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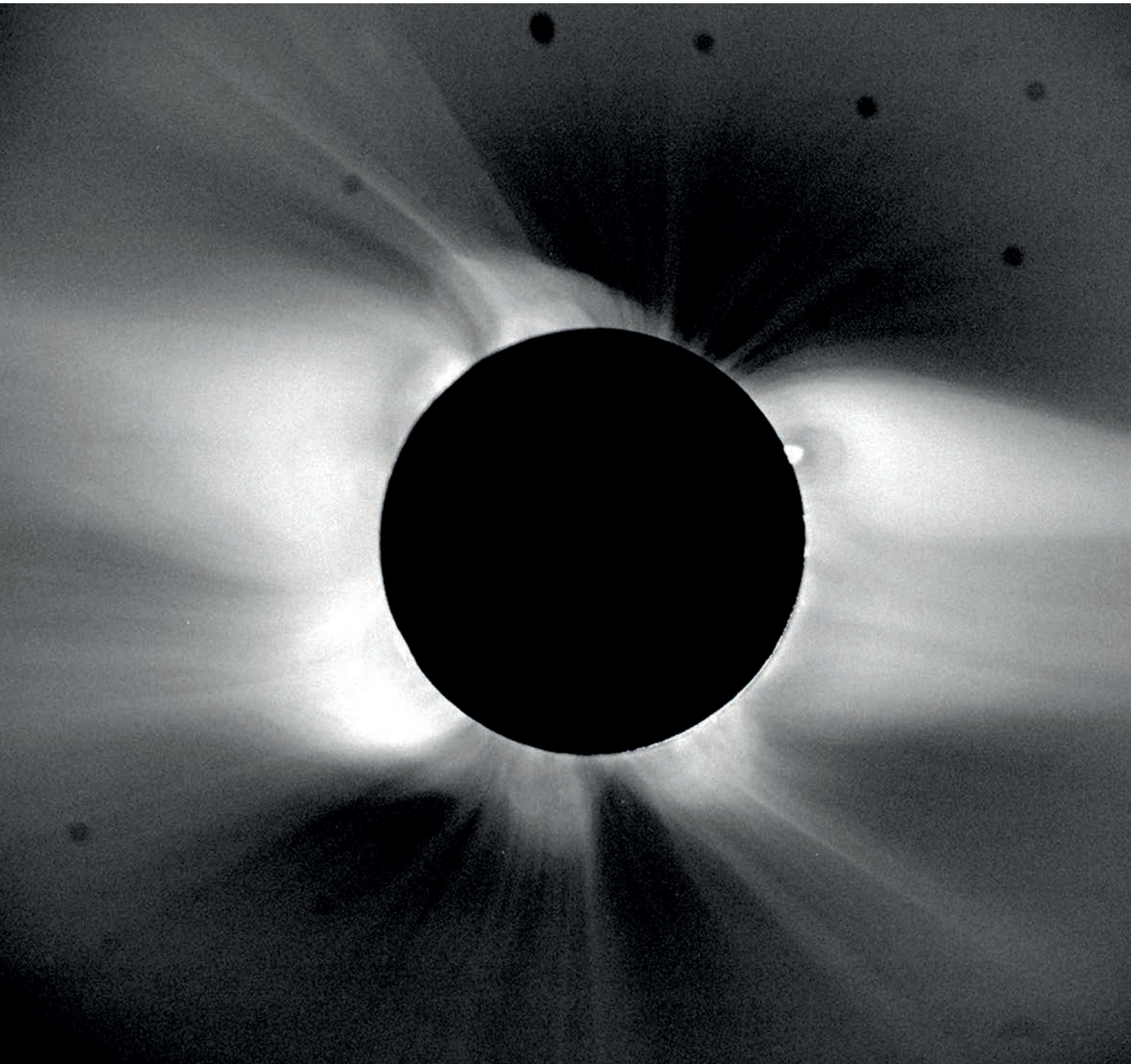

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‘A crowd of mercurial globules’: Microscopic Examination as a Precursor to Etching Daguerreotypes in 1839 and 1840

In today’s world, it is hard to imagine a time when publications were not illustrated with photographic images. We look back at early scientific works such as Robert Hooke’s *Micrographia*, from 1665, with awe and wonder. We struggle to understand not only the language, but also the accompanying illustrations, often laid out in multiple, engraved figures on printed plates. In the 1830s, however, Dr Joseph Berres, a professor of histological anatomy at the University of Vienna, was probably very familiar with this style and technique of illustrating microscopic views, since it had not noticeably changed for 170 years. [1–3] It remained a laborious and expensive task: the view seen through the microscope was drawn onto paper and subsequently engraved on a copper plate. Following a number of proofs, inspected by the engraver and the printmaker, then the author and publisher, corrections would be applied to the plate, and finally, a print run would be made, resulting in a stack of prints that could be trimmed and inserted into the folios of text before the book was bound.

Drawing a microscope image by hand inevitably meant translating it with a certain degree of interpretation. The illustration was sometimes made by a second person — someone skilled in the art of sketching — instead of by the scientist, who would merely check for accuracy.[1] Illustrations also clearly show an element of enhancement, increasing the contrast of the typically faint microscope image, and of the reduction of a three-dimensional specimen into the flat, two-dimensional image projected by the lens in the typical compound microscopes of the time. As an additional difficulty, the microscope’s plane of focus was very shallow, especially at higher magnifications. In order to grasp the true contours of the sample, the practitioner would have to continuously adjust the focusing knob.[2] The resulting publications typically show a characteristic, circular illustration, reminiscent of the tubular microscope oculars, often juxtaposed with further figures of related specimens drawn as three-dimensional objects by using shading and perspective. The illustrator had to enrich the microscopic image in order to make it useful to the reader, and one might argue that this would contradict the scientific principle of objective observation, at least as we understand it today. However, the laborious act of drawing an observation by hand has also been perceived as being the most meaningful method of actually grasping — and then depicting — what is being seen, since careful consideration is a prerequisite to every line applied to the paper. The resulting drawing can be as much a record as also a typified representation of the subject.[3]

It was this setting that photography, a new mechanical method of recording light, would change in many ways. Within a short period of time after the public announcement of the daguerreotype process in 1839, photographs through the microscope (photomicrographs) of natural specimens such as plant cross-sections and blood cells were being made with daguerreotypes in France, Austria, England and Bohemia.[4] In the years preceding 1839, Daguerre himself had made a daguerreotype of the enlarged projection of a spider with a solar microscope.[5] The next step would be to print these images so that they could be used in publications. Soon after the demonstration of the process at the Académie des sciences on 19 August 1839, two medical doctors, Dr Alfred Donné in Paris and shortly after him Dr Berres in Vienna, began experimenting with converting daguerreotypes into printing plates for

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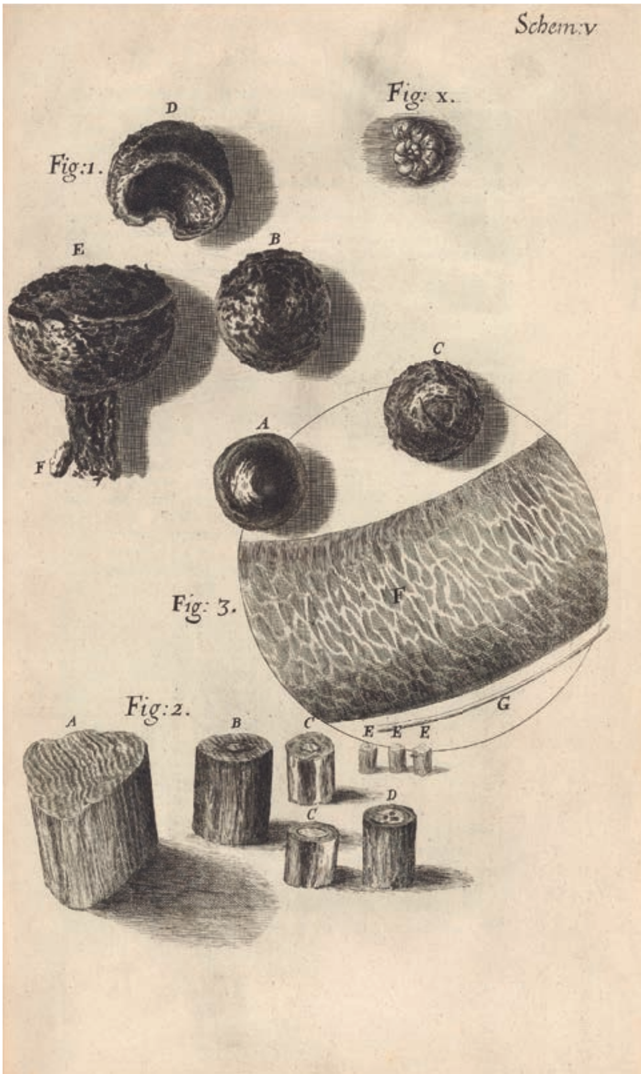
directly transferring photographic images in ink onto paper. Berres envisioned photography to be an ideal method for automating this task and, at the same time, for removing the interpretative and laborious hand of the artist: *'The well known* [sic] *expenses and difficulties attendant on the publication of an extensive work, requiring engravings as illustrations, led me in the first instance to hope, that I might be enabled to render the discovery of Daguerre available, by improvements, to represent and fix the objects necessary to my work.'*[6]

