The history of color photography and color film is a history of discovery, of the convergence of new findings from physical, chemical and optical experiments by countless international scientists and pioneers. Color photography and color film were invented over and over again, and their development always occurred in close dialogue with other media, such as graphic art and painting. The improved processes over the decades were often conditioned by business considerations and reproduction technologies. Sociocultural factors were also major influences on the processes' specific spectrum of applications, their integration into publication, exhibition, projection and projection praxis, and their institutional adoption.

Multiple hundreds of color processes were developed in the history of photography and film, often with close interconnections between the processes of both media. For example, raster processes like Autochrome were first developed in the context of photography before also being applied in film from the 1920s onward. In the other direction, the Gasparcolor film color process of the 1930s enjoyed a revival in photography as Cibachrome in the second half of the twentieth century.

Like the exhibition, the timeline presented here connects the historical approach with an experimental and self-reflexive approach from the present. The timeline's short texts on color, technologies, materiality, image creation processes and tendencies permit numerous ways of, and directions in, reading, as well as points of access that intersect in and with the exhibition space and join with it in dialogue.

FILM

Hand Coloring
1895

Colored films were already being produced in the early years of cinema. For example, it is documented that the inventor Thomas Edison (1847–1931) projected two hand-colored films at the first public presentation of the Vitascope in April 1896. Hand coloring is the earliest >Autonomous Color technique in film: it involved a black-and-white copy of the film being painted with a brush frame by frame. The color was applied in selected places, especially on figures, decoration, and landscapes. Any water-based paint could be used for this process, which was usually carried out by women. This gave rise to the first sector of the film industry to be dominated by women: from 1897 to 1938, Georges Méliès (1861–1938) hired a company headed by Elisabeth Thuillier (dates unknown) to color his films—it employed more than 200 female colorists (>Where Are the Women?). Among the early hand-colored films are numerous films on dance, some of which adopted the colorful serpentine dance invented by Loïe Fuller (1862–1928). Because hand coloring was very time intensive—and no longer made financial sense as films grew longer from 1900 on—it was soon replaced by >Stencil Coloring. Both techniques have parallels to >Colored Photography.

Cinema of Attractions 1895–1906

The early years of cinema were characterized by an aesthetic of showmanship and a sense of sheer visual pleasure and curiosity about the new moving images, the underlying technology, and the promise they held. In this “cinema of attractions,” the spectacle was more important than the narration of a coherent story. This also applied to the colors of early cinema, which were likewise perceived and deployed as a special attraction. The methods of >Hand Coloring and >Stencil Coloring that emerged in the first decade of cinema thus tended to be vibrant, and the films were often designed to present these colors as a kind of visual firework display. This is clearly exemplified by films such as MÉTAMORPHOSES DU PAPILLON (Metamorphoses of the Butterfly; Gaston Velle, FR 1904), in which a colorless caterpillar transforms into a vividly colored butterfly. In later narrative cinema, in which the story of the film became the focus, color lost its role as an autonomous protagonist and was put in service of the narration. Nevertheless, the “cinema of attractions” never vanished entirely, appearing in the form of special effects and excessive color compositions even within a narrative context.

Tinting
1896

The cinematic technique of tinting (>Autonomous Colors) was introduced at almost the same time as >Hand Coloring: this involved the immersion of black-and-white positive film in dye baths. This resulted in monochrome dyed segments in different hues and—depending on the concentration and temperature of the dye baths and the period of immersion—different intensities of color. Tinting can be identified by its bright pictorial elements—and by the perforation area—which are uniformly colored, whereas the darker parts remain black. Gradations of color are clearly visible at the splices on the film copy, where two differently or indeed similarly colored segments of film were glued together. Even if there were several conventional metaphorical associations with color—blue for night, red for fire—the general application of color was much more complex and not strictly schematized. Tinting was the most common color process of the silent film era into the late 1920s and was often employed in combination with >Toning. From the late 1910s, >Kodak, >Agfa, and others also marketed pre-tinted raw stock.

Toning
1896

Toning was introduced to film in the 1890s as an >Autonomous Color Process. It relied on early toning techniques from still photography (>Photogenic Drawing, >Early Paper Photography). As in >Tinting, in the toning process black-and-white positive film was placed in a bath in which, unlike with tinting, chemical reactions caused the image silver to be replaced by metallic pigments (metallic toning) or dyes (mordant toning). Used as a complement to >Tinting, shadows and dark areas of the image were dyed, resulting in a colored image on a colorless ground. Most film toning was in shades of blue, sepia, and brown, produced with iron, copper, sulfur, or even uranium. Not infrequently, these tones were used together with tinting. Combinations of pink (tinting) and blue (toning) or yellow (tinting) and blue (toning) were a particular feature of silent films.

Chromolithographic Films 1898–1930

Chromolithography is a lithographic process for producing multicolored prints that originated in the 1790s with Alois Sennefelder's (1771–1834) invention of lithography as a printing technique. In the nineteenth century, it proved to be extremely versatile in its range of applications: it was used, for example, for magic lantern slides and, from the 1890s, in the production of very short animation films, which were presented as loops. Tin toy manufacturers offered these "fine color filmstrips," "color lithographic films," or "print films" for private use. Motifs like clowns, dancing animals, and automobiles were extremely popular around 1900, as were adaptations of cinematographic films such as those by pioneers Georges Méliès (1861–1938), Max and Emil Skladanowsky (1863–1939; 1866–1945), and Auguste and Louis Lumière (1862–1954; 1864–1948). Although they were not reliant on photochemistry, lithographic films—as early color print films—are based on the same principle as the >Dye-Transfer Process, >Technicolor Nos. III–IV, and photographic printing techniques.

Stencil Coloring 1903–1928

In 1903, the French film production company Pathé Frères, under the direction of the brothers Charles and Émile Pathé (1863–1957; 1860–1937), began to experiment with stencil coloring. The company had been producing films employing >Hand Coloring since its founding in 1896, but they became increasingly unprofitable as films grew longer. Pathé developed a technique similar to the process of >Colored Photography, in which up to six colors could be applied to a black-and-white film print by means of stencils. Every color needed its own stencil, which was made by cutting out the areas to be colored from a positive print and then washing off the emulsion. This stencil was then lined up in place over a new copy, and the color was applied through the cutout areas. Later, a cutting machine simplified the process, and the stencil and copy were fed into a printing machine for coloring. In addition to Pathé, other companies—such as Gaumont and Messter—produced stencil-colored films. Until World War I, however, Pathé, with hundreds of female workers at its coloring workshops in Vincennes, dominated the international market for color films (>Where Are the Women?).

Kinemacolor
1908–1915

In November 1906, the film producers Charles Urban (1867–1942) and George Albert Smith (1864–1959) patented a mimetic two-color process called Kinemacolor based on >Additive Color Mixing. This red-green process adopted a principle of photographing color separations with the aid of rotating filters that had been proposed by Hermann Isensee (dates unknown) in 1897. In the case of Kinemacolor, the camera exposed the images of a black-and-white film with a red and a green filter used in alternation. When projected, the black-and-white film images were color filtered in exactly the same way. Together with the speed of recording and playback—which, at a rate of at least thirty-two frames per second, was twice as fast as usual—and the inertia of the human eye, it produced on the screen a color moving image in shades of red and green (temporal color synthesis, similar to >Biocolour). Kinemacolor was presented to the press in London in 1908.

Because of the reduction to two colors, it was not possible to reproduce the entire color spectrum, and small differences between the red and the green recordings led to color fringing. This did not, however, reduce the public's enthusiasm. Accordingly, Urban's marketing slogan for his Natural Color Kinematograph Company became "They are not pictures, but realities."

