JPEG images, storing information directly inside the format. The next step is for browsers to interpret this information and display it with adjusted RGB and gamma values on their own platforms as closely as possible to the original image. The present day version of browsers do not do this, but they will soon.

Another viable option is the new image format PNG as explained in the next section.

7.9 What is Gamma

As we just mentioned, images prepared on one computer often look different on another. Monitors may use different technologies and may come from different manufacturers. They have different electronic and screen properties because the color characteristics of the display and the non-linear relation between perceived brightness and the voltage/energy applied to generate light. The brightness is usually proportional to the applied voltage raised to a power. This power is known as *gamma* (www.cgsd.com/papers/gamma.html).

$$\text{lightoutput} = \text{voltage}^\gamma$$

The energy or *voltage* in this formula is derived from the pixel values in an image file (GIF, JPEG, PNG, and so on). If the value of the power γ (gamma) is 1.0 then there is no color distortion.

Typical computer display gamma values are close but vary slightly. Strictly speaking, the red, green, and blue components can have slightly different gamma values. Because of the difference in the gamma value, an image that is just right on a Mac will look too dark and more reddish on a PC. It is advisable to check all your images on different platforms and make color and brightness adjustments when necessary.

Figure 7.23: Gamma Correction



Gamma Correction

The idea of gamma correction is simple: to counter the effects of the gamma value of a target display, we can transform the image first so the transformed image will produce the correct display of the original image. The transformation applies a $\frac{1}{\gamma}$ power to the image to cancel the gamma on a target platform reducing it effectively to 1.0. Figure 7.23 shows the same JPG image with gamma 1.0 (left) and gamma 2.5 (right). You can experiment with gamma correction by applying different gamma values to an image on the WDP website.

An image file can contain the gamma and other color parameters of the platform where the image has been generated. This can allow automatic gamma and color correction on platforms where these parameters are different. GIF and JPEG, the two standard image formats for the Web, do not contain such information. But the PNG (Portable Network Graphics (www.libpng.org/pub/png/) format, endorsed by the W3 consortium, and regarded as a replacement for GIF, does. Further more, PNG uses a lossless compression scheme. But, browsers supporting PNG are still not widely available. See cgisd.com/papers/gamma.html the gamma correction page for more details.

7.10 Color Models and Color Encoding

Color models are different ways to quantify and represent colors. The RGB and CMYK are the most basic and well-known color models. Red, green, and blue (RGB) are the

primary stimuli for human color perception and are the *primary additive colors*. With RGB the red, green, and blue optical components are added together to form other colors. RGB are widely used for TV, computer monitor, and the Web. With CMYK, transparent materials (ink mostly) are used to absorb the cyan, magenta and yellow components (the primary subtractive colors) from white light the remaining un-absorbed optical components are reflected from the substrate. Because combining all of CYM won't produce pure black, black (K) has to be introduced in the CMYK model. CMYK is used primary in printers and the printing process.

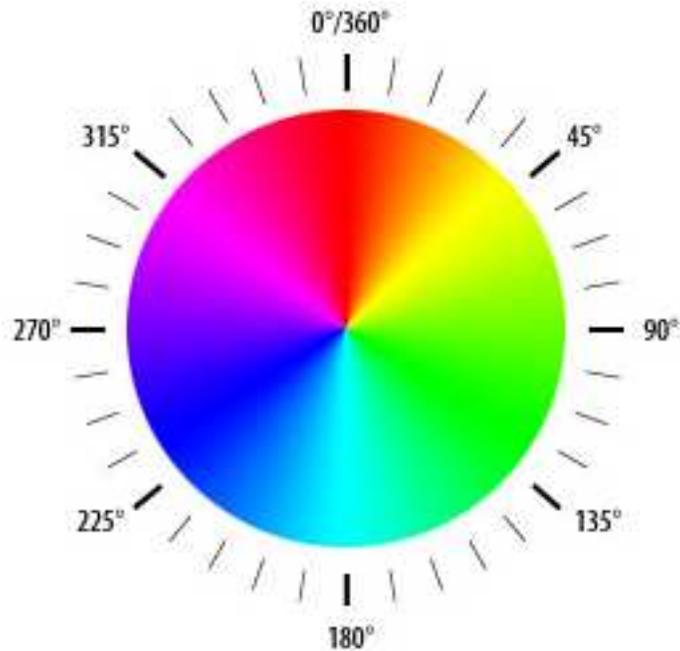
The whole range of human color perception is quite large. The set of possible colors (the GAMUT) that can be produced by the RGB or CMYK model is actually a proper subset of the human-perceivable color space.

