Microcinematography and the History of Science and Film

Article *in* Isis · March 2006
DOI: 10.1086/501105

1 author:

Hannah Landecker
University of California, Los Angeles

Microcinematography and the History of Science and Film

*By Hannah Landecker**

ABSTRACT

The history of microcinematography is explored here as an example of the possible historiographical directions for work on science and film in the twentieth century. Topics discussed include investigations of the role of time in experiment, and the constant interplay between static and dynamic modes of imaging in scientific research; the role of films as depictions of both the objects of science and the process of scientific looking itself; and the possibility for telling a social history of science through investigation of the production and reception of cinema.

It never would have occurred to the pioneers of cinema to dissociate research *on* film from research *by means* of film.

—Jean Painlevé, "Scientific Film"

THE HISTORY OF SCIENCE AND CINEMA in the early twentieth century is one of experimentation in a doubled sense of the word. The medium of film was itself relatively new, and scientists experimented with it by tinkering with film, film cameras, microscopes, and the parameters of exposure, magnification, and time. It was also the medium in which experiments could be recorded and analyzed. Jean Painlevé, a French biologist, filmmaker, and promoter of scientific film, thus commented at midcentury that research on film was indissociable from research by means of film. He was referring, in part, to the work of early twentieth-century biologists who began to film very small organisms and cells. The first films were of bacteria and blood cells, recorded in "real time"—that is, the time of the filming coincided with the time it took the film to unroll in projection. The flexible properties of film and projection were soon used to supplement these temporally faithful reproductions of movement as the human eye would normally see it. Time-lapse microcinematography was done by taking an image of the microscopic subject at evenly spaced intervals—for example, a minute—and then projecting the resulting film at a much

* Department of Anthropology—MS-20, P.O. Box 1892, Rice University, Houston, Texas 77251-1892; hll@rice.edu.

This work was funded by a fellowship from the National Endowment for the Humanities. Any views, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect those of the NEH.

Isis, 2006, 97:121–132

0021-1753/2006/9701-0008$10.00

higher speed, 16 or 24 frames per second. This accelerated very slow movements so that previously imperceptibly slow change was rendered accessible to observers, opening a whole realm of biological phenomena to examination and experimentation. One practitioner, after seeing films of microsurgery in which living cells were punctured or cut or injected with foreign substances—the effects of which would be inaccessible without recording the operation and watching the living cells' reactions accelerated by time lapse—reported being "literally haunted" by the films because of the "infinitely varied" experiments they suggested to him (see Figure 1).[1]

Whether in the microscopic or the macroscopic realm, film presented the haunting possibility of capturing over time phenomena that had escaped static means of representation such as histology, photography, or drawing.[2] This led to an explosion in experiments with and on film in scientific and medical disciplines from astronomy to psychiatry. The history of microcinematography, while interesting in its own right, also points to a number of historiographic possibilities for the study of film and science in the twentieth century more broadly. While there is no doubt that different uses of film in different sciences abounded, it is more difficult to know how to approach this history, as enumeration rapidly descends into compendium rather than analysis.[3]

The first of these possibilities is to think of film—or other visual media—as part of the exploration of the role of time in experimentation. Time is central to microcinematography,

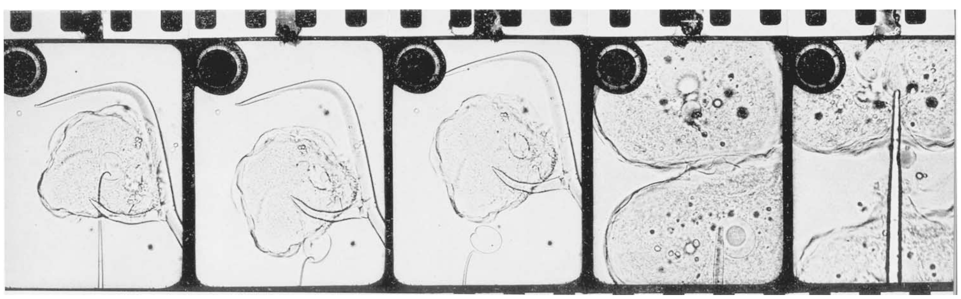

Figure 1. *Scenes of microsurgery: the first three frames show a nucleus being removed from a living cell, and the last two show a nucleus being transplanted from one cell to another. From "Substitution du noyau chez une amibe:* Amoeba Sphaeronucleus,*" by Jean Comandon and Pierre de Fonbrune, c. 1938.*

[1] Jean Painlevé, "Scientific Film," in *Science Is Fiction: The Films of Jean Painlevé,* ed. Andy Masaki Bellows and Marina McDougall, trans. by Jeanine Herman (Cambridge, Mass.: MIT Press, 2000), pp. 160–169, on p. 162; and Pierre de Fonbrune, "La Micromanipulation," *La Nature,* 15 Dec. 1936, no. 2967, pp. 543–547, on p. 543.