Friese-Greene and Biocolour 1911

The portrait photographer William Friese-Greene (1855–1921) was one of the pioneers in the field of early systems for color film based on >Additive Color Mixing. As early as 1898, he made a presentation in London, which, as he put out, demonstrated the “the first process of true natural-color cinematography.” Altogether, he would develop four different color methods, including the process developed together with the cameraman Colin Bennett (dates unknown) and published in 1911 as Biocolour. Like >Kinemacolor, Biocolour involved the projection of red and green images in alternation at double the projection speed. The difference between the two processes was simply that Kinemacolor worked with color filters, whereas Friese-Greene dyed alternate black-and-white images red and green on the film. A patent conflict between the two manufactures was decided in favor of Friese-Greene, although he proved incapable of turning it into a commercial success. In the 1920s, his son, Claude Friese-Greene (1898–1943), produced travel films using a process similar to Biocolour.

Kodachrome Two-Color 1915

In 1915, >Kodak introduced the two-color process Kodachrome Two-color. John G. Capstaff (1879–1960) had initially invented it for photography in 1913 and subsequently adapted it for moving images. Kodachrome Two-color is a mimetic process of >Subtractive Color Mixing with two layers of emulsion in red-orange and blue-green, one on each side of the film base (>Crystoleum). To make such a film copy, a special camera with twin lenses (and later with a beam splitter) was used to expose two images on a film strip at the same time (one located above the other): one through a red filter and one through a green filter.

In the printing and developing process in the film lab, these two images were transferred in several steps onto either side of a double-coated black-and-white film stock - which would become the projection print - and, in an imbition process (>Dye-transfer process) dyed red-orange and blue-green, respectively. Kodachrome Two-color should not be confused with the chromogenic multilayer color film >Kodachrome introduced in 1935.

Technicolor No. I
1916–1920

In 1915, the engineers Herbert T. Kalmus (1881–1963), Daniel F. Comstock (1883–1970), and W. Burton Westcott (1883–1952) founded the Technicolor Motion Picture Corporation. They first developed a mimetic color film process based on >Additive Color Mixing, which would be called Technicolor No. I. As a two-color, red-green process, it resembled >Kinemacolor but differed from it in the use of a beam splitter: When recording the film, in combination with filters in the camera the splitter divided the incoming light into a red and a green separation negative on the black-and-white stock. When projected in the cinema, the two images were combined by a process of additive mixing—using appropriate red and green filters—to create a single picture composed of red and green colored light (spatial color synthesis). In practice, however, it proved to be difficult to align the two images during the projection. This ultimately led Technicolor to abandon additive color processes and instead work with >Subtractive Color Mixing. The beam splitter was the most important invention of this first Technicolor process. The subsequent processes >Technicolor Nos. II–V would all work with this optical system.

Avant-Garde 1920–1940

For many directors of the early film avant-garde of the 1920s and 1930s, color was an important theme, especially in the abstract animations of “absolute film,” so called because such works focused on film as an autonomous art form, based on the specific characteristics of the medium: movement, time, rhythm, montage, light—and color. For example, in the films Lichtspiel Opus II–IV (DE 1921–1925), Walter Ruttmann (1887–1941) employed the technique of >Tinting for his experimental use of color, form, and movement. In the 1930s, Oskar Fischinger (1900–1967) and Len Lye (1901–1980) made their abstract promotional films using mimetic color processes such as >Gasparcolor and >Dufaycolor. The practical application of these two processes in advertising did not run athwart their artistic and avant-garde pretensions; quite the contrary, the promotional films of the 1930s were a creative platform for experimenting with color film.

At the same time, however, a discourse began that associated the art film with black and white and banished color to the realms of commercial cinema. Even if this debate was much more complex and nuanced—and there were certainly some who saw color in an artistic light—even today this artistic cherishing of black and white has become ingrained in our cultural memory (>New Vision).

Technicolor No. II 1922–1927

In 1922, Technicolor released its second color film process, a mimetic two-color process based on >Subtractive Color Mixing. Technicolor No. II resembled > Kodachrome Two-Color, since it also exposed two images on a black-and-white film strip (one located above the other) at the same time—one through a red and one through a green filter—and combined the two corresponding images on opposite sides of the projection print, one dyed red-orange and the other, blue-green. In contrast to >Kodak's process, however, Technicolor No. II used a beam splitter from the outset (>Technicolor No. I) to record the twin images, which were aligned on the camera film strip head to head in pairs. Moreover, the projection print of this new process was not composed, as it was with Kodachrome Two-color, of one film strip with emulsion on both sides; rather, two thin strips of special film coated on one side were glued back to back and then dyed blue-green and red-orange, respectively, as wash-out reliefs. Although it met with commercial success—Douglas Fairbanks (1883–1939) filmed THE BLACK PIRATE (Albert Parker, USA 1926) in Technicolor—the system ran into practical difficulties, and the costs were very high. Thus, in many cases, only certain scenes were produced in Technicolor rather than the entire film, as in the famous masked ball scene in THE PHANTOM OF THE OPERA (Rupert Julian, USA 1925).

Technicolor No. III
1927–1932

Technicolor’s third color process—another mimetic two-color process based on >Subtractive Color Mixing—came hard on the heels of >Technicolor No. II. No. III used the exact same recording technique as No. II but replaced the gluing together of two film strips—one dyed red-orange and the other, blue-green—with a >Dye-transfer Process to transpose the color images to the projection print. Two matrices, one in red-orange and one in blue-green, were produced and printed on both sides of a blank film strip by means of direct contact. The process was technically sophisticated and as a result Technicolor was in great demand and enjoyed considerable economic success. As a two-color process, however, Technicolor No. III was still not capable of reproducing the entire color palette. In addition, the company was unable to meet the sudden, enormous demand without sacrificing quality. Consequently, after peaking for a brief period around 1930, the number of films using it quickly dropped again.

Autochrome Film / Cinécolor 1928

The brothers Auguste and Louis Lumière (1862–1954; 1864–1948), whose first public presentation of the cinematograph in 1895 marked them out as pioneers of cinema, found themselves disillusioned shortly thereafter, as they saw no future in film and turned instead to color photography. In 1907, they invented the >Autochrome. Twenty years later, they merged their two inventions—film and color photography—in the so-called Cinécolor process or Autochrome film. For this mimetic mosaic screen process based on >Additive Color Mixing, transparent grains of potato starch were dyed red, green, and blue, and the areas between the grains blackened with carbon particles. This process produced a screen of colored grains through which the emulsion was exposed. A reversal process then produced the positive copy of the film. As in pointillism—a movement in painting around 1900 in which the sum of many tiny dots creates an image—the combination of the grains results in an overall color image. Several technical problems with the process, such as the formation of clusters of starch grains and high production costs, hampered the successful marketing of the Autochrome film.

Gasparcolor
1932

In Berlin in 1932, Hungarian chemist Béla Gaspar (1898–1973) presented a silver dye-bleach process based on >Subtractive Color Mixing. It can be traced back to texts by Raphael Eduard Liesegang (1869–1947) from 1889 in which he first mentioned the principle of the silver dye-bleach process in relation to color photography. After 1900, other inventors refined the process, but Gaspar was the first to implement it successfully in the context of color cinematography. Gasparcolor is a subtractive three-color process consisting of a multilayer film strip with a cyan emulsion layer on one side and two layers, for magenta and for yellow, on the other. The color image of the Gasparcolor print results from the controlled destruction of dyes relative to the amount of silver. Thanks to its bright, stable colors, Gasparcolor was popular in the 1930s and 1940s, especially for the animated films of the >Avant-Garde, such as Oskar Fischinger's ALLEGRETTO (USA 1936–1943). The political upheavals and strategies of the emerging fascist movement ultimately forced Gasparcolor out. In the late 1950s, however, the principle made a comeback in the form of >Cibachrome, which was used for photographic paper prints.

