Explorations in Light

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Early natural philosophers, including Aristotle, the tenth-century Arab philosopher Alhazen and the eighteenth-century Isaac Newton were enchanted by the rainbow, the behavior of light reflecting and refracting into a spectrum of perceivable colors (although no one in ancient times seemed to agree on what the rainbow's were). Darkness and Light have long been metaphors for Evil and Good, for ignorance and knowledge; but Lucifer, the "light-bearer," comes from the dark side of a Manichean universe. Since Goethe's *Farbenlehre* of 1810, darkness can no longer be defined merely as "the absence of light." Darkness and light conspire to create color, according to his findings.

Literary critics and art theorists who raised consciousness of the spiritual aspects of modernist art include Russian formalist Viktor Shklovsky,[1] German Romantic poet Johann Wolfgang von Goethe,[2] his advocate, theosophist and anthroposophist Rudolph Steiner,[3] and painter/musician/Bauhaus teacher Wassily Kandinsky. Others who were to influence painters in the late nineteenth and early twentieth centuries include French chemist M.E. Chevreul,[4] the Scots doctor Thomas Young (who augmented Newton's "corpuscular" theory of the movement of light with his explanation of the transverse wave motion of light and also supplanted Chevreul, to some extent, with the three-receptor theory of color vision), naturalist James Sowerby, Otto Runge (famous for his *Farbenkugel*), Ogden Rood, Wilhelm Ostwald, Clerk Maxwell and Albert Munsell (whose "color tree" is still a paradigm for color manufacturers such as Gamblin). All these men were concerned with the phenomenon of after-images and the electromagnetic vibrations of light. Several explored analogies between music and painting, as Isaac Newton had, adding indigo to the six spectral hues in order to achieve seven colors, to match the seven notes of the diatonic scale. In 1704, Newton suggested an analogy between color vision and hearing:

Qu. 13. Do not several sorts of Rays make Vibrations of several bignesses which, according to their bignesses excite Sensations of several Colours, much after the manner that the Vibrations of the Air, according to their several bignesses excite Sensations of several Sounds? ….

> *Q*
>
> *u. 14. May not the harmony and discord of Colours arise from the proportions of the Vibrations propagated through the Fibres of the optic Nerves into the Brain, as the harmony and discord of Sounds arise from the proportions of the Vibrations of the air? ….*[5]

As a result of his involuntary experiences of synaesthesia, Kandinsky, in collaboration with composer Arnold Schoenberg,[6] hoped to correlate spectral colors with musical tones, as did a number of other composers.[7] First performed in 1921, Schoenberg's "Suite for Piano, Opus 25" utilized his twelve-tone row, a technique abstracting apparently arbitrarily ordered half-notes from the chromatic scale—the "natural" diatonic scale of the tempered

keyboard. He believed that dissonance in music accurately portrayed the mood of the time. As the objective element in a work of plastic art was reduced and dematerialized by Kandinsky (during his Bauhaus tenure) to the point of becoming transparent and spiritualized, so Schoenberg's mystical thinking led him to experiment with dissolution of traditional harmonies. One might compare Schoenberg's principle of non-repetition of tones with the "serial" uses of color in Kandinsky's paintings of the 1920s.[8]

Composers Alexander Scriabin

[9] and Olivier Messiaen[10]were also highly affected by synaesthesia, but composed tonally within the harmonic scales, as did Stravinsky, despite experiments with dissonance as an aural evocation of colors. Scriabin became interested in Symbolist poetry and theosophy, both of which rely deeply on "correspondences." In his later compositions, he sought to synthesize music, colored light, incense, dance and poetry. Messiaen saw dazzling combinations of colors when he heard musical tones, treated rhythm as a fluctuating phenomenon and, like the painter Robert Delaunay, emphasized complementary colors. He and painter/musician Paul Klee incorporated musical terms and concerns with the temporality of music, duration and intervals, in the spatial composition of their paintings. Like Kandinsky, James McNeill Whistler titled his paintings with musical terms such as "Improvisation" and "Nocturne."

Whether or not one experiences *audition colorée* or any form of synaesthesia, the perception of vibrations of light and sound is common to all. Light refracted by raindrops or glass prisms becomes color; sound polarized becomes a musical tone. The order and curvatures of colors (hues) within the spectrum are mathematically constant, as are the tones and overtones of a plucked string on a musical instrument. The relatively narrow spectrum of visible light, as contained in full sunlight and broken up into the rainbow—bounded by ultra-violet beyond the perceptible long wave violet band and infrared beyond the perceptible short wave red band—"turns into" X-rays, Gamma-rays, cosmic rays, on the one hand, and heat, micro-waves, radio waves, to extremely low frequencies, on the other.[11] The miracle of the rainbow and the phenomena of all vibrational forces compose the very mystery of existential awareness and are the raw *immaterial* materials for art.

