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Sommerlund, Julie

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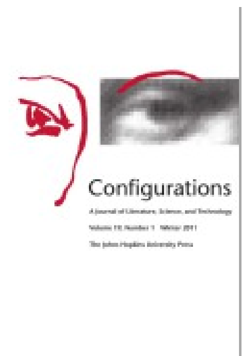

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Beauty and Bacteria : Visualizations in Molecular Microbial Ecology

Julie Sommerlund
The Danish School of Design

Introduction

In November 2000, *Nature,* the prestigious scientific periodical, ran a news feature entitled "Slimebusters." The feature dealt with biofilm, and was illustrated by a picture of biofilm made by a group of microbiologists working with Confocal Scanning Laser Microscopes (CSLM) at the Danish Technical University (Fig. 1).[1] Having a picture published in *Nature* was somewhat of an event for these researchers. At the time, I was doing observational studies in the group, and the researchers told me that this would probably be the only time that anything they produced would be published in *Nature*. They joked about it–that their only publication in *Nature* was a picture illustrating an article called "Slimebusters," and not a "real" scientific article. I did not understand what was "not really scientific" about it. I asked the professor in the group what the problem was, and he replied that the pictures they made had become "too

1. Biofilms are communities of bacteria—often comprising different species—that lump together on a surface and protect themselves with a layer of slime. Biofilms can be found anywhere—in water pipes, on teeth, in refrigerators—but only recently did researchers start creating and studying them in laboratories. Previously, scientists worked primarily with one species of bacterium at a time, which they suspended in water. Today there is a growing awareness that this is not how bacteria exist in nature—where they most commonly live in biofilms. For further discussion of the challenges that arise from biofilm research, which is by definition transdisciplinary, combining ecological methods with techniques from molecular biology, see Julie Sommerlund, "Multiple Classifications and Research Practices: Classifications in Molecular Microbial Ecology," *Social Studies of Science* (forthcoming).

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artistic"; the group had even been approached by an experimental jazz-saxophonist, who wanted to use the pictures as a visual background at a concert. Not that it matters as such, the professor said, but the group is becoming famous for the aesthetic qualities of its pictures, not for its contribution to "hard science." Interesting dichotomy, I thought.

In this paper, I intend to pursue the assumed dichotomy between science and aesthetics. One of the most remarkable features of the boundary between the two is that these researchers seem to disregard it in practice and to mix science and aesthetics in a quite radical way, while their verbal reflections of their practice seldom recognize this. In other words, there seems to be a major discrepancy between what the researchers say and what they do. In the following, I will trace the discourses and practices of science and aesthetics by analyzing the making of the group's emblematic photographs, the CSLM-images. In the first part of the paper, I will examine how bacteria in biofilms are modified in a fashion that makes them visible; in the second part, I will analyze how the pictures are edited and made understandable.

Science, Art, and Aesthetics

Like the stated aim of Alberto Cambrosio, Daniel Jacobi, and Peter Keating, my aim with this paper is to "contribute to the analysis of "nonart" (in the present case scientific) images."[2] The critical difference between art and nonart is arguably that aesthetics is an explicit actor in the construction of art, whereas aesthetics plays only an implicit, or even hidden, role in the construction of science. In the following, I will discuss the relations between these three phenomena: science, art, and aesthetics.

Traditionally, science is perceived as focusing solely on *content* while being completely oblivious to *form*, whereas aesthetics is perceived as concentrating exclusively on form and disregarding content. This division is so crude that it borders on caricature, and many scholars have written about the complexity of the relation between content and form.[3] Here, however, I will stay with the more "tradi-

2. Alberto Cambrosio, Daniel Jacobi, and Peter Keating, "Arguing with Images: Pauling's Theory of Antibody Formation," Representations 89 (2005): 94--130, on p. 96.

3. Prominent among these is Hayden White, *The Content of the Form* (Baltimore/London: Johns Hopkins University Press, 1987). The form analyzed is the narrative, and not visual imagery as in this paper; however, the point in this case—that content and form cannot be regarded as discrete parts, but rather are intimately intertwined—goes for the present study as well.

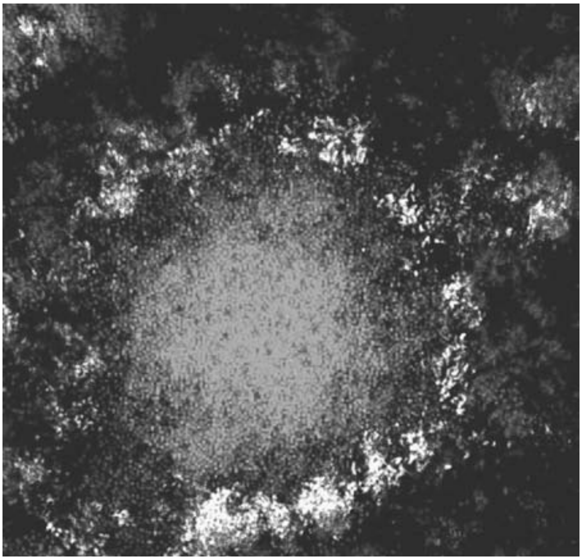


Figure 1. Christensen, Haagensen, Heydorn & Molin, Biofilm consisting of Acinetobacter and *P. putida* (Courtesy of Applied and Environmental Microbiology and the authors, re-published from "Metabolic Commensalism and Competition in a Two-Species Microbial Consortium," May 2002, Vol. 69, no. 5. p. 2496–202)

tional" stance on content and form for a while, because this is the stance that I have met in the laboratory when the researchers commented on their work, and therefore it will have a profound impact on the analyses that follow.

Important consequences of the traditional view of content and form—that they are different, and that aesthetic concerns have no place in science—are the divergent ways of regarding the *constructive processes* leading to the end product, be it scientific or aesthetic:

Aesthetics generally highlights the processes leading to the final product. Skill and technique are often major elements of the work, and are experienced as pleasurable to the viewer/listener/receiver. Thus, appreciating the violinist's ability to move her fingers rapidly and precisely is as vital a part of the experience when listening to Paganini as is the music "in itself". Appreciation of the painter's ability to apply paint to canvas and his ingenuity in coming up with new ways of doing so is as important a part of the experience when looking at a Van Gogh painting as are the colors and shapes "in themselves." Knowing that Bach composed *Das wohltemperierte Klavier* around the twenty-four scales, presenting a prelude and a fugue in each, adds grandeur and overarching structure to the music "in itself."

In *science*, however, the underlying processes behind the invention of scientific facts and data presented in publications are routinely suppressed. Working hypotheses are left unmentioned, failed experiments likewise, and—as we shall see—data are presented in styles that suppress the author as an individual and replace him or her by an impersonal, all-knowing author as anchor of the text.[4]

Thus, in science, the constructive processes deduct validity and weight from the end product; in aesthetics, the constructive processes add to the experience of the end product. The picture in *Nature* points directly to this dichotomy: If science is investigation of content, and aesthetics is invention of form, then the constructive aspects of the pictures' aesthetic qualities challenge their scientific status. The issue of science and aesthetics is central to a growing debate within Science Studies that focuses on visualizations in science. Examples are the anthologies *Representation in Scientific Practice*[5] and *Picturing Science, Producing Art*,[6] as well as a number of recent articles.

