NINETEENTH CENTURY LIGHT AND COLOR THEORY:
RAINBOW SCIENCE IN THE ART OF
FREDERIC EDWIN CHURCH

THESIS

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The purpose of this study was to investigate the depiction of rainbows in the art of Frederic Church in relation to mid-nineteenth century scientific developments in order to determine Church's reliance on contemporary concerns with light and color. An examination of four Church paintings with rainbows, three oil sketches, and nearly a dozen pencil drawings shows that Church's rainbow art represents a response to mid-century cultural values connecting science and art. Changes within Church's rainbow depictions occurred as the artist explored the visual representations of light, synthesizing the scientific knowledge of light and color available to him, and reconciling that information with the requirements of art.
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CHAPTER I

INTRODUCTION

In the summer of 1857, when he attended the London exhibition of Frederic Church's *Niagara Falls*, a large horizontal canvas showing the cataract cascading into a light-drenched mist, with distant rain clouds shielded by a broken rainbow, John Ruskin approached a window, believing that the prismatic effects were reflections on the canvas caused by sunlight entering from outdoors (2, p. 371). The fact that Church had "fooled" him with this rainbow meant that the young American had thereby established his reputation as a painter of scientific expertise, because Ruskin was then the most highly regarded art critic in Britain and the United States, and because Ruskin's major aesthetic belief was that art should be true to nature.

Rainbows involved particularly difficult problems for a painter at that time, because of the widespread expectations that art be scientifically correct. In fact, an 1860 article in *The Crayon*, America's main art periodical of the mid-nineteenth century, admonished artists not to attempt depicting rainbows, because of all the mathematical and geometric requirements necessary for an accurate rendering of the image (1, pp. 40-41). Such advice did not dissuade Church. *Niagara Falls* (Corcoran Museum, Washington, D. C.)
was just the first of four rainbow pictures that he painted from 1857 to 1878, which constituted the artist's most productive years. The others were *The Heart of the Andes* (1859, Metropolitan Museum of Art), *Rainy Season in the Tropics* (1866, De Young Museum, San Francisco), and *The Aegean Sea* (1878, Metropolitan Museum of Art). In addition to these finished oil paintings, Church produced three oil sketches (1853, 1853, and 1867) and nearly a dozen pencil sketches of rainbows, all located in the Cooper-Hewitt Museum. The sources of Church's confidence that enabled him to represent light through artists' pigments can be located in the scientific information about rainbows published in that period. This data provided the knowledge that enabled Church to represent rainbows accurately.

**Statement of the Problem**

The purpose of this study is to investigate the depiction of rainbows in the art of Frederic Church in relation to mid-nineteenth century scientific developments in order to determine Church's reliance on contemporary concerns with light and color.

**Review of the Literature**

Although many studies have explored cloud formations and their appearance in the art of this period, no one has endeavored to investigate the meteorological and artistic relationships of rainbows in American art in general, or in Church's art in particular.
Methodology

Bibliographic sources include cultural histories of the nineteenth century, *Crayon* and *Dial* articles related to this topic, color theory presented by Rood, Chevreul, and Goethe, as well as Ruskin's references to rainbows. Travel to New York City provided the opportunity to view two of Church's major rainbow paintings at the Metropolitan plus three oil sketches and numerous pencil drawings at the Cooper-Hewitt as well as to research the unpublished correspondence of Professor Ogden Rood at Columbia University's Butler Library. At Church's Olana estate on the Hudson River, four miles from Hudson, New York, I was able to tour the artist's home and review his correspondence. Now the Olana State Historical Site, Church's residence has been preserved, and curators there are in the process of cataloguing his photographic collection and the contents of his library, containing over 1500 volumes, many of which were itemized in David Huntington's dissertation. I also traveled to San Francisco to see Church's *Rainy Season in the Tropics* at the De Young Museum.

The results of this study not only provide a more complete understanding of the correlation between nineteenth-century science and art, but also form a foundation for further study of the rainbow art of other nineteenth-century American painters who explored the ultimate rendering of light and color that preceded Impressionism.
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HISTORICAL BACKGROUND

Scientific studies including meteorology and contemporary theory of light and color provide clues to Church's boldness in rendering these rainbow images on his major canvases. However, since both science and the development of American landscape painting are inextricably interwoven with prevailing religious, philosophic, and political ideas of an expanding nation, a brief exploration of these factors is essential to an understanding of Church's art and the scientific background.

Religious Ideas and Values

Religion, a major concern of mid-nineteenth century Americans, was interconnected with philosophy and science in the cultural foundations of American values and beliefs (1, pp. 5-6). The Christian ethic that permeated all fields--including education, science, and art--was meant to venerate the Creator through these endeavors. The worship of God and His gifts was more than a Sunday ritual to the mid-century American; it functioned as an impetus and justification to vocations and avocations of a devout citizenry. The prevailing ideology of Manifest Destiny, the conviction that history was unfolding in a way which proved that God (or
fate?) planned for the white man to extend his control over the whole territory which eventually became the United States of America, was also viewed as an opportunity to explicate Christian doctrine in the creation of new settlements dedicated to fostering religious ideals. Nature was an element to be dominated, but also contained inherent religious and didactic value, as these following quotations reveal. It was thought that nature "awakens higher aspirations, elevates character, and is emblematic of something spiritual" (16, p. 20). A love of nature invokes "religious sentiments" and "ends in the love of God" (16, p. 18). A reverence for nature was analogical to "sublime worship" (16, p. 18), to the point of including painting as a simile to devotion. "But when the skies and woods reveal their loveliness, then nature seems a glorious picture, of which our inmost soul is the painter..." (16, p. 17). Landscape painting as an expression of the wonders of nature was specifically addressed in The Dial, A Magazine for Literature, Philosophy, and Religion, a journal published from 1840-1844, whose very title confirms the inclusion of religion in philosophic thought. Requiring that art be created by a "universal mind," transcending cultural dictates (23, p. 373), the artist, as "angel of the Lord" (23, p. 373), was expected to look to nature to affirm "exalted sentiments" (23, p. 374).

Landscape painting, presenting images of an idealistic, primeval world, fulfilled the need of advertising the beauty
and wonders that existed in the new nation through religious allusions to Eden, portraying man as the new Adam in the midst of the beauty, splendor, and promise that the young country offered. Artists and art viewers "relived Genesis through the landscape" (15, p. 152). Based on extensive research into nineteenth-century Christian doctrine and ideas about landscape painting, David Huntington has portrayed Church as the painter of an Adamic New World Myth (9). Through depictions of an American paradise, the viewer was encouraged to see himself as an Adam through the experience of nature (9, p. 296). Wonder was the main emotion conveyed by these canvases. The spectator "could transcend the world of matter and unite with the Eternal and the Infinite" (9, pp. 296, 297).

Philosophical Ideas and Values

This exultation of nature and its relevance to religious worship is also to be found in mid-century philosophic thought. An extremely popular speaker as well as writer, Ralph Waldo Emerson's essential message--"that man was free and limitless in his powers"--appealed to an America united with the writer's religious thought--that "everything was possible if men adhered to tenets of religious faith" (1, p. 24). Emerson viewed the land as an American idyll (14, p. 229). In his essay Nature (1836), this proponent of American pastoralism reconciled two conflicting aspects of nature. On the one hand it was a source
of meditative power, on the other it was an inspiration for technological progress (14, pp. 230-233). By the time that Emerson wrote "The Young American" in 1844, his view of the New World as "our garden" sanctioned nature and technology as the dual forces necessary to sustain a national spirit and rural ideal (14, pp.234-36). Emerson "interpreted the nation's movement toward 'nature' (signifying both a natural and a spiritual fact--both land and landscape) as motion toward a new kind of technically advanced yet rural society" (14, p. 253). Emerson's transcendentalism had acknowledged the unity of nature and God (1, p. 23). "Religion, philosophy, and science continued to reinforce each other" (1, p. 31). Christian ideals of morality that governed the formation of the United States dominated the development of landscape painting in its observations and portrayals of nature. Glorifications of nature could be translated into a celebration of God through His natural creations.

Emerson's disciple, Henry Thoreau, tested his mentor's belief in the value of a communion with nature in 1845 with his sojourn at Walden Pond. Not published until 1854, the widely read results of this "experiment in transcendental pastoralism" revealed the depths of meditative powers attributable to the land and landscape (14, pp. 242-243). The "language of nature" (14, p. 261) reinforced the pastoral ideal, "inspiring a sense of infinite possibility"
When Thoreau, residing near the pond that separates Concord from the natural wilderness, heard the unwelcome intrusion of the train sounds that signified the presence of civilization, he was experiencing Emerson's vision of an American arcadian ideal.

Political Ideas and Values

Emerson affirmed political as well as religious and philosophical values (14, p. 253), believing that the duality of nature and technology would enhance political morality (14, p. 230). Americans at mid-century were proud of their heritage, liberty, and inventions, maintaining a deep respect for political leaders and offices (2, p. 12). The popularity of lithographs depicting presidents, American accomplishments, and national celebrations attests to this pervading sense of achievement (2, p. 13). Not having a European heritage to venerate, the new country was in the process of creating its own lineage, while celebrating its natural resources of land, water, forests, mountains, and other landscape features, as well as the attainments of its citizens.

The American Land and Its Impact on American Culture

One resource that Americans could readily claim as being superior to their European counterpart was the majestic, varied scenery, including idyllic, isolated farmlands, soaring mountains, and magnificent waterfalls (22, p. 104). The pristine wilderness, untouched by man, has been
described as the primeval landscape, with associations to the Creation and America's role as progenitor of the future (10, pp. ix-xi). Thus, American landscape painting, complete with references to the nation's religiosity as well as to political and philosophic ideals, developed as an expression of these concepts, while celebrating the beauty of America. Science became the means by which that expression was validated in the art of Frederic Church.

Just as it had been during the seventeenth-century European art of Poussin, Lorrain, Rosa, and the Dutch school, landscape painting developed as an important genre in nineteenth-century American art. The Hudson River School, which began c. 1825, often associated with the work of Thomas Cole (1801-1848) and Asher B. Durand (1796-1886), was America's first cohesive group of artists. It was a school united by a desire to portray the beauty and splendor of a new nation rather than by actual physical location. Belonging to the second generation of Hudson River artists, Frederic Church (1826-1900) has the distinction of having been one of Cole's few pupils. Thus the young artist was able to assimilate prevailing artistic theory as a foundation for his creative development. An early reliance on Cole's stylistic and thematic guidance (11, pp. 1-21) was eventually replaced by Church's unique fusion of art principles, and his interpretation of nature, science, religion, and subject matter.
One early divergence from Cole's technique, which interested Church throughout his career, was the younger artist's focus on light, as critics readily praised his use of light in creating atmospheric effects (11, p. 8). As a reference to religious associations, the Divine light of Church's landscapes has recently been seen as a symbol of the Creation, consistent with moral and philosophical codes of the time (11, p. 9).

Perhaps the most valuable lesson imparted to Church was Cole's belief that he was "content with nature" (11, p. 3). Canvases portraying threatening, sublime effects in Cole's early works were superseded by scenes in which man was clearly comfortable in the American environment, presenting a peaceful, more personal image of the landscape (11, pp. 2-3). In this image of the landscape, it was imperative to imitate nature. Truthfulness to nature was often discussed in the nineteenth century. Ruskin, having acknowledged a larger following in America than in England through his publications and regular excerpts therefrom in *The Crayon*, advocated an appreciation of nature that appealed to American landscape painters (17, p. 283). Frequently mentioned in *The Crayon*, J. M. W. Turner (1775-1851), the English Romantic artist, was considered the paradigm of landscape painters by both Ruskin and American writers.

American authors responsible for creating an interest in nature included not only Emerson and Thoreau, but also
poet William Cullen Bryant, architect Andrew Jackson Downing, and landscape architect Frederick Law Olmsted. Albert Ten Eyck Gardner believes that some of these men must have been known to Church—Olmsted, was, like Church, a native of Hartford; and Bryant was a friend of Church's teacher, Thomas Cole (8, p. 64).

Whether Church had meaningful direct contact with these men or not, it is clear that nature was a central factor in American religious, philosophical, and political ideas and values by the middle of the nineteenth century. It was against this background that Frederic Church launched his career and pursued his scientific approach to the depiction of rainbows.
CHAPTER BIBLIOGRAPHY


CHAPTER III

SCIENCE AND LANDSCAPE ART

The proliferation of inventions and investigations of nature in the nineteenth century resulted in a pervasive American fascination with scientific inquiry which cannot be over-stressed. Not only the academic community, but also the public-at-large fed its curiosity by reading the work of European scientists such as Alexander von Humboldt (Cosmos 1850), Sir Charles Lyell (Principles of Geology 1830), John Tyndall (clouds), Luke Howard (Climate of London 1818-20), Eugene Lommel (light), and M. E. Chevreul (color) (8, p. 64; 24, p. 75). American scientist-educators responsible for promoting a scientific interest in nature included Louis Agassiz [Harvard, Natural History, Glaciers], Asa Gray [Harvard, Botany], and Ogden N. Rood [Columbia, Electromagnetics, Color Perception] (24, pp. 62, 75). All of the preceding authors were represented in Frederic Church's library. In addition to these scientific and philosophic authors, the artistic community often focused on nature and landscape painting--The Crayon contained articles specifically on the topic of landscape art, its theory and technique, often citing the importance of empirical observation.
Irving H. Bartlett has outlined the cumulative effects of this American pre-occupation with science at mid-century. Relying on European products and technology in 1800, the new nation astonished Old World residents at the London Crystal Palace Exhibition of 1851 with its inventions (3, p. 26).

By 1851 thousands of American parlors were decorated with a steel engraving entitled 'Men of Progress' which included portraits of scientists and inventors like William Morton (ether), Samuel Colt (revolver), Cyrus McCormick, Charles Goodyear, Joseph Henry (electromagnetism), Samuel Morse, Elias Howe, and Richard Hoe (revolving printing press) (3, p. 26).

As a source of national pride, scientists, inventors, civic and religious leaders, educators, and artists, reflected the zeitgeist of mid-century America. It was during this time, in 1846, that the Smithsonian Institution was founded, creating a permanent exhibition reflecting American achievements.

The link between academia and the general public can be seen in the work of the enormously popular Harvard University science professor, Louis Agassiz, who was renowned for his research of glaciers and his teaching methods of scientific inquiry. Collecting and classifying plant and animal life was a popular pastime with Americans because "ordinary people could participate in this activity without special training" and its "pioneering aspect" in identifying natural resources was equated to a "mastery of the environment in a new country" (3, p. 27). There is reason to believe that Church could have shared scientific and artistic ideas with Agassiz, since a shipboard meeting in the summer of 1859 has
been documented (24, p. 132), and both men were members of the prestigious Century Club in New York. Agassiz's popularity was due in part to his adherence to religious tenets, believing that species originated through the Creator's plan (24, p. 62). Agassiz's ideas and methods were shaped by Humboldt of whom he was the foremost disciple in America.