Agfacolor Lenticular Film 1932–1937

In 1932, >Agfa released a lenticular film developed by Gerd Heymer (dates unknown) and John Eggert (1891–1973). The principle it drew on can be traced back to Raphael Eduard Liesegang (1869–1947), and after initial applications in photography, it was adopted for cinema by several producers: in 1928 >Kodak had brought out a lenticular film called Kodacolor, following the Keller-Dorian process introduced in 1922. The lenticular screen process relied on >Additive Color Mixing and combined a black-and-white film with an extra layer on the film base that was made up of thousands of tiny lenses. When exposed and projected through a three-color filter (red, green, blue), this lenticular layer could produce a color image on the screen by means of refraction. Agfa managed to double the resolution of earlier processes by reducing the size of the lenses. Its simplicity made the process extremely suitable for the amateur market, but it was unable to gain acceptance in professional film production. Moreover, the layer of lenses and the color filters resulted in light loss, so that the color image appeared quite dark onscreen.

Technicolor No. IV 1932–1953

With its fourth color film process, Technicolor switched from a mimetic two-color process to a three-color process. Like >Technicolor No. III, No. IV is a >Dye-Transfer Process. A special camera—of enormous size and weight—exposed three black-and-white negative films simultaneously using a beam-splitter prism that separated the incoming light on the three films so that the green, blue, and red parts were registered separately. On the basis of these three black-and-white color separations, printing matrices were produced, each of which was coated with complementary dyes (magenta, yellow, cyan; >Subtractive Color Mixing) and then transferred to blank film for the Technicolor projection print. The three layers of dye were thereby printed on top of each other, one after the other. Technicolor No. IV dominated the market for color film from the mid-1930s to the 1950s.

To handle problems of quality with >Technicolor No. III, Technicolor introduced the Color Advisory Service headed by Natalie M. Kalmus (1882–1965) (>Where Are the Women?). Together with her colleagues, Kalmus advised film productions on how to develop an appropriate color scheme and supervised a wide range of issues from coloring, costume and set design, makeup, and lighting all the way to camera work. In general, color advisors believed that the onscreen story was best served by a more restrained and therefore "natural" use of color. Paradoxically, Technicolor is now seen as epitomizing an excessive use of color—an impression that can be traced back to key scenes in specific films, such as the red sky in GONE WITH THE WIND (Victor Fleming, USA 1939) or the yellow-dominated sets in THE WIZARD OF OZ (Victor Fleming, USA 1939).

Dufaycolor
1933–1958

Just as the mosaic screen pattern of >Autochrome was used in the >Autochrome film in 1928, the line screen pattern of the >Dioptichrome invented by Louis Dufay (1874–1936) was employed in the Dufaycolor color film process. In this process based on >Additive Color Mixing, during recording and projection the light is filtered through a pattern of tiny dots of color, which appear as an extra layer on the black-and-white film. This pattern—the so-called réseau—was composed of red, green, and blue lines and, when seen from a sufficient distance, came together into a color image. The application of the réseau onto the film was an extremely complex procedure, and the results when exposing and projecting it were often very dark because of the high rate of light absorption. Nevertheless, Dufaycolor found opportunities to compensate for this in other ways. The British amateur and documentary film movement of the 1930s was a particular advocate of the use of Dufaycolor as a practical and affordable alternative to >Technicolor No. IV that could be used with standard black-and-white-film equipment. The Swiss documentary film about the textile industry PARURES (Werner Dressler, CH 1939) was produced using Dufaycolor.

Standardization of Color Aesthetics 1940s

The introduction of >Agfacolor Neu and the perfection of the >Dye-transfer Process by Technicolor led to a standardization of film colors in the 1940s. Because of the way >Technicolor No. IV worked, in order to ensure the quality of its product, Technicolor turned to a sophisticated business model that involved feeding its own camera people and color advisors into the operations of the film studios. As a result, it ended up supervising broad swaths of feature film production in Hollywood. This gave rise to a unique "Technicolor look" that could be found in melodramas and Westerns as well as in many musicals: a discreet use of color with pastel shades and earthy backgrounds, with spectacles of color reserved for narrative climaxes and musical numbers (>Cinema of Attractions). In Germany, by contrast, the standardization of color aesthetics was politically motivated, coming out of the centralization of film production during World War II. Many films, including the very first Agfacolor feature film FRAUEN SIND DOCH BESSERE DIPLOMATEN (Georg Jacoby, DE 1941), featured muted colors and little variation in the color combinations.

Eastman Color
1950

After >Kodachrome, >Kodak released another chromogenic color film process (>Chromogenic Developing) in 1950: Eastman Color. The company had been working on this process since 1937 and over time constantly adjusted and improved it. Like >Agfacolor Neu, Kodak's new multilayer film had dye couplers in the emulsion, which distinguished it from Kodachrome (where the dye couplers were in the developer bath). Moreover, Eastman Color was a negative-positive process; when used in still photography, it was also called Kodacolor (not to be confused with the additive lenticular film of the same name dating from 1928). Eastman Color films were multilayer color films whose layers were not separated after exposure (integral tripack). Into the 1970s, Eastman Color camera negatives were also combined with the >Dye-transfer Process of >Technicolor No. V. In the end, however, it was Eastman Color that became the market leader for color films, replacing Technicolor. Unfortunately, no one foresaw that Eastman Color films would prove extremely susceptible to color fading, like most of the chromogenic film stocks produced between the 1940s and the 1980s (including >Agfacolor). Famous films shot using the Eastman Color negative-positive process include JOHNNY GUITAR (Nicholas Ray, USA 1954), BLOW-UP (Michelangelo Antonioni, GB 1966), and ALIEN (Ridley Scott, USA 1979).

Color Films as the Norm late 1950s

From the late 1950s onward, color films became the norm in film production.

Technicolor No. V (1954)
Starting in 1954, Technicolor took the >Dye-transfer Process for producing three-color projection prints that it had perfected in >Technicolor No. IV and combined it with Eastman Color. >Kodak had introduced the chromogenic >Eastman Color negative-positive process (>chromogenic developing) in 1950. This made it possible for the former Technicolor No. IV recording process, which involved three separate film strips in the special Technicolor camera, to be replaced with one record using a normal single-film camera. Though, in the lab three black-and-white color separations were produced from the Eastman Color negative and then transferred to a blank film using the dye-transfer process, as with Technicolor No. IV. Numerous classic films were produced in this way up until the 1970s, including A STAR IS BORN (George Cukor, USA 1954), VERTIGO (Alfred Hitchcock, USA 1958), LAWRENCE OF ARABIA (David Lean, GB/USA 1962), and THE GODFATHER (Francis Ford Coppola, USA 1972).

Fujicolor
1966

From the late 1940s on, the Japanese company >Fuji produced color films (>Chromogenic Developing) that were marketed as Fujicolor. As Fuji changed its recipe for color film several times, this name was used for films employing different chromogenic processes: the first Fujicolor films from 1949 to 1955 were based on the principle of >Kodachrome (reversal process with dye couplers in the developer bath); in 1955, the company moved to the negative-positive process based on >Agfacolor Neu patents, and then to the >Eastman Color process in 1965. Fujicolor positive film type 8818 was thus the first "foreign" film to employ the Eastman Color process; the switch to negative film followed in 1968. Fujicolor established itself on the international market, and films such as Wolfgang Petersen's DAS BOOT (DE 1981) were shot with Fujicolor. The intensity and diversity of the color produced by this stock were especially prized—as witnessed by Rainer Werner Fassbinder's use of it in LOLA (DE 1981). It sold best in its country of origin, Japan, where in 1970 alone 210 out of 216 feature films were shot in Fujicolor.

