Name a topic that links science, history, art, and culture. How about color?

Let's follow the theme of color through the vast collections of the Smithsonian Libraries, and make a few unexpected connections and discoveries.

Most of us take color for granted. We simply see it the moment that light beams from or reflects off an object, enters our eyes, and is processed by our brains. But do we stop to think what color actually *is*?

Journeying through the collections of the Smithsonian Libraries — from chemistry to catalogs, from colorblind tests to couture — we might see color in a new light.

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the science of COLOR

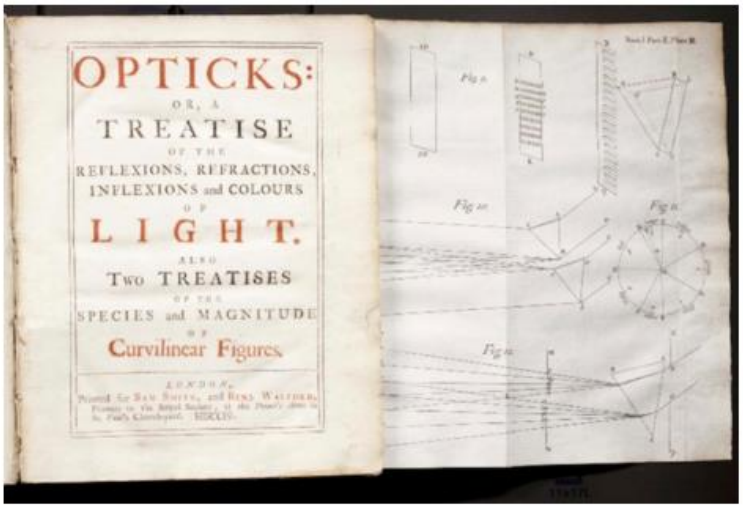
Newton's Rainbow

In the 1660s, English physicist and mathematician Isaac Newton began a series of experiments with sunlight and prisms. He demonstrated that clear white light was composed of seven visible colors.

By scientifically establishing our visible spectrum (the colors we see in a rainbow), Newton laid the path for others to experiment with color in a scientific manner. His work led to breakthroughs in optics, physics, chemistry, perception, and the study of color in nature.

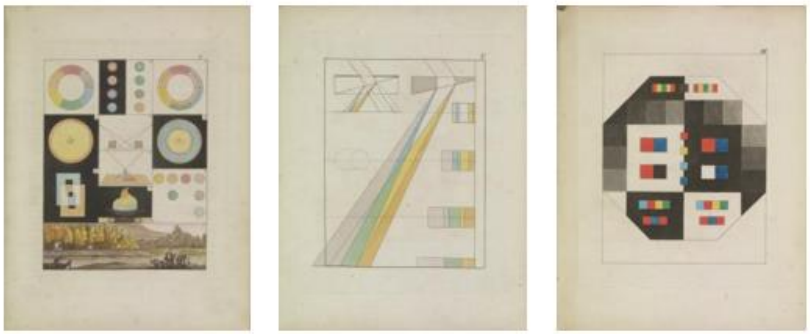
Aristotle developed the first known theory of color believing it was sent by God from heaven through celestial rays of light. He suggested that all colors came from white and black (lightness and darkness) and related them to the four elements – water, air, earth, and fire. Aristotle's beliefs on color were widely held for over 2000 years until being replaced by those of Newton.

Sir Isaac Newton experimenting with a prism. Engraving after a picture by J.A. Houston, ca. 1870. Courtesy of The Granger Collection, New York



Sir Isaac Newton
Opticks, or, A treatise of the reflections, refractions, inflections and colours of light...
London, 1704

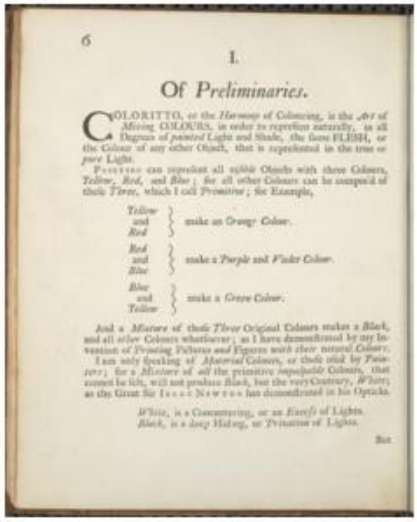
Opticks, one of the great works in the history of science, documents Newton's discoveries from his experiments passing light through a prism. He identified the ROYGBIV colors (red, orange, yellow, green, blue, indigo, and violet) that make up the visible spectrum. The visible spectrum is the narrow portion within the electromagnetic spectrum that can be seen by the human eye. Other forms of electromagnetic radiation, waves of energy, that we cannot see include radio, gamma and microwaves. The cells in our eyes called cones are sensitive to the wavelengths found in the visible spectrum. They allow us to see the all the colors of the rainbow.