The Ideas of Alexander von Humboldt

Leading the scientific direction of the nineteenth century, Alexander von Humboldt (1769-1859), German naturalist-explorer, published major tomes considered to be classics in scientific literature. Honored as the most broadly knowledgeable person before the specialization of the sciences, Humboldt's *Cosmos: A sketch of a Physical Description of the Universe* (1849) urged landscape artists to travel, sketching from nature, in order to "reproduce the character of distant regions" (34, p. 23). It is not surprising that Frederic Church has been described as the "artistic Humboldt of the new world" (33, p. 95), since his South American travels were a direct response to the naturalist's *Aspects of Nature* (1850) in which he narrated the wonders of the tropics (24, pp. 66-74). During Church's second trip to Ecuador in 1857, the artist stayed in the same house where Humboldt had resided, having a local artist duplicate the scientist's portrait that he found there (8, p. 64). Church's library at Olana contains not only the two
previously mentioned Humboldt volumes, but also the 1852 edition of *Personal Narratives* (14, p. 375).

Responsible for the international promulgation of naturalist-explorationist doctrines, Humboldt encouraged a generation caught in the scientific reverberations of the century to embrace science and to search for its truths. At the time of his death, Humboldt was considered to be the most famous man in Europe. His popularity has been compared to the esteem and honor accorded to Einstein in this century (8, p. 62). *Cosmos*, Humboldt's five-volume compendium of the natural science of the universe, was as popular in America as it was in Europe. Four editions were issued in New York between 1850 and 1859 (8, p. 62). Frederic Church was one of Humboldt's most devoted disciples, taking literally the scientist's exhortations for artists to travel and record nature.

Barbara Novak has written that "Church must have pored over his volumes of *Cosmos*" (24, p. 70). Gardner has noted the "immediate and profound" effect that Humboldt had on Church's work, recognizing the change within the artist's oeuvre from New England scenes to more scientifically-oriented landscapes soon after the first American edition of *Cosmos* was published in 1850 (8, p. 63). After tantalizing his reader with promises of the abundant beauty of nature present in the "mountains, rivers, and forest glades" with "luxuriance and diversity of vegetation," Humboldt called for "artists of merit" to paint the natural wonders of the
"tropical world" (24, p. 68). Church responded with The Heart of the Andes, The Cordilleras: Sunrise (1855, Private Collection), The Andes of Ecuador (1855, Reynolda House Museum of American Art), Cotopaxi (1862, Detroit Institute of Arts), Chimborazo (1864, Museum of Fine Arts, Boston), and Rainy Season in the Tropics (1866) following his two South American trips in 1853 and 1857.

Humboldt was also specific in his requirements for artists to "reproduce the character of distant regions," urging that painters draw or sketch "directly from nature a large number of separate studies of the foliage of trees; of leafy, flowering or fruit-bearing stems; of prostrate trunks, overgrown with Pothos and Orchideae; of rocks and of portions of the shore, and the soil of the forest" (24, p. 68). Novak has noted the "botanical veracity of Church's plant studies," which have been classified as "descriptive science" (24, p. 68).

Critical responses to the Church exhibitions repeatedly referred to the scientific accuracy that the artist was able to portray both in atmospheric effects and in geographic and botanic details. An Evening Post editor termed The Heart of the Andes "a scientific landscape, such as Humboldt earnestly suggested from his experience of this very region" (14, p. 151). The success of The Heart of the Andes has been credited to its simultaneous appeal to the "generation's pleasure in the exotic and its respect for science" (18, pp. 210, 212). The prismatic rainbow gently surfacing
in the distant clouds gleams as a subtle reminder of the scientific components of this painting.

As Henry T. Tuckerman has noted in his 1867 *Book of the Artists*, Church was able to present to America a "typical portrait" of the "picturesque distinction" of the South American region of which few people have more than a "vague notion" derived from their reading (35, p. 377). The biographer and critic noted that Church's "pure light, veritable clouds, all the tints of tropical atmosphere, and all the traits of tropical vegetation" (35, p. 377), combined to show the "scientific interest" of the landscape from an "exclusive study of nature" (35, p. 371). Humboldt's descriptions of the thundering volcano, Cotopaxi, and its tropical locale were illustrated by Church. Tuckerman has referred to the visual effects of *Cotopaxi* as being "absolutely and scientifically true to the facts of nature" (35, p. 380). When writing about *The Rainy Season*, Tuckerman admired Church's talent in rendering "the right perspective with the aqueous effects," the "exquisitely true aerial perspective," and the "radiant iris," which formed a "prismatic bridge" (35, p. 383). For these reasons Church's "original and scientific excellence" (35, p. 385) was responsible for stimulating "adventurous effort and renewed patience" for the "whole fraternity of landscape-painters" (35, p. 373).

Even without Church's devout reading of Humboldt's volumes, he and other landscapists could have read about the
scientist's cosmic ideas and ideals in The Crayon. An 1855 article, "Humboldt on Landscape Painting," summarized the naturalist's views that encouraged the study of nature in the "characteristic physiognomy of different portions of the earth's surface" (13, p. 199). In this century Church paintings have been termed "descriptive physical geography" by David Huntington, a leading Church scholar (14, p. 267). An 1856 Crayon article was devoted to summarizations of Humboldt's observations on landscape painting that focused on the "grander style of heroic landscape," that combined a "profound appreciation of Nature" with an "inward process of the mind" (9, p. 124). In recommending that American artists paint the beauty of Pennsylvania forest scenery, noted American scientist James Henry urged Crayon readers to apply Humboldt's concept of the component parts of the "magic of nature" to that northern area (10, pp. 129-130). In such an area "we are inspired with the same spirit of adoration that influenced Humboldt, amid the sylvan glories of a South American forest, where the earth's exuberance knows no bounds" (10, p. 131).

Church, not limiting himself to the study of the tropics, used the broadest interpretation of Humboldt's recommendations as he also traveled north to paint icebergs, to Jamaica, and to the Near East. Each site reflected the artist's detailed, scientific renderings that captured the "physiognomy" of the location while still fulfilling the "requirements of art" (35, p. 380). Tuckerman particularly
admired the "evanescent prismatic hues" of Church's *Icebergs* (1863) (35, p. 382). The "facts of nature" displayed in this painting typify the artist's "scientific conscientiousness and artistic skill" (35, p. 381). Gerald Carr has traced the lineage of this painting, currently in the Dallas Museum of Art, that was "lost" for more than 100 years, and has cited Church's reliance on Humboldt's scientific publications (5, pp. 106, 34). The artist's elevated esteem for the famous scientist is evident from a letter dated June 13, 1859 to Bayard Taylor in which Church wrote that "when a friend communicated the sad intelligence of Humboldt's death--I knew him only by his great works and noble character but the news touched me as if I had lost a friend--how much more must be your sorrow who could call him friend" (24, p. 71).

The Scientific Ideas of Writers on Art

The union of science and art was also addressed by other nineteenth-century writers. Goethe's contributions, specifically related to color, will be examined in a later chapter. James Jackson Jarves, American mid-century art critic, recognized the value of scientific truth in art. Ruskin urged the necessity of scientific accuracy in art--not as a stopping point, but as an essential quality (24, p. 90).

Jarves, one of the best-educated mid-nineteenth century writers on American art, and "no friend of Hudson River
School painting," displayed a "grudging admiration" for Frederic Church's paintings (17, p. 45). Writing in 1864 that "no one may be expected to excel Church," Jarves commended the artist's details, "vivid perception of color, quick, sparkling, though monotonous touch, and iridescent effects" (17, p. 46).

Calling for art's "alliance with science," Jarves connected science with religious connotations in mid-century art (24, p. 48). In his 1864 The Art Idea, science is shown as necessary in art to create a work of beauty with moral associations (16, pp. 279-80). "Christianity...requires of beauty the loftiest and purest unity with truth. The ideal of art or science must center in His beauty and law" (16, p. 281). Jarves saw the laws of science as emanating from the Divine, advancing the accumulation of knowledge, to be utilized in art to create icons to His largesse (16).

Apparently Jarves's ideas about art and science had solidified in the nine years since his first book, Art Hints, was scathingly reviewed in The Crayon. Frequently quoting Ruskin, the reviewer cited the errors in Jarves's opinions, although Ruskinian passages could also be found that could just as convincingly support Jarves in his ideas on travel, sublimity, scientific detail, and the aim of art. Perhaps Jarves's most compelling insult, inciting the barrage of contempt, was his criticism of Turner. "As a painter, I cannot consider Turner great" (29, p. 104).
Citing deficiencies in optics and color, Jarves particularly attacked Turnerian skies (29, p. 104).

The intensely fierce criticism by the Crayon writer shows the protective bond that existed between American artists and John Ruskin, who was a champion of Turner. The first volume of Modern Painters in 1843 asserted Turner's supremacy over all other landscape painters. To insult Turner was also to criticize adversely Ruskin, who was ardently admired in America.

As a child searches for parental approval, American artists sought approbation from the older, stronger, more-established mother-country, England. Artists looked to England for role-models, both in technique and artistic theory--Turner and Ruskin filled these needs. Often, when American artists were positively reviewed by the English press, The Crayon would mention the event, suggesting that their colleagues across the ocean would now have to recognize seriously the accomplishments of American art. Ruskin's remarks acclaiming the scientific accuracy of the Niagara rainbow were a credit not only to Church, but also to the quality of the genre of landscape painting in America as the critic acknowledged an example of its proficiency and excellence.

In their search for approval from England, American artists were not alone. As late as 1894 American scientists did not feel that they were receiving the recognition that they deserved from their European counterparts. Ogden Rood,
congratulating his colleague Albert A. Michelson in Chicago for his "genius" in the publication of a paper about wavelengths of light, wrote that "...every American should be proud of you and the people at the other side will begin to open their eyes, and think more of the Republic over the waters" (30).

A comparison of lectures delivered to students at England's Royal Academy in 1809 and 1866 demonstrates that Ruskin was not a lone voice favoring a more scientific art in Britain. This is germane to an understanding of mid-nineteenth century American art, since the art theory it inherited and emulated was British. Just as Americans granted England "parental" authority in other cultural values, so did they in the visual arts. Lectures to young art students at the Royal Academy in London delivered in 1807, published in 1809, by John Opie and in 1866 by Henry O'Neil reflect the increasingly pervasive impact science had on all cultural and intellectual levels as the first half of the nineteenth century progressed.

Concerned with drawing technique, an adherence to nature, and the minor, supportive role of light and color, the 1809 lectures recommended travel and reading, especially history and natural history as the "greatest stimulus to invention" to encourage imagination in art (26, p. 22, pp. 57-60). The 1809 lectures, while mentioning science and warning against an undue reliance on it, seemed to presage the scientific and exploratory events that were to occur.
These would include Humboldt's doctrines, the proliferation of scientific theories and experiments, and the scientific inventions displayed at the Great Exhibition of 1851 at the eve of industrialization.

In contrast, the 1866 lectures dealt with the state of art resulting from these discoveries and experiments. Whereas the earlier addresses cited Newton and Berkeley, "however sublime and beautiful," as being "but little calculated to assist the production of the sublime and beautiful in painting," the 1866 lectures readily recognized the interdependence of drawing, light, and color (25, pp. 18-22). Science was noted, not only for its impact on art, but also for its influence on literature, music, drama, and history (25, p. 24).

That science was an important concern to the art community in mid-century America is demonstrated by its topical inclusion in The Crayon. Calling for literature to "light up the imagination, by the powerful wand of science," novelist Henry James wrote that "our own literature has to strive after a more scientific scope and tone" (10, pp. 131-132). Four years later in 1859, an article appeared citing the relation between geology and landscape painting, stating that an artist must also be a geologist, since he "more thoroughly than any other can imitate what nature has produced" (28, p. 256). Strongly admonishing artists against defying the truth of nature, another Crayon writer cited this a "license of laziness," giving examples of
artists who "paint rocks, but neglect all indication of their kind; and trees, without caring whether they keep the marks of the species; who draw mountains, without the slightest thought whether the geologic truth be conveyed or not. Let us have none of it" (2, pp. 257-258). It was in this area of scientific accuracy that Frederic Church excelled, causing critics to commend his scientific approach to landscape painting.

Yet not all those who wrote about art then were as eager to venerate the role of science. Asher B. Durand (1796-1886), co-founder of the Hudson River School with Cole, while acknowledging its importance, cautioned against "total or undue reliance" on science, calling for an evocation of emotion as the "higher aim of art" (7, p. 66). This paralleled Ruskinian criticism of mid-century which called for art to elevate the emotions. However, Durand continued by citing another requirement of art, that of religiosity, when he wrote that art "declares the glory of God" (7, p. 66).

References to science in art are also to be found in The New Path, a Pre-Raphaelite publication issued monthly by American proponents of that movement, which had been formed in England in 1848. Published between 1863 and 1865, the often verbally militant periodical called for Ruskinian truth to nature, frequently mincing no words in criticism of artists' works and worth. An April, 1864 article showed the belief in the importance of science, and stated that "we are
all willing to admit an ignorance of science and ready to be
guided by those who have studied and thought on scientific
subjects" (1, p. 155). Writing about the aim and purpose of
art in 1864, the publication noted the necessity of the
unity of art "with the acquirements of modern science" (1,
p. 159). The same New Path issue criticized Bierstadt's
work for having "too little geology" (23, p. 163).

The following year, an extensive number of pages in the
November issue of The New Path dealt with the validity of
science in art, inspiring an article of rebuttal the
following month. The main premise of the initial article
was to show the necessity of scientific knowledge to art—to
paint as well as to appreciate art (32, pp. 169-172).
Believing that science and art "mutually assist each other"
(32, p. 169), the author contended that "science is the base
of real and of all great art" (32, p. 170). When discussing
the uses of science in art, the article enumerated the
knowledge of the chemical composition of pigments, the use
of perspective, geology, botany, and mineralogy. The
"greatest poet of modern Europe," Goethe "prided himself
more on his optical discoveries and theories than on all
else that he accomplished," including his botanical studies"
(32, pp. 185, 187).

This praise for science in art was challenged one month
later by another New Path article, which maintained that
science was the enemy of art since it destroyed emotion in
both the artist and the viewer. This second author,
ironically, cited Ruskin repeatedly to support his argument (11, pp. 195-97). Who won this debate in print is not important--what matters is that the role of science in art was significant enough in America during the 1860s to be debated.

Photography and Landscape Painting

One product of the scientific revolution was photography, which, despite experiments by Samuel Morse in America, Hippolyte Bayard in France, and William Henry Fox Talbot in England, marks the official start of its history in 1839 with the Daguerreotype process by the Frenchmen Niepce and Louis Daguerre. Other processes had been invented and gained wide use by 1866, when O'Neil said photography was "most injurious to landscape painting," (25, pp. 24-26). This new medium precipitated a need to call for the genre of landscape painting to operate between the poles of Claude's "conventional idealism" and the "mechanical realism" of photography, stating Turner's success in realizing that objective (25, p. 26). Turner's paintings "impress us with the spirit of Nature more than those of any other landscape painter" (25, p. 7).

