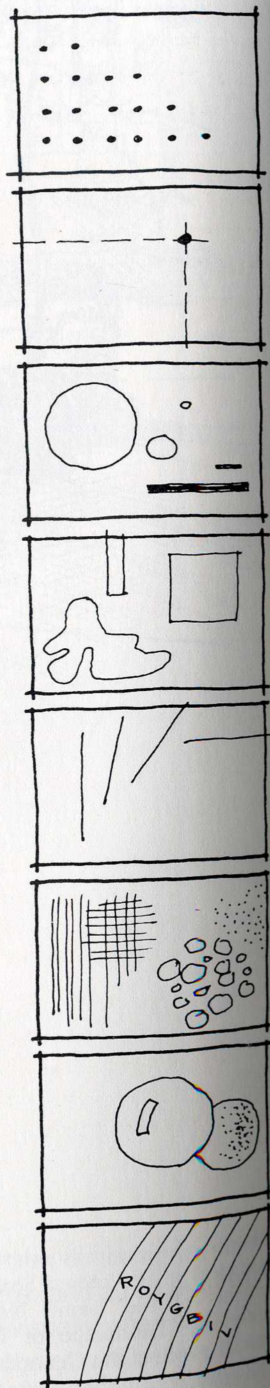
Problem 9



Color Attributes

With this exercise we move to a consideration of another aspect of the basic pattern area: that of color. You will be introduced to a systematization of three attributes of the appearance of color in the surface mode, and have an opportunity to discriminate them firsthand.

To begin let us imagine that we have gathered together a large number of differently colored objects: stones, bricks, boards, flowers, leaves, paper, carpet, clothing, ceramics, metals, and so on. What we want to do now is to find a way by which we can describe the many differences in the colors we see before us.

"If we are asked the color of an object such as a sweater, our first reaction may be to say, for example, that it is red. By this means, we identify the *hue* of the object, that is, whether it is red or yellow or purple.

"However, we are all conscious, at least in a vague way, that this description is inadequate. In an effort to be more specific, we may say that the sweater is light red or dark red. When we do this, we are describing the *brightness* of the color. If we stop to think about it, we realize that this characteristic of a color is independent of hue, that is, we can have two colors which are of the same hue but of different brightness.

"We might also say of the sweater that it is a dull red or a bright, vivid, or brilliant red. Here we are attempting to describe still another characteristic of a color, that is, its *saturation*. The saturation of a given color may be regarded as a measure of the extent to which it departs from a neutral gray of the same brightness.

"Thus any color perception has three characteristics, any one of which can be varied independently of the other two. In psychological usage, the correct term is *attributes*, because we are really describing sensations, not the object or the physical stimuli reaching the eye.

"While we experience little difficulty in detecting hue differences, we frequently become confused in judging brightness and saturation differences—we cannot decide whether two colors differ only in brightness or whether their saturation is also different. . . . The confusion between saturation and brightness is typified by the frequency in which the word 'bright' is used in everyday speech to describe a highly saturated color.

"Frequently we attempt to describe a color more or less completely by a single term, sometimes the name of some object which is more or less familiar to everyone. For example, pink, cherry, cerise, dusty pink, rose, scarlet, vermilion, crimson and rust are all used to describe various reds. The difficulty is that each term means one thing to one person, another to another person. We would all agree that pink describes a red which is high in brightness, fairly low in saturation, and slightly bluish in hue. Even within these limitations, however, there are many possibilites; we would certainly not think of buying yarn to complete a half-finished sweater, specifying only that it was to be pink. Instead, we would match the two yarns directly, and with some experience in the ways of color, we would also make sure that the two samples matched both in daylight and in artificial light.

Depending on the attitude of the observer, color can be perceived in five different "modes." As codified by the Committee on Colorimetry of the Optical Society of America in *The Science of Color* (New York: Thomas Y. Crowell, 1953), they are:

the **illuminant** mode, in which color is perceived as belonging to a source of light,

the **illumination** mode, in which the presence of illuminated objects reflecting light and casting shadows provides a basis for the perception of color,

the **surface** mode, in which color is perceived as belonging to a surface, based on the presence of a physical surface from which light is reflected,

the **volume** mode, involving the passage of light through a more-or-less uniform and transparent substance such as smoke or haze, and

the **film or aperture** mode, in which a color is seen through an aperture, as in a mask, isolated from and unrelated to other colors. This mode provides an experience closest to pure color sensation.

