THE INTERNATIONAL SCIENTIFIC SERIES.

MODERN CHROMATICS,

WITH APPLICATIONS TO

ART AND INDUSTRY.

BY

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WITH 130 ORIGINAL ILLUSTRATIONS.

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MODERN CHROMATICS

(Students' Text-Book of Color) with Applications to Art and Industry

PAGINATION. References in the commentary notes apply to the original page numbers of the Rood book. These numbers are at the top and run from 1 through 329. Numbers at the lower outside corners are the continued pagination of the entire volume.

Rood's book has had the titles shown here. The original edition of 1879 was *Modern Chromatics*. Later, perhaps, because of strong appeal to artists, the title became *Students' Text-Book of Color*. Although in this title *color* was spelled without a *u*, as in America, throughout the text itself the English *colour* will be found.

There is difficulty in trying to determine how many editions and printings were issued. While there are two copyright dates, 1879 and 1881, no editions refer to the number of actual *printings*. Also there is no difference in the text of these 1879 and 1881 editions: both are exactly the same, page by page. Checking various libraries the following title page dates for the American editions have been found: 1879, 1881, 1895, 1899, 1908, 1916, all by D. Appleton of New York.

In Great Britain the first edition of Rood's book was dated 1879, the same year as in America. The title was also the same, *Modern Chromatics*. The publisher in London was C. Kegan Paul & Co. However, at least five more editions were published up to 1910, with the title changed to *Colour, a Text-Book of Modern Chromatics*. The publisher now was Kegan Paul, Trench, Trubner & Co.

In the English language this would mean that Rood's work ran into at least eleven printings over a period of 37 years! This is a remarkable record for a book on color.

The French edition, *Théorie scientifique des couleurs*, is dated 1881 and was published in Paris by Librairie Germer Baillière et cie.

The German edition, dated 1880, had the title *Die Moderne Farbenlehre*. The publisher was F. A. Brockhaus in Leipzig.

Chapter-by-chapter notations and comments now follow for Rood's book. Faber Birren acknowledges the able help of

Ralph Evans in interpreting, in modern terms, some of the more technical aspects. Ralph Evans is a world authority on color. Associated for many years with the Eastman Kodak Company, he supervised color quality control and undertook the development of color processes and the researching of visual effects in photography. His book *An Introduction to Color* has become a general, standard reference source in the broad field of color.

NOTE: Rood's book is largely concerned with light and color. It is interesting to note that it was published in 1879, the same year in which Thomas Edison produced the first commercially practical incandescent lamp. Thus for light sources in his experiments, Rood used daylight or gaslight, as illustrated on page 155 in his book.

Too, the telephone, developed by Alexander Graham Bell around 1877, was hardly in use at the time of Rood's book. Communication at best was slow and time-consuming.

TITLE PAGE AND DEDICATION

The facsimile edition of Rood's book is that of 1879. Let it be remembered that the title was later changed to *Students' Text-Book of Color.*

Dr. Wolcott Gibbs, to whom the book was inscribed, was born in 1882 and died in 1908. He graduated as a chemist from Columbia in 1841 and became a close friend of Rood. During his life, Gibbs was Professor at the College of the City of New York, Professor of Science at Harvard, and dean of the Laurence Scientific School. He made important studies of complex compounds of cobalt and platinum metals. Rood mentions him on page 206.

In the facsimile of Rood's book, the frontispiece has been reproduced in black and white. At the time (1879) photographic halftone process printing had not been developed. Color illustrations were in lithography and were copied by the engraver from an artist's drawing. A true representation of Rood's frontispiece in different and larger arrangement—and reproduced through modern color-process methods—is shown on Color Plate VIII.

> To facilitate reference between the notations included in these introductory pages and the actual pages of Rood's book, circled numbers have been placed in the margins of both. This will aid the reader in shifting his interest back and forth with minimum difficulty.

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PREFACE

Ogden N. Rood was first an eminent scientist and second a: artist of fair merit. What is intriguing about his book is hi constant interest in and references to art. This is what so ir spired the Neo-Impressionists and other painters. As he clearl states in his preface, he wishes "to present in a simple an comprehensible manner the underlying facts upon which th artistic use of color necessarily depends." If this could n make artists out of ordinary mortals, it would at least help keep human attention well directed. He concludes by sayir that he has "devoted a good deal of leisure time to the practic study of drawing and painting." He could understand scien and be sympathetic with art—a rare combination.

—CHAPTER I—

THE REFLECTION AND TRANSMISSION OF LIGH

Rood was a remarkable man with broad knowledge, rare i sight, and exceptionally keen powers of observation. He w one of the leading American physicists of his day, a pioneer the new science of physiological optics—and an artist at hea Most books on the science of color up to his time had conce trated on light and color phenomena as they existed ap. from human experience and sensation. At the very start (pa 9) Rood declared, "the sense of vision can be excited with the presence of light." This introduced a new concept, which, as James Clerk Maxwell, the Scottish physicist, h also stated, "The science of color must . . . be regarded as sentially a mental science."

What no doubt startled the Neo-Impressionists was that the study of color as a *physical phenomenon* associated with radiant energy, wave lengths, and the like held little meaning. What went on inside human consciousness was all-important. And here Ogden N. Rood of America spoke like a prophet.

In his first chapter Rood discusses vision in general and the makeup of the eye. He then talks of light itself in the tradition of Newton.

On page 12, however, and as Ralph Evans has pointed
2 out, distinctions are drawn today between the reflection of an ordinary polished surface (a glazed vase) and polished metal (gold, brass). With a yellow or orange ceramic glazed vase, for example, some diffuse reflection may come from below the surface, and the eye will see the yellow-orange color. The specular highlight, however, may be colorless or a mirror of the light source. With polished metal, such as gold, reflection is from the outer surface only. Here the color of the light source will be affected, reflections on gold being a reddish-yellow.

Subtleties like these were later to interest the Gestalt psychologists concerned with "modes of appearance" for color, a viewpoint not recognized at Rood's time.

In reading Rood's text there are constant references to the artist. His discussion of the colors of sky and water (page 12), while largely empirical, are directly pointed toward the artist.

On page 13 he talks of the reflection of opaque materials, or what the Gestalt psychologists later called *surface* colors. Again, with the artist in mind, he cautions that a white drapery may be many colors, due to the proximity of other colored objects near it, which will cast reflections. On page 14 he describes the effect of yellow light from the sun together with blue light from the sky, a situation in nature that had fascinated Leonardo da Vinci many generations before.