Berres quickly set about etching daguerreotypes with nitric acid and subsequently had intaglio prints pulled from the plates. He soon found this process to be relatively successful, and in 1840 he self-published a pamphlet entitled *Phototyp*, of which only three copies are known today.[7] While both Donné and Berres wrote about their etching techniques, they did not describe how they had had the idea to place a daguerreotype into acid in the first place. The etching of silverware and etching and engraving plates for printmaking were traditional, centuries-old handcrafts, so the application of these techniques to daguerreotypes seems self-evident. However, how could Donné and Berres reason that, while the daguerreotype image shadows were being etched, the highlights would be protected from the acid? The discussions held at the French Académie des sciences in 1839 and the following years indicate that it must have been mainly the study of daguerreotypes with high magnification that enabled researchers to grasp the intricacies of the process.[8] This paper posits that it was precisely this microscopic examination that allowed Berres, and Donné before him, to adapt the traditional process of etching silver and copper to the new daguerreotype plates.



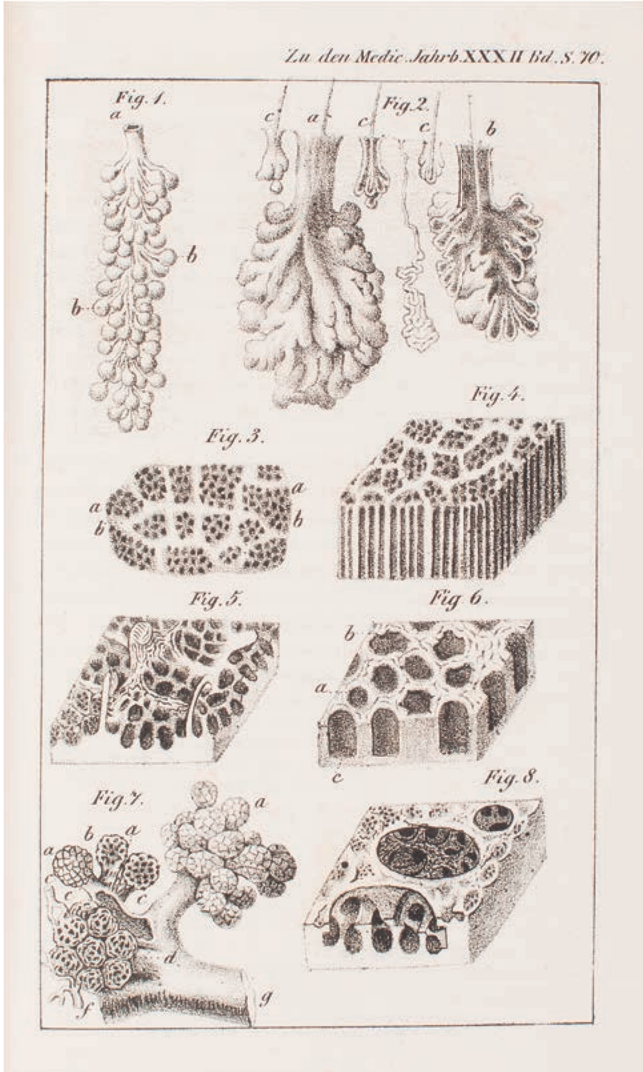
1 / **Microscopic study of samples of hairs and a shell specimen**, 1665
engraving from Robert Hooke, Micrographia, London 1665
Photo: Courtesy of Science History Institute

Daguerreotypes and Loupes

Directly after the first announcement of the daguerreotype at the Académie des sciences on 7 January 1839,[9] Daguerre received a stream of callers to his atelier who came to view his plates. Numerous reports tell us that his visitors, who were seeing a daguerreotype for the first time, also looked at his plates with a strong magnifying glass.[10] These first-hand accounts transport us to an era in which there was yet no set of technical terms for photography, and the smooth and shiny plates were often compared to the products of the illustration techniques of the time, namely drawings, engravings, etchings, and paintings. The editor of *The Athenaeum* wrote that *'M. Daguerre's process is so little understood, that it is scarcely possible to find words clearly to express the kind of effect which the works produce.'*[11] The exclamations of Samuel Morse on 7 March 1839 exemplify the visitors' excitement: *'the exquisite minuteness of the delineation cannot be conceived! No painting or engraving ever approached it.* […] *By the assistance of a powerful lens, which magnified 50 times* […], *every letter* [of a distant sign] *was clearly and distinctly legible, and also were the minutest breaks and lines in the walls of the buildings* […]. *The effect of the lens upon the picture was in a great degree like that of the telescope in nature.'*[12]

To Sir John Robison, visiting Daguerre in May 1839, it was immediately obvious that the daguerreotype's metallic surface enhanced its sharpness and capacity to render fine details: *'All the specimens I saw were on hard, plane, polished surfaces; none were on paper, and, in fact, the finest paper is incapable of receiving or conveying the delicate details, which* […] *the pictures are found to contain — the smallest crack, a withered leaf, or a little dust, which a telescope only will detect on a distant building, will be found in M. Daguerre's pictures, when sought for with the aid of a high magnifying power.'*[13] The telescope effect, described

2 / **Microscopic study of peripheral vascular branches (Microscopische Beobachtungen über die peripherischen Gefäß-Verzweigungen),** 1833
lithograph from Joseph Berres, Medicinische Jahrbücher des kaiserl. königl. Österreichischen Staates 14, Vienna 1833
Rijksmuseum Research Library (call no. 734 E 53)
Photo: Rijksmuseum Research Library



3 / **On the delicate structure of the glands of the human body (Über den zarten Bau der Drüsen des menschlichen Körpers)**, 1840
lithograph from Joseph Berres, Medicinische Jahrbücher des kaiserl. königl. Österreichischen Staates 30, Vienna 1840
Rijksmuseum Research Library (call no. 734 E 55)
Photo: Rijksmuseum Research Library

in both these reports, can still be experienced today: hold a magnifying glass over a daguerreotype and you will discover aspects invisible to the naked eye, opening up a whole new world of seemingly infinite detail. [4]

However, the same magnifying glass applied to a line engraving and to a lithograph reveals, in the former, the same lines as those visible to the naked eye, only larger, and in the latter, a rough grain on a fibrous paper support that forms a coherent image only at normal viewing distance. Here, magnification was bound to disappoint, since it gave the viewer less information instead of more. [5, 6] '*The strongest magnifying glass, which shatters so many illusions and causes us to discover terrible things and monsters in the most delicate and airy of masterpieces, examines and scrutinises* [daguerreotypes] *in vain; they withstand all the probes of the most vigorous investigation, foiling the malicious intent of the most penetrating gaze. On the contrary, the magnifying glass renders the great virtue of* [daguerreotypes] [...] *only more obvious; with every step, we discover ever new, ever more delightful details and innumerable subtleties and gradations that escape the naked eye in reality.*'[14] While engravings, lithographs and drawings were made for admiring with the naked eye and at a normal viewing distance, in 1839 it was not quite clear yet how the generally smaller daguerreotype would fit into the viewing practices of the time. The interconnection between viewing distance and the size of image-forming entities, a concept generally described today by the term resolution, is fundamental to the to the human eye's perception of an image and was

4 / **Telescope effect with a contemporary daguerreotype of the Rijksmuseum in Amsterdam**, 2020
left: magnification with a 15× loupe (20 mm diameter lens with 28 mm focal length) clearly reveals a stone figure, hunched on structural support, on the roof of the building
right: every small windowpane can be counted, and tonal variations in each individual brick in this building can be seen
Photomontage: Martin Jürgens

already understood at the time: '*a magnifying glass* [...] *will reveal the separate colour particles, which only appear as a continuous line because the distance between them is shorter than the visual angle.*'[15]

