HISTORY AND EVOLUTION OF PHOTOGRAPHY

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The Technical Evolution of Photography in the 19th Century

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Concept and First Attempts

Whereas the observation of numerous light-sensitive substances and the formative evolution of the camera obscura predate 1800, the invention of photography, as we know it, was essentially a 19th-century phenomenon. Who actually invented photography has been disputed from the very beginning, though the task would have been easier had there been a universally accepted definition of *photograph*.

Taken literally, the Greek words *photos* and *graphos* together mean "light drawing." Even today the term *photography* is being manipulated to fit digital imaging, but in its most elegant form, a photograph may best be described as a reasonably stable image made by the effect of light on a chemical substance. Light is energy in the form of the visible spectrum. If light or some other invisible wavelength of energy is not used to make the final picture by chemical means, it cannot, by this definition, be a photograph.

The stability of an image made by light is also important. Without stability, the term *photograph* could apply to the most fragile and fugitive examples of images such as frost shadows of buildings on a sunny November morning. The word *photography* was not the product of just one man. Its introduction was a logical choice by those with knowledge of Greek who contemplated the concept. The term may have been first used by Antoine Hercules Romuald Florence in 1833. Florence was living in Brazil, working in relative isolation, and had no apparent influence on the European scientific community. Sir John Herschel (Figure 30), in England, also used the terms *photography* and *photograph* in 1839, but his contacts were many. Because of this Herschel has traditionally been credited with the use of the terms by those seeking words to describe both the process and product.

Some of the first images to be recorded with light-sensitive materials were made by Thomas Wedgwood, son of Josiah Wedgwood, the well-known potter. His associate, the scientist Sir Humphrey Davy, published the results and observations in the *Journal of the Royal Institution* in 1802. Wedgwood and Davy made images on paper and white leather coated with silver nitrate. They laid leaves and paintings on glass upon the sensitive materials and exposed them to sunlight, which darkened the silver. In an attempt to keep the image, they washed the exposed materials without success. They found that combining the silver solution with sodium chloride produced the more sensitive whitish paste of silver chloride. Even with this improvement, Wedgwood felt the process was too slow to make images in a camera, and though they did make the first photographic enlargements of microscopic specimens by projecting the images using a solar microscope, they had no way to preserve the image once it was formed.

Many of the observations of Wedgwood and Davy were actually ideas already covered years earlier by Johann Heinrich Schulze (1725), Carl Wilhelm Scheele (1777), and Jean Senebier (1782), though without the same sense of purpose. Schulze discovered the sensitivity of silver nitrate to light rather than to heat. Scheele, in addition, observed and published that ammonia would dissolve unexposed silver chloride, the means to permanently fix silver chloride images. It is still difficult to understand why Scheele's published observation escaped Davy. The experiments of Wedgwood and Davy are important because their work combined photochemical technology with the sole intent to make images with light. Few doubt that success would have come to Wedgwood had he applied ammonia to his images, but he died a few years after publishing his findings. Davy did not continue the research.

Joseph Nicephore Niépce

Several years later Joseph Nicephore Niépce (Figure 110), living in the village of Saint-Loup-de-Varennes near the town Chalon-sur-Saône in France, began his own experiments using paper sensitized with silver chloride. Some time around 1816, Niépce made printed-out negative images on paper by using a camera obscura and partially fixed them with nitric acid. Not satisfied with the process, he moved on to another light-sensitive material, asphaltum.

Niépce had been involved with etching and lithography and was looking for a means to make etched plates without having to depend on skilled handwork. It is probable that he and others would have noticed that the asphalt etching ground was harder to remove with solvents when printing plates were exposed to the sun. He coated lithographic stones and plates of copper, pewter, zinc, and glass with asphaltum dissolved in oil of lavender. When the asphalt dried, the plates were covered with an object and exposed to light. The unexposed areas were then dissolved with a solvent such as Dippel's oil, lavender oil, or turpentine while the hardened exposed areas remained intact, creating a negative image. Why Niépce did not use his asphalt images on glass as negatives to make positive prints on silver chloride paper remains a mystery to photographic historians and scholars.

Niépce eventually placed waxed engravings in contact with these sensitive plates. After the unexposed areas were removed with a solvent, the plate negative image of the engraving was visible. The plate was then etched with acid and subsequently used as a conventional etching plate for printing in a press. Niépce called these plates heliographs, from the Greek words *helios* and *graphos,* meaning "sun drawing." The process eventually became the conceptual cornerstone of the photoengraving industry.

Of all the heliographic plates made by Niépce, the only known surviving example made in a camera has become an icon of photographic history. In 1826 Niépce prepared a heliograph with a thinner asphalt coating upon polished pewter. This plate was exposed in a camera facing out the window of his estate, known as Le Gras (Figures 38–40). The "View from the Window at Le Gras," now in the Gernsheim collection at the Harry Ransom Center in Austin, Texas, probably took two days of exposure to record the outline of the horizon and the most primitive architectural elements of several buildings outside and below the window. Niépce's image is both negative and positive depending on how it is illuminated, and it is permanent.

Louis Jacques Mandé Daguerre

It was 1826 when Louis Jacques Mandé Daguerre contacted Niépce though the firm of Vincent and Charles Chevalier (Figure 26), opticians in Paris from whom they were both purchasing lenses for their experiments. Daguerre, inventor of the popular Diorama in Paris, was also seeking a means to secure images by light in a camera. At the time of their meeting, Niépce was discouraged because of an unsuccessful trip to London where he had tried to generate interest in his heliograph process. Daguerre had nothing more to offer than some experiments with phosphorescent powder and a technique called *dessin fumee*—drawings made with smoke (Figure 41). Nevertheless, Niépce entered into partnership with Daguerre in 1829 for the purpose of working toward a common goal. It is assumed that he felt that Daguerre's energy and popular success would be of some benefit.

By the early 1830s, both Daguerre and Niépce observed that light would darken polished silver that had been previously exposed to iodine fumes. Niépce used that same technique to darken the exposed portions of heliographs made on polished silver plates. Niépce and Daguerre had also developed the physautotype, a variant of the heliograph that used rosin instead of asphalt on silver plates. The process was equally slow, but the images were superior to the heliograph, looking more like the daguerreotype that was soon to be invented. It is assumed that around this time Daguerre came upon the process that would make him famous. His experiments began by exposing silver plates fumed with iodine in the back of a camera obscura. Given sufficient exposure, a fully formed violet-colored negative image against a yellow ground was made on the plate within the camera. These images were beautiful, capable of infinite detail, but not permanent.

Daguerreotype

In 1833 Niépce died, leaving his heliograph process unpublished and his son Isadore to assume partnership with Daguerre. Two years after Niépce's death, Daguerre discovered that the silver iodide plate required only a fraction of the exposure time and that an invisible, or latent, image that could be revealed by exposing the plate to mercury fumes. Instead of requiring an exposure of hours, the new process required only minutes, and the image could be stabilized by treating it in a bath of sodium chloride.

The resulting image, called a daguerreotype, was both positive and negative depending on the lighting and angle in which it was viewed. The image was established by a delicate, frosty white color in the highlights and black in the polished silver shadows, provided the plate was tilted toward a darkened room. By the time he demonstrated the daguerreotype process to Francois Arago, the director of the Paris Observatory, Daguerre had a completely practical photographic system that included fixing the image permanently with sodium thiosulfate, a process that was discovered by Sir John Herschel in 1819. Sodium thiosulfate was known at this time as hyposulfite of soda or as hypo. In 1839 the French government awarded Daguerre and Isidore Niépce a pension for the technology of the daguerreotype and offered the discovery to the world.

Every daguerreotype was unique. The final image was the very same plate that was in the camera during exposure. The latent image and use of silver combined with iodine (silver iodide) that were introduced by Daguerre became the basis of every major camera process of the 19th century until the introduction of gelatin bromide emulsions used in the manufacture of dry plates and developing-out papers.

Photography on Paper

William Henry Fox Talbot (Figure 36), an English scholar in the area of hieroglyphics, began his own experiments with silver chloride in 1834. Talbot, however, came to understand how the percentages of silver nitrate to sodium chloride affected sensitivity. Nevertheless, images made in the camera could take hours. Why he did not use hypo to fix his images remains a mystery since he was in communication with Herschel. Hypo was an expensive chemical, and it is possible that Talbot sought another compound for the sake of economy.

His observations, however, led him to discover a way of making the unexposed areas of his images less sensitive. Talbot treated his images in a strong solution of sodium chloride and a dilute potassium iodide or potassium bromide, which resulted in the colors brown, orange, yellow, red, green, and lilac, depending on the chemical and degree of exposure. This process did not actually remove the unexposed silver chloride, so these images were simply considered "stabilized." Provided the image was not exposed to strong light, it could be preserved for years or even used to make a positive image by contact printing in the sun on a second piece of sensitized paper.

