LIVING DIFFERENTLY IN TIME: PLASTICITY, TEMPORALITY AND CELLULAR BIOTECHNOLOGIES

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The plant and microbial worlds have long been targets for discovery of therapeutic drugs, but insects have been left virtually untouched... Among the substances found in insects are molecules that kill cancer cells, proteins that prevent blood from clotting, enzymes that degrade pesticides, proteins that glow in the dark, anti-microbial peptides and toxins. (Cauchi, 2002; emphasis added)

Interest in biotechnology has been increasing in the humanities and social sciences, causing a proliferation of specific case studies of individual technologies or particular processes. This article offers ways to supplement these studies from the opposite direction, identifying genres of technique common to biotechnological objects of apparently disparate kinds, opening up avenues for research that are not organized by species (especially the human one) or particular object. What is biotechnology, not as a scientific and technical field, but as a field of social scientific or critical cultural inquiry? Different studies of different kinds of biotechnologies or biomedical developments are often bound together by the theoretical claim that they are all contributing to an analysis of biopolitics, the movement of 'life' to the center of contemporary political and capitalist processes. One difficulty with this Foucauldian use of 'life' is that it derives from an archaeology of nineteenth century sciences, not twentieth century ones. However acute Foucault was in elucidating the history of his present, that history for our present is as emergent as the sciences we are trying to study (Fischer, 2004). Thus an archaeology of twentieth century sciences specific to the conditions of possibility operating in today's research settings is a necessary complement to studies of the contemporary moment. However, life science in the twentieth century was a much different body of discourse and practice, of a much different scale than that analysed by Foucault, and so the very tools of such an endeavor also need to be identified.1

Particularly pertinent to our contemporary moment is the topic of cellular manipulation. Techniques of cloning and embryonic stem cell research appear as though they are a recent sudden swerve in direction for the life sciences, away from the prominence of the gene and genetic engineering. However, as Hans-Jörg Rheinberger has observed, even the power and significance of recombinant DNA techniques themselves derive not simply from the fact of sequencing, cutting, pasting, and redesigning genetic
sequences but through their enactment as molecular interventions in a wet environment – that is, the organism (or cell or tissue), via its inserted intracellular manipulated molecules, as *locus technicus*, rather than the test tube (Rheinberger, 2000: 25). In a very different context, Rayna Rapp shows how the genetic diagnosis at the core of amniocentesis depends on the ability to culture cells taken from the body, i.e. to grow and reproduce them *in vitro* for a certain period of time, so that there is enough material for the reading of chromosomal signs of genetic abnormality (Rapp, 2000). These ‘wet environments’ of living cells, tissues and organisms, though obviously essential, and possessing a material specificity and genealogy as complex as recombinant DNA, have existed as the background canvas to the genetics and molecular biology that have until now seemed of much greater significance. The dominance of scientific narratives of gene and molecule corresponds to a relative lack of comprehensive historical work on twentieth century cell biology (Maienschein, 2004).

It is never advisable, in any case, to wait for the historians. What I suggest below is that even contemporary studies of cellular technologies can be productively reconfigured by attention to their practical, material genealogies. This can be demonstrated historically, as I do by retelling a now very familiar (and seemingly exhausted) story – the cloning of Dolly – in utterly different terms than those usually given to it, or ethnographically, by asking questions of people who handle cells about what they do, how cells are cared for and grown, exchanged and stored, pushed and prodded. The historical perspective shows how practices of cryobiology (freezing and thawing of living things) and cell synchrony (artificial manipulation of cycles of cell division) of the 1950s and 1960s were constitutive to the developments in cloning in the late 1990s. These powerful techniques themselves belong to a genre of experimentation directed at *making cells live differently in time*, in order to harness their productive or reproductive capacities. The ethnographic perspective shows how these long-standing genres of intervention in cellular plasticity and temporality are now moving from the background into the foreground of biochemistry and molecular biology, disciplines previously focused on knowledge of gene sequences and molecules in a more disembodied, atemporal fashion. Taken together, these two perspectives show how the discoveries of one generation become sedimented in the protocols and biological commodities of the next, thus revealing some of the objects most in need of excavation as enabling conditions for contemporary events. This is not a focus on practice just for practice’s sake, although the attention to material and technique as well as concept and paradigm has become central to the history and social study of science in the last decades (Rheinberger, 1997). In both cases examined below, one important methodological result of a focus on practice is an altered set of historical and anthropological tools or frameworks for understanding how seemingly banal, technical, unheralded approaches to esoteric corners of the living world determine what is eventually done to and with human biological matter.
Understandably, most scholars interested in biotechnology and human life are drawn to study things that are already manifestly ‘human’ in some way, such as human genetics or human tissues or animals transfected with human genes; these categories and objects are readily available and already delineated by the professional specializations and diagnostic categories necessary to biological and biomedical research. Technique-watching would suggest, however, that a characteristic temporal feature of the structure of contemporary life sciences - as built up over the twentieth century - is that work with human matter usually comes late into the process of problematization and reorganization of approaches to living matter. Most bluntly, how we handle nematode matter or yeast matter or chicken matter may be more formative for what we do with and how think about human matter than any particularity of human matter as human.

