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Colouring the Human Landscapes

Lennart Nilsson and the Spectacular World of Scanning Electron Micrographs

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Abstract

This article explores the relationship between Swedish photographer Lennart Nilsson's scanning electron micrographs and commercial culture from the late 1960s to the mid-1980s. By retracing how Nilsson's micrographs of the internal structures of the human body were made, circulated, and received, its aim is to investigate three aspects of this relationship. First, it highlights how the complex and sometimes conflicting interplay between the photographer and various actors in science, industry and the media shaped the pictures and their trajectories. Second, it analyses the processes used to colour Nilsson's original black-and-white micrographs in relation to tendencies in the media and the advertising industry during this period. Third, it examines what motivated Nilsson and his collaborators in their use of colour and also the critical debates concerning the spectacular and commercial qualities of his pictures. In the concluding section, the implications of this analysis for the history of the objectivity of scientific images is discussed.

Keywords

Lennart Nilsson – scanning electron microscopy – scientific images and commercial culture

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In 1974 an image featured for the first time on the cover of the Swedish medical journal *Läkartidningen*, a space that earlier had been exclusively reserved for the index of its contents (Fig. 1). It was a scanning electron micrograph of a human embryo produced by the photographer Lennart Nilsson. Although photographs taken through scanning electron microscopes (SEM) had been around in the biological research literature for some years, they were still a novelty to the wider medical community. Moreover, Nilsson's cover image was bright blue whereas the majority of scanning electron micrographs were in black-and-white.¹ Clearly, this cover appealed to an interest in the representation of early embryonic life as much as to a fascination with the high resolution and three-dimensional quality of the image produced by the new instrument. For some contemporary commentators these kinds of colourful pictures signalled an alarming commercialisation of science and an assault on the objectivity of scientific work, whereas for others they offered an attractive means of communicating science to broader audiences.

At this time Nilsson (born in 1922) was already an internationally celebrated photographer with an extensive network of connections in the scientific world as well as in the media industry. He started off in the 1940s as a freelance photographer working mainly for Bonnier AB, the largest media company in Sweden. In the early 1950s he took a series of photographs of embryos and foetuses for a magazine article about the opposition to abortion among gynaecologists at the Women's Clinic of Sabbatsberg Hospital in Stockholm.² This article was the first publication in an extensive photographic project undertaken by Nilsson in collaboration with gynaecologists and researchers that culminated with the photo essay "Drama of Life before Birth," which was published in *Life* magazine in 1965, soon to be followed by the pregnancy guide *Ett barn blir till (A Child Is Born)*.³

Around 1970, through his informal and personal contacts, the photographer was given the opportunity to establish a SEM laboratory at Karolinska Institutet, the internationally renowned medical university in Stockholm (whose Nobel Assembly selects the laureates in Physiology and Medicine). With no scientific background or degree Nilsson nonetheless managed after some time to formalise his position within Karolinska Institutet's organisation, where for many years he collaborated with researchers on the documentation through micrographs of normal and disease processes (including cancer, HIV and SARS) in the human body.⁴

Earlier research on Nilsson, in particular by feminist scholars, has largely focused on the photographer's pictures of foetuses and their ideological meanings and uses.⁵ His SEM images

relating to subjects other than human reproduction have received less attention. Some have analysed the representation of the immune system in his book *Kroppens försvar* (*The Body Victorious*) and in *National Geographic* publications from the 1980s.⁶ Donna Haraway, for example, has observed that Nilsson's pictures of "inner space" are tethered to a colonial discourse.⁷ Further, Sarah S. Jain, Emily Martin and Marita Sturken have analysed the metaphor of warfare in Nilsson's imagery and noted that his highly aesthetic and vividly coloured images of the human "landscape" provide a kind of visual pleasure, even a sublime experience.⁸ Recent discussions have linked Nilsson's SEM images with other visual and media material, such as Nilsson's early television documentaries, in what Kim Sawchuk has described as the phenomenon of biotourism, the cultural fantasy of travelling through the interior of the human body.⁹

This article explores the relationship between Nilsson's SEM images and commercial culture primarily from the late 1960s to the mid-1980s. As Cyrus Mody has underlined, studies of scientific instruments have too often separated the phase of invention and replication from the phase of commercialisation and popularisation, tending to focus on the former. But the transformation of academic research into commercial products is not simply a one-way distribution process. According to Mody, the development and proliferation of advanced technologies are dependent on overlapping networks and organisations, both informal and formal, and money is only one factor in the exchange involved in academic research.¹⁰ Moreover, as a number of historians have pointed out, the commercialisation and mediatisation of science and medicine is far from being a recent historical phenomenon.¹¹ Drawing on these studies, I suggest that Nilsson's engagement with SEM did not follow a straight route from the laboratory to the market. Rather, commercial interests and considerations infused his work from the start.¹²

In particular, this article will investigate three aspects of the interaction between Nilsson's SEM images and commerce. First, it will highlight how the complex and sometimes conflicting interplay between the photographer and various actors in science, industry and the media shaped his pictures and their trajectories. Above all it will explore the formal and informal organisation of Karolinska Institutet through which Nilsson could gain access to and exchange knowledge, technical resources, personnel, prestige, PR and financial compensation. Second, it emphasises the pressure that the explosion of colour in the commercial culture of the period placed on the monochrome world of science. More

specifically, it will examine the processes used by Nilsson to add colour to his black-and-white micrographs, and how the photographer Gillis Häagg who assisted him refined these techniques based on his experience in the fields of art and advertising. Third, it will examine what motivated Nilsson and his collaborators in their use of colour and analyse the critical debates concerning the spectacular and commercial qualities of his pictures. By way of conclusion, the implications of this analysis for the history of the objectivity of scientific images will be discussed.

In Lorraine Daston and Peter Galison's account of the transformation of the ideals of scientific image making, they have argued that a shift from "representation" to "presentation" occurred in the late twentieth century.¹³ Their thesis seems to rely on the assumption that the impact of commercialisation and colour manipulation was a fairly recent phenomenon. I will instead suggest that the case of Nilsson's coloured SEM images demonstrates that these processes and practices were at work earlier, and that different ideals and practices regarding objectivity overlapped and co-existed.

This article draws on methodological insights from recent work in the history of science, as well as in the cultural history of media.¹⁴ It approaches the multifaceted character of Nilsson's work by looking at the production, dissemination, and reception of his SEM pictures. It was inspired by Robert Darnton's influential "communication circuit" model for analysing the interaction between the many agents involved in the transmission of meaning through different media and milieus.¹⁵ Such an approach is useful since it permits the recovery of the agency not only of Nilsson but also of researchers, commercial instrument-makers, collaborators in the image-making process, publishers and reviewers. However, Darnton's model has been criticised for not being able to capture the open-ended nature of the circulation of cultural objects. Acknowledging this, I emphasise the heterogeneous networks and conflicting motives of the contributors who were involved in the processes of disseminating Nilsson's scanning electron micrographs across various media and contexts.¹⁶

To achieve this I reviewed the comments on the photographer's colourised SEM pictures across a wide range of written and visual sources: the archives of Karolinska Institutet, scientific journals, popular science books, picture magazines, newspapers, television films, exhibitions, publicity material and advertisements. To complement this methodology, I conducted semi-structured interviews with key persons in Nilsson's network from the period, including co-workers, researchers and administrators at Karolinska Institutet, as well as sales

persons at scientific instrument companies and editors at the Bonnier publishing house.¹⁷ These interviews have provided me with crucial details not only concerning Nilsson's informal contacts and collaborators, but also regarding the introduction of SEM in Sweden. By comparing the interviews to one another and to written sources it has been possible to critically assess to some extent the information that was collected.¹⁸

1 Launching the New Vision

In 1965 the Cambridge Instrument Company marketed the first commercial SEM under the name of Steroscan. Researchers in biology, as well as physicists, chemists and metallurgists, were all interested in employing the instrument to visualize the surfaces of different objects. Within three years Cambridge Instruments was producing one hundred Steroscans per annum and Japanese companies were turning out even larger numbers of their own SEMs.¹⁹

With its seemingly three-dimensional images, the scanning electron microscope also created an international wave of interest among those working in the media and the arts. Pictures of crystal formations, pollen, blood cells, the eyes of flies and other subjects flooded the daily papers and illustrated magazines.²⁰ In addition, artists began to experiment with the new technology; Mark Boyle displayed images of enlarged sections of the human body at an exhibition held by the Institute of Contemporary Arts in London in 1969.²¹ In the mid-1970s David Scharf, an American engineer and photographer, started to produce SEM images that were presented as contributions to both art and science.²² There seems, however, to have been no direct contact between Nilsson and these international artists and photographers.