The process for both the stabilized negative and the subsequent positive print was called photogenic drawing. Like all silver chloride papers, the exposures required for a fully formed print were minutes for a contact image of a leaf printed in the sun and up to several hours for a negative made within a camera, depending on the size of the negative. Typically the procedure of using the original negative to make a positive print often darkened the former so much that it was useless for printing a second time. By 1839 Talbot's positive photogenic drawings were colorful, soft in focus, and still relatively sensitive. Compared to the speed, permanence, and infinitesimal resolution attainable by the daguerreotype, the photogenic drawing was very primitive, very slow, and impossible to exhibit in daylight without a visible change. Sir John Herschel is said to have remarked to Arago after seeing a daguerreotype in May of 1839, "This is a miracle. Talbot's [photogenic] drawings are childish compared with these."

1839 — The Race for Acknowledgment

Talbot was caught off guard when Daguerre's work was announced by Arago to the Academy of Sciences in Paris on January 7, 1839. Aware but not knowing the details of Daguerre's technique, Talbot rushed to publish his own photogenic drawing process in a report titled, "Some Account of the Art of Photogenic Drawing." The report was read to the Royal Society on January 31 and subsequently published in the English journal *The Athenaeum* on February 9. Talbot's account made a strong point of the utility of his process but contained no specific formulas or details of the actual technique of making photogenic drawings.

Daguerre and Isidore Niépce had accepted a government pension in exchange for the details of both the daguerreotype and heliograph processes. On August 19, 1839, Arago explained the daguerreotype process in detail to a joint meeting of the Academy of Science and the Academy of Fine Arts at the Palace of the Institute in Paris. A daguerreotype camera and complete set of processing equipment was manufactured by Giroux, Daguerre's brother-in-law, and offered for sale at this time. Daguerre also produced a manual, which was the first of its kind and remains one of the most comprehensive photographic treatises ever written. Within its pages are historical accounts, complete formulas, descriptions of Niépce's heliograph process with variations, and Daguerre's latent image process, and line illustrations of all the equipment needed to make a daguerreotype.

Bayard, Ponton, and Herschel

Hippolyte Bayard, an official at the Ministry of Finance in Paris, invented a direct positive process on paper in 1839. His process was based on the light bleaching of exposed silver chloride paper with a solution of potassium iodide. The prints were then permanently fixed with hypo. Bayard sought the attention of the French government to claim the invention of photography. His direct positive process was permanent but very slow and was rejected in favor of Daguerre's. In 1840 Bayard submitted his process a second time and was rejected again. In response he produced a self-portrait as a drowned man and sent it to the Academy accompanied with prose expressing his disappointment. Had this image been of a leaf or piece of lace, like so many of Talbot's photogenic drawings, Bayard and his process would probably never have been remembered with such pathos. In comparison, Bayard's direct positive self-portrait was technically superior to what Talbot was making at the same time.

In 1839 Mungo Ponton, in Scotland, observed that paper soaked in a saturated solution of potassium bichromate was sensitive to light. The delicate printed-out image was washed in water and had reasonable permanence. The process was not strong enough for a positive print and not fast enough for camera images, but Ponton's work led Talbot to discover the hardening effects of gelatin treated with chromium compounds. This characteristic of dichromated colloids became the basis of both carbon and gum printing and several photomechanical printing processes.

In the same year, Sir John Herschel made hypo-fixed silver carbonate negatives on paper. He also produced the first silver halide image on glass by precipitating silver chloride onto the surface of a plate and printing out a visible image within a camera. The process was similar and as slow as the photogenic drawing, however in this case the image was permanently fixed with hypo. When this glass negative was backed with dark cloth, it could be seen as a positive image. Herschel, who could have invented photography, seems to have been satisfied with helping others to do so. He held back on publicizing his processes as a courtesy to Talbot.

Improvements to Daguerre's and Talbot's Processes

The improved daguerreotype

Daguerre's original process of 1839 was too slow to be used comfortably for portraiture. Exposures were typically no less than 20 minutes. Because of the slow lens and optics of the time, the early daguerreotype process was limited to still-life and landscape imagery. Two improvements that were to change all this were the introduction of bromine fumes in the sensitizing step of the process and the formulation of a faster lens.

In 1840 several experimenters working independently discovered that different combinations of chlorine, bromine, and iodine fumes could be used to produce daguerreotype plates that were many times more sensitive than plates that were simply iodized. Because of these experimenters' research, daguerreotypists eventually settled on fuming their plates with iodine, then bromine, and once again with iodine. The bromine fuming procedure eventually became standard practice throughout the daguerreotype era, allowing daguerreotypists to make exposures measured in seconds.

The design of a faster lens, formulated in 1840 by Max Petzval, also allowed for shorter exposures. In combination with the more sensitive plate, this faster lens ushered in the first practical application of the daguerreotype process for portraiture. The Petzval lens was designed specifically for portraiture and became the basis for all portrait and projection lenses for the next 70 years. By the early 1840s, commercial daguerreotype portraits were being made in studios under a skylight (Figure 45).

Another important improvement in 1840 was gold toning, introduced by Hippolyte Fizeau. A solution of *sel d'or,* made by adding gold chloride to hypo, was applied to the fixed plate. The process became known as gilding. Gilding extended the range of tones and made the fragile image highlight less susceptible to abrasion.

The calotype

Talbot's photogenic drawing process, as introduced, was also impractical for portraiture even when improved lenses became available. In 1841, however, Talbot changed his formula to use silver iodide, which was more sensitive than silver chloride. It was the very same silver halide as used by Daguerre, though applied to paper. The iodized paper was sensitized with a solution of silver nitrate, acetic acid, and a small amount of gallic acid.

This new paper was exposed damp and required only a fraction of the time needed to print a visible image with the photogenic drawing process. It bore either a feeble or no visible image when removed from the camera. The latent image was developed to its final form in a solution of gallic acid and then stabilized in potassium bromide or permanently fixed in sodium thiosulfate. The new process was called the calotype, from the Greek *kalos,* meaning "beautiful." Despite the use of silver iodide, the calotype process usually required at least a minute of exposure in full sunlight using a portrait lens.

Calotype negatives could be retouched with graphite or inks to prevent transmission of light or could be made translucent locally with wax or oil. Talbot made positive prints from these as he did with photogenic drawings, by printing them in the sun onto plain silver chloride paper. Even after Talbot adopted the use of hypo for fixing his negatives, he occasionally stabilized these prints in salt or iodide solutions, presumably because he preferred the final image colors. Eventually Talbot and other calotypists chose to permanently fix their positive images in hypo, resulting in an image of colors ranging from deep orange to cool brown. These were called salt (or salted) paper prints (Figures 51 and 52). Another improvement was made by not adding the gallic acid in the sensitizing step of the process.

Those wishing to use the patented calotype process were required to pay Talbot for the privilege. This license was expensive, and the commercial potential of the calotype process was not particularly attractive to the average working person. The calotype seemed to appeal to the educated upper classes that had an appreciation for the arts, scientific curiosity, and plenty of leisure time. Variants of preparing calotype paper began to emerge as more people used the process. An early improvement to the process omitted the gallic acid in the sensitizer, allowing the paper to be used hours after preparation without browning spontaneously.

In 1844 Talbot published the first installment of a book titled *Pencil of Nature,* which was illustrated with salt prints from calotype negatives. The publication was sold by subscription, and subsequent issues were sent to the subscriber as they were produced. Because of technical difficulties, *Part II* was not sent until seven months after the first. *Part VI* was not available until 1846. The venture was not successful, but it offered a vision of what might be possible in the future. If there was ever a commercial use for the calotype, it was to be for the illustration of written material and particularly for documentation of architecture. Although not technically conducive to portraiture, particularly in a studio, the calotype process was used on occasion for this purpose.

The most ambitious and celebrated uses of the calotype process for portraits were made by the team of David Octavius Hill and Robert Adamson (Figure 50) as reference images for a painting that Hill was planning of the General Assembly of the Free Church of Scotland. The portraits for this project give a fair idea of the quantity of light required for an exposure. In many examples the subjects face sunlight as if it were a strong wind. Hill and Adamson produced several bodies of work from 1843 to 1847, including genre portraits and architectural views. Their work stands alone as the most comprehensive use of calotypy for portraiture.

Although the calotype process was licensed by Talbot to Frederick and William Langenheim of Philadelphia, the calotype would never become popular in the United States. Shortly after the process was perfected by the Langenheims, the daguerreotype was well established and not to be toppled until the invention of collodion photography in 1851.

Calotypes were made by a small number of photographers in the 1840s and early 1850s (Figures 58 and 60), the most famous examples being documentary images of architecture by French and English photographers. In 1851 Maxime du Camp produced major albums of views from Egypt, Palestine, and Syria, which were documented by the calotype process in 1849 (Figure 62). Documentary work by Edouard Baldus and Henri le Secq (Figure 59) were also made with an improved variant of the calotype called the waxed-paper process, introduced by Gustave Le Gray in 1851.

The waxed-paper process evolved because French papers were not ideally suited for calotype as they were sized with starch rather than gelatin. Le Gray saturated the paper with hot beeswax prior to treating with iodine and sensitizing with silver. The development was identical to the calotype. Waxing the paper prior to iodizing resulted in better resolution, and the process could be done with the paper completely dry, making it perfect for the traveler.