Among the writers participating in this debate, Bruno Latour is probably one of the most influential, in regard to both the scientific community in general and this paper in particular. Latour has written extensively about science,[7] and has also touched upon the topics of aesthetics, construction processes, and inscription devices,[8] which are all important to this paper. In an article entitled "How to be Iconophilic in Science, Art and Religion," he comments directly on the science/aesthetics debate.[9] He claims that matters of construction lie at the very core of art, which is in agreement with the points I made above. Art history, which explains how specific works of art

4. It is a common point within Science Studies that the sciences become sciences, aloof from other epistemological enterprises, by erasing the traces of work and contingency that have led to the data presented. See, e.g., Bruno Latour, "How to Be Iconophilic in Science, Art and Religion," in *Picturing Science, Producing Art*, ed. Caroline A. Jones and Peter Galison, (London.New York: Routledge, 1998), pp. 418–441.

5. Michael Lynch and Steve Woolgar, eds., *Representation in Scientific Practice* (Cambridge, Mass.: MIT Press, 1990).

6. Jones and Galison, *Picturing Science, Producing Art* (above, n. 4).

7. See, e.g., Bruno Latour and Steve Woolgar, *Laboratory Life* (Princeton: Princeton University Press, 1979); Bruno Latour, *Science in Action* (Cambridge, Mass.: Harvard University Press, 1987); idem, *Pandora's Hope* (Cambridge, Mass./London: Harvard University Press, 1999).

8. Inscription devices are technologies that translate phenomena into signs on paper.

9. Latour, "How to Be Iconophilic" (above, n. 4).

were constructed, is not perceived as challenging the works' status as art; rather, it adds to the pleasure of art: the more you know about the making of a certain painting or movie, the more you will enjoy it. Likewise, claiming that there is no work done in creating art would provoke most artists, who state again and again that their work is exactly that: work.[10] This is not the case in science, which is not perceived as constructing facts, but as uncovering or discovering facts. Thus, explicating the work done by inscription devices will be perceived as challenging to the sciences, for it will point to the purification work done by the inscription devices—which again indicates the complex and contingent layers of work that make inscriptions possible.[11]

In *Science in Action*, Latour describes how the world of the laboratory opens up to the spectator interested in what lies "behind" the inscriptions when confronted with controversy: "What is behind a scientific text? Inscriptions. How are these inscriptions obtained? By setting up instruments. This other world just beneath the text is invisible as long as there is no controversy."[12] In the Molecular Microbial Ecology Group (MMEG), I seemed to have stumbled upon one such controversy, opening up to investigations of the "world beneath"—the laboratory and its instruments.

Cambrosio, Keating, Jacobi, Lorraine Daston, and various others have written a substantial body of texts analyzing and discussing imagery in science.[13] These texts are an important backdrop and inspiration to this paper. Here, I will single out two that have had specific influence on my analyses—but that does not mean that the remaining articles have been forgotten.

The article "Of Lymphocytes and Pixels: The Techno-Visual Production of Cell Populations"[14] deals with visualizations created by

10. For further discussion, see also Bruno Latour, "The Promises of Constructivism," in *Chasing Technoscience: Matrix for Materiality*, ed. Don Ihde (Bloomington: Indiana University Press, 2003), pp. 27–46.

11. Latour, *Science in Action* (above, n. 7), p. 64

12. Ibid, p. 69.

13. See, e.g., Peter Keating, Alberto Cambrosio, and Michael MacKenzie, "The Tools of Discipline: Standards, Models, and Measures in the Affinity/Avidity Controversies in Immunology," in *The Right Tools for the Job*, ed. Adele Clark and Joan Fujimura (Princeton: Princeton University Press, 1992), pp. 312–355; Peter Keating and Alberto Cambrosio, "`Going Monoclonal': Art, Science, and Magic in the Day-to-Day Use of Hybridoma Technology," *Social Problems* 35 (1988): 244–260; Peter Keating and Alberto Cambrosio, "Biomedical Platforms," *Configurations* 8 (2000): 337–387.

14. Alberto Cambrosio and Peter Keating, "Of Lymphocytes and Pixels: The Techno-Visual Production of Cell Populations," *Studies in History and Philosophy of Biological and Biomedical Sciences* 312 (2000): 233–270.

means of a machine called a FACS (Fluorescence-Activated Cell Sorter).[15] The FACS distinguishes different species of bacteria "mechanically": the bacteria fluoresce in different colors, and the FACS responds to the differences in type of fluorescence. This differentiation is performed "manually" in a conventional fluorescence microscope such as the CSLM. In spite of this difference, the central point of Cambrosio and Keating's article—that imaging via the FACS technique breaks down the difference between representation and intervention—also goes for the CSLM technique discussed here. According to Cambrosio and Keating, "imaging as embodied in the flow cytometric practices does not simply break down Walter Benjamin's distinction between manual (for example, drawings and engraved diagrams) and mechanical (for example, photographs and micrographs) reproductions, but goes beyond that to collapse the epistemic distinction between intervening and representing."[16] This point is very similar to the one I will present in this paper, for the collapsing of "intervening and representing" can be seen as related to the implosion of reality and representation that is implied in the transformation of nonoptical events into optical ones. Thus, the point suggested by Cambrosio and Keating would be common to fields as different as astronomy, high-energy physics, and microbiology.

Another paper by Cambrosio, Jacobi, and Keating focuses on Paul Ehrlich's images of antibodies and points out that these images represented entities on which there was no consensus: "What made the use of visual imagery so controversial, was that it defined the relevant entities by the very process of representing them."[17] There are many similarities between this situation and the situation my researchers find themselves in, for biofilm is a new object of research with new methodological tools offered by molecular biology to ecological studies. Thus my paper and Cambrosio, Jacobi, and Keating's

15. This technology is central in the MMEG laboratory as well, although it was acquired only when I was finishing my work there; consequently the FACS is not included in my analyses.

16. Cambrosio and Keating, "Lymphocytes and Pixels" (above, n. 14), p. 235. Walter Benjamin was an influential German philosopher who published the ground-breaking article "The Work of Art in the Age of Mechanical Reproduction" in 1936, reprinted in *Illuminations* (London: Random House, 1999), pp. 211–244. The article discusses the technologies of film and photography, and how these technologies influence the status of the work of art and its special, authentic "aura," which is constituted by the direct physical link between the work and the artist.

17. Alberto Cambrosio, Daniel Jacobi, and Peter Keating, "Ehrlich's 'Beautiful Pictures' and the Controversial Beginnings of Immunological Imagery," *Isis* 84 (1993): 662–699, on p. 666.

share the focus on how representation shapes the entities represented. The difference is mainly that theirs is a historical study, while mine is real-time and material. Upon this note, I will return to the Molecular Microbial Ecology Group.