Thus the epigraph above on insects, which may seem a strange way to open a paper about cells. It illustrates the growing and avid interest in the previously abject, worthless or arcane of the earth characteristic of the human relationship to living matter occurring today under the sign of biotechnology. ‘A feeling for the organism’ updated for the early 21st century might well shift attention to this biotechnological touch, about to descend on insects (Keller, 1983). If this evokes for the reader the Midas touch, good. But this is about more than gold. It is about the touch itself, which transmutes something into another condition – fragments buzzing, swarming, virtually untouched forms of life into molecules, proteins, enzymes, glow-in-the-dark proteins, peptides and toxins, and reconstitutes them into products, tools, machines, therapies, subjects and objects of research and knowledge and profit.

It is not just that we are mining the living world for useable bees’ knees, but that a human relationship to living matter – not to insects per se, but to living matter more generally - is established and concretized in these practices of transformation. Biological matter derived from human bodies is a subset of all the biological matter that is out there in the world – it is, in the logic of the life sciences, not endowed with any particularly special qualities other than the usual species variations. Thus the more we develop ways to use insects, the more we develop approaches to human materiality that are continuous with the way we use insects, and this goes for all kinds of obscure organisms: when we change insects, we change what it is to be biological. We are most likely to develop these approaches prior to, or at least in concert with, using human things. Another way to put this is that the usual formula, ‘biotechnology changes what it is to be human,’ should have an interim step included in it in order to understand this process of change in any detail: ‘biotechnology changes what it is to be biological.’ This interim step, I would suggest, is key to understanding the specificity of ‘life’ after biotechnology rather than ‘life’ after nineteenth century physiology.

Although an archaeology of the twentieth century life sciences is of course
an enormous project, the focus here is on the development of the practice of tissue culture, as one thread crucial to understanding contemporary cellular biotechnologies. Tissue or cell culture is the practice of growing living cells of complex organisms outside of the body, often referred to as the in vitro culture of cells. Cells in this form are maintained continuously as indefinitely self-reproducing populations (called cell lines) as long as they are incubated and kept in nutrient media, or frozen at −70 degrees. It is a technique that first emerged around 1907, a time before the ascendancy of the gene, and well before the introduction of molecular biology, when the cell was a central object of inquiry in biology, physiology, embryology and even psychology (Landecker, 2002, 2004; Schloegel and Schmidgen, 2002). As Sarah Franklin and Margaret Lock have observed, with the reemergence of the cell as ‘a central unit of action, temporally and spatially as well as functionally’ in contemporary biological research, tissue culture techniques take on renewed contemporary salience as the basis for the manipulation of complex living cells in the laboratory, from their long-term maintenance and self-reproduction as substrates for engineered tissues, to their role as producers of desired molecules or substances (Franklin and Lock, 2003: 13). The historical and ethnographic examples that follow articulate the structure of that renewed salience, reconnecting apparently new objects such as cloned animals or embryonic stem cells to the conditions of their emergence.

Part 1. Before there was Dolly there was Frostie: Cell synchrony and cryobiology in the history of cloning

As observers of life science, we are given unreasonably sturdy, highly visible, ready-made categories of the relevance of biotechnology to the human, in part by the burgeoning science popularization industry, in part by the rhetorical underpinnings of funding structures in contemporary life science: health and homology. That is, new developments that use any kind of biological matter are seen as significant to human life, even revolutionary, because they (a) introduce a new therapeutic product, which affects humans by changing their health possibilities or longevity, and/or (b) suggest that the same is true of human beings and bodies. The latter homology narratives affect people not by giving them something new to ingest, but by changing their understanding of human nature via shared evolutionary history and structural or functional homology with other organisms. This implies the possibility of new processes or information being the same or doing the same thing in human bodies. However, there are less obvious ways in which manipulation of mouse or chicken matter becomes relevant to, or formative for, humans and human matter, such as genres of experiment, and material infrastructures for exchanging and storing living matter. Sometimes the freezer matters more than the species, or the medium more than the type of cell cultured in it, in events that become important to how human life is thought about or acted upon. These are just as important as ready-made relevance in understanding where biotechnological change comes from and
how it operates.