The Business of Photography

By the late 1840s, the daguerreotype process was being used commercially in every industrialized nation of the world. Although the total number of calotypes made in the 19th century might be counted in the thousands, this was still less than the yearly production of daguerreotypes in most major cities in the United States in the 1850s. The business of the daguerreotype was profitable for many daguerreotypists, the plate manufacturers, and the frame and case makers.

The American daguerreotypists in particular produced superior portraits (Figure 69). A technique perfected in America called galvanizing involved giving the silver plate an additional coating of electroplated silver. Galvanizing contributed to greater sensitivity, which was important for portraits, and it provided a better polish, resulting in a wider range of tonality. The works of Thomas Easterly and of the celebrated team of Albert Southworth and Josiah Hawes (Figure 56) remain as both technical and artistic masterworks. The daguerreotype was well established in the early 1850s as a commercial and artistic success, though it also had drawbacks. The images were generally small, laterally reversed direct positives that required copying or a second sitting if an additional image was desired.

Although not impossible, landscape work was a technical commitment and not commercially profitable considering the effort required to make a single plate. When properly illuminated, daguerreotypes were (and still are) awe inspiring; however, they were seldom viewed at the best advantage. This failure resulted in a confusion of negative and positive images juxtaposed with the reflection of the viewer.

Negatives on Glass

In 1847 a new negative process, producing the niépceotype, was published in France by Abel Niépce de Saint Victor (Figure 33). After initial experiments with starch, Niépce de Saint Victor came upon the use of egg albumen as a binder for silver iodide on glass plates. Variants of the same albumen process were simultaneously invented by John Whipple, in Boston, and the Langenheim brothers, in Philadelphia. Development of these dry plates was identical to the calotype, but they required much more time. Exposures too were much longer than those required for the calotype, but the results were worth the effort. Even by today's standards, the resolution of these plates was nearly grainless. The Langenheims took advantage of this characteristic and in 1848 invented the hyalotype (Figures 53 and 54). This was a positive transparency on glass that was contact-printed from albumen negatives.

The Niépceotype process was never to be used for studio portraiture, but for landscape and architectural subjects it was technically without equal even after the collodion process was invented. It was, however, still a tedious process, and after 1851 the only reasonable applications of the albumen process were for when a dry process was advantageous or for the production of lantern slides and stereo transparencies where resolution was important.

A major essay made during the latter part of the Crimean War in the mid-1850s was documented with large albumen plates by James Robertson (Figure 71), and Felice Beato. After the war Robertson and Beato made images in the Middle East, continuing a series started before the war, and in war-torn India. The pictures of the Siege of Lucknow and the Kashmir Gate at Delhi feature the first true glimpses of the horrors of war.

The Wet Plate Process

In 1848 Frederick Scott Archer (Figures 25 and 57), an English sculptor and amateur calotypist, experimented with collodion as a binder for silver halides as a means to improve the calotype. The term *collodion,* from the Greek word meaning "to stick," was used to describe a colorless fluid made by dissolving nitrated cotton in ether and alcohol. When poured onto glass, collodion dried to a thin, clear plastic film. In their calotype manuals of 1850, both Robert Bingham, in England, and Gustave Le Gray (Figure 67), in France, published the possible benefits of using collodion, but the first complete working formula of the wet collodion process was published by Archer in 1851 in *The Chemist.*

Archer's formula began with coating a glass plate with iodized collodion. The collodion film was then sensitized, while still wet, by placing the plate in a solution of silver nitrate. After exposure in a camera, the latent image was developed with either gallic or pyrogallic acid. The image was then fixed with hypo and washed. The fragile collodion film retained the alcohol and ether solvents throughout sensitizing, exposure, and processing, which is why it was known as the wet plate process.

Contested unsuccessfully by Talbot as an infringement on his calotype process, Archer's wet plate technique came at a time when the calotype, the waxed-paper, the daguerreotype, and the albumen processes were all being used. Originally the process was conceived by Archer to include coating the fixed image with a rubber solution and stripping the film from the glass plate. The thin rubber-coated collodion film was then to be transferred onto a secondary paper support for printing. The stripping and transfer method was quickly abandoned as unnecessary, though it eventually became an important technique used in the graphic arts industry until the 1960s.

Exposure times were reduced by half with the wet plate technique, making portraiture in the studio possible when ferrous sulfate was used for development. Although more sensitive than the calotype, the wet collodion negative process as generally practiced in the studio was not faster than the daguerreotype of the 1850s.

Collodion negatives were used to make salted paper prints, originally called crystalotypes by Whipple (Figure 63), but were perfectly matched to the albumen printing process introduced by Louis Deserie Blanquart-Evrard in 1850. The synergy of the collodion negative (Figure 91) and albumen print was to become the basis of the most commercially successful and universally practiced photographic process in the 19th century until it was eventually replaced by the gelatin emulsion plate in the 1880s.

By 1855 the collodion process had eclipsed the daguerreotype for commercial portraiture and was quickly being adopted by the amateur as well. The great photographic journals such as the *Photographic News, The British Journal of Photography, La Lumiere, Humphrey's Journal*, and the *Photographic and Fine Art Journal* were all introduced in the early 1850s. Such publications fueled the steady advancement of photography and were the "chat rooms" of the era, featuring well-documented research by chemists, empirical discoveries by the working class, and petty arguments between strong personalities.

The Art of Photography

From the 1860s onward, the photographic journals occasionally touched on the subject of art and photography, though like many art forms, there was little consensus. Photographic societies and photo-exchange clubs were formed in many cities, and exhibitions based on the salon style were held and judged. It is customary to mention in histories of photography the celebrated artists of the wet plate process such as Julia Margaret Cameron (Figures 30 and 84), Oscar Gustave Rejlander (Figure 84), and Gaspar Felix Tournachon, also known as Nadar. At the time, however, much of their work was not generally recognized by the public or the greater photographic community.

Critics also failed to take photography seriously as an art form, an attitude that continued for many years to come.

Cameron's genius was not recognized until late in the century when the pictorialists were deconstructing the convention of photography. Nadar on the other hand came to own a very successful Parisian Photo Gallery. His operators posed the subjects, processed the plates, and delivered the prints, producing commercial portraiture that was technically enviable though generally without the soul of his own early work.

The great landscapes documented with collodion such as those of Gustave Le Gray (Figure 67), Francis Frith (Figure 75), Leopoldo and Giuseppe Alinari, and John Thomson (Figure 90) were pictorial achievements by any standards and were made under very difficult conditions. The wet plate process was challenging enough in a studio, but to pour plates within a portable darkroom was an enormous task made more taxing when the plates were large. In Western America, Carleton Watkins, Eadweard Muybridge, William Henry Jackson (Figure 94), and Timothy O'Sullivan (Figure 88) also produced work under equally difficult conditions. In most cases the works of these landscape photographers were the first recorded images of a region. The final product, however, was most often seen by the general public not as an albumen print but as a wood engraving from the print.

Heavily retouched solar enlargements printed on salted and albumen paper were offered by progressive photographers in larger towns and cities throughout the 1860s and 1870s, but at great expense. The process of enlarging did not become commonplace until the acceptance of silver bromide developing papers, beginning in the late 1880s.

The most common connection of the public with photography in the 1860s was the commercial albumen print in the form of the small *carte de visite* (Figure 78) (calling card) portrait or a stereograph — two albumen prints on a card designed to be seen in three dimensions with a special viewer. By the late 1860s, the larger cabinet card photograph was also introduced. Cabinet cards (Figure 96) and *cartes de visite* ushered in an industry of mounts and album manufacturing. Larger framed prints were available at the portrait studios, but the two smaller portrait formats were the bread and butter of the working photographer until the end of the century. Stereographs remained popular until after the turn of the century and were usually a specialty item made by landscape photographers and sold by subscription or in stores.

Collodion Variants and the Positive Processes

The mid-1850s proved to be a fertile era for both new processes and variants of the collodion process. Soon after its introduction, collodion was used for stereo transparencies, microphotographic transparencies, and lantern slides. Direct collodion positives, called alabasterines by Archer, were originally made by bleaching an underexposed plate with bichloride of mercury. When ferrous sulfate was adopted as the developer and cyanide as the fixer for collodion positives, the plates were more sensitive and the positive images did not require bleaching. Exposures of these plates in the studio were faster than exposures for the daguerreotype. The plates were also a cheaper and easier-to-view alternative. These plates were generally known as collodion positives, verreotypes, daguerreotypes without reflection, or daguerreotypes on glass. Though the actual image-making technique was usually the same, there were many variants, and those who introduced them were quick to apply a new name to each type.

A patent was awarded to James Anson Cutting in 1854 for a method of sealing these positive images on glass with balsam, using the same technique as that used for covering a microscope slide. Cutting called his variant of the collodion positive process *ambrotype,* from the Greek word meaning "imperishable." Cutting eventually changed his middle name to Ambrose to commemorate the process. Though the name *ambrotype* was specific to Cutting's patented sealing technique, the word quickly evolved to be the generic term for all such images (Figure 70).