The Story of *Acinetobacter* and *Pseudomonas putida*

After talking to the professor about the picture from *Nature*, I went on to ask the young researcher who had made the picture what was so special about it. He told me that it was actually a part of a series of six, and that it was the *story* narrated by these six pictures rather than the single picture that was interesting. I asked him about the story, and he gave the following account: (Figure 2)

The series consists of six pictures (Fig. 2) that represent particular phases of development of biofilms consisting of *Acinetobacter* (red) and *Pseudomonas putida* (blue). The researcher and his colleagues had a hypothesis about these species: that together they were able to degrade the organic solvent toluene. When the two species grow on a bases of benzyl alcohol (replacing toluene), they go through different stages of cooperation: *Acinetobacter* is able to metabolize benzyl alcohol and excrete benzoate, which *P. putida* can metabolize. From the outset, the two bacteria live almost evenly scattered over the surface (A). However, it soon becomes obvious that *P. putida* is attracted to *Acinetobacter*, probably because of the excreted benzoate—this is visible because the active cells of *P. putida* (those that eat) shine with a greenish light. The next day (B), *Acinetobacter* starts to develop microcolonies, and *P. putida* gathers around these colonies. On the third day, large microcolonies of *Acinetobacter* are formed, with active *P. putida* cells around and on top of them (C–D). On the sixth day of the development of the biofilm, the large microcolonies have disintegrated, and *Acinetobacter* starts to migrate into the higher levels of the substratum (E–F). This probably happens because *P. putida* is so close to the *Acinetobacter* that it no longer gets the nutrients it needs.

At first, I was simply baffled by the story, as I had no idea how the single picture-frames A–F were connected to the stages in the story. The exploration of these connections is very much what my coming analyses will consist of.

Second, I was also a bit disappointed with the story in itself—I had expected something more dramatic after the introduction (it is not the single picture, it is the *story* that is interesting), perhaps a classic story of the rise and fall of a community.[18] I had hoped that

18. However undramatic, the story does have the basic characteristics of a narrative: it is structured in time; it has a fixed beginning, middle, and end; and it has a specific

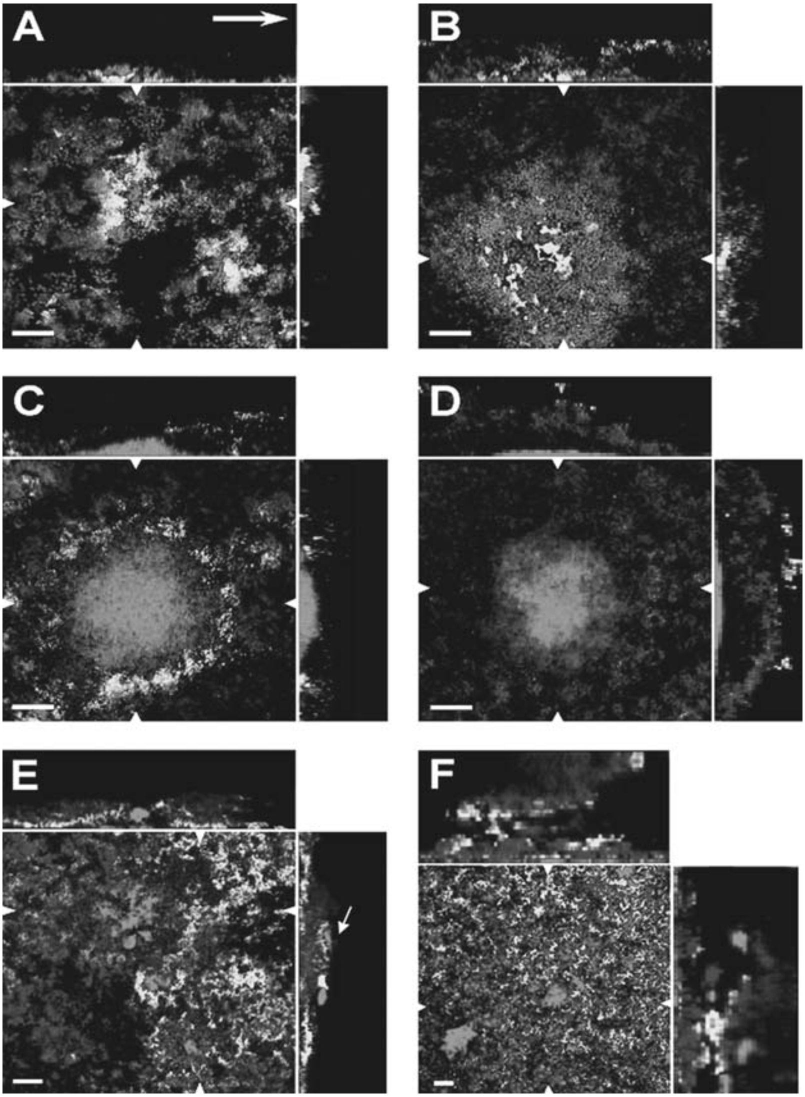


Figure 2. Haagensen, The Story of Acinetobacter and *P. putida* (unpublished images: Courtesy of the author).

the researcher would tell me more about the aesthetics/science schism. But to the young researcher the term "story" seemed to be more prosaic than it was to me; or perhaps the story of *Acinetobacter* and *P. putida* contained high drama within the context of microbiology, and I was simply not able to understand it.

Later, I was to discover that even for me, there was high drama to be found in this story: the translation of the story to a single picture in many ways serves as an analogy to the process of translating and purifying scientific practical work into Science. Thus, the complicated relation between image and narrative implied by the researcher had an impact on many topics other than that of *Acineotbacter* and *Pseudomonas*. More about that later on.

The Construction of a Sign System

I went on to ask the researcher who had made the picture if I could spend some days in the laboratory with him to see how the biofilm pictures were made. In the laboratory, it soon became apparent that a major issue when working with biofilm is to make visible the things you want to demonstrate. First, the researchers want the different species of bacteria to be distinguishable. Even when the bacteria grow species by species in a petri dish, it can be difficult to tell them apart: some may be oblong and others circular, and that is about all the difference there is. When more species are grown together in a glass chamber—which is how biofilms are grown in the laboratory—you have no chance of telling them apart by morphological differences. Second, the researchers want to be able to see whether bacteria of different species are living *next to each_other* or *together*. For instance, the biofilm depicted in *Nature* is interesting because the two species may feed off each other. How do you show that? The young researcher needed a representative system: a vocabulary to tell the story of the biofilm.[19]

The Molecular Microbial Ecology Group laboratory has made the construction of sign systems somewhat of a specialty: The researchers use *probes* to mark the different strands of bacteria with

causality. It should be noticed, though, that the causality originates from the bacteria rather than the "author"—the researcher. In this respect, reality and the representation of it are intermingled in the most intimate way.

19. The most commonly discussed sign system is human language. Umberto Eco, in *A Theory of Semiotics* (Bloomington: Indiana University Press, 1976), points to many more, such as zoology, olfactory signs, tactile communication, medicine, music, plot structures, mass communication, and written and visual languages. In *The Fashion System* (1969; London: Cape, 1985), Roland Barthes also mentions the fashion system, and I will add scientific systems to the list.

colors. These probes consist of specific DNA sequences that hook on to bacterial RNA, and they are marked with different fluorocromes—that is, with different colors. The use of probes is routine in the laboratory, and the probes are commercially available. How the commercial laboratories make the probes and how the probes actually connect to the bacteria remain a black box to the researchers[20]—they simply order the probes from a catalogue, as others would order art supplies.[21] By means of these probes we enter the world of *signification,* the making of meaning—a world that can fruitfully be discussed using concepts from semiotics. Therefore, I will turn to semiotics and discuss the color marking of bacteria in this light.