The now well-rehearsed set of conversations around the cloning of adult organisms in the late 1990s is a case in point. As Sarah Franklin has noted, the event that was Dolly has ironically enough produced an incredible proliferation of sameness in terms of responses about the so-called ethical or cultural aspects of cloning (Franklin, 2001). Will parents clone their deceased children? Will adult nuclear donors be the twin-parent-ogre of nuclear recipients’ lives? Where will all those enucleated eggs come from, anyway? Because it raised these questions, cloning was given as evidence of the thunderbolt of the new power of biotechnology hitting human existence at its core, helped along in no small measure by descriptions by the scientists themselves of this experiment as ‘The Second Creation’ and so on. But what if we refuse the pressure, and don’t make the leap directly from nuclear transfer to human nature? I suggest this event be read not as one which foreshadows the ability to clone humans or even clone human organs or even clone transgenic sheep producing human blood clotting factor in their milk. Rather, it is a tale of cell science and its attendant manipulations, which alters what it is to be made of cellular biological matter – a change which is very much still pertinent to the present and the imminent future.

We have heard much about this experiment as the unprecedented creation of a new individual from the nucleus of an adult cell, proving that differentiation and perhaps aging are not final, and revealing the scientific and economic possibility of creating more identical organisms from individual, adult organisms. But these are not mandatory as terms of discussion, just because they are prevalent. Instead, cloning adult organisms may be retold as a tale of cryobiology and cell synchrony. Cryobiology is the science of freezing living things such that they are still alive when thawed. It is standard practice these days to freeze microbes, cells and embryos for later use. And how does one synchronize cells? This refers to the practice of forcing each individual cell in a population of cells that are growing in a culture dish to go through the stages of the cell cycle – growth, DNA synthesis, and cell division – at the same time, something they would not do unless you deprived the cells of growth factors or subjected them to various other insults. If you deprive a whole population of some nutrient required for a stage of the cell cycle, they will all stop at that point, and then adding the withheld substance will cause them to all divide simultaneously, on cue.

In 1949, Chris Polge and his colleagues at the National Institute for Medical Research in England somewhat accidentally discovered that glycerol protected sperm when it was cooled slowly to below freezing, with the result that the sperm was still alive after thawing again. This spurred a flurry of research into adding things to the cellular medium as they froze, and before the 1950s were out, red blood cells, ovarian tissue, sperm and cell cultures were being frozen and thawed alive successfully. This was a boon to the agricultural artificial insemination business, as it would be later to reproductive biology more generally (Pegg, 2002). The ability to suspend
and transport frozen cells meant much greater spatial and temporal flexibility for disembodied living cells. This was true also for the wider community of biologists using cell culture, since cell lines could be grown up, frozen, shipped, banked at a central location, referred to later, and preserved unchanged. The central storage of cell lines at the American Type Culture Collection (ATCC), for example, dates from the early sixties. To keep large numbers of cell lines going by continuous culture, without outside contamination, over decades, was an unsupportable task; the freezer therefore acts as a central mechanism both within individual laboratories or companies and within the biological research community more generally used to stabilize and standardize living research objects which are by their nature in constant flux.

Freezing looped the line in lineage, making two of its points cross for side-by-side comparison. Peter Medawar wrote in 1952 that his principal object in studying the frozen storage of skin was to use it in experiments that wouldn’t otherwise be possible, such as the making of an ‘age chimaera,’ by grafting tissue from a young animal ‘to its own self when it has grown older. Such an age chimaera (an organism whose parts are the same genetical constitution but of different developmental ages) can be realized by the appropriate use of storage methods’ (Billingham and Medawar, 1952: 466). Freezing thus immediately suggested modes of previously impossible comparison of different points on the same arc of biological time, in the same individual. Whether this ‘individual’ was an organism or a cell line or strain, one could put the older and the younger selves together in the same experimental moment.