Direct positive collodion images on japanned iron plates were invented simultaneously by photographers working in England, France, and the United States. In 1853 Adolphe Alexandre Martin first published the process in France. Hamilton Smith, in the United States, and William Kloen, in England, both patented the process in 1856. Smith, who called his plates melainotypes, sold the rights to Peter Neff, who manufactured them. Victor Griswold, a competitor, also manufactured japanned plates, calling them ferrotypes, a name that would eventually be adopted by the general public along with the less-formal "tintype" (Figures 99 and 103).

It is important to understand that those who made commercial ambrotype or ferrotype images were not considered photographers. Although the term *photography* is often applied indiscriminately to any photosensitive process used in the mid-19th century, it is technically specific to the making of negatives used to produce prints. Those whose work cannot be strictly classified as photography were known as daguerreotypists, ambrotypists, and ferrotypists or tintypists.

Positive collodion transfers onto patent leather (Figure 68), oilcloth, and painted paper were called pannotypes and were also born in this era, along with the milk-glass positive (Figure 86), printed from a negative onto a sheet of white glass. But neither of these would approach the popularity of the tintype, which eventually replaced the ambrotype in the 1860s and continued to be made in various sizes throughout the 19th century.

Collodion Variants and the Negative Processes

In an attempt to make the collodion process possible without erecting a darkroom on location, some amateurs began experimenting with making preserved or dry collodion plates in the 1850s. Humectant-based processes relying on oxymel, a medical compound of honey and acetic acid, and various syrups to keep the sensitive plate damp were very successful. These plates, however, were up to five times slower than the conventional wet plate. The dry tannin and Taupenot plates were also very slow. These techniques, although an interesting footnote in the evolution of the collodion process, were never sensitive enough to be useful for anything but landscape work and were seldom used. Most landscape photographers preferred to see the plate develop on site should they need to make a second exposure.

In the late 1870s, collodion emulsions were being used by curious amateurs. Based on the technique that used initial silver chloride emulsions for collodion printing-out papers, collodion emulsions were made by mixing halide and silver together in the collodion rather than sensitizing an iodized plate in a separate silver bath. Although the collodion emulsion process for negatives did not come into general use, it was the basis for the gelatin emulsion process and the production of collodion chloride printing-out papers used well into the next century.

Concerns of Permanency

The correct processing of paper prints from collodion negatives was not fully understood during the 1840s and early 1850s, and the consequence of fading prompted committees in both England and France to investigate the problem and search for alternatives. Despite the gold-toning procedure applied to all albumen prints, most of these prints were prone to fading. This was usually caused by incomplete fixing or washing.

From this climate of questioning came the carbon printing process introduced by Alphonse Louis Poitevin and the developed-out salt printing processes of Thomas Sutton and Louis Deserie Blanquart-Evrard. The cool tones of developed-out salt prints were not embraced by photographers or the public, though the process was much more stable than any other printed-out technique. The process eventually found its niche with the technique of solar enlarging, which was introduced in the late 1850s. The typical printed-out solar enlargement from a collodion negative required more than an hour of exposure. Exposures on developed-out salted papers were counted in minutes.

The carbon process, based on the light sensitivity of pigmented gelatin treated with potassium bichromate, did not achieve its technical potential until the single-transfer variant patented by Sir Joseph Wilson Swan was universally adopted in 1864. Despite the superiority of the carbon process to albumen prints in both tonality and permanence, they were tedious to make, particularly for a single print. Carbon prints were better suited to making large runs of a single image but not for the typical studio portrait (Figure 89). Photographers preferred to make albumen prints over carbon prints until albumen printing was replaced with the collodio-chloride and gelatin-chloride aristotype printing-out papers late in the century. Carbon and gum prints based on the same principle continued to be available but in very limited numbers.

In 1873 one of the most beautiful printing processes of the 19th century was patented by William Willis (Figure 97), of London. Although platinum had been used on occasion for toning prints, Willis's process, perfected by 1879, was based on a faint image, formed with iron compounds, that was developed to completion into a pure platinum deposit. The Platinotype Company, established in 1879, produced sensitized platinum papers that were favored by a growing movement of artists using photography. The matte finish and neutral tones of the platinum print were ideally suited to the soft masses of tonality favored by the pictorialist and fashionable portrait galleries late in the century.

The cyanotype, a process invented by Herschel in 1841, was reasonably permanent, but the image was blue and not particularly suited to most imagery. With the exception of documenting botanical samples by contact and occasional printing from calotype or collodion negatives, the cyanotype process was not popular until the end of the century (Figure 106), when amateurs used it as an easy and economical way to proof their gelatin negatives.

Gelatin Emulsions and the Modern Era

It may seem out of place to call the last quarter of the 19th century the modern era of photography. However, the introduction and eventual acceptance of gelatin emulsion plates, papers, and flexible films in this period became a technology that was not challenged until digital imaging appeared at the end of the 20th century. Looking back from a 21st-century perspective, we might more appropriately call the late 1800s the last era of photography.

The complicated evolution of research, development, and manufacturing of silver gelatin photographic materials in the latter quarter of the 19th century is filled with simultaneous invention, lawsuits, and countersuits. Chronicling the history is beyond the scope of this essay, but what follows presents the essential progression.

The invention of emulsion plates was primarily English and began with collodion emulsions of the 1850s. In 1865 G. Wharton Simpson made printed images on paper coated with a collodion chloride emulsion. Soon after this, leptographic paper coated with a collodion chloride emulsion was manufactured by Laurent and Jose Martinez-Sanchez in Madrid. An innovation introduced specifically for collodion emulsions was the use of a baryta coating applied to the paper support as a smooth, white barrier layer. Leptographic paper was made until 1870 with limited success, but baryta papers reappeared several years later and were eventually used throughout the 20th century for all photographic papers.

In England W. B. Bolton and B. J. Sayce introduced a collodion emulsion for negative plates in 1864 that was based on bromides rather than iodides. These were nearly as sensitive as wet collodion plates and were processed with an alkaline developer. The use of bromides and of alkaline development was to become the key to making fast plates with gelatin emulsions. Collodion emulsion plates remained the territory of advanced amateurs for the next 20 years.

Based on the earlier experimental work of W. H. Harrison, Dr. Richard Leach Maddox added silver nitrate to a warm gelatin solution bearing some cadmium bromide and then coated some glass plates with the emulsion. After exposing the plates in the camera, Maddox developed them with pyrogallic acid and some silver. The process used with these plates was slower than the wet collodion process but was the first serious attempt at making a gelatin emulsion. Maddox's silver bromide gelatin emulsion process was published in the *British Journal of Photography* in 1871.

Additional experiments in the early 1870s were continued by John Burgess, who used pyro developer in an alkaline state. The problem with the Burgess emulsion was that although it contained the necessary silver bromide, it was also affected adversely with potassium nitrate, a by-product of the technique. Removing the unwanted compound was first accomplished by J. Johnson, who allowed his gelatin emulsion to dry into thin sheets called pellicles. He then cut them into small pieces and washed them in cool water. After washing, the sensitive gelatin was dried in darkness and packaged. These pellicles could be stored and rehydrated for coating at a later time. Richard Kennett patented a similar product of washed sensitive pellicles in 1873 and was selling both the pellicle and the precoated gelatin plates by 1876. The English market for gelatin plates was growing steadily but did not fully topple collodion technology until the mid-1880s.

Gelatin emulsion plates were a hard sell to professional photographers who were used to getting excellent results with the wet collodion process. The early gelatin plates were met with limited interest and limited commercial success. The discovery that changed everything was observed when the gelatin pellicle was rehydrated and the emulsion was melted. The longer the emulsion was heated, the more sensitive it became. The cause, called ripening, was first identified by Sir Joseph Wilson Swan in 1877 and was a trade secret until revealed in 1878 by Charles Bennett, who also observed the phenomenon. Bennett continued his experiments by keeping the emulsion hot for days.

A year later George Mansfield suggested ripening the emulsion at a higher temperature over a period of minutes, a method generally adopted by all those who continued research in this area. By 1879 gelatin emulsions were ripened by heat and then allowed to set to a firm jelly. The emulsion was squeezed through a mesh to produce noodles that were washed in cool water to remove the unwanted nitrate. The washed noodles were then drained and remelted with some additional gelatin and applied, while hot, onto glass plates by hand under dim, red light. Coated plates were then placed on marble leveling tables until the gelatin set to a stiff jelly, at which point they were taken to a dark drying room and packed in boxes. This was the way all commercial plates were made until the development of automated equipment in the mid-1880s.

Gelatin plates, also called dry plates, were being manufactured by hand on a much larger scale by 1880. Interest and acceptance by both amateur and professional was much slower in the United States than in England and the rest of Europe. The English photographic journals at this time were beginning to include more articles on the gelatin process than collodion, and these, in turn, were being reprinted in the American journals. Some American professionals began using the new plates with mixed results, and they published their findings.