A basic claim within semiotics is that the signified (the concept of *Acinetobacter*) is *arbitrarily* connected to the signifier (that which refers to the concept, in this case the word "acinetobacter," or, in a picture, a red dot).[22] This means that another sound or different letters would be just as efficient in referring to the bacteria as "acinetobacter," as would a different color than red. The connection is not given by nature, but is the result of a cultural and arbitrary definition. The sign system considered here—the color-marking of strands of bacteria, and the visualization of their level of activity—is special, for the link between signifier and signified has not yet been established. The unmodified, wild-type bacteria are out of reach of the researchers and only come within reach through the process of signification, a process that can be followed in the laboratory and that leaves no doubt as to the arbitrariness of the sign. This is an example of how turning nonoptical events into optical events also means removing boundaries between representation and intervention.

20. For further discussion of scientific techniques and their becoming "black boxes," see Kathleen Jordan and Michael Lynch, "The Sociology of a Genetic Engineering Technique: Ritual and Rationality in the Performance of the 'Plasmid Prep,'" in Clark and Fujimura, *Right Tools for the Job* (above, n. 13, pp. 77–115. The article is an analysis of the "plasmid prep," a technique that is also used extensively in the laboratory in question, and that has a status in many ways equal to the ones I discuss here.

21. In *Laboratory Life* (above, n. 7), Latour and Woolgar use Bachelard's concept of "reified theory" to designate this type of technology.

22. Ferdinand de Saussure perceived the sign as a whole comprising a *signifié* (conceptual content; henceforth, "signified") and a *signifiant* (expression; henceforth, "signifier"). The relation between signified and signifier is arbitrary, which means that there is no natural connection between these two sign levels. By denaturalizing the connection between signified and signifier it is possible to discuss the human language—as well as other sign systems—as classificatory systems. Poststructuralists have later claimed that not only is the relation between signified and signifier arbitrary, the signified itself is arbitrary and is constituted by the signifier—not the other way around. See Ferdinand de Saussure, *Course in General Linguistics* (1916; London: Duckworth, 1992).

In the laboratory, the connection between signified ("bacteria") and signifier (the colored dot) was made as follows: The researcher set up the flow chambers containing the biofilm in a system of tubes and pumps that ensured the circulation of nutrients through the system. The biofilm was then left to grow for a few days. When it was ready to be photographed, the researcher turned off the pump and removed the flow chambers containing the biofilms that were to be photographed; he then took a syringe filled with ice-cold fixative (silicone rubber) and injected it into the flow chambers, a procedure that killed the bacteria in the biofilm.

The six pictures represent stages in the development of a biofilm. But making a CSLM-picture kills the biofilm, and hence the single photographs in the series are of different biofilms. Thus, the picture-series representing the development of one microcolony in one biofilm is made using six different biofilms.

The researcher then applied the probes to the silicone with another syringe and told me that they would spread through the silicone and hook onto the RNA of the bacteria, thus making the organisms in the biofilm visible. In the case of *Acinetobacter* and *P. putida,* two probes were added to the silicone (red for *Acinetobacter*, blue for *P. putida*), and this way the two actors of the story were put in place.

However, in order to tell the story of the two strands of bacteria, the researcher needed yet another color code. The actors had been coded red and blue, but an indicator of interaction was necessary to combine the two codes into a story line. This procedure had been performed before I started my observations: the interaction indicator had been spliced into the DNA of the two strands of bacteria contained in the biofilm; consequently, the following is based on what the researcher told me, and not on my own observations.[23] The indicator is called "gfp" (green fluorescent protein), and it is as institutionalized as the probes mentioned above.[24] Gfp was originally isolated from a fluorescent jellyfish, *Aequorea vintoria;* it is used for gene encoding, or more specifically to show when a gene is induced, or "turned on." In the case of *Acinetobacter* and *P. putida,* gfp can be used to show whether *P. putida*'s metabolic system is more active when placed close to *Acinetobacter* than it is elsewhere. In other

23. Even if I did not observe the researcher splice gfp into *Acinetobacter* or *P. putida*, I feel fairly familiar with the procedure, as this was one of the experiments I performed myself when being "trained" prior to making observations.

24. During the past five to ten years, the natural gfp protein has been heavily mutated; thus, bfp (blue fluorescent protein), yfp (yellow fluorescent protein), etc. are all commercially available—again, just like art supplies.

words, if *P. putida* can eat what comes out of *Acinetobacter*, they will shine with a greenish light.

The practice of color encoding is routine and black-boxed, but every time a researcher performs the procedure it is at least theoretically possible to create a new color code and make the invisible visible in a different way. There is no "natural" line between visible and invisible; rather, the boundaries are based on the practical choices that researchers make in specific cases. Even more strikingly, though the goal of this experiment may be to examine the toluene-degrading capabilities of microbial communities, laboratory time is primarily spent working with signification. There is no mystery to this, for there is no way of examining toluene-degrading capabilities without in some way making them visible or detectable. In the words of Hans-Jörg Rheinberger, "Representation *is* 'eventuation' (it is about intervention, invention, and the creation of events)."[25]

This questions the practical relevance of the schism between aesthetics and science: in practice, there is no clear line separating the two. However, the researchers' verbalizations continue to differentiate sharply between them. This differentiation will be the object of discussion below.

"Subjectivity"

When the researcher chose red and blue and not two other colors to mark his bacteria, this was simply because "these colors stand out against each other nicely"—as he said in the laboratory. Later, in an interview, he developed the point further:

> *D*: For *Acinetobacter*, I chose a red probe, but I might as well have chosen a green one or a blue one. . . .
>
> *JS*: Then why did you choose red?
>
> *D*: I chose the red probe because that is what people have done earlier. And people have used the blue for putida.
>
> *JS*: So, it's becoming a code?
>
> *D*: It is becoming a color code—or at least it is within this group. I do not know if other groups use other codes. It is also a question of what you have in the freezer. And of course, you should not use green because the gfp monitor is green, so of course you will have to think about that. But otherwise, it is about what is in the freezer, and what other people have done with the bacteria you are working with.

25. Hans-Jörg Rheinberger, *Toward a History of Epistemic Things—Synthesizing Proteins in the Test Tube* (Stanford: Stanford University Press, 1997), p. 108.

What struck me—both during my observations in the laboratory, and later while doing the interview—was that the researcher seemed to dismiss all questions about color and choice of motif. They seemed to be unimportant to him, and he could not understand why I found the subject interesting.[26] Nevertheless, this specific researcher is known within the group to be a specialist when it comes to constructing and representing biofilms. To a layperson, the pictures are intriguing because of their beauty. I was mystified that the young researcher did not show more pride in this aspect of the pictures, and in the fact that even outsiders found them interesting.[27]

One way of understanding this could be to consider what the researchers refer to as the subjective quality of the photos. Subjectivity, when defined by these researchers, seems primarily to be about explicitness in *choice of motif*. The choice of photographing one microcolony rather than another is perceived as being highly subjective. In the following, another researcher from the group explains why this is the case:

> Because it is really very chaotic what goes on in one of those biofilms. So, it is very . . . I don't know if the others have told you, but often when they make pictures for publications, they scan more biofilms to find the best place that shows exactly what they want to show. Especially . . . acinetobacter and putida . . . those nice pictures they have. Everybody who works here knows that these kinds of pictures that make it to that kind of publication . . . they have spent maybe half an hour scanning the entire biofilm to find the best place, and then you say, it looks like that and that, and you've got this gorgeous picture to underline your hypothesis. But somehow it is not very scientific, doing that, but everybody does it. I guess somehow it's OK.