In 1983, Ian Wilmut was involved in work that produced the first healthy calf raised from an embryo that had been frozen. In retrospect, Frostie garnered ever so little media attention, but may be understood as continuous with the initial explorations of freezing in the 1950s and the more famous cloning experiments of recent years in two ways: at the level of material practice, due to the role that freezing plays, and at the level of something like genre – a genre of experiment directed at the controlled stopping and starting of biological time. In the case of the experiment that led to Dolly, tissue from the udder of a pregnant ewe that had been frozen since 1995 in a separate institute (the Hannah) was brought over to the Roslin Institute, thawed, cultured (which means the cells were plated on a petri dish and bathed in nutrient medium so they would start growing and dividing again), and used as ‘nuclear donors.’

That the cells had been frozen for a few years wasn’t particularly significant to the main point of the experiment: the demonstration that the nucleus of an adult differentiated cell could be used to clone a whole new individual. But how, once Dolly had been born and was conveniently continuing to live despite the many insults visited upon her originating cells, could they actually tell that she was ‘genetically identical’ to the adult ewe from which
The transferred nucleus had come, since that ewe was long dead? Well, the scientists went back to the freezer and got out another piece of the tissue they had used to start the cultures of nuclear donor cells in order to make the comparison. All this screwy generationality, the novel simultaneities, the gaps of time between death of one generation and birth of another with a suspension of continuity between them, all of these deeply unsettling temporal disruptions depend to some degree on the rather banal presence of a working deep freeze. But only banal because it has become so incredibly commonplace, where it was not fifty years before. Thus the story of making a cloned sheep has elements not just of suggestion for the possibility of cloning humans, but of the conditions of its own possibility: the ability to freeze, halt or suspend life, and reanimate, as an infrastructural element of contemporary biotechnology. In short, to be biological, alive, cellular, also means (at present) to be a potential ‘age chimaera,’ to be suspendable, interruptible, storable, freezable in parts.

The same may be argued for cell synchrony. Cell synchrony was noted in dividing marine eggs for more than a century. The fertilized egg divides into two, and then the two cells both divide simultaneously to make four cells, and then the four cells also divide simultaneously to make eight, until a certain level of multicellularity is reached and the cells start dividing at different rates. In the 1950s, scientists working with simple single-cell organisms such as microbes and amoebae, which could be kept in populations in the laboratory, realized that a similar synchronization of division in all the cells in a population could be artificially induced by exposing the cultures to cycles of light and dark or raising or lowering the temperature sharply.

In the very early 1950s, it was still not evident what the significance of periodic DNA synthesis was, but with the movement of DNA to the center of biologists’ attention as the hereditary material, it became much more clearly important to understand the process by which one cell became two with two sets of chromosomes. The investigation of the cell cycle, as it came to be called, coincided with the dawning realization that cells were not just ‘resting’ between divisions as had been previously assumed, but that the DNA in the cell was undergoing various changes as the cell synthesized another copy of its chromosomes in preparation for division. These various steps are marked by various biochemical changes – one could not investigate these changes in levels of enzymes or the increasing volume of DNA synthesis if all the cells in a test population were at different stages in the cell cycle. Furthermore, these things could not be measured in single cells, they had to be ‘amplified’ by making the same thing happen in lots of cells at once, so the molecules involved could be measured. Thus, ‘as an experimental technique, cell synchrony was developed primarily for the amplification of time-limited events within the cell cycle’ (Cameron and Padilla, 1966: vii).

The other major figure in the cloning story, Keith Campbell, had for a good part of his career worked on cell cycle research in yeast and frogs, meaning
that he was very good at the ‘amplification of time-limited events within the cell cycle.’ He transferred this expertise to working with mammalian cells. Once the mammary gland cells had been thawed, they were cultured and synchronized by withholding growth factors from the culture. Thus the nuclei used as ‘donors’ to put in the enucleated eggs were taken from the cells when they were all at a particular point in the cell cycle. Campbell and Wilmut claim that the age of the organism the cells came from - or the number of times the cells divided in culture, or the degree of differentiation of the cell - does not matter as much as catching the nucleus of the cell at this particular point in the cell cycle.

