lem. Industrial designers, eager to prove their worth, played up the problems of products before their redesign. Patents, another major source for Petroski, are also problematic. The American patent system requires an inventor to show how the new device is an improvement over earlier ones, that is, how the unimproved product fails. Petroski's use of patent claims as a source falls into the trap of telling the story, again, from the "winner's" point of view.

Not until the last few pages of his book does Petroski move from telling stories of failure and success to consider the larger systems within which technologies exist. These afterthoughts outline the problems with his simplistic formulation of technological change. For example, Petroski acknowledges that we have to "include not only things we can hold in our hands but also the organizations and systems that produce and distribute those things." He also begins to complicate his notion of failure. He suggests, for example, that different people—different players in the act of technological change—might have different criteria for failure. What might be an improvement to one person, he admits, might make things worse for another. There are many, often conflicting, notions of failure that drive technological change in different directions.

If Petroski had used this more complex theory in his discussions of forks, pins, and paper clips, his book would have been more interesting and more useful. But complexity undermines his model. For these last-second thoughts throw the whole notion of "evolution" of technology into question. Things don't evolve; they are pushed in different directions by the decisions of inventors, manufacturers, marketers, and users, people who have economic, social, and cultural as well as practical reasons to remake technological artifacts in ways that serve them best. For example, people managed just fine without the zipper. It took zipper manufacturers some 20 years of technological innovation and an additional 20 years of marketing to convince the public it needed zippers. Even then, the zipper was adopted not because of "need" or because button flies failed but because of cultural ideas about modernity and fashion. There are many players in technological change, not just inventors who see failure and ways to overcome it. Failure is in the eye of the beholder.

Looking back for the "failure" that leads to invention and defining present-day technology as the end process of successfully overcoming those failures doesn't tell us much. Too much is missing from the theory. What's left out is economics, culture, social structure, belief—almost everything that might serve to explain, rather than ratify, the direction of technological change. Building a useful theory of technological change from the stories Petroski gives in *The Evolution of Useful Things* is about as likely as coming up with the Darwinian theory of evolution from the evidence presented in Kipling's *Just-So Stories*. To understand the direction of technological change, the historian must look at the bigger picture—not the view from one side of a fork in the road, looking back, but an aerial view that shows the path we took and the path we didn't take, as well as what we saw when we made the choice.

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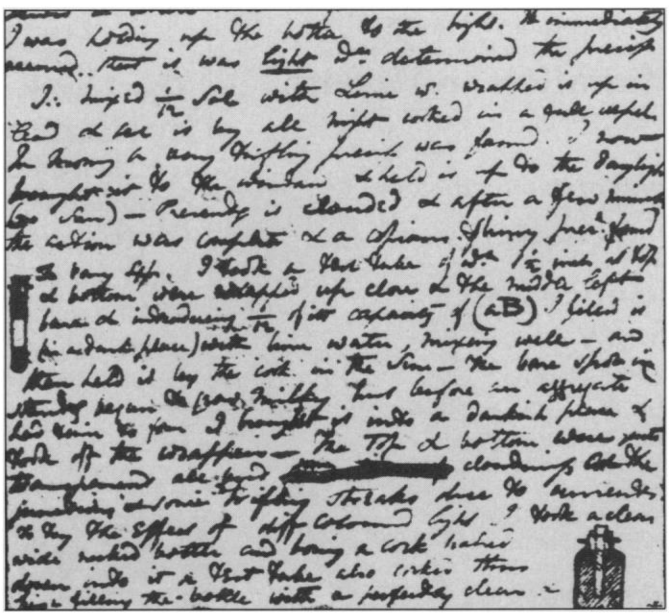
Fixing Images

Out of the Shadows. Herschel, Talbot, and the Invention of Photography. LARRY J. SCHAAF. Yale University Press, New Haven, CT, 1992. xii, 188 pp., illus. $50.