In 1880 the Photographers Association of America appointed a committee to investigate the new technology of gelatin plates. The quality of commercial plates varied considerably, but the plates had great potential in skilled hands. Many of the problems photographers had with these plates were due to increased sensitivity. Fogging, more often than not, was caused by overexposure in the camera or poor darkroom conditions that had little effect on the slower collodion plates.

As interest grew, more plate manufacturers appeared on the American horizon, and more professionals began taking the risk of changing their systems from wet to dry. The prices of plates were decreasing, and interest was growing. At the same time, all of the manufacturers of cameras and associated equipment were targeting a new generation of amateurs who could make images at any time without the skills that were previously necessary.

Gelatin plates could be relied upon at any time and developed later at a more convenient location. When plate-coating machines became a reality, the price of plates was reduced enough for the commercial photographer to adopt plates for their work as well. It can be assumed that most commercial photographers in America were using gelatin plates for both exterior and studio portraiture by 1885.

The popular developers for these early plates were alkaline solutions of pyrogallic acid or ferrous oxalate. Within a few years, hydroquinone was also used, followed by metol and a combination of the two chemicals, commonly called MQ developer. Developing powders were available in boxes of premeasured glass tubes.

Flexible Films

The concept of flexible film dates back to the calotype and Archer's initial idea of stripping collodion film from glass plates. Attempts to market paper roll film and sheets of celluloid-based film on a large scale did not succeed until the products were introduced by the Eastman Dry Plate Company in the mid-1880s. This stripping film was made by applying a standard silver bromide gelatin emulsion on a paper support previously coated with a thin layer of soluble gelatin. The machine that produced stripping film was also used to manufacture silver bromide developing-out paper for printing. Marketed as American Film, rolls of paper-support stripping film were designed to be used in a special holder that could be fitted to the back of any size of camera. The film, the machine that was used to coat the paper, and the system to transport the film in the camera were all patented at the same time.

The exposed film was cut into separate sheets in the darkroom with the aid of indexing notches and was processed as usual. The washed film was then squeegeed onto a sheet of glass coated with a wet collodion film and was allowed to set for about 15 minutes. The plate was then placed in hot water that softened the soluble layer of gelatin, which allowed the paper support to be removed. The plate could then be dried and used like any other gelatin glass negative, or the film could be stripped from the glass by applying a second layer of clear gelatin, followed by a second layer of collodion, and then cut from the plate with a sharp knife.

American Film was supplied in the first Kodak introduced in 1888. The Kodak was a small detective camera that spawned several generations of hand-held box cameras used by millions of amateur photographers. While not a commercial success, American Film bought enough time for the Eastman Dry Plate and Film Company to introduce Eastman Transparent Film in rolls and sheets of clear, flexible nitrocellulose in 1889.

Sensitometry

The concept of measuring the actinic effect of light or the sensitivity of photosensitive materials dates to the earliest days of photography, but the first reliable sensitometer was invented by Russian-born Leon Warnerke in 1880. With this tool a reliable rating number could be applied to an emulsion calculated against the average sensitivity of a collodion plate. Some companies in the 1880s used the Warnerke rating system while others simply addressed the matter by stating that a specific plate was fast, slow, or extra quick.

A unified standard for emulsion speeds did not come until much later, and even then there were different scales requiring conversion tables. Two major innovations that came from sensitometry were the evolution of the instantaneous lens shutter and an attempt to set a numerical standard to the apertures placed in lenses. Two systems of aperture standards evolved during the dry plate period: the f-numbering system and the US (Uniform System) introduced by the Royal Photographic Society. The US featured the numbers 1, 2, 4, 8, 16, 32, 64, and 128. The f-system as introduced used 4, 5.6, 8, 11.3, 16, 22.6, 32, and 45.2. The only rating that was common to both systems was 16.

Glimpses of Color

Throughout the 1880s gelatin-emulsion makers were engaged with increasing the sensitivity of their product. Though the speed of gelatin emulsions was gradually increased, the emulsions were still mostly sensitive only to the ultraviolet, violet, and blue wavelengths, a defect they shared with all of the previous photographic processes of the 19th century.

Increasing the spectral sensitivity of photographic materials was important for many reasons but essential to the evolution of color photography. Color daguerreotypes — invented by Levi Hill in the 1850s — and a similar product, the heliochrome, first exhibited in 1877 by Niépce de St. Victor, stood alone and were not influential in the evolution of modern color photography. However, in 1861 James Clerk-Maxwell made a celebrated demonstration of additive color synthesis, generating interest in finding a way to extend sensitivity of collodion plates for full-color photography. Thomas Sutton made three negatives of a colorful ribbon through red, blue, and green filters for Maxwell's demonstration. These separation negatives were used to make lantern slides that were projected from three magic lanterns through the same filters. The virtual image on the screen was convincing enough for the era.

In 1869 Ducos Du Hauron patented a procedure in France that relied on red, blue, and green additive dots applied to a sensitized plate. However, this type of additive screen process was not a reality until John Joly introduced the first commercially successful additive ruled plates in the mid-1890s. Du Hauron did, however, suggest the subtractive-color process with which he made assembly prints from yellow, cyan, and magenta carbon tissues exposed from additive color-separation negatives as early as 1877 (Figure 93). The subtractive-assembly concept evolved to be the basis for how all color photographs are made.

Adolph Braun, Hermann Wilhelm Vogel, and Frederic Ives (Figure 104) conducted promising experiments in the 1870s using dye-sensitizing emulsions with eosin and chlorophyll. Braun, Vogel, and Ives were sensitizing collodion bromide emulsions at the time. These so-called orthochromatic emulsions were still highly sensitive to the blue areas of the spectrum but also to green and some yellow.

By the 1890s other dye sensitizers helped to extend the range of gelatin emulsions to deep orange. Such plates were known as isochromatic. True panchromatic plates that were sensitive to the entire visible spectrum were not available until 1906, and even after they became available, few photographers embraced the technology. The fact was that panchromatic plates were seen as a disadvantage by photographers accustomed to developing negatives by inspection under safe light. The important experiments with isochromatic emulsions, however, were a great help to those in the printing industry and individuals interested in making color-assembly prints from separation negatives or experimental additive color plates.

Floodgate to the 20th Century

By the end of the century, more individuals, both amateur and professional, owned cameras than in the daguerreotype and wet plate eras combined. There was no need to go to a professional studio photographer anymore, even though studios could generally achieve better results. The photofinishing business was evolving to accommodate the amateur market, and manufacturers were introducing photographic equipment and materials at a dizzying rate. Enlargements on silver-bromide paper were being made by projection, using gas or electrically illuminated magic lanterns.

The photographic image, itself a copy of nature, was being reproduced in magazines and books by several different ink processes, making anything that was originally the product of a camera known as "a picture." In the 1890s photographs were common and available in a wide range of sizes on a variety of photographic papers, including platinum-toned collodio-chloride and gelatin-chloride printing-out papers, developed-out silver-bromide paper, silver chloride gaslight papers, cyanotypes, carbon and gum prints, and, if money was no object, pure platinum prints.

The influence of the impressionists, members of an artistic movement who rethought the role of painting in a world of photography, in turn released a 50-year grip on photographic convention. This allowed the pictorialist movement to redefine what a photograph needed to be. Photography, long appreciated for how it could copy nature in infinite resolution, was being used in a way that was, in a word, antiphotographic. The romantic photographic departures of P. H. Emerson in the 1880s had paved the way for the likes of Clarence White, Gertrude Kasebier, and F. Holland Day in the next decade. As a result, the pictorialists' soft imagery and romantic approach to photography influenced a new direction in commercial portraiture that remained popular for 30 years after the turn of the century.

Introduction to Photographic Equipment, Processes, and Definitions of the 19th Century

MARK OSTERMAN
George Eastman House and International Museum of Photography

This edition of the *Focal Encyclopedia of Photography* has been written at a time when the industrial production of silver halide materials is rapidly declining as a result of digital photographic technologies and practices. At this same time, the movement to preserve the technology of handmade processes from the 19th century is becoming stronger. The greatest challenge for future photohistorians will not be the understanding of photographic processes of the 1800s but rather the photographic industry of the 20th century that is being dismantled at this time.

The concept of photography was conceived two centuries and many technologies ago. Since 1802, when Wedgwood first made images with silver on paper and leather, every generation of photographer has seen the natural progression of technological changes, followed by their obsolescence. Deciding what information to preserve and publish from previous technologies is a difficult task when space is limited, and the decision will certainly create unavoidable disappointment for some readers. Limits, of course, are necessary within constraints of a physical book. We have made choices to anticipate what will be useful, instructive, and possibly influential. Unlike most references on the technological history of photography, including the previous edition of the *Focal Encyclopedia,* much of the information written for this new edition comes from observation of historic texts and experience with nineteenth century photographic processes.

Many of the following entries have been the topic of extensive research by scholars and practitioners over the years. Additional information for any of the subjects can be found in other publications and on the Internet. Unlike the printed page, anyone can post information on the Internet with implied authority and with much less effort. Primary research should always be considered as the best way to gain insight in the history and practices of photography.

FIG. 2 A skylight studio including portrait cameras, cloth background, posing chair and table, head stand, and diffuser. The Scully and Osterman Studio, Rochester, New York.