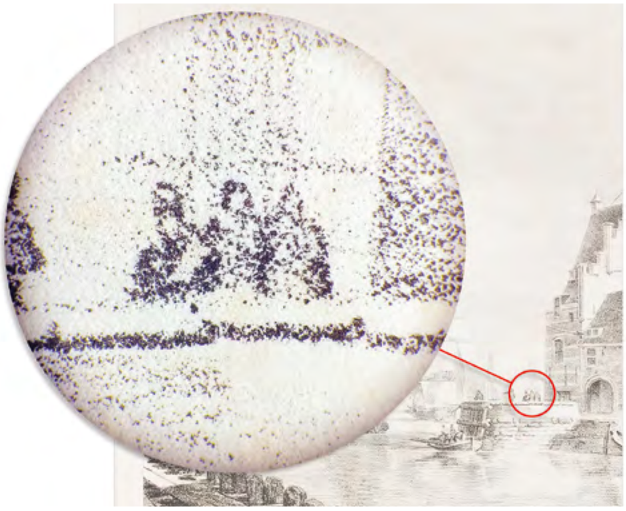
This simple loupe experiment demonstrates that the image-forming entities of a daguerreotype must be infinitely smaller than those of engravings and lithographs. As Edgar Allan Poe wrote, '*the closest scrutiny of the photogenic drawing* [meaning here: the daguerreotype] *discloses only a more absolute truth, a more perfect identity of aspect with the thing represented. The variations of shade* [...] *are those of truth itself in the supremeness* [sic] *of its perfection.*'[16] These variations in shade were unique to the daguerreotype, and their origin could only be understood by reaching for a microscope, which allowed for higher magnification than a simple loupe. Only beyond a certain enlargement would the image-forming particles of a daguerreotype become visible — this then would help explain the secret of the fine image of the silver plate, and perhaps help answer François Arago's query at the Académie des sciences: '*what* [...] *would be those numerous and so beautifully proportioned half-tints which are to be admired in the drawings of M. Daguerre?*'[17]

Daguerreotypes and Microscopes

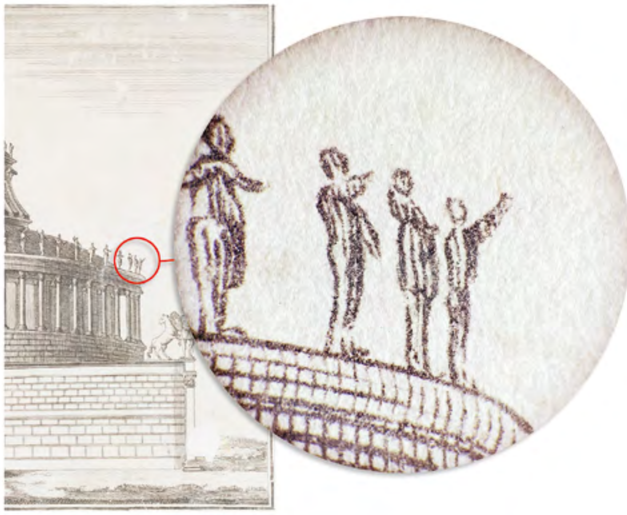
In this same recitation, Arago related the results of examinations previously conducted by the chemist Jean-Baptiste Dumas and the botanist Adolphe Brongniart, who determined the daguerreotype's image-forming particles to be small, regular '*sphérules d'amalgame*', that are very concentrated in the highlights, gradually decrease in number in the half-tints, and completely disappear in the shadows, and that have an average size of 1/800 of a millimetre — in today's terms: 1.25 microns.[18] Dumas may have used an ocular micrometre, a microscope accessory that, in some models, could denote distances as short as 20 microns,[19] or the projection method described by David Brewster to get such a precise measurement at the time.[20] With today's knowledge, he turned out to be very accurate: 150 years later, with the help of Scanning Electron Microscopy (SEM), which can have a resolution of around 1–2 nanometres, daguerreotype particles in ungilded highlights and mid-tones of daguerreotypes were measured to have a diameter of 0.1–2 microns.[21] [7]

This, then, was a key realization at the very onset of daguerreotypy: only the minute particles of the daguerreotype allow photography to be more than a binary reproduction method (such as a line engraving, which can only produce more or less uniform areas of light and of dark). The particles must be smaller than the subject they are depicting; only this makes photographic half-tints possible. Understanding that the visual effect of the daguerreotype is the result of the physical structure of its surface — its micro-topography — was only possible with the aid of the microscope. High magnification also helped the keen minds of early researchers to explore the mechanisms of how that topography had formed.

Alfred Donné was among the first to study this by examining plates, at various stages of their making, at 150–200× magnification, illuminated by light rays bundled with a magnifying glass reflecting off the surface



5 / **Detail of a litograph viewed with the same magnifying glass used in Fig. 4**
from the restoration study collection of the Rijksmuseum
22 × 32 cm
Photomontage: Martin Jürgens



6 / **Detail of an engraving viewed with the same magnifying glass used in Fig. 4**
from the restoration study collection of the Rijksmuseum
18 × 32 cm
Photomontage: Martin Jürgens

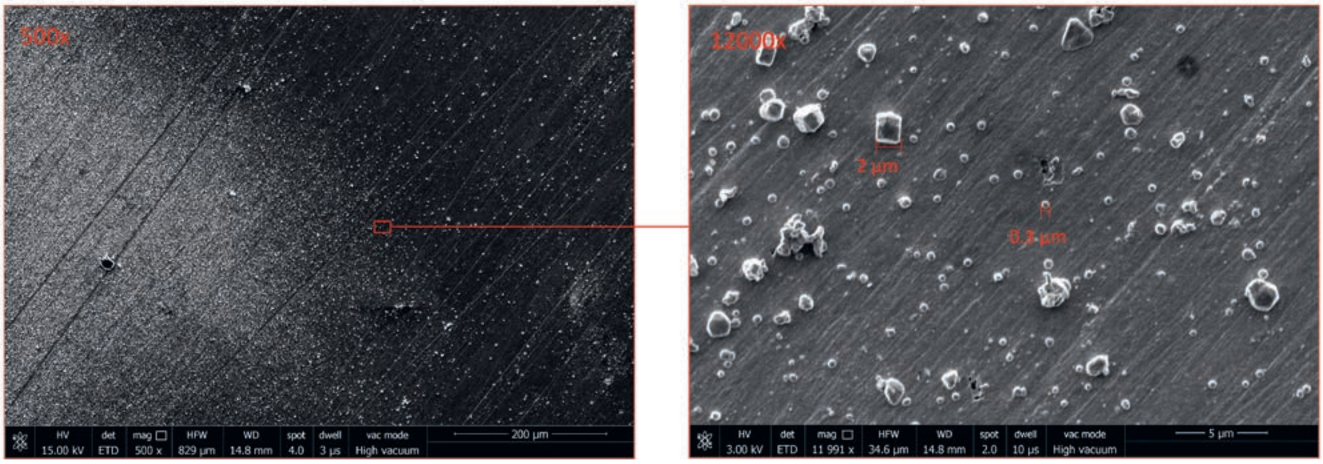
of the plate. He described the final image particles with the term *'petite goutelettes'*, or small droplets.[22] The British journal *The Chemist* reported on his work with a more colourful, yet quite accurate phrase: *'the microscope shews* [sic] *a crowd of mercurial globules.'*[23] Paul Golfier-Besseyre concurred that the particles were round, resulting in a bumpy, or *'mamelonnée'*, micro-surface.[24] Given the lack of appropriate terminology for this new thing, the daguerreotype, researchers fell back on the descriptive vocabulary of other disciplines. The excitement created by the novelty of the extremely small elements of the daguerreotype's surface often called for comparison to another unfathomable realm, on the opposite side of the scale: the vastness of space. The editor of *The Literary Gazette* wrote, for example, of Antoine Claudet in 1841: *'He compares the daguerréotype surface, when viewed through a powerful microscope — the darker parts to the starless heavens; the gradations of tints to the constellations and stars, according to their numbers and assemblage; and the brighter portions, composed of a multitude of globular molecules of mercury, to the milky way, thickly studded with myriads of luminaries.'*[25]

However, the physical and chemical nature of the daguerreian image was not that easy to fathom, and even ten years later, in 1849, microscopes were still the main tool to conduct, in a rather modern-sounding phrase, *'analysis of the surface.'*[26] In his 1841 experiments with electrotyping the surface of daguerreotypes, a process that created exact copy plates in copper,[27] Claudet's 'great many microscopic observations' of daguerreotypes indicated that their surface held *'molecules of mercury which are crystallised on those parts that form the image'*, which produce a *'relief on the plate, although very minute.'*[28]