The researcher quoted above regards "subjectivity" as being in opposition to "science." Almost all the researchers of the group echo

26. Alex Pang notes a similar inclination toward aesthetic considerations in astronomy, and quotes a late nineteenth-century astronomer as saying, on the introduction of photography to astronomy, that "stars should henceforth register themselves"; Pang goes on to state that "aesthetics would not even exist in this new order. `Their pictorial beauty,' the Review ["Astronomical Photography," *Edinburgh Review*, 1888] said of astronomical photographs, 'is the least of their merits,' and comparisons of photographs would be made without considering whether one was more beautiful or striking than another" (Alex Pang, "Technology, Aesthetics, and the Development of Astrophotography at the Link Observatory," in *Inscribing Science*, ed. Timothy Lenoir [Stanford: Stanford University Press, 1998], pp. 223–249, on p. 224).

27. Not all researchers are as shy of speaking of the aesthetic qualities of their work. For instance, James D. Watson speaks freely of aesthetics in his account of the "discovery" of the double helix, often saying that the prettiness of the figures was an important standard of truth in the work of constructing a visual representation of DNA: James D. Watson, *The Double Helix* (1968; London: Penguin Books, 1997).

this viewpoint, and the quote is intended to illustrate a general point rather than an individual statement. Subjective matters may be relevant when discussing art, but proper science is objective. William J. Mitchell describes this stance as being typical in scientific—and photographic—procedures:

> Such exclusion of human bias is the point of many standard scientific procedures, such as random sampling, double-blind clinical trials, and setting the statistical significance levels before conducting experiments. . . . The photographic procedure, like these scientific procedures, seems to provide a guaranteed way of overcoming subjectivity and getting at the real truth."[28]

Likewise, Lorraine Daston and Peter Galison write of scientists' use of mechanically produced images in the late nineteenth century that,

> at issue was not only accuracy but morality as well: the all-too-human scientists must, as a matter of duty, restrain themselves from imposing their hopes, expectations, generalizations, aesthetics, even ordinary language on the image of nature. Where human self-discipline flagged, the machine would take over. Wary of human intervention between nature and representation, [scientists] turned to mechanically produced images to eliminate suspect mediation."[29]

This—the alleged connection between mechanically produced images and objectivity—could explain why the researcher did not react positively to my attempts toward a more aesthetic discussion of his pictures, even though their aesthetic qualities are very much "in your face." According to Galison and Daston, aesthetics and beauty are phenomena that are morally tainted in science, like subjectivity, and that the researchers should avoid—or at least ignore. Seen from this angle, it is not so strange that the young researcher tried to avoid discussions of something as "subjective" and "nonscientific" as colors and choice of motif. Still, the practice of making the photographs legitimately entails both types of consideration: it is not *either* aesthetics *or* science; rather, it seems that science in this case could not exist without aesthetic considerations.

COMSTAT: New Biofilm Representations

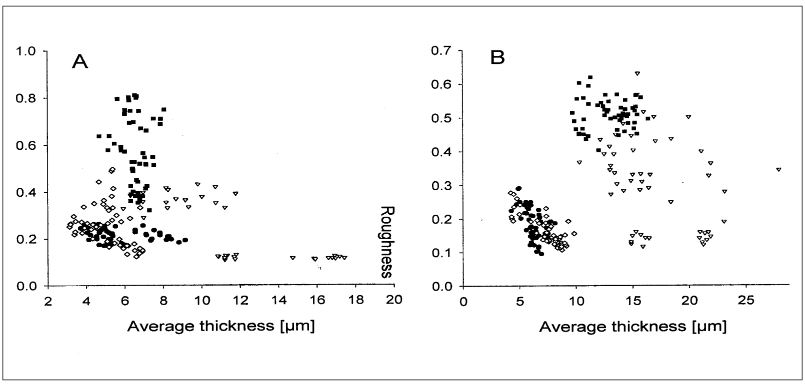
After this discussion of the preparation of the CSLM-pictures and the experimental and biological "content" of these visualizations—that is, the color-marking and thereby the visualization of the bacteria

28. William J. Mitchell, *The Reconfigured Eye* (Cambridge, Mass./London: MIT Press, 1992), p. 28.

29. Lorraine Daston and Peter Galison, "The Image of Objectivity," *Representations* 40 (1992): 81–128, on p. 81.

in the biofilm—I will go on to discuss the making and editing of the CSLM-photographs. However, before doing this I will consider another type of visual representation of the biofilms, namely COMSTAT-diagrams, because it makes analytical sense to consider COMSTAT at this point. COMSTAT is a piece of software that analyzes stacks of images produced by the CSLM, and produces diagrams to represent these analyses.

As argued by Ferdinand de Saussure, signs acquire meaning not through their relation to reality, but rather through their relations to other signs. When I was trying to understand how to make and read CSLM-photographs, the researchers kept referring to COMSTAT and telling me that I should really look into those representations as well. This suggests that the two types of representation give meaning to each other through their difference. I asked the professor for his interpretation of the meaning of COMSTAT. He told me that COMSTAT was able to generate other types of representation of biofilms than the somewhat problematic CSLM–photographs: by measuring different parameters randomly across the biofilm, the software could generate *quantitative* rather than *qualitative* data. Thus, the more "subjective" (and thereby aesthetic) extra meanings of the photographs would be countered by representations that were more traditionally scientific.[30]



30. The sign is often classified into different types. Famous among these is the triad of Charles Sanders Peirce: icons, indices (often called "indexes"), and symbols. The iconic sign is the sign type I work with in this paper. It is characterized by resembling the conceptual object ("signified," in Saussure's terms); the usual examples are photographs, paintings, sculptures, and cinematic signs, but mathematical signs such as graphs and curves can also be put into this category. Peirce would say that both types of signs (pictures and graphs/curves) are icons, and thereby equally arbitrary. But even though

After having spoken to the professor, I went on to talk to the researcher who worked on the COMSTAT software. I asked him why the COMSTAT program was so important. I will quote from this interview at some length:

H: It [COMSTAT] is not as subjective as the CSLM-pictures. When you look at one of these biofilms, it shouldn't be like ... you look at one biofilm and another biofilm, and then you go: nahhh, I think this one is a little bigger, and this one is a bit thicker and this one's a bit thinner. If you do that, it becomes very subjective. Like, in some way, you know what you want . . . .

JS: OK, so it's the quality of the description that gets better?

H: Yes, the quality gets better. The numbers in themselves aren't that interesting at all. But the quality gets better because you discover that maybe it wasn't right what you thought you saw, because you wanted to see something specific.

JS: The CSLM-pictures *are* really difficult to look at, or so I think. Or maybe you get better . . . .

H: It *is* difficult, and I think that one thing that is difficult about our way of doing research is that we're really marked by our models, or not models, but when looking at the biofilms we have strong hypotheses of why things are the way they are. And it is hard to look at them without having a hypothesis. It is difficult to look at them in a completely objective way . . . . So, the idea with this program is to quantify how these things look three-dimensionally.

JS: But even with the program, there must be some prior understanding . . . . There must be some boxes to put the results into?

