

Coloring Agents

Artists, architects, and designers must use materials in the creation of their works and these materials all contain color that is either **achromatic** (neutral, such as black, white, or grays) or **chromatic** (hued, such as red, yellow, or brown). The aim of the practitioner is to reproduce the colors found within the visible spectrum and their variations. Each work or medium employed in a project requires a different form of color usage or coloring agent. Prior to the nineteenth century, artists mixed their own pigments according to desired usage. Now, however, the artist usually deals with premixed colors, although the components of a color can differ from manufacturer to manufacturer and from medium to medium.

ADDITIVE COLOR MIXING

Let us begin with the mixing of light, which is an additive process. The art media using light mixing include theater, film, video, and television. The lights are mixed by placing colored filters (red, blue, or green) in front of a projected light ray. If red, green, and blue are all projected we get white light (fig. 4.1).

The video camera records images that are transmitted as light patterns. Again, we see three light primaries at work: red, blue, and green. The transmitted light patterns are converted into signals indicating **chromaticity**, a measure of the combination of hue and saturation, and **luminance**, a measure of value, or lightness and darkness. The picture tube is coated with dots of phosphors in red, green, and blue that are activated by the transmitted signals, resulting in the color television image. Magnification of a television image reveals combinations of tiny red, green, and blue-violet dots. When two light rays are projected their sum or combination is brighter than either ray by itself. For instance, yellow is much brighter than the red and green light beams projected as its components.

Computer graphics color monitors function in much the same way as video with the same light primaries of red, blue, and green (see pages 147–148). While the light primaries are the basis for computer graphics, the computer graphics color menus are fashioned after the Munsell system of color notation, which allows the artist to function in a pigment-like environment. Thus, although the computer-screen image is based on additive color mixing, the computer-printer image is

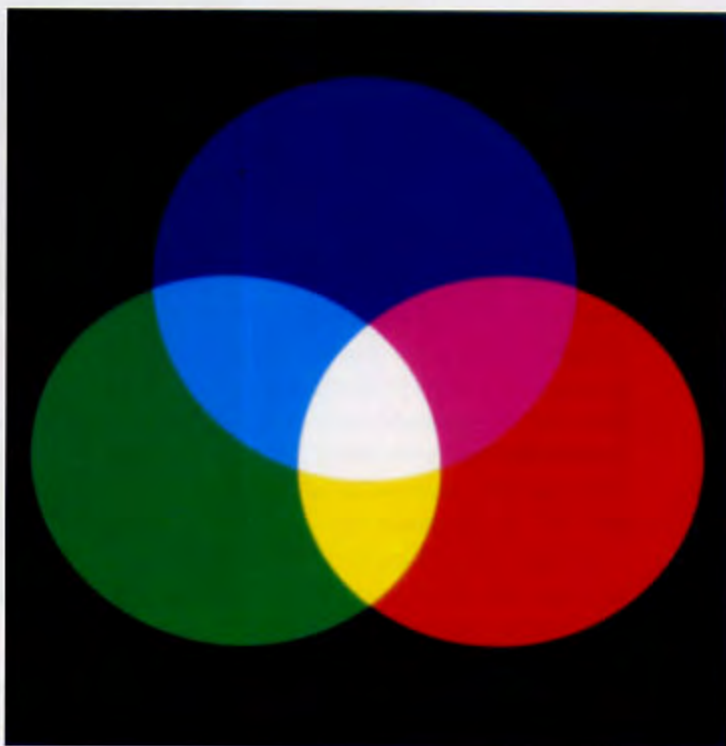
based on subtractive color mixing. The printout of the screen image will be duller than that seen on the screen.