On page 14, "Nature paints always with light, while the artist is limited to pigments." However, both could paint with light, and on this point Rood would have more to say.

3 It is often said that transmitted colors (as seen through glass) are brighter than reflected colors (as from an opaque surface). In most instances this may be true. If a person looks at a spotlight through clear red glass, the red color seen will be far more brilliant than the color that might be *reflected* from a red surface illuminated by the same spotlight. Involved here as well is the difference between *related* and *unrelated* colors to be discussed later. As Ralph Evans points out, the difference between transmitted and reflected light may be "purely a matter of the *relative* intensity of the light reaching the eye." If the transmitted red and the reflected red are balanced as to intensity, the two may well match in a physical sense. However, they may *look* different perceptually. Red light on a white surface, white light on a red surface, and white light shining through a piece of red glass or plastic conceivably could be made to match as to hue, purity, luminosity, brightness, and the like, but there would be three quite different *appearances*. Modern studies of the psychology of perception have dealt with phenomena such as this. Many visual sensations, alike to the physicist, may well be unalike to human experience.

—CHAPTER II—

PRODUCTION OF COLOUR BY DISPERSION

This is a fairly technical chapter. In it Rood goes over the dispersion of light, repeating the prism experiments made famous by Sir Isaac Newton. While artists have little need to be interested in wave lengths, the Neo-Impressionists were probably enlightened to be told that the pure spectrum of light extended from red, through orange, yellow, into green, blue, and violet, but contained no purple.

Regarding the mathematics of color, the Fraunhofer lines mentioned by Rood (pages 20, 21, 22, 25) are today given by
the scientist in terms of nanometers (*nm*), one nanometer 4
equaling a millionth of a millimeter. Thus Rood's Fraunhofer lines on the chart on page 21 and table on page 22 can today be stated in nanometers as follows:

A (red) = 759 *nm*	E (green) = 527 *nm*
a (red) = 720	b (green) = 517
B (red) = 687	F (blue) = 486
C (orange-red) = 656	G (violet-blue) = 431
D (orange-yellow) = 589	H (violet) = 410

In dividing the spectrum into 1,000 parts (pages 21, 22, reference ④) Rood embarked on an arbitrary but highly significant approach to color organization. This suggested a decimal system of color notation and probably influenced Albert H. Munsell, who studied Rood's book, corresponded and met with him, and carried out many of the experiments described by him. Munsell's eventual color solid was based on a decimal system and used color-wheel measurements that Rood set forth and credited to Maxwell.

The colors of the spectrum were not evenly divided in terms of human, visual perception. The eye, in effect, saw spectrum colors in terms of bands. As on page 22 and using 1,000 as a total, blue and blue-violet occupied the largest space (311), followed by space for violet (194), red (149), with least space occupied by yellow (10). Here Rood took the innumerable wave lengths of light and noted that in terms of human sensation, spectrum colors were not infinite in number but fell into bands or groups. (Rood gives this two interpretations, page 22 and page 24.)

Finally, on page 28 in Chapter II, Rood cautioned that in a normal spectrum "we found no representative of purple." He promised to explain later the existence of "other possible tints and hues," plus "the whole range of browns and grays."

—CHAPTER III—
THE CONSTANTS OF COLOR

5 By *constants*, Rood was referring to what science today calls *variables* or *parameters*. Rood's constants were purity, luminosity, and hue (page 39). These are still recognized today, but may be given different names. *Purity* referred to "the sense of freedom from white light" (page 39) in a color. *Luminosity* referred to "the relative brightness of the colours of the solar spectrum" (page 33). Rood considered this dimension to present a fascinating problem. *Hue* referred to the factor of dominant wave length that distinguished red from yellow, blue, green, violet, etc. On the matter of *luminosity* he presented a table (page 41), noting in connection with it that "the total luminosity of the warm colours will be rather more than three times as great as that of the cold colours."

The Optical Society of America has this to say about color dimensions: "The dominant characteristics of light are dominant wave length, purity, and luminance. They correspond in a very general way to hue, saturation, and brightness which are the attributes of color sensation."

Artists refer also to purity and luminosity (but with different meanings from those of Rood), plus intensity, saturation, tint, shade, tone, and many other nouns. To Munsell, there are hue, value (brightness), and chroma (saturation). As to Rood's *luminosity*, Munsell in measuring his dimension of chroma used the color-wheel and noted, as Rood did, that high percentages of cool colors were required to cancel or balance low percentages of warm colors.

There is not a great deal in this chapter of interest to artists. Rood tells of experiments in which white light is added to colored light to effect matches with surface colors. He continues to refer to the artist and to concepts of such terms as *purity* (page 32), *luminosity* (page 33). Much of this, however, is quite complex. Few artists would care to experiment with mixtures of light, no less concern themselves with the physical (not visual) aspects of color.

Yet when Rood takes up the matter of disk mixtures
(page 34) his technical points get closer to problems that con- 6
cern art—and Neo-Impressionism. Ralph Evans observes that "Grassmann's assumption" (page 35) is usually called "Abney's law." Rood's work was an early check on the validity "that the total intensity of the mixtures of masses of different coloured light is equal to the sum of the intensities of the separate components." This idea of totality in color (components always equaling unity) was to be employed again, but in other ways, by men such as Ewald Hering and Wilhelm Ostwald.

By endeavoring to measure his "constants," Rood laid the
groundwork for systematic color order and (page 41) was able 7
to assume that hues which were varied "by the addition of dif-

ferent quantities of white light" could lead to distinguishable tints "as high as two million." This is debatable today, the physicist getting down to fine points and insisting on high numbers, the psychologist and practical worker with color insisting that the human eye and brain struggle to see few rather than many color variations—probably in the order of 30,000 or less.

—CHAPTER IV—
PRODUCTION OF COLOUR BY INTERFERENCE AND POLARIZATION

This chapter again deals with the physical aspects of color. Rood writes at some length of the beauty of colors produced by the polarization of light. On page 44 he describes and illustrates a polarizing apparatus that makes use of a Nicol's prism. For the reader's information, ordinary light emits waves that vibrate in all directions (like water spray from a shower head). Where light is polarized, only waves vibrating on one plane are admitted; waves in other planes are blocked out.