The following pages contain entries written by this editor, Mark Osterman, and entries that were published in this encyclopedia's Revised Desk Edition (1969) or Third Edition (1993) by the following authors: Ira Current, John Fergus-Jean, Michael Flecky, Roger Hailstone, Grant Haist, Mike Leary, Judy Natal, Michael Teres, Paul Schranz, Martin Scott, Leslie Stroebel, Sabine Süusstrunk, Hollis Todd, Howard Wallach, and Richard Zakia.

Photographic Equipment, Processes, and Definitions of the 19th Century

A

Abrading medium

An abrasive powder often made of emory used to reduce the density of a gelatin-emulsion negative. The powder is gently rubbed onto the surface of the emulsion to gradually remove the

Wratten, Frederick Charles Luther (1840–1926)
Frederick Wratten was an English inventor and manufacturer. In 1878 he founded one of the earliest photographic supply businesses, Wratten and Wainwright, which produced and sold collodion glass plates and gelatin dry plates. He invented, in 1878, the "noodling" of silver-bromide gelatin emulsions before washing. With the assistance of Mees, he produced the first panchromatic plates in England in 1906 and became a famous manufacturer of photographic filters. Eastman Kodak purchased the company in 1912 as a condition of hiring Mees.

FURTHER READING

Mees, E. C. K. (1961). *From Dry Plates to Ektachrome Film*. New York: Ziff-Davis.

Zeiss, Carl (1816–1888)
Carl Zeiss was a German lens manufacturer who founded the Zeiss optical firm in 1846. With collaborators Ernst Abbe and Otto Schott, he devised the manufacture of Jena glass, the finest optical quality glass. Zeiss became famous for its excellently designed microscopes, binoculars, optical instruments, and cameras. Zeiss photographic lenses became the standard in the field. Chief lens designer, Paul Rudolph, produced the first anastigmat (1890) and the still-popular Tessar (1902).

FIG. 37 Portrait of Carl Zeiss, ca. mid-1800s. (Courtesy of Carl Zeiss MicroImaging, Thornwood, New York.)

Selected Photographs from the 19th Century

MARK OSTERMAN
George Eastman House and International Museum of Photography and Film

Joseph Nicéphore Niépce has been credited with creating the first photograph, titled "View from the Window at Le Gras." It was taken in 1826 in Saint-Loup-de-Varennes, France. This picture, a heliograph on pewter, was made using a camera obscura. After an exposure of at least 8 hours, the camera obscura created a single, one-of-a-kind image. Reproduced here are three versions of that image. The first version was made at the Kodak Research Laboratory in Harrow, England. The rephotographing process produced a gelatin silver print in March 1952. The second version was created by Helmut Gernsheim and the Kodak Research Laboratory in Harrow, England. The second version, a gelatin silver print with applied watercolor reproduction was created March 20–21, 1952. It is interesting to note that Gernsheim, a well-know photographic collector, historian, and author had written several essays and consulted this encyclopedia's first edition before creating the print. The most recent version of Niépce's piece, produced in June 2002, was completed by the Harry Ransom Center and J. Paul Getty Museum.

The images on the following pages were selected by the editor to represent the pictorial evolution of the photograph and to include pictures that have not been published before. They have been arranged chronologically, starting at 1830 and concluding at the turn of the century. All images, except where

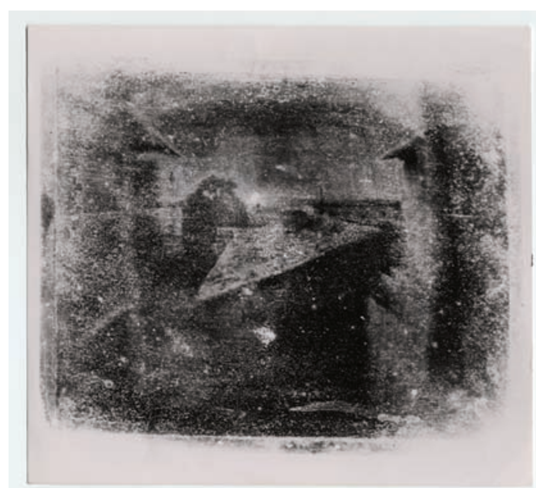

FIG. 38 First version of "View from the Window at Le Gras," made at the Kodak Research Laboratory in Harrow, England, 1952. Gelatin silver print, 20.3 × 25.4 cm. (Reproduced with permission of the Gernsheim Collection, Harry Ransom Humanities Research Center, University of Texas at Austin.)

noted, are courtesy of the Image Collection at the George Eastman House International Museum of Photography and Film in Rochester, New York.

The photography collection at the George Eastman House International Museum includes more than 400,000 photographs

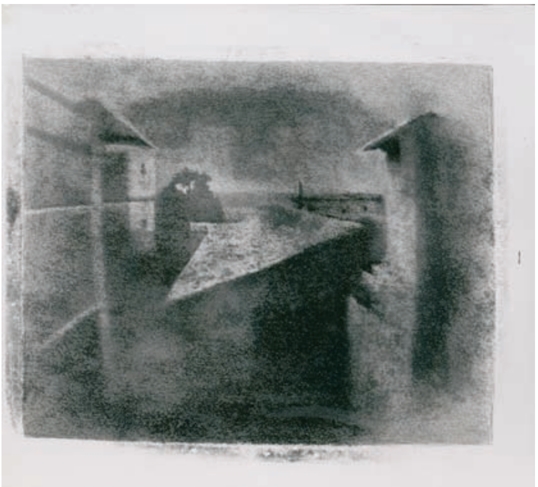

FIG. 39 Second version of "View from the Window at Le Gras," made by Helmut Gernsheim at the Kodak Research Laboratory in Harrow, England. March 20–21, 1952. Gelatin silver print and watercolor, 20.3 × 25.4 cm. (Reproduced with permission of the Gernsheim Collection, Harry Ransom Humanities Research Center, University of Texas at Austin.)

FIG. 40 Digital print reproduction of "View from the Window at Le Gras," made by Harry Ransom Center and J. Paul Getty Museum, June 2002. Color digital print reproduction, 20.3 × 25.4cm. (Reproduced with permission of the Gernsheim Collection, Harry Ransom Humanities Research Center, University of Texas at Austin.)

FIG. 41 Louis Jacques Mandé Daguerre, French (1787–1851). "Gothic Ruins," ca. 1830. Dessin fumée, 7.7 × 6 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 42 Samuel A. Bemis, American (ca. 1793–1881). "Abel Crawford's Inn at the Notch of the White Hills, White Mountains, New Hampshire," ca. 1840. Daguerreotype, 16.5 × 21.6 cm, full plate. Gift of Eastman Kodak Company.

and negatives dating from the invention of photography to the present day. The collection embraces numerous landmark processes, rare objects, and monuments of art history that trace the evolution of photography as a technology, as a means of scientific and historical documentation, and as one of the most potent and accessible means of personal expression in the modern era. More than 14,000 photographers are represented in the collection, including virtually all the major figures in the history of the medium. The collection includes original vintage works produced by nearly every process and printing medium employed. (For more information, go to http://www.eastmanhouse.org.)

FIG. 43 Antoine-Francois Jean Claudet, English (1797–1867). "Portrait of Claudet Family," ca. 1855. Stereo daguerreotype with applied color. Gift by exchange of Mrs. Norman Gilchrist.

FIG. 44 Unidentified photographer. "Portrait of a Man at a Table," taken with a gaudin camera, 1840. Daguerreotype, 8.2 × 7.4 cm (1/6 plate). Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 45 Louis Jacques Mandé Daguerre, French (1787–1851). "Portrait of an Artist," ca. 1843. Daguerreotype, quarter plate, 9.1 × 6.9 cm (visible) on 15.6 × 13.0 cm plate. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 46 Robert Cornelius. “Self-Portrait with Laboratory Instruments,” 1843. Daguerreotype. Gift of 3M Company, ex-collection Louis Walton Sipley.

FIG. 48 Cromer’s Amateur, French. “Still Life, Bouquet of Flowers,” ca. 1845. Daguerreotype, 8.2 × 7.0 cm, 1/6 plate. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 47 Unidentified photographer. “Chestnut Street, Philadelphia,” ca. 1844. Daguerreotype, 8.2 × 7.0 cm, 1/6 plate.

FIG. 49 Hill and Adamson, Scottish. “The Gowan,” ca. 1845. Portrait of Mary and Margaret McCandlish. Salted paper print, 15.3 × 20.4 cm.

FIG. 50 Hill and Adamson, Scottish. "D. O. Hill and W. B. Johnstone," ca. 1845. Salted paper print, 18.8 × 14.5cm. Gift of Alden Scott Boyer.

FIG. 52 William Henry Fox Talbot, English (1800–1877). "The Woodcutters," ca. 1845. Salted paper print, 15.2 × 21.2cm. Gift of Alden Scott Boyer.

FIG. 51 William Henry Fox Talbot, English (1800–1877). "Lace," ca. 1845. Salted paper print, 23.0 × 18.8cm (irregular). Gift of Dr. Walter Clark.