SUBTRACTIVE COLOR MIXING

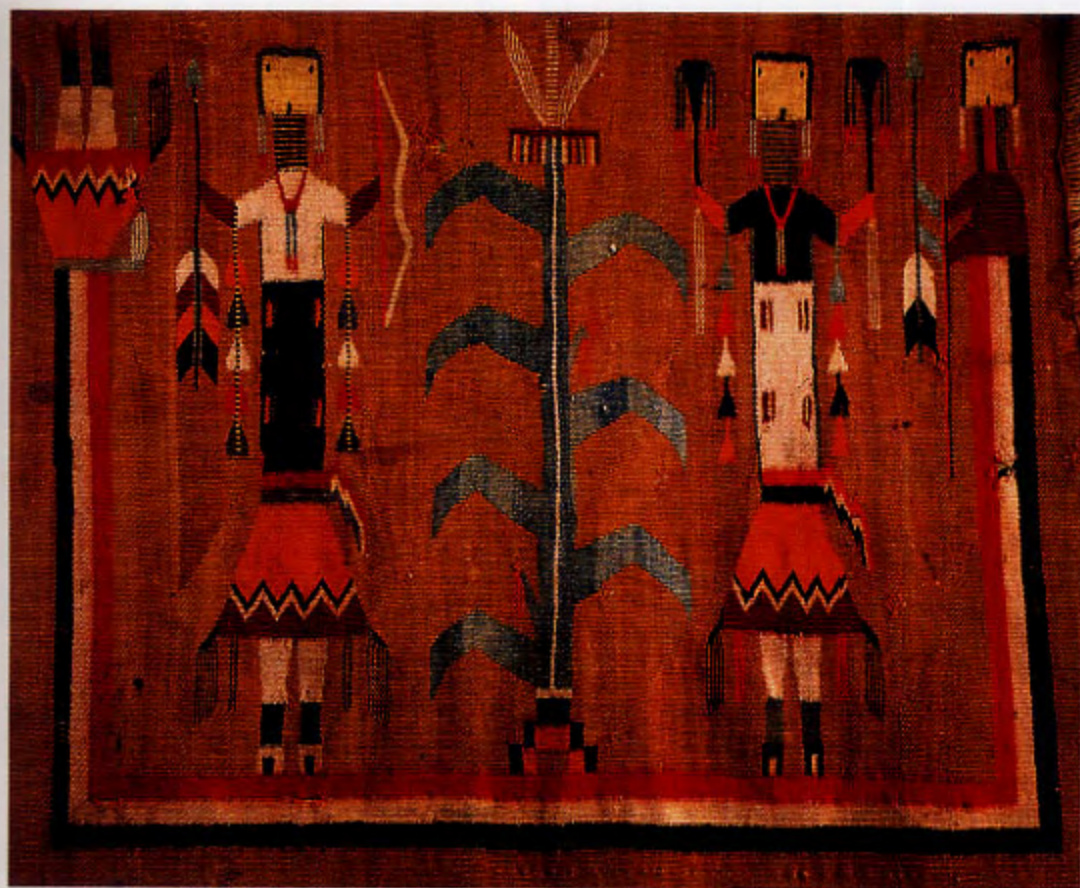
Pigments and Dyes

Subtractive methods of creating colors are based on pigments or **dyes**. Pigments are powders that are in a **binder** such as acrylic or oil which cover or adhere to a surface. Dyes are pigments that are dissolved and absorbed in a fluid. **Lakes** are organic pigments or dyes that are combined with inorganic **mordants**, or fixatives, to extend the pigment range and create brighter colors. The color of a pigment is determined by how it absorbs light rays. By approximating the appearance of reflected light, pigments attempt to match the color seen in the visual spectrum.

The art media of drawing, painting, printmaking, ceramics, textiles, enameling, and embroidery are all



4.1 The mixing of light. When two of the projected additive primary colors—red, green, and blue—are overlapped, they create the secondary colors of yellow, cyan, and magenta. White light is the result of combining the three primaries.



4.4 Navajo blanket, nineteenth century. Based on a sand-painting design, this blanket shows two supernatural beings flanking the sacred maize plant, which was their gift to ordinary mortals. The artist designed the piece with a number of orange/blue and red/blue-green complements in mind. The yarn fibers were dyed in a variety of colors before being woven together.

based on pigment usage (figs. 4.2–4.4). Pigments can be categorized into dry (drawing, employing pencils, chalk, crayons, and conté crayon), liquid (painting, printmaking, ceramics, enameling, batik, employing paints and inks), and combination (embroidery, weaving, both of which employ yarns that have been dyed).