In 1968 two Cambridge Steroscans were acquired by institutions in Sweden – the Swedish Institute for Silicate Research at Chalmers University of Technology in Göteborg and the Geological Survey of Sweden at the National Museum of Natural History in Stockholm. Allan Danielsson, the head of the Geological Survey of Sweden, was also co-director of a commercial company – Analytica – that provided industry and universities with services such as chemical and environmental analyses, x-ray diffraction, and tests of materials. In 1969 he and three partners borrowed money to purchase a Cambridge Steroscan, installing it in Analytica's laboratory which was housed in an Art Nouveau villa just outside Stockholm. One of the partners was Göran Alsterborg, a physicist and colleague of Danielsson, and he undertook to market the instrument and interest customers in the new type of images it could

produce.²³ He held open lectures and courses, and contacted the press and other media, which followed up with articles and reports displaying spectacular pictures of objects such as diatoms, soot particles, rust on sheet iron, the edge of a broken razor blade, and the foot of a ladybug.²⁴ This eventually led Alsterborg to invite Nilsson to come and see what the instrument at Analytica was capable of doing. He was hoping that an association with the well-known photographer could help to generate interest in their services. To the scientist's immense satisfaction, Nilsson was thrilled by the images he could create with the Steroscan and soon started to work in the laboratory.²⁵

Nilsson already had some experience with optical microscopes, which he used in the late 1950s when working on a series of photographs of sperm and cervical mucus for his book *A Child Is Born*. He had acquired his microscopes from Carl Zeiss and established contacts with one of the company's sales representatives in Sweden who taught him elementary microscopy and the principal techniques for enhancing the contrast in his sample images.²⁶ But working with the SEM revealed itself to be an altogether different experience.

In contrast to the optical microscopes that Nilsson was familiar with, this instrument depended not on radiant energy but on electrons as its light source, which meant that many of the qualities that usually gave life to the surface studied (such as colour and reflections) ceased to exist. The world of the SEM was in black and white, even if the screen emitted a blue glow that lent a monochrome colour to the images photographed. Another difference was the three-dimensional quality of the SEM image, which was normally lacking in micrographs created by other means. The preliminary preparations were also more challenging. First the specimen had to be fixed, dehydrated and dried, and coated with gold or some other metal. The sample was then scanned by a focused electron beam, resulting in the formation of an image on a small screen. The final step was to photograph the image on the screen using a camera, and the end result was a black-and-white photo negative.²⁷

Nilsson brought all sorts of materials to Analytica's laboratory to be scanned: dust particles, white blood cells, bacteria, hair, taste buds from the tongue, embryos, etc. But he had to rely on the researchers and laboratory assistants at Karolinska Institutet to prepare his specimens. Some of these were new acquaintances made at the villa, such as the members of the research group from the Gustav V Research Institute who were working on a project on the inner ear. When taking his photographs, Nilsson used to sit at the Steroscan next to Alsterborg, who in practice managed the microscope while Nilsson told him what images he wanted and decided

when it was time to press the camera button, which he himself did. After many years of working with the SEM, Nilsson became more skilled at producing the images, but he was always reliant on technical support to prepare the specimens and maximise the performance of the instruments.²⁸

Several of the images that Nilsson made at Analytica were published in 1970 in a photo essay in *Life* entitled “The Worlds Within Us.” (Fig. 2) Alluding to the recent moon landings, the theme of a journey through the human body was evoked. The pictures of the interior of the body were described as human landscapes waiting to be revealed and traversed. For instance, a portion of the scalp with its hair was likened to a forest of aspens, a single hair from a beard was said to resemble a terraced hillside, and the taste buds in the mouth a field of mushrooms. It was suggested that these images were not only fascinating, but also crucially important for the scientists of the new decade: “In this underland of the commonplace may lie the answers to riddles that enwrap life itself.” Swedish picture magazines followed with similar images and stories.²⁹

After this international success, JEOL – a Japanese company that was seeking to obtain a foothold in the Western market – approached Nilsson, hoping to interest him in one of their scanning electron microscopes. Again the expectation was that the famed photographer would generate interest in the new technology and add extra value to JEOL’s brand. The outcome of these negotiations was that in 1970 Nilsson gained access to a JSM U3, the first year for free and then on a rental basis. In January 1976 he bought his own microscope, a JSM 35. During the next decade he bought four more models from JEOL, some of which were the highest resolution scanning electron microscopes available in Europe. All of these instruments were installed in the Department of Forensic Medicine at Karolinska Institutet. More than once JEOL was granted permission to use Nilsson’s pictures as marketing material. For instance, a micrograph of a killer cell was reproduced on the cover of the company’s journal.³⁰

It was no coincidence that Nilsson and his microscope were given space in the Department of Forensic Medicine. This was a strategic location for the photographer, since the forensic medical centre and the morgue were situated in the same building, giving him access to autopsy material. During the years spent working at different hospitals on material for *A Child Is Born*, Nilsson had become acquainted with Jan Lindberg, a forensic physician who later was employed as a doctoral student at Karolinska Institutet. Together they collaborated at Södersjukhuset to produce the series of images taken inside the heart and arteries that

eventually featured in an acclaimed article in *Life* in 1968.³¹ It was through Lindberg that Nilsson informally received permission to set up a SEM laboratory in the cellar of the department building, where laboratory animals had once been kept. He invested his own money in the renovation of the laboratories, but did not have to pay any rent or utility costs. In return it became one of the first departments at Karolinska Institutet to have a SEM. This laboratory obviously became an important resource for scientists interested in trying out the new visualization technique on their particular research material.³²

For several decades this provided the platform for Nilsson's collaboration with different individuals and groups at Karolinska Institutet. Many of the researchers, physicians and laboratory assistants who helped him did so without expecting any economic recompense. Nevertheless, the expensive, state-of-the-art equipment demanded not only specialized personnel but also other sources of funding. After the success of *A Child Is Born*, which was translated into many languages, Nilsson signed a contract on favourable terms with Bonnier, and his editor was eager to publish more of his work. He also had a contract with *Life* that brought him a good income until 1972, when the magazine ceased to be published weekly and came out sporadically, and then monthly from 1978. In the mid-1970s Nilsson signed an agreement with the German pharmaceutical company Boehringer Ingelheim, giving them the copyright to many of the images produced in the laboratory at Karolinska Institutet in return for economic support. In the end these arrangements would create conflicts over who owned the right to use Nilsson's pictures and for what purposes.³³

2 Selling and Disseminating Collaborative Work

From about 1970 Nilsson's SEM images of biological structures and entities started to circulate back and forth between different media and contexts. It is interesting to note that the making of the micrographs did not follow a simple path from the laboratory to the marketplace. Rather, there was intense traffic in both directions. As I will show, the content of the images was "remediated", or modified, in collaboration or independently by actors in various areas.³⁴

In a large part of these activities Lindberg acted as Nilsson's co-worker and, like most of his collaborators, helped him without any financial recompense. It seems that during the initial years of their collaboration the forensic physician had plans to write his dissertation on a topic

related to SEM, but for unclear reasons it was never finished and the images made at the laboratory were fed into Nilsson's commercial projects.³⁵ The first book that they worked on together was *Se människan (Behold Man)*, which was an anatomy book for the general public and was published by Bonnier in 1973. Initially conceived as a sequel, *The Body Victorious* which appeared in Swedish in 1985 turned out to be quite a different book, focusing on the human immune system.³⁶

A former editor at Bonnier, Rune Pettersson, testified to the difficulty of realizing the project *Behold Man*. When in the late 1960s Nilsson brought his first SEM images to the publisher's office, no one was quite sure what to make of them. There were thousands of transparencies and paper copies, without any notes telling what part of the body was being visualized. Pettersson, a zoologist recently recruited as a scientific and technical specialist by Bonnier, was set the task of making a book out of this material. Together with Nilsson and Lindberg he spent several weeks sorting the images on the basis of organ systems. After a while he realized that some of the images were useless because they showed artefacts resulting from damage incurred during the drying process. In other cases there were hundreds of almost identical copies of the same subject, such as a single hair, while other parts of the body were completely passed over. Nilsson himself had no distinct idea of what kind of book he wanted to create. Pettersson and Lindberg discussed several alternative models, but finally decided on the theme of "a journey through the body" since this was the only idea that worked with the miscellaneous collection of images brought by Nilsson, and for the title they chose a biblical quotation, "Behold Man". Pettersson then compiled long lists of the images required to complement the existing material and made sketches that Nilsson used when taking further SEM images in the laboratory at Karolinska Institutet. It seems that an analogous process characterized most of his subsequent book projects.³⁷

Some of the SEM images in *Behold Man* were produced by Nilsson in collaboration with the WHO Research and Training Centre in Human Reproduction, which had been established at Karolinska Institutet in 1972. The program was directed by Egon Diczfalussy and focused on research and the development of new contraceptives and abortion methods. In particular, Nilsson participated in Elisabeth Johannisson's research on the functioning of the human endometrium and the factors that were thought to affect it.³⁸ He also made SEM images for a related study of the fallopian tube undertaken by Eva Patek, and these were eventually published in journals such as *Fertility and Sterility*. Patek's doctoral dissertation, finished in

1974, was the first to use his pictures and it was not without pride that in the acknowledgements she thanked “the world-famous photographer” who had introduced her “to the fascinating world of the scanning electron microscope.”³⁹ An article on the advantages of using SEM in biological research signed by Nilsson, Patek, Johannisson and Lindberg appeared in *JEOL News*.⁴⁰ This joint publication earned Patek and Johannisson a reprimand from Diczfalussy not so much for the commercial context in which the study had appeared, but because he considered it inappropriate for the prestigious WHO centre to be associated with a forensic physician still lacking scientific accreditation.⁴¹