Early in January 1839, François Arago announced to the French Academy of Science that Louis Jacques Mandé Daguerre had discovered a method for making permanent the image formed within a camera obscura and that shortly the exact nature of this process would be revealed to the public. There was an excited response to Arago's announcement that was immediate and far-reaching. In England, William Henry Fox Talbot was taken aback. In 1835 he had devised a process like the one described by Arago but had never publicized his discovery. The French announcement pushed Talbot to make a counterclaim for priority and apparently dealt him a personal blow from which he never recovered. Although Talbot and Daguerre were not the only people to disclose photographic discoveries in 1839, Talbot's photogenic drawing and Daguerre's daguerreotype were the most important and influential processes announced that year. The introduction of photography brought about a technological revolution then as profound as the introduction of the computer in recent times. There is a great deal of tradition and myth surrounding the history of early photography, and only in the last ten or so years has there been a reevaluation of that history using original sources. The story is complicated and has often been cast as a nationalistic rivalry between the English and the French. However, the importance of photography and the greatness of the principals involved in early photography are diminished when looked at from such a simplistic point of view.

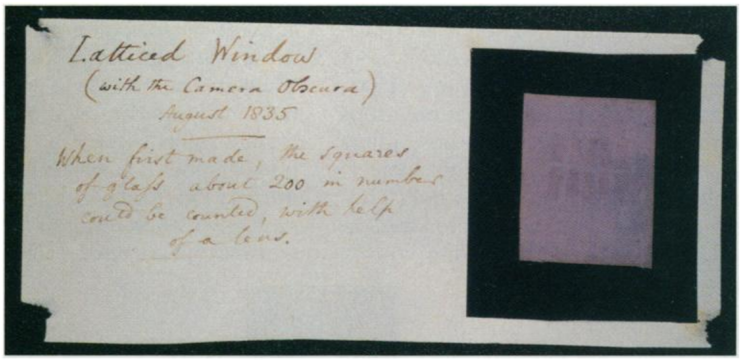
Out of the Shadows by Larry J. Schaaf is an account of Talbot's role as discoverer of photography. Schaaf uses many primary sources not previously available to scholars, including Talbot's diaries, notebooks, and correspondence with his friend Sir John Herschel. Schaaf briefly describes the state of early-19th-century British science and through short biographical portraits of Talbot and Herschel shows how they fit into the scientific community. He then provides a résumé of the prehistory of photography and some of the work that led to its discovery, including Talbot's first work with photogenic drawings, which began in 1834. The majority of the book describes Talbot's and Herschel's experiments, discussions, and public presentations of photogenic drawing and the development of the more successful calotype process. Herschel is revealed to be a strong supporter of Talbot both as an interested friend and as an active scientific colleague. We also see the interests of the two friends diverge as Talbot becomes more involved in the art of producing images and the commercialization of the process while

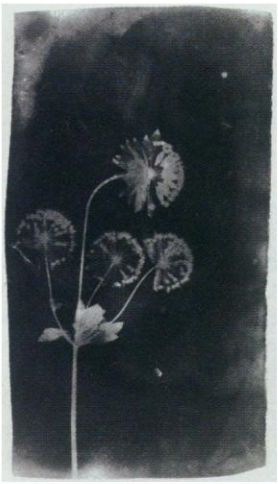


John Herschel's research notes. "In March and April of 1831, Herschel conducted a series of experiments on the action of light on platinum salts. In addition to using flower juices as color filters, he used light to make rudimentary patterns on the surface of a solution. These experiments were demonstrated to Henry Talbot at the time." [From *Out of the Shadows*; Science Museum Library, London]