A Re-enactment

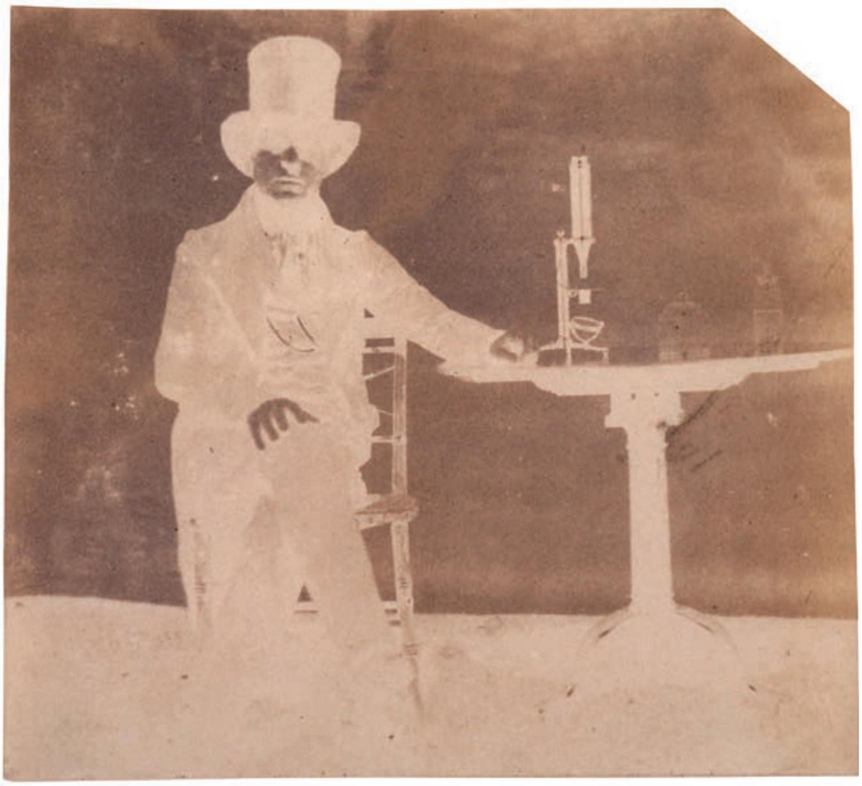
In their quests to understand the nature of the surface of these new plates, what were Donné, Berres, Dumas and Claudet actually observing when they looked through the ocular of the microscope? Their reports are written descriptions of their experiences, but can we today really understand their amazement at discovering crowds of minute spherules on a silver plate? Microscopic images made both by light and by scanning electrons over the past decades have formed our contemporary visual understanding of the surface of daguerreotypes, so it is difficult for us to overcome what we expect to see — to reset our minds to a nineteenth century, pre-daguerreotype state. It follows that we may not be able to completely re-experience the emotional level of the first expeditions into microscopic examinations of daguerreotypes.[29] With this aspect removed, however, the simpler aim of 'seeing what they were seeing' through a microscope based on the optical capabilities of the device is more readily attainable to us today. Using this approach, and in the tradition of re-enacting historical experiments, a daguerreotype was first examined through a modern microscope and then through historical microscopes from the 1830s and 1840s.[30]

Microscope technology underwent steady development during the eighteenth and nineteenth-centuries. While the solar microscope, invented in 1738 by Nathaniel Lieberkuhn,[31] enjoyed great popularity,



7 / **SEM secondary electron image (1.2 nm resolution) of a daguerreotype plate at 500× (left) and at 12,000× (right) magnification**, 2017
showing image particles of different shapes and sizes
Analysis performed on a QUEMSCAN 650F by Dr Iris Buisman, Department of Earth Sciences, University of Cambridge, for Martin Jürgens, Nicholas Burnett and Magdalena Pilko

especially at public events where it was used to project enlarged images onto a wall, the more common compound microscope easily fit on a desk and was much simpler to manipulate. In the early nineteenth century, great improvements were made with the production of achromatic lenses, which had the advantage of correcting chromatic aberration, a colour shift effect that distorted the visibility of the microscopic image.[32] Objectives for microscopes could typically be combined to increase magnification, and most microscopes were sold with a selection of oculars that would further enhance the compound image, resulting in a typical magnification range from 30× up to over 500×.[33] Using a number of devices such as concave mirrors and prisms, illumination was either transmitted, for transparent specimens, or reflected, for opaque ones. Typical light sources were



8 / **William Henry Fox Talbot, Sir David Brewster seated at a table with Talbot's microscope**, 1842
Calotype negative, 13.2 × 14.4 cm
Private collection (Schaaf no. 2666)
Photo © The William Henry Fox Talbot Catalogue Raisonné

direct sunlight, oil lamps, candle lamps, or the relatively new oxyhydrogen light, also called Drummond light, limelight or calcium light.[34] The *'inconstancy of the sun'* had *'very soon become an insurmountable obstacle, at least during eight months of the year'*,[35] so Alfred Donné and Jean-Baptiste Biot experimented with the oxyhydrogen lamp and demonstrated that it emitted wavelengths that were capable of exposing the narrow spectral sensitivity of the daguerreotype, thereby making this artificial light source a valid alternative to natural daylight.[36]

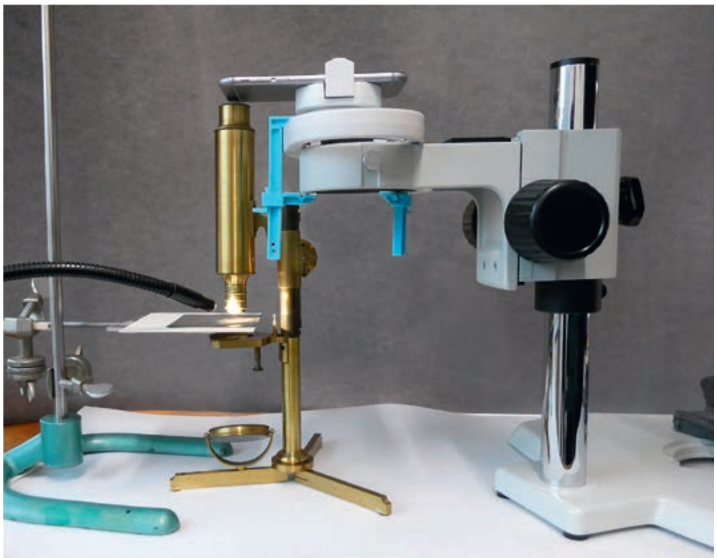
A typical device of the time, with a single brass tube and ocular, a sturdy tripod stand and a concave mirror on a gimbal mount, can be seen in a calotype negative from 1842, which depicts Sir David Brewster sitting at a table with William Henry Fox Talbot's compound microscope, made by the French optician Charles Louis Chevalier.[37] [8] Joseph Berres, in Vienna, was more familiar with microscopes made by the Austrian optical instrument maker Simon Plößl,[38] which were very similar to the French devices.

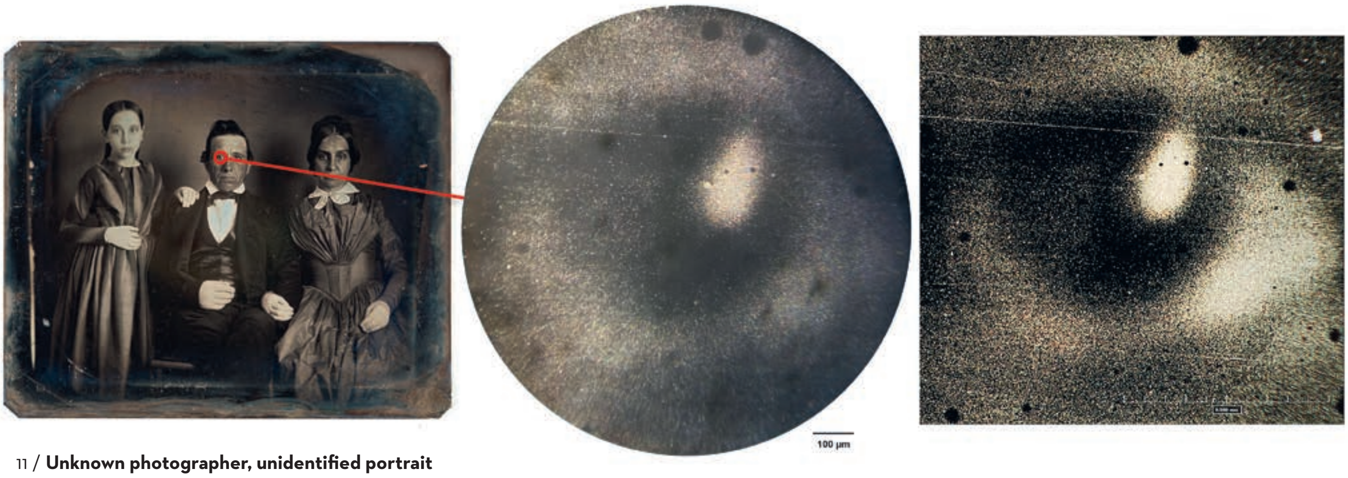
For the re-enactment experiments, two Plößl compound microscopes were chosen.[39] The methodology consisted of trying different objective and ocular combinations in order to view a daguerreotype at approximately 150–200×, a magnification that Donné reported using,[40] indicating that this must have been enough to be able to individually distinguish the particles in both the densely populated highlights as well as the near-empty shadows of the image. A historical daguerreotype from the author's collection was laid on a separate stage under the lens and illuminated with a fibre-optic LED lamp.[41] A smartphone camera was fixed on a modern microscope stand above the ocular. [9–10] The live view on the screen was easy to see, and images could be taken and then later viewed and processed.