A couple of these SEM images of the human endometrium and the fallopian tube made their appearance in a setting that was quite specific to the period. One major policy directive of the government during the 1970s required scientists to disseminate their results in the public domain. After many political proposals and considerable debate, the directive was codified in the University Act of 1977, and their two main missions – education and research – were supplemented by what was increasingly referred to as the “Third task” of the universities.⁴² One early initiative was the publication of the journal *Forskning och framsteg* (“Research and Progress”) with the support of the Swedish Natural Science Council and the Medical Research Council. From the outset its editor Eric Dyring, a physicist, expressed his intention to include many pictures in the publication. Nilsson contributed illustrations for several articles, and one of these was written by Patek on the subject of the fallopian tube.⁴³

Another initiative was the exhibition *Synligt och osynligt: Vetenskapens nya bilder* (“Visible and Invisible: The New Images of Science”), which was inaugurated in 1973 at the Moderna Museet in Stockholm. Curated by Dyring, this exhibition displayed a large amount of visual material from the natural sciences, medicine and technology; for instance, remote sensing of the earth’s surface, high-speed photography, ultrasound scans and computer images. In the museum’s film room around sixty of Nilsson’s photographs of the human reproductive system were presented. A number of these images had been taken with the SEM. A JEOL microscope was also placed on display, which visitors were probably allowed to view but not interact with in any way. The exhibition then moved to the Louisiana Museum of Modern Art near Copenhagen and later to several art museums in Canada and the United States.⁴⁴

In addition to being displayed in art museums, Nilsson’s SEM images were “remediated” and used by the media and advertising industry. For instance, embryonic images from the same series as the picture that appeared on the cover of the 1974 issue of *Läkartidningen*

(mentioned at the beginning of this article) was reproduced in an essay by Nilsson and the journalist Stig Nordfeldt for the women's magazine *Damernas Värld* ("Ladies' World") on the difficult choice of abortion.⁴⁵ Further, a series of SEM images showing bacteria and caries were used in a 1976 advertisement for Bofors toothpaste, a product that had been developed by the Swedish weapons company of the same name, but without much success.⁴⁶ (Fig. 3) Similar pictures appeared in *The Body Victorious*, emphasising the public health aspects of the prevention of dental caries. Likewise, a micrograph image of a hair shown in a 1970 Clearasil shampoo advertisement was included in *Behold Man*.⁴⁷ Moreover, a selection of SEM images was borrowed by the Swedish public television service for films such as *Med Lennart Nilssons kamera i människans inre* (*Portrait of a Killer*, 1977) showing the progress of cardiovascular disease, and *Sagan om livet* (*The Saga of Life*, 1982) on human reproduction.⁴⁸ As these examples indicate, it is not always easy to determine whether a SEM image was originally produced for scientific/educational or commercial use. Through circulation and revision the same set of micrographs taken by Nilsson could acquire different meanings in different contexts.

There was an inherent tension in this fusion between the scientific and the commercial realms concerning who owned the copyright in cases of collaborative work. Since Nilsson had pressed the button on the camera the copyright to the micrographs belonged to him, but the issue could not be settled as easily as that. Alsterborg had invested considerable time in training and assisting Nilsson, hoping that Analytica might draw some commercial benefit from the partnership. But when the photographer published several pictures that had been taken at Analytica in his *Life* photo essay "The Worlds within Us" neither Alsterborg nor the company was mentioned.⁴⁹ The researchers from the Gustav V Research Institute who had shared their anatomical samples with Nilsson were also left out. When a report on the new vision of SEM in 1970 was published in *Kosmos*, the yearbook of the Swedish Physics Society, it included a jointly produced SEM image of the sensory cells in the inner ear, giving credit to all of the authors. However, when the same picture was published in *Life* only Nilsson was acknowledged. As a consequence the researchers decided not to give any credit to the photographer when they later used one of the pictures in an article published in a specialised scientific journal. Because of this dispute over credit, one of the scientists did not speak to Nilsson for several years but the disagreement was finally resolved. In *Behold Man*, which contained several images produced by Nilsson and members of the institute, the researchers were given a general thanks at the end of the book.⁵⁰

But there were other sources of disagreement in addition to these personal conflicts. Commercial interests had a concrete effect on the appearance of the SEM images, as the monochrome world of science suddenly exploded into colour. Clearly this was happening simultaneously in several scientific areas and fields. As Michael Lynch and Samuel Y. Edgerton have shown, astronomy was one of the earliest sciences to make use of digital image processing and the creation of “false colour” palettes in the handling and analysis of huge data sets. However, the resulting “pretty pictures” were mainly produced for press releases, popular science magazines and coffee table books, whereas “scientific images” – normally in black-and-white – appeared in scholarly publications such as the *Journal of Astrophysics*.⁵¹ By focusing on the colouring of Nilsson’s SEM images, and the disputes surrounding these activities, it is possible to reconstruct similar practices and tensions in medical research fields during the 1970s and 1980s.

3 Colouring the Inner Landscapes

It would however be a serious mistake to claim that colour had no particular relevance in scientific image making before the 1970s. On the contrary, as has been shown by several scholars, the skilful handling and appreciation of colours were characteristic of, for instance, scientific atlases during the sixteenth and seventeenth centuries. Anatomical wax models and *moulages* of skin diseases were also both three-dimensional and in colour. Not least of all, in the field of optical microscopy colour played a crucial role in enhancing contrast and highlighting details. From the mid-nineteenth century colour was added to black-and-white photographs either manually or by other processes to meet scientific or pedagogic objectives. The use of colour in brain imaging has also been highlighted in recent research.⁵²

At the same time it is crucial to note that the majority of the pictures in *Läkartidningen* and other medical publications around 1970 were still being printed in black-and-white. In contrast, the commercial domain was ablaze with colours. Since the late nineteenth century colour had slowly moved into a series of media that until then had been dominated by black-and-white: first chromolithography, then still photography, cinema, and finally television. Importantly, printing photographs became much simpler and less expensive with the development of offset lithography. By the mid-1960s colour pervaded the mainstream media and soon became a norm that, in opposition to black-and-white, signalled the “*here and now*

of perceived reality.”⁵³

This new chromatic media landscape is important if we wish to understand the conditions under which Nilsson was producing and selling his images. It was as a colour photographer that he had made his international breakthrough. The cover of *Life* magazine in 1965 presented his photo essay on human development as an “Unprecedented photographic feat in color.”⁵⁴ The series of spectacular photographs showing the inside of the heart and arteries which appeared in *Life* in 1968 were also produced using conventional colour film.⁵⁵ But the images taken using the SEM were necessarily on a grey scale. When Nilsson presented his first SEM images showing the taste buds in the mouth to the editors at *Life*, they are said to have declined them since the photographs were not in colour.⁵⁶ This was wholly in line with *Life*’s editorial policy as one of the first picture magazines to promote the use of colour in photojournalism.⁵⁷

In 1969 at a conference in Oslo arranged by the organization Europhot (European Professional Photographers) Nilsson met Gillis Häagg, an advertising and commercial photographer who was the director of a photo studio called the Flamingo. Häagg was quite well known in photographic circles in Sweden as a frequent contributor to major photographic magazines with pictures for their covers, and for making pop art posters. He was also one of the first photographers to exhibit colour photographs in an art gallery. At the conference Häagg gave a talk about his experiments in colour photography and showed landscape studies from the west coast not far from Göteborg. Nilsson was in the audience and afterwards he invited Häagg to come and see the SEM images of taste buds and hair on display in an exhibition arranged at the same time as the conference. (Fig. 4) Nilsson asked Häagg if it would be possible for him to add colour to these images using a technique similar to the ones described in his talk and, impressed by Nilsson’s work and international career, the commercial photographer accepted proposal at once.⁵⁸

A few experiments with the colouring of electron microscope images had already been made, some of them for use in publicity by the Cambridge Instrument Company but Häagg was not aware of any of these early, exploratory techniques.⁵⁹ Instead, he developed an original method that was extremely complicated and time-consuming. He had worked out the principle in the 1940s, when he was still in his teens and taking lessons in oil painting from artists associated with the “Halmstad group”, the most significant exponents of Surrealism in Sweden. While appreciating their visual style, which was influenced by artists such as

Salvador Dali and Yves Tanguy, Häagg found himself drawn more and more strongly to the medium of photography. He first took a job producing printing clichés and then at a photo firm. At home he experimented with different ways of controlling the colours he wanted to introduce into black-and-white photographs. Based on his work experience etching clichés he came up with the idea of making gelatin coatings which he could then colourise. But this proved unsuccessful and he then turned to the carbro-process that was popular in the advertising business at the time. This process was controllable under laboratory conditions and used separations that could be manipulated and retouched. With their vivid, glossy colours, carbro prints were often adopted by commercial photographers preparing advertisements for consumer products. Häagg's technique for colouring Nilsson's early SEM images was based on this process.⁶⁰ The underlying principle was to separate the grey tones in the original photograph and then translate them into shades of colour that had been estimated mathematically. (Fig. 5) First of all Häagg used a black-and-white negative to make several positives on lith film, an extremely high contrast film that was originally designed for the printing industry (the name derives from the lithographic process used to print magazines and books). Sometimes he made as many as twenty copies, each with different exposure time. In this way it was possible to cover the degrees of blackness in the negative, from the subject's darkest to its lightest part. He also used a tone-line technique to produce a line image similar to an outline drawing in ink on another piece of film (this was a popular visual effect in the media industry during the 1960s, especially for pictures of products, but also for posters and music album covers).