Colors are produced on a display screen by creating color pixels. Each pixel on the screen consists of three closely positioned dots: a red, a green and a blue. By varying the strengths of the RGB components, you get different color pixels. The RGB model is used widely on computers and the Web/Internet. CSS uses color names and RGB codes to specify color. Section 2.12 lists ways to specify colors in style sheets. The RGB Hex encoding is due to the binary nature of computers where numbers grow by powers of 2. With 8 bits, an RGB component can be represented in 256 different strengths (0 through 255). A total of 24 bits is enough for all distinguishable colors in the RGB GAMUT.

HSB (or HLS) is another color model. In HSB, colors are represented by hue, saturation, and brightness (or lightness/luminance).

- *Hue*—the basic property that distinguishes one color from another, blue from red for example. Hue is measured as the degree of an angle between 0 and 360 (0 red, 120 green, 240 blue, Figure 7.24).
- *Brightness*—the strength of the hue measured as a percentage of the full strength. For example, a red with R=200 is at a brightness of 78% (200/255). A color with zero brightness is black.

Figure 7.24: Color Hues



- *Saturation*—the purity of a color, at a given hue and brightness, measured as a percentage. For example the green color `rgb(20, 80, 20)` has a saturation of 75% $((80 - 20)/80)$. Reducing the saturation to 0% gives `rgb(20, 20, 20)`, a gray-scale color. The hue of a color with zero saturation is undefined.

Figure 7.25 shows the brightness and saturation of the color red (Hue=0).

Photo-processing tools often allow multiple color models. For example, the color picker in Photoshop uses HSB, RGB, CMYK, and CIELAB color models and converts between them automatically.

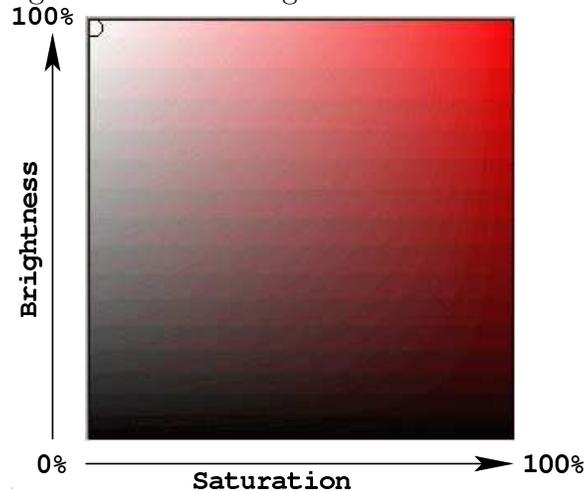
To illuminate the HSB model further, let's consider conversion from RGB to HSB (Ex: **RGB2HSB**). Let floating-point double quantities `max` and `min` be

```
max = maximum(R, G, B);
min = minimum(R, G, B);
```

where `R`, `G`, and `B` are integers in the range $[0, 255]$. The **Brightness** and **Saturation**, as percentages, are simply:

Brooks/Cole book/January 28, 2003

Figure 7.25: Red Brightness and Saturation



```
Brightness = (int) (100*(max / 255));
Saturation = (int) (100*(max - min) / max);
```

The Hue is a bit more complicated to compute. The following Javascript (Chaptercite9) function shows the logic for computing the HSB values from given RGB values:

```
function rgb2hsb(R, G, B)
{ var Brightness, Saturation=0, Hue=0;
  var max, min, d, factor, ans;
  R = check(R); G = check(G); B = check(B);
  max = Math.max(Math.max(R, G), B);
  min = Math.min(Math.min(R, G), B);
  // compute brightness
  Brightness = Math.round(max*100 / 255);

  // if not black, compute Saturation and Hue
  if ( max > 0 )
  { d = max - min;
  // compute Saturation
  Saturation = Math.round(d*100 / max);

  // compute Hue
  if (d > 0)
  { if (max == R)
    factor = (G - B)/d;
    else if (max == G)
```

```

        factor = 2 + (B - R)/d;
    else
        factor = 4 + (R - G) / d;

    if (factor < 0)
        Hue = Math.round((6 + factor)*60);
    else
        Hue = Math.round(factor*60);
    }
}
ans = [ Hue, Saturation, Brightness ];
return ans;
}

```

The HSB model covers a total of $360 \times 101 \times 101 = 3,672,360$ definable colors, much less than the 16,777,216 defined in the RGB space. The number of actually different HSB colors is even smaller. For example, all colors with `Brightness==0` are black and all colors with `Saturation==0` have no defined hue. Therefore, multiple RGB values may convert to the same HSB value.