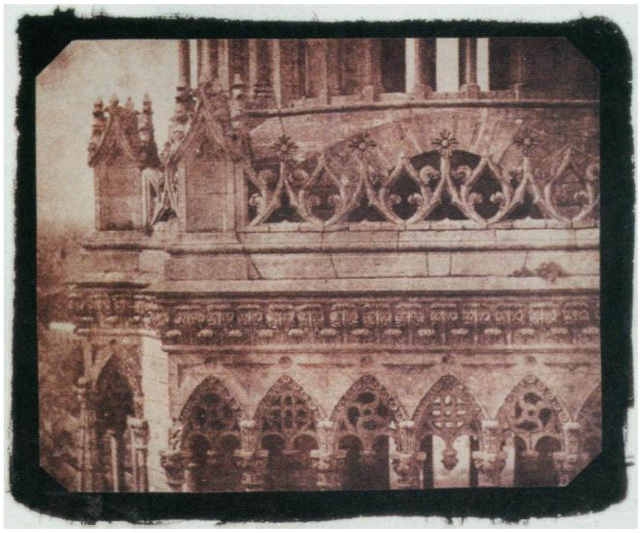
Photographs by Talbot

"Latticed window taken with the camera obscura," photogenic drawing negative, August 1835. Image size 3.6 × 2.8 cm. Talbot's "photogenic drawing paper" was sensitized by painstaking application of common salt and silver nitrate. His first photographs were direct contact images produced by placing the paper under an object and leaving it in the sunlight, typically for about 15 minutes. When the image shown here was first made, according to Talbot's annotation, "the squares of glass about 200 in number could be counted, with help of a lens." [National Museum of Photography Film and Television]

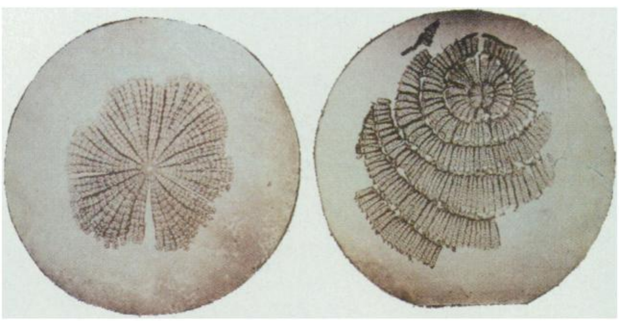




"Botanical specimen," photogenic drawing negative, 13 November 1838. 17.4 × 9.6 cm. "Talbot seems not to have made very many photographs in 1836 and 1837. Near the end of 1838, shortly before Daguerre's public announcement, he produced a number of botanical photographs, apparently with the intention of revealing his photogenic drawing process to the public." [Royal Photographic Society]



"Cathedral at Orleans," salt print from a calotype negative, June 1843. 16.3 × 20.1 cm. "The brush marks were typical of the hand-coated papers Talbot employed at [the time]. Many of the prints produced later . . . were prepared by floating the paper on the chemicals and these have uniform borders." [National Museum of Photography Film and Television]



"Photomicrographs of plant sections," salt print made from two solar microscope negatives, around 1839. 18.9 × 22.9 cm. "In the Photogenic or Sciagraphic process," Talbot wrote, "if the paper is transparent, the first drawing may serve as an object, to produce a second drawing, in which the lights and shadows would be reversed." The solar microscope produced an "intensely sunlit image [that] made possible some of the earliest 'camera' negatives." [National Museum of Photography Film and Television]

"Books in disarray." Salt print from a calotype negative, early 1840s. 14.16.3 × 17.9 cm. "Photography's ability to capture the variation in bindings fascinated early viewers and pictures of books on shelves were a repeated theme in Talbot's work . . . . These bookshelves, in fact, were set up in the courtyard of Lacock Abbey to take advantage of the sunlight." [National Museum of Photography Film and Television]

From *Out of the Shadows*

Herschel is drawn toward the more idealistic applications of photography in spectroscopy and photochemistry.