Rood describes the effects of polarized light in eloquent terms. They are like "the most intense sunset hues . . . the spots on a peacock's tail, glowing like coals of fire." Good materials to experiment with were crystals of tartaric acid, thin layers of selenite, common sugar. He writes, regretfully (page 48), "In ordinary life the colours of polarization are never seen; the fairy world where they reign cannot be entered without other aid than the unassisted eye."

Rood would have been pleased to know that, years later, Edwin D. Land would succeed in creating plastic film that did the work of Nicol's prism. The product was called Polaroid, and it was economical in cost. Polaroid soon was used for sunglasses, camera filters, optical and photometric equipment—and then for psychedelic slides!

In so-called light shows these days, discotheques, the electric circus, polarizing crystal slides are commonly found. In these slides are bound a basic glass-mounted crystallized organic chemical, a wrinkled film of clear plastic, and a film of Polaroid. This is then projected on a screen. In front of the projector is another film of Polaroid which is slowly revolved. Although the materials of the slide itself may be colorless, in the procedure just described there is a fantastic display of brilliant spectral color that *moves and shifts* both weirdly and spectacularly. The patterns seen may resemble frost on a window pane—but in rainbow hues. What was once, in Rood's day, a laboratory novelty, is now part of a modern age of color.

Rood ends Chapter IV with notes on colors produced by interference and diffraction—colors as seen in thin layers, such as oil on water, peacock feathers, the wings of some butterflies and beetles—and on the soap bubble "which displays every colour which can be produced by polarization" (page 50).

What would have intrigued Rood today are phenomena associated with what are called liquid crystals. These are highly sensitive to temperature changes and will change color accordingly. Perhaps the reader has seen (or purchased) a novelty called "Touch me" which looks like a coaster and has a clear center disk filled with a liquid crystal. As this is touched, pressed, twisted, the colors change like a molten mass of yellow, green, blue, violet. In medicine, and because of extreme sensitivity to heat, liquid crystals coated on the body can be used to detect certain forms of cancer, skin tumors, arthritic joints, muscular irritations. As an art form they may one day be applied to abstract paintings or plastic forms, shifting in color as they are exposed to changes in heat, or as they are touched by the art patron.

—CHAPTER V—
ON THE COLOURS OF OPALESCENT MEDIA

In reading Chapters IV and V, Ralph Evans suggested the following: "Perhaps a general note might be in order to the effect that the observations in Chapters IV and V are correct but that the explanations have been found to be considerably more complex than he [Rood] thought. The explanations include, among others, the subjects of colloidal particles, selective scattering, resonance phenomena, and metallic reflection, none of which were known at that time. They are to be found in the difficult subject of 'physical optics.' "

Because in this tribute to Rood the chief concern is with art, with Impressionism, Neo-Impressionism, and schools of color that came later, it is perhaps best to place emphasis on Rood's remarkable insight, his experiments and empirical observations, and his constant references to painting and painters.

In Chapter V, Rood took up phenomena which have intrigued artists as well as scientists. Some artists, for example, have attempted to simulate opalescent effects with pigments. Opalescence, of course, is not due to the reflection or transmission of colored materials, but to the "selective scattering" of light—with no pigments involved. Yet the beauty of opalescence has and can be convincingly duplicated by the resourceful artist.

On page 56 Rood discusses the bluing effect encountered
9 with black- and white-pigment mixtures. A thin coat of white may appear bluish on a dark ground. And black added to yellow will form an olive-green (page 57). This might well introduce ugliness in a painting—and the bluing effect would be untrue to nature. Pigment mixtures with black did not produce the same result as color-wheel mixtures (page 57), "showing that the blue hue is not, as many suppose, inherent in the black pigment." Any artist would profit from this.

He ends with color phenomena associated with "minute suspended particles," the beauty of sunrise and sunset, which has inspired more artists than any other of nature's wonders.
10 He offers a beautiful description of light changes in nature (pages 59, 60, 61), touches on aerial perspective (the graying effect of distance). On page 61 he lists the colors of sunset: yellow, orange, red, purple, violet-blue, gray-blue.

One wonders why he did not include pink, which Evans mentions is "the simple additive mixture of the yellow-red from the sun and the blue of the sky." And how about lack of mention of green? An artist should know that in a sunrise or a sunset, as yellow blends into blue, *in light*, green is not formed. If with watercolors, oils, or pastels, the artist includes greens in a sunset because yellow and blue mix this way, he is portraying a visual untruth.

—CHAPTER VI—

PRODUCTION OF COLOUR BY FLUORESCENCE AND PHOSPHORESCENCE

If Rood had written this chapter today, it no doubt would have been longer than a mere two and a half pages. Fluorescence
(and to a lesser extent, phosphorescence) is very much part of 11
the modern world. These days fluorescent materials are commonly available in papers, textiles, paints, dyes, plastics, chalks, crayons, posters, "invisible inks."

Fluorescent substances exist everywhere in nature, in chemicals, minerals, metals, liquids, glass, even foodstuffs. First, there is the use of "black light," long-wave ultraviolet (UV). In night club, cocktail lounge, studio, theater, discotheque, with ordinary lights off and UV lights on, the surround is weirdly and compellingly luminous with color. Fluorescent paints, posters, textiles shine vividly and, esthetic or not, represent an uncommon experience.

Second, with ordinary lights and UV lights alternating, different colors can be made to appear (or disappear) on the same object. Works of art that are virtually colorless with ordinary lights on, will reflect red, orange, yellow, green, under UV light.

Third, daylight fluorescent colorants are now on packages, displays, billboards, magazine pages. There are reds, oranges, yellows, greens, brighter and more saturated than ever seen before. Many artists have featured fluorescent paints.

In fluorescence it is assumed that the ultraviolet component of a light source (invisible to the eye) is converted to radiant energy that becomes visible. This probably is only part of the story, for the phenomenon is quite involved and has several aspects. What is obvious, however, is that fluorescent colors are "brighter than bright" in that certain hues which formerly seemed to have a maximum purity (in average light) now are transcended and are more like luminous sources than like mere reflecting ones.

—CHAPTER VII—
ON THE PRODUCTION OF COLOUR BY ABSORPTION

On page 65, Rood mentions that his previous chapters were largely concerned with a "scientific point of view." With colors produced by absorption (selective transmission, as with glass or watercolors, or selective reflection, as with opaque materials) he came closer to the mediums of the artist. The first pages of this chapter are of technical or academic interest only. There is little value to an artist in the physical nature of color or in spectroscopy.