For too many people, the arts are mere ornaments or luxuries in the face of material needs that are addressed more directly by practical medicine and scientific research. During the Enlightenment, drawing, music and mathematics were taught together with natural philosophy. Today, art and music classes are often terminated in public schools as if such "extra-curricular" studies were not essential to cognitive and psychological development. This idea of the arts as non-essential is a fundamentalist aesthetic, one that treats the arts literally and simplistically, as if they were meant to convey only information of a specific sort. Yet the arts have a function in attaining and maintaining health—both spiritual and civic—that is not merely quantifiable.

Having been dubbed an "Impressionist" after his 1872 painting *Impression: Sunrise*, Claude Monet advised:

> *When you go out to paint, try to forget what objects you have before you…. Merely think, here is a little square of blue, here an oblong of pink, here a streak of yellow, and paint it just as it looks to you, the exact color and shape, until it gives your own naïve impression of the scene before you.*[12]

Monet holds an important place in the transitional period between the science and idealist philosophy of the Romanticist nineteenth century and early twentieth-century modernism, with its increasing interest in subjectivity. Monet's Water Lilies series is the product of a prodigious effort founded in a unique vision, physical as well as metaphysical. Roger Shattuck has posited that Monet worked intuitively in relation to fields of electromagnetic wave patterns around objects, as theoretically explained by James Clerk Maxwell (c. 1873). Shattuck outlines four stages of Monet's art:

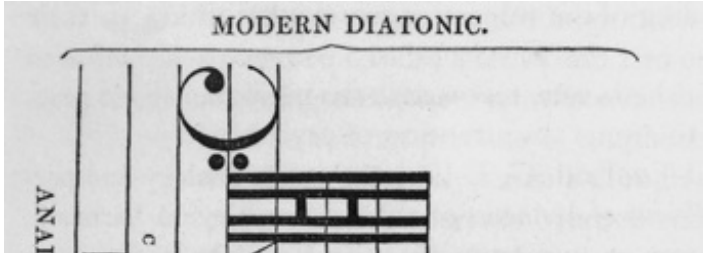
> *1. The garden: appearances on a conventional human scale seen "out there" as the real world of nature.*
>
> *2. The vibrating field: both tiny and infinitely great forces behind or beyond appearances, discernible by a hyper-aesthetic sensibility as the constituent elements of the universe.*
>
> *3. The retinal impression: what a painter may gradually become aware of taking place in his own eye as a physiological phenomenon prior to seeing, looking, recognizing—a stripping away of the culturally influenced categories of vision.*
>
> *4. The screen: a painter's absorption in the optical surfaces he is constructing (often very large) to the verge of their blocking him off from the three previous forms of perception.*

Shattuck believes Monet remained a representational painter while becoming non-figurative.[13] The water lily paintings all concern themselves with reflections which, in the real world as in painting, are distortions of their subjects, immaterial creatures of light. Monet, and certain other modern painters, depict what and as they see, rather than reproducing an ideal copy of what they think should be there. This is the foundation for training in contour drawing and akin to the inductive approach of a scientist who works from direct vision (as with Alhazen, Newton and Goethe), rather than deductively working from a premise or hypothesis that hinders new insight. Shattuck makes a persuasive argument for Monet's ability to recall and record a fleeting perception with a minimum of interference from the mind, thus becoming "pure eye."

However, Floyd Ratliff, Professor Emeritus of Biophysics and Physiological Psychology at Rockefeller University, dismisses Shattuck's speculations, and demonstrates how Josef Albers and his students Richard Anuszkiewicz and Julian Stanczak use physiological discoveries such as the Young-Helmholtz Trichromatic Theory of color-processing in the eye.[14] Psycho-physiological studies show that three independent types of photoreceptor cones in the retina, each with a unique spectral sensitivity (red, green, blue) are required to recognize the appearance of (refracted, reflected) light. Colors are not stable; color context is crucial to our perception of value, saturation and even hue itself. Newton truly was right when he remarked, in *Opticks*, that colors do not exist but are "mere phantasms" in the mind.