FIG. 53 W. and F. Langenheim, American. "Anna Langenheim Voightlander," 1848. Hyalotype transparency from albumen negative; image: 13.3 × 10cm; frame: 17.6 × 14.5cm. Gift of 3M Company, ex-collection Louis Walton Sipley.

FIG. 54 W. and F. Langenheim, American. "Portrait of Anna Langenheim Voightlander," 1848. Albumen negative, 18.9 × 14.4 cm. Gift of 3M Company, ex-collection Louis Walton Sipley.

FIG. 55 Baron Jean-Baptiste Louis Gros, French (1793–1870). "Monument de Lysicrates, Vulgairement Appelé Lanterne de Demosthenes; Athenes," May, 1850. Daguerreotype, half plate, 10.8 × 14.7 cm (visible). Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 56 Southworth and Hawes, American (active ca. 1845–1861). "Unidentified Bride," ca. 1850. Daguerreotype, whole plate, 21.5 × 16.5 cm. Gift of Alden Scott Boyer.

FIG. 57 Frederick Scott Archer, "Kenilworth Castle," 1851. *Sel d'or*–toned albumen print from whole-plate wet collodion negative. Scully & Osterman Archive, Rochester, New York.

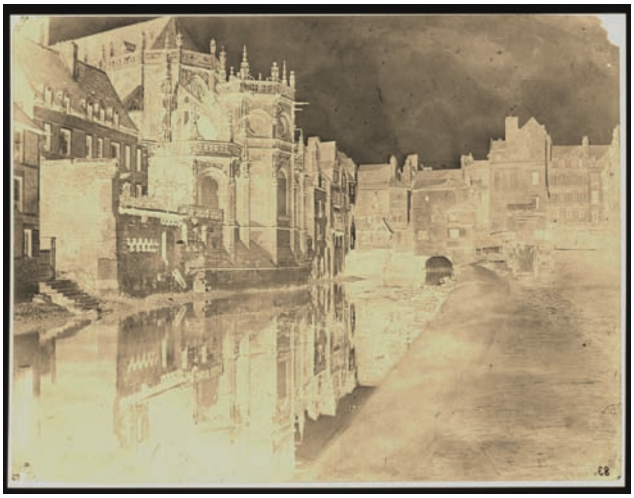

FIG. 58 Unidentified photographer. "Chevet de l'Eglise de Saint-Pierre de Caen," ca. 1850–1855. Calotype negative, 20.5 × 26.8 cm. Gift of Eastman Kodak Company, Vincennes, via the French Society of Photography, ex-collection Henri Fontan.

FIG. 59 Henri Le Sec, Chartes. "Portal with Wood Supports," 1851. Cyanotype from paper negative, 32.2 × 21.5 cm.

A B

FIG. 60 John Shaw Smith, Irish (1811–1873). (A) "Tomb and Mosque of Sultan Eshraf," November 1851. Calotype negative, 16.8 × 22.0 cm (irregular). (B) Reverse, showing selective waxing on lower areas. Gift of Alden Scott Boyer.

FIG. 61 Adolphe Braun, French (1812–1877). “Still Life of Flowers,” ca. 1854–1856. Albumen print, 43.8 × 46.5 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 62 Maxime du Camp. “Façade Septentrionale du Gynecee de Ramses Meiamoun,” 1854. Developed-out salted paper print from a paper negative from *Egypt and Syrie.*

FIG. 63 Hesler. “Driving a Bargin,” 1854. Crystalotype print by John A. Whipple from original daguerreotype. Reproduced from *Photographic and Fine Art Journal.*

FIG. 64 Édouard Baldus, French (1813–1889). “Pavillon de Rohan, Louvre, Paris,” ca. 1855. Salted paper print, 44 × 34.5 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 65 Unidentified photographer. "Facade of Mexico City Cathedral and 'El Parian,'" ca. 1840. (The two-story structure to the right was the enclosed marketplace known as the Parian. It was torn down on June 24, 1843.) Daguerreotype, 16.4 × 21.5cm, full plate. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 66 Roger Fenton, English (1819–1869). "Hardships in the Camp," 1855. Salted paper print, 18.3 × 16.6cm. Gift of Alden Scott Boyer.

FIG. 67 Gustave Le Gray, French (1820–1884). "Mediterranean Sea with Mount Agde," ca. 1855. Albumen print from collodion negative, 31.9 × 40.7cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 68 Unidentified photographer. "Unidentified Woman, Head and Shoulders Portrait," ca. 1855. Pannotype (collodion on leather), image: 6.5 × 5.5 cm. Gift of Reverend H. Hathaway.

FIG. 69 Unidentified photographer. "Two Men Eating Watermelon," ca. 1855. Daguerreotype with applied color, 5.8 × 4.5 cm., 1/9 plate. Museum purchase, ex-collection Zelda P. Mackay.

FIG. 70 Unidentified photographer. "Woman Seated, Holding Young Girl on Lap; Young Boy Seated on Posing Table beside Them," ca. 1855. Ambrotype; image: 10.5 × 13.9 cm, 1/2 plate. Gift of Eastman Kodak Company.

FIG. 71 James Robertson, British (1813–1888). "The Barracks Battery," 1855. Salted paper print, 23.8 × 30.2 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 72 Adrien Tournachon, French (1825–1903). “Ratter-Filly,” ca. 1855. Salted paper print; image: 16.8 × 23 cm; mount: 31 × 47 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

FIG. 74 Unidentified photographer. “Seated Man,” ca. 1855. Collodion positive on slate, 10.5 × 8 cm.

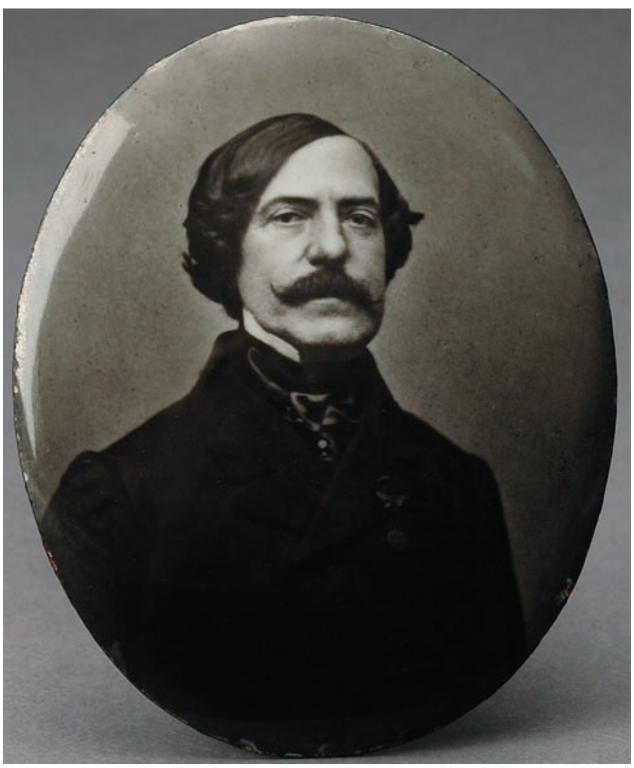

FIG. 73 Nadar et Cie. “The Marquis du lau D’Allemans,” ca. 1855. Vitrified photograph on enamel, 9 × 7.3 cm.

FIG. 75 Francis Frith, English (1822–1898). “The Great Pillars and Smaller Temple,” ca. 1863. Albumen print, 23.4 × 16.3 cm. Gift of Alden Scott Boyer.

FIG. 76 Unidentified photographer. "Portrait of a Woman, Portrait of a Man (Husband and Wife?)," in double case, ca. 1857. Daguerreotype with applied color, 5.0 × 3.7 cm (each); 1/9 plate. Museum purchase, ex-collection Zelda P. Mackay.

FIG. 77 Henry Peach Robinson, English (1830–1901). "She Never Told Her Love," ca. 1858. Albumen print, 18.6 × 24.3 cm.

FIG. 78 Matthew B. Brady, American (1823–1896). "Prof. Dunn, Reading Book and Posed with Stoppered Bottles and Beaker," ca. 1860. Albumen Carte de viste print, 8.5 × 5.7 cm (image), 10.1 × 6 cm (mount). Gift of Graflex Corp.

FIG. 79 Franz Hanfstaengl, German (1804–1877). "Portrait of Count Johann von. Yrsch (1797–1862)," ca. 1860. Albumen print or treated salted paper print, 22.0 × 16.8 cm.

FIG. 80 Oscar Rejlander, English (1813–1875). "Hard Times," ca. 1860. Albumen print, 13.9 × 19.9 cm.

FIG. 81 André-Adolphe-Eugèene Disdèri, French (1819–1889). "Madame Petipa," June–August 1862. Albumen print (uncut *carte-de-visite* sheet); image: 20.1 × 24 cm. Gift of Eastman Kodak Company, Gabriel Cromer Collection.

FIG. 82 Alexander Gardner, Scottish (1821–1882). “Completely Silenced! (Dead Confederate Soldiers at Antietam),” 1862. Albumen print stereograph, 7.6 × 15.0 cm, ensemble. Gift of 3M Company, ex-collection Louis Walton Sipley.