Fibers can be dyed by either natural or synthetic means. *The Color Index* lists over 8000 dyes available to the fiber artist. Prior to dyeing, many fibers must be washed or scoured and then treated with a mordant. The mordant helps the fiber accept and fix the dye, and can affect the color. The most common mordants are alum, iron, tannic acid, tin, and copper. Dyeing procedures vary: direct dyeing, when a mordant is not required, is most commonly seen in hand or natural dyeing procedures; dispersed dyeing is used for artificial fibers such as nylon that will not take water-soluble dyestuffs; reactive dyeing is used for cellulose fibers that need to bond chemically with the fiber; and vat dyeing

achieves coloration after the fiber has been treated and exposed to sunlight, air, or an acid solution. The most common vat dye is indigo, which becomes activated when exposed to the air. Indeed, vat dyeing derives its name from the original method of dyeing indigo in a vat. The first synthetic dyes were developed in 1856 and are known as **aniline dyes**. These were based on alcohol and coal-tar derivatives. The aniline dyes were succeeded by azo dyes, which are petroleum-based. The azo dyes are more colorfast and brilliant than the aniline.

Pigments come from both natural and artificial sources. Natural pigments are derived from animal and vegetable substances (both organic), as well as from inorganic materials. The inorganic materials may include various oxides, metal compounds, minerals, and clays, which must go through a series of transformations prior to their final use as pigments. They are mined, sifted, washed, crushed, pulverized, sometimes baked (calcination), ground, baked again, and reground

(fig. 4.5). The fineness of the resulting pigment particles determines the quality of the color and its covering ability. The coarser the pigment powder, the greater are the chances of cracking, dirt damage, discoloration, and general deterioration. Natural organic pigments are derived from all aspects of nature—plants, woods, mosses, roots, nectars, animals, and so on—which are chopped, ground, boiled, and dried to extract the pigment powders. Natural pigments have a tendency to fade, but as they fade their basic color does not change. Chemical pigments, by contrast, fade to a different color.

Pigments can also be derived from synthetic means, and the chemical world offers us myriad possibilities. Artificial pigments are obtained by dry distillation (burning) of various substances such as charcoal, coal, peat, petroleum, and fossils, which results in tar. The tar is further distilled to form oils, naphthas, pitch, and benzol. The colorless liquid resulting from fossil coal tar forms the base for aniline dyes.

The various pigments have entirely different mixing properties and require diverse types of vehicles or binders to transform them into workable tools. This variety also causes each medium, such as the paint, drawing tool, or yarn, to behave differently, especially when we try to mix them. White paint is fifty times brighter than black so when mixing a light hue such as



4.5 Pigments. This Nigerian woman is grinding leaves to make a color pigment. The resulting paste is mixed with black pigment to produce a glaze for decoration.

yellow with neutrals, it takes very little black to change it but a larger quantity of white. Conversely, a dark hue such as violet requires a large quantity of black to effect a change and very little white. When two pigments are mixed the result is duller or darker or both.

All color use is affected by atmospheric conditions, either natural or artificial. These conditions will result in color deterioration; the artist, therefore, should use the highest-quality materials available to slow down this inevitable process. In order for a pigment to function at its best it should:

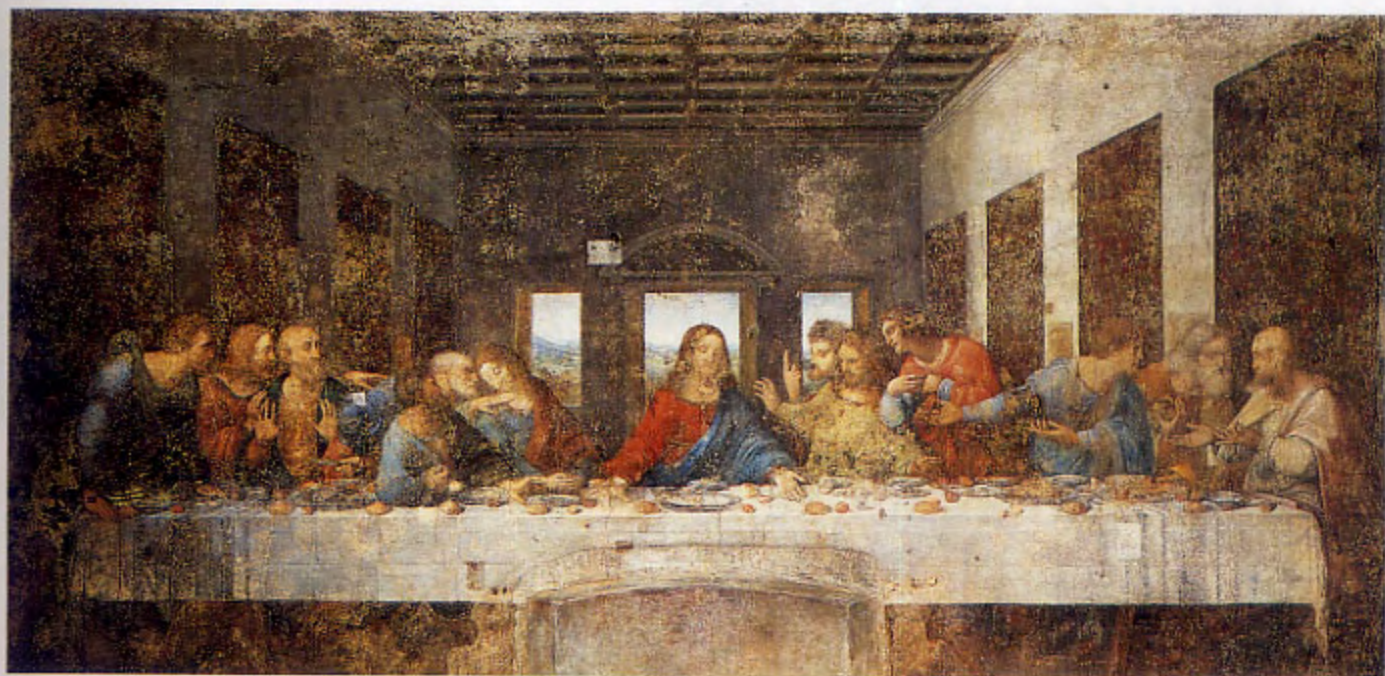
- 1 not react (fade or turn pale) when mixed with light or any liquids;
- 2 have permanence—in other words it should remain stable in any atmospheric conditions imposed on it by light, heat, or cold;
- 3 cover the support or ground well and retain its brilliance (fig. 4.6).

Binders and Grounds

The materials an artist employs in any work are usually a combination of pigment and another substance. It is this combination that reflects and absorbs in varying degrees the light hitting it, resulting in varying qualities of color. The artist must be concerned with the behavior of any pigment, especially its **tinging strength**. Tinting strength refers to how a pigment's intensity reacts when mixed with white and the binder. The combining or binding agent is known as the **vehicle** and can consist of oils, waxes, gums, water, or acrylics. The pigments themselves, whether natural or synthetic, are usually in fine powder form; they are then mixed or suspended in a medium or binder that serves as the vehicle. The binder must also allow the pigment to adhere to the surface or ground. The binder thus has a twofold effect, and the nature of the binder will determine how a particular medium works or feels. The binder totally surrounds the pigment particles and controls the effects of atmosphere, oxidation, drying time, and transmission of light reflection. Because of this we find that art media are often referred to by the terminology used to describe their binders.

Binders are classified as dry or liquid. A survey of the dry (pigment plus substance) binders can be found in Appendix 1. Liquid binders are formed by suspending pigment in fluid. A survey of liquid binders can be found in Appendix 2.

Surfaces or grounds may be prepared in a variety of ways. Most grounds the artist employs begin with white. This is because white is a neutral and represents



4.6 Leonardo da Vinci, *The Last Supper* (before restoration), c. 1495–98. Fresco, 15 ft 1 $\frac{1}{8}$ in x 28 ft 10 $\frac{1}{2}$ in (4.6 x 8.6 m). Refectory, Convent of Santa Maria della Grazie, Milan. Fresco technique requires the application of paint to a damp plaster wall in order for pigments to fuse with the plaster as it dries. However, Leonardo's methods were slow and he couldn't keep pace with the speed of the drying process. Pigment and plaster did not fuse well and over time the paint began to flake off. The fresco has recently been restored, with mixed results.

the total absence of color. We recognize color in terms of its relationship to white even though most art progresses to a finished work where little or no white is visible. The painter normally prepares the canvas or surface by priming it with gesso, originally a combination of chalk, powdered plaster, or whiting mixed with glue. Most painters today use an acrylic polymer-based primer to provide a uniform painting surface.

