the microscope

NATASCHA SADR HAGHIGHIAN
IN CONVERSATION WITH
EVELYN FOX KELLER

COINCIDENCES

The following conversation with Evelyn Fox Keller was recorded in Paris on December 27, 2006. It was my second visit to Paris. At our first meeting, which had taken place two weeks before, my DAT recorder deceived me. I switched it on, looked at the display, and checked the levels. The LED display showed that the tape was rolling and that it was in record mode. Only afterwards did I understand that the tape had gotten stuck in the first second. There was nothing on the tape. I had trusted the display, but what else can I trust if I can't look inside while recording?

The prime focus of our one-hour conversation was to look at the problems of visualization in life sciences. Evelyn Fox Keller has observed and questioned the challenging history of microscopy and visualization in science. She observed the observer: the scientist who looks through the microscope in order to understand how the mind's eye shapes what we think we see with the retina. She looked at technological developments and the making of the image in order to understand the often very abstract visual product; and she analysed the scientific language that embeds abstract visualizations into the realm of real events.

NATASCHA SADR HAGHIGHIAN ▶ I've been investigating representational structures in various contexts, especially image production, and I noticed that they play a large role in science. This is how I came across your books. I found your analysis of the conditions of image production in science – and I would probably even say of the production of reality, which is a question I might return to later on – very profound and detailed. I'm referring particularly to three of your texts. The first is »The Biological Gaze« in the book, *FutureNatural*,[1] where you describe how an object of study is prepared for observation, how some objects are not necessarily visible, that one must render them visible. You take the microscope as an example, and you describe how it works. Could you explain what you mean when you talk about the biological gaze and what your motivations for analyzing that process have been?

◀ EVELYN FOX KELLER What were the other texts?

▶ In the second one, in *Making Sense of Life*,[2] you are talking about a visual culture in molecular biology. The third one that I want to refer to later on is in *Refiguring Life: Metaphors of Twentieth-Century Biology*.[3] In this text you talk about Austin's speech act[4] as a way of introducing a reality into science.

◀ Actually, I wouldn't pretend to do as much as you credit me with. I don't try to give an account of how visual representations are produced or how they constitute reality. Rather, each time I have – and I have a number of times – returned to one or another aspect of the role of vision in science and each time with a rather particular concern. »The Biological Gaze« was an inquiry into the innocence of looking, and the motivation for that paper was prompted by Rosalind Franklin's remark in *Race for the Double Helix*, »I just want to look. I don't want to touch.«[5] This remark expresses a certain romanticized yet, I think, fundamentally fallacious view of science, and echoes in many different ways. One echo is the division between pure and applied science. Pure science is just looking, just thinking, just understanding. It's just representing, if you

1 EVELYN FOX KELLER, »The Biological Gaze,« in *FutureNatural: nature, science, culture,* ed. George Robertson, Melinda Mash, Lisa Tickner, Jon Bird, Barry Curtis, and Tim Putnam (New York: Routledge, 1996), 107, 121.

2 EVELYN FOX KELLER, »The Visual Culture of Molecular Embryology,« *Making Sense of Life: Explaining Biological Development with Models, Metaphors, and Machines* (Cambridge: Harvard University Press, 2002), 205-233.

3 EVELYN FOX KELLER, Refiguring Life: *Metaphors of Twentieth-Century Biology* (New York: Columbia University Press, 1995).

4 See J.L. AUSTIN, *How to Do Things with Words* (Cambridge, Massachusetts: Harvard University Press, 1962).
Austin's theory of the speech act says that language functions not only descriptively, but can also execute an act. In other words: in saying something, we *do* something. Different from a descriptive sentence, a speech act is not checked for its verity, but instead has to be judged by its »felicity,« its success, and consequences. Therefore, it is conditional upon common societal ideas and agreements. Evelyn Fox Keller claims that scientific language also has to be judged by its felicity, not only by its verity. Scientific reality therefore is also produced with the help of speech acts.