Johann Wolfgang von Goethe
Zur Farbenlehre [Theory of Colors]
Tübingen: J.G. Cotta'schen Buchhandlung, 1810

Goethe challenged Newton's views on color, arguing that color was not simply a scientific measurement, but a subjective experience perceived differently by each viewer. His contribution was the first systematic study on the physiological effects of color. Goethe's views were widely adopted by artists. Although Goethe is best known for his poetry and prose, he considered *Theory of Colors* his most important work.

COLORITTO;
OR THE
Harmony of Colouring
IN
PAINTING:
Reduced to
A MECHANICAL PRACTICE,
UNDER
Easy Precepts, and *Infallible Rules*;
Together with three
COLOURD FIGURES,
By *J. C. le BLON.*



6

I.

Of *Preliminaries.*

COLORITTO, or the *Harmony* of Colouring, is the *Art* of *Mixing* COLOURS, in order to represent naturally, in all Degrees of *painted* Light and Shade, the Stuff FLESH, or the Colour of any other Object, that is represented in the true or *pure* Light.

PAINTING can represent all *visible* Objects with three Colours, *Yellow*, *Red*, and *Blue*; for all other Colours can be compos'd of these *Three*, which I call *Primitive*; for Example,

Yellow and *Red* } make an *Orange Colour.*

Red and *Blue* } make a *Purple* and *Violet Colour.*

Blue and *Yellow* } make a *Green Colour.*

And a *Mixture* of these *Three* Original Colours makes a *Black*, and all *other* Colours whatsoever; as I have demonstrated by my Invention of *Painting Pictures and Figures with their natural Colours*: I am only speaking of *Material Colours*, or those shut by *Painters*; for a *Mixture* of all the primitive *impalpable* Colours, that cannot be felt, will not produce *Black*, but the very Contrary, *White*; as the Great Sir ISAAC NEWTON has demonstrated in his Opticks.

White, is a Concentering, or an *Excess* of Lights.
Black, is a deep Hiding, or *Privation* of Lights.

But

J. C. LeBlon
Coloritto, or, The harmony of colouring in painting . . .
London, ca. 1722

This very rare book formed the foundation for modern color printing. Le Blon was the first to outline a three-color printing method using primary colors (red, yellow, blue) to create secondary colors (green, purple, orange). He makes an important distinction between "material colors," as used by painters, and colored light, which was the focus of Newton's color theories. Le Blon's distinction marks the first documentation of what is now referred to as additive and subtractive color systems. Rainbows, TVs, computer screens and mobile devices all emit light and are examples of an additive color system (the subject of Newton's Opticks). Red, green and blue are the primary additive colors and when combined they produce transparent white light. Books, paintings, grass and cars are examples of a subtractive color system which is based on the chemical makeup of an object and its reflection of light as a color. Subtractive primary colors - blue, red, and yellow – are often taught to us as children, and when mixed together they create black.

Henry E. Roscoe
Spectrum Analysis: Six Lectures . . .
London: Macmillan, 1869

These colorful line diagrams reveal the chemical compositions of metals. When a pure metal is burned and viewed through a spectroscope, each element gives off unique spectra, a sort of color fingerprint. This method, called spectral analysis, led to the discovery of new elements, and marked the first steps towards quantum theory.

Shinobu Ishihara
The Series of Plates Designated as Tests for Colour-Blindness
Tokyo: Kanchara & Co., 1936

Can you see the numbers in the circles? 4.5 percent of the population cannot see the entire visible spectrum, a condition called color vision deficiency, or color blindness. Ishihara plates are used to test patients for the various types of color blindness.