[2] Histology depends on fixing and staining tissues and cells to make them visible under the microscope. Except with the use of a few vital stains, this mode of examining living things usually requires killing the organism—stopping and fixing it at a certain moment in its life processes—in order to see it.

[3] This is borne out by various works of the first half of the century that took the medium itself as the organizing principle: if it was on film, and involved science or medicine, it belonged. By 1955 this enumeration verged on an unmanageable project. For a discussion of cinematography in astronomy see P. Thevenard and G. Tassel, *Le cinéma scientifique français* (Paris: Jeune Parque, 1948). For psychiatry see Alison Winter, "Screening Selves: Sciences of Memory and Identity on Film, 1930–1960," *History of Psychology,* 2004, *7:*367–401. For everything in between see Martin Dreiser, *Medizinische Kinematographie* (Dresden/Leipzig: Steinkopff, 1919); F. Paul Liesegang, *Wissenschaftliche Kinematographie* (Düsseldorf: Liesegang, 1920); Liesegang, *Handbuch der praktischen Kinematographie* (Leipzig: M. Eger, 1912); Blodwen Lloyd, ed., *Science in Films,* Vol. 1: *A World Review and Reference Book* (London: Sampson, Low, Marston, 1948); and Anthony R. Michaelis, *Research Films in Biology, Anthropology, Psychology, and Medicine* (New York: Academic, 1955).

as acceleration of the very slow through projection was what made it useful to biologists. It was as though a whole new world of temporal phenomena, previously below the threshold of perception, was opened up by the manipulation of the time of observation compared to the time of the experiment. Paying attention to the specificity of film as a time-based medium is key to understanding its emergence and then departure from scientific photography; this temporal dimension allowed new forms of recording and analysis in a wide array of disciplines. It is also one way to think through the significance of scientific film so as to connect it both to other concerns in the history of science and to other instances of the introduction of new media, such as computer modeling, into science in the twentieth century. Second, these experiments in film did not just offer new images of natural objects, such as cells or particles; they were also a means of allowing people other than scientists to participate visually in the sights of scientific work and the mode of experimental looking. This opening up of the scientific gaze to other participants can be seen not just in popular reception; the very theorization in the early twentieth century of what cinema was or could be was bound up with scientific film. Whether in popularization or in pedagogy, scientific films did not just teach audiences about things such as cells but, indeed, suggested a very particular way of looking at the world. Finally, films are made by a long series of choices, from the initial framing of the subject to the final editing of a narrative form in terms of both images and accompanying words; a rich social history of science is thus opened up by the study of scientific film.

FROM CHRONOPHOTOGRAPHY TO CINEMATOGRAPHY

What difference does time make in experimentation? There is the time of experiment, the time of recording, and the time of demonstration, and these parameters can be manipulated in relation to one another in order to see new phenomena or to see well-known phenomena in a new way. Although cinematography developed from chronophotography, its ability to contract or expand the time of observation of movement through projection meant that it differed radically from the still medium of photography. It is well known that the technologies of twentieth-century cinema owe their origins to the chronophotography of Etienne-Jules Marey.[4] Chronophotography, which involved taking photographs of a moving object at regularly spaced intervals, was designed primarily to dissect very fast movements. Paradoxically, the focus on origin stories of cinema in the physiological work of Marey may have contributed to historians' lack of interest in scientific cinema after his death in 1904. Much attention has been paid to the analytics of movement produced by Marey within a scientific framework of chronophotography, but little to the later syntheses of movement within a scientific framework of cinematography. The assumption of a radical bifurcation of scientific imaging of movement and entertainment cinema appears explicable via Marey's avowed disinterest in reproducing movement as the eye would normally perceive it.[5] This declared disdain has encouraged a retrospective and artificially stark dis-

[4] See François Dagognet, *Etienne-Jules Marey: A Passion for the Trace,* trans. Robert Galeta with Jeanine Herman (New York: Zone, 1992); and Marta Braun, *Picturing Time: The Work of Etienne-Jules Marey (1830–1904)* (Chicago: Univ. Chicago Press, 1992). It is an oversimplification to name a single scientist's work as the origin of cinematography, particularly given the proliferation of optical toys and devices at the end of the nineteenth century and the wide variety of practices of scientific demonstration being used before cinema. See, e.g., Henning Schmidgen, "Pictures, Preparations, and Living Processes: The Production of Immediate Visual Perception (*Anschauung*) in Late-Nineteenth-Century Germany," *Journal of the History of Biology,* 2004, *37:*477–513.