H: Sure. I decided what variables were to be calculated, like the thickness of the biofilm, and how big the surface is. Sure, that's sort of a model that I have chosen. *I* chose to describe the biofilm this way.

JS: How did you decide which variables and parameters to work with?

H: I just took all I could think of, and then I ordered it according to rank. An immediate and intuitive thing: when something

Peirce—who worked as a chemist and mathematician as well as a semiotician—might regard CSLM-photographs and graphs as having the same status, the lack of color and the randomness of choice of motif made the graphs, curves, and numbers more palatable to the microbiologists.

> grows on a surface, then how thick is it? The next thing that comes to mind is: how much does it vary, is it very flat or does it go up and down? That's "roughness." The next thing that comes to mind is: how big is the surface of this one, that's important, because how does fluid get in and out of this biofilm? And then there are a number of variables further down.

The researcher refers directly to the "subjectivity" of the CSLM-pictures as constituting a problem. At the same time, he describes the outline of the COMSTAT program as neutral and objective, in spite of his "*I* chose to describe the biofilm this way." His descriptions of the variables chosen as descriptive parameters of the COMSTAT-representation seem logical and obvious—however, it is also obvious that other variables could have been chosen, or they could have been ordered in a different way. Thus, it seems that the creator or designer of the representations is as present in the COMSTAT-graphs as he or she is in the CSLM-pictures. However, the quantification, abstraction, and generality of the COMSTAT-representations make them seem more scientific.

Relevant to this point, Latour addresses the creation of diagrams and graphs representing the soil of the rain forest. He describes this process as simultaneous reduction and amplification: the researchers *reduce* materiality, locality, and multiplicity, and they *amplify* compatibility, standardization, and so forth. He writes: "In losing the forest, we win knowledge of it."[31] Likewise, in the COMSTAT-representations, the researchers lose the biofilm, but win knowledge of it.

In the eyes of the microbiologists of the Molecular Microbial Ecology Group, the graphs obviously belong to a different class of representation from the CSLM-photographs. I use the plural—"microbiologists"—deliberately, since this researcher's views are repeated by the majority of the researchers in the group; I presented an early draft of this analysis to the group at a research seminar, and the response was unanimous: the COMSTAT representations *are* more scientific, because they *are* more objective, which again makes them more *true*. As Rheinberger writes, the sciences aim at *true* representations of the world.[32] In this case we have two, very different, representations of the same "world"; the question then becomes, which is truer?

The two types of scientific representation are common to many branches of science, and may be categorized using Marie-José

31. Latour, *Pandora's Hope* (above, n. 7), pp. 38.

32. Rheinberger, *Toward a History of Epistemic Things* (above, n. 25), p. 102.

Bertin's terms *graphisme* (polysemic imagery, such as pictures and photographs open to multiple interpretations—in the present study, akin to CSLM-photographs) and *graphique* (monosemic data representation such as diagrams that have only one predetermined interpretation—here, COMSTAT-diagrams).[33] Peter Galison presents a related differentiation in *Image and Logic*, where he describes two types of visual scientific traditions. One, the image-tradition, makes visualizations that have as the ideal "images . . . that are presented . . . as *mimetic*—they purport to preserve the form of things as they occur in the world"; in the present study, these mimetic images can be compared to the CSLM-photographs, while the COMSTAT-diagrams can be seen as a part of the other tradition that is marked by an ideal of logic, which again visualizes using machines that are "counting (rather than picturing) . . . aggregate masses of data to make statistical arguments for the existence of a particle or effect."[34]

The latter class of scientific representation seems to be performed by a researcher who is an innocent medium rather than an active creator.[35] Many trends within Science Studies (notable in this context is the feminism of, e.g., Donna Haraway) criticize this way of regarding science and scientists: the sciences' claim of seeing everything while remaining invisible is a "god trick," a claim that the scientist's position does not influence the knowledge produced. In the present study, the COMSTAT-representations of biofilm do not point as explicitly to the "author" as do the CSLM-photographs, but they are still dependent on authors and subjective choices, as the above interview clearly shows. They are not made by a "god," and some "subject" other than the computer has chosen the parameters used for scanning the biofilm, even when computers do the scanning randomly. Thus aesthetics and form, in the sense of composition, are included in the COMSTAT-representation to the same degree as they are in the CSLM-photographs.[36]

33. Marie-José Bertin, *La graphique et le traitement graphique de l'information* (Pairs: Flammarion, 1977). For further discussion, see Cambrosio and Keating, "Of Lymphocytes and Pixels" (above, n. 14).

34. Peter Galison, *Image and Logic* (Chicago: Chicago University Press, 1997), p. 19.

35. Daston and Galison, "Image of Objectivity" (above, n. 29), p. 81, note that "Let nature speak for itself" became the watchword of a new brand of scientific objectivity that emerged in the latter half of the nineteenth century. At issue was not only accuracy but morality as well: the all-too-human scientices must, as a matter of duty, restrain themselves from imposing their hopes, expectations, generalizations, aesthetics, even ordinary language on the image of nature.

36. It is also useful to compare to Cambrosio, Jacobi and Keating's discussion, in "Arguing with Images" (above, n. 2), of "figuration" and "demonstration." Ideally,

Making and Editing CSLM-Photographs

I now return to the analysis of CSLM photography, since the construction of sign systems and the creation of visualizations and stories do not stop at the coloring of bacteria: the researchers also have to capture the colors on film and make them into photographs. This part of the representational practice requires as much work and consideration as the first one.

The CSLM that makes the pictures of the biofilm is not one simple piece of equipment, but rather a cluster of machines taking up most of one room, and an extended network of apparatus. This was where I went with the researcher after he had killed the bacteria and injected the probes. The room containing the CSLM is very different from the benches where most laboratory work takes place: the latter benches are well lit, fully occupied by researchers and technicians, and bustling with small talk, music, and jokes; the room where the CSLM is placed is dark and quiet, for only one person at a time can work there (or two, if one is observing the other). The researcher and I started out by transporting the biofilm system on a trolley to the CSLM room. The researcher then disengaged glass chambers from the system, and placed them under the microscope. He looked, and asked if I wanted to have a look, too. While I was looking, he explained that a laser makes it possible to see how the biofilm is organized inside. However, he added, there is an important trade-off connected to this procedure: each time the laser cuts through the biofilm, it bleaches out some of the color. Thus, the more layers are cut, the better the picture; but the better the picture, the more the motif vanishes, making it impossible to produce any future pictures.