Häagg used this process, for instance, to colour the image of a staphylococcus bacteria being approached by white blood cells. (Fig. 6) In the darkroom an unexposed colour slide film was mounted in a print frame, and over this film the tone line, a mask that covered a part of the entire image – the part showing the staphylococcus – and one positive lith film were placed, and the composite was exposed to blue, green and red light in turn, with a different exposure time for each colour. During the exposures Häagg's son, who was almost ten years old, stood outside the darkroom directing the timekeeping. The procedure was repeated on the same colour slide film using each of the positives prepared by Häagg. Next, the mask that covered the staphylococcus was changed to a mask that covered other parts of the film and the entire procedure was repeated. Finally a colour slide with green shining bacteria could be sent to Nilsson for approval.⁶¹

During the 1980s Häagg started to use another technique for colouring the SEM images called the Kodak dye transfer, which he had mastered many years earlier. This process was introduced in 1945 and, like the carbro print, was a separation-based colour method demanding special skills and equipment and a great deal of time. Working from one of Nilsson's original SEM images, Häagg made three negatives by exposing the image three times with three different colour filters – blue, red and green. These negatives were then exposed to a “matrix” film (a gelatin-coated material), resulting in positives (often called “matrices”) that stood out from the surface in slight relief. Each of the matrices was soaked in a dye of the correct subtractive colour, and then sequentially printed on gelatin-coated paper. This method allowed Häagg to make subtle changes in the hues and contrasts of the individual print by changing the acidity of his dye baths. He could alter the background, highlight a detail, compose montages and retouch the image. Several of the pictures in *The Body Victorious* were made using this process.⁶² (Fig. 7)

Thus, in the 1970s and 1980s carbro and dye transfer provided Häagg with the tools to convert Nilsson's black-and-white images into colour images with the precise shades of hue that he wanted them to have. These techniques were creative adaptations of processes that had dominated commercial photography three decades earlier. Interestingly, Technicolour motion films, famous for their vivid and vibrant colours, were produced using an analogous subtractive colour system.⁶³ These were complicated and expensive techniques that fell out of use when single-sheet colour films such as Kodachrome and Agfacolour were invented shortly before the Second World War. Once dominant, they nevertheless did not completely disappear, but persisted as “residual” media, to use a term suggested by Charles R. Acland.⁶⁴ Häagg was part of an increasingly exclusive group of photographers who continued to use dye transfer for the depths of pure glowing colour that it could achieve as well as for its resistance to deterioration over time (conventional colour images and film tended to fade and discolour). Unbeknownst to him the nature photographer Eliot Porter, as well as Harold E. Edgerton who was famed for his high-speed flash photography, both taught themselves the intricacies of this process.⁶⁵ In the early 1990s the Eastman Kodak Company ceased production of the matrix film for dye transfers. However, Häagg had stockpiled enough chemicals, dye and paper to allow him to continue printing for several years. Up until that moment, for commercial reasons he had kept his methods for colouring micrographs secret.

Häagg, in contrast to the forensic physician Lindberg, had signed a contract with Nilsson and

was compensated financially for his work, but he was seldom given much credit in the publications. This did not undermine their professional relationship and they continued to collaborate on various projects for many years. But when a new edition of *A Child Is Born* was prepared in the late 1990s, the editors at Bonnier wanted to use digital techniques to colour the material instead of Häagg's meticulous process.⁶⁶ Nilsson agreed and a company in central Stockholm worked for two years with both a series of new SEM images and some of the older images that Häagg had once used as originals for his coloured versions. But all of a sudden, Nilsson changed his mind and paradoxically declared that he wanted no digital images to be used since they were faked. Apparently he had become aware of the widespread debate over the manipulation and fabrication of digital images.⁶⁷ As a result he resumed his collaboration with Häagg, who coloured most of the pictures for the fourth edition of *A Child Is Born*, published in 2003.

This, however, was their last collaborative effort because Nilsson's image archive then entered the Photoshop era, although he himself refused to give up his analogue cameras.⁶⁸

4 Colours in Conflict

From 1970 onwards Nilsson's micrographs circulated in books, journals, magazines, daily papers, films, exhibitions, health campaigns, publicity material, advertisements and even on the Swedish 100 kronor banknote. Many of these pictures were in colour, but Häagg had not always been involved in their production. Some of the blue images in *Behold Man* and *The Body Victorious* were simply photographs taken of the image projected on the screen of the microscope without subsequent manipulation. Others were in monochrome yellow, an effect that Nilsson may have achieved using colour toning or filters. It was expensive to call upon the creative talents of Häagg and other, less expensive methods allowed Nilsson himself to add at least some touch of colour to his material. At the same time and for other reasons, some images were displayed in black-and-white. It is worth trying to understand these different uses and justifications for colour – or the lack of colour – in photography from a cultural historical perspective.

As observed by the film historian Tom Gunning, colour played a contradictory role for most of the first period in the history of photography and the cinema, from 1860 to 1960. From one perspective, the development of colour technology was necessary to attain the ideal of

producing realistic images of the visual world. But colour was applied much more often for its sensuous and spectacular effects. Gunning also stresses that the proliferation of colour in everyday life threatened the conceptions of elitist high culture. Colour was thought by many critics and intellectuals to be dangerous because it represented the emerging commercial culture, which addressed the senses and emotions rather than rational behaviour. By the 1960s colour won a degree of acceptance, but could still disturb cultural hierarchies through its association with artificiality and fantasy.⁶⁹ Nonetheless, as another film scholar, Richard Misek, has pointed out, colour images were frequently perceived as a format of the present, whereas black-and-white images documented the past, or else signified 'realism'. In the 1970s such uses of monochrome were most apparent in documentaries and news reports.⁷⁰

Nilsson's editors and co-authors seldom commented on the colouring of his SEM images, and when they did so it was only in vague, generalized terms with the assumption that the objective was to achieve complete realism. For instance, in the 1970 issue of *Life* magazine, it was stated that after Nilsson had produced his black-and-white pictures, "[a] team of experts, using filters, then added colour that matched as closely as possible most of the hues of the original tissues." In *Behold Man* Nilsson explained that the pore had been colourised to create a more highly defined image.⁷¹ In subsequent books, from *Nära naturen (Close to Nature)* and *The Body Victorious* to the fourth edition of *A Child Is Born*, the same justification was given – "for the sake of clarity" the images had been colourised artificially using a special method.⁷²

The desire to create realistic effects was clearly the driving force behind Häagg's work with Nilsson's micrographs. His ambition was to add colour that looked natural so the viewer did not have the impression that the images had been colourised. In consultation with Nilsson, he created a kind of standardised palette based on the notion that some colours matched the biological objects in the images more closely than others. Although not applied consistently, this idea was put into practice in *Behold Man*, as well as in *The Body Victorious* and *The Incredible Machine*. Red, brown and pink were linked to what was "human", while to the "alien" were assigned "non-organic" colours. Red blood cells became red, macrophages and lymphocytes pink or lilac, bacteria and viruses green or yellow. In the world of human reproduction, egg cells were coloured yellow and spermatozoa became blue or grey. The brain was assigned a bluish shade since it was considered to be associated with "cool" rational thinking. However, Häagg did not wish to regard them as "false colours" (unlike the

astronomers when they began using digital technology, as Lynch and Edgerton observed in their ethnographic study), as this would have implied that he was trying to *deceive* his viewers. Rather, through his colour code he wanted to provide a pedagogical key that would help viewers to understand what was depicted in the images.⁷³ All the same, this colour palette was an expression of culturally established norms of body, sexuality and gender.