Gerald Handerson Thayer
Illustrstions by Abbott Handerson Thayer (his father)
Concealing-Coloration in the Animal Kingdom
New York: The Macmillan Co., 1909

Can you find the animal hiding in this image? Camouflage uses color to conceal forms by creating optical illusions. American artist Abbott Thayer introduced the concept of *disruptive patterning*, in which an animal's uneven markings can disguise its outline. In this illustration Thayer shows how a peacock can disappear into its surroundings.

Thayer, an American artist, devoted much of his life to understanding how animals conceal themselves in nature for survival. In his book, Concealing Coloration in the Animal Kingdom, Thayer presented his beliefs of protective coloration as an essential factor in evolution helping animals disguise themselves from predators. He received much praise and criticism. He was extreme in his views arguing that all animal coloration was for protective purposes and failing to recognize other possible reasons such as sexual selection – characteristics for attracting a mate. Teddy Roosevelt most notably attacked his theories by pointing out that this concealment doesn't last all season, or even all day, but was dependent on a single frozen moment in times. Despite these shortcomings, Thayer went on to be the first to propose camouflage for military purposes. Although his suggestions were initially rejected, his former students were among the founders of the American Camouflage Society in 1916 and his theories were eventually adopted and are still used today.

Albatross D.Va, 1917-1918
Courtesy of the National Air and Space Museum

The colorful pattern on this German aircraft from World War I is called lozenge camouflage. Its disruptive pattern applied Abbott Thayer's theories in an effort to inhibit enemy observation from the air and on the ground.

making COLOR

Making Color

Until the mid-1800s, all dyes came from natural sources, such as insects, roots, or minerals. Producing them was difficult and expensive.

In 1856, an 18-year-old English chemist, William Henry Perkin, accidentally discovered one of the first synthetic dyes. In search of a treatment for malaria, Perkin experimented with coal tar, a thick, dark liquid by-product of coal-gas production. His experiment failed but left behind an oily residue that stained silk a brilliant purple. He called the dye mauveine.

Perkin's purple changed history. He applied for a patent and abandoned the lab for the path of manufacturing. He paved the way for modern chemistry to move into industrial applications, and indirectly led to advances in modern medicine, explosives, photography, and plastics.

William Henry Perkin (1838–1907)
Self-portrait photo at age 14
Courtesy of the Chemical Heritage Foundation

"Milking" *Plicopurpura pansa*, Oaxaca, Mexico.
© Fulvio Eccardi

Cotton yarn with *tixinda* dye, 2012
Pinotepa de Don Luis, Oaxaca, Mexico
Gift of Marilyn Murphy, www.clothroads.com

Sea snails like these are found around the world. When poked (milked) or crushed, they secrete a substance that was used for making purple dye as early as 1570 BC. Thousands of snails were needed to color a single robe, and for centuries purple dye was more valuable than silver and worn only by royalty.

Mixtec weavers in Oaxaca, Mexico, color locally grown cotton with natural dyes — including the rare purple *tixinda*, extracted from the *Plicopurpura pansa* mollusk. The introduction of synthetic dyes and the decline of mollusk populations have greatly reduced the production of natural purple dye.

Anthracite coal
National Museum of Natural History, Department of Mineral Sciences
Gift of Frederick A. Canfield

"Perkin mauve" dyed silk, 1860
Photo courtesy of National Museum of American History

When coal was carbonized to make coke (a fuel), or gasified to make coal gas, one of its by-products was coal tar.

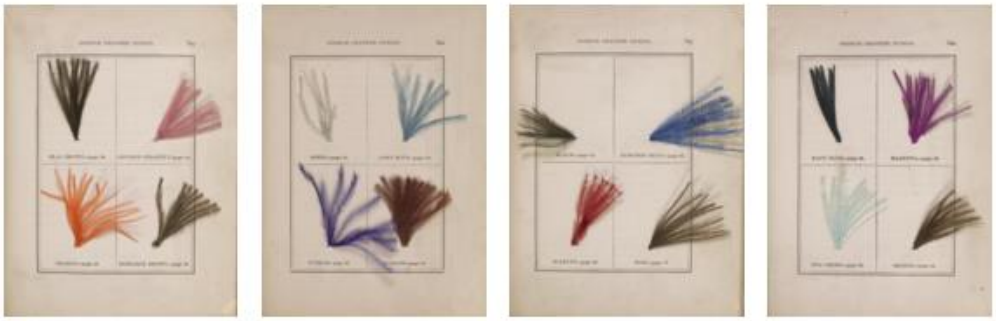
William Henry Perkin presented a sample of dyed silk to American industrialist William John Matheson, founder of the National Aniline and Chemical Company. Matheson in turn donated it to the Smithsonian.