The affinity of the work of Monet to that of Albers may not at first be evident. Monet did not include black in his palette, yet he was a master of light/dark illusion; he used translucent lakes (the word derives from lacquer) such as geranium lake (*laque de Garance*), as well as opaque earth pigments such as venetian red, the ochres and Payne's grey. Although Monet's subject became the colors of light as reflected back to him from his ponds, flowers and trees, he was also concerned with more than local color. The positioning of an image, say a pale water lily on a dark green surface, takes on the complementary glow of magenta-pink. A pale water lily on a purple-lavender surface takes on a yellowish tinge. Albers, in his smoothly painted non-representational "Homage to the Square" series, shows us the same phenomena of color interactions. Jean-Dominique Rey discusses the traumatic experience of the double cataract operation that left Monet unable to perceive colors for a time: "An artist who had stared the sun in the face, and who, by observing its effects, had invented a new type of light, was suddenly struck with near-blindness…."[15] Monet told the physician that he could see blue, but not red nor yellow: "That annoys me terribly because I know these colors exist and because I know that on my palette there's red, yellow, there's a special green, there's a certain violet. I can't see them as I once could and yet I remember clearly the colors as they used to look." Rey gives a fascinating extended discussion, stating that Monet allows us to enter inside sight itself, perhaps thinking of Cézanne's famous *mot*, that Monet was "only an eye—but what an eye!"[16] That he continued to capture his visions in paint into the 1920s and recovered his health is, perhaps, a testament to the healing capacity of art.

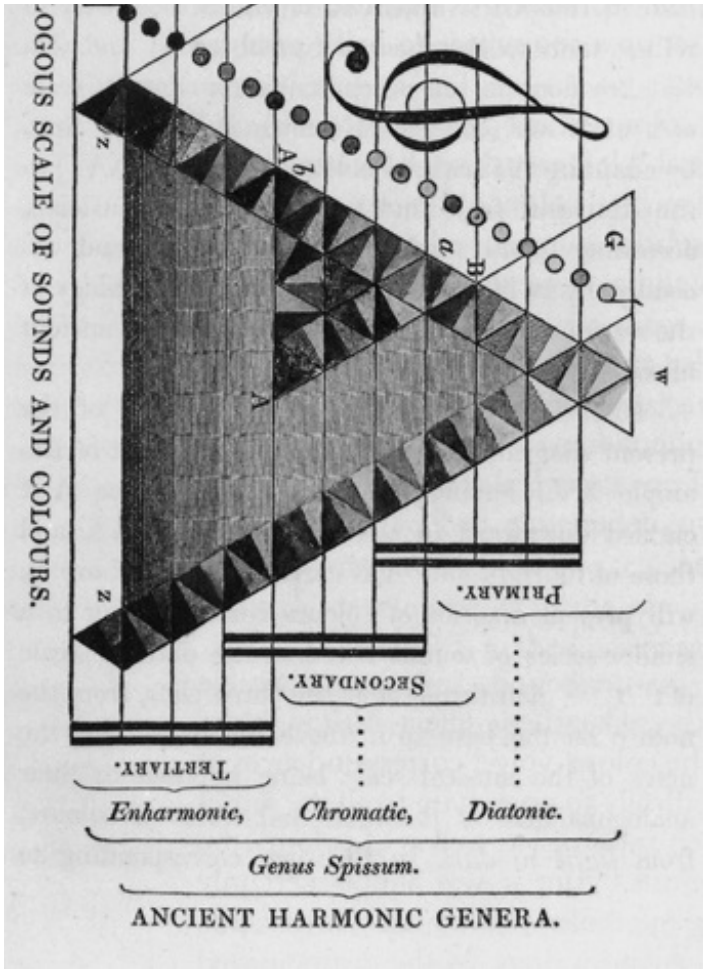
In the early twentieth century, many artists were influenced by the music/color affiliations explored by Kandinsky, Klee and other Bauhaus color teachers. Parallel influences were at work from M.E. Chevreul through Impressionist painters, including Monet, Seurat, Serusier, Delaunay—all interested in capturing the effects of colored light in opaque pigments and inducing optical mixing. By the time we get to Rothko's shimmering fields of color, the atmospheric "envelope"



evoked in Monet's landscapes has itself become the subject, the impalpable vehicle for a spiritual experience.