When the researcher had found a good place on the biofilm, he took pictures, which could be seen momentarily on a computer screen to the right of us. He started editing the image right away; this, he said, is always necessary because the CSLM tends to blur the colors: "The CSLM does not register the colors clearly." I looked into the microscope to check how the pictures were supposed to look—assuming that the image in the microscope would be the "original"

"figuration" is the process that "concretizes notions" (p. 124) by giving them graphic form; this process can be likened to the work that lies behind the CSLM-images. "Demonstration" builds on figuration and partakes in "show-and-tell exercise [rather] than logical proof" (p. 126). In practice, these authors argue, these two types of visualizations are superimposed and intertwined, as is also the case when regarding the CSLM/COMSTAT-representations.

we were trying to re-create on the computer screen and subsequently on paper. However, it was very difficult for me to tell what was insignificant blur and what was significant variation. This was true for the color-tagging as well as the gfp markers: it was impossible for me even to establish how the original looked. I asked the researcher, who was sitting next to me editing the picture, how he could be sure that what he was doing on the screen was "correct," when it was so difficult to see what the original looked like. Judging this, he answered, is a matter of practice. Having said that, he continued changing the blur into clarity: violets were changed into reds, grays into blacks, and turquoise into greens.[37]

The blurry quality of the line between reality and representation, and the interpretation necessary to decide whether turquoise "really" means blue or green, are aspects that the researchers are very familiar with. To illustrate this, I will quote another researcher from the Molecular Microbial Ecology Group:

> *F*: You have to touch it to understand it—I guess you do, too? It is a funny abstract way one makes it [the pictures]. You have some colored dots, and then you can make a lot out of that. It must be damned abstract for people coming from other areas. To me it is very simple . . . easy to understand . . . but I have to admit that it is difficult to explain. Especially to explain how we make conclusions . . . . It is hard to explain what we see from green and red. It has to do with legitimate interpretations. How much can you defend to put into those interpretations? There is a line . . .
>
> *JS*: How do you establish that line?
>
> *F*: It is something you learn from routine and experience . . . how much can you conclude from such a thing, and where is the line? Where do we stop? At which point can we no longer believe what we say? These are some of the hardest things.

By referring to tacitness, routine, and experience, this researcher stresses the contingent nature of scientific work. In effect, this was also what the researcher I observed did, when he dismissed my questions as

37. Samuel Edgerton and Michael Lynch notice something similar within astronomy: "What aesthetics means [in astronomy] is not a domain of beauty or expression which is detached from representational realism. Instead it is the very fabric of realism: the work of composing visible coherences, discriminating differences, consolidating entities, and establishing evident relations. . . . This hands-on process of "interpretation" can be treated as an art situation within the performance of scientific practice" (Samuel Edgerton and Michael Lynch, "Aesthetics and Digital Image Processing," in *Picturing Power*, ed. Gordon Fyfe and John Law [London/New York: Routledge, 1988], p. 212).

based on lack of practice. This is very interesting, for the trait commonly connected with *hard science* would be *universality* and not *contingency*. In regard to the CSLM-photographs, however, the researchers stress contingency as *legitimizing* the scientific status of the photographs (and not, as might be expected, the opposite), thus again suggesting that science and aesthetics cannot be seen as opposites in connection with the CSLM-pictures.[38] Likewise, the researchers stress *interpretation* as being a crucial task when working with the pictures. Interpretation is traditionally connected to aesthetics and not to science, hence the concepts of "interpretive sciences" and "exact sciences." This stresses that even references to universality and contingency, respectively, are contingent, and a part of the artisanal practices of science.

The Extra Meanings of Photography

Photography in itself bears many extra meanings that add to the meanings of the CSLM-photographs and influence their scientific status.

A photograph (of, e.g., a bacterium) can be argued to be an *iconographic* sign: a signifier that refers to the signified by means of physical resemblance;[39] interestingly, so is a graph.[40] The signified in this case is a system of bacteria, which has been placed in a specific situation—a now—that has been immortalized on the filmstrip. In "Rhetoric of the Image," Roland Barthes argues that photography holds a special status within sign systems, which originates in a direct link to the re-

38. Karin Knorr Cetina, in *Epistemic Cultures* (Cambridge/London: Harvard University Press, 1999), notes that the senses play very different roles in the two branches of science studied, particle physics and molecular biology. In molecular biology, she argues, the sensory body is important as a secondary tool: materials are continuously visually inspected, and on this background the status of the experiment, photograph, etc. is determined. Likewise, the researchers studied by Knorr Cetina—and the ones studies by me—underlined the importance of "being there" in the laboratory. Even researchers with many junior researchers and laboratory technicians working for them insisted on doing important experiments "with their own hands".

39. It has also been argued that pictures depict through denotative symbols. For further discussion, see Mitchell, *Reconfigured Eye* (above, n. 28), p. 24.

40. Rheinberger (*Toward a History of Epistemic Things* [above, n. 25], p. 103) notes that scientific representations follow the sign triad of Charles Sanders Peirce: symbols (analogies, hypothetical constructs), icons (models or simulations), and indices (experimental realizations). It is interesting that both CSLM and COMSTAT representations are icons (although their histories include different types of signs—e.g., indexes in the form of experiments), while at the same time they represent the two primary representational traditions pointed out by Peter Galison in *Image and Logic* (above, n. 34). This suggests that the type of sign is extremely plastic as regards content, and that differences in respect to attitudes toward them should be found elsewhere.

ality it refers to; in comparison, other sign systems are completely cut off from reality—not referring to reality, but addressing that which we think of as reality in what seems to be naturalness.[41]

This characteristic of the photographic medium—that it holds a special status among sign systems because of a closer correspondence to reality—means that photography in some aspects resembles "hard science," which also claims a special status (among epistemological systems) because of a closer correspondence to reality. This is commented on by Mitchell, who writes: "We feel the evidence it presents *corresponds* in some strong sense to reality, and (in accordance with correspondence theory of truth) that it is true because it does so."[42] He continues: "We have come to regard [photographs] not as pictures, but as formulae that metonymically evoke fragments of reality."[43] Thus, this characteristic of the photographic medium brings the photograph closer to the core of hard science: it is perceived as an objective, neutral investigation of something already existing. This is what Mitchell calls "the extraordinary tenacity of the camera's claim to credibility."[44]

Barthes´s claim that photography holds a privileged position when it comes to referring to reality can be disputed—and has been so by the later Barthes,[45] among many others. For instance, W. J. T. Mitchell writes the following of the postmodern "pictoral turn":

> Whatever the pictorial turn is, then, it should be clear that it is not a return to naïve mimesis, copy or correspondence theories of representation, or a renewed metaphysics of pictorial "presence": it is rather a postlinguistic, postsemiotic rediscovery of the picture as a complex interplay between visuality, apparatus, institutions, discourse, bodies, and figurality.[46]

On a less philosophical note, it has become obvious to all that the photographic medium is no more innocent than any other medium. Thus, it can be claimed that photography—both before and after the button is pressed—holds a number of possibilities of manipulation in regard to the CSLM-photographs. I regard this manipulation as being divided into three main categories: selection, manipulation,

41. Roland Barthes, "Rhetoric of the Image," in *Image, Music, Text*, ed. Stephen Heath (New York: Hill and Wang, 1977), pp. 32–51.

42. Mitchell, *Reconfigured Eye*, (above, n. 28), p. 24.

43. Ibid, p. 27.

44. Ibid.

45. Roland Barthes, *Camera Lucida* (London: Flamingo, 1981).

46. W. J. T. Mitchell, *Picture Theory* (Chicago/London: University of Chicago Press, 1994), p. 16.

and editing.[47] Through these examples of manipulation, photography is also removed from science and pushed toward aesthetics.

First, the very selection of a motif can be seen as an instance of manipulation. Many photographs would not only *look* different, they would also *mean* something different if what has been left out were still in the frame, or vice versa. In relation to the work done in the Molecular Microbial Ecology Group, this is what most of the researchers stress as a problem when explaining to me the pros and cons of CSLM-pictures: it is only too obvious that an individual has selected the motif—it has not presented itself, and it has not been chosen randomly.