Perkin's new purple took the fashion world by storm. First appearing in Paris and London, it quickly spread to America and was heavily featured in popular women's magazines of the day.

Godey's Lady's Book and Magazine, 1861-1877

Badische Anilin- & Soda-Fabrik
Aniline Colors on Cotton Yarn
New York: Badische Company, ca. 1900

Synthetic dyes became big business after 1860, with Germany in the lead. This BASF dye sample catalog displays the vibrant variety of new synthetic colors. Founded in Germany in 1865 to manufacture dyes, BASF is one of the oldest chemical companies in existence today.



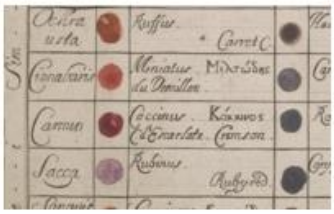
Alexander Paul
The Practical Ostrich Feather Dyer
Philadelphia, Pa.: Published by Mrs. Dr. M. Frank, 1888

You don't need to be a chemist to dye feathers! This instruction manual provides "simple" recipes using natural and synthetic dyes, encouraging readers to pursue the "profitable business" of feather dyeing. Ostrich feathers were a major fashion accessory in the late 1800s and early 1900s, adorning hats and dresses.

matching COLOR

Matching Color

I say green; you say green. How do we know we're talking about the same color?



Richard Waller
"*Tabula colorum physiologica ...*"
[Table of physiological colors]
Philosophical Transactions of the Royal Society of London, 1686

Color charts, created as early as the 1600s, included color samples and names, providing a standard for others to follow. These charts helped naturalists to identify plants and animals and helped manufacturers to produce consistent dyes and paints.

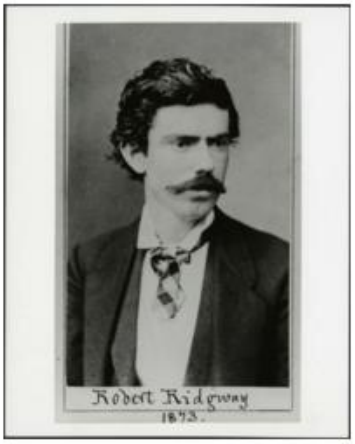
The mass production of synthetic dyes in the 1800s demanded improved color-classification systems. A variety of color models and instruments were created; many are still in use today. However, color remains elusive to scientists and color experts, who have yet to discover a truly uniform color model.

Richard Waller
Tabula colorum physiologica ... [Table of physiological colors]
Philosophical Transactions of the Royal Society of London, 1686

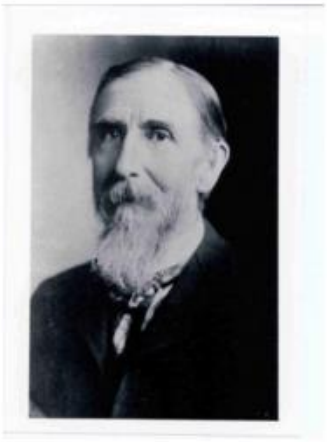
This table is one of the earliest known color charts. Waller created it as a tool for describing plants and animals. Collectors and scientists could compare their specimens to this table and use the names provided to identify the colors of leaves, bark, flowers, feathers, plants, and animals.

Wiener Farbenkabinet [Vienna color cabinet]
Vienna; Prague: im Verlage der v. Schönfeldschen Handlung, 1794
Gift of Virginia Hamill Johnson

One of only four known copies in the world, this early manual on the preparation of colors contains 2,592 hand-colored natural dye specimens, along with details on how to apply them to silk, cotton, wool, leather, wood, bone, paper, and other materials.



Robert Ridgway (1850–1929)
Smithsonian Institution Archives



Milton Bradley (1836–1911)
Courtesy of Hasbro, Inc.

Board game pioneer Milton Bradley (also a manufacturer of crayons and watercolors) was fascinated with finding a precise method for identifying and reproducing colors. Smithsonian ornithologist Robert Ridgway adopted Bradley's color philosophy in his own work, devising a system for naming the colors of birds. Each made significant contributions to the standardization of colors.