(12) On page 71, Rood observes that when transparent colors are seen in different thickness, there will be color change. A thin layer of yellow glass, for example, will be seen as yellow, but subsequent layers of the same yellow will form orange in transmitted light. Even more layers may produce red. A liquid solution of chloride of chromium may appear green in thin solution and dark red in thick solution. Transparent watercolors were likely to produce similar results. (Many years before, Goethe had made the same observation by studying the appearance of white at different depths in tanks of dyed liquid.)

It may be that Rood's scientific explanations would need revision today, but the empirical facts were there and were worth regarding. Then on page 73, he remarks that transparent colors (glass) have a high degree of luminosity, whereas pigment colors "appear feeble and dull, or pale." As has previously been stated (see comment ③), transmitted colors and reflected colors would probably be the same if the same amount of colored-light energy reached the eye. Rood in his day did not recognize the distinction between *related* and *unrelated* colors (nor did the great Hermann von Helmholtz in his masterful book *Physiological Optics*, 1867). When a person looks at transmitted light (unrelated) it usually will be seen in a dark environment. If such light gets bright or dim, the eye will adapt and adjust itself accordingly. Yet when opaque colors are seen, the condition is one in which the general surround is fixed and there is little or no eye adjustment. (The color is *related* to its environment.) To give a simple example, sitting in a dark room, an orange light will remain orange in sensation whether it is bright or dim, for the eye will accommodate itself to all luminous differences. Thus unrelated colors usually appear pure in hue and are not likely to have black in them. Sitting in an illuminated room, however, black paint added to orange paint will form brown, for the light in the room will hold the eye to a stable adjustment. Some black content, as Ostwald observed, nearly always exists in surface or opaque colors. Here, fluorescent colors would be excepted.

Black seems to be a negative factor with unrelated colors and a positive factor with related colors.

On pages 77, 78, Rood comments on certain visual qualities encountered with pigments and on differences found with pastels, oil paints and watercolors, facts which most artists understand. Lighting was significant: "Almost any surface looks beautiful if very brightly illuminated."

Beginning on page 78, Rood comments on the different visual qualities of fabrics, of silk, wool, cotton. "Coloured light (13) which is reflected from silk is more saturated or intense." There are pertinent observations on the "colour of water . . . and of vegetation" (page 81). Here his excellent powers of observation would surely hold vital meaning to an artist, He writes of skies, lakes, vegetable matter, and how they appear under various conditions. Chlorophyl in plants reflected colors, which green paint did not, a fact later confirmed. Were the leaves of a tree green? "Under the red light of the setting sun foliage may assume a red or orange red hue" (page 83). Painters of the school of Fauvism were to see this, whether or not they had studied Rood's book.

In his remarks on photography (page 86) Rood was frustrated by the fact that the photographic materials of his time were based on silver, which was sensitive mainly to blue and ultraviolet. As Ralph Evans notes, sensitizing dyes for the other regions of the spectrum were not discovered until later years.

Finally, his Appendix (page 88) in which he lists pigments and their resistance to the action of light no longer applies, except in small part. Progress in the formulation of new colorants has since been substantial.

—CHAPTER VIII—
ON THE ABNORMAL PERCEPTION OF COLOUR, AND ON COLOUR-BLINDNESS

A vast fund of knowledge on color blindness has been accumulated since Rood's time. Important findings will be found in the writings of Deane B. Judd of the United States and W. D. Wright of Great Britain. What Rood had to say on the matter was good for his time, and his descriptions of color-blind individuals are essentially correct.

14 In this chapter, Rood once again reveals his powers of observation and his diligence in conducting experiments related to vision. On page 92 he begins a discussion of what Aristotle centuries earlier had referred to as "the flight of colors." After looking at a brilliant white surface or light source, subjective afterimages will be seen. These may be positive or negative in character. With the aid of black and white disks (page 93) color effects can be stimulated.

That vision is as much in the brain as in the eye is well confirmed these days. Edwin D. Land, inventor of the Polaroid camera, demonstrated a few years ago that by combining two projected black-and-white photographic images on a screen, through a clear and a red filter, colors such as blue and violet could be perceived—even though no blue or violet wave length existed in the light sources used to project the two images. (See *Scientific American*, May, 1959.)

Equally startling are the results of taking psychochemicals such as LSD. Under their effects a world of brilliant, luminous, and flowing color is experienced. Rood would have been fascinated. Through the taking of hallucinogenic drugs has come a school of psychedelic painting in which abstract and fanciful forms are seen and recorded. In recently popular discotheques an attempt was made to create psychedelic experience, without drugs, by pounding the senses with projected lights, mobile color, motion pictures, polarizing slides, stroboscopic flashes—plus sounds amplified to stentorian and often nerve-racking excess.

Rood's reference to Hugo Magnus on page 101 is of passing interest. Studying language as a key to color perception, Magnus concluded that the color sense evolved within the span of recorded history. However, if man in his early writings had few words for color, what he expressed in his art was clear enough; what he saw centuries ago is definitely the same as he sees today. Curiously, the eminent William Ewart Gladstone, prime minister of Great Britain, in analyzing the Homeric poems reached the same erroneous conclusion as Magnus.

—CHAPTER IX—
THE COLOUR THEORY OF YOUNG AND HELMHOLTZ

Ogden N. Rood introduced the Neo-Impressionist painters to celebrated scientists such as Sir David Brewster, Thomas Young, James Clerk Maxwell, and Hermann von Helmholtz. He inspired them to spin colored disks and to note that the results with them were not the same as with the mixture of pigments. This surprising fact turned the views of the artists from paints to lights and led to a wholly original school of color expression. Brewster's theory that the primaries were red, yellow, and blue, gave way to the triad of red, green, and blue (ultramarine) championed by Young and Helmholtz, and to the assumption that nerves in the eye responded primarily to these three hues. Ralph Evans considers Rood's presentation of the Young-Helmholtz theory excellent (page 115). Evans notes, however, that "the concept of absolute primaries as such has pretty much been abandoned." The fundamental curves, which Rood shows on page 114, must be liberally rather than literally accepted.

15 Beginning on page 110, Rood talks of the mixture of colored *light* and demonstrates methods of experimentation. The Neo-Impressionists took note of this and soon developed theories and techniques (divisionism) of their own. Yellow and blue formed green in pigments, but with disks they formed "yellowish grey" or "reddish grey." In lights themselves, "Helmholtz proved that the union of the pure blue with the pure yellow light of the spectrum produced in the eye the sensation, not of green, but of white light" (page 112).