5 SEE EVELYN FOX KELLER, »The Biological Gaze,« 107-08:
The film version of *Race for the Double Helix* [BBC Television, 1986] shows Rosalind Franklin gazing down, admiring the evidence of her latest experiment and murmuring beatifically, 'I just want to look, I don't want to touch.' …Rosalind Franklin is a scientist of the grand tradition of innocent inquiry. She is a pure scientist. Like Barbara McClintock, she has no interest whatsoever in the use value of the objects she studies. She is not after control, only understanding.

will, to make a reference to Ian Hacking's book, *Representing and Intervening*.[6] Pure science is good, applied science is what's dangerous. It is intervening, it is technology, etc. I had myself accepted – bought into, if you will, an innocence, or a romanticism about basic science. I was in fact trained in it. I was a theoretical physicist, and theoretical physics is the purest of the pure, right? We just think; we don't do. I also think that this innocence infected to some degree my biography of Barbara McClintock. I wanted to reexamine the relation between looking and touching, because I knew that this dichotomy was not going to hold. It wasn't so simple. So I focused on the fact that in biology – I argued more generally as well – that to look is in some sense already to touch, already to interact with, to disturb the object that one is observing. That the gaze is penetrating, and it's not just in the sense – in the almost trivial sense, I might say – of quantum mechanics and the uncertainty principle, but rather more deeply. Take the microscope: the question is how do you know what you see is real?[7] That's one aspect, that the reality of what one sees is established by being able to touch it, I argued (though hardly originally, other people claimed this too). If you can touch it, it's real. It's similar to the proverbial notion of stubbing your toe against the rock. The touching makes it real, and this also is true in the history of microscopy

6 IAN HACKING, *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science* (Cambridge: Cambridge University Press 1983), 21-23.
Ian Hacking describes both realist and antirealist arguments in »What is scientific realism?« in his book *Representing and Intervening*:
Scientific realism says that…protons, photons, fields of force, and black holes are as real as toe-nails, turbines, eddies in a stream and volcanos.

On page 23 he describes an experiment by LaRue, Fairbank, and Hebard at Stanford to hunt down »free« quarks. They used a ball made of niobium which is cooled below its superconducting transition temperature of 9°K to detect the quarks:
…Once an electric charge is set going round this very cold ball, it stays going, forever. …The initial charge placed on the ball is gradually changed, and…one determines whether the passage from positive to negative charge occurs at zero or at +- 1/3e. If the latter, there must surely be one loose quark on the ball….
Now how does one alter the charge on the niobium ball? 'Well, at that stage,' said my friend, 'we spray it with positrons to increase the charge or with electrons to decrease the charge.' From that day forth I've been a scientific realist.
So far as I'm concerned, if you can spray them then they are real.

A passionate scientific realist himself, Hacking admits that anti-realists arguments are legitimate due to different intertwining scientific and philosophical concepts of what is »true« or »real« and due to unobservable entities and their »fictional« representations. On page 21 he states:
We have indeed mastered many events in nature, says the antirealist. Genetic engineering is becoming as commonplace as manufacturing steel, but do not be deluded. Do not suppose that long chains of molecules are really there to be spliced. Biologists may think more clearly about an amino acid if they build a molecular model out of wire and coloured balls. The model may help us arrange the phenomena in our minds. It may suggest new microtechnology, but it is not a literal picture of how things really are….

7 KELLER, »The Biological Gaze,« 109-10:
There was of course the microscope, one of the great developments of the seventeenth century. Long before biologists came to agree about the need for an experimental science, an instrument had appeared that promised to do for the living form what the telescope was already doing for cosmic form, namely that would vastly enhance the power of the naked eye to peer at, and even into, the secrets of life. But even from the start, there was a crucial difference. The preparation of an object required for the microscopic examination was necessarily more intrusive than that required by the naturalist. Before looking at an animate being, it was necessary to first cut and fix it, in a word, to de-animate it.