[5] Braun, *Picturing Time,* pp. 150–151.

tinction to be drawn between entertainment and scientific cinema, one that is increasingly being challenged by work such as Lisa Cartwright's *Screening the Body: Tracing Medicine's Visual Culture:* this examination of physiological, microscopic, and X-ray cinema shows that scientists did not stop making films and that film pioneers such as Auguste Lumière did not stop being scientists doing laboratory work. Scott Curtis has examined the role of film in the exploration of the physics of Brownian movement in Germany, and Tom Gunning has demonstrated the error in using today's categories of science and entertainment, or news and fiction, to think about the very early days of cinema, in which the novelty of the medium itself was more important to viewers than such distinctions.[6]

The history of microcinematography shows that while scientists were deeply influenced by Marey and the graphic method of chronophotography, after his death they began to experiment with the temporal flexibility afforded by projection of the film strip. Julius Ries, a Swiss biologist who made one of the first time-lapse films of sea urchin fertilization and development, went to the Marey Institute in Paris; in 1907 he produced a two-minute film that condensed the fourteen hours of the process to two minutes (see Figure 2). His motivation was in part the difficulty of observing this phenomenon:

> On the one hand, a good many things in a living object happen too quickly, whereas on the other hand the advancing segmentation demands hours of the observer's attention. In this way, impressions become blurred and one gets tired. But if one attempts to capture individual pictures through sketching, one gets at the end only a composition of remembered images. The segmentation happens so fast that even the fastest sketch-artist cannot keep up with it.

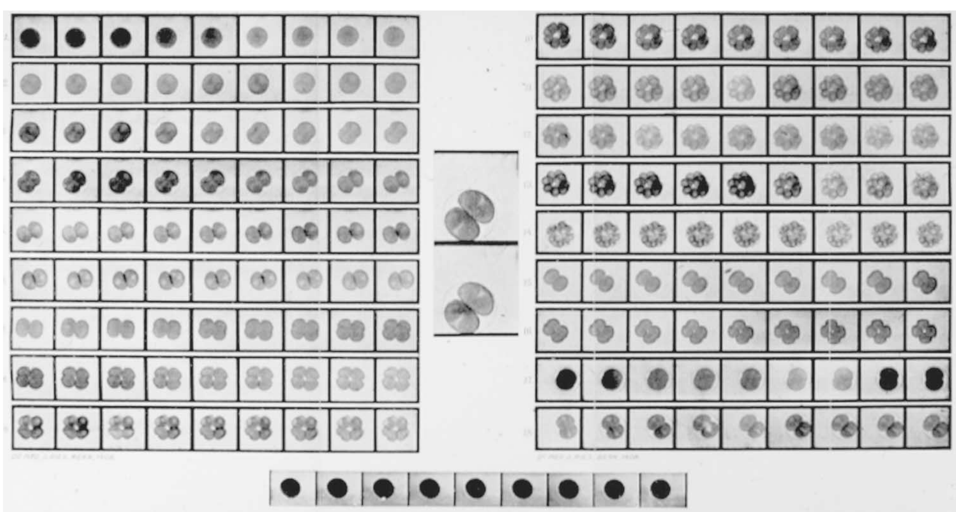

Figure 2. *Stills from one of the first microcinematographic films made to be projected, circa 1907. These frames of the fertilization and development of the sea urchin embryo accompanied the article "Cinematography of Fertilization and Development," published by Julius Ries in 1909, and are the only remaining record of the film itself.*

[6] Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis: Univ. Minnesota Press, 1995); Scott Curtis, *Managing Modernity: Art, Science, and Early Cinema in Germany* (New York: Columbia Univ. Press, forthcoming); and Tom Gunning, "An Aesthetic of Astonishment: Early Film and the (In)credulous Spectator," in *Viewing Positions: Ways of Seeing Film,* ed. Linda Williams (New Brunswick, N.J.: Rutgers Univ. Press, 1995), pp. 114–133.

Marey had complained of chronophotography that it "only gives an approximate idea of the sequence of the various phases of movement, because its record is one of intermittent indications, instead of the continuous record of a curve," but Ries meant the film strip to be projected rather than looked at as a static set of sequential images.[7] Instead of suppressing the separation between individual film frames by striving toward a continuous curve, Ries explicitly sought to put that separation to use as a time lapse.[8]

The early films of Jean Comandon also show this explicit transition from chronophotography to cinematography and, with it, the importance of moving from a static to a dynamic medium in the study of life. Comandon, a Parisian medical researcher who hoped to quantify and characterize the movements of the syphilis spirochete—much as he had seen others study Brownian movement with microcinematographic films of rubber particles in suspension—gained the support of the Pathé Frères film production enterprise in setting up a microcinematographic laboratory in 1907. At the outset, Comandon used the separate frames of the film in an analytic manner very similar to the physiological chronophotography established by Marey: the comparison of sequential images allowed quantitative comparisons and the construction of graphic traces of movement (of fat particles, spirochetes, blood cells). As in the studies of Brownian motion, the aim was to reconstruct continuity between frames in the form of a linear trace of movement, from which quantitative data could be drawn. Soon, however, the realization that projection could serve as a tool of research overtook these chronomicrophotographic projects; Comandon saw the film camera as a new tool that enhanced the temporal dimension of perception as much as microscopes had opened up the spatial dimension of investigation:

> *Microcinematography* alone is capable of conserving the traces of phenomena occurring in the preparation. Like the retina of an eye which never tires, the film follows, over a prolonged period, all the changes which occur; even better, the cinematograph is, like the microscope itself, an instrument of research, while the one concerns visual space, the other concerns time, in *condensing* or *spreading out* movements by *accelerating or slowing them;* it reduces their speed to a scale that is more easily perceptible, which, indeed, reveals to us that which we had never suspected.[9]

Not only could the images be taken at different intervals over the time of the experiment, seconds to minutes or hours apart; the film could be projected at different speeds or run backward. The unfolding of living processes could be readjusted to a time more convenient to the investigator, frustrated by the too slow and the too fast.

[7] Julius Ries, "Kinematographie der Befruchtung und Zellteilung," *Archiv für Mikroskopische Anatomie,* 1909, *74:*1–29, on p. 1 (here and elsewhere, translations are my own unless otherwise indicated); and Etienne-Jules Marey, *Mouvement,* p. 285, quoted in Mary Ann Doane, *The Emergence of Cinematic Time: Modernity, Contingency, the Archive* (Cambridge, Mass.: Harvard Univ. Press, 2002), p. 333.

[8] Alison Winter has observed that when film was used in psychiatry it had some of the characteristics of technologies associated with the "graphic method" in the late nineteenth century, in that it "produced a visual record correlated with specific kinds of otherwise-imperceptible motion. However, in contrast to the line of ink that was intended (in part) to be a substitute for narrative evidence and the hermeneutic challenge of interpreting the subtleties of human self-expression, film worked by embracing these very complexities" because it offered researchers a way of making "subtle, intensive and repeated studies of the human body in motion." See Winter, "Screening Selves" (cit. n. 3), p. 371.

[9] Jean Comandon, "Le cinématographie et les sciences de la nature," in *Le cinéma, des origines à nos jours,* ed. Henri Fescourt (Paris: Éditions du Cygne, 1932), pp. 313–322, on p. 320. The idea of the camera as a mechanical retina, replacing the faulty or less reliable human eye, was already a feature of writing about scientific photography; this comment adds the idea of the film camera as a mechanical eye that works not just on the dimension of space but on that of time as well.

After Marey, then, there is a distinct development of cinema as a scientific tool. In the case of microcinematography, the tool was specifically suited to the analysis of the very slow movements of cells. Later, fields such as ethology would make particular use of film to manipulate the time of representation of phenomena versus the original time of their unfolding.[10] The scientific significance of being able to see things over time lay not just in making visible things or movements that had never been suspected but also in the contrast film provided to other, static means of representing the same thing. The conventions and assumptions of serial microchronophotography, single-exposure microphotography, drawing, and histology were all highlighted by their contrast with the new time-based medium of cinema. Ries wrote that "even in the demonstration of my only twenty-meter-long film, which took at most two minutes to unfold, the effect was surprising; visible in the same egg is the formation of the fertilization membrane and the advancing segmentation up to the morula. One really believes one has a living, developing egg before one." While it may seem odd to remark that the surprise here arises in part from the knowledge that it is the same egg before the viewer at all times, it is important to remember that this form of representation—and its particular temporality—stood in contrast to the other contemporary forms of depicting development. Ries's earlier attempts at fixing each stage had involved a series of different eggs, each at a different (and, he hoped, sequential) moment in development. As the work of Nick Hopwood indicates, development had been "produced" by late nineteenth-century embryology exactly through these sorts of sequential representations, arranged into *Normaltafeln*—thousands of individual moments in thousands of individuals built into an ascending temporal series of static moments.[11] Thus to have the same individual specimen, "fixed" as it were every seven minutes by the photograph and then put back into a highly foreshortened moving image of the developmental course by projection, was no doubt a surprise. The sensation—by comparison to viewing histological or graphic depictions of development—was of viewing the living organism itself.