Second, the motif itself can be manipulated. To say that the motifs of the CSLM-pictures are heavily manipulated is no exaggeration: the natural setting that the pictures refer to has very little to do with glass chambers, tubes, and pumps in a laboratory. Likewise, the bacteria in the chambers are not the same as those they represent: the wild types are not blue or red, and they are not able to shine with a green light when their metabolic systems are activated.

Third, much can be done during editing. In the rough end of the spectrum, shapes can be inserted into and removed from the picture; and in the more refined end, colors can be made brighter, fragments highlighted, and so forth. Editing the CSLM-photographs is a major task, the purpose of which is precisely to make the unclear become clear.

In conclusion, the medium of photography contains forces that pull it toward the core of traditional science (the direct link to reality established through the physical resemblance to reality—that which Mitchell calls the correspondence-theory quality of photographs), while others pull it toward aesthetics (selection, manipulation, editing). Thus, photography acquires a peculiar duplicity in its relation to reality: it can be perceived as the most "genuine" medium (when perceived in the commonsensical way of "Rhetoric of the Image"), but also as the most "fake" one (which should be obvious from the list of manipulations above). Thereby it also acquires a double status in relation to the scientific status of work that uses photography as representation and documentation.

This point can be illustrated further through Galison and Daston's discussion of "mechanical objectivity," which analyzes how, historically, the very mechanism of the mechanical representations was taken as a token of objectivity.[48] This somewhat naïve belief that ob-

47. William J. Mitchell's discussion of "Intention and Artifice" in photographs (*Reconfigured Eye* [above, n. 28] pp. 23—59) suggests that this is characteristic of photographs in general.

48. Daston and Galison, "Image of Objectivity" (above, n. 29).

jectivity can be ensured by mechanism has been tainted (we all know famous examples of "photos that lied"), and the photograph now holds a paradoxical double status in regard to subjectivity and objectivity: on the one hand, it is still seen as the most objective representative medium; and on the other hand, we all know that photographs can be manipulated, chosen for the purpose, edited. . . .

The researchers at the Molecular Microbial Ecology Group seem to perceive the forces that push the photograph toward aesthetics to be as powerful as the forces pulling toward science. In Galison's book *Image and Logic*, he describes the "image-tradition" and the "logic-tradition" as equally strong within physics.[49] If this goes for biology as well, this could explain the researchers' need for representations from both traditions.

In contrast, the layman seems to perceive photography as more reliable than graphs and diagrams. One way of understanding this difference between scientists and the rest of us is to consider the *practical work* that goes into the photographs, both in the sense of working with the motif (color-marking the bacteria) and in editing. It is obvious to anybody that these pictures are not the result of holding a snapshot camera over a lump of bacteria. This also means that technology is very visible in the photographs. They do not offer an easy way just to look at the bacteria represented; on the contrary, you are struck by questions such as How did they make this? How did they color the different strands? How is the 3-D effect achieved? It should be noted that these questions relate to the technology and work-practices, and *not* to the bacteria. Technology and practices end up being an implicit—but very important—motif, as is the case with works of art.[50] This is underlined by the fact that some researchers express great pleasure in technology: the visibility of technology means the visibility of practical skills—the mastering of that technology.

You could say that the photographs function as starting points of different chains of signifiers: one connoting the explicit, scientific meaning of the pictures (*Acinetobacter*, *P. putida*, benzyl alcohol, gfp, metabolism, toluene-degrading), the other connoting the implicit, aesthetic meaning of the pictures (techniques [gene splicing, probing], technology [CSLM], skill, artistry, creativity.) From this per-

49. Galison, *Image and Logic* (above, n. 34).

50. I think of the CSLM-photography as a medium that refers to itself, just like certain traditions within visual arts. Traditions such as cubism point to the work of applying paint to the canvas, and the work of the eye in deciphering that paint and making it into a picture, as much as they point to the motif. The motif can almost be perceived as an "alibi," and the result is a merger of representation and that which is represented.

spective, the sign-chains are equal, and it is no longer possible to separate denotative and connotative meaning. Instead, both sign-chains become connotations, underlining how "denotation is not the first meaning, but pretends to be so; under this illusion, it is ultimately no more than the last of the connotations."[51]

Conclusion

Aesthetics and science are intertwined in a very basic and practical sense in the making of CSLM-photographs. At the same time, traditional scientific representations (such as those produced by the COMSTAT program) are as constructed as the photographs. The essential difference to the researchers is that construction is not as *visible* in the COMSTAT-representations, which makes the representations seem less aesthetic and thus more scientific.

The schism between aesthetics/construction and science/investigation seems almost irrelevant when observing the *practice* of the researchers. Their practice utterly blurs the boundaries between the two and implodes the difference between representation and reality. However, there are still boundaries to consider; they do exist and do have practical consequences for the researchers. They exist as discourses within the scientific community and play decisive roles in many of the researchers' practical representational choices. The status of the CSLM-photographs—as boundary objects between science and aesthetics, between which strong demarcations can also be found—is something of a paradox: they are both the flagship and eye-catching device of the group—its face to the world—*and* something to be trivialized and joked about.

Interestingly, through my narration of the story of the CSLM-images and the COMSTAT-graphs, a series of concepts have been presented—concepts that can themselves be regarded as elements in a narrative, and analyzed as such. The elements I refer to are placed in a dichotomous relation throughout the story.[52] On the one side we find *images*, which were linked to *aesthetics* by the researchers in the beginning of the paper, and later to *subjectivity* by the same researchers. Subjectivity was linked to *scientific practice*, for no researcher would deny the presence of real and embodied researchers in the laboratory. Last, scientific practice was linked to *narratives*, first by the researcher who told the "real story" of the pictures of *Pseudomonas putida*, and second by me in narrating the story of the images. On a

51. Roland Barthes, *S/Z* (London: Cape, 1974), p. 9.

52. In setting up dichotomous structures to analyze narration, I am inspired by Algirdas Julien Greminas, *Strukturel Semantik* (1966; Copenhagen: Gorgen, 1974).

more general level, narrativity seems to be better able to capture practices, because it is stretched out in time as practices are, and it suits the type of real-time study that I have sought to conduct here.

On the other side of the dichotomy, *objectivity* was linked to *science*—through the description of aesthetics and subjectivity as nonscientific. Thus, science was equated with "Science" and not with "science in practice," which is obviously performed by real researchers in real time, and is hence deemed subjective. *Science* was then linked to *truthful images* because Scientific Truth is expressed in images (images performing the work of correspondence theory, presenting fragments of reality). The CSLM-images are the epitome of the efforts of the laboratory, the result of the purification work of inscription devices.

It is extremely important to notice, though, that the point of this paper is *not* to point out some dichotomous relation between science and aesthetics. Rather, it is the opposite: the important thing to notice in the presented dichotomy is the presence of the *image* on *both sides* of the dichotomy. Here is an occasion of "slippage": the "double nature" of the image underlines the point that a neat dichotomous split between science and aesthetics is never complete, because that which is cut out of science is also a prerequisite for science. In the laboratory in question, this double nature of the relation between science and aesthetics means that the aesthetically beautiful CSLM-photographs function simultaneously as the laboratory's crown jewel and as a back door through which all kinds of muddy, contingent, and "nonscientific" phenomena can slip in.

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