where one sees the intimate relationship between looking and touching or looking and cutting.[8] As we see, there are many echoes of this entanglement. Isn't it interesting that we use the word »shoot« both for guns and for cameras? That captures something of what I am getting at. However, more generally, there is another aspect of the entanglement: that is, that we represent in order to intervene. We look in order to act, touch, interact with. Touching doesn't have to be aggressive. The gaze doesn't have to be phallic. I don't want to buy into another kind of romanticism or simplistic construction of the world. Neither looking nor touching is either good or bad. The gaze is multivalent, as is the touch. In another paper I wrote a long time ago called »The Mind's Eye«[9] I was concerned precisely with the erasure from the history of western thought of the affiliative dimension of looking, of vision. Vision is not just to distance; it is also to make contact, to touch in an erotic sense, to lock eyes, to make a connection. So you can't attach the division of looking and touching as an attempt to make vision pure and touching impure. Nothing is pure, and nothing is totally impure. Touching is essential. With regard to »The Biological Gaze,« the title was not meant to embrace or buy into the early simplistic arguments about the penetrating gaze being phallic, etc. The gaze is multivalent. Gazes can be loving; gazes can be hostile; gazes can be of all kinds. So, when I say we look in order to touch, in order to interact with, this is not a criticism. It's just to destabilize those simplistic divisions that we tend to buy into. That was the purpose of that article.

▶ You describe, however, that the process of rendering something visible by touching it also produces artifacts,[10] or that the danger is that one mistakes the representation for the object.

◀ Correct. That's the history of microscopy, and that's the question: how do we know that what we see is the way it is, that what we see is really there? The answer is that we don't. As scientists we need to persuade ourselves that what we're looking at is real, but vision is never veridical. We know this physiologically in terms of the neurophysiology of vision; but still, one of the values of vision for science is to produce veridicality.

8 KELLER, »The Biological Gaze,« 108:
Despite the crucial (and somewhat infamous) role the photograph of DNA turned out to play in Watson and Crick's race to the double helix, in leading them to their discovery of the secret of life, it is not, in fact, an image of a cell or of any other living object. It is an X-ray photograph of a crystalline structure composed from cell extracts – that is, from extensive preparations and purifications (or, manipulations) of the homogenized contents of a vast number of cells. No living object could possibly survive these preparations. Indeed, no living object could even survive the process of imaging. To obtain this image, one needs to bombard the object at issue with a barrage of X-rays that would quickly destroy the vital functions of any living thing. X-ray crystallography is thus too transgressive to enable us to see an animate entity in its living state.

9 See Evelyn Fox Keller and Christine R. Grontowski, »The Mind's Eye,« *Feminism and Science (Oxford Readings in Feminism)*, ed. Evelyn Fox Keller and Helen Longino (Oxford: Oxford University Press, 1996), 187-202.

10 KELLER, »The Biological Gaze,« 110-11:
...What does it mean to see through a microscope? What in fact can one see? For most of us, even with a modern-day microscope, the answer is precious little – apart, that is, from one's own eyeball. Only with a great deal of practice, fiddling with the focusing knob, does one learn to see anything at all through a microscope. And once one does, the question arises, is it a real thing one sees? Is it an object on the slide, or a spot on the lens? And if on the slide, is it a shadow or a ridge?

▶ What's veridicality?

◀ The truth, the way it really is, some aspect of the way it really is. We always need to try and confirm that what we see is real; and that was part of my argument – that touching was a way of confirming reality.

▶ Would you agree that reality could be seen as a relationship between the physical world or physical events in the world and their abstract representation, that this is what produces reality?

◀ This is what produces our understanding, our conception of reality (what is out there); and our means of interacting with it and representing it are our mode of access. All we have is our perception of reality. We never have anything more then our representations, our experience of the phenomenon. That's all we ever have. Our experience of the phenomenon is always mediated, e.g., it's mediated for scientists by their instruments. Also, experience is rarely first hand. There are many distinctions to be made. For example, in *Making Sense of Life,* I write about the scanning electron microscope as a wonderful development in biology,[11] because it gives us visual access to the living cell. It does not require us to kill a cell in order to see it, and that's really wonderful and very important for biology. But first of all, there is the scientist who looks through the scanning microscope. What does he see? He sees an image that is a constructed image rather than seeing the thing itself; he sees an image that has been manipulated. The thing itself has been altered to make it visible, and the visual recording of what has been seen is computationally processed. So, the scientist who looks through the scanning microscope has an experience, his experience of the cell; but between his experience and the cell there are layers and layers of processing, of intervention of various kinds. Then there is the audience or reader to whom the scientist who has looked through the scanning microscope reports his experience. What he shows is a representation, maybe a photographic image of what he saw. There are many levels of representation involved, and there are many layers or levels of experience; e.g. the experience of looking