Thus, the standardised colour scheme further accentuated Nilsson and Häagg's rendition of the inner body as landscape. It emphasized the sense of depth in the SEM images and created an impression of vast terrains waiting to be explored. The reds, blues, yellows and greens made it possible to distinguish different elements in the image and thereby assign to them roles in a drama featuring valiant sperm fighting their way to the waiting egg or a story about the body's defence forces combating hostile invaders.⁷⁴ But at the same time the colours performed something more than a narrative function. The astonishing brightness of the pictures in *The Body Victorious* and *National Geographic* publications is an indication that they could also be placed in the tradition of sensual and spectacular colours relating to advertising and commercial photography, as well as to Pop Art. They functioned as attention-grabbing attractions rather than the work of a subtle and delicate hand.⁷⁵

This association of colour with the realm of sensationalism and artificiality was articulated in several reviews of *Behold Man* in the daily press. Nilsson and Häagg's pictures were praised as surrealistic landscapes, rendering the tiny as huge and monstrous, and painting these elements in strange and fantastic colours. But some commentators complained that the colour degraded the informational value of the book. They questioned the introduction of aesthetic and commercial aspects into Nilsson's anatomy project. As one of them put it: "It may sound petty but what functions will the book serve? And an unpleasant but very possible answer is: it will lie on a table in the salon and be a colourful flip book; the gift book of year." He felt that it was a "lie" to depict the human inner body in artificial colours.⁷⁶

This tension between using colours for realistic or for spectacular effects could also explain the inclusion of hand-drawn illustrations in Nilsson's books. Pettersson, his editor at Bonnier, who had a background as zoologist, wanted drawings for *Behold Man* since he thought that the photographs were not sufficiently clear and distinct. He felt that they needed supplementation so that readers could understand from what angles the objects had been visualized. Both Nilsson and the editor-in-chief protested since they were afraid that this would make his book look like a dry academic text. However, Lindberg took Pettersson's side

and some drawings were produced. In subsequent books such as *The Body Victorious* drawings were used as devices for clarifying Häagg's colourised images.⁷⁷ Sometimes it was the colour scheme rather than the difference in media (drawing versus photograph) that clashed. For instance, when the medical illustrator Urban Frank made the drawing of a cell for *The Body Victorious* he envisaged it as slightly transparent with blue and violet tones. But since Häagg's colourised micrograph of the same cell was in shades of brown and yellow he had to draw it again.⁷⁸

Initially not many researchers at Karolinska Institutet appreciated Nilsson's colourised SEM images. Some even asked whether someone brought in from the outside and without any scientific training should be allowed to use their SEM at all. Particularly among the more theoretically-oriented researchers – such as the institute's histologists, chemists and physiologists – there were several who criticised the photographer, although not officially. They maintained that micrographs in black-and-white were more valuable since it was in the grey scale that the information resided, and colour did not add data of any significance. Nilsson's images were not considered to be true, but manipulated or in some cases fake. Even some of his collaborators remained sceptical and dismissed them as “pseudo”.⁷⁹ Significantly, the images appearing in Patek's dissertation were in black-and-white.⁸⁰ This critique reminds us of the hierarchical distinction that was made between “pretty pictures” and “scientific images” by the astronomers who shortly afterwards introduced colours into their digital images.⁸¹

Although the motivation for rejecting colour was declared to be scientific, it is possible to detect a cultural dimension in this attitude. As already indicated, the use of black-and-white in some mainstream and experimental media continued to be regarded as the expression of an indexical or documentary relationship between image and reality. At the same time and from another perspective, the majority of art photographers continued to prefer monochrome images during the 1960s and well into the 1970s. Walker Evans, for instance, viewed colour as being too deeply ingrained in commercial culture to be used by serious artists.⁸² The early SEM images by the artist Mark Boyle and the photographer David Scharf were rigorously presented in black-and-white.⁸³

The dismissal of Nilsson's coloured images can be seen in this context. His contribution to colour photography disqualified him in the eyes of the art world and, evoking associations to kitsch and commerce, he was sometimes called the “McDonald's of photography.”⁸⁴ I would

suggest that these types of cultural ideals and values also informed the declaration of the researchers at Karolinska Institutet that scientific truth lies in the grey scale. This cultural prejudice can also explain why the commercial sector sometimes preferred Nilsson's black-and-white SEM images. Desiring an authoritative and "scientific" look, the advertising agency which produced the 1976 advertising campaign for Bofors toothpaste was not interested in colouring the micrographs of bacteria and a tooth cavity.⁸⁵

Nilsson himself at one point was anxious to point out that colourisation was not introduced with distorted motives: "I describe *everything* completely objectively. I never have an ulterior motive, I am never subjective. Never. I depict life in itself, which operates without personal intervention".⁸⁶ On another occasion he admitted that he manipulated his images, but only for the sake of clarification and then added: "I am no friend of colourising black-and-white images and in the future I will do it more seldom".⁸⁷ These statements, made in the daily press, were unmistakably directed at critical researchers and colleagues. But "pretty pictures" had come to stay in the medical world, as suggested by the cover of *Läkartidningen*. After the 1974 issue with the spectacular blue SEM image of a human embryo on its cover, the journal – which was the official organ of the Swedish Medical Association – began to regularly feature colour images by Nilsson, as well as other photographers, on its front cover.⁸⁸

Nevertheless, as his national and international reputation grew, Nilsson gained more acceptance even among his critics at the institute. In 1976 Karolinska Institutet awarded him an honorary medical degree, stating among his achievements that he "had made unique contributions to medical research and education." His images were said to be "strongly suggestive and informative," and it was not only instructive but also "an aesthetic experience of great stature to take part in Lennart Nilsson's photographic production." Shortly afterwards an exhibition dedicated to Nilsson's optical microscopic and SEM images was held in the administration building and, among the fifty images on display, several were in colour. At this point Karolinska Institutet began to use his work in its campaign to promote itself as a leading university of international stature, while at the same time the photographer was able to legitimise his work as scientific.⁸⁹

5 Objectivity and the Colourisation of Nature

As this article has shown, Nilsson's SEM activities were from the very outset embedded in

commercial enterprises. At Analytica's private laboratory his early use of the Cambridge Stereoscan with the assistance of Alsterborg was in part intended to gain recognition for the company and its services. When he decided to upgrade to a state-of-the-art instrument from JEOL, the Japanese company granted him use of their microscope free of charge, hoping to capitalize on the growing international fame of the *Life* photographer in order to expand its market share and profits. When Nilsson set up his SEM laboratory at Karolinska Institutet researchers from around the world flocked to Stockholm to try out the visualization technology on their biological materials. Later the micrographs were used to brand and market the university both nationally and internationally. The photographer, on the other hand, could mobilise his expanding network of contacts to obtain the specimens and expertise necessary to produce spectacular images of the inner body which he then sold to *Life*, Bonnier Publishing, the Swedish public television service, Bofors, Clearasil and Boehringer Ingelheim. Another arena for Nilsson's images was provided by the initiatives taken in the wake of the new governmental law that emphasized the dissemination of information on publicly funded research and development to the public. Thus, Nilsson's SEM images demonstrate how the scientific and commercial worlds were already closely interconnected in the 1970s.

What is the pertinence of this case to current historical discussions on the relations between science, photography and conceptions of truth? In Lorraine Daston and Peter Galison's influential account of the history of objectivity in the observational sciences, they stress that ideals and practices do not replace one other, but rather messily co-exist. Yet it is difficult not to read their account of the shift from representation to presentation in current scientific image making as a progressive story.⁹⁰ Traditional atlases aimed, through representation, at fidelity to nature following the idea either of "truth to nature" or "mechanical objectivity" or "trained judgment". Collections of the newer forms of images, on the other hand, have less to do with representation than with "presentation". According to Daston and Galison, these types of pictures function as tools to transform things: presenting scientific objects as commodities or as works of art. At the same time, the scientific self is transformed into a "hybrid figure" combining the attitudes of the scientist and the engineer as well as the artist.⁹¹ This analysis seems to rely on several assumptions only vaguely hinted at by Daston and Galison. Firstly, it can be related to discussions that have emphasised the growing commercialisation of scientific research.⁹² From this perspective the transformations in scientific image making become instances of the growing number of intersections between science, industry and

commerce taking place from the 1980s onwards. Secondly, it is evident that the advent of digital technology has shaped Daston and Galison's perception of the manipulation, simulation, and false colour as something characteristic of the contemporary image landscape.⁹³ They dwell at length on the novelty and impact of these processes. It is hard to escape the impression that, in order to be able to locate the shift from representation to presentation, they have allowed for less messiness and overlapping in their analysis of the present situation than earlier periods.

However, an examination of the uses and connotations of colour in Nilsson's SEM images disrupts this orderly account of recent shifts in the history of objectivity. As I have shown, Hägg's colourisation of his three-dimensional looking images was initially undertaken for commercial reasons. Drawing on his experience of pre-Second World War colour photography and inspired by the explosion of colour in the visual culture of the 1960s and 1970s, his objectives as he coloured the "human landscapes" were a mixture of realism and sensationalism. Thus, well before the advent of digital colour manipulation, and with a little help from some friends and a powerful scientific research institution, Nilsson manufactured and circulated SEM images in ways that were meant to be pleasing, clarifying, persuasive, and selling.

As my discussion above has indicated, it is not possible to distinguish one particular conception of objectivity linked to Nilsson's early SEM images. While he himself, at least officially, professed an ideal of mechanical objectivity, the argument developed by his editor at Bonnier that traditional scientific drawings were indispensable to clarify what the photographs were displaying was more in line with a truth-to-nature strategy. Researchers at Karolinska Institutet, on the other hand, advocated the notion of trained judgment and those who were critical of Nilsson claimed that he totally lacked the capacity to evaluate the information contained in black-and-white SEM images. Thus, several overlapping and sometimes contradictory ideas and uses of objectivity existed at the same time.