Although scientific cinema developed out of the chronophotographic work of Marey, the time-based medium of film made to be projected was quite different from the static representations of chronophotography. Not only did film provide a tool for observing over time things that could otherwise not be apprehended; it rendered other, dominant ways of representing change less transparent. Even in 1962, C. H. Waddington wrote that "many biologists *still* seem to experience something of a shock when they see such films and realize that cells have to be considered as highly active bodies in which movement of the internal constituents is continuous and uninterrupted." Like Ries, Waddington felt that film was a necessary corrective to the de-animating effects of microscopic technique. While he readily admitted that "time-lapse films, of course, exaggerate the speed with which these movements are carried out," he also argued that "the point they bring home so forcefully, that cytoplasm is always in a state of physical activity, is a perfectly valid one." In fact,

[10] See the discussion of filmmaking in ethology in Gregg Mitman, *Reel Nature: America's Romance with Wildlife on Film* (Cambridge, Mass.: Harvard Univ. Press, 1999); and Tania Munz, "Die Ethologie des wissenschaftlichen Cineasten: Karl von Frisch, Konrad Lorenz und das Verhalten der Tiere im Film," *Montage AV,* 2005, *14*(4).

[11] Ries, "Kinematographie der Befruchtung und Zellteilung" (cit. n. 7), p. 6; and Nick Hopwood, "Producing Development: The Anatomy of Human Embryos and the Norms of Wilhelm His," *Bulletin of the History of Medicine,* 2000, *74:*29–79. Hopwood explores the work that went into making these tables in an argument that sees development as an effect that the embryologist His had to labor to produce.

exaggeration was "useful to counterbalance our tendency to envisage cells in terms of the static pictures presented by ordinary microscope preparations."[12]

IMAGES OF SCIENCE, DEPICTIONS OF SCIENTIFIC LOOKING

These examples from the history of microcinematography demonstrate two ways in which the conduct of experimental science can be changed by the adoption and exploration of different media: new phenomena can be seen, and older representations that may have become entrenched as transparent reality are shown up for their particular artifice. There are consequences for both the observation itself and the theorization of the objects being watched, particularly when time-based media are brought to bear on phenomena previously apprehended with static media.[13] Sometimes two media may be pitted against one another in what might be called a battle of artifacts, each medium's proponents claiming that what is seen in the others' preparations must be an artifact of the process of observation, not the thing observed.[14] Beyond their interest in investigations of the conduct of experimental science, the manipulation of an experiment's temporality, and the role of representation in knowledge production more generally, film and other media should be of particular use to historians of science in exploring the depiction of science to audiences beyond the investigator him- or herself. These include both other scientific audiences and nonscientist spectators. The history of microcinematography provides insight into how visual media in science not only showed previously unseen things to broad audiences but showed many people how scientists saw things.

While some critics were deeply suspicious, doubting that any medium as popular as film could be a proper scientific tool, for its proponents the infinitely repeatable, flexible film strip represented both an innovation in research and an innovation in the communication of that work. In 1919 Martin Weiser, a medical officer and roentgenologist in Dresden, included microcinematography in his survey of the uses of cinematography in medicine, writing glowingly of its ability to aid both research and teaching thanks to the ability of the films to travel from laboratory to auditorium. No more fussing about trying to project from a microscope containing a slide of a live specimen; no more fumbling attempts to explain to the layman what being a scientist was about. The audience could just watch the film and see what the scientist himself saw.

> [Microcinematography] records that which the scholar in his quiet study room has pursued and published; with it he can later demonstrate to a larger gathering, be it a congress, a doctor's association, or in an auditorium in front of students. Microcinematography not only documents research of movement-events, it is also a good aid to the research itself. For it records every single phase of movement and gives him the opportunity to look through every single image of those phases, and to study movement-events in their temporal and spatial context with leisure and care.

[12] C. H. Waddington, *New Patterns in Genetics and Development* (New York: Columbia Univ. Press 1962), p. 154.

[13] For an elaboration of this argument see Christopher Kelty and Hannah Landecker, "Toward a Theory of Animation: Cells, L-Systems, and Film," *Grey Room,* 2004, *17:*30–63; and Scott Curtis, "Still/Moving: Digital Imaging and Medical Hermeneutics," in *Memory Bytes: History, Technology, and Culture,* ed. Lauren Rabinovitz and Abraham Geil (Durham, N.C.: Duke Univ. Press, 2004), pp. 218–254. Marc Shell suggests that the stasis and kinesis of film is an integral part of the cultural history of both polio and cinema in *Polio and Its Aftermath: The Paralysis of Culture* (Cambridge, Mass.: Harvard Univ. Press, 2005).

[14] James Strick, "Swimming against the Tide: Adrianus Pijper and the Debate over Bacterial Flagella, 1946–1956," *Isis,* 1996, *87:*274–305.