Magnified at approximately 215×, the centre photomicrograph in Fig. 11 shows a detail of the gentleman's eye, as viewed through the historical microscope at the Universiteitsmuseum in Utrecht. The overall quality of the image is very good, despite it not being sharp from edge to edge; even modern-day microscopes can show aberrations at the edges that lessen the acuity of the image. The individual image particles can be seen quite clearly, and it is indeed apparent that they are present at a higher frequency (that there are 'crowds') in the image highlights than in the shadows. It is also discernible that some particles appear to be larger than others; however, at this magnification it is hard to determine whether these might just be clusters of smaller particles. The visual impression gained in this re-enactment was that the plates had a rough surface that almost resembled that of sandpaper. Given that the historical microscopes only had one lens tube, the resulting image also appeared flat to the eye — it lacked the three-dimensionality that modern stereomicroscopes give us. Today's practice tells us that with an optical microscope, it can be quite difficult to see the actual form of the daguerreotype particles, even if high magnifications of 1000× or more and high-resolution lenses are used. Only the Scanning Electron Microscope, which uses electron beams instead of light rays, can give us a precise idea of the shape of the particles, which

9 / **Detail of the LED fibre-optic lamp and the daguerreotype plate under the objective**
Photo: Martin Jürgens, 2020

10 / **Simon Plößl's compound microscope**, ca. 1830
Teylers Museum with an experimental setup
Photo: Martin Jürgens, 2020



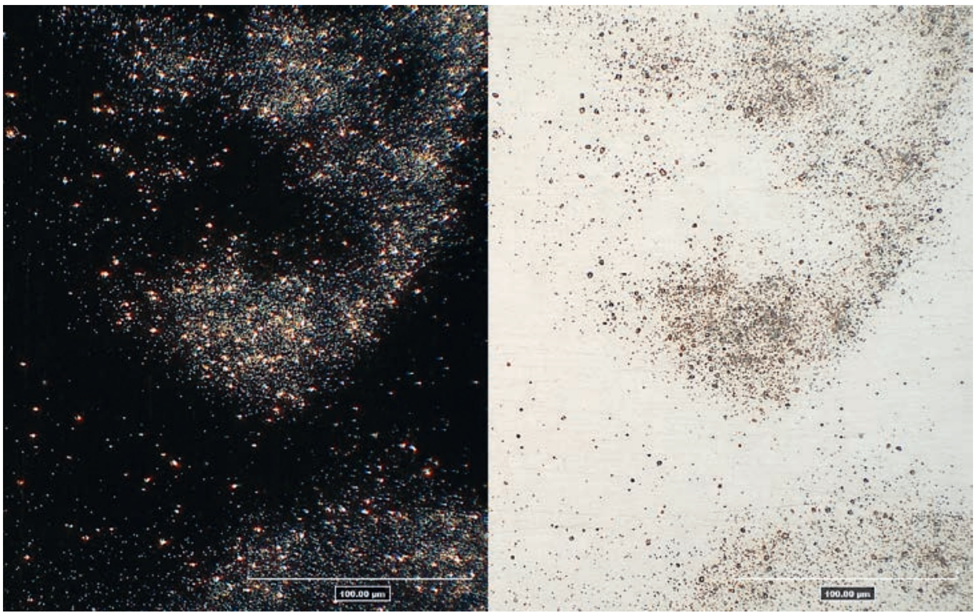


11 / **Unknown photographer, unidentified portrait**
daguerreotype plate, 6.9 × 8.2 cm
Photomicrograph of a detail taken with the Plößl microscope at the Universiteitsmuseum, Utrecht (centre) and the same spot photographed at ca. 215× magnification with a modern Hirox microscope at the Rijksmuseum (right)
Private collection
Photomontage: Martin Jürgens, 2020

can be round, flat, or even crystalline. Donné and his colleagues described the surface as 'mamillary' and compared the particles to 'small droplets'. Their choice of terminology may stem from their notion that, during development, the hot mercury vapours were condensing on the surface of the plate.

The image on the right is of the same spot taken for comparison with a modern Hirox microscope at the Rijksmuseum in Amsterdam. While the overall contrast is higher and the image is cleaner, the modern image is not necessarily very much sharper, nor does it seem to render more detail.[42] The Plößl microscope in Haarlem had an objective combination that resulted in a higher magnification, namely approximately 310×. Further combinations of objectives were not possible because some of the lenses had become firmly adhered to each other over the decades or the glass elements had clouded considerably. The visual results of both historical microscopes were very comparable. This experiment demonstrated that, with the microscopes of the time, it was clearly possible to determine that the image-forming particles rest on the surface of the plate.

One can only imagine the thrill of Donné, Dumas, and Berres when they discovered this minute world populated by an almost infinite number of tiny particles, seemingly arranging themselves into such a design that,



12 / **Photomicrograph of the daguerreotype in Fig. 4 taken in reflected dark field illumination (left) and reflected bright field (Köhler) illumination (right)**
Both images taken at 700× magnification with a Hirox microscope
Photo: Martin Jürgens, 2020

13 / **Daguerreomicrograph of the daguerreotype in Fig. 4 taken with reflected dark field illumination at approximately 30× magnification**
8 × 11 cm
Photo: Martin Jürgens, 2020

as the viewing distance of the eye increased, an image began to form that would, at a certain moment, turn into a perceptible feature. It must have become clear to them that the recognisability of a picture is dependent on the size and frequency of the image-forming particles (its resolution) as well as the degree of magnification used for viewing it (the viewing distance). As with line engraving and the lithograph, even the daguerreian image breaks down into individual entities once a sufficient level of enlargement has been reached. However, these men were first and foremost scientists, and, excitement aside, one may presume that they were primarily interested in the chemistry and physics of the daguerreian image, its surface characteristics, essentially its micro-topography — and, following from that point of departure, how one could put these distinctive features to further use.

The Daguerreomicrograph

As previously mentioned, daguerreotypes were being used to make photomicrographs of botanical and biological specimens; in this function, the daguerreotype was essentially a tool of scientific enquiry. It has also been shown that the daguerreotype medium could be the object of scientific enquiry; the plates themselves were being examined with microscopes to better understand how the process worked. However, while there are many written reports on these studies, there appear to have been no attempts at visually documenting the daguerreotype surface in the 1840s, be it by drawing and engraving the image or by photographing it.[43] It is striking that, given the technical possibilities of the time, not one researcher is known to have made a daguerreotype photomicrograph (might it be called a 'daguerreomicrograph'?) of a daguerreotype plate, nor have any examples been found in collections so far.

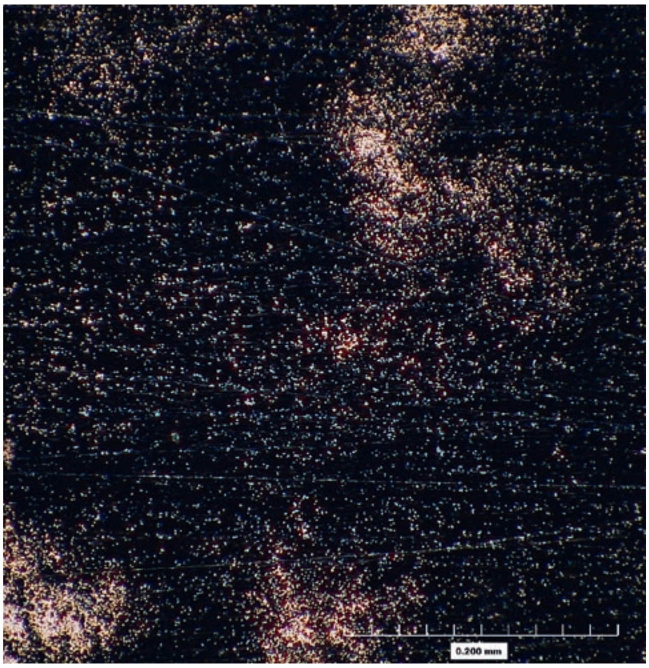
There may be simple technical reasons for this: a daguerreotype is an opaque sheet of metal, and most if not all early photomicrographs were made of transparent specimens that were illuminated by transmitted light. In fact, solar microscopes could only project the image of a transparent specimen, and compound microscopes were made primarily for transmitted light as well. As anyone who has used a microscope knows, transmitted light images can be very brilliant, whereas reflected light can make the same specimens look comparatively dull. The image-forming particles of the daguerreotype image appear as minute white specks on a primarily dark background. While reflected bright field (or Köhler) lighting will turn the polished silver surface of the daguerreotype plate into an intensely bright mirror,[44] with the image particles appearing as dark silhouettes, this illumination technique only became common in the twentieth century. [12] Was there, in the first half of the nineteenth century, simply not enough light to take a good daguerreomicrograph of a daguerreotype, illuminated with reflected light? Or was the enlarged daguerreotype surface not visually exciting enough — too technical perhaps — to merit the trouble of reproducing it? Were written descriptions more accurate in the sense of relating a viewing experience?