Early efforts to use color musically—for example, the Jesuit Louis-Bertrand Castel's 1720s "ocular harpsichord," G.G. Guyot's table-top "Musique Oculaire" of 1769 and Alexander Wallace Rimington's "color organ" of 1910

[17]—forecast the interest in pure color, color as harmony, color as visual music with an ability to create the illusion of form and space. Finally, color is freed from the medium of pigment altogether, as in the Lumiaproduced by the Clavilux of Thomas Wilfred,[18] the light sculptures of Robert Irwin and the installations and illusions of James Turrell.[19] Pure colored light would become an artistic end in itself by the 1970s.



Arthur Zajonc refers to "the explosion of light"[20] in modern art, the fascination with, and freedom allowed by, new synthetic pigments and paint in tubes that allowed for plein-air painting by the Impressionists, as well as the ability, with the advent of electricity, to cast more and different types of light in interior spaces, and to capture light photographically. J.M.W. Turner rejoiced in the advantages of the Industrial Revolution, as evidenced by his many light-filled paintings, including the Goethe-inspired allegory of light, *The Morning after the Deluge* (c. 1843), *The Fighting Téméraire*, which depicts the ghostly hull of Nelson's famous sailing ship being pulled to the scrapyard by a shining, muscular tugboat belching smoke and fire, and the dynamic *Rain, Steam & Speed—the Great American Railway* (1844). The Italian Futurists rejoiced in the "machine age" and strove to capture light and kinesthetic effects in paintings such as *The Street Light—Study of Light* (1909) by Giacomo Balla who, like his fellow Futurists F. Marinetti, Luigi Russolo and Gino Severini, depicted motion and light. Another example is Balla's charming *Dynamism of a Dog on Leash* (1912). More abstract interactions of form and color are explored in *Dynamism of a Cyclist* (1913) by Umberto Boccioni.

Kandinsky, in *Reminiscences*, records a moment around 1908 when, entering his studio and seeing his own painting on its side, he at first did not recognize its subject. He then realized that a painting might be only "about" color and form in themselves. His *Concerning the Spiritual in Art* (1912) is symptomatic of the growing interest of early modernists in the connection between art and spirituality, an interest which originated in the Romantics and Symbolists, for whom Nature was rescued from the materialism of the Enlightenment and perceptual intelligence replaced the theoretical.

The body provides information about the nature of light and color. Goethe describes his own perceptual discovery of a common phenomenon, a spontaneous "after-image," in his *Farbenlehre* of 1810:

> *I had entered an inn toward evening and, as a well-favored girl with a brilliantly fair complexion, black hair, and a scarlet bodice, came into the room I looked attentively at her as she stood before me at some distance in half shadow. As she…turned away, I saw on the white wall, now before me, a black face surrounded with a bright light, while the dress of the perfectly distinct figure appeared a beautiful sea-green.*[21]

Goethe realized that the eye itself tells us what the complementary contrasts are: scarlet generates sea-green. Likewise, the switch from black to white, blue to orange, yellow to purple occurs spontaneously in the eye. Are heard overtones in music akin to after-images in the eye?

Goethe, in his revolt against the *Opticks* of mathematician Sir Isaac Newton, nevertheless shared his method of working inductively, from observation, to achieve new insight into "*Urphaenomena*." The basic difference in their methods of

handling the triangular prism is perhaps symptomatic of the difference between the Enlightenment personality and the Romantic one. Newton held the prism away from his eyes, so that the "corpuscular ray" (as he put it) shone unobstructed from the pinhole in the blind through the darkened room and into the prism, to be refracted into a spectrum, the angles of whose various perceptible hues could be mathematically measured. But Goethe held prisms up to his eye and observed two "spectra"—one, the cool hues (blue/magenta), the other the warm (yellow/reds) as they displayed themselves along the dark edges of a white surface. Green appears only when the two extreme spectra are brought close together. We can get the same results by looking through a glass prism held to the eyes at the edge of a sheet of typing paper.

Naturally, varying methods yield different results. What Goethe derived from his approach were reverberations, not in the scientific arena so much as the spiritual and artistic. But he was convinced (as was Aristotle long before) that color is generated out of dark and light together. For him, insight into nature was meant to aid painters, as well as bring a general philosophical understanding of the marvels of the natural world. Like Goethe, M.E. Chevreul utilized the phenomenon of "after-image" in his *Principles of Harmony and Contrast of Colors and their Applications to the Art* (1839),[22] which resulted from his analysis of problems caused by certain juxtapositions of colored threads at the Gobelin tapestry works. Subsequently, Chevreul's work would influence a number of painters—Pissarro, Serusier, Monet, van Gogh, Delaunay and, notably, Seurat in his experiments with Pointillism.