Because of this confusion, in our work with color as perceived in the surface mode, we will use the term "lightness" or *value* to refer to this attribute. Technically, brightness refers to the perception of luminance, which is the effective intensity of the light reaching the eye; while lightness refers to the perception of reflectance, which is the fractional part of the light reflected from a surface under given conditions. Reflectance is a characteristic of the surface for a given light, and luminance is a characteristic of the light itself.

For a good description and comparison of several different color systems, see Martina Duttmann, Friedrich Schmuck, and Johannes Uhl, *Color in Townscape* (San Francisco: W. H. Freeman, 1981).

"The need for an accurate language of color becomes acute when, as often happens, circumstances do not permit direct comparisons. Actually, we do not have a universal language, but we do have systems of color specification and notation which answer most of our needs. The importance of such systems to manufacturers of dyes, pigments, paints, inks, papers, etc., and to many workers in science and industry can hardly be overestimated.

"In the United States, the best-known and most widely used system of color notation is that developed by Albert H. Munsell. Essentially, this system is an orderly arrangement into a three-dimensional solid of all the colors which can be represented by actual surface samples prepared from stable pigments. . . .

"The various hues are spaced horizontally around a circle in such a manner that they appear approximately equidistant to a normal observer, provided he examines them under illumination of the correct quality. The circle . . . is divided into ten Major Hues, consisting of five Principal Hues (Red, Yellow, Green, Blue, and Purple) and five Intermediate Hues (Yellow-Red, Green-Yellow, Blue-Green, Purple-Blue, and Red-Purple). Each of these ten Major Hues is number 5 of a hue series of 10 numbers. Thus the complete hue circle consists of 100 hues, 40 of which are represented by actual samples in the *Munsell Book of Color*. This book is supplied as a Matte Finish Collection and a Glossy Finish Collection; a number of abridged collections designed for special purposes are also available.

"Extending vertically through the center of the hue circle is the scale of reflectances, known as *values* in the Munsell System. Number 10, at the top of the value scale, is a theoretically perfect white (100 percent reflectance); number 0, at the bottom, is a theoretically perfect black (0 percent reflectance). In between, there are value steps represented by actual samples.

". . .the value scale deserves more than passing notice. Superficial reasoning would indicate that the midpoint of the scale should have a reflectance of 50 percent, that is, it should reflect 50 percent of the light falling on it. However, the eye tends to see as equal tone steps not equal differences in reflectance (e.g., 10, 20, 30, and 40 percent, where there is a constant difference of 10 percent), but rather equal ratios of reflectance (e.g., 10, 20, 40, and 80 percent, where the ratio of each reflectance to the preceding one is 2). As a result, the gray which impresses the eye as falling midway between white and black actually has a reflectance of about 18 percent. . . .

"Radiating out from the scale of values, which is the central core of the color solid, are the steps of saturation, known as *chroma* in the Munsell System. Here again the steps appear approximately equidistant to a normal observer. The numbers extend from 0, which is the neutral gray, to numbers as high as 16, depending on the degree of saturation attainable with a given hue at a given value level. Because of variations in attainable saturation with hue and value, the color solid is not symmetrical. For glossy samples, the highest chroma of 5 Red is 14, whereas the highest chroma of 5 Blue-Green, opposite Red, is only 8. Yellow reaches its maximum chroma at a high value; Purple-Blue, opposite Yellow, reaches its maximum chroma at a low value. The Munsell System has the advantage over some other systems that if a new pigment is produced which permits samples of higher saturation to be prepared, there is no difficulty in adding the new samples to the appropriate hue chart."