To rectify this lacuna in early photomicroscopy and to further explore the concepts of the daguerreian 'telescope' and the connection between viewing distance and image resolution, a modern daguerreomicrograph of a daguerreotype was made by the author. [13] This plate shows an enlargement of a gargoyle-like figure on the Rijksmuseum's roof found on the daguerreotype from Fig. 4, taken with a present-day microscope. The magnification was low enough to show the figure as a whole but also high enough to reveal the clusters of image-forming particles of the original plate. We appear to be on the border between the usefulness of the daguerreian 'telescope' — the revelation of minute pictorial details invisible to the naked eye — and the betrayal of those details by their dissolution into individual, image-forming entities.

However, a magnification device reveals only what its user is capable of seeing and understanding.

A space telescope, pointed at the night sky, discloses to the layperson merely bright dots against a black background, but the astronomer recognises individual stars and nebulae.[45] The daguerreian 'telescope' of 1839 — a simple loupe — presented, to Daguerre's visitors, features of the picture invisible to the naked eye, but only scientists and photographic pioneers were curious enough to go further in researching the genesis, form and function of the particles that made up those features, which they examined with the higher magnification of a microscope. In the contemporary field of conservation, a researcher might detect in a modern print under magnification minute, irregular, coloured specks in the printing pattern, which confirm that the print was made with the digital dye diffusion thermal transfer process.[46] The daguerreomicrograph of a daguerreotype in Fig. 13 goes one step further, thereby creating a self-referencing loop: if we continued to magnify the image by means of photomicrography we would find at some point that each one of the reproduced image particles of the original plate is in itself actually made up of clusters of minute particles on the copy plate.[47] [14–16]

Our cognitive horizons can be broadened by looking both up into the wide heavens as well as down the tube of a microscope. In the natural philosophy of the nineteenth century, these two extremes wouldn't have seemed that distinct, with astronomy and microscopy not yet being strictly separated as scientific specialties. When, in 1839, Jean-Baptiste Dumas reported that the light-sensitive iodide layer on a silver plate, as the first step in making a daguerreotype, was no more than 1 millionth of a millimetre thick,[48] Alfred Donné exemplarily commented that this concept was *'of an infinite smallness that our minds can no more imagine than the immensity of heavens, the eternity of time, or the infinity of space'*.[49] It may have been this sensitivity for the unfathomable that drove Donné to study the image-forming mechanisms of daguerreotypes and subsequently come up with a method for etching and printing the daguerreian image.



14 / **400× magnified view of the daguerreomicrograph in Fig. 13, showing the individual image-forming particles that make up the magnified particles of the original daguerreotype**
Photo: Martin Jürgens, 2020

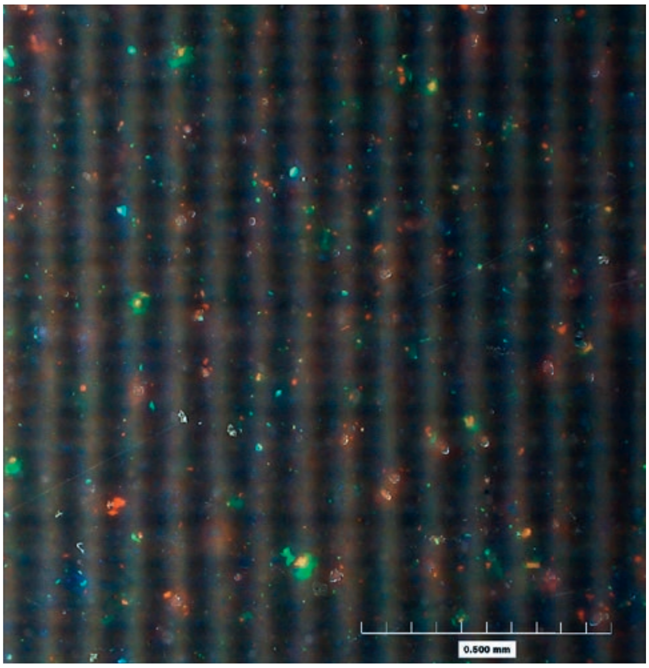
Etching and printing daguerreotypes

Keen on producing intaglio prints to illustrate his medical papers, Joseph Berres plunged his daguerreotypes into nitric acid to convert them into printing plates. Although he did not once report on what basis he assumed this might work, we can assume that, as a doctor of histology well-versed in microscopy, he would have examined a daguerreotype under a microscope the first moment he put his hands on one. Berres had also collaborated with engravers for illustrating his medical publications, and, since he knew their techniques, he may have taken it for granted that etching the daguerreotypes would lead to success. Alfred Donné, on the other hand, clearly stated that the daguerreian image formed a superficial layer on the surface of the metal plate and that he had understood that acid would only bite into the bare shadow areas of the daguerreotype plate, but not the highlights, which were protected by the image-forming particles. In 1840, he summed up his reasoning in one long yet ingenious sentence that first described the daguerreotype process in four stages and then, as a logical outcome, outlined the methodology for his further experiments:

'After having ascertained, 1st, that the yellow layer, produced on the face of the silver […] *was* […] formed *of iodide of silver; 2nd, that light* […] *acted on this layer by modifying its adherence with the silver* […]*; 3rd, that the mercurial vapour, to which the plate* […] *is exposed, touching the silver in all the points not guarded by the layer of iodine, was amalgamated with it, and thus caused the appearance of the image; 4th, that* […] *the layer of iodine having served as a momentary covering* […] *was dissolved and removed by a solution of hyposulphite of soda, and by washing in water; 5th, that the photographic image resulted from a more or less condensed amalgam of mercury and silver, forming light parts and demi-tints, and bare surfaces producing shades, like pieces of ice which reflect black; I thought it might be possible to find some chemical agent able to attack the bare parts of the silver, sparing the light parts formed by the amalgam of that metal with mercury.'*[50]

It was the study of the daguerreotype under a microscope that brought Donné to this conclusion. This understanding would also allow the daguerreotype to be used as a scientific tool above the microscope, namely to photographically document microscopic examinations and disseminate the resulting images in prints made directly from the plates. In practice, however, it remained

15 / **Hubble Space Telescope view of NGC 4789A, a dwarf irregular galaxy in the constellation of Coma Berenices**, 18 November 2016
Photo: Courtesy of ESA/Hubble & NASA



16 / **140× magnified view of a dye diffusion thermal transfer print, showing an abundance of coloured specks formed by dust on the dye ribbons used to print the image**
Photo: Martin Jürgens, 2020

difficult to pull good prints from etched daguerreotypes, and the plates and prints that have survived until today tend to be of slightly arbitrary, experimental subject matters.[51] Only a small number of prints were actually used for publications in larger runs. Among these are the three made by Hippolyte Fizeau's process that are found in copies of *Excursions Daguerriennes: Vues et monuments les plus remarquables du globe*, published in two volumes by Noël Marie Paymal Lerebours between 1840 and 1843. Although many daguerreomicrographs were made, only very few of them are known to have actually been etched and printed.[52] For their 1845 publication *Cours de microscopie complémentaire des études médicales. Atlas execute d'aprés nature au microscope-daguerréotype*, Donné and his collaborator Léon Foucault had originally planned to use prints made directly from etched daguerreomicrographs. However, in the end they chose to use engravings made after their plates instead of direct prints from the plates, since, as the first printing tests showed, direct prints did not result in the necessary print quality, and the etching process had completely changed the nature of the precious plates.[53]

Conclusions

This study set out to examine the role that the microscopic examination of daguerreotypes played in devising methods of etching and printing them in 1839 and the early 1840s. A central aspect was the use of a loupe to reveal image details that were not immediately visible to the naked eye. The function of this daguerreian 'telescope' was dependent on the magnification factor of the viewing device and the size and distribution of the image-forming entities on the silver surface. As magnification increased with the help of a microscope, the photographic image became less recognisable, since the individual daguerreian particles that made up the image became progressively discernible. The discovery of these particles allowed nineteenth century scientists to theorise about image formation mechanisms. It also enabled Berres, Donné and other pioneers to conclude that etching the daguerreotype plate in acid would convert it into an intaglio printing plate, since the particles would act as a resist layer that would protect the underlaying silver support from the etchant. While the resulting etching practice did turn out to be relatively successful, ten years later Donné's proposed model was contested by George Mathiot in Washington, D.C., and the process still merits further research today.[54]

The re-enactment of the examination of daguerreotypes with historical microscopes demonstrated that, in 1839 and the 1840s, it must have been straightforward to recognise that the daguerreian image consisted of a great number of minute particles clustered on the silver surface.