It may not matter whether a donor cell comes from a young embryo, a fetus, or an adult animal, or whether it is cultured before transfer or not, or, if it is cultured, whether it goes through one passage or a dozen or more – that is, it may not matter as much as everyone anticipated. If you adjust the cell cycles of donor karyoplast and recipient cytoplast, you can produce viable reconstructed embryos from differentiated cells and perhaps, with better understanding and technique, from any kind of cell. (Wilmut et al., 2000: 105)

They also manipulated the enucleated egg. Before injecting the cycle-adjusted nucleus the egg was put in calcium-free medium. An egg penetrated by a sperm is ‘activated,’ i.e. induced to enter the series of steps in which the fertilized egg divides to become an embryo by the accompanying inrush of calcium. Normally, therefore, puncturing the egg to remove its chromosomes and inject a nucleus will cause activation. Withholding calcium acts to delay activation – allowing for the adjustment of the cell cycle of the ‘recipient cytoplast.’ The scientist may thus manipulate the egg by adding or withholding calcium in the medium, and both the giving and the receiving cell are kept poised in certain temporal states amenable to the wanted outcome. In other words, not just the matter of the cells is manipulated, great effort is put into controlling how they live in time.

Importantly, the scientists put as much emphasis on the technique as on its refutation of what everyone thought would matter. Wilmut et al. indicate that a choice has been made between an idea of the immovable intrinsic age of living matter (according to whether it comes from an adult or has been living in the laboratory for a long time), and an idea of biological time not as a boundary but a moveable quality. This is an attitude to living matter more likely to be found in individuals who have spent decades freezing and thawing, stopping and starting cell cycles than in other kinds of life scientists.

By the time it was put to use in this particular experiment, cell synchrony had become a relatively familiar technique of cell biology, as had the idea that cells have cycles. As had the various technical aspects of getting cells to live outside of the body, where they can be experimented on and observed, and
the media in which they live can be fully controlled. As had the practices of extracting cells from complex bodies and those of manipulating reproductive cells outside of the body before re-implantation in the body. The authors themselves admit that like so many other events in science, the novel combination of existing techniques resulted in something startling to all. Pointing out that the experiment was constituted by these techniques of cell culture and cryobiology and cell synchrony is not to say that it was all old hat and that the actual origin of their work lies elsewhere. There is no need to argue the long-term importance of this event as its aftermath is still unfolding, but in order to pull the terms of analysis away from claims to revolution of this single development, it is necessary to diminish the particularity of this event – to see cloning as an extension of an infrastructure that has been in the making for the better part of a century. This in turn is an effort to find a way to speak to its significance as part of (and not the cause of) the ongoing operationalization of biological time – not just its suggestion of the possibility of doing the same procedure in humans.

These practices, now standard in contemporary biology and biotechnology, are also standard in that they assume and exploit a certain plasticity of organisms - that is, the ability of living things to go on living, synthesizing proteins, moving and reproducing, despite catastrophic interference in their constitution, environment or form. The very ability to grow cells outside of bodies in artificial environments or on scaffolds, to puncture eggs and inject foreign things into them, to cut and paste genetic material and so on without killing the organism in question altogether, are also good examples of this. Where would biotechnology be if after being spliced or frozen or fused or extracted from its original environment, the cell or organism just up and died? In my view, the history of biotechnology from 1900 to now may be described as the increasing realization and exploration of the plasticity of living matter. And, like cryobiology and cell synchrony, the manipulation of the plastic matter of the organism is often, if not inevitably, linked to a disruption of temporality, whether that be of lifespan or continuity or smaller scale cycles of growth and metabolism. Whether halting something in a certain state, for example inducing stem cells to remain in a state of continuous potentiality as if they were blastocysts for eternity, or driving something to completion like a transgenic salmon, material interventions result in things living differently in time.

As a subset of this longer twentieth-century course of biotechnology, the cloning story makes it matter differently to be composed of cells and cell cycles. Being a cellular entity after cryobiology and cell synchrony means being freezable and open to artificial synchronization; any live thing made of cells, after these interventions, becomes an object that can be stopped and started, suspended and accelerated. Being cellular after cloning thus entails a different sense of biological progression being yoked to historical time in any given, predictable way. Obviously, the story presented here could be told in much greater detail but the point should be clear: the operationalization of
biological time has been a dominant characteristic of the interactions of humans and cells in technical environments over the last fifty years. It has been enabled by the infrastructural build-up of freezing technologies and cell-cycle interventions and concepts (which have reached the status of unarticulated assumptions) of living matter as stuff which can be stopped and started at will. It is these changes that are at work in the production of novel cellular objects today, of which cloning is but one example.