FIAF Congress in Brighton 1978

During the 34th Congress of the International Federation of Film Archives (FIAF), held in Brighton in 1978, around 600 silent films from the period from 1900 to 1906 were screened that had previously been overlooked by archives and film scholars alike. The screening of so many unknown silent films fundamentally changed film historiography. This congress is therefore regarded today as a key moment in the rediscovery of early cinema, enhancing our understanding of the history of early film, which had its own aesthetic, practice, and function and cannot simply be seen as a “primitive precursor” of its later “mature” form. Closely associated with this was the rediscovery and reevaluation of the >Autonomous Colors from the era of silent film. After Brighton ’78, film scholars became increasingly interested in unexplored collections in film archives and turned especially to early color films, which led to a workshop in 1995 specifically on that subject at the Netherlands Filmmuseum/EYE, followed since by many others. In addition, the focus shifted to restoration—an essential prerequisite for the preservation, study, and viewing of color films.

COLORS

The Color Spectrum According to Newton 1672–1676

The British natural scientist Isaac Newton (1643–1727) published his theoretical reflections on light and color in the Royal Society journal from 1672 to 1676.
Newton refracted white light with a prism, resolving it into its component colors: red, orange, yellow, green, blue, indigo, and violet.These results formed the basis for his magnum opus: Opticks: Or, A Treatise of the Reflexions, Refractions, Inflexions and Colours of Light (1704). Newton's experiments with light and color were followed by many others and can be seen as the foundation of >Additive Color Mixing and >Subtractive Color Mixing in photography and film.

The Color Sensitivity of Silver Halides 1777–1810

Experiments that can be said to relate to color photography are much older than photography itself. In 1717, German polymath Johann Heinrich Schulze (1687–1744) discovered the photosensitive properties of silver halides. Around sixty years later, German Swedish chemist Carl Wilhelm Scheele (1742–1786) followed up on Schulze's experiments. His results, published in 1777, indicated that silver halides darken most quickly when exposed to the violet and blue rays of the spectrum (>The Color Spectrum According to Newton).
In 1782, the Geneva-born natural scientist Jean Senebier (1742–1809) observed that silver chloride turns blue when exposed to violet light and can take on other nuances of color in red light. In 1810, the German physicist Thomas Johann Seebeck (1770–1831 conducted similar experiments. Using silver chloride, he was able to reproduce a >Color Spectrum. His method was refined by other scientists in the second half of the nineteenth century and is better known as >Heliochromy.

Three-Color Theory circa 1800

British ophthalmologist and physicist Thomas Young (1773–1829) discovered around 1800 that the human eye can primarily perceive only three colors: red, blue, and green. His thesis was refined by the German physicist Hermann von Helmholtz (1821–1894), which is why it is often called the Young-Helmholtz theory. It forms the basis for >Three-Color Photography and all the three-color mimetic photographic and cinematographic processes of >Additive Color Mixing and >Subtractive Color Mixing. The theory is clearly demonstrated by modern chromogenic photographic film and film stock (>Chromogenic Processes), whose emulsion is composed of superimposed photosensitive layers responsive to red (bottom layer), green (middle layer), and blue (top layer).

Autonomous Colors

Since the invention of photography and film, numerous experiments have been conducted to obtain color images that have been created photochemically. The focus initially was on applying colors to an existing black-and-white image. These autonomous colors were particularly popular in the photography of the nineteenth century and in silent films until around 1930; they are still found today in experimental works. The four main processes of applied colors, which in some cases were employed in combination as well, are >Tinting, >Toning, >Hand Coloring or >Colored Photography, and >Stencil Coloring. They differ from mimetic processes based on the principles of >Additive Color Mixing and >Subtractive Color Mixing.

Additive Color Mixing

In 1861, Scottish physicist James Clerk Maxwell (1831–1879) gave the first demonstration of a color photograph to the Royal Institution of Great Britain. Taking >Three-Color Theory as his starting point, Maxwell illustrated the process he had been developing since 1855 by projecting three superimposed positive photographic slides through a red, a green, and a blue filter onto a screen. This resulted in a color image produced by additive color mixing—the overlapping of blue, green, and red light from adjacent sources. Along with >Subtractive Color Mixing and >Autonomous Colors, additive mixing is one of the three basic principles of color photography and color film. It has been employed in diverse mimetic processes in film and photography, including >Autochrome, >Kinemacolor, >Technicolor No. I, and >Dufaycolor. Compared to >Subtractive Color Mixing processes, additive processes are chemically simpler, since there is no development of color dyes during the process. However, they also have lower resolution and tend to be darker.

Subtractive Color Mixing

Subtractive color mixture, on which most modern mimetic color processes are based, goes back to Louis Ducos du Hauron's (1837–1920) and Charles Cros's (1842–1888) descriptions of >Three-Color Photography, published at almost the same time in 1869. In contrast to >Additive Color Mixing, here certain ranges of light are filtered out—i.e., "subtracted"—from white light by superimposed filters in yellow, magenta, and cyan, thereby altering the color and brightness. For example, superimposing the yellow and magenta filters produces red; the cyan and yellow, green; and the cyan and magenta, blue. In the subtractive color processes of photography and film, such as >Kodachrome, >Agfacolor Neu, >Gasparcolor, and >Cibachrome, the dyes or pigments in the emulsion filter out the given ranges of light. If all the dyes are present at maximum density in the emulsion, black results.

Agfa
1873

For decades, the German company Agfa ranked alongside >Kodak and >Fuji as one of the leading manufacturers of photographic and cinematographic film stock and laboratory equipment. Founded in 1873, the Actien-Gesellschaft für Anilin-Fabrication (Agfa), was formed from a merger of the Gesellschaft für Anilinfabrikation GmbH—established in 1867 by German chemists Paul Mendelssohn Bartholdy (1841–1880) and Carl Alexander von Martius (1838–1920)—and the Berlin chemical factory they purchased in 1872 from Max August Jordan (1818–1892). In 1909, they built a film factory in Wolfen, modern-day Saxony-Anhalt, and began experimenting with color photography and color film. For example, the company marketed the
Agfa- (>Agfa Screen Plate) in 1916 and was one of the manufacturers of tinted and toned films (>Tinting; >Toning) in the silent film era; it went on to release the >Agfacolor Lenticular Film in 1932 and chromogenic photographic film and cinematographic film stock (>Chromogenic Development) in 1936 under the name >Agfacolor Neu. After World War II, Agfa split into two companieseach producing their own color film: Agfa-Leverkusen in West Germany, which merged with the Belgian company Gevaert in 1964, and Agfa-Wolfen in East Germany, which rebranded itself as ORWO or ORWO color (ORiginal WOlfen), also in 1964.

Dye-Transfer Process
1880

The dye-transfer process goes back to the “hydrotype” developed by Charles Cros (1842–1888) in 1880. It is a photographic color printing process based on >Subtractive Color Mixing, which employs a gelatin relief to transfer a color image to a support. In 1935, >Kodak introduced a dye-imbibition printing process based on this principle—the so-called Eastman Wash-Off Relief process—which was replaced in 1946 by an improved dye-transfer technique with three dye matrices and saturated pigment dyes and launched under the same name. The dye-transfer process found its most widespread commercial use in Technicolor feature films—first with two dye matrices (>Technicolor No. III), as of 1927, and then with three (>Technicolor No. IV, >Technicolor No. V), from 1932 on.