Analytical studies of the daguerreotype surface, often based on ever-increasing levels of magnification, are still being published on a regular basis today. Our current, advanced understanding of the daguerreotype microstructure puts us in a strategic position to re-examine and re-evaluate nineteenth century image-formation theories, which themselves were based, to a great extent, on microscopic examination. On 19 August 1839, François Arago shrewdly declared that *'thousands and thousands of drawings will be made with the Daguerréotype, ere its mode of action be completely analysed.'*[55] Even today, 180 years later, new methods of analysis are giving us new insights into how the daguerreotype works, and there are many questions still left to be answered.*

NOTES

1 We know this division of labour, or 'four-eyed sight', to be the case for Dr. Berres, at least.

Lorraine Daston and Peter Galison, *Objectivity*, Princeton 2007. — Martin Jürgens, Ioannis Vasallos and Lénia Fernandes, 'Joseph Berres's Phototyp: Printing Photography in the Service of Science', *The Rijksmuseum Bulletin* LXVI, 2018, pp. 144–169. This topic is more complex than can be further discussed in this paper. See, for further reading: Omar W. Nasim, *Observing by Hand: Sketching the Nebulae in the Nineteenth Century*, Chicago and London 2013. — Idem, 'The Labour of Handwork in Astronomy: Between Drawing and Photography in Anton Pannekoek', in Chaokang Tai, Bart van der Steen and Jeroen van Dongen (eds), *Anton Pannekoek. Ways of Viewing Science and Society*, Amsterdam 2019, pp. 249–283. — Kärin Nickelsen, *Draughtsmen, Botanists and Nature: The Construction of Eighteenth-Century Botanical Illustrations*, Dordrecht 2006. — Jutta Schickore, *The Microscope and the Eye: A History of Reflections, 1740–1870*, Chicago and London 2007.

2 While reports of the use of a camera lucida at the viewing end of an ocular exist, they are not very common. The camera lucida allowed the user to trace the outline of the image instead of draw it from scratch, but it can be a difficult tool to use and requires much practice.

3 This principle has been described as 'truth-to-nature' by Daston and Galison (note 1), pp. 55–113. — Nasim, *Observing by Hand* (note 1), pp. 15–16. — Idem, 'The Labour of Handwork' (note 1), p. 257.

4 Alfred Donné and Léon Foucault, *Cours de microscopie complémentaire des études médicales: Anatomie microscopique et physiologie des fluides de l'économie. Atlas exécuté d'aprés nature au microscope-daguerréotype*, Paris 1845. — Monika Faber and Maren Gröning, *Inkunabeln einer neuen Zeit. Pioniere der Daguerreotypie in Österreich 1839–1850. Beiträge zur Geschichte der Fotografie in Österreich* IV, Vienna 2006, p. 68. — Normand Overney and Gregor Overney, *The History of Photomicrography*, 2011, p. 2, http://www.microscopy-uk.org.uk/mag/artmar10/history_photomicrography_ed3.pdf, 20. 2. 2020. — Petra Trnkova, 'Stašek's Cross-Section of a Plant. Another Daguerreotype Photomicrograph', *Daguerreotype Journal* II, 2015, pp. 38–47.

5 Samuel Morse, 'The Daguerrotipe [sic]', *New York Observer* XVII, 1839, 20. 4., p. 62.

6 Dr Berres was one of a number of early practitioners who was interested in printing daguerreotype images on paper. For more details on his work, see: Jürgens, Vasallos and Fernandes (note 1). — Joseph Berres, 'Method of permanently fixing, engraving, and printing from daguerreotype pictures', *The Magazine of Science*, 1840, 6. 6., pp. 78–79.

7 Jürgens, Vasallos and Fernandes (note 1). — Joseph Berres, *Phototyp nach der Erfindung des Prof. Berres in Wien*, Vienna 1840.

8 See, e.g., François D. Arago, 'Le daguerreotype', *Comptes rendus de l'Académie des sciences*, 1839, 19. 8., pp. 250–267. — Alfred Donné, 'Sur ce qui se passe pendent les diverses parties de l'opération: Lettre de M. Donné à M. Arago', *Comptes rendus de l'Académie des sciences*, 1839, 16. 9., pp. 376–378. — Alfred Donné, 'Images photogéniques d'objets microscopiques', *Comptes rendus de l'Académie des sciences*, 1840, 24. 2., p. 339. — Paul Golfier-Besseyre, 'Sur les phénomènes produits par le daguerréotype', *Archives des découvertes*, 1839, pp. 135–136. — Auguste Waller, 'Memoire sur la photochemie, Première partie', *Comptes rendus de l'Académie des sciences*, 1840, 5. 10., p. 568.

9 François D. Arago, 'Fixation des images qui se forment au foyer d'une chambre obscure', *Comptes rendus de l'Académie des sciences*, 1839, 7. 1., pp. 4–6.

10 See Steffen Siegel's anthology of these reports: Steffen Siegel (ed), *First Exposures. Writings from the Beginning of Photography*, Los Angeles 2017. See also Siegel's subsequent publication, which includes the reproduction of a lithograph depicting Daguerre's visitors with magnifying glass in hand:

Steffen Siegel, 'No Room for Doubt? Daguerre and his First Critics', in Sabine T. Kriebel and Andrés M. Zervigón (eds), *Photography and Doubt*, London and New York 2017, pp. 29–43.

11 John Robison [attributed to], 'Our Weekly Gossip', *The Athenaeum* DCVI, 1839, 8. 6., p. 436.

12 Morse (note 5).

13 Robison (note 11), p. 435.

14 J. K. Ludwig Schorn and Eduard Kolloff, 'Der Daguerrotyp', *Kunst-Blatt* XX, Supplement to the *Morgenblatt für gebildete Leser*, 1839, No. 77, 24. 9., p. 306. Translation from: Siegel, *First Exposures* (note 10).

15 Anonymous, 'Ueber die Erfindung des Hrn. Daguerre', *Königlich priviligierte Berlinische Zeitung* XVI, 1839, 19. 1., p. 1. Translation from: Siegel, *First Exposures* (note 10). In the vision sciences, the visual angle (in the German original: '*Sehwinkel*') is a measurement that is used for calculating the resolution of an image. It consists of the angle between the light ray bundles that are reflected from two distinct points and enter the eye, forming an image on the retina. The farther apart the two points are from each other, the greater the visual angle will be, so the larger that distance will appear to the eye. The perception of the distance between the points is influenced by the viewing distance: the closer the points (e.g., dots on a sheet of paper) are to the eye, the greater their distance from each other will appear, so the more easily they will be distinguishable to the eye. As the sheet of paper moves farther and farther away from the eye, the distance between the dots appears smaller and smaller, and at some point the dots cannot be distinguished any more. This occurs as the visual angle approaches zero.

16 Edgar Allan Poe [attributed to], 'The Daguerreotype', *Alexander's Weekly Messenger* IV, 1840, No. 3, 15. 1., p. 2.

17 Arago (note 8), p. 258. Translation from: Siegel, *First Exposures* (note 10).

18 Arago (note 8), p. 259. In 1846, Dr Auguste Waller measured daguerreotype image particles to be 1/500 of a millimetre in diameter. See Auguste Waller, 'Observations on Certain Molecular Actions of Crystalline Particles, &c; and on the Cause of the Fixation of Mercurial Vapours in the Daguerreotype Process', *The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science* XXVIII, 1846, No. 185, p. 100. Given the many challenges of measuring microscope specimens in the 1830s and 40s, it was not uncommon for different practitioners to come up with different values, as is discussed at length in: David Brewster, 'A Treatise on the Microscope: Forming the Article under that Head in the Seventh Edition of the Encyclopaedia Britannica', in *Encyclopaedia Britannica* VII, Edinburgh 1837, pp. 124–134.

19 Erich Steiner and Peter Schulz, 'Plössl-Mikroskope — Ein Vergleich mit modernen Geräten', *Annalen des Naturhistorischen Museums in Wien* CVII B, 2006, p. 44.