FIG. 83 Alexander Gardner, Scottish (1821–1882). “Ruins of Arsenal, Richmond, Virginia.” April, 1863. Albumen print, 17.4 × 22.5 cm. Gift of Alden Scott Boyer.

FIG. 84 Julia Margaret Cameron, English (1815–1879). “Wist Ye Not That Your Father and I Sought Thee Sorrowing?” 1865. Albumen print, 25.2 × 28.8 cm. Gift of Eastman Kodak Company, Gabriel Cromer collection.

A

B

FIG. 85 Unidentified photographer, American. (A) "Unidentified Man, Seated"; (B) "Unidentified Man, Seated, Wearing Coat, Vest, Hat; Holding Chain of Pocket Watch," ca. 1865. Tintype, 8.5 × 7.5 cm (each image), 1/6 plate. Gift of Donald Weber.

FIG. 86 Unidentified photographer. "Unidentified Man," ca. 1860. Albumen positive on white glass plate, 11 × 8.4 cm.

FIG. 87 Unidentified photographer. "Mr. Sutherland, Mr. W. Cochrane, Mr. Balfour, Mr. Machonachie, Mrs. B. Cochrane, Mr. W. Machonachie, Lady M. Hervey, Mr. Powlett, Mr. J. Cochrane, Lady Dunlo, Miss H. Farqhuarson," 1867. Albumen print photomontage with watercolor embellishment, 28.9 × 23.1 cm. Constance Sackville West album, London.

FIG. 88 Timothy H. O'Sullivan, American (1840–1882). "Pyramid Lake, Nevada," April, 1868. Albumen print, 19.8 × 27.0 cm. Gift of Harvard University.

FIG. 89 Thomas Annan, Scottish (1829–1887). "Close, No. 148, High Street," 1868–1877. Carbon print, 27.3 × 23 cm.

FIG. 90 John Thomson, Scottish (1837–1921). "Wah Lum Chu, Canton," ca. 1868. Albumen print, 23.0 × 27.9 cm. Gift of Alden Scott Boyer.

FIG. 91 Unknown photographer. "Studio Portrait of Woman," ca. 1870. Quarter-plate wet collodion negative. Scully & Osterman Archive, Rochester, New York.

FIG. 92 Eadweard J. Muybridge, English (1830–1904). "Loya—Valley of the Yosemite. (The Sentinel, 3,043 Feet High)," ca. 1868. Albumen print, 42.3 × 53 cm. Gift of Virginia Adams.

FIG. 94 William Henry Jackson, American (1843–1942). "Hot Spring," 1871–1872. Albumen print, 10.4 × 18.4 cm.

FIG. 93 Louis Ducos du Hauron, French (1837–1920). "Still Life with Rooster," ca. 1869–1879. Transparency, three-color carbon, 20.5 × 22.2 cm.

FIG. 95 Lewis Carroll (Rev. Charles Ludwidge Dogson), English (1832–1898). "Xie Kitchin as 'a Chinaman,'" 1873. Gum platinum print. Print ca. 1915, by Alvin Langdon Coburn. Gift of Alvin Langdon Coburn.

FIG. 96 Richter and Company. “Unidentified Child at Fence,” ca. 1880. Albumen print, cabinet card; image: 14.6 × 10.1 cm; mount: 16.2 × 10.5 cm.

FIG. 97 Pach Bros./William Willis, Jr. “Group of Four Military Cadets Under a Tent Opening,” ca. 1865. First platinum print made in America (1877) by William Willis, Jr. From ca. 1865 negative, made by Pach Bros. Studio. Image 18.1 × 23.7 cm., mount 20.4 × 25.5 cm.

FIG. 98 Samuel M. Fox. “An Old Saw Mill,” ca. 1880. Albumen print from (dry) collodion emulsion negative, 16.5 × 21 cm. From a Philadelphia Exchange Club album, ca. 1880.

FIG. 99 Unknown photographer, page from a gem album with ferrotypes; each image is 2 × 1.5 cm; each page is 8.5 × 8.1 cm. Personal album.

FIG. 100 Peter Henry Emerson, English (1856–1936). "The Clay-Mill," ca. 1886, Photogravure print (ca. 1888), 20.1 × 29 cm. Gift of Alden Scott Boyer.

FIG. 101 Raymond K. Albright, American (d. 1954). "Ascending Vesuvius, Naples," ca. 1888. Albumen print, 6.8 cm (diameter). Gift of Mrs. Raymond Albright.

FIG. 102 George Davison, English (1854–1930). "The Homestead in the Marsh," ca. 1890. Platinum print, 22.5 × 18.0 cm. Gift of 3M Company, ex-collection, Louis Walton Sipley.

FIG. 103 Unknown photographer. "Group of Three Men and Three Women," ca. 1890. Tintype, 9.3 × 6.3 cm.

FIG. 105 Laura Adelaide Johnson. "Man Playing Banjo for a Woman," ca. 1892. Platinum print, 19 × 12.1 cm. Family album.

FIG. 104 Frederic Ives. Transparency set for additive color projection, ca. 1890. Silver bromide gelatin emulsion plates, each image is 5.5 cm in diameter; object is 7.5 × 23 cm.

FIG. 106 Unidentified photographer. “Varnishing Day, Wassonier Salon,” 1892. Cyanotype, 11.5 × 19 cm.

FIG. 107 Unidentified photographer, “Collection of Stuffed and Mounted Birds,” ca. 1895. Color plate screen, Joly (natural color) process, 10.2 × 8.2 cm.

FIG. 108 Gertrude Käsebier, American (1852–1934). “Adoration,” ca. 1897. Brown platinum print. Gift of Hermine Turner.

FIG. 109 Clarence H. White, American (1871–1925). "The Readers," 1897. Platinum print, 19.4 × 10.7 cm.

FIG. 110 F. Holland Day, American (1864–1933). "Into Thy Hands I Commend My Spirit," from *The Seven Last Words,* 1898. Platinum print, 20.2 × 15.1 cm.

FIG. 111 Dr. J. Murray Jordan. "Mar Saba," from *Travel Views of the Holy Land, etc.,* ca. 1900. Platinum print, 13.5 × 18.5cm. Personal album.

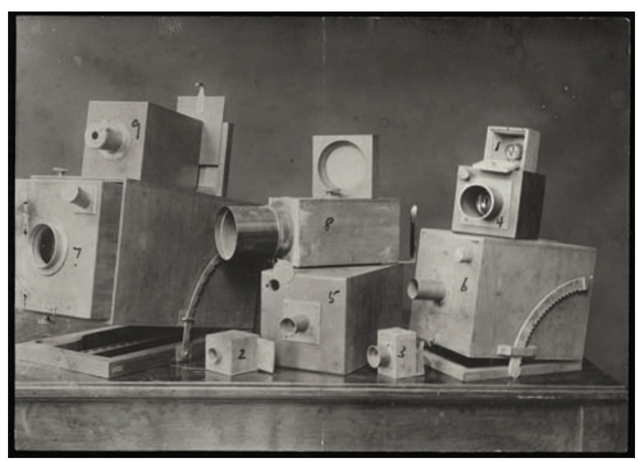

FIG. 112 A. Bartlett. "Display of Talbot's Cameras," ca. 1900–1907. Gelatin silver print, 10.3 × 14.6 cm. Gift of the Eastman Kodak Patent Museum.

FIG. 113 Gabriel Lippmann, French (1845–1921). "Garden at Versailles," 1900. Direct color (interference process); Lippmann plate. Gift of Eastman Kodak Company.

Cameras of the 19th century

All images on the following pages are courtesy of the Technology Collection, George Eastman House International Museum of Photography and Film, Rochester, New York. Comprising more than 16,000 objects, the George Eastman House technology collection is one of the world's largest collections of photographic and cinematographic equipment. It contains 19th- and 20th-century objects of photographic technology, including cameras, processing equipment, motion-picture devices, and a broad range of early historical accessories. Many of the objects are unique, representing distinguished historical ownership and significant scientific achievement.

This collection is the most comprehensive held by any institution in North America and is equaled in overall quality by only three other holdings worldwide. From devices that predate the formal invention of photography in 1839 to the most modern state-of-the-art instruments used by both amateurs and professionals, the collection offers visitors an unparalleled opportunity to examine and learn about photographic technology.

Evolution of the Photographic Lens in the 19th Century

MILAN ZAHORCAK
Private Collector

Working constraints in lens design

From the very beginning, lens makers were constrained by the properties of light and its behaviors in glass, the availability of suitable glass, and the practicalities and limitations of the manufacturing process.

The physical properties of glass cause it to bend or refract light as it passes through a lens, but in the process, it will also separate or diffract light into its component colors. A perfect photographic lens would bring all light, of all colors, from all portions of the lens into focus on a flat plane without distortion.

Aberrations are problems of focus caused by the inability of a lens to bring light from all portions of a lens into focus at the same point, or the inability to bring light of all colors to focus at the same point. Distortions are a problem of geometry