Kodak
1892

“You press the button, we do the rest”—a simple advertising slogan that made the Eastman Kodak Company, better known as Kodak, famous worldwide. This manufacturer of camera equipment and film stock grew out of the Eastman Dry Plate Company in 1882, which had been founded in 1880 by inventor George Eastman (1854–1932) and businessman Henry Alvah Strong (1838–1919). In addition to mass-produced cameras, from 1888 onward the company produced roll films—first in 70 mm for its Brownie camera and then from the 1890s also as 35 mm celluloid film, which was used in the nascent film industry.

Kodak marketed various color processes and color film stocks for photography and film, including >Kodachrome Two-Color, >Kodachrome, >Eastman Color, and a >Dye-Transfer Process, and introduced >Kodak Shirley Cards to calibrate its color materials. During the silent film era, the company also produced tinted (>Tinting) and toned (>Toning) film copies.

Chromogenic Developing 1911–1912 & Chromogenic Processes 1935

Chromogenic dye couplers are chemical components that produce dyes in the three primary colors during the developing process according to the principle of >Subtractive Color Mixing. They are either in the emulsion (>Agfacolor Neu, >Eastman Color) or in the developer solution (>Kodachrome) and react with the oxidation product of the developer to form yellow, magenta, and cyan dyes. These dyes, which are evenly spread in the layers of the emulsion, can be described as dispersed clouds of dye. The basic principle of chromogenic developing was devised by German chemist Rudolf Fischer (1881–1957) and his assistant Hans Sigrist (dates unknown) in Berlin and patented in 1911/1912. It was not until the mid-1930s, however, that it gained acceptance and became the foundation of the development and commercialization of the modern chromogenic color process in photography and film. The invention of chromogenically developed multilayer color films—Kodachrome, Agfacolor Neu, Eastman Color, and >Fujicolor—finally completed the shift away from coloring techniques to chemical processes.

Fuji
1934

In 1934 the Japanese company Fuji Photo Film Co., Ltd., began to produce cinematographic film stock and expanded its product range in the following years to include photographic film as well. From the late 1940s, Fuji was producing chromogenic photographic film and cinematographic film (>Chromogenic Developing) under the name >Fujicolor, and its color-reversal process was based on >Kodachrome until the mid-1950s. In 1955, the company switched its color photographic and cinematographic negative and positive films to a chromogenic process based on >Agfacolor Neu patents, and ten years later switched again to the >Eastman Color process. Fuji film became a household name in Western Europe around 1981 as a supplier of slide films, specifically Fujichrome 100. These films successfully competed with the market leaders, its American (>Kodak) and German (>Agfa) competitors, because it offered comparable quality at around two thirds of the price.

Kodachrome
1935

In 1935, >Kodak presented the first multilayer color film (>Chromogenic Developing), which had been invented by Leopold Godowsky Jr. (1900–1983) and Leopold Mannes (1899–1964) and had superimposed layers of emulsion sensitive to red, green, and blue. Kodachrome, which is based on >Subtractive Color Mixing, is a reversal process in which the positive is exposed directly in the camera, and the true colors emerge only from chromogenic dye couplers in the developing process. In Kodachrome—in contrast to >Agfacolor Neu and other stocks—these dye couplers are not contained in the emulsion but are added in a controlled way during development. It should not be confused with >Kodachrome Two-color, which is an entirely different process. In 1935, Kodachrome was first brought out in a 16 mm amateur film format; the formats for still photography followed in 1936. The process is distinguished by its sharp focus, fine grain, and natural color reproduction. Famous users include the photographers of the Farm Security Administration, who took pictures of the Great Depression in 1937 as part of a documentary (and propaganda) campaign in the United States. It was also used in films, with (semi)professional filmmakers turning to Kodachrome soon after the process was introduced, even though it had originally been presented purely as a format for amateur films. In 1961, Kodak released a new, further improved version: Kodachrome II.

Agfacolor Neu
1936

In 1936—one year after its competitor >Kodak—>Agfa presented to the public its first subtractive multilayer color film for photography and film under the trade name Agfacolor Neu. It had been developed by the chemists Wilhelm Schneider (1900–1980) and Gustav Willmanns (1881–1965). Based on >Chromogenic Developing, the process worked with water-soluble, lipophilic dye couplers embedded in the emulsion. This was the crucial difference from >Kodachrome (dye couplers in the developer bath). In 1936, Agfa first marketed reversal films with this process. In 1938, negative and positive films followed, so that Agfacolor Neu became the first chromogenic, negative-positive process in photography and film. The color of the original image to be projected was reversed to an image of complementary colors. When transferred to photographic paper or film, the color of the original image returned, opening the way to the mass reproduction of color still photographs and color film stock. The name Agfacolor Neu was chosen to distinguish the new products from earlier >Additive Color Mixing processes (>Agfacolor Lenticular Film). In 1938, the “Neu” (i.e., “new”) ending was dropped. After World War II, following Agfa’s involvement in propaganda activities and the use of its color films for military purposes, the Agfacolor patents were published worldwide, and numerous Agfacolor derivatives were produced (e.g., by >Fuji). In 1965, the name Agfacolor disappeared, having been replaced by ORWO color in East Germany and Agfa-Gevaert in West Germany.

Kodak Shirley Cards, “China Girls,” and Diversity 1940s and1950s

For a long time, the photographic and cinematographic films produced by >Kodak were designed to render light (skin) tones with particular precision. For that reason, photo cameras in the 1940s and 1950s were calibrated using so-called Shirley Cards. They owe their name to the light-skinned, Caucasian photo model illustrated on them. The cinematic equivalent was the so-called China Girl—three to five frames on the reel leader showing a female employee of the film lab or a model together with a color chart. For decades, photo and film technicians used these cards and control strips as a test reference to determine how to reproduce color, above all skin tones. For a long time, little attention was paid to reproducing darker skin colors, and they could not be depicted well without special exposure. In 1977, French director Jean-Luc Godard (b. 1930) therefore called such film stock “racist” and refused to use Kodak film when shooting in Mozambique. However, in the 1970s, Kodak had already begun to extend the Shirley Cards to include models with other skin colors. This was also true of other film manufacturers, who produced their own versions of Shirley Cards.

Where Are the Women?

The public reception of the history of photography and film—just like this timeline, which is based on it—can easily convey the impression that only men were the "players" and "pioneers." Women, by contrast, seem to have been only executive assistants or "objects" in front of the camera, appearing as actresses or photo models and posing for film tests (>Kodak Shirley Cards). This connection between the presentation of color and the female body is part of a visual tradition that has been widespread at least since the nineteenth century across all media: from early photographs and films via >Technicolor all the way to current blockbusters.

Yet despite this reductionism in the discourses, women made a crucial contribution to the history of both media, photography and film, as photographers and filmmakers—also when it comes to color. For example, botanist Anna Atkins (1799–1871) created the first book illustrated with photographs in 1843 (>Cyanotype).