20 Brewster (note 18), p. 124–134. The numerical aperture of the microscope objective is the key factor in this discussion: a higher numerical aperture denotes a better resolving power, resulting in more information in the enlarged image. A lens that has high magnification but only low resolution can only deliver a poor image, in which the minute daguerreotype particles might not be resolved. In his 1837 contribution to the Encyclopaedia Britannica, David Brewster writes of attainable resolutions of a 10 to an 18 thousandth of an inch (2.54–1.4 microns) and finer. See Brewster (note 18), p. 177. This resolution is not far from today's common resolutions of below 1 micron for lenses beyond 10× magnification. Mortimer Abramowitz and Michael W. Davidson, *Numerical Aperture and Resolution*, https://www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/, 27. 1. 2022.

21 Susan Barger and W. B. White, *The Daguerreotype — Nineteenth Century Technology and Modern Science*, Baltimore 1991, pp. 122–123.

22 Donné, 'Sur ce qui se passe pendent' (note 8), p. 377.

23 Anonymous, 'On the Discovery of M. Daguerre', *The Chemist* I, 1840, p. 20.

24 Golfier-Besseyre (note 8), p. 135. In English, the term '*mamillary*', meaning '*having several smoothly rounded convex surfaces*', is typically used by geologists to describe the form of malachite mineral clusters.

25 Antoine Claudet [attributed to], 'Daguerreotype and Electrotype', *The Literary Gazette*, No. 1301, 1841, 25. 12., postscript.

26 Antoine Claudet, 'Researches on the Theory of the Principal Phœnomena of Photography in the Daguerreotype Process', *The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science* XXXV, 1849, No. 237, p. 375.

27 Claudet had hoped that the daguerreotype electrotype would become a business asset for his photographic studio in London, so he experimented extensively with this process. See his advertisements for electrotypes in: *The Athenaeum*, Nos. 723 (4. 9. 1841) and 724 (11. 9. 1841).

28 Claudet (note 25). Here, Claudet also shows a keen understanding of the role that the relief of particles on the silvered plate played in the reflective phenomenon of the positive-negative effect of the daguerreotype image, a singular characteristic that we can still enjoy today.

29 The emotional response will undoubtedly vary from person to person. The author certainly does experience a sense of amazement every time he gets a chance to view daguerreotype particles under a microscope.

30 While it is clear that the scientific validity of this type of re-enactment is a whole discussion in itself, this topic will not be further treated in the context of this paper. It will, however, be examined in the upcoming PhD research of the author at the Photographic History Research Centre, De Montfort University, Leicester, UK. Three related projects are recommended here for further reading: J. van Zuylen, 'The microscopes of Antoni van Leeuwenhoek', *Journal of Microscopy* CXXI, 1981, No. 3, pp. 309–328. — Steiner and Schulz (note 19), pp. 39–55. — Peter Heering, 'The Enlightened Microscope: Re-Enactment and Analysis of Projections with Eighteenth-Century Solar Microscopes', *The British Journal for the History of Science* XLI, 2008, No. 3, pp. 345–367.

31 John Thomas Quekett, *A Practical Treatise on the Use of the Microscope* IV, London 1848, p. 14.

32 Ibidem, pp. 32–40.

33 Steiner and Schulz (note 19), p. 46. As previously described, independent of the magnification, a lens will only be able to resolve a fine structure if it has a significant enough numerical aperture and resolution power.

34 Donné, 'Images photogéniques' (note 8). — Quekett (note 31), pp. 14–15, 133–139.

35 Alfred Donné, 'New Apparatus for Lighting the Microscope, by means of the Light of Oxyhydrogen Gas', *The Chemist* I, 1840, p. 44.

36 Jean-Baptiste Biot and Alfred Donné, 'Employment of the Drummond Light in Photography', *The Chemist* I, 1840, p. 45.

37 This microscope is in the collection of the Fox Talbot Museum at Lacock Abbey, UK.

38 Anonymous, 'Wissenschaftliche Nachrichten', *Wiener Zeitung*, 1840, No. 60, 29. 2., p. 397.

39 In the Netherlands, microscopes made by Simon Plößl are held in various collections. The microscopes used were from the Teylers Museum in Haarlem (inv. no. FK-0815, ca. 1830) and the Universiteitsmuseum in Utrecht (inv. no. UM-296, 1840–1843). I would like to thank both institutions for granting me permission to use these historical devices.

40 Donné, 'Sur ce qui se passe pendent' (note 8), p. 376.

41 Despite the brightness of this light, it was challenging to see the image through the ocular. First, the diameter of the historical ocular is much smaller than what we are used to today, so it was difficult to find the right viewing angle. Secondly, the glass elements of the device have suffered over time, resulting in a somewhat dull and clouded image. Finally, the wearing of a face-mask, required for protection against COVID-19 transmission, tended to cause the glass of the ocular to fog up at close proximity.

42 No resolution measurements were made, since this experiment focussed on experiencing a personal sense of what could be seen in 1839, not on a technical comparison of microscopes.

43 In 1846, Dr Auguste Waller recommended the use of a camera lucida for 'mapping' the microscopic image of mercury globules on a daguerreotype plate for 'future inspection', but none of these 'maps' have been found so far. Waller (note 18), p. 101, unnumbered footnote.

44 Yang Leng, *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Weinheim 2013, pp. 12–13.

45 Daguerreotypes were also used to take photographs of the moon very early on. These plates offer a double telescopic view: the first being a result of the use of a space telescope for taking the photograph, resulting in a close-up image of the heavenly body very far away. The second view is that of the daguerreian 'telescope': hold a loupe over the highly resolved daguerreotype plate and you will be able to see yet more details of the lunar surface than were visible to the naked eye.

46 For further explanation, see: Martin Jürgens, *The Digital Print: Identification and Preservation*, Los Angeles 2009. — Idem, *The Eye*, http://www.the-eye.nl, 12. 1. 2020. Conservators often examine works of art with microscopes, and especially those specialized in photographic materials have been educated in identifying photographic processes with the help of photomicrographs of different types of prints. Enlarging the view of a photographic print with a loupe or microscope helps us understand the image-forming elements of each process: dots, lines, or, specifically, the absence of them in the case of continuous tone processes such as silver gelatine photographs. Microscopic examination of the surface, with the help of varying angles of illumination with different light sources, allows us to grasp how the print was made, for example, whether the image rests within an emulsion or was printed with ink on paper.

47 This is reminiscent of the Agfa additive screen plates that were used to take photomicrographs of screen plate patterns in 1925 (G.H. Rodman, 1925, Royal Photographic Collection, Victoria and Albert Museum), mentioned courtesy of Dr Kelley Wilder.

48 Arago (note 8), p. 258. It is not yet clear how Dumas arrived at this value. For modern studies of the iodide layer on daguerreotype plates, see: Irving Pobboravsky, 'Study of Iodized Daguerreotype Plates' (diploma theisis), Rochester Institute of Technology, Rochester 1971. — Michael A. Robinson, *The Techniques and Material Aesthetics of the Daguerreotype* (dissertation), Photographic History Research Centre, De Montfort University, Leicester 2017.

49 Alfred Donné, 'Exposition du Daguerreotype', *Journal des débats politiques et littéraires*, 1839, 20. 8., p. 2. Translation from: Siegel, *First Exposures* (note 10).

50 Alfred Donné, 'Engraving from Photographic Images', *The Chemist* I, 1840, p. 244.

51 The reasons for this will be explored in detail in the author's ongoing PhD research at the Photographic History Research Centre of De Montfort University, Leicester, UK. The conclusions reached in this paper may not yet be final.

52 The only two prints known today were made with the '*procédé Fizeau*' from etched daguerreotypes. They are held at the New York Public Library: Cimex lectularius — the common bedbug (inv. no. 106PH1349.015) and Beer yeast globules (inv. no. 106PH1349.016). The latter image is very similar to that of an unetched daguerreomicrograph made by Foucault for *Cours de microscopie*, now held at the Société française de photographie (inv. no.151-2).

53 Julia Bärnighausen and Christiane Stahl, 'Von Froschzungen und Blutkörperchen: Léon Foucaults Mikro-Daguerreotypien auf der Spur', *Rundbrief Fotografie* XXVII, 2020, No. 2, pp. 8–21. — Donné and Foucault (note 4), p. 14.

54 George Mathiot experimented in 1854 and 1855 with the etching processes of Alfred Donné, Sir William Robert Grove, and Marc-Antoine Gaudin. Mathiot claimed that the daguerreotype particles did not function as a resist layer, but rather that the acid bit the silver preferentially at the unexposed areas since the metallic grain of the exposed silver was crystallised and rendered less susceptible to etching during development. Anonymous, 'Engraving from Daguerreotypes', *Annual of Scientific Discovery*, 1856, pp. 185–187.

55 Arago (note 8), p. 259.

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