It is probably not necessary to go into Rood's many details (pages 115–121). While his book was written before the days of process printing, the reader may profit from knowing that today the primaries of light (red, green, blue-violet), in the form of transparent filters, are, in order, used to make the plates for cyan (blue-green), magenta, and yellow printing inks.

Rood ends his chapter with a prejudiced note about green that seems to be shared by many artists. Green was "troublesome to handle." When it was pure in quality "it becomes at once harsh and brilliant, and the eye is instantly arrested by it in a disagreeable manner" (page 122).

—CHAPTER X—
ON THE MIXTURE OF COLOURS

This is one of the most important of all chapters in Rood's book and one that brought excitement, enlightenment, and glee to the Neo-Impressionists. For a review of fundamentals, Rood clearly established the fact that, with pigments, red (magenta), yellow, and blue (cyan) were primary, while with light, the primaries were red, green, and blue or blue-violet (ultramarine). What he did not appreciate at the time, but which came to his attention later, was that a third set of primaries existed, these being in the visual and psychological realm. At the end of his book (page 324) Rood has a note on a theory of color then recently proposed by Ewald Hering (ca. 1878), a German psychologist. Hering assumed that through a process of "assimilation or dissimilation" the nerves of the eye responded to white (and black), red, green, yellow, and blue. In effect, there were four psychological primaries, red, yellow, green, blue. If Hering's theory has not been confirmed or accepted to explain the mystery of color vision, his concept of four primaries in vision is today admitted.

In the opening pages of Chapter X, Rood discusses mixtures of colored lights. With tables (page 128–130) he lists the results of different light combinations. All this is still quite in order.

He then proceeds to "another method of mixing coloured
16 light. . . . We refer to the method of rotating disks" (page 130). If Rood had known better of the work of Ewald Hering he would not have assumed that colors mixed with lights were precisely the same as colors mixed visually on color wheels or through the optical diffusion of small dots of paint.

To explain. If 60 units of red light are cast upon a screen, and if 40 units of green light are superimposed, the brightness of the resultant yellow will equal 100 units. Here the two sums add up. However, if a visual disk-mixture of 60 per cent red and 40 per cent green is spun, the resultant color will have a brightness of only 50 units. Here the two percentages are averaged.

In defense of Rood, what is significant here is that light mixtures and color-wheel mixtures bear resemblance to each other, and differ essentially from pigment mixtures. The Neo-Impressionists were being properly directed. Rood describes color-wheel effects in some detail (pages 131–136) and gives credit to Maxwell for the method. He shows how visual mixtures of complementary hues can be made to match combinations of black and white.

Then at the top of page 140 he makes one of the several
brilliant statements for which his book came to be revered. 17
"We refer to the custom of placing small dots of two colours very near each other, and allowing them to be blended by the eye placed at the proper distance." When he adds that "The results obtained in this way are true mixtures of coloured light," he overlooks that fact, mentioned above in notation (16) that while light mixtures are additive, visual mixtures on a color wheel or through dots are medial. If complements in *lights* form white, on disks they will form gray. Evans remarks, "It is, of course, impossible to produce a true white by juxtaposed complementary dots as long as they are seen against the white background." The Neo-Impressionists had to expose some of Rood's statements to trial and error.

On page 140, Ruskin is quoted on the practice of English painters such as Turner and Constable of "crumbling" their paints—dragging two or more colors over the surface without a thorough mixture of them. Monet was a master of this.

On page 141 he refers to situations in nature "not much used by physicists." Where blue sky and orange sunlight may simultaneous exist within a scene, the colors of objects will naturally be modified. It takes the sensitive eye of the painter to observe this and to include it in his art.

When Rood discusses the effects of colored light shining 18
on colored (pigment) surfaces (pages 149–158) he again

would have profited from the observations of later psychologists. When he studied the results of shining colored light on colored surfaces, as in the illustration on page 155, he did so under conditions in which *the area seen was isolated from its environment.*

In what is known as color constancy, colored areas will *tend* to appear normal under radically different conditions of *general* illumination, if such illumination pervades the larger field of view. For example, looking into an area of white enclosed within a box (such as figure 63, page 155), if red light is introduced through an aperture, the white spot will, of course, be seen as red—which indeed it will be. However, if in an open room, an area of white is placed amid areas of other surface colors—red, green, blue, or anything else—and if the room *at large* is showered with red light, the white area will persist in appearing white, despite the fact that it actually reflects red light. This is color constancy.

Thus Rood's tables on pages 152–154 hold true only if the areas viewed are isolated. Color effects in which the phenomenon of color constancy is capitalized and in which colored illumination is *implied* with pigments have been treated in Faber Birren's *Creative Color*. Here a visual art, as in Neo-Impressionism, is extended to a perceptual art in which brain functions supplement optical ones.

—CHAPTER XI—

COMPLEMENTARY COLOURS

The Neo-Impressionists were quite serious about the matter of complements. Because of Rood, and because of the newly developed divisionist technique, light complements rather than pigment complements deserved attention.

(19) Complements, of course, are not invariable; if they happen to be absolute and to form gray under one condition of illumination, hue adjustments may be necessary for other illuminations. Rood points this out on page 173 in referring to gas-light. (Incandescent and fluorescent light was not yet available.) What Rood has to say holds true mostly for daylight. On page 170 he advised the reader to construct disks and what pigments to use for them (Appendix, page 178).

The matter of complements would be discussed later in Chapter XV.

—CHAPTER XII—

ON THE EFFECT PRODUCED ON COLOUR BY A CHANGE IN LUMINOSITY, AND BY MIXING IT WITH WHITE LIGHT

Of this chapter, Ralph Evans notes, "The modern reader will be surprised to learn that not much more is known about this subject today than what Rood has included here." This is quite flattering.

(20) Due to the phenomenon of color constancy previously mentioned in notation (18) color changes brought about by different intensities of illumination have only minor interest to the artist. He may do his painting under daylight, and his canvases may be seen under artificial light. A few of the old masters (notably Georges de La Tour) did compositions that appeared to be illuminated by candlelight—even when the viewer saw them in full daylight.*

It is quite true that pigments mixed with white or black tend to shift in hue, but here much will depend on their tinting characteristics. Surface colors seen under bright light may also appear to have their hues shift when the light level is reduced. In empirical observation, bright light on surface colors tends to shift them toward yellow; under dim light the shift will be toward blue and violet.