In the early film coloring workshops, it was primarily women who determined what the colors of countless silent films would look like (>Hand Coloring, >Stencil Coloring). Natalie M. Kalmus (1882–1965) worked as a color supervisor, responsible for the coloring of nearly all Technicolor feature films of the 1930s and 1940s (>Technicolor No. IV). In the late 1970s, Susan Meiselas (b. 1948) revolutionized the use of color in social documentary photography with her publication Nicaragua. They were joined by a long list of women—including Julia Margaret Cameron (1815–1879), Lotti Lylle (1890–1925), Edith Head (1897–1981, costume designer), Gisèle Freund (1908–2000), Joan Bridge (1912–2009, color consultant), Helena Smith Dayton (1883–1960), Vera Chytilová (1929–2014, director), and Barbara Kasten (b. 1936)—who made appreciable contributions to the discourse on color, photography, and film but have thus far received only

inadequate or belated recognition from scholars and the public. A fresh critical take on the history of media and art is thus required, re-evaluating it in the light of gender-related issues and recalibrating the discourse.

PHOTOGRAPHY

Heliography
1826–27

Color was incorporated into the theoretical concept of photography long before it could actually be implemented. For example, the French photographic pioneer Joseph Nicéphore Niépce (1765–1833) wrote in a letter to his brother in 1816 that he wanted to “realize colors.” After addressing the issue of reversing negative tone values into positive ones, his next task in his experience with photosensitive papers was “to record colors,” which would be easy. Starting from Alois Senefelder’s (1771–1834) invention of lithography in 1796 (he also invented >chromolithography, color lithography, in 1799), Niépce was interested in developing a simpler, faster reproduction process better suited to larger print runs. In 1826 or 1827, he made the earliest photograph in the world that is still extant. It shows the monochrome view from his study into the courtyard of his family estate Le Gras in Saint-Loup-de-Varennes. Niépce called the asphalt-covered tin plate, which he exposed in a camera for around eight hours, then removing the unexposed areas with turpentine, a heliograph. Contrary to what he had supposed, capturing colors would prove to be one of the largest hurdles in the history of photography.

Photogenic Drawing 1834–1839

For his first cameraless process, the British polymath and photography pioneer William Henry Fox Talbot (1800–1877) placed parts of plants or lace fabrics on writing paper treated with a solution of table salt, then silver nitrate. On the resulting photosensitive paper, objects were imprinted as a photographic negative in white, whereas the parts exposed to the sun took on shades of sepia and brown. In “Some Account of the Art of Photogenic Drawing” (1839), Talbot observed that the resulting images were white, but their ground had its own color and could be altered to suit the theme and taste by adjusting the proportions of the chemicals. Based on the principle of the contact print, photogenic drawing resembles >toning in film, since there, too, the silver image was replaced with metallic pigments or dyes.

Daguerreotypes
1839

In his speech on the occasion of the public announcement of the daguerreotype, the physicist François Arago (1786–1853) placed the photographic process in a graphic tradition: that of the mezzotint. The intaglio printing technique, developed by Ludwig von Siegen (1609–1680) in 1642, is distinguished by high-contrast light-and-shadow effects, which Arago argued could also be found in the technique created by Louis Jacques Mandé Daguerre (1787–1851). The colors in daguerreotypes, which were usually made on silver-plated copper sheets, were initially limited to cool shades of white, black and gray. Later it became possible to vary these shades through new chemical formulations. For example, gold toning, developed in 1840 by the French physicist Armand Hippolyte Fizeau (1819–1896), made possible warmer colors and stronger contrasts. There were also colored daguerreotypes (>colored photography).

Early Paper Photography: Calotypes,1840–1860 Albumen, 1851

William Henry Fox Talbot (1800–1877) continued to develop his 1839 process of >photogenic drawing in the years that followed into the negative-positive process of calotypes. These made it possible for the first time to make multiple prints of a single image. The exposure was waxed to create a transparent negative, which was then placed on another sheet of light-sensitive paper to create a positive image. In his first photo publication, The Pencil of Nature (1844–1846), Talbot emphasized that, when selecting subject matter, "as the process presents us spontaneously with a variety of shades of colour, it was thought best to admit whichever appeared pleasing to the eye, without aiming at an uniformity which is hardly attainable." He also found that the light-sensitive paper responded well when capturing shades of blue, whereas shades of green could be depicted only with difficulty. Like photogenic drawings, calotypes were monochrome and created in a variety of sepia and brown tones (>toning in film). Building on calotypes, the French entrepreneur Louis Désiré Blanquart-Evrard (1802–1872) developed his 1851 albumen process, a paper process that yielded prints that were sharper, more durable and with more contrast. The albumen process was characterized by a coloration in brown and violet into blue-black with slight yellowing (>tinting in film).

Colored Photography 1840s

The British entrepreneur and photographer Richard Beard (1801–1885) remarked in 1843: “It was colour that was wanting to crown all the other improvements and give perfection to the whole.” Numerous photographic methods were developed in the 1840s in pursuit of this desire to use color to bring new life to silver >daguerreotypes and to paper photographs. Beard developed one such color process for daguerreotypes. As with the >stencil coloring later used in film, Beard cut out stencils for each color. He then dusted dye mixed with glue powder onto the image through the stencil, fixing the dye in place by breathing on it. The St. Gallen painter and engraver Johann Baptist Isenring (1796 –1860) developed a mixture of gum arabic and pigments, applied with a fine brush and fixed with a heat treatment. This process is one of the ancestors of >hand coloration in film. It was also a common practice to add color to >early paper photography from the 1840s on, as was done by the Italian-British photographer Felice Beato (1832–1909) with photographs of his travels in Japan. The colorists, many of whom had previously worked as miniaturists, did not attempt a complete depiction of color. Often only the cheeks would be shaded a light pink, jewelry would be accentuated in yellow or ochre, or the background would be dyed blue.

Cyanotypes
1842

The photographic printing process of cyanotypes was developed by the British astronomer John Frederick William Herschel (1792–1871) in 1842. Herschel, one of the most influential natural scientists and photographic pioneers of the nineteenth century, replaced light-sensitive silver salts, as were generally used in >photogenic drawing, with iron salts. These give the prints their eponymous luminous blue tone. In the following year of 1843, the botanist Anna Atkins (1799–1871), a friend of Herschel's, published the first photographically illustrated book, Photographs of British Algae: Cyanotype Impressions (>Where are the women?). Cyanotypes were not only used for botanical images, but were also precursors of the blueprints still used today to reproduce architectural and engineering drawings and also of blue >toning in film.

Heliochromes 1848–1865

In 1848, the French physicist Alexandre Edmond Becquerel (1820–1891) took an exposure of the solar spectrum in color, building on the process of >daguerreotypes. Becquerel published two methods of direct heliochromes. In the first method, a silver sheet is dipped in a solution of sodium chloride and copper chloride. In the second method, a silver chloride layer is applied to a sheet via electrolysis in a chlorhydrate solution. Becquerel was unsuccessful, however, in fixing his results. He thus called his own work “phantoms of spectra” (fantômes de spectres). His experiments were continued in 1851 by Claude Félix Abel Niépce de Saint-Victor (1805–1870), nephew of the inventor of >heliographs. Niépce de Saint-Victor reduced light sensitivity via a coating made from a mixture of dextrin, a carbohydrate hydrolyzed from starch, and the lead salt lead chloride. The French chemical engineer Louis-Alphonse Poitevin (1819–1882) undertook further experiments on heliochromes, working on the basis of Becquerel’s findings, from 1865 on. He showed his results in a closed album at the International Exposition of 1867 in Paris; as had been the case with his predecessor Becquerel, Poitevin’s exposures were still too light-sensitive for an extended presentation.