Excerpted from *Color As Seen and Photographed*, Kodak Data Book E-74H, second ed. (Rochester, N.Y.: Eastman Kodak Company, 1972)

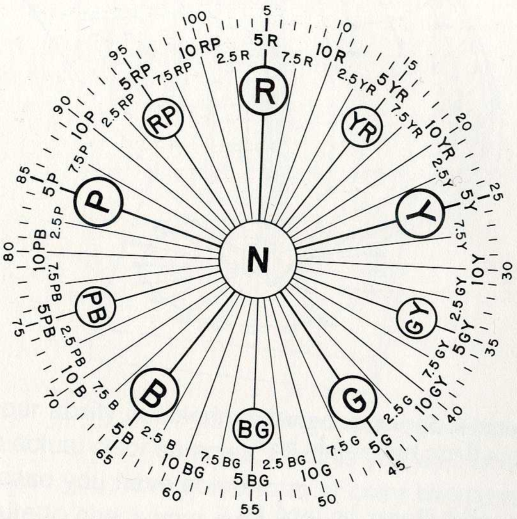


FIGURE 1 The Munsell hue circle

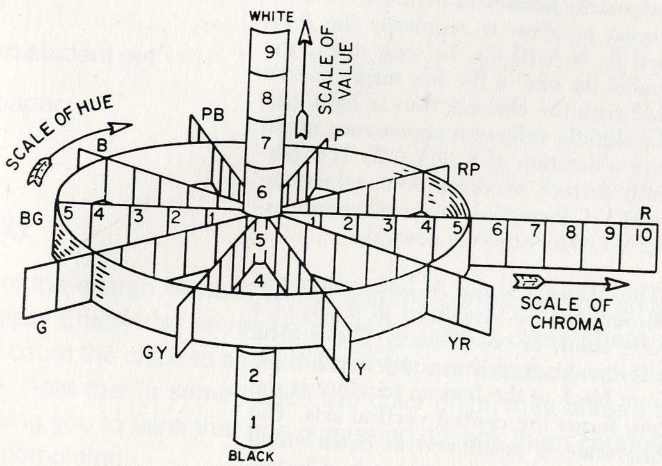


FIGURE 2 Munsell hue, value, and chroma scales in color space

Munsell Color (Macbeth Division of Kollmorgan Corporation, 2441 N. Calvert St., Baltimore, Md., 21218) describes the system as follows:

"The system of color notation, developed by A. H. Munsell, identifies color in terms of three attributes: hue, value and chroma. This method of color notation arranges the three attributes of color into orderly scales of equal visual steps; the scales are used as dimensions or parameters for the accurate specification and description of color under standard conditions of illuminating and viewing.

"The hue (H) notation of a color indicates its relation to a visually equally-spaced scale of 100 hues. There are 10 major hues (5 principal and 5 intermediate) positioned ten hue steps apart within this scale. The hue notation in general use is based on the ten major hue names: Red, Yellow-Red, Yellow, Green-Yellow, Green, Blue-Green, Blue, Purple-Blue, Purple and Red-Purple.

"Any one of several symbols may be used for the notation of hue, as shown in Figure 1. Hue initials for the ten major hue families, shown in the inner circle, may be used alone for rough identification of hue. Numerals from 1 to 100, as shown in the outer circle, may be used alone for statistical records, cataloging and computer programming. The combination of

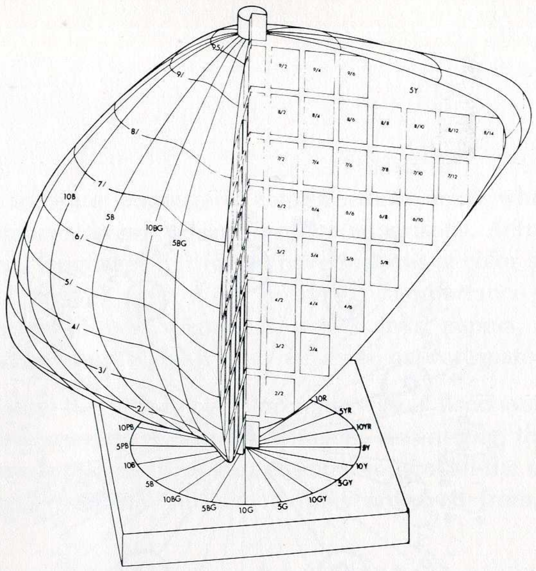


FIGURE 3 Munsell color solid with one quarter removed

numerals with the hue initials is considered the most descriptive form of the hue notation. This combination is shown between the inner and outer circles in Figure 1, and this is the form used on the 40 constant hue charts displayed in the *Munsell Book of Color*.