11 KELLER, »The Visual Culture of Molecular Embryology,« 213, 217-18, 216-17:

…The great age of biological microscopy came in the nineteenth century with the arrival of better lenses, greater magnification and resolution, improved preparation of microscopic specimens, and, above all, renewed confidence in the veridicality of the basic instrument. Nineteenth-century microscopy enabled virtually all the classic observations–of eggs, sperm, fertilization, and the contours of embryonic cleavage–on which modern embryology is based…

But no improvement in technique could extend the power of resolution of optical microscopes beyond the limit imposed by wavelength of visible light, and despite even the substantial advances that developments in optical microscopy brought in our ability to see inside living cells, these were soon overshadowed by the dramatic increase in resolution provided by the electron microscope.

On page 216 of the same volume, Keller states:

Bringing molecules within view was the great achievement of the electron microscope. The advent of this new visual technology in the middle of the twentieth century–increasing powers of resolution by as much as three orders of magnitude–undoubtedly marked a triumphant advance in the history of microscopy.

at a photograph that somebody has taken or at a movie that somebody has filmed is very compelling. Or, you might be looking at a computationally processed virtual reality, at a representation of a simulation.[12] This is one of my favorite examples. What do you see when you look at the representation of a simulation, especially in artificial life? It's just wonderful. You look, you see insects, you see animals, biological entities. Ah, you see them emerge, you see them evolve. Isn't that amazing? Well, what are you looking at? You're looking at a representation that is a representation of what? In the case of artificial life, it is the representation of bits of code, computer code. Nobody has photographed living insects or filmed how living entities emerged. No, they have simply transformed bits of coding, sequence, bits of information into insects. I write a lot about how biologists learn from each other by way of their displays and the increasing brilliance and persuasiveness of the displays, about the aspect that is so important for the communication of knowledge – making it look real, making it look as if one is sitting in the audience. I'm seeing life emerge. I'm seeing the organism develop. I envision that scientist looking into the microscope, which already is a kind of metaphor for the magnifying glass; but a microscope is not a magnifying glass. Even a magnifying glass transforms. There are so many layers and levels of transformation involved. There are so many distinctions to be made, and they all involve levels and layers of processing, mediation and representation.

▶ There are two things that I see as connected: at some point you describe something you call a »dead« metaphor, and I was thinking that this »dead« state might also apply to what we call representation. At one point you say that seeing is an equivalent for knowing, or a metaphor, an analogy, and that this is an abstract relationship in a sense that comes from a certain western tradition of knowledge production – the connection between seeing and knowing, and to see that it's not the same, that it's just a reference. It has been used so much that the transfer became unrecognizable.

◀ You're absolutely right. It is like a dead metaphor, and in fact it's very interesting that we're so deeply imbued with that association between seeing

12 EVELYN FOX KELLER, »New Roles for Mathematical and Computational Modeling,« in *Making Sense of Life* (Cambridge, Massachusetts: Harvard University Press, 2003), 261-63:

A close admixture of conceptual and material tools has characterized experimental biology throughout the past century. What lends the mix in contemporary molecular biology its principal novelty, I argue, is the arrival of new technologies. The computer vastly extends the range of tools available, while the techniques of recombinant DNA make such an extension virtually mandatory. But there is more, for the recombinant DNA revolution has also added new horizons to the very meaning of words like tool and practice. In the past, the possibilities for intervening in the course of biological development–without causing its disruption–were limited to control of the mating process and, only under special circumstances and in relatively isolated cases, to the manipulation (cutting and pasting) of body parts. Now, however, and for the first time in biological history, it has become possible to directly intervene in the internal dynamics of development without interrupting the process, and to do so on the molecular scale.