It might be objected that Nilsson has no place in the history of scientific objectivity since he was not a scientific image-maker and even his SEM images belong to popular science rather than to scientific research. But there has never been a clear-cut divide between the world of science and the world of commerce and popular culture. As this article has demonstrated, Nilsson's SEM activities were entangled with academic, industrial and commercial interests from the very start. Together with his collaborators at Analytica, JEOL, Karolinska Institutet,

Life, Bonnier, Boehringer Ingelheim and the Flamingo photo studio, Nilsson was linked to a partially informal network that exchanged resources of various kinds. Turning black-and-white SEM images into colourful attractions made them easy to market in various sectors: from scientific evidence, research information, pedagogy and popularisation to art, publicity and advertising.

Captions

1. In the early 1970s Lennart Nilsson and Jan Lindberg presented a series of scanning electron micrographs of human embryos in the Swedish medical journal *Läkartidningen* that attracted considerable attention. This was due both to the newness of the visualization technique and the occurrence of a colour image appearing for the first time on the front page of the journal. Cover of *Läkartidningen*, 1974, 71 (35). Lennart Nilsson/TT News Agency.
2. One of the first scanning electron micrographs Nilsson published showed the taste buds of a newborn's tongue. From Lennart Nilsson and Stig Nordfeldt, "Detta är du: En okänd värld på väg att upptäckas", *Se*, 1970 (10). Lennart Nilsson/TT News Agency.
3. Scanning electron micrographs of dental caries appeared both in Nilsson's popular medicine book *The Body Victorious* and in this advertisement for Bofors toothpaste. The caption reads, "Look at Lennart Nilsson's pictures and you will understand what Bofors protects you against". From *Veckojournalen*, 1976 (8). Lennart Nilsson/TT News Agency.
4. Lennart Nilsson at the photographic exhibition in Oslo in 1969. On both his sides are displays with the early black-and-white scanning electron micrographs on taste buds. From Göran Alsterborg, "Bilder med otroligt skärpedjup genom nytt scanning-mikroskop", *Fotonyheterna*, 1969, 9 (8).
5. The photographer and adman Gillis Häagg was engaged to colour Nilsson's black-and-white scanning electron micrographs. He developed a complicated method that was based in separating the grey tones and then convert them into shades of colour. From Lennart Nilsson and Stig Nordfeldt, "Här går startskottet till en ny människa!", *Se*, 1970 (11).

6. The staphylococcus bacteria in one of Nilsson's black-and-white images became green shining by Gillis Hägg's creative employment of the carbro-process. From Lennart Nilsson and Jan Lindberg, *Behold Man: A Photographic Journey of Discovery Inside the Body* (London: Harrap, 1974). Lennart Nilsson/TT News Agency.

7. Gillis Hägg used the dye transfer process to colour this picture of two cancer cells each on the side of a killer cell. From Lennart Nilsson, *The Body Victorious: The Illustrated Story of Our Immune System and Other Defences of the Human Body* (London: Faber and Faber, 1987). Lennart Nilsson/TT News Agency.

¹ Jan Lindberg, Lennart Nilsson, "Embryonalstudier med svepelektronmikroskop," *Läkartidningen*, 1974, 71:3181–3196

² Solveig Jülich, "Lennart Nilssons tidiga fosterfotografier: Från abortdebatt till sexualundervisning", in *In på bara huden: Medicinhistoriska studier tillägnade Karin Johannisson*, edited by Torbjörn Gustafsson Chorell, Maja Bondestam (Nora: Nya Doxa, 2010).

³ Lennart Nilsson, Albert Rosenfeld, "Drama of Life before Birth," *Life*, April 30, 1965:54–72a; Lennart Nilsson, Axel Ingelman-Sundberg, Claes Wirsén, *Ett barn blir till: En bildskildring av de nio månaderna före födelsen: En praktisk rådgivare för den blivande mamman* (Stockholm: Bonnier, 1965). The first American and British editions were published in 1966 and 1967. For a recent study, see Solveig Jülich, "The Making of a Best-selling Book on Reproduction: Lennart Nilsson's *A Child Is Born*", *Bulletin of the History of Medicine*, forthcoming, Summer 2015.

⁴ Solveig Jülich, "Objektiva bilder: Ideal och strategier," *Medicinen blir till vetenskap: Karolinska Institutet under två århundraden*, edited by Karin Johannisson, Ingemar Nilsson, Roger Qvarsell (Stockholm: Karolinska Institutet University Press, 2010).

⁵ There is an extensive literature on this theme. See, for instance, Sarah Franklin, "Fetal Fascinations: New Dimensions to the Medical-Scientific Construction of Fetal Personhood," *Off-Centre: Feminism and Cultural Studies*, edited by Sarah Franklin, Celia Lury, Jackie Stacey (London: HarperCollins Academic, 1991); Emily Martin, "The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles," *Signs*, 1991, 16:485–501; Carol A. Stabile, "Shooting the Mother: Fetal Photography and the Politics

of Disappearance,” *Camera Obscura*, 1993, 28:179–205, and, more recently, Mette Bryld, Nina Lykke, “From Rambo Sperm to Egg Queens: Two Versions of Lennart Nilsson’s Film on Human Reproduction,” in *Bits of Life: Feminism at the Intersections of Media, Bioscience and Technology*, edited by Anneke Smelik, Nina Lykke (Seattle: University of Washington Press, 2008).

⁶ Lennart Nilsson, *Kroppens försvar: En bilderbok om hoten mot kroppen och hur kroppens immunförsvar fungerar* (Stockholm: Bonnier, 1985). The full title of the English edition was *The Body Victorious: The Illustrated Story of Our Immune System and Other Defences of the Human Body* (London: Faber and Faber, 1987). *The National Geographic* publications include C.D.B. Bryan, *The National Geographic Society: 100 Years of Adventure and Discovery* (Oxford: Phaidon, 1987); Robert M. Poole (ed.), *The Incredible Machine* (Washington, d.c.: National Geographic Society, 1986).

⁷ Donna Haraway, *Simians, Cyborgs and Women* (New York: Routledge, 1991), p. 222.

⁸ Sarah S. Jain, “Mysterious Delicacies and Ambiguous Agents: Lennart Nilsson in National Geographic,” *Configurations*, 1998, 6:373–394; Emily Martin, *Flexible Bodies: Tracking Immunity in American Culture from the Days of Polio to the Age of aids* (Boston: Beacon Press, 1994); Marita Sturken, *Tangled Memories: The Vietnam War, the aids Epidemic, and the Politics of Remembering* (Berkeley: University of California Press, 1997).

⁹ Solveig Jülich “Televising Inner Space: Lennart Nilsson’s Early Medical Documentaries on the Interior of the Human Body,” in *Representational Machines: Photography and the Production of Space*, edited by Anna Dahlgren, Dag Petersson, Nina Lager Vestberg (Aarhus: Aarhus University Press, 2013). On other instances of “biotourism” in popular culture, see Kim Sawchuk, “Biotourism, Fantastic Voyage, and Sublime Inner Space,” in *Wild Science: Reading Feminism, Medicine and the Media*, edited by Janine Marchessault, Kim Sawchuk (London: Routledge, 2000). See also the collection of essays in the recent monograph issue “Ways of Voyaging through the Human Body: A Multimedia Survey,” edited by Francesco Paolo de Ceglia, Claudio Pogliano, *Nuncius*, 2011, 26:7–241.

¹⁰ Cyrus C.M. Mody, “Corporations, Universities, and Instrumental Communities: Commercializing Probe Microscopy, 1981–1996,” *Technology and Culture*, 2005, 47:56–80.

¹¹ Virginia Berridge, Kelly Loughlin (eds.), *Medicine, the Market and the Mass Media: Producing Health in the Twentieth Century* (New York: Routledge, 2005); Jean-Paul Gaudillière, Ilana Löwy (eds.), *The Invisible Industrialist: Manufactures and the Production of Scientific Knowledge* (Basingstoke: Macmillan, 1998); Karl Grandin, Nina Wormbs, Sven Widmalm (eds.), *The Science-Industry Nexus: History, Policy, Implications, Nobel Symposium 123* (Sagamore Beach, MA: Science History Publications/USA, 2004); Bernward Joerges, Terry Shinn (eds.), *Instrumentation: Between Science, State and Industry* (Boston: Kluwer Academic Publishers, 2000); Steven Shapin, "Ivory Trade", *London Review of Books*, September 11, 2003, 25:15–19.

¹² There are interesting similarities between Nilsson's adaptation of new visualization techniques and the way that science, engineering and commerce came together in the highspeed photographs and movies made by the American engineer and photographer Harold E. Edgerton in the 1930s and 1940s. However, Nilsson is not himself an inventor or researcher but has been dependent on other people's inventive skills and expertise. For a recent study of Edgerton, see Richard L. Kremer, "Educating the High-Speed Eye: Harold E. Edgerton's Early Visual Conventions," in *The Educated Eye: Visual Culture and Pedagogy the Life Sciences*, edited by Nancy Anderson, Michael R. Dietrich (Lebanon: Dartmouth College Press, 2012).