Rood's explanation of such phenomena is most involved and of doubtful value to artists. Yet at times he takes the painter's view: In the painting of moonlight landscapes, "the best of them are very decided as to the prevalence of various shades of blue, greenish-blue and violet-blue" (page 187).

He mentions the Purkinje effect, in which, under dim light, blue may appear brighter than red (page 189). Recent studies (of which Rood seemed unaware) further emphasize that as light goes dim white will continue to appear white (it holds its "constancy"), while all other colors and degrees of brightness will tend to blend together and appear like black or near-black.

A gray scale, for example, will have clearly defined steps from white down to black when seen in full light. In very dim light, while white will still be seen as such, the rest of the gray scale will tend to blend together and to appear almost uniformly dark. Curiosities like this dramatize wide differences between color as sensation and color as light energy.

—CHAPTER XIII—

ON THE DURATION OF THE IMPRESSION ON THE RETINA

Rood writes (page 202), "The sensation of sight is always prolonged after the light producing it has ceased to act on the eye." (Edison's Kinetoscope, based on durations of impressions on the retina, did not reach the public until 1893.) In this chapter Evans praises Rood for the early role he played in interesting later workers in a method known as flicker photometry which led to data related to the Standard Observer in colorimetry.

21 While much of the chapter describes methods of studying retinal duration effects, Rood, as almost always, has something to say to the artist. Ocean waves under sunlight (page 207) resemble streaks, whereas they are indeed moving "round images of the sun," elongated by their motion. Similarly involved are turning wheels that appear transparent, running animals whose legs are only visible when "their motion is being reversed." An artist could portray this much better than "the less discriminating photograph."

—CHAPTER XIV—

ON THE MODES OF ARRANGING COLOURS IN SYSTEMS

22 Mention was made in the introduction that in 1892 Rood published a paper *On a Color System* and used colored paper disks spun on a color wheel to organize his thoughts. He begins Chapter XIV with the observation that there are colors to be seen by the eye that do not exist in the spectrum, such as brown. Without realizing it he was distinguishing between related and unrelated colors previously discussed in comments ③ and ⑫.

The physicist is often inclined to look upon color as color and to neglect or avoid psychological implications. In what is called *adaptation*, the sensitivity of the eye increases with decreased illumination. If brown does not exist in the full spectrum of light, it most certainly does exist as a *sensation*. A brown swatch of paint with a brightness (in foot-lamberts of 5) if seen in an illuminated room (where colors are related) would not *appear* the same as an area of reflected or transmitted orange light having the same brightness, if it is seen in a dark room (where colors may be unrelated). In effect, equal *facts* of color in the physical sense do not assure equal sensations and equal perceptions. Color constancy also plays a part in this strange but remarkable state of affairs. (See comment ⑱.)

Rood was not aware of adaptation or color constancy when, on page 210, he talks of red taken into a dark room (where visual adaptation would change) and red reduced in "luminosity" by spinning a proportion of black with it on a color wheel (where adaptation would probably not change). There is a world of difference between these two situations. With most of Rood's experiments with color-wheel mixtures it must be assumed that he conducted them in average light.

On page 214 he begins to shape up a color system or color solid by placing 12 spectral hues about an equator and scaling them toward a white center (figure 94).

When "we now diminish somewhat the luminosity of our spectral colours" by introducing black, he formed what could be called shades.

Then on page 217 he put two cones together, one reaching up toward white from a circumference of pure hues, and 23
the other scaling down toward black. With confidence he states: "In this double cone, then, we are at last able to include all the colours which under any circumstances we are able to perceive."

Albert H. Munsell studied Rood's book and met Rood in person. He undoubtedly was influenced (a) to use a decimal system of notation, (b) to try to compromise light and pigment and visual primaries with five base hues, (c) to develop sequences and scales through the use of disk and color-wheel mixtures, and (d) to regard, as Rood did, the fact that to keep "luminosity" (or what Munsell called "chroma") in balance warm colors like red were "stronger" than cool colors like green.

According to Munsell's own diary, he made twirling models of two triangular pyramids and applied colors to two tetrahedrons, which he had constructed. Both forms had been conceived by Rood. (In the sphere that he eventually designed, Munsell acknowledged the previous concept of Philip Otto Runge, a German contemporary of Goethe, who had written and illustrated a monograph, *Die Farbenkugel,* in 1810.)

Rood's concept was a great deal like that of Ostwald, who also created a double cone. However, where Rood had "constants" in luminosity, wave length, and purity (page 210), and where Munsell had hue, value, and chroma, the Ostwald system was based on full color, white-content, and black-content. With little question, Munsell developed what later became the best possible system for color identification, while Ostwald's concept (based on principles set forth by Ewald Hering) is better liked by artists as being closer to psychological factors in vision. (Comparisons of the two systems can be made in books edited by Faber Birren and published by Van Nostrand Reinhold in 1969: Munsell, *A Grammar of Color;* Ostwald, *The Color Primer.*)

On page 220 Rood describes what is generally known as the Maxwell Triangle. This is illustrated in black and white on page 221 and *is in full color in Rood's frontispiece.* (For reasons unknown, the colors on the angles of the triangle on page 221 and on the frontispiece do not have the same order. The engraver or printer must have misinterpreted Rood.)

The Maxwell Triangle is based on mixtures in light of
(24) spectrally pure red, green, and blue. (See also comment ⑮.) The discussion that follows in the Appendix—pages 224 to 234—would be of small interest to artists, being much involved with Rood's personal concepts of color order. The Maxwell Triangle, duly refined, has become basic to an international colorimetry system.

—CHAPTER XV—

CONTRAST

This generous chapter by Rood meant prophesy and gospel to the Neo-Impressionists. It dealt with afterimages, alternate and simultaneous contrast, brightness contrast effects, color circles, true complements, colored shadows, the influence of backgrounds—phenomena that were close to the heart of the painter and that needed to become an intimate part in his expression.

Just about all the experiments described by Rood could, with little difficulty, be repeated by any average person. Anyone could do more than believe what Rood said—he could literally see for himself.

He begins Chapter XV with the simple device of illustrating that a small square of red paper will appear less brilliant on a similar red ground than on a contrasting green ground. To the artist: "We can actually change colour to a considerable extent without at all meddling with it directly" (page 235).