...In short, just as the distinction between theoretical and experimental begins to dissolve upon examination, so too does the distinction between pure and applied.

and knowing,[13] or more specifically, with the collapse between seeing with the mind's eye and seeing with the retina – seeing with what we might call the body's eye – that even very assiduous, very conscientious scholars fail to make the distinction between seeing and representing. Now, as I said it's not a simple distinction; but there is certainly a distinction between a mental image and a visual image; or there are different ways of understanding and seeing. It's a very complex relationship, so one of the things I argued in *Making Sense of Life* was that yes, it is true that we come from a tradition in which to know is to see with the mind's eye. We talk about understanding as seeing, as in, »Oh, now I see.« Enlightenment is about understanding. It's not about literally lighting up the world, the dark, the unknown. It's figuratively lighting up the dark, the unknown; and the way we figuratively lighten up the dark, the unknown, is through science. That's what science does. Now which science? Well, in physical science mathematics has been a crucial tool for lighting the unknown, for casting light on the unknown; and in fact for physical sciences it's mathematics that is the mind's eye, the true eye. You can't trust what you see on your retina. You can't trust what you see with the body's eye. At best it can provide evidence for what's really there. What's really there is not what you see with the retina but what you can access only through the mind's eye with, for example, mathematics. Historically, the life sciences have a different tradition. I raise the question: is it possible to configure seeing and knowing differently? Look at the word evidence, evidential. This already has a double meaning. It is made explicit, available, visually available, but for the sake of something else. So, I ask the question: when is seeing with the body's eye already an end in itself, an answer to the question? When is it that you will say, »Oh, I see!,« because you've seen with the eye? (And at that point it's an end to the question, it's an answer.) »Oh, I see. I saw what happened.« It's not evidence for something else. It is itself an explanation. When is visual evidence itself an explanation, an account that is satisfying in itself? I argue that in the life sciences for many people it was *only* what you could see with the body's eye that was to be trusted, that the intellectual arguments and the conceptual arguments were not as reliable. I suggested that the microscope was to the life sciences what the calculus

13 KELLER, »The Visual Culture of Molecular Embryology,« 206:

...The colloquialism 'I see' is hardly innocent, for it indicates the depth with which the meaning we give to understanding has been bound up with seeing, and the difficulty of speaking–or for that matter, of thinking–about understanding without invoking the metaphor of vision. The aim of science is to discover Nature's secrets, to see her unveiled. To explain is to make things 'clear and evident,' to illuminate and enlighten. We have understood when we have seen with the mind's eye. The visual metaphor for knowledge is everywhere. And as is the way with metaphor, it simultaneously reflects and enforces a dynamic interdependence between mind and eye too complex to permit disentangling, and too embedded in our cognitive apparatus to do without.

was to the physical sciences, that the calculus was the metaphoric microscope, the tool for knowing, or the tool that enabled the mind's eye to see. The microscope was the tool that enabled the body's eye to see, but I think I strayed from your question…

▶ No, not at all. But could you explain again what a dead metaphor is?

◀ In general, a dead metaphor is a metaphor, the metaphoric status of which we are no longer conscious.[14] If you refer to the legs of a table you're not conscious that »legs« is a metaphor. It's now literally the legs of the table, and you don't see any metaphor there. Does its metaphoric origin still carry force? Well, I argue that it does, and often it carries greater force simply by virtue of being unconscious. To say, »Oh I see,« to speak of the Enlightenment, to speak of illumination, or to say, »Let's bring clarity to this problem,« these are all metaphors. They are all relying on the fundamental metaphor of the mind's eye, but it's a dead metaphor. This is what we now mean by clarity, Enlightenment, etc. So, is the metaphor still working? I think it is working, and I think it works very powerfully. For example, it is working through the difficulty we have in distinguishing between what you see in the microscope and what you see in the representation. We also have difficulty for technical reasons, because the modes of seeing have been so confounded, particularly by computer graphics. It's difficult in the first place to make the distinction because of the persistence of the metaphor. When we say, »Oh, I see,« it's almost as if we've seen with the eye, or maybe for the biologist when you present a mathematical argument it's the converse. He might say, »Oh, I see,« only when you translate the mathematical argument into a visual representation.