Milton Bradley
Elementary Color
Springfield, Mass.: Milton Bradley Co., 1895
Gift of Binney & Smith, Inc., makers of Crayola Crayons

Bradley sought to educate adults and children about the physics and psychology of color. In his book *Elementary Color* he emphasized that color instruction for children should employ a simple naming system.
He promoted his color wheel as a device that could scientifically match and measure colors. When spun rapidly, overlapping colored disks mix colors before your eyes. Different combinations of disks create a multitude of hues based on measured proportions.

Emily Noyes Vanderpoel
Color Problems: A Practical Manual for the Lay Student of Color
New York: Longmans, Green, 1903
Gift of Mr. and Mrs. G. Glen Gould

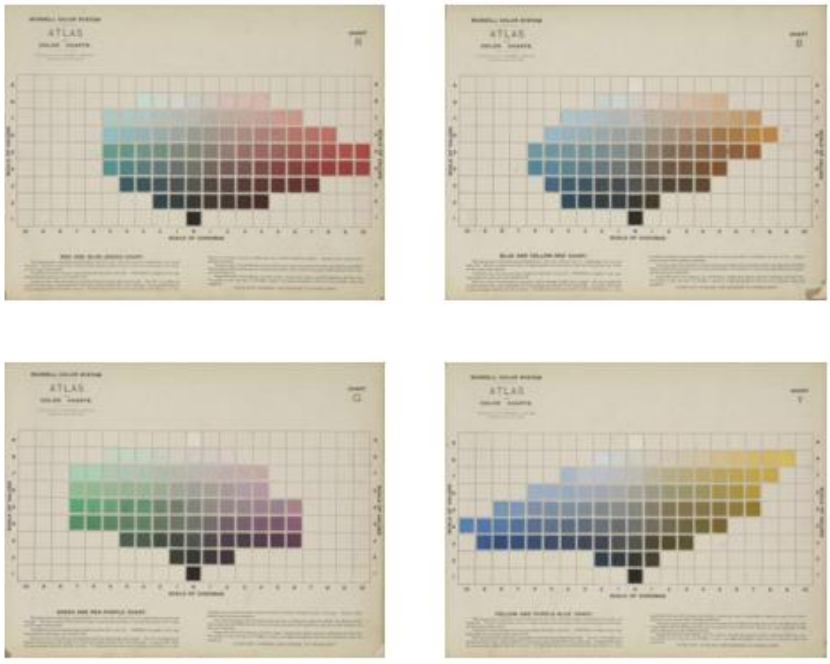
These illustrations from *Color Problems: A Practical Manual for the Lay Student of Color* demonstrate the principles of mixing colors using the Bradley color wheel. Spinning these color combinations (in the proportions shown) produces the gray shade in the center square. The center also shows the proportions of black and white needed to achieve the same results. (Surprise! Gray is not always an issue of black and white!)

Robert Ridgway
Color Standards and Color Nomenclature
Washington, D.C.: Published by the author, 1912

Ridgway, the Smithsonian's first curator of birds, used color as a tool to help identify bird species. Unsatisfied with existing color standards, he created his own color dictionary for naturalists in 1886. His expanded edition of 1912 contains 1,115 named colors. Some names directly refer to bird species. Look for "Warbler green" on this chart.

Leaf-warblers, a species found mostly in Europe, Asia, and Africa, come in many leaf-like colors. Do these warblers match the "Warbler green" on Ridgway's chart?

Phylloscopus olivaceus / Philippine Leaf-warblers
National Museum of Natural History, Birds Division



Albert Henry Munsell
Atlas of the Munsell Color System
[Malden, Mass.: Wadsworth, Howland & Co., Inc., Printers, ca. 1915]
Gift of Binney & Smith, Inc., makers of Crayola Crayons

Albert Munsell was an American painter, teacher of art, and inventor of the Munsell color system. Using numbers to identify colors (Munsell disliked "foolish" color names), the Munsell system continues to influence color theory and practice today.