In Paris, Robert Delaunay realized the failure of Pointillism to control optical mixing in the beholder's eye—the dots were not small enough, the viewing distance impossible to establish. Instead he painted with larger color patches directly from observed color, as in his "Windows" series. In 1912, Klee translated Delaunay's essay "On Light" for the Expressionist magazine *Der Sturm*. Delaunay did not want art to be subservient any longer to depicting objects; the painter was to do away with description and narrative. Light itself was now to be treated as the subject of painting, independent of representation. This was true for Bauhaus teachers including Johannes Itten (who would establish a school in Switzerland to teach color physics until his death in the 1960s) and Lazlo Moholy-Nagy (who created both paintings and, like his contemporary Naum Gabo, three-dimensional sculptures that manipulate light effects). After the Bauhaus was finally shut down by the Nazis in 1933, Moholy-Nagy and his wife, Sibyl,[23] came to America to teach Bauhaus ideals.

Henri Matisse, Mark Rothko and Ad Reinhardt juxtaposed variations of dark hues and blacks in many of their non-figurative paintings, creating dark light. Manet, Caravaggio and many old masters before Reinhardt had, of course, used velvety blacks as contrast, to enhance effects of light on surfaces within figurative compositions. Using dark light as a subject in itself suggested a new attitude. We see, in nature, the dark light of outer space "shining" through the atmosphere and the polarized blue light of the sky. One thinks of Matisse's *Icarus*, falling through black and dark blue, enlivened by a yellow star. Rothko was influenced early in his carreer by the celestial light and meditative quiet of Fra Angelico's frescoes at San Marco monastery in Florence. He began to "breathe-on" highly thinned pigments built up in glazes, color "organisms" that became quiet, dark maroons, purples and blacks, during his execution in the 1950s of murals for the restaurant in the Mies-designed Seagram building in New York. The de Menils commissioned further "dark paintings" for the circular Rothko Chapel in Houston, Texas, where they serve as foci for meditation.

"Darkness is the receptive medium through which light travels…an energy of its own that attracts light."[24] Sound waves need a physical medium through which to travel; light needs none. We do not perceive light directly, but only as reflected, refracted, diffused or polarized by physical surfaces. Sound (as compressional waves) travels relatively slowly, making its lugubrious way through air, liquid or a solid, like the vibrating sound-box of a musical instrument or a hi-fi speaker, at approximately 331 meters per second. Sound relies on moving longitudinally through particles of matter, back and forth, parallel to the direction in which the energy travels. Light, on the other hand, travels as transverse electromagnetic waves and can move from a visible (material) source, transmit itself invisibly through a vacuum at a finite speed of approximately 184,646 miles per second, and reappear when it rebounds from a material surface, such as a planet or a mote of dust. In its transverse movement, packets of energy (photons) move at right angles to the direction of travel. Photons transmit—shine—through any transparent medium, such as air, glass or water, as well as through a vacuum, since pure energy does not rely on a physical medium for propagation.

The mysteries of light and dark, sound and silence, take us into subjective realms that find their expression in material or ephemeral works of art. Light is invisible until it encounters material objects. Color exists only in the mind. Without encounters between the material and immaterial, we would perceive no light, no color, no harmony of the eye. Without the reverberations (movement/stillness patterns) in our material body, including the tympanum, we would have no music. Wendel Barry has observed that "it is the impeded stream that sings." We are the "impedimenta" in the streams of light

and sound.

This essay was adapted from a slide talk given at the 73rd Annual Conference on Light and Vision of the College of Syntonic Optometry, Santa Fe, New Mexico, May 12–15, 2005.