▶ The relationship between the mind's eye and the retina is quite tricky. It seems to produce some kind of blind spot. One doesn't work without the other; but on the other hand, the way we perceive with the retina is so very dependent on the mind's eye that one could say it almost makes the retina blind.

14 KELLER, »The Visual Culture of Molecular Embryology,« 208-09:
It is difficult to talk about things that are obvious, about images that have become so familiar as to be effectively invisible. For example, when feminist scholars first began to call attention to metaphors of gender in the language of science, one of the principal obstacles they encountered lay in the very ubiquity of such metaphors. The most obvious figure was of course Mother Nature, her secrets hidden from view, simultaneously provoking and resisting the penetrating gaze of science, but here was a metaphor so commonplace as to have become effectively unnoticeable. Even when noticed, its significance was often discounted on the grounds of its being a 'dead' metaphor and hence devoid of force. But metaphors are dead only because we cease to notice them, because we are no longer conscious of their effects on our perception. It might even be argued that dead metaphors are the most forceful of all, just because their mode of operation is beyond the realm of consciousness, effectively screened by their very banality. In any case, all dead metaphors were once alive.
Certainly, the figure of the maternal womb as the harbor of primal secrets was once very much alive, not only in historical time but in the lives of all of us as inquirers, as seekers of knowledge, and it left its trace. In the early history of science, the mystery of embryonic life provided a readily accessible image for representing Nature's ultimate secret; it could stand for the unknown precisely by virtue of being so deeply hidden, so fully sequestered beyond the range of human vision.

◀ Well, in fact we don't see with the retina. We see with the mind. We see those words, and we think we see them. However, they are physiologically entangled. There is no seeing without the mind's eye at work, and is there seeing with the mind's eye that does not depend on seeing with the literal eye. I suppose there must be.

▶ Our mind's eye is very much shaped, though, by a certain history of seeing or of understanding, of knowing.

◀ The mind's eye is our history of knowing, but it is, I think, shaped also by a history of visual representations. Absolutely.

▶ Do you also critique this tradition by analyzing visual representation in science?

◀ I have not focused on the extremely complex tradition of visual representations in science. It's now a big and very interesting field that examines the way in which visual representations shape our understanding. It's very important, but I'm just not in the position to advance it.

▶ In *Making Sense of Life* in the chapter »Visual Culture in Molecular Embryology,« you wouldn't say that that's about...

◀ I know it's primarily about seeing with the body's eye, about the importance of that, and I say that in the beginning of the chapter. I am not writing about the role of representations in the construction of knowledge. I want to look at the role of the embodied experience of seeing.

▶ In its extensions through technology.

◀ Yes.

▶ It seems, however, so difficult for me to even think without talking about

the theories, the preconceptions and all these things that work behind this apparatus.

◂ Of course it does, but I still don't want to erase the distinction between representing and seeing, however confounded the seeing is.

▸ So, would you say that it is about trying to reactivate a dead metaphor in order to be able to speak about it?

◂ Yes, that's exactly it. By doing so I'm asking different kinds of questions than the people who ask how representations have shaped the construction of scientific knowledge. I have to keep these questions separate in order to see what they are and how they are different.

▸ I do understand what you mean, although you keep on referring to systems of representation, for instance, when you say that our perception of real time assimilates with our perception of reel time. [15]

◂ Yes, I'm not pretending that seeing with the retina is pure. It's not, even though I am interested in how the representation shapes the mind's eye by way of the illusion of seeing, by the illusion of a visual experience. You thought you saw. If you walk down the street and you see a guy come up to somebody with a gun to steal his wallet, you are a witness. You saw it happening, but really you only think you saw. There is always that problem, but it's nonetheless compelling that you saw it. To the viewer or to the observer it's very compelling. You could be wrong. The microscope can lie. There are visual illusions but that doesn't diminish the force of seeing. I know what I saw. You can't tell me otherwise. I am trying to focus on the subjective power of seeing, or of thinking one is seeing and how that shapes our understanding, especially in biology. We sit there and we look through the scanning microscope or we look on the screen. What are we looking at? I saw that happening! But you only saw it on the screen. Did you see it in real life? Do you always know?