¹³ Lorraine Daston, Peter Galison, *Objectivity* (New York: Zone Books, 2007). For critical discussions, see Theodore M. Porter, "The Objective Self," *Victorian Studies*, 2008, 50:641–647; Jennifer Tucker, "Objectivity, Collective Sight, and Scientific Personae," *Victorian Studies*, 2008, 50:648–657; Amanda Anderson, "Epistemological Liberalism," *Victorian Studies*, 2008, 50:658–665; Lorraine Daston, Peter Galison, "Response: *Objectivity* and Its Critics," *Victorian Studies*, 2008, 50:666–677.

¹⁴ For current discussions with relevance for this study, see especially James A. Secord, "Knowledge in Transit", *Isis*, 2004, 95:654–672; Anders Ekström, Solveig Jülich, Frans Lundgren, Per Wisselgren, "Introduction", in *History of Participatory Media: Politics and Publics, 1750–2000*, ed. idem (New York: Routledge, 2011).

¹⁵ Robert Darnton, "What is the History of Books?," in *The Kiss of Lamourette: Reflections in Cultural History* (London: Faber and Faber, 1990), pp. 107–135; "An Early Information

Society: News and the Media in Eighteenth-Century Paris,” *The American Historical Review*, 2000, 105:1–35.

¹⁶ On the critique of Robert Darnton’s “communication circuit,” see for instance, Helen Smith, *Grossly Material Things: Women and Book Production in Early Modern England* (Oxford: Oxford University Press, 2012), pp. 6–8.

¹⁷ The interviews were conducted in 2008–2009 and the recordings are in the possession of the author. An interview with Nilsson (January 17, 2009) has not been included since, due to his advanced age, he did not recall the details of the events I inquired about.

¹⁸ For a discussion on related methodological issues, see Soraya de Chadarevian, “Using Interviews to Write the History of Science,” in *The Historiography of Contemporary Science and Technology*, edited by Thomas Söderqvist (Amsterdam: Harwood Academic, 1997), pp. 51–70.

¹⁹ The history of microscopy has been the focus of several in-depth studies. See for instance Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton: Princeton University Press, 1995); Nicolas Rasmussen, *Picture Control: The Electron Microscope and the Transformation of Biology in America, 1940–1960* (Stanford: Stanford University Press, 1997); Cyrus C.M. Mody, *Instrumental Community: Probe Microscopy and the Path to Nanotechnology* (Cambridge, Mass.: MIT Press, 2011). SEM has received less attention, but for some short historical overviews, see Brian J. Ford, “The Royal Society and the Microscope,” *Notes and Records of the Royal Society*, 2001, 55:29–49, p. 43; Dennis McMullan, “SEM – Past, Present and Future,” *Journal of Microscopy*, 1989, 155:372–392; Nicolas Rasmussen, Peter Hawkes, “Microscopes, Electron,” in *Instruments of Science: An Historical Encyclopedia*, edited by Robert Bud, Deborah Jean Warner (New York: Science Museum, London, and National Museum of American History, Smithsonian Institution, in association with Garland, 1998), p. 384.

²⁰ See, for instance, “Fly’s Tongue in 3–d,” *Life*, May 1, 1964:69–70, p. 72.

²¹ J.L. Locher, Mark Boyle, *Mark Boyle’s Journey to the Surface of the Earth* (Stuttgart: Hansjörg Mayer, 1978), pp. 124–130. According to his son, Sebastian Boyle, these SEM images had been taken at Brunel University of London. See e-mail from Sebastian Boyle to the author (May 21, 2010).

²² David Scharf, *Magnifications: Photography with the Scanning Electron Microscope* (New York: Schocken Books, 1977).

²³ The description in this paragraph is based on an interview with Göran Alsterborg (January 30, 2009), and e-mail correspondence with the author (February 11, 15 and 18, 2009).

²⁴ Interview with Alsterborg (cit. note 23). Björn Berglund, Göran Alsterborg, Urve Miller, Gunnar Källström, “Nu kan vi se kiselalgerna: De okända skönhetererna i en vattendroppe”, *Dagens Nyheter*, November 30, 1969; Stig Nordfeldt, “Miljön under mikroskopet,” *Teknik och miljö*, 1970, 2:15–19; Sven Rydén, “Vad gör vi för makrofagera?” *Svenska Dagbladet*, January 19, 1970.

²⁵ Interview with Alsterborg (cit. note 23).

²⁶ Interview with Åke Brunkener (February 16, 2009). For many years Brunkener was a salesperson and Nilsson’s contact at Carl Zeiss.

²⁷ For contemporary descriptions on photographing with the SEM, see Göran Alsterborg, “Bilder med otroligt skärpedjup genom nytt scanning-mikroskop,” *Fotonyheter*, 1969, 9:1, 24; Nilsson, Lindberg, “Embryonalstudier med svepelektronmikroskop” (cit. note 1).

²⁸ The description in this paragraph is based on interviews with Alsterborg (cit. note 23), Åke Flock (March 17, 2009) and Per-Gotthard Lundquist (March 11, 2009). Flock and Lundquist were researchers at the Gustav V Research Institute.

²⁹ Lennart Nilsson, “The Worlds within Us,” *Life*, January 9, 1970:40–56, p. 40; Lennart Nilsson, Stig Nordfeldt, “Detta är du: En okänd värld på väg att upptäckas,” *Se*, 1970, 10:30–45.

³⁰ This was told to me by Alsterborg (cit. note 23) who, after SEM studies at Analytica were interrupted in 1973, continued his work using the Cambridge instrument at other companies for a couple of years before he was hired in 1978 by JEOL (Skandinaviska) AB. The image appeared on the cover of *JEOL News*, 1983, 21e (2)

³¹ Lennart Nilsson, “The Corridors of the Heart,” *Life*, January 19, 1968:22–31.

³² This description is based on interviews with Sten Orrenius (November 12, 2008), who served as a head of the department, and Margareta Almling (September 10, 2008), head of administration at Karolinska Institutet 1964–1986.

³³ This is based on an interview with Bo Streiffert (March 12, 2009). Streiffert was publishing manager of Bonnier from 1969 to 1985.

³⁴ According to the media theorists Jay David Bolter and Richard Grusin, “remediation” is the process whereby one medium is represented in another, and they note that new and old media achieve their cultural significance by refashioning one another. See their book *Remediation: Understanding New Media* (Cambridge, Mass.: MIT Press, 1999).

³⁵ Lindberg reported on his PhD project in a letter (December 21, 1971) to the university council. This document is conserved in the Archive of Karolinska Institutet, Solna, Sweden. Institutionen för rättsmedicin. Publikationsförteckningar. 1978–1994. d3: 1.

³⁶ Lennart Nilsson, Jan Lindberg, *Se människan: En fotografisk upptäcktsfärd i din kropp* (Stockholm: Bonnier, 1973). The full title of the English edition was *Behold Man: A Photographic Journey of Discovery Inside the Body* (London: Harrap, 1974); Nilsson, Lindberg, *The Body Victorious* (cit. note 6).

³⁷ The description in this paragraph is based on an interview with Rune Pettersson (January 13, 2009). Pettersson was editor at the professional publishing division of Bonnier from 1968 to 1972. On the challenges encountered in producing other books by Nilsson, see Jülich, “The Making of a Best-selling Book on Reproduction” (cit. note 3).

³⁸ Letter from Elisabeth Johannisson to the author (June 5, 2009). On the WHO centre, see Egon Diczfalusy, Elisabeth Johannisson, Tabitha Standley, “WHO:s forskningsprogram inom området ‘Human Reproduction’,” *Läkartidningen*, 1974, 71:3176–3177.

³⁹ Eva Patek, *The Epithelium of the Human Fallopian Tube: A Surface Ultrastructural and Cytochemical Study* (Diss. Stockholm: Karolinska Institutet, 1974), p. 26.

⁴⁰ Lennart Nilsson, Eva Patek, Elisabeth Johannisson, Jan Lindberg, “Scanning Electron Microscopic Studies of the Human Fallopian Tube,” *JEOL News*, 1972, 10:53–55.

⁴¹ Interview with Eva Patek (January 27, 2009).

⁴² Fredrik Bragesjö, Aant Elzinga, Dick Kasperowski, “Continuity or Discontinuity? Scientific Governance in the Pre-History of the 1977 Law of Higher Education and Research in Sweden,” *Minerva*, 2012, 50:65–96.

⁴³ The editorial goal of *Forskning och framsteg* was expressed in “Ny tidskrift – forskningsinformation”, *Forskning och framsteg*, 1966, 1:1. Eva Patek, Lennart Nilsson, “Äggledarens topografi kartlagd”, *Forskning och framsteg*, 1972, 8:2–9.

⁴⁴ Eric Dyring, Annagreta Dyring (eds.), *Synligt och osynligt: Vetenskapens nya bilder* (Stockholm: Allmänna förlaget, 1973). Also see the interview with Pettersson (cit. note 37).

⁴⁵ Lennart Nilsson, Stig Nordfeldt, “Människans okända tid”, *Damernas värld*, 1974 (no. 35–38).