Yet Turner was very much interested in photography, as was Frederic Church. Landscape painting in America was influenced by photography as artists attempted to rival the camera in portraying aspects of nature. "The invention of photography in the nineteenth century was the result of obsessions with the objective registration of visible
phenomena which had become the basic preoccupation of both art and science. The invention demonstrated an absolute identification of artistic and scientific strivings" (21, pp. 5-6). Humboldt sanctioned and encouraged the use of photography to record the elements of nature (21, p. 35). Ruskin first praised, then later condemned the new invention (21, p. 11). Used extensively by the British Pre-Raphaelites (21, pp. 10-13), photography provided artists with the instrument to achieve that which was most required at mid-century--the objective and thorough imitation of nature.

The three-dimensionality of photographs achieved by the use of the stereoscope was another factor that assisted artists in their goal of realistically recording nature. When Brewster's invention was displayed at the 1851 Great Exhibition, it quickly created a sensation (21, pp. 36-37). Frederic Church's panoramic paintings have been linked to the stereoscopic illusionism manifested by stereographic photographs (21, p. 101), characterized by detailed three-dimensional foregrounds and hazy, less-focused backgrounds (21, p. 95). Among the Bierstadt stereographs found in Church's attic were scenes from Egypt, Palestine, Africa, and Yosemite Valley, copyrighted in 1874 (21, p. 81). Other photographers represented in the artist's collection include John Moran and Eadweard Muybridge (21, p. 106). Joel Sweimler, Curator at Olana, reports that more than 500 photographs are currently being catalogued at the artist's
residence. Elizabeth Linquist-Cock has divided the Church photography collection into four categories that assisted the artist in his paintings: the Arctic, the Near East, New England, and landscape details (21, pp. 106-107). By comparing photographs with Church's finished paintings of his Near Eastern tour of 1868, the historian has concluded that the artist relied on photography to supplement his sketches of the scenes (21, pp. 112-116).

Although none of the photographs supplied in Lindquist-Cock's dissertation is useful to this study beyond a composite photograph of a gorge that could be related conceptually to Church canvases of a panoramic scope (21, p. 120), an 1867 Muybridge photograph, Rainbow at Vernal Falls (Figure 1), deserves particular attention due to its

![Rainbow at Vernal Falls (1867), Eadweard Muybridge.](image)
subject. What is significant in this photograph is the flash effect in portions of the rainbow, similar to those observed in Church's *Niagara* and *Rainy Season*.

Church was able to incorporate photography into his paintings because "he saw no inherent conflict between the goals of scientific observation and artistic imagination" (20, p. 71). To Church, photography, science, art, and nature were interrelated (20, p. 70). Lindquist-Cock believes that the stereoscopic illusionism of Church's *Niagara Falls* was the result of the artist's "intensive study of photographs," especially noticeable in the haziness of the scene, characteristic of early photographs that show water with a "whitened and bleached" effect (20, p. 73).

There is evidence that a cooperation existed between artists and scientists in nineteenth-century America in their quest for truth. Not only did *The Crayon* review and provide excerpts from international scientific authorities such as Humboldt, Chevreul, and Goethe, but also individual Americans within the two disciplines corresponded, sharing information about their interests. The two Bierstadt brothers photographed the western regions of the country, making their results available to both scientists and artists. Albert Bierstadt (1830-1902) often rivalled Church in popularity as a result of his romantic paintings representing the American West. As photographers the brothers were interested in perfecting their craft. A letter dated July 9, 1891 from Edward Bierstadt to Columbia
professor Ogden Rood presented the scientist with "a copy of my most successful attempt in printing photographs in the most natural colors" (4). After acknowledging the benefits derived from Rood's *Modern Chromatics*, the photographer described the printing process. "This picture is printed from four negatives; three of them made by the aid of colored light according to the theory of Young, Helmholtz and Maxwell; and printed in colors according to the Theory of Ducas du Hanson and Albert" (4). Further evidence of the cooperation between science and art is shown when Edward stated that "I have sent a set of prints in each of the colors alone to Prof. Chandler for the School of Mines Collection" (4). That Edward Bierstadt was conversant with the scientific theories of Young, Helmholtz, and Maxwell is important to this study of Church's rainbow paintings, because their experiments with light and color formulated nineteenth-century understanding of the rainbow and prismatic colors.

**Artist-Scientists**

Occasionally the interests of science and art were united within an individual, as he strove to experiment and perfect his area of expertise with knowledge derived from the other discipline. Ogden Rood, an important figure in color theory whose work will be examined in Chapter Four, was also an artist. Among Rood's correspondence in Columbia University's Butler Library Archives is an 1878 letter from
Charles Eliot Norton expressing the author's pleasure in Rood's satisfaction of the purchase of thirty-three Turner etchings. The letter concludes with Ruskin's address, in response to Rood's previous request, which also illustrates the extent of Ruskinian ties to America (22). Samuel F. B. Morse (1791-1872), famous as the inventor of the telegraph, was also an artist whose scientific achievements were vital to American progress. Morse, having earlier abandoned his own pioneering experiments to invent photography, met Louis Daguerre, also a painter, in Paris in 1839. Tremendously impressed with the Daguerreotype process, the American hoped to be able to apply the new field to portraiture (21, pp. 41-43). "The blend of scientist and artist in Morse" was important in forming opinions about the use of photographs in art, which he considered "not copies of nature, but portions of nature herself" (19, p. 146).

Meteorology and American Art

The field of meteorology became important to American landscape painters seeking scientific sanctions in their art. Barbara Novak has concluded that "American artists were meteorologically aware" (24, p. 87). This awareness stems from the English heritage of cloud studies, in the tradition of Constable and Turner, both of whom were known to American artists. Science and art shared a simultaneous interest in clouds. Luke Howard was the first to classify clouds in his 1818 *Climate of London*, which was so
influential to Constable’s cloud studies that he noted the cloud type, time of day, and weather conditions of the sky on the reverse side of his sketches (31, p. 424). Turner’s mastery of cloud renderings was praised by Ruskin, who admired the artist’s skies (24, p. 83).

American landscape artist Jasper Cropsey (1823-1900) advised his contemporaries to observe and experience the changing sky, noting its various atmospheric and color characteristics in an August, 1855 Crayon article. Specifically citing the beauty of the nimbus cloud, "on account of its being the cloud in which the rainbow appears," Cropsey admired the color, filtering sunbeams, and "deep emotive sensations" of this cloud group (6, pp. 79-80). He contended that an artist demonstrates his meteorological knowledge as well as natural powers of observation in recording changing atmospheric occurrences, color, and light sensations (6, p. 80). Since Cropsey was a member of the second generation of Hudson River School artists, his postulations are significant in illustrating the scientific trend in American mid-nineteenth century landscape art.

Yet Cropsey was unable to document his beliefs visually when, two years later, the same year as Church’s monumental canvas of the same subject, he painted an inaccurate rainbow image in Niagara Falls from the Foot of Goat Island (Museum of Fine Arts, Boston, Figure 2). Although the rainbow is on a plane parallel to the viewer, the angle of the arc could not exist in reality, being more circular than could
Fig. 2--Niagara Falls from the Foot of Goat Island (1857), Jasper Cropsey.

actually be observed from the low vantage point of the painting. The artist did attempt to capture the filtering effects of sunlight in the cloud-laden sky, as clouds alternately obscure and are protected by the rainbow. Beyond his technical concerns, Cropsey felt that a rainbow picture's ultimate goal was to elicit in a viewer "emotive sensations of hope and praise" (6, p. 80). Whether he succeeded here each viewer must judge for himself.

Frederic Church's early and direct linkage to science was from his mentor Thomas Cole, who was fascinated with the "new sciences of geology and meteorology" (27, p. 171). Cole's notebooks show an interest in the sky and cloud formations, detailing the time and sky descriptions. An 1825
journal noted that "a very fine sky about four o'clock in the afternoon in March the sun to the right—the large center cloud extremely light...the rainbow is on the outer edge of the rain and gradually mingles with it" (24, pp. 90-91). Cole's attraction to painting meteorological phenomena was noted in an 1856 Crayon item that mentioned that his Tornado was then in Church's studio (9, p. 124).

Earlier cloud studies were painted in America by Alvan Fisher (1792-1863), who produced canvases and sketches concentrating on the sky region (24, p. 90). Durand admired Constable's cloud studies, having viewed them at C. R. Leslie's during his 1840 London trip (24, p. 244).

The scientific basis of Church's reading is revealed by the contents of his library. In addition to the Humboldt Cosmos volumes, the following scientific books are listed in his collection: Humboldt's 1849 Aspects of Nature, 1852 Personal Narrative of Travels, and the 1850 Views of Nature; Robert Hunt's The Poetry of Science (1854); Gray's Lessons in Botany (1868); Botany, A Classbook of Botany for Colleges, Academies (1850); Rood's Modern Chromatics (1879); James De Kay's 1844 Zoology of New York or the New York Fauna; the 1856 Exploration and Survey for the Pacific Railroad; James Hall's 1852 Paleontology of New York; Isaac Hayes's 1867 An Arctic Boat Journey in the Autumn of 1854, The Open Polar Sea: A Narrative of a Voyage of Discovery Towards the North Pole (1867), Pictures of Arctic Travel (1881); William Herndon's 1854 Exploration of the Valley of
the Amazon; Prof. Klencke's Alexander von Humboldt: A Biographical Monument (1852); Elisha Kent Kane's 1856 Arctic Explorations in the Years '53, '54, '55; Physiological Chemistry (1855) by Prof. C. B. Lehman; F. Marion's 1870 The Wonders of Optics; and The Physical Geography of the Sea (1859) by Matthew Maury. In addition to these volumes, many travel books and histories of South America and the Near East were in Church's library as well as numerous books on architecture (14, pp. 348-402; 24, p. 117).

Science and the pursuit of scientific endeavors had infiltrated all aspects of mid-nineteenth century life in America, including the arts. Frederic Church's involvement with scientific knowledge was noted by his contemporaries who praised the artist's use of science to create stunningly realistic effects in his paintings, evocative of Humboldt's recommendations to travel and to record nature. Some of the areas to benefit from the nineteenth century's propensity to attain truth through the increase in scientific knowledge were the fields of meteorology and optics, both of which involved the study of light and color and the rainbow.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

LIGHT AND COLOR

As a "student of light and color" (23, p. 15), Frederic Church was heir to the information and occasional misinformation about these topics that existed in the nineteenth century. In addition to summarizing nineteenth-century light and color theory and the role of color in art theory, this chapter also explores specific pronouncements about light and color which show that leading theorists disagreed over not only the number of color components of light, but also which colors comprise white light. In attempting to divide color into its primary hues, writers created a confusion from a failure to differentiate between the color properties of pure light and those of pigments. This is especially significant for rainbow images, which required that the artist paint the colors of light with the inadequate resource of pigments.

Scientific Theories of Light and Color

Light is the source of all color; the absence of light results in darkness, without color. These precepts were generally accepted in the nineteenth century. When Isaac Newton (1642-1747) discovered that refracted, or bent light produced the seven colors of the rainbow, he illuminated the basis for optical studies that progressed to quantum
mechanics and are still continuing in the twentieth century (10, p. 129). Although Newton's classic demonstration of the seven prismatic colors contained in the spectrum was published in his 1704 *Opticks*, universal acceptance of this theory was not realized in the nineteenth century.

Primary opposition to Newton's light and color experiments originated with Goethe, who believed himself to be the "most knowledgeable person of his time in the field of color," and whose 1810 *Farbenlehre* was translated from German into English in 1840 by C. E. Eastlake (10, p. 128). Goethe challenged the validity of Newton's theory, postulating that colors were created by an interaction of light and shadow (7, pp.173-88). To cloud the matter further, Thomas Young in England and C. E. Wunsch in Germany had concluded from their experiments early in the century that light was composed of three primary colors—red, green, and violet, theories readily rejected by Goethe (7, pp. 14, 223). By mid-century these theories of Young and Wunsch had been substantiated by both Helmholtz and Maxwell (7, p. 15). Although Helmholtz made clear in 1867 the distinction between the mixtures of light and pigments, "even this did not dispel for some time popular misconceptions about the differences" (22, p. 433).

Today we know that the primary colors from an artist's palette of pigments are red, yellow, and blue, which, when mixed produce a neutral brownish color. Twentieth-century color knowledge also distinguishes the primary components of
white light to be magenta, cyan, and green, in opposition to pigment primaries. Such information was not available to mid-nineteenth century artists. Believing that the seven basic colors of light could be further reduced to a fundamental triad, artists were frustrated by the inability of pigments to form the color white. Newton himself added to the confusion when referring to artists' colored powders in conjunction with his experiments (22, p. 433).

Thomas Young, important in re-establishing the wavelength theory of light, identified in 1802 three types of color receptors in the eye, red, yellow, and blue (10, p. 128). This set the foundation for physiological optics (25, p. 93). The following year Young amended his theory, substituting red, green, and violet as the color receptors (2, pp. 292-293). Young's work was significant to generations of scientists and artists because it recognized color as a sensation of the eye, establishing a framework for investigations of visual color mixtures.

Art Theories of Light and Color

Just as the scientific community was vigorously pursuing explanations of the natural world, European developments in light, optics, and theory of color were important to artists in Europe and America who looked to science to validate their portrayals of the natural world. Yet a distinction between art and science, consistent with the emotionally uplifting requirements of art was also
necessary. During the first half of the nineteenth century, "the study of colour in painting underwent one of the profoundest revolutions in the history of Western art" (7, p. 11). Gage has stated that this reversal of the traditional, conservative attitude that color played a minor role in painting was due to a new interest in color theory as well as to the growing belief that scientific information was essential to art (7, p. 11).

One source of art theory--vital to those in America as well as in Britain--was published versions of lectures delivered by officers of England's Royal Academy to young students. Views expressed by leaders of that august body were of concern to the American art community, since that academy was the most esteemed institution of art in the English-speaking world, at least through the middle of the nineteenth century. A renewed interest in light and color in nineteenth-century art theory is evident from a comparison of the content of lectures at England's Royal Academy published in 1809 and 1866, changing from a denial of the need for optical knowledge in painting to an emphasis on its value. John Opie (1761-1807), whose lectures were published posthumously in 1809, believed that it was not necessary for a painter to be "profoundly versed in optics" (17, p. 101). Yet in another lecture, Opie recommended that artists be "acquainted with all the phenomena of the reflection and refraction of light, of its composition, and divisibility into red, orange, yellow, green, blue, purple, and violet-
coloured rays" (17, p. 131), while warning artists not to overrate the importance of color (17, p. 132). In contrast, the 1866 lecture series by Henry O'Neil stressed that "painting should impress with its sensation of color" (16, p. 19), and dealt less with the technical aspects of colors than with the emotive sensations possible through their usage. Turner, the master colorist, was lauded as the "most eloquent preacher of the truth...and his pictures impress us with the spirit of Nature more than those of any other landscape painter" (16, p. 10).