CIELAB

LAB is a standard color model established by CIE (Commission Internationale de l-Eclairages) an international body of color scientists. The LAB standards make it possible to communicate color information accurately. L describes relative lightness; A represents relative redness-greenness, and B represents relative yellowness-blueness.

Photoshop uses LAB as its *native color space* because LAB can be converted to other color spaces accurately. The LAB color space may well become the preferred mode for communicating color information from one computing device to another in the graphic arts because of its ability to store the data and convert it without loss.

7.11 Color Palettes

A computer color monitor can display all $256^3 = 16,777,216$ colors. But it takes more than just the monitor to achieve 24-bit TrueColor. You also need a video memory of 24 bits per pixel on the screen and a video card capable of processing 24-bit data. To reduce cost, some computers support only 16-bit per pixel, or on older models 8-bit per pixel. With 16- or 8-bit color, an operating system color table, called the *system palette*, is used to map color codes to actual colors to be displayed. The system palette can associate the 4096 16-bit colors (256 8-bit colors) to any chosen set of 4096 (256) colors. By loading a different color palette, an application program can use a different set of colors.

Reloading the system palette is possible but time consuming and will make other applications that use the default system palette appear in strange colors. Because of this, Web browsers tend to rely on the operating system default palette.

When a Web page requests a color outside of the color palette, a browser may take one of two approaches: It can use the closest supported color instead or it can *dither the color*. Dithering is a technique of using an overlapping lattice of two colors in the palette to simulate the un-supported color. Dithered color regions and images can look strange and unattractive. It is advisable to stay within the supported colors and avoid dithering.

In the 256-color days, Web designers were advised to stay within the 216 so-called *Web-safe colors*: colors with RGB values limited to 00, 33, 66, 99, CC, FF. These used to be the only colors supported consistently across major browsers and operating system.

The majority of modern computers support 16-bit or full 24-bit color and current browsers render colors with a high-level of consistency. It is no longer necessary to limit your design to the Web-safe colors any more. Checking your design on different browsers and computers is still a good idea.

Color palettes are also used in graphical images to provide *indexed color*. The palette is simply a table associating color codes with colors. The number of colors could be 2 (B/W), or 16, 256 (GIF). A palette in the image file can specify which 2, 16, or 256 out of the possible colors to use. Raster image manipulation programs, such as Photoshop, allows the

user to create, edit, manipulate and save palettes for images. For example, in reducing an image to 16 colors, the program can compute a *best fit* set of 16 colors for the image at hand, or you may pick a standard 16-color palette such as the Windows color palette.

What is Duotone?

A grayscale image may have 256 shades. But normally a single color can only accommodate 50 shade levels. By adding colors, the number of different shades increases by 50 per color. A Duotone involves any two colors, tritone 3 and quadtone 4 colors. The latter two are less frequently used. Convert a grayscale to a Duotone to add richness. Color images must first be converted to grayscale before turning them into Duotones.

7.12 Image Encoding Formats

Figure 7.26: Raster Image



Graphical images can be stored in many different digital formats that have different characteristics. In *raster graphics*, images are digitized by recording its colors at a grid of *sampling points*. The finer the grid the larger the number of sampling points and the better the resolution. Each sampling point result in a *color pixel* (picture element) stored in a *raster image file*. A raster image usually does not need to record each and every pixel individually. Compression methods can significantly reduce the image file size. Display software simply reproduces the pixels to render a raster image on a computer screen or printer.

In *vector graphics*, images include geometric objects such as points, lines, and curves.

Geometric information can be combined with raster information to represent a complete image. Vector image encoding provides accurate information on geometric objects in the image and avoid representing every pixel. Hence, vector images are usually smaller and easier to scale. Display software must understand the geometric information in order to render vector graphics files.

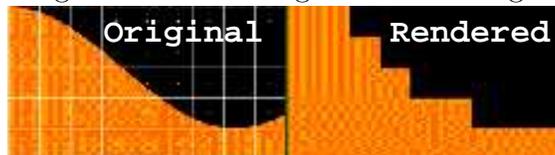
Currently, the only widely used vector graphics system is Macromedia Flash. The W3C is recommending the *Scalable Vector Graphics* (SVG) standard for the Web. Although support for vector graphics is still lagging behind, we expect major browsers to provide native support for SVG in the near future.