15 KELLER, »The Visual Culture of Molecular Embryology,« 232-33:

...Four-dimensional representations have become a central component of presentations of new results to colleagues in seminars and conferences, and the accessibility of video clips on the Internet and the use of CD-ROMs as adjuncts to traditional journals have brought the observation of intra-and intercellular dynamics to yet larger audiences of specialists and nonspecialists. Accordingly, it is not only the researcher who has the opportunity to watch these processes unfold in living time: the remote spectator, too, who is often far removed from the site of 'direct' observation, has 'virtually' the same opportunity.

Fifteen years ago, Steven Shapin and Simon Schaffer introduced the felicitous term 'virtual witness' to describe the role of such remote spectators, and the expression has since become a part of the basic vocabulary of historians of science. But the CD-ROM, I suggest, gives new meaning to the notion of 'virtual witnessing.' For, as anyone who has seen high-quality video representations of biological developments will recognize, the experience is at once thrilling and compelling, and in ways that traditional representations can scarcely begin to rival. So lifelike can the animated spectacle be made to appear that it induces a powerful sense of firsthand witnessing, the conviction that one is watching 'life itself.' Thus, the very technology that has so vastly increased our visual access to the inner workings of living organisms also has an ironic side-effect–namely, that our perception of 'real time' comes to be more and more closely assimilated with our perception of 'reel time.'

▶ Is there a consciousness about that in science?

◀ No.

▶ Not so much?

◀ Well, yes and no.

▶ That's also why you bring it up as a point of discussion.

◀ Yes, it's a constant leading back and forth.

▶ At one point you differentiate between seeing and watching.

◀ Now that's really important. Historically, or more specifically until the twentieth century the difference between a representation and seeing something was, first and foremost, the same as the difference between seeing and watching. That is to say, representations were pictures. They were static images frozen in time; whereas, actually seeing something happening was watching, seeing in time. Nobody would mistake a frozen image, a static image for a real event, right? One recognizes this as a representation, because it's not moving. With the advent of moving pictures, however, it became more difficult, and as we develop the technologies of representation, the distinction becomes ever harder to access. Even into the twentieth century and toward the latter part of the twentieth century after we had movies, movies were still sequences of stills.

▶ Sequences of frozen images.

◀ As a matter of fact, you could not watch the living cell, because you had to kill it in order to get an image. All you could do is construct the illusion of seeing the living cell by pasting one frozen image on top of another; however, if you can get visual access to the interior of the living cell without killing it, then

you can watch. That's the idea. It is, indeed, true that you still have a series of images, but they are much, much faster. You say, what's the difference between the scanning microscope and a movie camera? Well, it's speed. You can see things happening very fast that the frozen images, however sophisticated the stacking of the frozen images is, miss. You catch things on the fly. The difference between watching and seeing is quantitative, but also qualitative. When we watch we see events happening. We don't in fact see things happening, because our temporal resolution is not perfect. We can't see things happening if they happen too fast. Our eyes are also limited. It almost becomes a question of quantitative difference. Still, there is the distinction between a living cell and a dead cell, a distinction that is qualitative rather than merely quantitative. We can now capture aspects of that cell, because we can get in there so fast. We have such exquisite temporal resolution.

▶ Something comes into my mind when you describe how a cell had to be killed before it could become visible or be seen. In *The Birth of the Clinic,*[16] Foucault describes the medical gaze and this tradition of dissection, of cutting up bodies in order to understand where the organs are located and how the body works.[17] It was a matter of trust that one could look at a dead body and understand the living body, and I wonder where that trust comes from. We seem to have a tradition of understanding in which that abstraction seems possible. This tradition is also quite a strong one, to take something inanimate and…

◀ That's absolutely right. And I think it has precisely to do with our embeddedness in, with the depth of our commitment to the structural view, to structuralism, that the world is made of structures, of things, of entities. If you have to kill something to see what it is made of, *tant pis!* The important thing is that you get at the structures of things, and this, of course, shapes not only what we see but what we think. I also pointed out that, according to this view, the stable structures are what are important, and if you have to kill this cell in order to see it, you will only see the most stable structures. If you look at a dead cell what do you see? Chromosomes. They are all that's

16 MICHEL FOUCAULT, *The Birth of the Clinic: An Archaeology of Medical Perception,* (London: Routledge, 1973).

17 XAVIER BICHAT (1771–1802) quoted in Foucault, *The Birth of the Clinic: An Archaeology of Medical Perception,* 146:

…for twenty years, from morning to night, you have taken notes at patients' bedsides…and all is confusion for you in the symptoms which, refusing to yield up their meaning, offer you a succession of incoherent phenomena. Open up a few corpses: you will dissipate at once the darkness that observation alone could not dissipate.