Color theory did not become the subject of serious study in the British Royal Academy until after 1815, when painting joined a curriculum that had previously concentrated on drawing technique (7, p. 12). This change has been attributed to artists' readiness to accept scientific theories as relevant to art and to the growing accessibility of color theory to artists (7, p. 11). Of greatest importance to artists in this new attention were two issues: the number of basic colors and the "harmonious effect of their juxtaposition" (7, p. 12). This color harmony was an important facet of nineteenth century art theory, because it showed that artists were increasingly concerned with color perception as a sensation. Speaking in 1818 as Professor of Perspective at England's Royal Academy, J. M. W. Turner reduced Newton's spectrum to three basic primary colors of red, yellow, and blue, summarizing that "light is color" (7, p. 113). Turner helped foster a concern with color
perception when he included a lecture on vision, the structure of the eye, and the mind's role in perceiving color (7, p. 110). Turner's color circles of 1818, were both based on a red-yellow-blue triad, showing that the artist did not differentiate between the properties of light and color (7, pp. 113-115). After reading Turner's notes and comments, Gage believes that Turner's 1843 *Light and Colour (Goethe's Theory)--the Morning After the Deluge* was painted as a negative reaction to Goethe's anti-Newtonian ideas (7, p. 173). Turner's scientific interest in light and color was not limited to theory and pigments. The new field of photography provided experiments with light and polarities that intrigued the artist. He often visited American photographer J. J. E. Mayall's London studio to discuss the "operation of light on iodised silver plates" (7, p. 121). Another scientific invention involving light and color was Sir David Brewster's kaleidoscope, which tallied sales of 200,000 items when marketed in London and Paris in 1816 (7, p. 122). References to the instrument have been found in Turner's notes, although the independent value of color sensations was seen as an amusement rather than providing useful information about light and color (7, p. 123). One artist, James Elmes, wrote that Brewster's time was wasted on the invention, preferring that the scientist had answered some "real artistic need: the practical investigation of methods and materials" (7, p. 124).
Frederic Church's connection to Turner's art was through his teacher, Thomas Cole, who met the English artist in 1829 (19, p. 98), through Crayon articles, Ruskin's publications, the set of Turner engravings that he owned, and his London trip in 1869, when he viewed pictures by Turner, who had died in 1851. American artists were cognizant of developments in English art since many considered European travel essential to their education.

Church's strong ties to English art were typical of American artists in the eighteenth and nineteenth centuries. In London the Pennsylvania-native Benjamin West was a helpful contact to Americans studying abroad, from the 1770's until his death in 1820, through his hospitality and professional guidance (3, p. 3). American expatriate artist C. R. Leslie (1794-1859), also active in the Academy, wrote regularly in the Crayon about art events in England, and was instrumental in introducing visiting American artists to their English colleagues. It was Leslie who introduced Cole to both Turner and Constable in 1829 (19, p. 100).

Central to the "revolution" in the study of color in painting was M. E. Chevreul's 1835 The Principles of Harmony and Contrast of Colors, translated into English in 1854, and listed among the books located in Frederic Church's library (8, p. 352). The French chemist and Director of Dyes for the Gobelins tapestry works recorded in that book his experiments in simultaneous and alternate contrasts of color and of visual color mixtures. These experiments were later
duplicated by Delacroix. Chevreul's book also influenced the Impressionists in the late 1860's and the Neo-Impressionists at the end of the century (21, pp. 20, 22, 24; 3, p. 130).

Chevreul's investigations formed a foundation for Columbia Physics Professor Ogden N. Rood's 1878 *Modern Chromatics*, located in Church's library, and an essential link to Albert H. Munsell's early twentieth century color system. Although the date of that book coincides with Church's final rainbow painting, *The Aegean Sea*, one cannot discount Rood's possible influence on the artist. Work on this publication began in 1868, and the scientist delivered two lectures on the topic of optics in painting to the National Academy of Design in 1874 (21, p. 13). Church's social connections to Rood, through the prestigious Century Club in New York and correspondence indicate that color discussions could have occurred between the two Connecticut-born Americans. Rood indicated in the preface to his book that he had "enjoyed the great privilege of familiar intercourse with artists" during the previous twenty years (21, p. vi). The Rood book, which Church owned, would have been of particular interest to the painter in creating rainbow images because the physicist had duplicated Newton's spectral experiments. Rood illustrated his book with the sequence of the bands of color in the rainbow and their widths and blended demarcations (21).
Numerous other publications in Church's library demonstrate how vital scientific ideas on light and color were to him. Marion's 1870 *The Wonders of Optics* described the physical structure of the eye, the appreciation of color, and optical illusions as well as defining light and its inherent laws (12). Other books dealing with light and color that were listed in Church's library included Robert Hunt's 1854 *The Poetry of Science or Studies of the Physical Phenomena of Nature*; Eugene Lommel's *The Nature of Light with a General Account of Physical Optics*, published in 1876; the 1872 *The Forms of Water in Clouds and Rivers, Ice, and Glaciers* by John Tyndall; John P. Ridner's 1850 *The Artist's Chromatic Hand-Book. Being a Practical Treatise in Pigments, Their Properties and Uses in Painting*; and Thomas W. Satter's undated *Field's Chromatography: or Treaties on Colours and Pigments as Used by Artists*. George Field's work in chromatics was known in London among Academicians by 1811, although not published until 1817 (7, p. 116) and provided an important link for Church to English color theory. A chemist and philosopher, Field accomplished much to improve the purity and range of pigments in the nineteenth century (7, p. 15). Field's research of color science was an important source to Constable in the artist's rainbow paintings (22, p. 437).

Another source was available to provide Church with light and color information. "Meteorology. A Glance at the Science," a summary of the "leading science in physics," was
published in the July, 1860 edition of Atlantic Monthly (13, p. 1). Characteristics of the atmosphere were discussed and explained including, weight, elasticity, density, temperature, reflection, refraction, light, color, wind, optical effects, vapor, clouds, sunsets, and electricity—all items that appealed to Church in the representation of light and atmospheric effects on canvas (13, pp. 2-15). Humboldt was often mentioned for his observations in temperature and climate variations (13, pp. 5, 6). The article stated that color was the result of light, and "there is no inherent color in any object we look at, but that it is in the light itself which falls upon and is reflected from the object (13, p. 7). Admitting that the "theory of color has never been fully agreed upon," the article presented current proposals by Goethe, Brewster's triad of red-yellow-blue, the red-yellowish green-blue-violet theory by Wollaston, as well as Newton's solar spectrum (13, p. 7). The article concluded by outlining the importance of meteorology as an international concern and the noble and distinguished characteristics of those who support the science, believing meteorology to be "commensurate with Nature itself" (13, pp. 14-15).

Also known to Church were Crayon and New Path articles devoted to light and color, which were numerous, often presenting technical information as well as theoretical beliefs. Some titles of these articles included: "Chevreul--Contrasts of Color", "Up Among the Clouds",
In 1855 Asher B. Durand (1796-1886) addressed the problem of painting sunlight, recognizing that pigments were incapable of reproducing the qualities of light. "This glow of sunlight is the great charm and secret of light, most difficult to realize" (6, p. 16). Noting the "inherent lack of the glowing quality in our pigments," Durand recommended a warm palette and the "use of imagination in rendering effect and color" (6, p. 16). This was a challenge to Church, whose paintings throughout his career had been praised for their light effects. In another of his "Letters on Landscape Painting", Durand saw sunshine as the "joyous expression of Nature", and urged artists to explore atmospheric gradation (5, p. 209). Also viewing sunlight as a manifestation of God, the artist presented hints for reproducing the quality of light, advising artists to use warm colors for sunlight and cool colors for shadows and recession (5, p. 210). Referring the reader to Goethe for more information on color theory, Durand stressed the importance of the artists' observations of sunlight and the accuracy of color (5, p. 210).

The difficulty of painting the glow of sunlight was addressed again in an 1855 Crayon article in which the author recommended that artists exaggerate the colors in nature "to obtain the fuller and clearer statement of a
truth" (1, p. 257). This exaggeration was justified for the sake of producing a greater glow and effect of light, believing that a local falsehood enforced a general truth, and that "the whole impression is more entirely that of Nature..." (1, p. 257). The author maintained that the glow and intensity of an object in sunlight cannot be realized if the artist adheres to true color (1, p. 257).

This concept of sanctioning artistic license in the portrayal of light and color is significant because the artist was viewed as an authority in interpreting the natural world. However, even blatant errors in shadows and light sources were not only condoned, but praised by the writer for their effects, although viewers might become conscious of the inaccuracies. Since the inaccuracies in the use of light included examples of Turner rainbows, they will be examined in the next chapter. This article, as others, is important in showing at mid-century the religious associations that light held for Americans who revered the "glow--the essential quality of the all-pervading, glorious light,"(1, p. 257), which eloquently illuminated the beauty of the Creator's gifts.

Summarized in two Crayon issues, Ruskin's views on color paralleled those of American theorists in recognizing the inadequacy of pigments in duplicating nature's brilliance (15, p. 275). While verbosely praising color as an art element (14, p. 141), Ruskin also stated that "...color, even as a source of pleasure, is feeble compared
to form" (15, p. 274). Ruskin was aware of the modification of local color when he stated that "color, in association with other colors, is different from the same color seen by itself" (15, p. 273). This was important to artists in their efforts to imitate nature and to understand the complexities of color. Ruskin cited red, yellow, and blue as the primary colors yet perpetuated the confusion existing between light and pigments when he added that "which, in certain proportions, mix together and form white light..." (14, p. 54).

In contrast to Ruskin, another 1855 article stated that the mixture of the three primary colors produces brown, "the universal color of Nature" (18, p. 117). While suggesting that white be used to simulate light, the writer stressed the inadequacy of black and white to duplicate the dark and light of nature (18, p. 55). Disdaining the English School because the paleness of their paintings was unrelated to the natural world, the author recommended the study of old masters, "together with what science has done for us, and the increase of knowledge" as the path to true use of color (18, p. 117).

Jarves advocated, in 1864, that artists respond to science as a source of clarifying the elusive mysteries of light and color. Citing a need for the study of the theory of light, the writer also required that experiments with pigments be examined to provide a base of knowledge in opposition to the practice of "luck mixtures" (9, p. 285).
The topic of light was first discussed by Jarves nine years earlier in Art Hints, when he stated that the failure of many paintings was due to an "ignorance of the primary laws of vision," believing that not all areas of the canvas should be equally distinct (20, p. 102). A Crayon reviewer countered that, following the laws of optics, since only a small area can be focused on at one time, as in the natural world, the entire canvas should be painted with clarity (20, p. 102). Both Art Hints and Art-Idea are in Church's Olana library.

The Crayon tried to educate the artistic community in the technical aspects of color by analyzing pigments displayed at London's Great Exhibition from international sources. A very lengthy and detailed article, the information presented chemical compositions as well as ratings of the colors' characteristics, including brilliancy, mixability, intensity, effect of intense light and gases, oil, opacity over time, and susceptibility to fading. Recommendations were given as the various hues were divided into permanent, objectionable, and rejected colors (11, pp. 300-303).

To educate artists about color was also the goal of an 1859 article that presented a lengthy listing of harmonious color combinations followed by nineteen rules for the use of color (24, pp. 238-245). The author presented colors in groups of three, four, five, and occasionally more, giving judgments about the harmony of the colors in each group.
For example, one of the hundreds of entries stated that "blue, red, and yellow harmonize, if in proper proportion, but there are other more agreeable combinations, such as blue, scarlet, and yellow" ...blue and crimson (or scarlet) and yellow and a little green and black and brown and white harmonize, but not very agreeably (24, pp. 239-240). Of the nineteen general rules outlined at the conclusion of the article, several showed the extent of color experimentation. Knowledge of visual color mixing is indicated by the fifth precept, "yellow should be placed between or near to red and blue to obviate their purple effect." Another rule urged artists to consider the effect of simultaneous contrast, the difference in perception of the same color on different backgrounds, while a more specific dictate advised the use of bright green "to lighten up a composition" (24, pp. 244-45).

The education of artists was also one of the goals of the National Academy of Design in New York. Established in 1825, and patterned after the Royal Academy of Art in England, this institution was founded to promote the arts in America. Samuel F. B. Morse was its first president, serving in that position until 1845. The goal of the school associated with the Academy was to provide visual and technical training in anatomy and perspective to young artists (3, p. 90). Instruction in color was provided in 1835 with the appointment of John J. Mapes as Professor of Chemistry and Natural Philosophy of Colors, who delivered a course of
lectures on the subject of color (4, p. 135). A frequent exhibitor at the Academy, Frederic Church was elected an Associate of the National Academy in 1848 and an Academician the following year at the age of twenty-five.

Color theory began with Newton, becoming increasingly mathematical over the next three hundred years with developments of wave theories of light. Rainbow theory developed concurrently from Newton's observance of the color composition of light. Despite disagreements among scientists and artists about the nature and properties of light and color, both groups continued to strive for solutions to explain and represent the natural world. That Frederic Church had a "scientific mind" (3, p. 119) can be supported by the diversity of scientific publications in his library and the canvases that he painted. Since the information available to Church about light and color was vast, it is no wonder that he chose to render the rainbow, a most ethereal form of light and the purest form of color in nature.
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CHAPTER V

RAINBOWS IN NATURE AND ART

Two years prior to Frederic Church's epic Niagara, James Jackson Jarves criticized Turner's skies, stating that "the bright atmospherical colors should appear of prismatic tenderness of outline and texture as in the rainbow arching space" (22, p. 104). Church responded to this call for prismatic transparency, the ultimate expression of light through pigments, by depicting a rainbow in his 1857 Niagara Falls canvas and in three additional paintings during his career. In turning his attention to the rainbow repeatedly, Church was not alone in the middle of the nineteenth century. There was a marked increase of its appearance in American and European paintings. Scientists in various nations wrote specialized studies about them; people became fascinated with recording in articles their sightings of unusual rainbow configurations such as double and triple arcs. Advice of a scientific character was published to aid artists in the accurate representation of rainbows.

Scientific Ideas about Rainbows

The development of rainbow science was inextricably linked to studies of light and color. The earliest explanation of the physical nature of the rainbow was provided in 350 B. C. by Aristotle who saw the arc as a
reflection of light from raindrops (11, p. 76). Although Aristotle proposed the existence of eight basic colors, including black and white, he claimed that the rainbow was comprised of three colors--red, green, and blue (3, p. 48). René Descartes's observations in 1637 of the double refraction of light and its angle of approximately forty-two degrees in the creation of a rainbow was the next important step before Newton's isolation of the rainbow's colors of the spectrum (11, pp. 76-77). The optical interference of light, discovered by Thomas Young in 1801, "unlocked one of nature's best-kept secrets--the cause of the supernumerary rainbows" (3, p. 285). With George Airy's 1836 publication of the theory of diffraction, which further explained the supernumerary bows, or multiple reflections, "the story of the rainbow had become inextricably interwoven with the development of mathematics" (3, p. 307). Geometric and trigonometric functions led to the development of quantum mechanics of physics to research light and rainbow theory.