For those unfamiliar with the history of early photography, this book will provide a good background and chronicle of the seminal years. The lavish use of primary material and extensive annotations make this a useful source for those interested in further pursuit of the subject. Examples of Talbot's and Herschel's photographic experiments are reproduced in both duotone and full color and convey the variety and subtlety of tone found in the earliest paper photographs. For those already familiar with the early history this book may prove frustrating, in spite of the author's far-reaching research. There is not an integration of the source material adequate to provide a historian's insight into many of the questions that still surround Talbot's role in the discovery of photography. There are tantalizing bits of information given only passing mention, such as visual problems (a lack of stereopsis) that may have caused Talbot's trouble using a camera lucida—the impetus that led to his discovery of photogenic drawings. The postscript of the book only adds to this disappointment because in it Schaaf shows us that he does indeed have great insight into his subject that might have been applied more consistently throughout the book.

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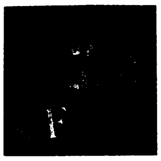


Mathematical Structures

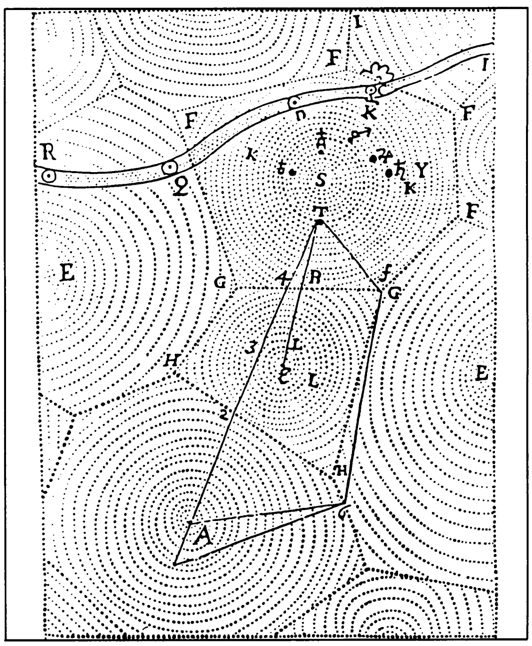
Spatial Tessellations. Concepts and Applications of Voronoi Diagrams. ATSUYUKI OKABE, BARRY BOOTS, and KOKICHI SUGIHARA. Wiley, New York, 1992. xii, 532 pp., illus. $89.95. Wiley Series in Probability and Mathematical Statistics.

The year 1603 saw the publication of the magnificent *Uranometria* by Johann Bayer of Augsburg, a book of copper plate engravings of the constellations as described by Ptolemy. Within each constellation, the stars are labeled according to brightness. Bayer's pictures, one of which is shown at left below, are a fascinating mix of old and new astronomy, both efforts to introduce some coherence into that cultural Rorschach test, the night sky.

Contrast this now with a 1644 drawing of the heavens by Descartes (below right); the culture has changed entirely. Descartes's starry sky is divided into polygons, each with a star at its center (S is the star called Sun). The wavy path is the path of a comet; the concentric circles around the stars represent possible planetary orbits. Each star holds sway over a polygonal region of the sky or, more properly, a polyhedral region, since Descartes surely understood that the stars are distributed in space, not in a plane. The image is like a froth of soap bubbles.

The difference between these two drawings lies not only in Descartes's rejection of mythology in favor of Copernicanism; there is another important distinction. To give meaning to the star clusters called constellations, Bayer (like many modern scientists) tried to connect the dots. Since—unlike the connect-the-dot workbooks we played with as children—the stars do not come with numbers attached, this can be done in many different ways: the picture one draws is inherently subjective. Descartes did *not* connect the dots: he *isolated* them by assigning a region of the sky to each, according to a very

Copper plate engraving of the constellation Leo from Johann Bayer's *Uranometria* (Augsburg, 1603). [Rare Book Room, Smith College Library]



The disposition of matter in the solar system and its environs as represented by Descartes. S is the Sun; ε is a star; RQD represents the path of a comet; polygonal areas represent heavens. [From *Spatial Tessellations*]