Scientific films were often structured by the experimental analysis they were made to perform. Comandon's films, for example, often juxtaposed different magnifications of the same thing, mimicking the action of the microscopist flipping between lenses. Further, the narrative structure of the experiment was given in sequential scenes: the behavior of white blood cells and pathogens such as trypanosomes in the blood of unexposed animals was compared to that in the blood of previously exposed animals. A 1909 newspaper account of a screening of some of Comandon's films did not shrink from sensationalism, referring to this "great combat carried out in the organism," this "intestinal battle" with "one of the most dreadful microbes," whose drama is for physicians "far more interesting than the most poignant events of everyday cinematography." However, it also carefully incorporated the experimental narrative of medical research, with the comparison of different blood sera, and clearly cautioned that the viewer should not "forget that the scenes shown to us happened in laboratory preparations." That the films should be seen as a staging of what happens in the body was also emphasized in the concluding line of the article: "We hope that the attack, engulfment and death of trypanosomes is as well realized when it happens in the human body."[15] Viewers were thus simultaneously encouraged to lose themselves in the spectacle of the great internal battle and to observe the processes of isolation and comparison going on in French research into tropical diseases.

Comandon produced films that were simultaneously scientific investigations of biological phenomena, money-making features of the Pathé Frères salons and catalogue, and teaching films for students of science and medicine. Other production companies, such as Charles Urban (England) and Gaumont (France), also had scientific filmmakers on staff, and scientific films were an integral part of their early catalogues, although these were more overtly designed to reach a popular audience.[16] Although there were certainly films made specifically as experimental data and others made as popularizations of science, in many cases these categories overlap, particularly when scientists depended on the resources of the large film production companies or when the same films were shown to scientific meetings, general scientific audiences, and the paying public.

Contemporary film theorists and filmmakers, some of them originally trained in the sciences, picked up on the demonstration of magnification and acceleration in these films as a means of thinking through the new medium of cinema and the technical possibilities and philosophical implications of "digging through the visual planes" beyond normal human vision with a film camera.[17] Walter Benjamin wrote that one of the revolutionary

[15] Dreiser, *Medizinische Kinematographie* (cit. n. 3), p. 62; and Salagnac, "Le cinématographie de l'infiniment petit: Comment nos globules blancs dévorent les microbes," *Le Journal,* 31 July 1910, p. 1, in Papers of Jean Comandon, Box Com 8, Pasteur Institute Archives, Paris.

[16] Thierry Lefebvre has shown the flourishing of the popular science film in the factories and catalogues of early film production companies such as Gaumont and Eclair between 1911 and 1914: Thierry Lefebvre, "The *Scientia* Production (1911–1914): Scientific Popularization through Pictures," *Griffithiana,* 1993, *47:*137–155. Oliver Gaycken has expanded this historical focus on popular science film in "'A Drama Unites Them in a Fight to the Death': Some Remarks on the Flourishing of a Cinema of Scientific Vernacularization in France, 1909–1914," *Historical Journal of Film, Radio, and Television,* 2002, *22:*353–374; and Gaycken, "The Sources of *The Secrets of Nature:* The Popular Science Film at Urban, 1903–1911," in *Scene-Stealing: Sources for British Cinema before 1930,* ed. Alan Burton and Laraine Porter (Trowbridge, Wiltshire: Flicks Books, 2003). The work of the "hybrid" scientist/filmmaker Jean Painlevé has recently been documented in *Science Is Fiction,* ed. Bellows and McDougall (cit. n. 1). On the general subject of early nonfiction film see *1895,* no. 18, Summer 1995: *Images du Réel: La Non-Fiction en France (1890–1930),* ed. Thierry Lefebvre.

[17] Germaine Dulac, "Visual and Anti-Visual Films," trans. Robert Lamberton, in *The Avant-Garde Film: A Reader of Theory and Criticism,* ed. P. Adams Sitney (New York: New York Univ. Press, 1978), p. 31. For an extended discussion of the role of scientific films in early film theory see Hannah Landecker, "Cellular Features: Microcinematography and Film Theory," *Critical Inquiry,* 2005, *31:*903–937.

functions of film would be "demonstrating that the artistic uses of photography are identical to its scientific uses." The work of analysis and isolation possible with film made it difficult, in his opinion, for viewers "to say which is more fascinating, its artistic value or its value for science." Techniques used to depict scientific analysis or explanation cinematically, such as intense magnification, X-ray imaging, and flashbacks, in turn found their way into avant-garde and artistic filmmaking.[18]

Texts of lectures that accompanied screenings of early microcinematographic films bear out the contention that audiences were taught to see with new visual technologies in particular ways. As Iwan Rhys Morus has pointed out in this Focus section, the relationship between the production and the consumption of scientific knowledge is an important aspect for understanding the cultural and historical specificity of any instance of the making and viewing of images of science. The film medium has its own specificity when it comes to directing spectators to see or pay attention in particular ways; the ability to frame, juxtapose, move close up, and accelerate or decelerate both mimics and manipulates human attention.[19] Audiences of microcinematography were told that their bodies were made of cells, and here on screen were images of cells—so in effect they were watching the lives of their own bodily constituents. One audience was shown films of protoplasm and instructed to imagine the living cells of grass being crushed under the viewers' feet as they walked about: "You certainly comprehend now the life in these plants that you trample underfoot, that you believe to be insensible. You believe that, Mesdames, because they have no way of crying out, but in reality, what do you know?"[20]