Hillotypes
1850

In 1850, the American pastor Reverend Levi L. Hill (1816–1865) announced that he was able to create color daguerreotypes through sunlight alone and had solved the problem of direct color photography. Hill was initially unwilling to make his process available to the public, saying that it required improvement, and he did not publish a description of the process until 1856. Hill's process was not accepted for many years, and it was not until 1980 that demonstrations took place that showed that his method could actually function. The process is comprised of a series of interventions: A copper plate coated with silver is repeatedly sensitized with iodine monochloride, chlorine and mercury vapors. After exposure, the chemicals are washed off with a variety of solutions, whereby the exact composition and interactions of these solutions is still unknown today. Hill, too, was unable to solve the problem of fixing color, requiring the images to be stored in the dark. Hillotypes attracted renewed interest in 2007 when researchers found that the red and blue tones were for the most part in fact photographically reproduced, whereas other colors were added by hand.

Ambrotypes
1852–1870

The ambrotype process, developed by Louis Désiré Blanquart-Evrard (1802–1872), created a collodion negative on glass. The glass plate was underexposed and then moistened with a solution of collodion, chloride and iodide, forming a thin layer. The silver image was thus given a whitish tone. Translucent dyes were then sometimes added as additional >hand coloration. Affixing a dark background could cause the negative image to look like a positive image. As with >daguerreotypes, the plate is usually placed in a case or frame together with backing material. The resulting similarity in appearance between the two processes can make it difficult to distinguish between them with the naked eye and is a frequent cause of confusion.

Gum Bichromate
1855–1858

One of the most popular color photographic printing processes of >pictorialism was gum bichromate printing. The French photographer Louis-Alphonse Poitevin (1819–1882) and the Briton John Pouncy (1818–1894) are jointly regarded as its inventors. A sheet of paper is sensitized with gelatin or gum arabic mixed with colored pigments and gum bichromate. This emulsion hardens when left out in the sun. A distinction is made between simple one-layer gum bichromate prints and multiple-layer gum bichromate prints in which colors are superimposed atop one another. Images created in this way are matte with soft transitions reminiscent of painting with a brush, charcoal or even red chalk. Among those who worked with this process were the French photographers Robert Demachy (1859–1936) and Constant Puyo (1857–1933), the German brothers Theodor (1868–1943) and Oskar Hofmeister (1871– 1937), and the "Wiener Trifolium" ("Viennese Trefoil") of Heinrich Kühn (1866–1944), Hugo Henneberg (1863–1918), and Hans Watzek (1848–1903) (>Where are the women?). The comparatively labor-intensive gum bichromate process declined in significance with the invention of >Autochromes.

Three-Color Photography 1869

The French photo pioneer Louis Ducos du Hauron (1837–1920) developed what he called three-color photography beginning in 1862, working on the basis of Maxwell's >additive color mixing. He patented the process in 1869 and presented it for the first time to the Société française de photographie alongside similar results by the French poet and inventor Charles Cros (1842–1888). In a letter written in 1862 to a friend of his family, M. Lelut, du Hauron argued that it would be possible to create a color image by taking separate photographs of the red, yellow and blue parts of an object, dyeing these photographs the correct colors and superimposing the results. This study, entitled Méthode de reconstitution photographique des couleurs (1859), is the earliest known description of >subtractive color mixing and calls to mind, in its idea of color separation followed by recombination, >Technicolor No. IV and the >dye-transfer process.

Photochromes
1872–1874

The French photographer Léon Vidal (1833–1906) patented this photomechanical coloration and printing process between 1872 and 1874. In the 1880s, the technique was further developed by the Zürich lithographer Hans Jakob Schmid (1856–1924) for the established Swiss printing firm of Orell Füssli & Co. (later Photoglob), which commercialized and marketed it, in particular for postcards. To produce a photochrome, a negative of a black-and-white photograph is exposed on a lithographic stone brushed with asphalt. An asphalt copy is made of each color. Finally, the superimposed images are printed on paper, one atop another, in different color tones. For nearly one hundred years, photochrome printing was regarded as the most effective rasterless flat printing process for high-quality color reproductions, and it was particularly popular in the years before the First World War. As a color printing process, it can also be regarded as a predecessor of >Technicolor No. III and >Technicolor No. IV (>dye-transfer process).

Crystoleum
1880–1910

A special case of >hand colored photography is presented by crystoleum, composed of multiple layers. An albumen print (>early paper photography) processed to be transparent is pasted face down on the inside of a concave piece of glass. Once the adhesive is dry, the paper backing of the print is rubbed away, with only the transparent emulsion remaining on the glass. The image is then painted by hand with oil paints. Another piece of glass is placed on the back, which can be colored by hand as well. These multiple layers of material together create the multi-colored crystoleum, the name combining “crystal” (the glass) with “oleum” (oil). A similar principle—applying color to both sides of the substrate—was the basis for the >Kodachrome Two-Color and >Technicolor No. II film processes.

Interference Photography 1891

Gabriel Lippmann (1845–1921), while a professor of physics at the Paris Sorbonne, presented his photographic process on the basis of the interference phenomenon to the French Academy of Sciences in 1891. Lippmann determined that light propagates as waves, and that each of these waves has its own frequency, a sort of tone. These waves are perceived by the eye as different colors. He was able to demonstrate the physical existence of standing waves of light, for which he received the Nobel Prize in Physics in 1908. In Lippmann's process, a fine-grained, nearly transparent emulsion of silver bromide in an albumen layer is applied to a glass plate that is subsequently coated with a mercury film. This mercury reflected the light that had passed through the emulsion back onto itself, creating standing waves. The developed plate resembled a conventional negative, but appeared as a brilliantly colored positive when viewed from the right angle. Lippmann's presentation in 1891 included an exposure of the solar spectrum, as had already been attempted by Alexandre Edmond Becquerel (1820–1891) with the >heliochrome method, although Becquerel, unlike Lippmann, had failed in his attempts to fix the image. The combination of a black-and-white image with an additional layer creating an impression of color is a commonality between interference photography and lenticular film processes such as >Agfacolor lenticular film.

Pictorialism around 1900

As the necessary equipment and chemicals became more affordable and accessible, photography developed into a mass medium over the course of the nineteenth century. One consequence was the rise of a movement of amateur photographers elaborating their own independent artistic aesthetics in distinction from those of professional photography. The amateur photographers, including Alfred Stieglitz (1864–1946), Edward J. Steichen (1879–1973), Frank Eugene (1865–1936), Anne Brigman (1869–1950), Gertrude Käsebier (1852–1934), Zaida Ben-Yusuf (1869–1933), and Eva Watson-Schütze (1867–1935), sought to achieve painterly effects. To this end, they experimented with a variety of photomechanical processes, such as monochrome photogravure, colored >gum bichromates and the single-color >bromoil process, imbuing photographs with a variety of colors and textures. This movement in the years around 1900, the reception of which today takes place under the names of “pictorialism” and “art photography,” was also distinguished by a specific choice of subject matter that focused on open-air photography of nature and leisure activities and also, in particular for the movement’s American exponents, city life.

Bromoil Process
1902

The bromoil process was developed in 1902 by the British architect and amateur photographer Charles Welborne Piper (1863/1864–1919), who later, together with George Edward Brown (1872–1934), prepared the first English handbook on >Autochromes in 1907. The bromoil process, like >gum bichromate, was a popular photomechanical printing process of >pictorialism. Its soft, painterly contours are created through inking with pigment in oil that adheres to a tanned bichromated gelatin layer of a silver bromide positive, dispensing with photochemical developing entirely. A positive color image is created with a tone determined by the choice of oil paint, ranging from blue to sepia and brown. A transfer to paper of the oil paint-treated positive yields a bromoil print.