Methodologically, then, the approach via technique reveals different, previously invisible modes of connection between the yeast and bull sperm of twentieth century life sciences and human life. It introduces a specificity to understanding how biotechnology, with its characteristic interventions in plasticity and temporality, changes what it is, what it means, to be cellular living matter. As an approach to the living, biotechnology changes what it is to be biological, a step which must be analyzed instead of leaping straight into how biotechnology changes what it is to be human. Detailing this step provides different avenues of analysis than the accepted links of therapeutic applicability or genetic homology, and gives the observer of the life sciences a way to cut across the structure of arguments and terms of debate already well-defined by other agendas and actors in the currently very public life of biotechnologies. This is as true of any specific example one wants to pick as it is of cloning, which is something to think about at a time when it seems like every second news item is about embryonic stem cells.

A problem that arises with accepting high profile entities or practices as given categories of analysis or boundaries of research projects is that one can easily mistake the thing as the origin of the phenomena which follow it or accompany it in the discourses under study. To pick just one typical example: in an article ‘on’ ontology and stem cell technologies, we read that ‘embryonic stem cell technologies introduce’ decisive disruptions in human biographical narratives, that they are ‘literally immortal’, and that they ‘effect a major redistribution of tissue vitality from the first moments of life to the end of life’ (Waldby and Squier, 2003: 32, 35). This seems to make good sense: human embryonic stem cell technologies are new, they seem to be in the middle of unprecedented rearrangements of the manipulation and narration of human life spans; why thus not assume that they are, as powerful objects with their literal immortality, introducing and effecting this change?

As should be indicated by the story recounted above, embryonic stem cells are an arbitrary starting point. It is actually more likely that major redistributions in tissue vitality were fundamental to the appearance and consolidation of what have come to be known as embryonic stem cell technologies, which are just one of many outcomes of a systemic change in the way living matter is manipulated and thought about. Immortality came into being as a scientific entity that could be researched in cells, and therefore as a technical descriptor of cells, in the course of these changes, not in the early twenty-first century, but many decades earlier (Daston, 2000; Landecker, 2000). Just as gene therapy and cloning have come and then
diminished as high-profile scientific objects or processes, so will embryonic
stem cells settle from their current prominence, but the conditions which
produced all of these novel forms and objects will still be in operation, busily
generating yet more new things and perturbing human biographical
narratives. It is toward these conditions that analysis should be directed.
Looking at embryonic stem cells is one way to characterize these conditions,
but it is not in itself sufficient, particularly if it is meant to stand in for a
general category such as life or biopolitics.

The exclusive attention to things human is a result of just this kind of
mistaking of material and efficient causes for formal and final causes, a
difficulty perhaps particularly acute in the study of modern life science
because of its scale and diversity, and the aforementioned temporal feature
of its reasoning in which the human application comes late in the process.
The connections between the scientific or technical work concerning living
matter of all kinds, particularly when favored model organisms are chosen
from the lowly worms and fungi of the world, and changes or
problematizations of human life, are not necessarily simple or already
articulated. There are many kinds of connections, only some of which are
visible from an outside perspective, are called revolutions, or are made
otherwise obvious by practitioners. Keeping an eye on practice, protocols,
methods, technique, touch, or infrastructure is one way to access the actual
complexity of ways in which work on some life (nematodes, insects, yeast)
reshapes human life even when it does not take the form of a therapeutic
product or a homology narrative, but first introduces systematic change into
other facets of being biological.

The scale, pace and nature of biological experimentation has of course
changed greatly from the 1950s and 1960s when research in cell culture
was primarily government or foundation-funded. The focus on practices of
plasticity and temporality provides only a partial characterization of the
conditions in which new biotechnical objects emerge today. Nonetheless, the
genealogies given above map in interesting ways onto current practice. In
particular, the material intersections of the operationalization of biological
time with the temporal structures of capitalism in these settings opens up a
further avenue of characterization of biotechnology (Fortun, 1998; Franklin,
1997; Sunder Rajan, 2003). To this end, the discoveries of the first half of
this paper will be followed as they sediment as the practices and
commodities of the second half, which gives a brief ethnographic sampling of
life as a cell culturist today.