Although calculations involving geometry, calculus, and trigonometry were beyond the scope of most nineteenth-century artists, some, such as Constable, consulted these contemporary sources (24). That an extensive number of papers delivered and published in London and Edinburgh dealt with rainbow theory in conjunction with light and color in the first half of the century underscores the importance of the topic in scientific circles. From the eighteenth century, sightings of unusual rainbow phenomena
were recorded in England as residents looked to science to explain the events (3, pp. 277-281).

An 1842 German publication also cited rainbow configurations that had been observed, including multiple arcs, white rainbows, lunar bows, and arcs in a cloudless sky (16, pp. 271-275). After an explanation of primary and secondary bows and the corresponding angles of each, the author recommended the waterfalls at Reichenbach as an excellent place to view rainbows (16, pp. 270-271). Another German author pondered whether a rainbow could be viewed from the side (21, p. 108). This is not possible since the sun must be at the viewer's back in order to observe a rainbow, which is always on a plane parallel to the viewer.

Rainbow-related articles also appeared in The American Journal of Science and Arts, established to advance scientific truth in 1818 by James D. Dana and Benjamin Silliman, Yale University Professor of Chemistry, Geology, and Mineralogy (2, p. 5). Silliman was also responsible for securing Yale's Trumbull Gallery of Paintings not only as a collection of art, but also as an illustration of American history and biography (2, p. 3). An 1854 Journal article reported a student's detailed description of the place, time, appearance, weather conditions, and degree positions of the bows while observing a tertiary rainbow, followed by a note from Professor Snell of Amherst College. The scientist concurred with the conclusion, stating its significance due to the rarity of the occurrence of a tertiary rainbow,
the first recorded by an American observer. Two British sources of optical treatises were consulted by Snell to support his conclusion, including Professor Forbes's University of Edinburgh's Report on Meteorology of 1840, which described a German sighting and the theoretical basis that acknowledged the probable existence of such a phenomenon (12, pp. 56-57).

As an explanation of a reflected rainbow, Professor Snell offered a theory, complete with sectional diagram, in a Journal entry later that year. An extraordinarily brilliant double rainbow was observed, with a third bow nearly superimposed on the scene, which Snell theorized was due to the sun's angle and the reflection from placid water, causing the third bow to be reflected to the sky (25, pp. 18-19).

An optical phenomenon viewed in the Catskills was reported to the scientific community through the Journal in 1858, when a complete circular rainbow was observed from a high vantage point following a rain in a valley of the region. The effects of the images from a glory were described as well as a notation that as the sun became lower in the sky, the circular form became oval, with paler colors (19, p. 298). These articles show that interest in rainbows was developing in America concurrently with other countries.

Another source was available to provide nineteenth-century Americans with current meteorological information. The rainbow was one of the atmospheric phenomena discussed
in the *Atlantic Monthly*'s July, 1860 article, "Meteorology: A Glance at the Science." Attributing the rainbow's appearance to the refractive power of the atmosphere, the article defined and explained this principle as well as that of reflection and its equality with the angles of incidence (17, pp. 6-7).

However, Church had to look no farther than his library to read about specific rainbow information. Robert Hunt's 1854 *The Poetry of Science or Studies of the Physical Phenomena of Nature* presented scientific information from all fields including geology, plant and animal life, electricity, motion, molecules, gravitation, and chemistry. The chapter on light discussed the prismatic colors contained in a ray of white light, citing Newton's observation of seven colors, enumerating each in "strict order" (13, pp. 134-135). Claiming the rainbow to be the most "beautiful natural illustration of luminous refraction," this chapter also presented Brewster's theory that a red-yellow-blue triad comprises white light as well as Goethe's belief in the reduction theory of the colors of light (13, pp. 135-137).

Especially significant to Church in search of rainbow information was the knowledge that yellow was the "most intensely luminous" color of the rainbow, that the colors of a secondary rainbow are lighter and in reverse order, and that the colors in the spectrum blend into one another (13, pp. 134-135). Page notations referred the reader to scientific authors' treatises for more information, including
both Brewster's and Young's lectures and publications on light and color. Other information in this chapter on light that would have interested Church was a discussion of polarized light and Daguerreotype plates and information about the structure of the human eye and vision (13, pp. 141-148).

In addition to its inclusion in scientific and popular publications, other writers also addressed the rainbow in the nineteenth century. In 1817 John Keats stated that Newton 'had destroyed all the poetry of the rainbow, by reducing it to its prismatic colours,' and that the rainbow had been robbed of its mystery (26, p. 191). Ruskin's Romantic vision was similarly dulled by the knowledge of Newton's discovery, since the English critic wrote in Modern Painters, "I much question whether any one who knows optics, however religious he may be, can feel in equal degree the pleasure or reverence which an unlettered peasant may feel at the sight of a rainbow" (23, p. 387). In an 1826 poem about rainbows, Goethe referred to the charming landscape created by a rainbow arching over the hills (21, p. 37). Charles Darwin described in his Journal a rainbow that he observed near southern Chile on his voyage on the H. M. S. Beagle in 1834:

It was an ominous, sublime scene. During a few minutes there was a bright rainbow, and it was curious to observe the effects of the spray, which, being carried along the surface of the water, changed the ordinary semi-circle into a circle--a band of prismatic colours being continued from both feet of the common arch across the bay, close to the vessel's side: this forming a distorted, but very nearly entire ring (26, p. 200).
Both the Darwin and Ruskin publications were in Frederic Church's library. In 1873 Ruskin was lenient in criticizing Rubens's flagrant misrepresentation of a rainbow:

Rubens' rainbow... was dull blue, darker than the sky, in a scene lighted from the side of the rainbow. Rubens is not to be blamed for ignorance of optics, but for never having so much as looked at a rainbow carefully (18, p. 170).

Religion and Rainbows

The mixture of religion in art and science is also a factor in rainbow images. The iconography of the rainbow as a sign of the covenant between God and man originates in the Bible:

I do set my bow in the cloud, and shall be for a token of the covenant between me and the earth. Genesis 9:13.

Used frequently in religious art, especially in the Middle Ages, the rainbow has signified hope as God's promise, or despair, reflective of the transient effect of the rainbow. Historically the subject of myths and mysticism, these colorful phenomena had been explained by most civilizations in terms of cultural legends.

The dual iconography of rainbows has been addressed by Landow in his investigation of nineteenth-century English paintings with rainbow depictions. Passages from writers such as Wordsworth, Byron, Shelley, and Keats are cited that indicate an ambiguity of thought in connection with the rainbow that is paralleled in the art of the time. For example, the rainbow in Millais's The Blind Girl (1865, City Museum and Art Gallery, Birmingham) is seen as a symbol of
hope, while the arc in Turner's *The Wreck Buoy* (1849, Walker Art Gallery, Liverpool) is cited as being ambiguous in its formation over a disaster scene (15, pp. 361-369).

Rainbows in Art

An exhaustive study of the development of rainbow science in England was completed by Paul D. Schweizer in analyzing Constable's 1831 *Salisbury Cathedral from the Meadows* (Private Collection, Figure 3). Connecting Constable's notations on rainbow drawings, Schweizer has

![Salisbury Cathedral from the Meadows (1831), John Constable.](image)

has shown that the artist was understandably unable to reconcile current thought about the nature of light and color and the rainbow. Citing Constable's notes, as well as
investigating current knowledge of optical and color theories of the rainbow, the scholar documented the artist's accuracies and inaccuracies in rainbow images. Beneath a rainbow sketch Constable had written "3 primary" and "7 prismatic", indicating his indecision about the number and exact coloring of the rainbow (24, pp. 431, 439). Additional Constable diagrams of light, including its angles of reflection and refraction when entering spheres of water show that the artist was intent on comprehending the geometric requirements for an accurate rainbow representation. What is so surprising, then, is Constable's deviation from these angles when he painted the bow in the Salisbury canvas, where the arc is theoretically impossible due to the viewpoint and position of the sun. Schweizer concluded that Constable's inability to determine the appropriate number of colors in the rainbow was due to the conflicting opinions of the time--whether light was trichromatic or whether the Newtonian theory of seven bands of color was valid (24, p. 431).

Considered Constable's most monumental and dramatic rendering of a rainbow, his Salisbury Cathedral has been shown to reflect meteorological facts, with some inconsistencies, while also incorporating Constable's concern over the reform movement within the Anglican Church. Schweizer has concluded that the artist shared the nineteenth century's confusion about the distinction between the colors of light and pigmentation colors (24, pp. 424-
Some theorists, being unable to differentiate the colors, could not reconcile the fact that pigments of the primary colors could not be combined to form a representation of white light.

Schweizer has written that Turner was one of the few artists of the period who did not accept the rainbow as a source of color in painting, believing that the red-yellow-blue triad was the fundamental source of color in nature. Turner's use of pigment in the 1823 *Norham Castle* watercolor, in which he juxtaposed and superimposed the basic triad to create colored light, was the "predictable result of his age's general misunderstanding of color science" (24, p. 439). Turner, fascinated by light and color, was equally enthralled by their manifestations in the rainbow. Mayall recalled the artist's 1847 visits to his photography studio:

> He came again and again, always with some new notion about light. He wished me to copy my views of Niagara--then a novelty in London--and enquired of me about the effect of the rainbow spanning the great falls. I was fortunate in having seized one of these fleeting shadows when I was there, and I showed it to him. He wished to buy the plate...He told me he should like to see Niagara, as it was the greatest wonder in Nature; he never tired of my description of it (10, p. 121).

Turner's deviations from nature in his rainbow paintings were likely known to Church from an 1855 *Crayon* article justifying Turner's scientific inaccuracies in *Keswick Lake*, where shadows indicate the sun is shining from the right, thus making the background rainbow a physical impossibility. "This is, of course, a bold and positive falsehood...and though Turner knew this well, he wanted the rainbow to make..."
out his color, and wanted, also, a shadow falling that way to make out his light and shade,... and so he gave us both, each exquisitely true..."(1, p. 257).

Apparently such artistic license was less condoned by 1860, when an article appeared, scientifically explaining rainbows to American artists "so that the images will be in accordance with nature, therefore, not merely decorative or contrived" (4, p. 40). Noting a proliferation of rainbows in art, the writer urged discretion in their use, preferring that they be eliminated from landscapes. Defined as an arch consisting of "all the colors formed by the refraction and reflection of rays of light from drops of rain or vapor," the rainbow was diagrammed, illustrating Descartes's theory that the arch formed would create an angle between approximately forty-two and fifty-two degrees (4, p. 40). This diagram (Figure 7), drawn in perspective, could have created confusion in the readers' eyes, since a rainbow can never be seen in perspective, even if the light source is accurate,
since the viewer's sight must be perpendicular to the rainbow. Equally disconcerting is the difficulty in ascertaining the placement of the sun, at the points of refraction at entering, the reflection at the opposite side of the raindrop, and the refraction, or bending, at leaving the water surface.

Describing Newton's law, the article gave the angles where the red and violet rays can be see, and claimed that other prismatic colors would be between these two rays. The discussion of refrangibility, the colored rays within a beam of white light, is significant in its differentiation of colors created by pigments in that the mixture of colors to form white is distinct from the mixture of pigments that do not form white. The outer bow in a double rainbow was identified as being less distinct, being the result of two reflections (4, p. 40). Other rainbow information presented to the artist included that the arch cannot be larger than a semi-circle unless the spectator is on elevated ground, that a partial arc is possible due to cloud formations, and that a rainbow can appear in a clear sky if vapor is present but not dense enough for cloud formation (4, p. 40).

A second diagram (Figure 5), illustrating the use of a rainbow in a landscape painting, correctly positioned the spectator perpendicular to the horizon line, stating that the sun is in a vertical plane behind the viewer. Affixing letters to indicate lines of the sun's rays, the angles corresponded to the degrees of the rainbow's appearance.
Noting that the higher the sun's position in the sky, the lower the rainbow's position, would have been important to artists in arranging the light source for their landscapes (4, p. 41). This article presented more than a mere assertion of the scientific basis for the phenomenon of the rainbow; it showed that there was a tremendous concern for scientific accuracy and consistency of light in the depiction of rainbows, and that color differences between white light and pigments were known to the artistic community at mid-century.

The use of rainbows was not limited to European art, as many American painters included the arch in their landscapes. Although rainbows are rarely depicted in the work of the first generation of Hudson River artists, Thomas Cole recorded his observations of clouds and rainbows in his journal as early as 1825 (20, p. 90). In contrast, the second generation of the Hudson River School, beginning in the 1850s, frequently painted the natural phenomena, which are found in the art of Church, Jasper Cropsey, Albert
Bierstadt, and George Inness. Having established his scientific reputation in 1857 with the exhibition of *Niagara Falls*, future Church canvases were also noted for their scientific basis—in portraying the physical aspects of a locale and the accurate delineations of vegetation and atmospheric effects. Church's inclusion of rainbows was not unique to his generation, however, the artist selectively incorporated the prismatic arch into his paintings.

Church's final rainbow painting, the 1878 *The Aegean Sea*, was the artist's last picture to be shown publicly. Physical impairments, the result of severe arthritis, and Church's interest in his home and property at Olana, prevented him from exhibiting during the last quarter of the nineteenth century. Church continued to build his library, adding scientific, art, architecture, and travel publications during this time, and usually wintered in Mexico. Returning from such a trip in the spring of 1900, Church died in New York at the age of seventy-four.

It is evident that changes occurred in the rendering of rainbows during the first half of the nineteenth century. The thin, linear, hard-edged bands produced in Vanderlyn's 1804 *A View of the Western Branch of the Falls of Niagara* (Senate House State Historic Site, New York State, Figure 6) are only equalled in their caricature-like qualities by John Trumbull's *Niagara Falls from Below the Great Cascade on the British Side*, c. 1808 (Wadsworth Atheneum, Figure 7). These two rainbow images differ significantly from the prismatic
effects of Church's \textit{Niagara Falls} (Figure 8). Even within Church's \textit{oeuvre} there was an evolution towards greater accuracy as will be seen in his rainbow art.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig6.png}
\caption{A View of the Western Branch of the Falls of Niagara (1804), John Vanderlyn.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig7.png}
\caption{Niagara Falls from Below the Great Cascade on the British Side (c. 1808), John Trumbull.}
\end{figure}
Frederic Church rarely talked about his art publicly. No interviews were found in which the artist could have expounded on his ideas about landscape art, light and color; nor did he contribute any articles to art publications. Unlike his mentor, Thomas Cole, Church did not keep a journal of his artistic theories, thoughts, and travel experiences. Therefore, the most accurate picture of the artist and his interests is revealed by his correspondence, which is preserved at Church's home, near Hudson, New York, now the Olana State Historic Site.