"The value (V) notation indicates the degree of lightness or darkness of a color in relation to a neutral gray scale, which extends from absolute black to absolute white. The value symbol 0/ is used for absolute black; the symbol 10/ is used for absolute white. The symbol 5/ is used for the middle gray and for all chromatic colors that appear half-way in value between absolute black and absolute white. Figs. 2 and 3.

"The chroma (C) notation indicates the degree of departure of a given hue from a neutral gray of the same value. The scales of chroma extend from /0 for a neutral gray out to /10, /12, /14, or farther, depending upon the strength (saturation) of the sample to be evaluated. A color classified popularly as 'vermilion' might have a chroma as strong as /12 or as vivid as /16, while another color of the same hue and value, classified popularly as 'rose,' might have a chroma as weak (grayed) as /4. Figs. 2 and 3.

"The complete Munsell notation for a chromatic color is written symbolically: H V/C. The complete notation for a sample of 'vermilion' might be 5R 5/14, while the notation for a sample of 'rose' might be 5R 5/4. When a finer division is needed for any of the attributes, decimals are used; for example: 2.8R 4.5/12.4.

"The notation for a neutral (achromatic) color is written: N V/. The notation for a sample of black, a very dark neutral, might be N 1/; the notation for a sample of white, a very light neutral, might be N 9/, while the notation for a gray, visually half-way between these two, would be N 5/.

"The chroma symbol /0 may be used in the notation for neutral colors but it is customary to omit it. Blacks, grays, and whites of chroma weaker than /0.3 are customarily notated as neutrals; if a more precise notation is required, the form used is: N V/(H,C). In such cases, the symbol for one of the ten major hues is used with the chroma; thus, a light gray of a slightly yellowish appearance might have a notation of N 8/(Y,0.2). It is perfectly correct, of course, to use the regular H V/C form to describe all colors, using N V/O for absolute neutrals.

"The Munsell scales of hue, value and chroma can be visualized in terms of a color solid, or color space. The neutral value scale, graded in equal visual steps, from black at the bottom to white at the top, forms the central vertical axis. The hue scale is positioned in equal visual steps around the neutral axis. Chroma scales radiate in equal visual steps from the neutral axis outward to the periphery of the color space. Figs. 2 and 3. Color space as defined by the Munsell color solid is quite irregular, roughly conforming to the shape dictated by absolute limits of reflecting materials.

"The scales shown in Figures 1, 2 and 3 are intended to illustrate the concept of three dimensional color space; they are not limited to the notations shown. By the use of decimals, each scale may be divided into increments as small as may be required for the most accurate color notation. The chroma scales may be extended to include the chroma notation of all material samples. The value scale is limited by the end points (absolute black and absolute white); these are not achievable in material form. The hue scale forms a closed circle."

Now, let's test your ability in discriminating these concepts of hue, value, and chroma with actual color samples. For this you will need the materials listed below. In case you have some form of color blindness and are not aware of it, be sure to check your work at each stage with two or three of your colleagues.

About 8 to 10 percent of the male population suffer from marked color blindness, and 4 to 5 percent of the total population possess some degree of seriously abnormal color vision. See W.A.H. Rushton, "Visual Pigments and Color Blindness," *Scientific American*, March 1975.

Materials

Munsell 11-chart student set

Sheet of white paper

Knife

Procedure

Select any one of the eleven Munsell charts and the corresponding envelope of color chips. Empty the envelope carefully onto a clean sheet of white paper and count the chips to see if the number corresponds with that on the envelope. Note that in some cases two color chips may adhere to each other, causing you to think that one is missing. Check them carefully before you file a complaint!