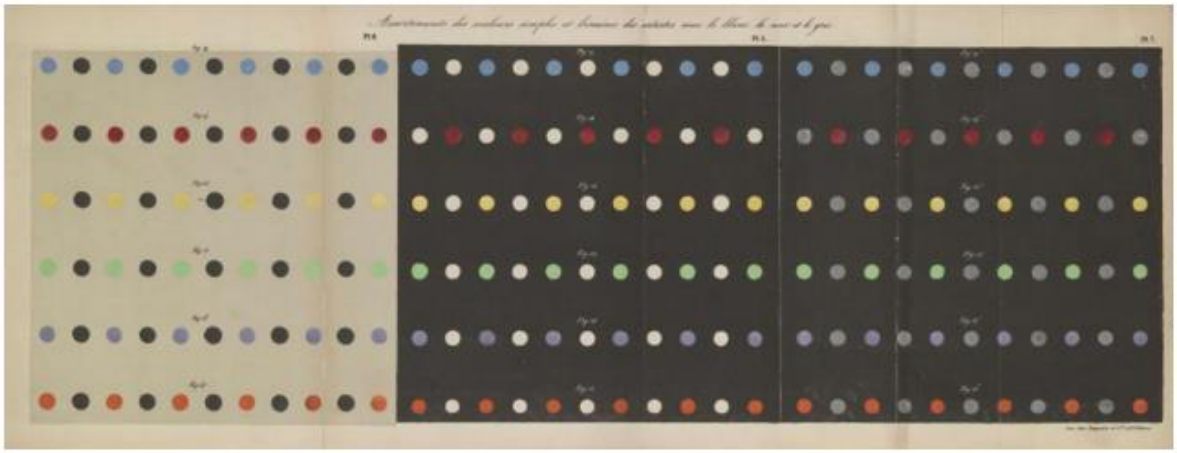
using COLOR

Michel Eugène Chevreul
De la loi du contraste simultané des couleurs
[On the law of simultaneous contrast of colors]
Paris: chez Pitois-Levrault et cie., 1839

As manufacturers improved their ability to reproduce any color imaginable, the problem of choice arose. How do consumers decide what colors they want? How do designers know what colors to offer?

Experts published guides to color harmonies, and in time a new profession emerged: corporate colorists. From forecasting color trends to creating pleasing environments, from car paints to kitchenware, their work is seen everywhere, yet they remain largely invisible.

The Smithsonian Libraries have this field covered, from works on color psychology and optical tricks, to trade catalogs and color chips.



Michel Eugène Chevreul
De la loi du contraste simultané des couleurs
[On the law of simultaneous contrast of colors]
Paris: chez Pitois-Levrault et cie., 1839

Colorful dots demonstrate "simultaneous contrast," the optical effect that two colors have on each other. The French chemist Chevreul was hired by a textile manufacturer to improve the "murky" color of their dyes. He discovered that it was not the dyes, but the placement of colors next to one another, that made them appear more or less vibrant.

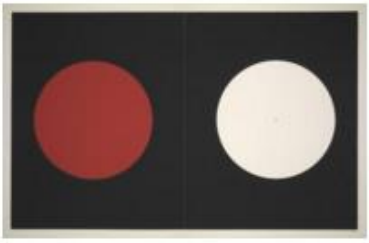


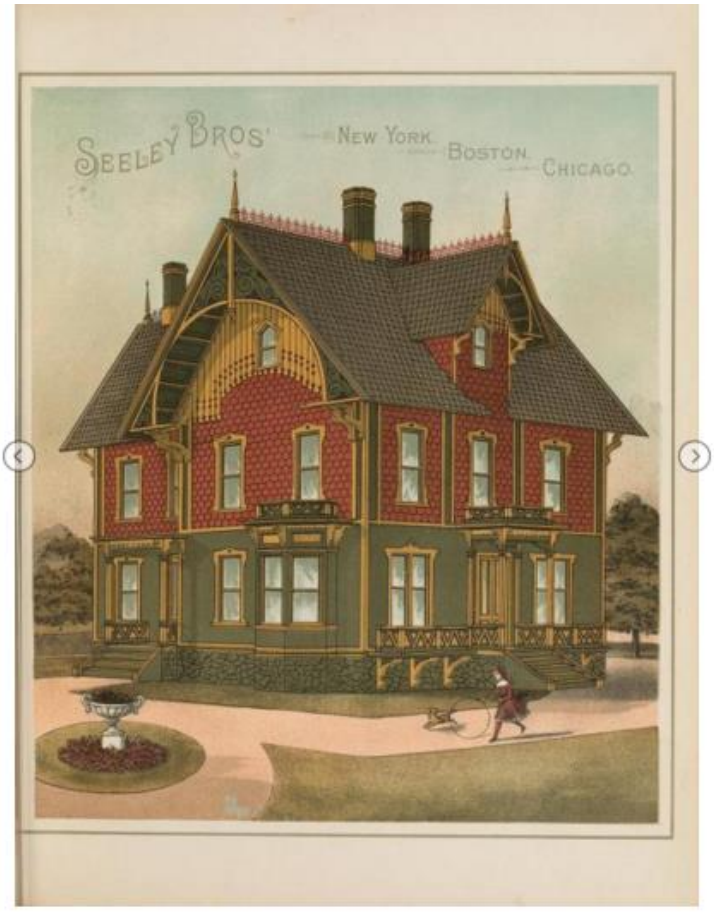
Plate from
Josef Albers
Interaction of Color
New Haven; London: Yale University Press, 1963