Church's earliest reference to rainbows was in a letter to his mother from Bogota during his first trip to South America in 1853, in which he described a local waterfall "...and bright rainbows in the mist served to enliven the
scene" (5, p. 3). This description shows the artist's early awareness of the rainbow's prismatic effects of light and color, observing them from nature, and predates his Niagara canvas by four years. By the time Church resided in Rome during the winter of 1868, his reputation as a master of atmospheric effects had been established, since fellow-American artist G. P. A. Healy (1813-1894) had asked for his help in rendering them, as Church reported to his friend, William Osborn (6).

Church had also established his reputation as a pre-eminent painter of rainbows. Later that month, November 30, 1868, Church wrote again to Osborn from Rome:

   But-alas-I am not only in demand to cure men but pictures also. Sometime since Healy asked me to show him how to paint a rainbow which he wished to introduce into a large picture of Lincoln, Grant, Sherman and Porter--a few days later a Mr. Welsh, a German-American also begged me to show him how to paint a rainbow for a waterfall that he was painting, and also a Mr. Richards came in for instructions in rainbows. I gave them all my best prismatic touches and retired as I supposed with my best bow--but today--T. Buchanan Read--who is painting the ex-Queen of Naples called upon me to show him how to do something in his picture. To my surprise this time--there was no bow--only a volcano and sunset (7).

Apparently Church's renown as a painter of the prismatic effects of Niagara, The Heart of the Andes, and Rainy Season in the Tropics, the last painted only two years prior to his Roman visit, was well-respected by his colleagues.

Church's concern with color and capturing sky effects is discernible from a letter to Martin Johnson Heade in 1870.
We are having splendid meteoric displays—magnificent sunsets and auroras—red, green, yellow, and blue, and such—in profusion. I have actually drawn away from my usual steady devotion to the new house to sketch some of the fine things hung in the sky (8).

As late as 1891 Church was still enjoying the sky, writing to his friend, the Albany sculptor Erastus Dow Palmer (1817-1904) that the "magnificent effect this morning—beautiful clouds, and opalescent atmosphere and lovely tint in the landscape distract me every minute" (9). Church truly loved nature and reveled in its majestic effects.
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CHAPTER VI

FREDERIC CHURCH'S RAINBOW ART

Tremendously popular during his lifetime, Frederic Church received public acclaim from an appreciative audience, willing to pay for private showings of his panoramic canvases. Creating quite a sensation, his art was sometimes viewed through opera glasses in order to experience vicariously the minute details of the locale depicted in his landscapes. Church responded to Humboldt's dictates, traveling twice to South America to record the wonders of the tropics, to the north to paint icebergs, to Jamaica, Mexico, Europe, the Near East, Canada, and extensively throughout New England. The paintings resulting from these trips were often noted for their atmospheric qualities and precision of detail in the scientific rendering, presenting exotic wonders of foreign lands to Americans.

Interspersed throughout his career, Church's rainbow paintings manifested just one aspect of his continuing fascination with light and atmospheric effects. Niagara Falls (1857) established Church's scientific reputation (19, p. 380), which was still intact in 1862, when Cotopaxi, a painting of the South American volcano, was described as "absolutely and scientifically true to the facts of nature and the requirements of art" (19, p. 380). As early as
1855, light was noted as the key ingredient in Church's first epic landscape, The Andes of Ecuador, since it "animates and unifies the entire scene" (14, p. 78). The artist's 1859 iceberg trip was important for his captivation by displays of light and color (14, p. 108), recording these atmospheric effects in iceberg and Aurora Borealis canvases.

Sunsets, a source of devotion for Church, were the subjects of many landscapes, the light and atmospheric qualities constantly appealing to the artist. "For both Thoreau and Church sunset was a daily pageant of light and color that never became boring, and both men delighted in recording its effects throughout their lives" (14, p. 87). In discussing his offering of simple supper fare to his friends, Church wrote to Ogden Rood that "we can usually recompense our hungry guests by a substantial sunset" (5).

Fig. 9--Twilight in the Wilderness (1860)
Frederic E. Church.
Considered his most well-known sunset, Church's *Twilight in the Wilderness* (1860) (Cleveland Museum of Art, Figure 9) brilliantly recreates the colorful solitude of the setting sun. Church's technique in the striated areas of pigment to emphasize form and direction in this painting has been termed Turnerian (14, p. 112).

However, art historian, Barbara Novak, states that the greatest resemblance between Church and Turner is "their enveloping, all-consuming light" (17, p. 248). Although this may be a mere coincidence, there are reasons to believe that Church was influenced by Turner's consummate use of light and color. In addition to studying Turner engravings, Church viewed two Turner landscape paintings belonging to a client in New York, both consumed with "light and atmosphere in diffused and vaporous states" (14, p. 112). Church visited the National Gallery during his London visit in 1867 to view Turner's work (12, p. 155). Although Church knew Turner's work, he wrote from Rome to his friend William Osborn, that he preferred Cole's work to Turner's, and in some instances to Claude: "Thomas Cole was a remarkable genius--far superior in the highest qualities to Turner--and if not quite equal to Claude in those respects--yet was so much his master in others that I feel that I should prefer to own one of Cole's best landscapes in preference to any other landscapes the world can furnish" (3).

That Church would admire Claude's luminosity is not surprising. The veil of light encompassing many Church
canvases can often be viewed as attributable to the tranquil golden light that permeated the Baroque master's paintings. Some Church landscapes have been associated with the Luminist art of the nineteenth century, identified primarily by Heade, Lane, Gifford, Kensett, and occasionally Church. Noted for their "glassy, mirror-like quality" and "silent stillness," (17, p. 41) of these transcendental landscapes have their antecedents in Claude's silky light.

Niagara Falls, considered an American icon, was the subject of scientific investigations in the eighteenth century to measure the height and breadth of the cataract and to record observations of the flora and fauna of the area (15, p. 18). A 1768 engraving by Thomas Davies, An East View of the Great Cataract of Niagara (Figure 10), includes a hard-edged rainbow, shown in perspective, which

Fig. 10--An East View of the Great Cataract of Niagara (1768), Thomas Davies.
is a technical impossibility since rainbows always appear parallel to the plane of the viewer. This engraving begins an immense lineage of renderings intent on replicating the majesty of the internationally-known falls. Those artists of Church's generation who painted multiple images of the falls, both with and without rainbows include the Americans Kensett, Cropsey, Inness, Catlin, Bierstadt, Samuel F. B. Morse, William Morris Hunt, and the Frenchman Gignoux.

Church's early awareness of the effects of the rainbow is shown in his description of a waterfall in Bogota in a letter to his mother, dated July 7, 1853, "...and bright rainbows in the mist served to enliven the scene" (4).

Church recorded that Colombian scene in June, 1853 in a sketch, Waterfall with Rainbow Effect (1917-4-705), his first rendering in oil of a rainbow. Unusual in its close view of a rainbow, appearing to be a detail study for a larger canvas, the June, 1853 Waterfall With Rainbow Effect contains no sky elements. Rather one observes a diagonal formation of foreground rocks, followed by a waterfall that echoes the oblique angle, culminating in a rainbow arc in the lower mists of the falls that reinforces the dynamic diagonals of the study. In an otherwise neutrally shaded composition, the rainbow is painted with broad, flat bands of color, in a heavy, harshly striated five-color sequence from red through violet.

This painterly effect of the pigments plus the lack of a visible light source detract from the realism in the
rainbow. In contrast, the loose applications of tonal values of the foreground rocks, background hues hinting to form vegetation, and the central waterfall foaming downward are quite dramatic in their spontaneous expression. This sketch is not an exercise in depicting the light, color, and atmospheric effects that marked Church's more mature works. The rainbow seems stiff and contrived in comparison to the freedom and dynamism of its surroundings. Church's use of the rainbow colors "to enliven" the monochromatic scene is painterly and opaque, with no hint of the translucence that would be displayed in later paintings.

Church must have known Cole's 1833 Manfred (Yale University Art Gallery, Figure 12) since the similarities between the paintings are striking. Compositionally, both feature dramatically diagonal white waterfalls on the left
behind foreground rocks with rainbows appearing in the cascading water on the right side of the canvas. Cole's rainbow consists of a narrow red band and a wider band of yellow, while Church's sketch features a five-banded strip of color. With this sketch, Church is already
beginning to excel his teacher in achieving accuracy in the natural portrayal of rainbows.

Another 1853 oil sketch, *Clouds, Rainbow over Hut* (Figure 13), shows that Church was experimenting with rainbow colors to achieve an approximation of light with the pigments. In this painting, Church was intrigued by the rainbow, using the arc segment as a compositional device to enliven an expansive mountain area of the canvas. Probably the result of that year's South American journey, the oil sketch, approximately 12 x 18 inches, displays a brown, mountainous middle zone preceded by a valley with a small, white structure perched on a foreground precipice. Andean snow-covered peaks are seen in the distance. The rainbow segment is adjacent to the building, gently curving toward the paler, rose-tinged heights of the background.

![Fig. 13--Clouds, Rainbow Over Hut (1853), Frederic Edwin Church Oil Sketch.](image-url)
Unlike future canvases, no storm clouds have passed the scene for the sun to create the pleasant arch. Nor does one see tropical surface moisture veiling the valley. The sky is rather bland, the rainbow being the key meteorological element in the composition. Frontally focused, the light in this oil sketch does not approximate the often mystical treatment of Church's final canvases. Fortunately, the sun source is properly located to cause the rainbow reflection. What is amazing is that Church, admittedly early in his career, could err so blatantly in painting the sequence of colors in the rainbow. Four years prior to the magnificent rendering of *Niagara*, the artist was not aware of the sequential arrangement of the colors, by placing blue on the outer edge, followed by bands of red, yellow, and green.

Constable shared a similar confusion concerning the number of colors in the prismatic range of the rainbow, noting on his drawings both the three and seven-color theoretical components (18, pp. 429-431). The opacity of Church's bands of colors in stiff brushstrokes can be attributed to the looseness of an oil sketch in opposition to a finished product. Yet the artist did attempt to superimpose the bow over a rock formation and mountains, achieving a transparency that he was unable to do in the earlier *Waterfall with Rainbow Effect*. At this still early stage of Church's career, the artist was not aware of the properties of light and the potential of atmospheric effects that would later be so acclaimed. Scientific accuracy was of secondary
importance to the painter of the transcendental landscape as he was formulating his aesthetic and technical goals.

An 1856 Niagara drawing provides more accurate clues about the artist's objectives in rendering the falls, although the sketch does not include a rainbow. By describing the lower mist as "luminous" and noting "brilliant foam" in another section, Church was attempting to transfer these adjectives into pigment. Colors were also noted on this sketch, including "grey cool, purple blues, yellow green, and dark purple blue (thunder)" (1917-4-141).

Another Niagara study of the same year, while not displaying written notations, does include a double rainbow, arching left from the curve of the falls. Several thin, unparallel lines comprise the rainbows, with a hatching technique used between the arcs. While this is a closer view than that portrayed in the finished canvas, the most obvious difference is the placement of the rainbow. From the cataract's far right curve in Canadian Bank with Double Rainbow, the arch was moved to the left on an extended canvas, encompassing a wider panoramic view of the falls (1917-4-148a).

The rainbow in the 1857 Niagara Falls, just one element in the composite of pictorial sensations in the famous painting, was Church's premiere representation of this image, garnering praise in America as well as in England, where it was exhibited prior to its being engraved. It was the realism of the scene of Niagara that captured the
public's attention. Adamson has credited the painting's popularity to its ability to give the viewer the sensation of being physically present at the scene (1, p. 95).

Church accomplished his objectives through several devices, including the canvas dimensions, being an unusually horizontal composition measuring 42 x 90 inches, to encompass the maximum magnitude of the dramatic Canadian side of the Falls. From a murky foreground, the viewer immediately witnesses the technical virtuosity of the artist, where water, gushing over rocks, creating wonderful sensations of purposeful turbulence as it journeys to the brink of the falls, is so accurately rendered that one can almost feel its presence. It is no wonder that one critic described Church's cataract as only lacking the roar of the great natural wonder (13, p. 2).

Another component of the canvas which contributed to Church's achievement of realism was the compositional unity of the depiction. The horizontal parabolic curve of the falls is offset on the left by the arch of the rainbow. The dark clouds of a rainstorm interrupt the rainbow, creating a contrast in the sky elements.

The light-infused, colorful arch also accentuates depth in the painting. As one contemporary account observed, "On the extreme left, you see a part of the depth into which the river falls, and through the mist discern the familiar rocks below, while above them is a palpitating broken rainbow rising from its birthplace in the foam, and seeming to
change while you look at it" (12, p. 86). This rainbow that so intrigued Ruskin was considered by Tuckerman in 1867 to be the "perfect optical illusion of the iris" (19, p. 371).

How did Frederic Church so convincingly paint an object that was in reality pure light? The artist must have had extreme confidence in his abilities to attempt such a project. Church was aware of the seven-color theory of prismatic color from his knowledge of optics, yet chose to display this rainbow with primarily yellow pigment, softly including blue on the inner edge of the segment meeting the falls and faintly incorporating rose on the outer edge of the sky segment of the arc. As a student of nature, Church would have observed that the rainbow does not always display its complete panorama of color, and may, depending on the season and time of day, exhibit three or less colors. Church, unlike some artists, showed meteorological accuracy in displaying the proper hierarchical sequence of the colors used in the rainbow. Without appearing to be contrived as were earlier landscape paintings with rainbows, Church's subtle arc gives the impression of light complete with the flash effect of a burst of pure light as the sun playfully dispenses its rays on the moving darkened area of water-laden storm clouds as they recede, while the water droplets in the nearer cloud form the delicate arc segment described as "palpitating."

The rainbow that we see today in Niagara at the Corcoran Gallery differs slightly from Church's original.
The painting was returned to the artist in 1886 for repairs, but the aging artist did not merely restore the work to its former appearance, he made changes which he believed improved the canvas. Evidently a restorer had damaged the painting, which the museum asked Church to correct. Instead of returning the canvas to its original condition, Church changed aspects of it in ways he regarded as improvements. A letter to his friend, the Albany sculptor, Erastus Dow Palmer, described the occasion. "I am busy in various ways—I have the Niagara Falls here—from Washington-An energetic picture cleaner removed the sky—for repairs I suppose—mopped up most of the water and added grandeur of chaos to the scene. ...I repainted the sky and I think [I] have made it in some respects better than before in as much as it is more subservient to the cataract" (6).

Continuing the chronological development of Church's rainbow art, the next arc of record is a pencil sketch, Double Rainbow over Falls, dated 1858. In this drawing, (1917-4-151B) the rainbows connect a river bank with the top of the falls on the right. The secondary bow does not complete the semi-circle, but edges off the paper, leaving two quarter-segments. A series of lines denotes the bows, and no notations were made to indicate colors. However, the drawing is important in that it shows that Church continued to sketch the phenomena.