The combination of pigment and surface very often creates a new surface: the quality of the color emitted as reflected light by the pigment therefore changes. In painting, for example, the paint covers the background surface or ground and becomes another surface—the one that is most visible to the viewer. In watercolors, the paint and the ground are both surfaces and form a new combined surface. The weaver utilizes pigmented yarns to form an entirely new surface composed of many components—the warps and wefts. Their yarns, however, have become surfaces impregnated by pigment that is applied in dye form. The embroiderer, like the watercolorist, often uses a ground that is a textile embellished with yarns, resulting in combined surfaces that form new surfaces. The photographer's

paper ground is changed by the chemical dyes (yellow, magenta, or cyan) used for color photography which creates the image and a completely new surface. The photographer and yarn dyer use less dye or weaker dye solutions to achieve a paler color. The watercolorist usually works this way as well. The opaque pigment painter (using oils, gouache, etc.) must add white pigment to lighten the color.

Artists' colors all have certain characteristics that are the result of their pigment origination. A list of these characteristics can be found in Appendix 3.

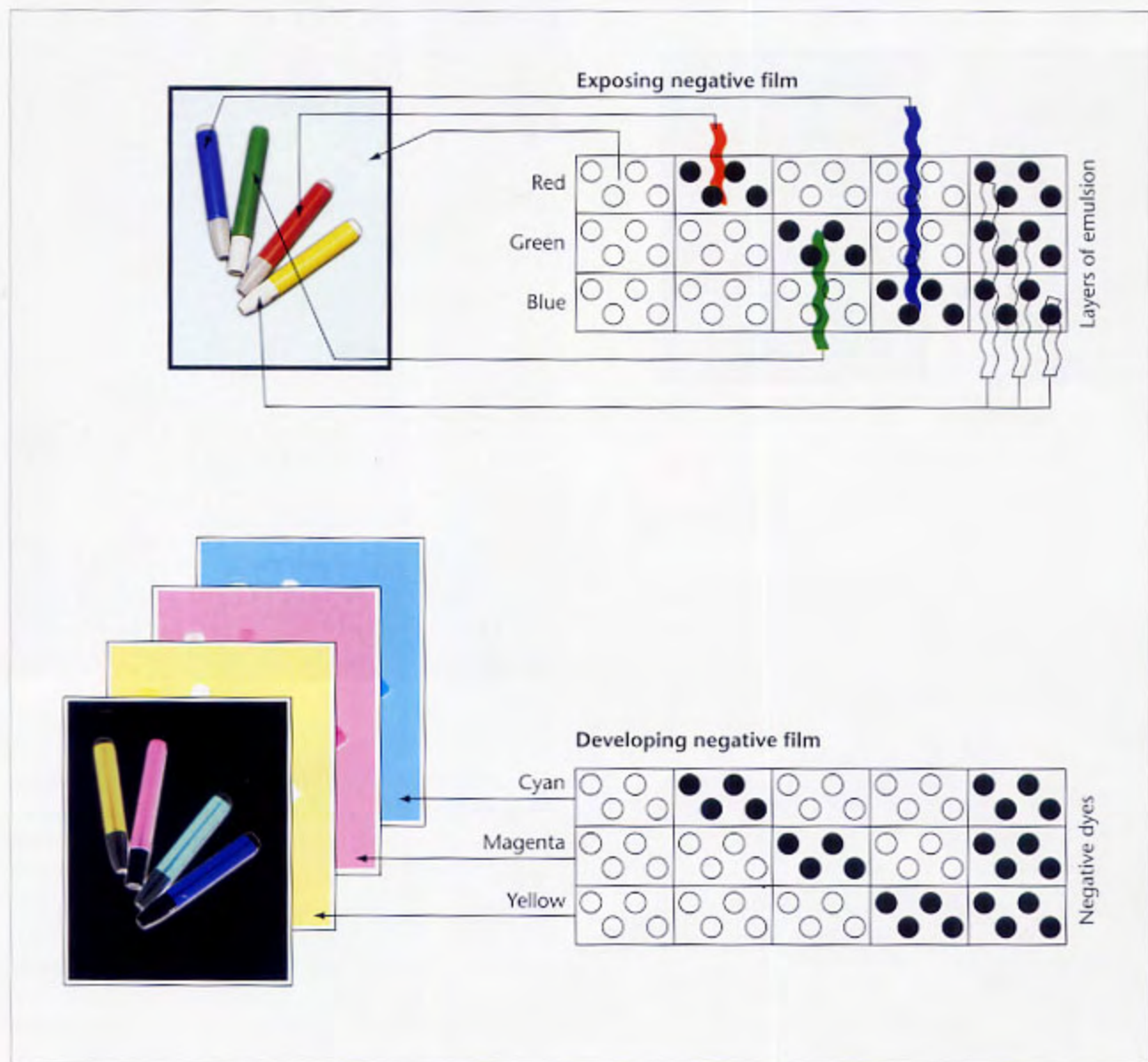
Color Printing

The artist wants red pigment to absorb all the light rays except red and to reflect the red back to the viewer. We do, however, find that artists have attempted to cause pigments, which are subtractive color, to behave as additive or light color. This was the basis on which the Impressionists and Neo-Impressionists sought to achieve their effects. The pseudo-additive color was formed by the placement of colors next to each other. The easiest method of accomplishing this was the use of small dots, as seen in pointillism.



The same concept is found at work in color printing. In four-color process printing, screens of dots are layered on top of each other, each screen containing a different color (fig. 4.7). The screens used are black, process yellow, process magenta, and process cyan inks. The eye optically mixes these dots to form all the hues. The density of the screen and the size of the dots determine the lightness or darkness of the color. The smaller the dots, the paler the color will be. Flat color printing also works with transparent overlays of yellow, magenta, and cyan that are superimposed upon each other. Here, however, the designer indicates on the overlays which areas are to be printed in which colors.

Printers also rely on the **PMS system** (Pantone Matching System) for color matching (fig. 4.8). Based on nine colors, plus black and transparent white, the system shows the percentages of these colors required to produce a particular color. "Recipes" are given for 747 different colors, allowing the printer to mix the inks to produce the desired color. The graphic designer using printing inks must take care when attempting to reproduce various colors accurately. Dark blues, dark greens, and very warm reds cause problems because printing inks are transparent; these color choices require numerous layers of printing ink to achieve the desired result. Many graphic designers are also faced