Part 2. Care of the cells: Studying the biotechnological touch in the
present

In 2002, I attended the annual meeting of the Society for In Vitro Biology. I
wanted to talk to people about hands-on techniques of handling biological
matter, techniques which cross between individual instances of
biotechnological work, or generate the infrastructure in which different biotechnological projects operate. Having written an abstract for a conference which promised that I would track the fate of the adjective ‘human’ as it applied to biological nouns, material things well-removed from the bodies of persons by years in the laboratory or layers of technical removal from its original state, I wanted to interview tissue culturists about this issue. The absolute failure of this project informs the current work in fundamental ways. I ran into two barriers; first, I kept meeting biochemists who were also there to learn about tissue culture. I had some interesting conversations about rice culture. Apparently without irony, one biochemist from Pfizer said it was outside his usual field, but that there was no way around it any more – he simply had to learn to work with cells, now that he had a laboratory full of mouse stem cells – and since the meeting was being held at Disneyworld, he could bring his kids. Second, when I finally did find some tissue culture specialists to interview, they were, to a person, absolutely disinterested in my questions about distinctions between human and animal matter in their laboratories, responding with much more detail and emotion on quite separate issues of practice, many of them linked to infrastructural and economic changes in the field in which they work.

In what follows, I will dissect in some detail one of these conversations, with the dual aim that frames this paper: to see how the use and conceptualization of cells is changing, and to demonstrate the methodological point that starting with questions of the human is not the only way to get at how these changes in cellular practice will end up affecting human life. This is not ethnography in the sense of research based in long-term studies of tissue culture practitioners, but a small piece of interview-based research informed by the kind of genealogical work done in the first half of this paper. It is clear that as biological research moves in the direction of cell-based technologies, more and more scientists are getting involved in learning and revising tissue culture techniques to their own ends. During the course of the conversation analysed below, a number of themes came up around this rapid uptake of cellular techniques into fields such as biochemistry and molecular biology.

The first of these was scientific research as itself a distinct market. That is, huge numbers of academic, industrial and medical laboratories require tons of materials, from petri dishes to large machines to biological things such as cells or DNA pieces. Plasticity and temporality here become linked to packageability – freezing, shipping, and storage enables the fast, industrial-scale distribution of cell lines and their associated needs (specialized nutrient media, manipulation tools, etc.). The scientist as consumer was a figure addressed by my interlocutor in generational terms, indicating that the scientific problems of one generation, such as the dynamics of the cell cycle or the growth factors involved in cell differentiation, turn into the protocols of the next, becoming sedimented as routines, unarticulated assumptions, and now, packaged commodities.
The second, linked theme that emerged in this conversation was conflict at the interface of biochemistry and cell biology around how to care for cells. This was simultaneously a practical issue of how to keep one’s research base alive and a normative issue of what counted as the right way to do science. Thus another field of discussion that is potentially resectioned by this conversation about tissue culture practices is that of ethics, or what kinds of questions or problems are posed to human life by new technical forms of cellular life, other than the directly controversial ones of using parts of humans or experimenting on living persons.6

Here then is a sample of a conversation about contemporary tissue culture practice, interspersed with my detailed commentary on the implications of each statement for these issues of the research market and care of the cells. Wandering the confines of the Coronado Springs Disney Resort Hotel, between the biochemists and the hordes of plant biotechnologists who seemed to be replicating on the spot, more of them every time I looked at another company-sponsored hors-d’oeuvres table, I finally found a scientist who described herself as a ‘die-hard’ attendee of the annual meeting of the Society for In Vitro Biology. Rita Elliott (a pseudonym) studies gastrointestinal diseases through in vitro cultures of intestinal tract cells, and is a specialist in establishing cell lines, that is, taking pieces of tissue from whole animals and coaxing them to live in the laboratory such that they maintain their specialized differentiated characteristics, and are used for understanding the functioning of the digestive organs at the cellular level. In her late 40s, she has been doing tissue culture work for 25 years - but biochemists were obviously on her mind as well. Reacting to my off-hand comment that there were more biochemists at the meeting than I had expected, she emphatically agreed. Her explanation of this phenomenon veered almost immediately into a reflection on how it had changed her own scientific life.

Biochemistry is going cell-specific after years of being mass tissue. The molecular biologists down the hall treat cells as if they were just reagents, something to transfect into. People fail to understand that they’re complex living entities, not reagents on the shelf. They change over time. We grow old – so do they.