Autochromes
1907

In 1907, the French brothers Auguste (1862–1954) and Louis Lumière (1864–1948), film as well as photographic pioneers, brought to market the first practical mimetic color photography process (unlike >autonomous colors). The Autochrome, based on >additive color mixing via color grains, used dyed potato starch that, since coarse-grained, endowed the resulting glass plates with a painterly, soft aspect. In 1916, Agfa began to market a similar process that replaced potato starch with gum droplets (>Agfa Screen Plate). Since each Autochrome slide is a unique specimen, a technical device is required for viewing, for example a projector, making Autochromes difficult to reproduce and exhibit. The Autochrome prompted great enthusiasm at first. In 1907, a selection of Autochromes was exhibited at the New York art gallery "291" as part of the Photo-Secession photography movement in the United States. Alfred Stieglitz (1864–1946), who participated in the exhibition, wrote in the London journal Photography: "We venture to predict that in all likelihood what the Daguerreotype has been to modern monochrome photography, the Autochromotype will be to the future color photography. … In short, soon the world will be color-mad, and Lumière will be responsible." The Autochrome was ultimately supplanted by other processes. It required exposure times sixty times longer than black-and-white photography. The modern color processes of >Kodachrome and >Agfacolor Neu conquered the market from the mid-1930s on. A final disadvantage of the process was the fragility of its colors, which faded when exposed to light. The process nevertheless underwent further development, becoming >Autochrome Film/Cinécolor in the 1920s.

Dioptichrome 1907–1909

In 1907, the French lawyer Louis Dufay (1874–1936) patented a process based on closely spaced fine lines of color using combinations of colloids, which are glue-like substances such as gum arabic, fish glue or gelatin, together with greasy ink and their absorptions. The process employs red, green and blue elements, the primary colors of >additive color mixing. First dubbed Diopticolor in 1908, the process was renamed Dioptichrome the following year. The plates were distributed by Guilleminot, Boespflug et Compagnie of Paris and marketed by the Société des plaques et produits Dufay. Although the Dioptichrome process allowed color development six times faster than the >Autochrome, it fell into obscurity during the First World War. In the realm of motion pictures, it reappeared as the >Dufaycolor process in 1934.

Agfa Screen Plate
1916

Having experimented with color photography from 1909 on, >Agfa began selling the Agfa Screen Plate commercially in 1916. This was a color grain-based glass plate for color slides, similar to the >Autochrome and using the principle of >additive color mixing. Here Agfa drew on the patents of 1908 patents of J. H. Christensen (dates unknown). The potato starch used in the Lumières' process was replaced with gum droplets to generate the impression of color. In 1932, Agfa released a raster process for film as well, which instead of using colored dots or grains was based on tiny lenses embedded in the film's backing layer (>Agfacolor lenticular film).

Neues Sehen [New Vision] 1934–1946

Many artists' works of color photography did not receive recognition until quite late. This has often been traced to the break in the art world after the Second World War, the use of color film for propaganda (>Agfacolor Neu), and lastly the long debates in the academic discourse. From the 1960s on, this discourse tended to link color to popular culture, such as advertising, >magazines and color television, and elevated black-and-white photography to a means of artistic expression (>avant-garde). Thus the French philosopher Roland Barthes (1915–1980) called color in photography a "coating" and "an artifice." This had an impact on the acceptance of color photography by museums, something that would change only in the course of the >New Color Photography in the 1970s. The Bauhaus artist László Moholy-Nagy (1895–1946), though for many years known above all for his black-and-white photographs, created numerous color photographs in Chicago between 1934 and 1946. Moreover, he understood the media of photography and film as being in dialogue with one another. With regard to the development of color film in particular, he wrote in 1934: "I am convinced now that new aspects of color in photography have to come from kinetic experiments, from an interplay of color on film. There the third-dimensionality, which after all is the essential nature of light, can be combined with color. The superimpositions and the interplay have to come from optical instead of chemical combinations." His work on film is nonetheless entirely in black and white—as far as we know today.

Magazines 1950s and 1960s

Magazines in the 1950s and 1960s provided one of the first platforms for color photographs. The first issue of the American magazine LIFE in 1936 contained individual color photographs. Over the course of the 1930s, the emergence of modern color film processes such as >Agfacolor Neu and >Kodachrome increasingly standardized the publications' color appearance. While >Kodak cooperated with the fashion magazine Look in the United States, the German political magazine Stern featured photographs shot on >Agfa film. In Switzerland, the Zürich culture magazine DU may be mentioned. Although on founding in 1941 it printed only advertisements in color, it began printing photo series in color as well starting in 1943.

Polaroid Polarcolor 1963

The Polaroid Corporation was founded in 1937 by the American physicist Edwin Land (1909–1991) to develop polarization filters and optical apparatuses. In 1947, he introduced an instant camera that could develop a black-and-white film, called Polaroid, immediately after exposure. The first color films based on >subtractive color mixing were released in 1963 under the trademark of Polarcolor. A scene is recorded on each emulsion layer of the three-layer color film. During processing, the three color images—in cyan, magenta, and yellow—coalesce through the principle of >chromogenic development, leaving their original position and becoming a single layer to create a unique image in full color. Unlike with black-and-white film, this film is developed outside of the camera.

Cibachrome (later Ilfochrome) 1967

Cibachrome prints continue the tradition of >Gasparcolor, a color film process employed in the 1930s and, with its luminous colors, popular with certain filmmakers of the >avant-garde. One of the advantages of Gasparcolor was that its colors were stable and did not fade. This silver dye bleach process fell into disuse in film in the early 1940s but enjoyed a revival in photography from the 1960s on under the name of Cibachrome. The Swiss firm of Ciba, specialized in the production of dyes and pharmaceutical products, began experiments in color photography in the 1950s and released Cibachrome paper in 1967. After its sale to the International Paper Corporation of America, the product continued to be marketed under the name of Ilfochrome after 1991.

New Color Photography 1970s

The 1970s can be termed the “age of color,” an era of the (re-)discovery of color as a means of artistic expression in photography, as it had been in earlier currents such as >pictorialism and the >Neues Sehen. Given a prominent exhibition by curator John Szarkowski (1925–2007) at the Museum of Modern Art (MoMA) in New York in 1976, the works of the American photographer William Eggleston (*1939) cleared the way for modern color photography to enter the museum. Hotly discussed at the time as “the most hated exhibition of the year,” the exhibition is regarded today as the birth of New Color Photography. New Color artists sought to realize an artistic vision through the targeted use of color, in parallel with color film and the emergence of color television and >magazines and technical advances in the field of color photography in the 1960s. The >Kodachromes that Eggleston exhibited at MoMA depicted everyday life in the American South. The American artist Stephen Shore (*1947) can be regarded as a “forerunner” of Eggleston. His series American Surface (1972) was the only color series presented in the 1975 exhibition New Topographics: Photographs of a Man-Altered Landscape at the George Eastman House (now the George Eastman Museum) in Rochester, New York.

Polaroid SX-70
1972

With the release of the SX-70 instant image system, the first foldable reflex camera, in 1972, Polaroid made photographic history again (>Polaroid Polarcolor). Innovations included the elimination of the previously required separation of positive and negative, with the image slowly appearing on the backing. It was now, in other words, a one-step photographic process. Artists soon discovered this unique method of creating one-off photographs, such as the American pop artist Andy Warhol (1928–1987), who often depicted himself, including at times with his SX-70. The >Kodak Company followed Polaroid's lead in 1976, but took its instant film back off the market in 1985 following a patent dispute with Polaroid. The instant image process is still used today for >Fujifilm Instax cameras, introduced in the late 1990s.