As to afterimages and successive contrast, when the eye (25)
is exposed to an area of color for short lengths of time and the attention then transferred to another area, a complementary image will be seen. These are negative afterimages. (Positive images were referred to in comment ⑭.) Apparently as certain nerves on the retina of the eye are tired by the excitation of a particular hue, the unfatigued nerves, sensitive to the complementary color, will go into action. Explanations are unimportant. On a gray ground the afterimage of green will be rose (page 236). Red "will give rise to a greenish-blue image, blue to a yellow, violet to a greenish-yellow" (page 237). (Rood's complements are diagrammed on pages 246 and 250.)

In "more complicated" cases, where other colors were substituted for the gray ground, more interesting effects were to be seen. A green afterimage on yellow would produce an orange (page 238). Here the red afterimage of the green, being red, would mix with the yellow ground to form orange. Such mixtures, though visual, were subtractive in nature, and artists could relate them to actual pigment mixtures.

Where a black square was held on a red ground and then removed (page 239) the afterimage of the space occupied by the black square would appear quite saturated, while the larger red area would appear comparatively dull "as though gray had been mixed with its colour."

These were examples of successive contrast. An understanding of them was vital to any artist—and the Neo-Impressionists were quite aware of this.

26 Regarding simultaneous contrast, on page 243 Rood properly credits M. E. Chevreul for "his great work on the simultaneous contrast of colours." (An English reprint of Chevreul's masterpiece, with annotations, is listed in the references of the introduction, page 60.) Where, for example, a gray pattern was placed on a hued ground such as green, the gray would take on a complementary tint of red. Complementary effects would be as charted on the figures of pages 246 and 250. To verify Chevreul's findings on simultaneous contrast it was to be noted that effects were best (a) when the ground hue was saturated, (b) when the ground hue completely surrounded and was larger in area than the pattern or surface being contrasted, (c) when the two colors were side by side or placed one upon the other. In Chevreul's work he further noted that effects were at a maximum where *brightness contrast was low*. In effect, simultaneous contrast with light and dark colors was not as dramatic as with colors of similar or equal value (brightness).

On page 245 (after Chevreul) Rood lists changes to be seen in simultaneous contrast. To select one simple example, red on yellow becomes purplish (the blue afterimage of the yellow mixing with the red), while the yellow becomes greenish (the green afterimage of the red mixing with the yellow). Exact complements caused no hue change but added intensity to each other.

27 Colors close to each other in hue tended to dull each other, while complements tended to enhance and brighten each other. "It is evident in general that the effect of contrast may be helpful or harmful to colours: by it they may be made to look more beautiful and precious, or they may damage each other, and then appear dull, pale, or even dirty" (page 251). Let the artist be aware of this.

Rood's contrast-diagram on page 250 (also on page 293) became law to some of the Neo-Impressionists. An exact copy of it, with the color names in French, was found among Seurat's possessions after his death.

28 Colored shadows. There is cause to wonder why Rood in his book made no reference to Goethe. Rood spoke and wrote German fluently and spent much time in Germany. Goethe's *Farbenlehre* was published in 1810, and an English translation by Charles Lock Eastlake, an eminent art authority, was issued in 1840. Goethe was world famous as a poet and devoted a number of years to the subject of color. One must conclude that Rood could hardly *not* have known of Goethe's work, but as Goethe bitterly disputed Newton and physicists in general, Rood probably passed the *Farbenlehre* aside as too empirical and unscientific.

Goethe undertook classical experiments with colored shadows, which Rood, beginning on page 254, more or less repeated. (Others had also been intrigued, including Helmholtz.) With a white background softly illuminated with white (daylight) or near-white light, the shadow cast by an object which in turn is lit by a spot of colored light coming from another direction will take on a hue that is complementary to the hue of the latter light source. (See Figures 121, 122, 123, pages 254–256.) A yellow candle-flame will appear to cast a blue shadow. With the background still illuminated by a white or near-white light, a red beam will cast a green shadow, a blue beam will cast a yellow shadow, a green beam will cast a pink shadow. The illusion is quite startling and has never been satisfactorily explained. Artists needed to know about colored shadows. Orange dusk will cast blue shadows on snow. Shadows, in effect, should be complementary, both to the tint of the light source (if it has a tint) and to the object itself. Painters of the Fauve school would later show green shadows on pink faces and red shadows from green leaves, with striking results.

29 With other contrast effects, on page 260 Rood describes a unique experiment attributed to H. Mayer. If a square of gray is placed within an area of strong color, the two areas will at first appear as such. But if a semi-transparent sheet or film is placed over the entire field, the gray square will now appear as if tinted with the complementary hue of the background. As

advice to the painter (page 262), "Saturated or intense colours in a painting have less effect on white or grey than colours that are pale." Whites and grays in a painting were likely to appear tinted when surrounded by chromatic hues. Strong effects of contrast needed large areas to influence the appearance of small areas.

Simultaneous contrasts tend to make weak colors look weaker and strong colors stronger when they are side by side (263). On pages 265, 266 Rood has much to say to the painter about the colors of distance in a landscape, "large masses of foliage," willow trees "agitated by the wind." These paragraphs can be read to great profit just as they are presented in Rood's book and do not need repeated notation here.

In brightness contrast, where areas of gray are placed
30 against each other, as in flat tones of a gray scale, the edges will be strongly influenced. The edge of the darker color will look lighter, and the edge of the lighter color will look darker. Flat strips of gray tend to appear fluted (page 268). These edges, which seem shaded, are known today as Mach bands, after Ernst Mach who noted them years ago. For the artist, when "mountains rise behind one another, the lower portions of the distant ranges [appear] lighter than the upper outlines." A sky seen at horizon may look brighter than the sky overhead (it sometimes is, however) because of contrast with the dark earth. A red on a white ground will appear darker (page 270); on black it will become more luminous. Other colors will be similarly influenced.

—CHAPTER XVI—

ON THE SMALL INTERVAL AND ON GRADATION

If, in relatively *large areas*, adjacent colors tend to dull each
31 other in simultaneous contrast, and if opposite colors tend to intensify each other, where such combinations are optically mixed or blended quite contrary results may be encountered. Now Rood gets down to important points that greatly concerned the Neo-Impressionists and the divisionist technique. Chapter XVI is another one for the artist to read in its entirety.

As set forth on page 275, similar colors will blend harmoniously with each other, while opposite colors, if blended, may produce "a strange and often disagreeable effect." Rood proceeds to give a few examples of this in nature, referring to sky, grass, water. Nature creates infinite variations of color. Even a sheet of white paper (page 277) needs to be portrayed "by delicate gradations of light and shade and colour."