Inspired in part by Chevreul's theories, artist and art educator Josef Albers published a landmark study of color phenomena.

Stare at the red circle for 30 seconds then look at the white circle — what color do you see? You have just experienced "successive contrast," or afterimage. Josef Albers' masterwork examines a wide range of color phenomena in 150 plates.

Édouard Guichard
Die Harmonie der Farben
[The harmony of colors]
Frankfurt a.M.: Wilhelm Rommel, 1882
Purchased by the Margery F. Masinter Endowment

Harmony of Colors contains 166 spectacular full-color plates with 1,300 color combinations. Architect and decorator Édouard Guichard promoted the concept of color harmony for the design of wallpaper, curtains, upholstery, and paint schemes in architecture and interior design.



Seeley Brothers
Seeley Brothers: Manufacturers of Averill Paint, Ready for Use
Chicago, Illinois: Seeley Bros., [1886]

In the late 1800s, the range of available paint colors expanded exponentially, making possible the multi-colored paint schemes of the Victorian age. Victorian homeowners typically applied harmonies of three to five colors.

Benjamin Moore & Co.
Moore's Superfine Coach and Car Colors: A line of colors of exceptional merit . . .
New York; Chicago; Toronto, ca. 1890
Gift of Robert D. Mussey Jr.

This trade catalog shows that cars and horse-drawn coaches were available in a wide variety of colors in the 1890s. Founded in Brooklyn in 1883, the Benjamin Moore company is best known today for their innovative interior and exterior house paints. Smithsonian Libraries has a collection of Benjamin Moore trade catalogs that can be viewed here.

Fiesta pitcher, ca. 1936
Cooper Hewitt, Smithsonian Design Museum
Gift of Paul Walter, 1991-68-14

Bold colors were introduced to common household objects in the first half of the 20th century. In 1936, the Homer Laughlin China Company introduced Fiesta Dinnerware in five vivid colors. Brilliant orange-red had uranium oxide in the glaze, which made the product slightly radioactive. The color was discontinued in 1944.

Costume Color Council Presents Costume Color Families for Fall 1950
New York, 1950
Gift of John R. Evans & Company

In the 20th century, advisory groups arose for the purpose of forecasting and managing color trends for fashion, home decor, and advertising. Sample books announced color palettes for each season.

events & INFORMATION

Exhibition Events

Indoor Recess

Smithsonian Libraries Presents: INDOOR RECESS a lunchtime getaway

Featuring your favorite classes as a kid, Library and Art!

#ColorOurCollections Coloring Event

From Feburary 1-5, 2016 the New York Academy of Medicine (NYAM) is encouraging cultural institutions and crayon enthusiasts to join together for #ColorOurCollections. Institutions such as NYAM, the Biodiversity Heritage Library and the Smithsonian Libraries will provide inspiration and coloring sheets for artists of all ages to fill in. Colorers can share their creations on social media by tagging the organization and using the hashtag #ColorOurCollections.

digital LIBRARY

View books from *Color in a New Light* and more!

View the Digital Library

View Benjamin Moore trade catalog collection

coloring BOOK

As part of the #ColorOurCollections event, we've created a coloring booklet. Download and share!

Download Now

VIDEOS

View videos and Periscope broadcasts related to *Color in a New Light*. More coming soon!

View the Videos