GIF, JPEG and PNG

Currently, the only image compression formats generally accepted on the Web are:

- Graphics Interchange Format (GIF)—a raster format suitable for icons, logos, cartoons, and line drawings. GIF images can have up to 256 colors (8-bit).
- Joint Photographic Experts Group (JPEG) format—a raster format usable for color and b/w pictures with continuous changing color tones to be displayed for the eye. JPEG images can store up to 16.8M colors (24-bit). Images created using a scanner or digital camera are usually stored in TIFF (Tagged Image File Format), JPEG, or GIF.
- Portable Network Graphics (PNG) format—a format designed to replace GIF. PNG really has three main advantages over GIF: alpha channels (variable transparency), gamma correction (cross-platform control of image brightness, Section 7.9), and two-dimensional interlacing (a method of progressive display). Browser support for PNG is increasing steadily and hopefully soon PNG will really replace GIF.

Figure 7.27: Aliasing in Raster Images



Aliasing and Anti-aliasing

As you may expect, sampling a continuous image at discrete points may run into problems. Raster images often contain jagged edges (for example, staircase effect on slanted lines), lost or distorted details (fine features missed or hit by sampling points), or disintegrating texture patterns (Figure 7.27). Such errors are known as *aliasing artifacts*.

Anti-aliasing methods have been developed to reduce the effects of aliasing. One popular anti-aliasing technique involves sampling at a resolution several times (say 3 times) higher than the target image file resolution. Then compute the value of each image pixel as the weighted average of the values from a number of neighboring sample points (say 9 points). There are many fine anti-aliasing algorithms. No matter what the method, anti-aliasing seeks to soften the jagged edges by setting pixel values so that there is a more gradual transition between one color to a very different color. Figure 11.10 shows the effect of anti-aliasing.

Anti-aliasing makes lines and edges in a picture look much smoother to the eye by using pixels whose color is a blend of the object color and the background color. A graphical object or text font anti-aliased with one background color won't look right on a different background.

Colors in Raster Images

In a raster image, each picture is a color dot. The size of a raster image file depends on how many colors it uses. You have these choices:

- Monochrome—black/white
- Grayscale—different levels of gray (up to 256 shades)

- Indexed—Each pixel color is indicated by an index into a color palette. The palette may contain a set of up to 256 colors. The smaller the palette, the fewer bits are needed for each index.
- High Color—thousands of colors 15 to 16 bits per pixel
- True Color—16.8 million colors, 24 bits per pixel

Dithering

Dithering is the attempt by a computer program to approximate a color from a mixture of other colors when the required color is not available. Dithering can occur when reducing the number of colors of an image or displaying a color that a browser on an operating system don't support. In such cases, the requested color is simulated with an approximation composed of two or more other colors it can produce. The result may or may not be acceptable to the graphic designer. The image may also appear somewhat grainy since the colored area in question consists of different pixel intensities that average to the intended color.

There are several methods or algorithms for color dithering:

- *Pattern dithering* uses a fixed pixel pattern
- *Diffusion dithering* propagates the error made in replacing a color pixel by a supported color to neighboring pixels.

Pattern dithering is most useful in filling a larger area with a desired color. Diffusion dithering works well for continuous tone pictures.

7.13 Web Samples Color Critique

The Web has always been a democratic medium where people could quickly learn from one another. Whether learning new code or learning new tips about software, this medium has increased development of many new ideas including the ones about how to improve site

Figure 7.28: Adobe Level 1 and 2



design. Although there seems to be a plethora of poorly designed sites on the Web, we can learn a great deal from some of the good ones that exist today.

Design students often ask, which color should I use? How much color should I include? Is one color enough? What is the best way to use two colors? How can I work within a corporate identity palette and still use other colors? Let's take a look at how some companies have answered these questions.

The Adobe Corporation (adobe.com) has answered this question with the always popular “less is more” solution. By using red, black and white in their navigation bar, they have simplified a major part of their interface design. In Figure 7.28, we see that full color is only applied to the featured products and other significant images. This kind of treatment allows the viewer to focus on the most important things on the page, leaving interface design to quietly stay in the background supporting corporate identity and providing directions for where to go in the site.

Lufthansa Airlines (lufthansa.com) chose a similar solution. By using yellow and blue, two complements for their corporate color, they also used a full color in images only. Gray and black is used as supporting colors in rectangles, and other areas provide contrast, create hierarchy and direct attention to the text.