Watching things in motion was an essential part of effecting belief in audiences that what they were seeing was really life. Julius Ries emphasized that one reason he made his film of sea urchins was to convince medical students that cell theory was really true; because they had little access to live specimens (being a long way from the sea), cell theory tended to be "for the student something true that he must believe, without being able to convince himself of it."[21] The aim of the film was to get audiences *really* to believe that all cells came from other cells. Both filmmakers and film viewers commented on the gripping reality of the films, which indicates that recording over time had a direct practical effect of rendering things visible but also a less definable effect of making the subject seem more real or more true to life than in still depictions. At the same time, spectators

[18] Walter Benjamin, "The Work of Art in the Age of Its Technological Reproducibility" (third version), in *Selected Writings,* Vol. 4: *1938–1940,* ed. Howard Eiland and Michael W. Jennings, trans. Edmund Jephcott and Harry Zohn (Cambridge, Mass.: Belknap, 2003), pp. 251–283, on p. 265. Yuri Tsivian sees science as "part of the cinematic text" of early film, arguing that early microscopic and X-ray films were incorporated into criticism and artistic filmmaking. Their representation of the normally unseen—the very small and the interior of the body—generated a concept of "penetrating vision" that was reappropriated metaphorically into techniques such as the dissolve by "writers and directors biased toward artistic experiment": Yuri Tsivian, "Media Fantasies and Penetrating Vision: Some Links between X-Rays, the Microscope, and Film," in *Laboratory of Dreams: The Russian Avant-Garde and Cultural Experiment,* ed. John Bowlt and Olga Matich (Stanford, Calif.: Stanford Univ. Press, 1996), pp. 81–99, on pp. 81–82. Alison Winter draws parallels between the use of the flashback in psychiatric films and wide interest by filmmakers in the use of flashback devices in the 1940s and 1950s; see Winter, "Screening Selves" (cit. n. 3), p. 396.

[19] Winter has argued, following Hugo Münsterberg's 1916 *The Photoplay: A Psychological Study* (New York: Appleton), that film was used by psychiatrists between 1930 and 1960 as a technology to give scientific and popular audiences access to the power of barbiturate treatments of psychotic and war-traumatized patients, making them feel as though they were standing right there as treatment occurred. Films were structured to mimic the attention and perception not of the patient but of the psychiatrist administering the treatment and analyzing the results, thus "objectifying sensation, by embodying acts of attention in the choice of shots and the proximity of the camera, and in some cases by scripted voiceovers": Winter, "Screening Selves," p. 396.

[20] Jules Guiart, "La vie revelee par le cinematographie," *Revue Scientifique,* 1914, pp. 740–750, on p. 743.

[21] Ries, "Kinematographie der Befruchtung und Zellteilung" (cit. n. 7), p. 1.

were never allowed to forget the technical means that made access to this reality possible; it was not *any* reality, but a scientifically mediated one, in which audiences were allowed access to the previously private, individual view of the lone biologist at the microscope.

SCIENTIFIC FILM AS SOCIAL NARRATIVE

Microcinematography, with its views into the realm of the very small and the very slow, was part of early twentieth-century modernism and the attendant shifts in understanding and representation of time and space.[22] The cinematic examination of the particles and cells subtending the world as seen with the unaided eye became part of discussions and representations of reality far beyond the laboratory. In turn, conventions of other kinds of filmmaking, ideas about science pedagogy, and commercial and artistic interests shaped both scientific film and what has been called "the cinema of scientific vernacularization."[23] Film analysis can reveal much about broader social issues beyond the nature of laboratory work, and this is the third possible direction for histories of science and film: a social history of science through film. It is in this area that the history of science has the most to learn from disciplines such as film studies, where scholars have more experience in the close analysis of film, the interface of film and philosophy, and the contextualization of cinema in a larger cultural history, as well as with the practical issues of film archives and preservation.[24]

In his account of the nature film in America, Gregg Mitman considers various elements—from the choice of subject to the framing of shots to the construction of a narrative—that went into depicting nature and wilderness. The irony of the effort it takes to construct images of what is supposed to be unmediated aside, the choices and practices that made up the nature cinematographers' particular mode of artifice are an excellent historical source. Both the films themselves and the stories of the making of them allow Mitman to explore with great specificity assumptions and practices brought to the linked subjects of nature, wilderness, animals, exploration, and indigenous peoples in American science and culture in the twentieth century. The films grew out of particular ideas of nature and wilderness, which influenced perceptions of the subjects chosen for film projects, from lions to dolphins: stories of lions are also portraits of American attitudes toward Africa at a point in time; stories of dolphins are telling for the features of dolphin sexual behavior that were carefully left out. In addition, the financial, institutional, and public constraints on scientific projects and expeditions when they became film projects provide fascinating insight into what science studies scholars have recently taken to calling the

[22] Mary Ann Doane analyzes early cinema as part of a general discourse on the problem of the "representability of time" happening across many cultural domains in the early twentieth century in *The Emergence of Cinematic Time* (cit. n. 7).