Each chip belongs in one of the x-marked locations on the hue chart. Your problem is to position them on the chart so that each x is covered *and* so that the values and the chromas also are arranged in the proper order. A knife blade is useful in picking up the chips to transfer them to the position on the chart. Slip it under the chip with your finger on top of the chip (this way there is less chance of bending the chip).

When you believe all your color chips are properly positioned, check your work with your instructor, or two or three of your colleagues. When you are sure you have the correct arrangement, either replace all the chips carefully in the proper envelope for subsequent use in the same exercise by another colleague or, since we will be using a set of the assembled charts later in Problem 11, cement the chips in place on the chart using the double-coat rubber-cement technique.

Continue this operation until you have arranged the chips on each of the ten hue charts and on the eleventh hue value/chroma chart.

Discussion

It must not be assumed that the use of an alphanumeric system of color notation (such as the Munsell system) is intended as a replacement for the more commonly used names of colors found in the natural language. Any objective system of color specification should be understood as necessary only when we want to analyze color in technical and professional terms (as we do here). The poetic and allusive names of colors are of course most effective in conjuring up subjective associations in the use and appreciation of color. See, for example, the adjacent list; perhaps you will recognize some specially evocative terms in it.

For a little experiment, take any dozen or so of these words and find what you think are examples of them in the Munsell charts. Then compare your identification of each (in alphanumeric terms) with that of several of your colleagues, or with those in A. H. Munsell, *A Color Notation* (Baltimore, Md.: Munsell Color Co., 1967), which is included with each Munsell student set. You will probably discover some interesting individual differences in color images.

Another challenging exercise is to start a collage/mural of color-samples collected from all possible sources in your daily world, and to continue it collectively with your colleagues over a period of time. Swatches of paper, cloth, metal, foil, tree bark, cardboard, paint samples, leather, and so on, all trimmed to about the same size and shape and mounted on the studio wall will provide an enriching enlargement of your color horizons, as well as suggest some of the color nuances that result from the various surface qualities of the samples.

See B. Berlin and P. Kay, *Basic Color Terms: Their Universality and Evolution* (Berkeley: University of California Press, 1969), A. Maertz and M. Rea Paul, *A Dictionary of Color* (New York: McGraw-Hill, 1950), and Kenneth L. Kelly and Deane B. Judd, *Color: Universal Language and Dictionary of Names* (Washington, D.C.: Department of Commerce, 1976).

adobe
alabaster
alfalfa
alice blue
almond
amber
amethyst
apple green
apricot
aquamarine
auburn
azure
beige
biscuit
bisque
blond
bottle green
bronze
buff
burgandy
canary
cardinal
carmine
cerise
cerulean
charcoal
chartreuse
cherry
chestnut
chocolate
cinnamon
citron
claret
cocoa
coffee
copper
coral
cordovan
cork
cornflower
cream
crimson
daffodil
delft blue
dove gray
drab
dun
ebony
ecru
emerald
fawn
fern
flax
flemish blue
flesh
fuchsia
fudge
gamboge
geranium
gilt
ginger
glacier blue
gold
grass green
grotto blue
gunmetal
havana brown
hazel
heather
heliotrope
henna
indian red
indigo
ivory
jade
khaki
killarney green
lavender
lead
lemon
lilac
lime
magenta
mahogany
maize
mandarin
maple
maroon
mauve
mist
moss
mulberry
mustard
navy
nickel
nile green
nude
nut brown
ochre
olive
orange
orchid
pea green
peach
peacock blue
pearl
pecan
peppermint
pewter
pink
pistachio
pitch
platinum
plum
port
powder blue
primrose yellow
prune
puce
purple
putty
raspberry
raven black
red
robin's egg blue
rose
ruby
russet
sable
saffron
sage
salmon
sapphire
scarlet
sea green
seal brown
sepia
shamrock green
sherry brown
sienna
silver
sky blue
slate
smoke
soot
spinach green
steel gray
straw
strawberry
sulphur
tan
tangerine
taupe
terra cotta
toast
tobacco brown
tomato red
turquoise
tuscan red
ultramarine
umber
vermilion
violet
viridian
walnut
wisteria