Metadesign (metadesign.com) used a similar treatment of black, and red, but they decided to saturate the eye with a red background, one of their corporate colors chosen for its powerful, gripping effect. The pure, red background is at times overwhelming, and at other

times, strong and confident. Depending on which way you prefer to see this combination, the Metadesign site designers did a good job of controlling text readability, on often difficult task by using solid, dark backgrounds. The designers also used good judgment by choosing navigation symbols to streamline directions to different locations of the site. Full color, square cut photos add geometric strength to classic grid oriented, Swiss design.

If you're a computer illustrator and wanted to have a presence on the Web, which colors would you choose for your website? Ron Chan (ronchan.com) decided to go with nostalgic, classic, light blue as a background, and simple black and white text, allowing his flat, colored illustrations to do all of the work in promoting his portfolio. In this case, the illustrations are featured on a white background, allowing maximum contrast between background and foreground. Open black navigation squares, effectively placed out of the way, point to the main feature of the site. Secondary navigation appears discretely to the right of the illustrations, allowing viewers to quickly select another illustration.

Pursuing the Web for your next car purchase can be fun for the viewer, but it is a competitive business for car manufacturers and dealers. The sites are loaded with automobile features, color photos, spec sheets, and lots of extras to entice you to choose them over the competition. Toyota (toyota.com) decided to designate each of their sections with a different color, creating a pleasing, harmonious palette which helps shape their identity. In Figure 7.33 and 7.33, you see two examples of how color was used to support layout structure, identify a particular section and enhance negative space. A combination of full and black and white

Figure 7.29: Lufthansa Homepage and Level 1



Figure 7.30: Meta Design Site Level 1 and 2



Figure 7.31: Ron Chan Site Level 1



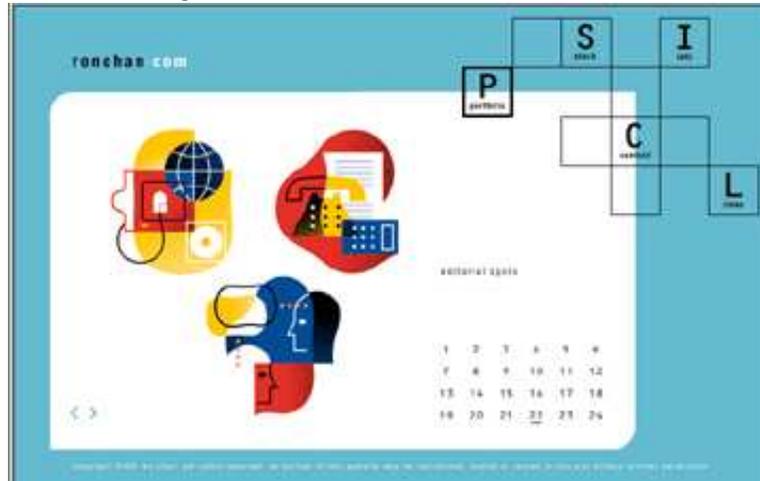
color photos adds to the richness of imagery on the page. Again, as in our previous examples, simple black, white and red navigation is used to direct viewers to many complex parts of the site.

Strong, traditional, safe, Volvo (volvo.com) went with navy blue, their primary corporate color, along with red and yellow as supporting colors. Their well directed photographs were controlled with a specific palette which adds to the richness of the viewing experience and creates unity throughout the site.

Rugged, earthy, irreverent, Harley Davidson (harley-davidson.com) has consistently maintained their corporate image in promotion and advertising. Their website is no exception. The strong palette of earthy colors is used throughout the site. Primary brown and

Brooks/Cole book/January 28, 2003

Figure 7.32: Ron Chan Site Level 2



orange are used as accents in text and bars. Rusty reds and yellow ochers appear in carefully chosen, well-placed photographs. Black navigation and background lends support to their already strong image.

The Motivo, (motivo.com) marketing/design firm took the quiet, understated approach with their light periwinkle blue, light lemon, green and soothing grays as their primary colors. Color in this case reflects the “light” graphics created with thick and thins, stressing depth on the page. Working in conjunction with logo colors, their site is unified with square cut photos, clean, readable typography and lots of white space. Full black and white color images are used to create drama on the page, leading the eye to important points in the content.