4.9 Exposing and developing color film. The diagram above shows different color layers of film exposure. The diagram below reveals the process colors of cyan, magenta, yellow, and black that are used in printing from plates exposed to negative film.

with a tight budget, and so often find themselves working with only one or two colors. The knowledge of how color behaves is most important if the graphic designer is to get a single color to function or appear as many.

Photography

The photographer works in black-and-white or color. Black-and-white photography relies on value changes from dark to light. Color photography, in both print and transparency forms, is made possible by a film that

consists of an **integral tripack** made up of three layers of a gelatin (fig. 4.9). Each of these layers takes care of a different color. The top layer comprises silver halide which is sensitive to blue light; a yellow filter beneath the silver halide layer blocks the blue light from passing to the second and third layers. A second layer is sensitive to green and blue light, and the third layer is sensitive to red light. These sensitizing dyes, therefore, are the primaries red, green, and blue. The camera exposes the tripack layers to the light mixtures it records, and the developing process activates the

dyes. The result is a full color print or transparency. Photographers also have the option of attaching a colored filter to the lens which will impose the desired color reaction on to the tripack.

CONCEPTS TO REMEMBER

- Coloring agents are the means by which the artist imposes color on an image or object.
- Additive color principles apply to the media of film, video, television, and computer graphics, and utilize the light primaries of red, green, and blue.
- Subtractive coloring agents depend upon colors being created from pigments (powders plus a binder) and dyes (pigments dissolved in a fluid).
- Pigments are of three types—dry, liquid, and combination—and are derived from either natural or artificial sources. The ideal pigments do not react to being mixed, have permanence, provide good coverage, and retain brilliance. Pigments are usually mixed with binders, which are classified as dry or liquid.

- Four-color process printing uses layers or screens of yellow, magenta, and cyan which optically mix to form colors. The Pantone Matching System (PMS) is also used for printing and relies on nine colors, black, and transparent white to create the desired color of printing ink.
- Photography is of two types—black-and-white and color. Color photography employs a tripack of three light-sensitive layers combined on the film.

Exercises

- 1 Collect or create color-chip examples of one color from various media (oil paint, pastels, yarn, photography, printing, and so on) and observe the different effects of that color.
- 2 Collect examples of photographs and the objects photographed, and examine the color changes between them.