⁴⁶ “Titta på Lennart Nilssons bilder så förstår du, vad Bofors skyddar dina tänder mot,” *Veckojournalen*, 1976, 8:44–45.

⁴⁷ “Hur Clearasil mjukschampoo håller fett hår rent längre,” *Se*, 1971, 19:61.

⁴⁸ Jülich, “Televising Inner Space” (cit. note 9).

⁴⁹ Interview with Alsterborg (cit. note 23).

⁵⁰ Allan Danielsson, “Svepelektronmikroskopet,” *Kosmos*, 1970, 47:127–139; Per-Gotthard Lundquist, Åke Flock, Jan Wersäll, “Raster- und Elektronen-Mikroskopie des menschlichen Labyrinths,” *Monatsschrift für Ohrenheilkunde und Laryngo-Rhinologie*, 1971, 105:285–300. Also see the interviews with Flock and Lundquist (cit. note 28).

⁵¹ Michael Lynch, Samuel Y. Edgerton Jr., “Aesthetics and Digital Image Processing: Representational Craft in Contemporary Astronomy,” in *Picturing Power: Visual Depiction and Social Relations*, edited by Gordon Fyfe, John Law (London: Routledge, 1988). Also see Elizabeth A. Kessler, “Resolving the Nebulae: The Science and Art of Representing M51,” *Studies in History and Philosophy of Science*, 2007, 38:477–491.

⁵² More general studies of the uses and meanings of colours in a wider scientific context over a longer period of time are still needed, but for important case studies and discussions see Anne Beaulieu, “Images Are Not the (Only) Truth: Brain Mapping, Visual Knowledge, and Iconoclasm,” *Science, Technology & Human Values*, 2002, 27:53–86; Carin Berkowitz,

“Systems of Display: The Making of Anatomical Knowledge in Enlightenment Britain,” *British Journal for the History of Science*, 2013, 46 (3): 359–387; Soraya de Chadarevian, Nick Hopwood (eds.), *Models: The Third Dimension of Science* (Stanford: Stanford University Press, 2004); Daston, Galison, *Objectivity* (cit. note 13); Joseph Dumit, *Picturing Personhood: Brain Scans and Diagnostic Identity* (Princeton: Princeton University Press, 2004); James Elkins (ed.), *Visual Practices Across the University* (München: Wilhelm Fink Verlag, 2007); Bettyann Holtzmann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick: Rutgers University Press, 1997).

⁵³ On the cultural and media history of colours, see the work of Tom Gunning, “Colourful Metaphors: The Attraction of Colour in Early Silent Cinema,” *Fotogenia*, 1994, 1:249–255; Mary Warner Marien, *Photography: A Cultural History* (New York: Harry N. Abrams, 2010); Pam Roberts, *A Century of Colour Photography* (London: Andre Deutsch, 2007). Citation from Richard Misek, *Chromatic Cinema: A History of Screen Colour* (Malden, Mass.: Wiley-Blackwell, 2010), p. 77.

⁵⁴ Nilsson, Rosenfeld, “Drama of Life before Birth” (cit. note 3).

⁵⁵ Nilsson, “The Corridors of the Heart” (cit. note 31).

⁵⁶ Sven Möller, “Falkenbergares färgmetod möjliggjorde reportage för en kvarts miljard läsare,” *Hallandsposten*, February 24, 1970.

⁵⁷ Mary Panzer, *Things as They Are: Photojournalism in Context Since 1955* (New York: Aperture Foundation/World Press Photo, 2005), p. 24.

⁵⁸ This account is based on an interview with Gillis Häagg (November 5, 2008), and a letter to the author (September 21, 2009).

⁵⁹ Stig Nordfeldt, “Detta är en cancercell!” *Veckojournalen*, 1969, 47:8–9, 39.

⁶⁰ Interview with and letter from Häagg (cit. note 58). On the carbro-process, see Richard Benson, *The Printed Picture* (New York: Museum of Modern Art, 2008), p. 192.

⁶¹ Interview with and letter from Häagg (cit. note 58).

⁶² Ibid. On dye transfer, see Benson, *The Printed Picture* (cit. note 60), p. 194.

⁶³ Misek, *Chromatic Cinema* (cit. note 53), p. 39.

⁶⁴ Charles R. Acland (ed.), *Residual Media* (Minneapolis: University of Minnesota Press, 2007). The term “residual” stems from Raymond Williams’s study of culture’s emergent, dominant and residual forms. See his book, *Marxism and Literature* (Oxford: Oxford University Press, 1977), p. 122.

⁶⁵ Roberts, *A Century of Colour Photography* (cit. note 53), pp. 142–151.

⁶⁶ Lars Hamberger, the co-author of Nilsson, told me this in an interview (March 3, 2009).

⁶⁷ Important references in this debate are Fred Ritchin, *In Our Own Image: The Coming Revolution in Photography: How Computer Technology is Changing Our View of the World* (New York: Aperture, 1990); William J. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* (Cambridge, Mass.: MIT Press, 1992).

⁶⁸ Lennart Nilsson, Lars Hamberger, *Ett barn blir till*, 4. ed. (Stockholm: Bonnier, 2003). The American and British editions were published in the same year. Also see the interview with Hamberger (cit. note 66).

⁶⁹ Gunning, “Colourful Metaphors” (cit. note 53).

⁷⁰ Misek, *Chromatic Cinema* (cit. note 53), p. 87.

⁷¹ Nilsson, “The Worlds Within Us” (cit. note 29), p. 40; Nilsson, Lindberg, *Se människan* (cit. note 36), p. 106.

⁷² Lennart Nilsson, *Nära naturen: En upptäcktsfärd i naturens mikrokosmos* (Stockholm: Bonnier fakta, 1984), p. 6; Nilsson, *Kroppens försvar* (cit. note 6), p. 195; Nilsson, Hamberger, *Ett barn blir till* (cit. note 68), p. 236.

⁷³ This description is based on the interview with Häagg (cit. note 58). On the digital images produced by astronomers, see Lynch, Edgerton, “Aesthetics and Digital Image Processing” (cit. note 51).

⁷⁴ Compare Sturken, *Tangled Memories* (cit. note 8), pp. 235–239.

⁷⁵ Nilsson, *Kroppens försvar* (cit. note 6); Bryan, *The National Geographic Society* (cit. note 6); Poole (ed.), *The Incredible Machine* (cit. note 6).

⁷⁶ Bengt Cederback, “Människokroppen i bild”, *Upsala Nya Tidning*, March 5, 1974. Also see Bertil Walldén, “Insyn i människokroppen”, *Vestmanland Läns Tidning*, November 17, 1973.

⁷⁷ See the interview with Pettersson (cit. note 37).

⁷⁸ This description draws upon an interview with Urban Frank (March 19, 2009).

⁷⁹ See the interview with Margareta Almling (cit. note 32), and a letter to the author (September 19, 2008).

⁸⁰ Patek, *The Epithelium of the Human Fallopian Tube* (cit. note 39).

⁸¹ Lynch, Edgerton, “Aesthetics and Digital Image Processing” (cit. note 51).

⁸² Marien, *Photography* (cit. note 53), p. 361; Roberts, *A Century of Colour Photography* (cit. note 53), p. 140.

⁸³ E-mail from Sebastian Boyle (cit. note 21). Later, however, in the early 1990s David Scharf developed a colouring system “utilizing multiple electron detectors to encode an intuitive coloration.” See David Scharf’s website: <http://www.scharfphoto.com/about/> (accessed October 13, 2013).

⁸⁴ In an interview (April 7, 2009) Hasse Persson, the photographer and former art museum director, cited this characterisation as typical of the low esteem in which Nilsson was held in the art world and expressed his view that this was unfair.

⁸⁵ “Titta på Lennart Nilssons bilder” (cit. note 46).

⁸⁶ Anita Lagercrantz-Ohlin, “Han är en kamera i mikrovärlden”, *Svenska Dagbladet*, November 16, 1974.

⁸⁷ Gunilla Winsnes, “Nu ska han visa hur människan påverkas av alla miljögifter”, *Stockholms-Kuriren*, March 30, 1977.

⁸⁸ See the note on this collaboration between *Läkartidningen* and Nilsson in *Läkartidningen*, 1975, 72 (1–2):1.

⁸⁹ Jülich, “Objektiva bilder” (cit. note 4), pp. 339–340.

⁹⁰ A similar point has been made by Rebecca Kukla, “Naturalizing Objectivity,” *Perspectives on Science*, 2008, 16:285–302, on p. 294.

⁹¹ Daston, Galison, *Objectivity* (cit. note 13).

⁹² For an overview, see Philip Mirowski, Esther-Mirjam Sent, “The Commercialization of Science and the Response of STS,” in *The Handbook of Science and Technology Studies*, edited by Edward J. Hackett et al., 3rd ed. (Cambridge, Mass.: MIT, 2008).

⁹³ Martin Lister, “Photography in the Age of Electronic Imaging”, in *Photography: A Critical Introduction*, edited by Liz Wells, 4th ed. (London: Routledge, 2009).