Figure 7.33: Toyota Corp. Level 1 and 2



Leading the way with a smart use of the Web media, HotWired (hotwired.com) has always taken a colorful approach to their web design. Color, color and more color, used sparingly, makes this site interesting and fun to read. Like many news and magazine websites, HotWired is in the business of providing lots of information about lots of different topics on the Web. Since their emergence on the Web, they have made many revisions to their site, deliver more speed, improved efficiency and at the same time added more content. HotWired is a good example of how one Web savvy company continues to make effective use of the media through evolving design.

7.14 Color Application

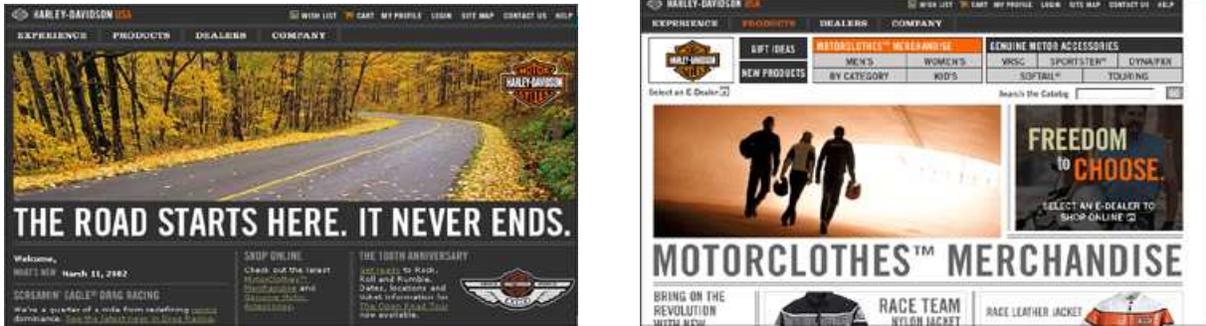
By now you have learned some basic things about color, but would you know how to choose appropriate colors for your next website project? Would you know how to program those colors? Here are a few more suggestions on color application and coding.

Let's say that you were commissioned to design a website for a gardening center. If you're like most people, you would probably choose greens or yellows or other springtime colors. If asked to design a website for a traditional, full-service travel agency, you may consider using blue to represent the oceans, or green for golf courses, or yellow and oranges found in sunsets. We instantly recall images of familiar subjects, and it may be tempting to use those comfortable solutions on our own projects. Unfortunately, that familiarity may also make your design appear trite. Luckily, design does not need to reinvent the color wheel in order

Figure 7.34: Volvo Homepage and Level 1



Figure 7.35: Harley Davidson Homepage and Level 1



to be engaging and effective. On the contrary, many successful design solutions are based on familiar cliches which have been reinterpreted to communicate a new message. That is exactly what makes them interesting.

If gardening centers bring to mind the color green, what colors do the less visual, insurance or legal firms bring to mind? These companies don't necessarily conjure up immediate colors making them more difficult to define. One of the obvious and perhaps over-used colors used in insurance industry or law firms or medical centers may be blue, green, or gray, which may be associated with stability, reliability and strength. Be sure to listen carefully to your client when discussing identity and perception. If they want to be perceived as ultra conservative, these colors may be fine, but there is still ample room for variation within that palette. Your client may want to be perceived as stable, traditional, but also catering to a wide audiences and wants to "stand out" from the competition. You need to be able to adapt and go beyond