Long training might be required to comprehend the beauties of nature. As great effects in oratory required modulation in tone (page 278), so did art require modulation in color. Turner was particularly famous here.

On page 279, Rood again takes up the matter of visual
mixtures of color. Let the reader also refer to pages 139, 140, 32
and to comment ⑰. While visual blends correspond to color-wheel mixtures, they are not additive but medial in result. What the Neo-Impressionists came to find out was that opposite colors in small dots, seen from a short distance, tended to appear lustrous. From a greater distance, however, and when the dots could not be held separate, visually, they tended to cancel each other and appear dull. Adjacent or analogous colors, slightly mixed by the eye, also appeared somewhat lustrous; from a distance they retained a certain richness and did *not* cancel each other. Such blending can be seen in sky, water, grasses, and in "minute sparkling grains of sand" (page 281).

In oil painting, visual mixtures lend "a magical charm." With unusual foresight, Rood described the technique that, under his influence, became known as divisionism and distinguished the Neo-Impressionist style: "If the stippling is formal and quite evident, it is apt to give a mechanical look to a drawing, which is not particularly pleasant; but properly used, it has great value, and readily lends itself to the expression of form" (page 282). All this, for example, will be found evident in Color Plates V, VI and VII devoted to paintings by Seurat and Signac. They are formal and mechanical, but they do express form.

—CHAPTER XVII—

ON THE COMBINATION OF COLOURS IN PAIRS AND TRIADS

33 Formal principles of color harmony seem academic today. On page 286 Rood notes that while some color combinations are pleasant, others are not. In his day, most art was supposed to be pleasant and harmonious. The Fauve period, which immediately followed Neo-Impressionism and which was the first new art movement of the twentieth century, changed this. Colors that shocked, irritated, broke with convention were quite acceptable and a decided relief from the niceties that had gone before.

For principles of harmony, Rood credits the great Frenchman, Chevreul. In checking the lists of excellent, good, disagreeable, and bad combinations, hardly anyone these days would be impressed. For example, is vermilion with blue excellent, and vermilion with violet bad? On page 291 Rood writes, "Green and blue, for example, make a poor combination." Op Art has introduced dramatic contrasts of green with blue, red with blue, orange with pink, and few viewers are disturbed.

There is evidence that the Neo-Impressionists respected the counsel of Rood and Chevreul and planned color schemes accordingly. If the paintings of Seurat, Signac, and others are original as to technique, their color arrangements are conventional. The interest was with light and mixtures of light, the esthetics of color harmony being of lesser importance.

Page 293 repeats the contrast diagram of page 250 and is the one copied by Seurat. Rood favored complementary hue combinations, as did the Neo-Impressionists, but even here "some of the complementary colours are quite harsh from excessive contrast." Artists today would not agree with this, having known the freedom of bold expression.

Further prejudice against green is found on page 295. Here Rood considered emerald-green to be a difficult color, and one that "exhausts the nervous power of the eye sooner than light of any other colour." Yet green predominates in nature.

On page 299 Rood brings up the harmony of triads—colors that are separated by an angle of 120° in his contrast diagram (Figure 131, page 293). Triads were found in red, yellow, blue; orange, green, violet; orange, green, purple-violet. Such combinations were quite pleasing and were used by the Neo-Impressionists. Yet again, the idea of triad harmonies seems academic.

On page 301, Rood talks of balance. He states, "It has been a common opinion among English writers on colour, that the best result is attained by arranging the relative areas of the colours in a chromatic composition in such a way that 34
a neutral grey would result if they all were mixed together." Albert H. Munsell later thoroughly agreed with this and, using the color wheel as proposed by Rood on page 303, declared that gray-balancing arrangements of color were necessarily harmonious. To Munsell, harmonies were to be found in the balancing of light and dark values and of complementary or triad arrangements. And if the gray balance was at middle value, beauty was automatically assured. Unfortunately, modern art has rebelled at fixed rules. If beauty was to follow law, then law was open to suspicion. Rood himself (page 303) was wise enough to comment that in "the works of good colourists . . . there is always an excess of some positive colour."

Chapter XVII ends with negative remarks as to possible analogies between colors and sounds. Here Rood differed from many men before and after him. To Rood, color had only one octave; the individual hues in a mixture of color could not be distinguished as could notes in a musical chord; there were no measurable intervals in the wave lengths of color as there were vibrations in music. "Any theory of colour based on our musical experience must rest on fancy rather than fact" (page 304).

Let the reader know that relationships between color and music have been championed (if only in fancy) by such men as Aristotle, Newton, George Field (mentioned by Rood), and painters such as Wassily Kandinsky. Opposed have been Thomas Young, Goethe, Chevreul, Helmholtz. Yet color as color, related to music or not, has in recent years found expression in an independent art called lumia.

—CHAPTER XVIII—

ON THE USE OF COLOUR IN PAINTING AND DECORATION

This is a chapter written for artists by a scientist-artist. It should be read in its entirety by artists, students of art, and students of color. Chapter XVIII, the last one in Rood's book, is largely an essay written by a sensitive and perceptive man. While the power to perceive color was not essential to human life and survival, it added vast pleasure. "The love of colour is a part of our constitution as much as the love of music" (page 305).

In Rood's day, art was primarily concerned with drawing
35 and form. Color was "less important than form." This view, of course, was later rejected when color for the sake of color (independent of form) became the chief fascination of Abstract-Expressionism and Op Art. Color could be pursued for its own sake, having charm, beauty, and deep meaning in and of itself. Abstract art proceeded on its own, free of "representation of natural objects" (page 306).

On page 308 he writes of decorative art and unknowingly anticipates abstract art by remarking that "the ornamenter enjoys an amount of freedom in the original construction of his chromatic composition which is denied to the painter." He can disregard realism. Rood then proceeds to make suggestions and observations regarding color decorations.

There are references to the Alhambra (page 312), to Renaissance art (313), admitting (page 314) that "In decorative art the element of colour is more important than that of form." Abstract artists would later agree.

Rood's admiration of Turner is expressed on pages 315 and 318. He noted that Turner often avoided the use of green. (Turner was also known to dislike purple.)

The road to greatness in color was not an easy one. The artist did not need rules (page 316) but would profit from a study of nature and fine works of art. He was lucky who was blessed with "a natural feeling for what might be called the poetry of colour." He will work hard, "and this work will be pushed on month after month with patient energy, till, after a score of years or so, the student finally, if gifted, blossoms out into a colourist" (page 323).