Received with equal, if not greater acclaim than Niagara, Church's 1859 The Heart of the Andes, (Figure 14),
solidified the artist's reputation. An epic portrait of South America, this painting was a novelty to North Americans for its subject matter, method of exhibition, and sales price. The geographical physiognomy of the Andes painted with photographic accuracy in the year of Humboldt's death, was a direct response to the naturalist's dictates to travel and record accurate delineations in an ideal landscape (10, pp. 59-63). Contemporary accounts of the Heart of the Andes focused on the scope of the project, including Church's travels, the beautiful effects of the painting and

![Image of Heart of the Andes](image_url)

**Fig. 14--The Heart of the Andes (1859), Frederic E. Church.**

its realism. Surprisingly, there were no references to the faint rainbow in the upper right corner. Rather, critics concentrated on the overall atmospheric effects in the replication of the remote regions of an exotic land. The
sensation of the entire scene was one of wonder as each
detail was meticulously rendered.

Perhaps a reference to Church's success two years
prior, the rainbow in *The Heart of the Andes* appears to be a
prismatic glow from the effect of the light caressing the
atmospheric vapor of dense yet individual cloud forms.
Occupying such a small space on the enormous canvas, the
colors have not consolidated into a distinct rainbow arch,
but remain expectantly in the sky as a transparent prelude
to a grand and powerful sight. The rose, yellow, and blue
rainbow colors from the *Niagara* arch subtly blend and flow
into one another, with an even greater transparency than in
the earlier painting. Rather than being of equal widths,
the red band is distinctly wider than the other two, echoing
the tints of distant mountains below. The vaporous delights
of the sky are given the same delicate attention that Church
applied to the foreground mists created by a gentle water-
fall. Church would have been pleased had he known of a
diary entry by a young viewer in 1859, who would one day
establish the Isabella Stewart Gardner Museum, who declared
this painting equal in quality to any Claude Lorrain (13, p.
7). Even while citing deficiencies in composition and
unity, one critic praised the sky area, acknowledging the
beauty, transparency, and delicacy of the clouds forming
"celestial depth" with "fleecy lightness" (11, p. 193).

During the seven years between *The Heart of the Andes*
and Church's next rainbow painting, *Rainy Season in the*
Tropics, 1866 (Figure 16), the artist continued to record his explorations of the world, always aware of atmospheric effects and color. Twilight in the Wilderness (1860), a tranquil American sunset in an unadulterated forest, The Icebergs (1861), Cotopaxi (1862), Chimborazo (1864), and Aurora Borealis (1865) were produced, the last three exhibited in London in 1865. A new boldness in the use of color was achieved in the sunset and South American canvases, the two volcano paintings, as if the artist had emerged from an earlier conservatism to explore a warmer sun-enriched palette of reds and oranges. The subjects, time of day, and atmospheric conditions suggested such colorful treatment to Church, who was always truthful to nature.

If Church did not paint rainbows in oil during this time, he did sketch them. Of the numerous Church drawings containing rainbows, many include written notations of color and atmospheric descriptions, indicating the methods used by the artist from initial conception or recording of a scene. Often Church would place numbers on the drawing, corresponding to a numbered, descriptive color key. Occasionally the notations would be imprecise, such as the Number Five in the legend accompanying a wonderful cloud study, "darkish slightly warm indescribable color" (1917-4-1413).

Church made such a notation on Sky Study, Mountain Ridges, Rainbows, a drawing dated in the 1860s (1917-4-1172). A double rainbow of four quickly sketched lines
curves downward from clouds where Church wrote "blue light fading". Foreground information includes "reddish shadow-yet luminous". A distant scene from a high viewpoint in the 1865/66 drawing Hills, Rainbow shows a rainbow comprised of four lines, indicating three colors, with the word "glow" over the hills to the right where the rainbow arches. (1917-4-1173b). To the left in the valley Church had written "luminous" and the foreground notation states "dazzling green". With the same date, the drawing Cloudy Sky, Rainbow (1917-4-1174a) is tremendously important because it shows a wide rainbow, without banding, with the word "red" written on the outside edge, showing Church's observation that the red color is on the outer edge of the rainbow. To the right of the rainbow, the words "warm glow" and "reddish-purplish glow" indicate Church's concern with luminosity. In his studio he would try to recapture these effects of nature in his paintings. The nimbus clouds in this drawing were number-coded to a side legend, and included the notations "blue silver" and "warm smoky."

From the same time period, the drawing Part of a Cloud, Hills, Rainbow (1917-4-1174b) is a lightly sketched distant, horizontal view of hills with a rainbow arching through clouds on the left. The rainbow is drawn with two parallel lines with a third line marking one-quarter of the bow. The number 3 is written on the wider portion of the rainbow. Notations at the bottom of the approximately four by seven inch sketch state: "2. rich green, 3. rainbow red
predominates, 4. faint transparent". The number four corresponds to an area to the right of the rainbow, above which Church has written "yellowish". Therefore, the effects of light were paramount to Church's rainbow sketches. No notations were made about hills, other landforms, or vegetation. Only the effects of light, atmosphere and color were noted on these drawings.

The 1865/66 sketch Rainbow Segment (1917-4-1176) is comprised of only three short lines, angled to the right. Between the outer two lines Church wrote "red", the next band contained the word "green", while on the outside, or lower edge of the rainbow it appears that Church had started to write "blue", since the "b" remains, with the word "purple". These colors correspond to the current scientific ideas of the nature of colored light, as if Church were attempting to justify their appearance through observation.

A preparatory sketch (Cooper-Hewitt Museum, Figure 15) for Church's 1866 Rainy Season differs from other drawings in that it is lined with vertical parallel lines, presumably as a guide for making an enlargement (8, p. 63). In this study the area of the bands of the rainbow has been left empty, while shading between the primary and secondary bows is darker on the left, corresponding to the natural effect of the light.

More rectangular than the extreme elongation of the first two rainbow paintings, Rainy Season in the Tropics (Figure 16) presents a double bow, that approaches the edges
Fig. 15--Study for Rainy Season in the Tropics (1865/66), Frederic Edwin Church.

Fig. 16--Rainy Season in the Tropics (1866), Frederic Edwin Church.
of three sides of the canvas, forming a major compositional element in contrast to the more sedate, subtle bursts of prismatic color of the earlier paintings. The colorful semi-circular images, remarkable for their thinness, dominate the canvas, uniting the two land masses that are separated by a deep chasm. Described as a "prismatic bridge" by Tuckerman, the Vasari of nineteenth century American art, the rainbow challenged Church since no scene could be "more difficult to represent on canvas" (19, p. 383). The critic cited certain positive attributes of the rendering: "To combine the right perspective with the aqueous effects is a problem hard to solve; but Mr. Church has succeeded; the aerial perspective is exquisitely true--the floating vapor, the blue sky, the radiant iris--the brooding mists in the foreground, and green, rugged declivity and mule-path--water, air, cloud, hill, and vale--all wear the tearful glory of 'The Rainy Season in the Tropics,' whereby the assiduous and accomplished artist has added another phase of nature to his grand and gracious expositions of her picturesque enchantments" (19, p. 383).

Still appreciated in the twentieth century for its atmospheric effects, this painting has been described as "an unprecedented outpouring of exuberant atmospheric energy" in a recent catalogue accompanying an exhibition of Hudson River School paintings. (16, p. 292). The dramatic dynamism of the atmosphere, heavy with tropical rain is a contrast to the silent solitude of the Andes scene. Suggestive of a
Genesis reference in its pristine, primeval locale complete with the arch of the Covenant, this painting may have symbolized more than Creation by alluding to Church's optimism at the prospect of his child's birth, following the death of the first two infants from diphtheria the previous year (13, p.56).

Adhering primarily to previously successful formulas of red, yellow, and blue pigments, this rainbow also delicately blends the intervening colors of orange-yellow and green-blue, while eliminating the lower violet of the spectrum. Church again demonstrated his knowledge of optics in the sequential arrangement of the hues and by reversing the color order in the secondary rainbow. The transparency of the rainbow makes the image appear as liquid light in the moist atmosphere, a contrast to the solid, pigmented forms of rock and vegetation. That pencil lines of demarcation can be seen specifying the semi-circular bands of color is aesthetically disconcerting on close inspection of the painting. The visual impact of Church's rainbow rendering is achieved from a distance. The resultant soft coalescence of color in the rainbow, originating from rigidly structured areas shows that Church purposely attempted to treat the prismatic light of the arch differently from the earth elements of the scene.

Light is the unifying element in this painting. From a frontal position, it illuminates the scene, displaying foreground details, veils of mist, the prominent brilliant
rainbow, and distant snow-covered mountains and tropical sky. Adding to the realism of the rainbow, Church employs a flash effect of a burst of light that had been so successful in the *Niagara* canvas. The primary bow fades from brilliant to alternate with duller sections, creating the illusion of pure light.

Scientific accuracy in the rendering is also shown by the sun's position, on a plane parallel to the rainbow. Viewed from a promontory, the scene could believably produce the full semi-circular arch. The area between the two bows is darker than the outer cloud region, indicating the artist's knowledge of rainbow science, which he acquired from his reading.

If the third oil sketch, *A Rainbow*, were not dated circa 1867, a year after the *Rainy Season*, the rainbow could be considered a study for the famous tropical arch. Actually begun in 1863 and not completed until 1866 (16, p. 292), the prismatic double rainbow in *Rainy Season* bears little resemblance scientifically to the full semi-circular arch in the sketch, *A Rainbow*, on first inspection. While the earlier painting displays minimal sky area, the oil study is reminiscent of Dutch seventeenth century landscape art with an extremely low horizon line.

Painted a full fourteen years after the two earlier oil sketches, *A Rainbow* shows that Church's interest was now focused entirely on the sky and its atmospheric effects. The rainbow was originally longer, since nearly an inch of
the arch was repainted on each side with horizon-level hills, which also indicates the importance of the sky region, being applied first to the paperboard. Encompassing nearly two-thirds of the board, the area of the sky is a study of clouds and color, with a small glimpse of clear, cloudless blue in the upper right corner. The interior region under the bow is delicately shaded from darker to lighter rose colors from left to right; the exterior clouds surrounding the arch are bluish-grey. The slim rainbow displays the tripartite colors of the Niagara and The Heart of the Andes canvases, however, the colors are reversed.

One can only speculate on the reasons for this reversal. Church, fully cognizant of the order of spectral colors judging from previously completed canvases and notations

Fig. 17--A Rainbow (c. 1867), Frederic Edwin Church, Oil Sketch.
made on three pencil drawings dated 1865/66, may have intentionally placed the normally top red band on the interior side of the rainbow. Perhaps the artist's intent was to study the effects of the outer bow of a double rainbow, in which case this placement of reflected colors would be correct. This seems particularly likely since the darker area between the bows was included in this oil study. Therefore, this sketch could pre-date the Rainy Season canvas.

The atmospheric effects and colors described on an 1868 pencil drawing, Mountains Against a Plain, Two Rainbows, (1917-4-1106) give more information about Church's methods of recording nature. The double rainbow arches to the left; the primary bow has "red" marked on the outer edge with the word "darker" between the bows. The sketch is covered with numbers and word notations. Church's goal of recreating "rich light" is prominently written in the middle foreground. The number two to the left of the rainbow is keyed to the words "like fire." "Glow" is written above the hills on the right, above which Church noted "3. Open sky, cold greenish. Bow very rich subdued." Other descriptors on the drawing include "rich, golden, both gleaming." Church's notations about the quality of the light on this and other sketches suggest that light was one of his major concerns in replicating rainbow scenes.

The double bow was also used in Church's last major rainbow canvas, the 1878 The Aegean Sea, painted twelve
years after the Rainy Season. Described as a characterization of the Old World (12, p. 341), The Aegean Sea (Figure 18) presents Greece in a verdant landscape with classical ruins and an open sepulchre. Termed "too merely pictorial and theatrical," the rainbows and clouds were
criticized in a contemporary account as "unimportant in view of the great success of the whole" (12, p. 210). The same article compared Church to Turner, believing that the painting had "power, beauty, and imagination--the qualities that made Turner so famous; but it [had] none of the eccentricities of that painter to pique the critic or to force it into unjustified notoriety" (12, p. 210).

Although titled The Aegean Sea, the painting presents a composite of images from ancient Rome, Jordan, and Greece. The left foreground contains a fallen column in ruins in front of a high, mountainous region with an elaborate rock-cut tomb, reminiscent of Petra. Three foreground figures, garbed in Eastern attire, converse near smaller rock formations, with Greek temple remains in the middle ground. The calm sea reflects distant islands with Greek and Turkish architecture and what appears to be a Roman bridge or aqueduct connecting two islands, with a brilliant double rainbow segment arching in front of a distant ancient city. Foreground vegetation is meticulously rendered, with ancient trees, gnarled and bent with time, and green undergrowth.

The components of this painting present a composite view of an Eastern scene--an ideal, romantic vision of Greece, garnered from the artist's travels in the East. The mists following a recent shower reflect a double rainbow that is compelling in its brilliance, appearing as a burst of colored light. Colors of the primary bow range from red, slight orange, yellow, slight green, to blue, in proper
sequence, with colors reversed and lighter in the secondary bow, with a darker area of rain between the arcs.

These rainbows are not realistic in two other respects --a consistent light source and placement of the bows. Shadows on the foreground trees and rocks indicate that the sun is shining slightly from the right. This is offset by frontal areas of light in the open space occupied by the travelers and the frontal, direct view of the classical cliff image. Optical fault can be found in the dimensions of the arcs. To be accurate, a viewer must be in the center of the semi-circle formed by the rainbow. In this instance, the radius of the arch would have to be placed at the far left edge of the canvas.

The transparency of the light on the mists of a receding rain shower has a translucent effect as a boat and the more distant Greek acropolis are veiled in golden light. The bridge and island buildings are reflected in the calmer areas of the sea, and Church did not attempt to reflect the rainbow into the water, as other artists have painted. In nature, a rainbow cannot be reflected, since it is not an object. In the areas where the bows meet the water, the light and color are gently diffused.

Although The Aegean Sea was Church's last publicly exhibited work, the artist painted several additional canvases, but mostly concerned himself with his home and property near Hudson, New York for the next twenty-two years, since severe rheumatism precluded extensive painting (12,
Church often wintered in Mexico, before his death in New York in the spring of 1900, returning from such a trip (13, p. 129).

Church, in his concern with light and atmospheric effects, preceded his rainbow paintings with studies in pencil and oil that showed knowledge of the proper colors and light effects of this phenomenon. The artist progressed from early studies in which the colors and opacity of the pigments did not reflect the later scientific basis in his art that was so praised by his contemporaries to transparent renderings of the bows, simulating light. It was this quality that so intrigued Ruskin in 1857 that Church perfected during his career.

Huntington has written that Church must have "immediately devoured" Volumes III and IV of Ruskin's Modern Painters when published in 1856. Ruskin's explanations of Turner's representations of water served as the impetus for Church's Niagara Falls. Art, science, and poetry played major roles in Church's development through the writings of Humboldt and Ruskin, both of whom urged artists to travel, study a region, and record the observations of nature (13, pp. 66-67). Church accurately portrayed botanical and geological details in his paintings. He depicted the rainbow with equal devotion to scientific accuracy.