Figure 7.36: Motivo's Site Level 1 and 2

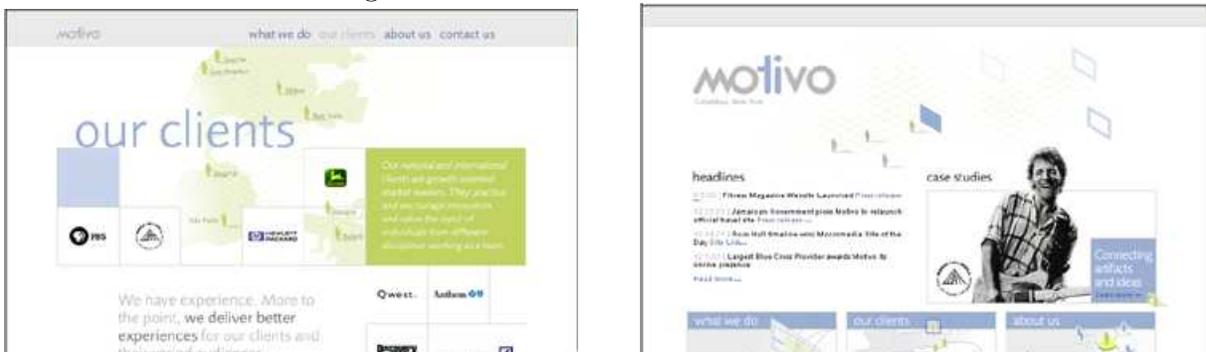


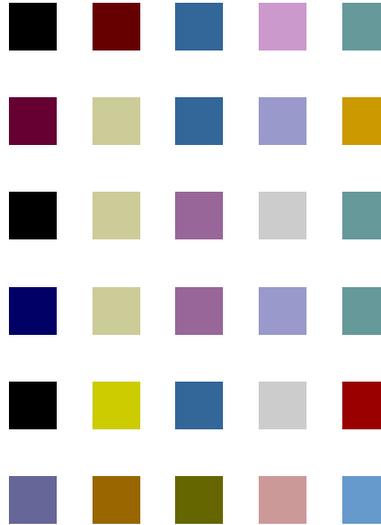
Figure 7.37: HotWired Site Level 1 and 2



cliche choices. Color themselves are neither conservative or radical—it is our perception that makes them so. When it comes to colors, a good rule of thumb is choose a palette of colors that works well together and helps to support your concept.

Figure 7.38 takes five often considered conservative colors (brown, black, green, blue, burgundy, dark purple) and shows you variations on this old theme. Each row has five common color choices, but with a different twist. Varying even one color in the palette is going to give you a different feel of the overall website.

Figure 7.38: Conservative Color Palette

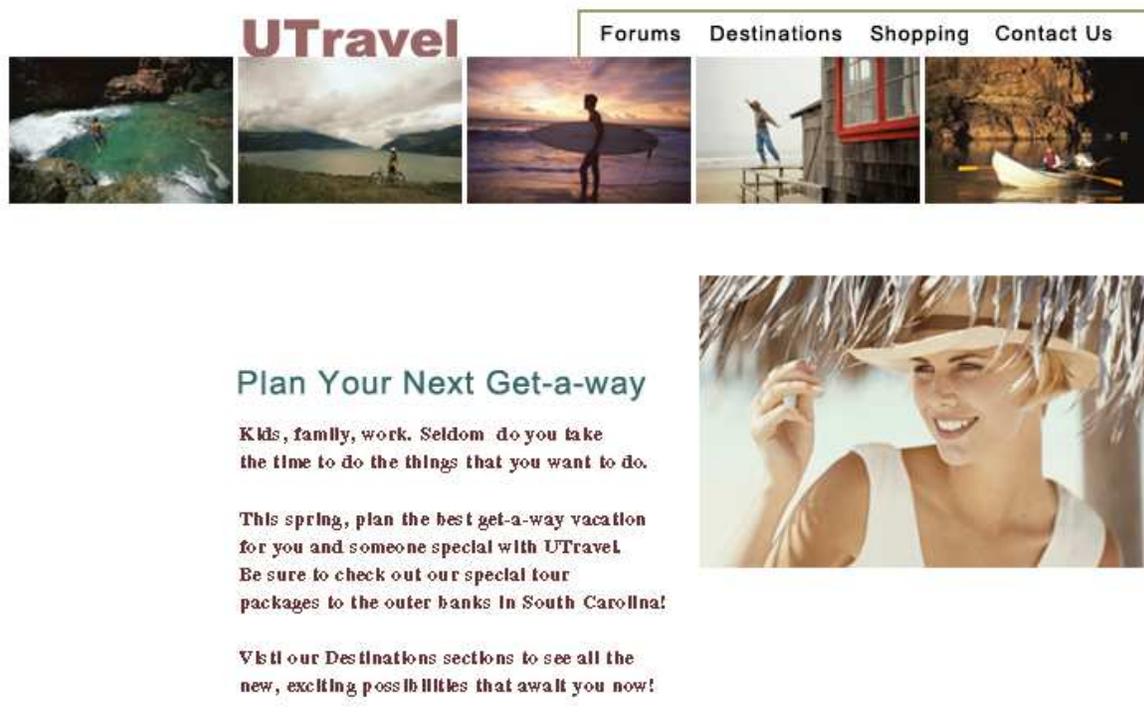


Now, let's go back to the travel agency example. One way designers derive at engaging solutions is to think beyond the cliches. Suppose I were to give you an assignment to create Brooks/Cole book/January 28, 2003

a home page for a travel agency which takes a different approach in their color treatment. Instead of the usual sunsets and blue waters, what would you use? The answer lies with the problem itself. What destinations does the travel agency specialize in? Are the exotic planners or are cruises their specialty? Do they specialize in Europe, or Asia or continental U.S? Your color choices will be greatly be influenced by these answers.