In the same volume on page 170, Foucault states:

The figure of the visible invisible organizes anatomo-pathological perception. But, as one sees, in accordance with a reversible structure. It is a question of the *visible* that the living individuality, the intersection of symptoms, the organic depth, in fact, and for a time, render invisible, before the sovereign resumption of the anatomical gaze. But it is as much a question of this *invisible* of the individual modulations, whose extrication seemed impossible even to a clinician like Cabanis (an old-school physician), and which the effort of an incisive, patient, eroding language offers at last to common light what is *visible* for all. Language and death have operated at every level of this experience, and in accordance with its whole density, only to offer at last to scientific perception what, for it, had remained for so long the visible invisible–the forbidden, imminent secret: the knowledge of the individual.

left, practically. Well, not all that's left, but they stand out. Ah, they must be important! The processes, the dynamics, the things that happen very fast have disappeared, and they have also disappeared from our biology, from our science. They didn't just disappear from our vision; they disappeared from our science. So, I do think that your observation is a profound one, and it's very deep within our cultural history and in our language. I gave a talk one-and-a-half years ago in Beijing at the International History of Science Congress about this. I was asking the question: are there languages that are better suited to the apprehension of process and the dynamical world? There have been arguments that East-Asian languages are better suited to dynamical and relational experiences.

▶ Because there is a different tradition.

◀ It's a different linguistic tradition. You can't separate the linguistic tradition from the intellectual tradition; they go hand in hand. I'm not a Whorfian, i.e., I'm not saying that we only think what we can say. We say also what we can think, but there are different traditions. I think it's very, very deep. I also think that our language and what we are taught to think shapes our brains just as our brains shape our thinking.

▶ It seems so obvious that there are certain limitations to this type of practice, limitations that come from a certain western tradition upon which our understanding of science is based, and this has so much to do with the tradition of the Enlightenment. I was wondering: if it's so obvious that there are these limitations and that there might be something beyond – or it seems to be in need of an extension or some sort of…

◀ Yes, but how do we talk about what we can't talk about? How do we think about what we can't talk about?

▶ I want to read this quote to you. It's by Thomas Keenan and it says, »One can, and must, oppose as militantly as possible all new obscurantisms, fight for the

extension and radicalization of all enlightenments (Aufklaerung, Glasnost, and Oeffentlichkeit) and still insist: no matter how bright the light, the crossing occurs at night.« [18] I would like to ask you whether or not you could imagine some sort of new Enlightenment, and what that should consist of (if you agree that the one we have right now is not sufficient – I'm not sure). Do you see shifts of paradigms or of certain elements of the discussion that are trying to develop a new Enlightenment?

◀ Well, it is in the nature of the scientific endeavor to always try to find new ways of shedding light on things that cross in the night. To extend the Enlightenment is the mandate of science. Are there changes in paradigms? Always, just as there are changes in technology. There are always changes in paradigms. I just talked to you before about the shift to a more dynamic relational focus. That's happening in biology, and it is happening in part because of the technological transformation. That is a kind of shift of paradigm. The problem for scientists is, as it also is for Thomas Keenan, just like that of the microscope. How do you know what you're seeing is really there? How do you know that your extension of the Enlightenment is not a form of obscurantism? That's always the problem. Keenan hasn't solved it, and scientists haven't solved it, but they try. We all try. But you can't just by fiat say, »Okay, I am just going to think about the things that pass in the night.« How do you know that what you think you are »seeing« is there?

18 THOMAS KEENAN, *Fables of Responsibility: Aberrations and Predicaments in Ethics and Politics* (Palo Alto: Stanford University Press, 1997), 12.

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