Other sources might also have prompted Church's initial rainbow representation at Niagara in 1857. A March 1856 Crayon article described the sublimity of the Falls and the
reverence and fear of nature that the cataract inspired. A Divine presence and power were displayed to the observer who penned the article (7, pp. 76-77). To judge from the grandiose pictures he painted, this article's compelling description would have enticed Church to paint Niagara. The article offered even more of a challenge for Church to attempt capturing the ephemeral but stunning effect of a rainbow at Niagara Falls: "The sun shone brightly; the cloud of spray below was white as drifted snow, and the rainbow had followed us all day....but upon that very veil is painted the rainbow, and to every soul that looks up there is a separate bow of promise" (7, p. 77).

While we cannot know for a fact that Church did read this article and answer it with his impressive Niagara the next year, there is every likelihood he read it, since reading *The Crayon* was as central to the nineteenth-century American artist as reading *The Wall Street Journal* is to a stockbroker today. Beyond a doubt Church read the next issue of *The Crayon* (April 1856), because it had an article that criticized his art "for several years past" for departing from the laws of landscape painting in aerial perspective, color, excessive detail, poor composition, and execution. The article further said, "Here it is not Mr. Church's knowledge of Nature, but his ability to paint that is at fault." As if that were not devastating enough, the conclusion claimed that "Mr. Church has yet to learn a great deal about art" (9, pp. 116-117). If he did not read the
critique of his own accord, surely someone would have
brought it to his attention. Church would probably not have
been able to ignore this assessment of his talents at that
everly point in his career, because even at the height of
achievement, he was sensitive to criticism. In 1869 he
wrote from Rome to his friend Osborn, "Longfellow was in the
other day and spent an hour over it [Damascus, a recent
Church painting]. He calls it highly poetical--but must be
wrong as the Saturday Review denies that I can paint a
poetic picture" (2). Perhaps when Church went "dashing off
to Niagara" (13, p. 66) to sketch the falls in 1856, he was
inspired by more than just his reading of Humboldt and
Ruskin and his knowledge of Turner. Maybe those March and
April articles in The Crayon motivated him; the one to prove
he was indeed a capable artist, the other to offer proof in
the form of a majestic subject, Niagara Falls, heightened by
a feature difficult for the most talented of artists to
capture with both scientific accuracy and awe, a rainbow.

This accuracy was achieved by observing nature as well
as by consulting the many scientific publications in
Church's library. From Chevreul and Rood, Church understood
that color in pigments differs from those qualities in
light. Young's tri-color theory of light based on a red-
green-violet triad must have been known to Church when he
noted those colors on three short diagonal lines on the
pencil sketch Rainbow Segment. Yet Church's rainbow canvas
of the next year, Rainy Season, reflected the Newtonian
seven-color prismatic theory. The preceding two rainbow images relied primarily on the red-yellow-blue triad. Perhaps Church was attempting to reconcile the scientific facts that he knew with his observations of nature. While Church was aware of the seven prismatic colors of the rainbow, and had read that the mixture of red, green, and violet produced white light, he also was aware from observation that rainbows frequently display only three dominant colors—red, yellow, and blue.

Church attained a reputation as a scientific painter through his portrayals of light, atmospheric effects, and geological and botanical details. His rainbow images, scientifically true to nature, reinforced this reputation, beginning with the powerful plaudits he received from his epic Niagra Falls. Church's ability to paint colored light so convincingly was recognized by his contemporaries as an outstanding achievement. Church also responded to the requirement of nineteenth-century art that it imitate nature and create an emotional response for the viewer. Those who observed Church's rainbows could experience the transient phenomena in the midst of glorious ideal landscapes, scientifically precise, and the attendant emotions of hope and praise that the arcs inspired.


4. Church, Frederic E., Letter to Mother dated 7 July 1853 from Bogota, Olana State Historic Site.

5. Church, Frederic E., Letter to Ogden Rood dated 16 May 1875 from Hudson, Columbia University.


CHAPTER VII

CONCLUSION

In 1842, following a discussion of rainbow symbolism and the correct mathematical calculations necessary for the rainbow's appearance, W. Menzel concluded that since painters, including Rubens, Poussin, and Koch, had misrepresented the rainbow in their art, it "can only prove that rainbows cannot be painted" (8, pp. 265, 270). With the exhibition of *Niagara Falls* in 1857, Frederic Church proved that statement to be false. The 1859 *The Heart of the Andes*, 1866 *Rainy Season in the Tropics*, and the 1878 *The Aegean Sea* reinforced the artist's reputation as a painter of rainbows, capable of capturing prismatic colors on canvas and mastering the depiction of light and atmospheric effects.

Not only have twentieth-century Church scholars referred to the scientific basis of Church's landscapes, but also his contemporaries regarded the painter as an artist-scientist. In 1867 Tuckerman wrote that Church's art was "scientifically true to the facts of nature" and contained the "most true and exquisite effects of light" (11, p. 380). The "scientific conscientiousness" that Tuckerman admired in Church's art was the result of the artist's research of scientific sources and his careful observations of nature.
An 1858 *Crayon* article acknowledged Church's precise scientific rendering of the vegetation in a South American scene, "The foreground is a botanical study, consisting of various flowers and plants, the names of which are easily bestowed by one who is familiar with the vegetable kingdom of this region" (4, p. 87). It is no coincidence that a publication, *Lessons in Botany and Vegetable Physiology*, by the Harvard scientist who rivaled Agassiz in popularity and esteem, Asa Gray, was in Church's library along with Humboldt's volumes. Similarly, the artist's collection of books about light, color, and optics were influential in his portrayals of these qualities, which led to Church's popular reputation as the pre-eminent painter of light and atmospheric effects. Just as Church "devoured" Humboldt and Ruskin, he consumed publications on light and color.

Church's rainbow art records his progressive experimentation with pigments to reproduce an "all-consuming light" in his art (10, p. 248). The 1860 *Crayon* article strongly urging artists to desist from painting rainbows did not deter Church as he continued his successful formula and forged into new depictions of the scientific wonder. Church's first rainbow depiction, *Waterfall with Rainbow Effect*, 1853, was comprised of five colors, red, yellow, green, blue, and violet, with linear brushstrokes visible in opaque paint. There was no attempt to blend the colors with "prismatic tenderness," nor to make the rainbow appear with the transparency of light. This first oil sketch is
important, because it shows Church's knowledge of the proper
sequence of the Newtonian prismatic colors. In comparison
to the stiff brushwork of the rainbow, the free, loose
rendering of the falls, gives the impression of immense,
vviolent power of the water. At this point Church was not
consciously treating the rainbow as colored light, but
rather as an object. The rendering could not be successful,
since an artist must imbue three-dimensional objects with
color and shade to give form and the realism of nature to
their execution in a two-dimensional representation. Church
had not yet been able to paint "light." Ruskin wrote that
"there is no shade in a rainbow,...only various hues of
perfect color" (3, p, 80).

Another early oil sketch, Clouds, Rainbow over Hut,
1853, shows Church's progressive experimentation with ways
in which to depict the transparency of light. The appli-
cation of the paint is less opaque, with mountain and
building forms revealed through the pigments. The solid
demarcations between the colors that were seen in Waterfall
are not as pronounced since the bands of color are more
blended into one another. Church's deviation from the
spectral sequence can be explained by his concern with
optical effects.

Church's pencil sketches of rainbows are as important
for their descriptive words about color and atmospheric
effects as they are for their delineations of rainbow
arches. Dating from 1856 to 1866, these drawings show the
rainbow most often in a semi-circular arch or partial arc from the consistent and optically correct position of the viewer being central to the rainbow. Whether as a segment or a full arch, the arcs were positioned with meteorological accuracy. This is a contrast to the 1853 oil sketch Rainbow over Hut where the end of the bow, rather than its center, coincides with the viewer's vision. In reality, the viewer must always be at the center of the diameter of the rainbow. From such descriptive words as "like fire," "gleaming," "brilliant," and "luminous" contained on the rainbow drawings, as well as color notations about the rainbow, Church consciously and deliberately examined the scenes and noted the atmospheric effects, to translate later with pigments onto canvas. When Church recorded the colors red-green-purple on the diagonal lines of Rainbow Segment, the artist was trying to reconcile current ideas of light with the prismatic colors of the rainbow.

Church's frontal, semi-circular rainbows are the most meteorologically correct depictions of the rainbow's position. The 1860 Crayon article made that clear to Church (2, p. 41), and his rainbows after that date frequently adhered to this optical principle. This principle requires a scientifically accurate depiction of a rainbow to situate the viewer at the center of the arc's diameter and to position the rainbow on a plane perpendicular to the viewer's line of vision. According to this standard, Church rendered scientifically correct rainbows in many of his pencil sketches,
one of his oil sketches, and only one of his major canvases, *Rainy Season*. In this painting the source of the sun is parallel to the rainbow, behind the viewer. The flash effect of bursts of pure color as the sun strikes the drops of water shows the brilliant effect that Church could create in simulating light.

That same brilliance of light is visible in the last rainbow canvas, *The Aegean Sea*, as the lower arc of the rainbow gleams with reflected sunlight, a contrast to the earthly landscape elements in the painting. As in each of the previous three oil paintings, Church adhered to optical color accuracy, each bow progressing from red through the prismatic colors. In contrast to the harsh striations of his early oil sketches, Church attained in his four major paintings of rainbows a transparency of color technique for rendering light, giving the viewer the sensation of light. In those paintings with double rainbows, *Rainy Season* and *The Aegean Sea*, the secondary bows are always painted with the color sequence reversed, in lighter colors, with a darker area of rain between the bows, conforming to nature and rainbow science.

In the paintings where Church deviated from nature and optical laws in the position of the rainbow, he did not do so from ignorance of scientific principles. Enough canvases and drawings exist to conclude that Church was familiar with the optical requirements of the rainbow. In deviating from those principles, Church was employing visual effects to
reach beyond the scientific to represent a higher requirement of art. In creating ideal landscapes, the emotive sensations of the rainbow are linked to complex associations with life and death, hope and despair. Novak believes that Church's use of light departed from the purely scientific goals of Darwin and Humboldt, and supported the loftier goals of religion (10, p. 74). The optimism that Kelly has noted in Church paintings in general (6, pp. 69, 73), is evident in the artist's rainbow renderings in particular, and these rainbow images embodied the flavor of fervent religious and nationalistic values in nineteenth-century America.

Church's interest in science continued throughout his life. Long after the artist stopped exhibiting, or had completed major works on the subjects, Church persisted in his acquisition of science-related books, judging from the copyright dates of some of the volumes in his library. These included Elizabeth Cary Agassiz's 1885 *Louis Agassiz, His Life and Correspondence*; Charles Darwin, written by Grant Allen in 1885; Elroy M. Avery's 1885 *Elements of Natural Philosophy*; Thomas George Bonney's 1893 *The Story of Our Planet*; Dr. G. Hartwig's *The Tropical World: Aspects of Man and Nature in the Equatorial Regions of the Globe*, 1873; Louis Pasteur, *His Life and Labours*, 1885; *A Journey Across South America from the Pacific Ocean to the Atlantic Ocean*, 1873; *The Mountains of California*, 1894; *Life and Nature in the Tropics*, 1871; *From the Greeks to Darwin, An Outline of
the Development of the Evolution Idea, 1894; Aspects of the Earth, a Popular Account of Some Familiar Geological Phenomena, 1889; The Geographical Distribution of Animals, 1876; and Natural Selection and Tropical Nature, 1891. Church's quest for scientific knowledge was an inherent characteristic of the individual--his paintings reflected the accurate information about nature that he acquired.

Rainbow information was available to Church not only from scientific sources and observation, but also from the new product of science, photography. Just as Turner was captivated by a photograph of the Niagara rainbow, so Church would have been. The American artist used photographs as an aid in painting; a photographer accompanied Church and his wife during part of their trip to the Near East (7, p. 74). Sanctioned by both Humboldt and Ruskin as an artistic aid in reproducing scientifically accurate details, photography appealed to Church as an artist-scientist. The hundreds of photographs currently being catalogued at Olana attest to Church's interest in photography. There is the possibility that the collection could contain rainbow photographs. The flash effect of a burst of pure light that is visible in the Niagara and Rainy Season rainbows could only have been witnessed from an example of light striking light, such as Muybridge's rainbow photograph showed. Church's handling of oil color to reproduce the flash effect added to the impression of realism in the essence of pure light depicted in the rainbows. Church must have taken his own photographs
since William Henry Thornwaite's 1856 *A Guide to Photography, Containing Simple and Concise Directions for Obtaining Views, Portraits, etc., with the Method of Taking Stereoscopic Pictures* was in his library. The artist's interest in the camera continued during his career. Hartford, Connecticut photographer H. J. Rodgers's 1873 *Twenty-three Years under a Sky-light, or Life and Experiences of a Photographer* was also in his collection of books.

Almost without exception, Church's clients were fellow-members of New York's Century Club. Originally comprised of artists and writers, the early membership was expanded to 250 people in 1857 to include "educators, politicians, clergymen, lawyers, physicians, bankers, and engineers" (1, p. 9). The elite social organization met regularly to promote art and literature and the members' interests (1, p. 14). A member from 1850 until his death in 1900, Church regularly exhibited at the Century Club, whose members had the wealth with which to purchase costly paintings. The Appleton publishers, "one of the richest publishing concerns in the world...paying special attention to the diffusion of scientific knowledge," were original members of the organization (1, p. 13). Ogden Rood maintained a membership from 1864 to 1902; Samuel F. B. Morse, from 1858 until 1860. Besides establishing a clientele, the Century Club provided Church with associates equally interested in science.

These clients and acquaintances were, like Church himself, products of their time, concerned with the future
of America and their individual enterprises. Church's art appealed to the public because it presented images of nature, reflective of current ideologies, including science and religion. The scientific accuracies in Church's art were appreciated as well as the overall composition and atmospheric effects. Church's interest in rainbows coincided with that in popular and scientific thought. John K. Howat has referred to Church's "deep interest in the study of the anatomy of nature (geology, botany, meteorology, and optics), as well as his religious wonder at the world around him" (9, p. 239).

The rainbow art of Frederic E. Church can be considered a reflection of time in four respects—chronological, physical, geologic, and primordial. The chronological aspect of time was employed as Church explored the visual representations of light, synthesizing the scientific knowledge of light and color available to him, and reconciling that information with the requirements of art. Physical time is represented as the sunlight reached the water droplets, and through the reflective and refractive laws of nature, created the beautiful, but transient rainbow. Geologic time, with associations to past glorious civilizations, as in The Aegean Sea is a third aspect of time portrayed by Church. Time, in the primordial sense of the Light of Creation with associations of Divine Light as a
manifestation of God with optimism for the future is another conception of time illustrated by Church in his rainbow canvases.

Additional studies could be undertaken to examine other meteorological and optical elements in Church's art. The artist's clouds, sunsets, and depictions of the Aurora Borealis, were admired during the nineteenth century. Similarly, these atmospheric wonders could be studied in the œuvres of other Hudson River landscape artists.
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