[23] Gaycken, "'A Drama Unites Them in a Fight to the Death'" (cit. n. 16).

[24] A few examples of film studies scholars working in this area: Scott Curtis embeds an in-depth analysis of the early twentieth-century cinema of Brownian motion in a broader history of motion pictures in education, medicine, and aesthetics in Germany in *Managing Modernity* (cit. n. 6). Kirsten Ostherr analyzes films, made and distributed by the World Health Organisation, that were intended to represent visually and thereby counteract disease in "Contagion and the Boundaries of the Visible: The Cinema of World Health," *Camera Obscura,* 2002, *50*(17[2]):1–38. For an assessment of film in anthropology in the context of ideas of racial difference and colonialism see Fatimah Tobing Rony, *The Third Eye: Race, Cinema, and Ethnographic Spectacle* (Durham, N.C.: Duke Univ. Press, 1996); the anthropologist Alison Griffiths has also examined early anthropological film in *Wondrous Difference: Cinema, Anthropology, and Turn-of-the-Century Visual Culture* (New York: Columbia Univ. Press, 2002).

"co-production" of science and society.[25] Public appetites, new forms of media, and scientific work all shape one another in the making of nature films.

As Martin Pernick has demonstrated, the history of eugenics, too, is differently inflected when read through the making, dissemination, and reception of film rather than through the archival documents of scientists or institutions.[26] Film can reach very large numbers of people: both scientific and popular audiences can be large, and many copies of the same film can be distributed. This seemingly mundane point is actually very important. Both Mitman and Pernick have, by virtue of focusing on film, gained access to a history of science as a public phenomenon when it is conducted in and through a mass visual medium. Familiar issues, such as witnessing and repeatability, arise here on a different scale. Psychiatry and psychology, for example, were uniquely plagued by problems of documenting, validating, and interpreting evidence about psychic states. Alison Winter has detailed how films made for specialists offered an experience of patients and therapy more immediate and reliably repeatable than even a visit to the psychiatric ward: they were constructed to be a transparent view of the individual under treatment, and the viewer could be closer to the patients than the doctor himself.[27] The power of that intimacy was called on in 1946 by the U.S. Army, which was seeking to reassure the public that returned soldiers suffering from war neuroses could recover fully with treatment. But the commissioned documentary, John Huston's *Let There Be Light,* was subsequently suppressed by the Army—and perhaps for the same reason: the very power of film to convey mental states was in the end regarded as too threatening, the insights into the pain of the afflicted American soldier too disturbing to release for public viewing.

CONCLUSION

All of the topics treated here address the basic question, Why cinema? What is the specificity of the film medium as a historical source in the history of science? More answers are waiting to be elaborated, but the history of microcinematography offers a number of directions to work with. Scientific film and practices of projection open up a realm of phenomena accessible only through the manipulation of the time of experiment, observation, and demonstration; they throw other forms of representation into question or newly animate them by setting static depictions into motion. As has been observed, this is not just experimentation done with a given medium but, rather, simultaneous research on and by means of film. As a result, scientific cinema impacts the nature of filmmaking, not just the study of the phenomena seen on film. The history of film and science also opens a window onto how spectators at various times in the twentieth century were taught to see the world around them—in the case of microcinematography, as subtended by a previously unseen realm of microscopic movement and activity. This history is also one of the communication of scientific seeing itself: viewers were simultaneously taught to see the world as made up of cells and particles and to recognize the analytic structure of investigation

[25] Mitman, *Reel Nature* (cit. n. 10); and Sheila Jasanoff, ed., *States of Knowledge: The Co-production of Science and Social Order* (New York: Routledge, 2004).

[26] Martin Pernick, *The Black Stork: Eugenics and the Death of "Defective" Babies in American Medicine and Motion Pictures since 1915* (NewYork: Oxford Univ. Press, 1995).

[27] Winter, "Screening Selves" (cit. n. 3).

of that unseen world. Finally, film is an infinitely replicable and widely distributable medium that circulates easily across many cultural domains, giving insight into the co-production of science, technology, medicine, and society. For all these reasons, science is part of the history of cinema, and cinema is a rich and still largely untapped source for the history of science.