Notes

1. A founder of the Moscow Linguistic Circle, 1915, concerned with the function of poetics.
2. Goethe became annoyed with Isaac Newton's mathematical quantitative approach to color and carried out his own experiments, which, while in correspondence with von Helmholtz, resulted in Theory of Colors, 1810. This is a wonderful instance of sensuous Romantic rebellion against the materialism of the Enlightenment, of the perceptual and intuitive versus the rational intellect.
3. At a young age, Rudolph Steiner was given the task of editing Goethe's papers. His work culminated in the Waldorf Education system, still important today.
4. He directly influenced many painters; Pissarro directed the Impressionists to Chevreul's The Principles of Harmony and Contrast of Colors and their Applications to the Arts (1839). Chevreul (1786–1889) had a remarkable career, but he never understood the difference between additive (light) and subtractive (pigment) colors and their consequent behavior. Red, green and blue are the primaries of light and when combined create white light. Their secondary colors are cyan blue, magenta and yellow. Red, blue and yellow are the primaries of pigments and when combined form an opaque grey-brown.
5. Opticks or a Treatise of the Reflections, Refractions, Inflections & Colours of Light, based on the fourth edition, London, 1730. Foreword, Albert Einstein; Preface, I. Bernard Cohen (New York: Dover, 1979), pp. 345–46.
6. Correspondence reproduced in Arnold Schoenberg–Wassily Kandinsky: Letters, Pictures and Documents, edited by Jelena Hahl-Koch; translated by John C. Crawford (London: Faber & Faber, 1984). Kandinsky was a violinist during his early career of practicing law, as well as in later life as painter and teacher of art. Schoenberg painted in addition to composing and teaching music. Schoenberg published Theory of Harmony in 1911.
7. For a color chart that compares Newton, Castel and twelve others, between 1704 and 2004, see Visual Music (London & New York: Thames & Hudson; Hirshhorn Museum, 2005), p. 213.
8. See Jelena Hahl-Koch, "Parallels in Their Artistic Development," in Arnold Schoenberg– Wassily Kandinsky, p. 143.
9. Composed Prometheus, a Poem of Fire (1908–10); his orchestral scores included "Luce."
10. His avant-garde orchestral piece Chronochromie (1959–60) reflected his interest in bird-song. His pupils at the Paris Conservatory included Pierre Boulez and Karlheinz Stockhausen.
11. See John Davidson, Subtle Energy (Essex, UK: Saffron Walden, 1997), p. 107.
12. Quoted by Philip Ball in Bright Earth: Art and the Invention of Color (New York: Farrar, Straus and Giroux, 2001), p. 168.
13. See "Claude Monet: Approaching the Abyss," in The Innocent Eye: On Modern Literature & the Arts(New York: Farrar, Straus and Giroux, 1984), pp. 224 ff.
14. Color Function in Painting, Selections from the Collection of Neil K. Rector: Essays by Floyd Ratliff and Sanford Wurmfeld (Winston-Salem: Wake Forest University Fine Arts Gallery),
pp. 5ff.
15. Denis Rouart, "Appearances and Reflections"; Jean-Dominique Rey, "Mirrors of Time"; Julie Roart, "Catalogue raisonné" (Paris: Flammarion, 2008), p. 93.
16. Ibid., pp. 92; 94 ff.
17. A professor of art at Queens College, London, and a gifted painter, Rimington published Colour-Musicin 1912, based on experiments; from 1895, when he built a large color organ with fourteen arc-lamps. He gave performances accompanied by music, but also advocated silent performances of color only. See Peter Vergo, That Divine Order (London & New York: Phaidon, 2005).
18. In 1905, Wilfred, who had studied color theory and music in Copenhagen and at the Sorbonne in Paris, began to formulate his Clavilux, an instrument to generate silent "lumia," or light compositions. A trained singer and lute player, he gave numerous performances of music, and later of his silent light compositions in North America and Europe, until his death in 1968. See Donna M. Stein, Thomas Wilfred: Lumia, A Retrospective Exhibition (Washington, D.C.: Corcoran Gallery of Art, 1971).
19. Born 1943, Turrell comes from a Quaker family; his manipulations of projected and ambient light include the Roden Crater in the desert near Flagstaff, Arizona; a viewing room shows the changing intensities of the light in the sky through an oculus that reveals color phenomena not otherwise experienced.
20. Catching the Light: The Entwined History of Light and Mind (Oxford: Oxford University Press, 1993).
21. Johann Wolfgang von Goethe, Theory of Colours, translated by Charles Lock Eastlake (London: John Murray, 1840;

Cambridge: M.I.T. Press reprint, 1970), p. 22.
22. A newly revised edition with special introduction and commentary by Faber Birren, based on the 1854 English translation, is available from Schiffer Publishing, West Chester, Pennsylvania.
23. See Sibyl Moholy-Nagy, Experiment in Totality, Introduction by Walter Gropius (Cambridge: M.I.T. Press, 1969). After his death in 1946, she continued to carry on his vision of a total approach to seeing, teaching and creating, using synthetic materials such as chromium and Plexiglas for art works, motion photography and stage sets based on light alone.
24. Carol K. Anthony and Hannah Moog, I Ching (Stow, Massachusetts: IChingbooks, 2002), Hexagram K'un/Li.

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