The travel site in Figure 7.39 made a particular point of not using blue on their site. Instead, the color palette is light and neutral, with small splashes of color; in this case red, green, brown, gray, pink and yellow—something you would not necessarily expect.

Figure 7.39: Hypothetical Travel Site



Examine the example carefully, then notice how the HTML scripting is used to recreate this page in the browser.

7.15 Summary

The Web, with its combination of computer screens, color encoding standards, and color specification in Web pages, constitutes a distinct medium for the presentation and manipulation of color. Mastery of color on the Web requires a combination of artistic and programming abilities.

As you develop your own websites, keep in mind that color is subjective and color choices will probably be made in collaboration with your clients. Contrast in value, as well as color, plays an important role in design. Trust your intuition as well as theoretic knowledge when applying color, and remember that color is just one of the factors in your design. It should not be used to simply “enhance” black and white forms. It should add something meaningful to your message such as setting the mood, introducing cultural meaning, or connecting through spontaneous associations with your viewers.

Finally, experiment with color! Use digital image tools such as Photoshop and try to apply different colors to your images. Don’t necessarily settle on your first choice. Study websites which you think use color effectively and take note of the combinations used. Being aware of color and its use will give you the confidence to create effective, aesthetically pleasing websites.

Exercises

Review Questions

1. What is a color wheel and what is its purpose?
2. What are primary colors?
3. What are secondary colors? How are they created?
4. What are tertiary colors and how are they created?

5. What is the difference between complementary and analogous colors? Where do you find each one on the color wheel?
6. What are color contrasts and why are they important?
7. Describe color dominance in design.
8. What is the difference between hue contrast and value contrast? Which one is more critical in design of websites?
9. You can produce color contrasts but not necessarily value contrasts. Explain how this works and give examples.
10. What is color context and why is it important?
11. What is simultaneous contrast and how would you use it in Web design?
12. Describe the difference between warm and cool colors? Site examples of each.
13. What does saturation mean? How can it be achieved in a tool such as Photoshop?
14. How does type and readability relate to color? What is the most critical aspect of choosing type color?
15. According to Peckolick, what are the three key factors for color selection? Discuss each one.
16. What is Gamma? What is gamma correction?
17. What are color models? What is the difference between print and computer screen color models?
18. Discuss hue, brightness and saturation? What is the difference between them?
19. What is a duotone? How would you make one in a tool such as Photoshop?
20. What are GIFs and JPGs? What is the difference between these two? When would you use each one and why?

Assignments

1. Study Itten's contrasts. Choose or create a simple image using geometric shapes and design a composition which you can manipulate. See if you can demonstrate your understanding of his contrasts by duplicating your illustration using contrast of hue, light-dark contrast, cool-warm contrast and so on.
2. Create 3 simple images. You can use a photograph or a spot illustration for this exercise. Create one using 3 primary colors, the other using only 3 secondary colors and the last one using 3 tertiary colors of your choice. Compare the illustrations. What differences do you see between the three? Which one is more attractive? Does each one communicate differently? How?
3. Select a website which you think uses color well. Identify the color scheme used on the site. Are they primary, secondary, analogous colors or complementary colors? Identify the palette.
4. Select one page of the site which you think is designed well. Create 2 variations on the original color scheme. Make one color dominant, the other value dominant. Use maximum contrast in both color and value designs. Compare the two compositions. Analyze which one looks more aesthetically pleasing.
5. Go to your favorite museum and choose a painting which you really like. Write down or draw in color pencil or marker, the colors used. As an exercise in a tool such as Photoshop, create a simple Web page, using any design you wish using those same colors. Try to find interesting color combinations, ones you may not have thought of before.
6. In a tool such as Photoshop, select or create one image with two variations. Create one using warm colors, the other using cool. Compare the two images.
7. Create 3 simple geometric shapes in a tool such as Photoshop. Color one using CMYK color and the other using RGB color. Examine each image on a 216 monitor, thousands

- of colors, and millions of colors? Then convert the RGB values to Browser safe color? Discuss differences.
8. Consider the RGB to HSB conversion function in Section 7.10. In your own words, explain how this function works and explain each line of the code.
 9. Make the `hsb` program (Section 7.10) into a complete C++ program. Run it and check the conversion values against those displayed by a tool such as Photoshop.
 10. Use a programming language you know, write a program to convert HSB to RGB.