Some dissection is in order here: Biochemistry is going cell-specific after years of being mass tissue. This means that instead of taking a slice of liver tissue, grinding it up to release all the cell contents, and studying the molecules or molecular complexes such as enzymes or ribosomes, biochemists are now starting to try and understand how molecules interact inside the intact cell. It is one thing to understand how molecules interact with one another while floating free in solution in a test tube, it is another to understand where they are in the cell – on the surface of the cell, embedded in a membrane, sequestered in the mitochondrion, floating in the cytoplasm, etc., in what numbers and when. Marker proteins that light up red or green
are attached to antibodies specific for a particular molecule and are used to see exactly where they are in the intact cell. Using markers of different colors, two or more proteins can be localized, and their relationship studied, in an increasingly nuanced topographical understanding of cell function. Measurement techniques for DNA and proteins are so sensitive that a single cell can be broken up for study and comparison with another cell. For example, if one cell is signaling to another, the nature of the signal can be studied in a very specific way; thus the unit of the cell has become more technically meaningful in biochemistry. In order to work with cells, it is necessary to learn how to keep them alive as research subjects in the laboratory. This is what it means to go cell-specific.

The molecular biologists down the hall. Elliott works in a university health sciences center setting on the West coast of the United States, and her funding comes from a mix of university, government, and corporate sources. She studies the gastrointestinal tract and its diseases, and the potentially wide therapeutic application for her research means that although she does so-called ‘basic’ biology of animal gastrointestinal cells, she has no lack of resources to draw on. She is primarily self-identified as a cell biologist and a cell culturist, and thus has been trained quite differently from biochemists or molecular biologists. Over the last few years, she has felt that her situation has changed; she is feeling increasingly pressured by the biochemists and the molecular biologists in her department, who left her alone before, to help them learn how to grow cells for their increasingly cell-specific experiments, and this interaction has damaged her own work in very tangible ways.

[They] treat cells as if they were just reagents, something to transfect into. In addition to the shift in basic cell science that sees biochemistry and molecular biology going ‘cell-specific,’ there is the shift in applications for this knowledge. And here too, the words should be connected to the scene. The Society for In Vitro Biology has been in existence since 1946, when it began as the Tissue Culture Association, formed to standardize and teach the methods for growing cells in vitro and using tissue culture in research. At that time, a close-knit community of animal cell culture people were most firmly in charge, and this was the case until about five years ago. As we sat having this conversation surrounded by indoor palms and Disney paraphernalia, streams of people bearing green name tags and hip one-shoulder back-pack conference bags were going past us. This year, the ‘plant’ people (marked by green name tags rather than blue ones) outnumbered the ‘animal’ people ten to one, and their side of affairs was clearly where the money was.

Why? It could be answered in the single word: transfect, whose basic meaning encompasses all forms of directed insertion of ‘foreign’ DNA into the genome of a target cell, with the aim of having that cell produce a particular protein of interest. One enthusiastic graduate student, standing by his poster presentation, explained to me that ‘in simple terms’ his aim was to become the perfect parasite – by hollowing out the genomes of plant
parasites but keeping the mechanism by which they inject their DNA into the host’s cells, he could harness and perfect this infectivity for the purposes of injecting ‘his’ DNA – this was his phrasing, not mine, and I presume he did not mean his own personal DNA. Once the ‘foreign’ DNA was integrated into the plant cell genome, he could culture plates of the cells and eventually regenerate whole plants from them (something which can not, to date, be done with animal cells in culture). He could then harvest these proteins from the growing plants, without the need to build expensive pharmaceutical factories. This imparts a new kind of relevance of in vitro plant cells to people, or at least their health and wealth. Transfection is a key experimental tool for understanding how cells work, but increasingly the emphasis has been on its role in making cells do things they wouldn’t otherwise do. In other words, parasites also see cells as something to transflect into, there is a certain adoption of the parasite’s point of view in regarding cells and the plants or animals they constitute as DNA and protein factories.

People fail to understand that they’re complex living entities, not reagents on the shelf. A reagent is defined as a substance for use in a chemical reaction, and perhaps not surprisingly for people who have made a career out of understanding the chemistry of biological molecules, cells are seen as something to add to something else in order to get a third substance – something to use in the work of synthesis and analysis. Where does one get reagents? One orders them from a laboratory or chemical supply company. Where does one get living cells? One orders them from a laboratory supply company. In fact, many chemical supply companies are becoming suppliers of biologicals to this growing market.

Take, just as an illustrative example, the Cambrex Corporation, which started out in the nineteenth century as the H. L. Baker company, making castor oil from castor beans, moved into castor oil derivatives for the personal care, ink, and coatings industries, as well as polyurethane systems for a variety of industries including telecommunications, electronics and biomedical devices. Starting in the 1980s the company that is now Cambrex began to move through a series of mergers and acquisitions, as well as products, from inorganic salts to biocides for paint to synthetic organic chemicals, to cell culture products, including both the media in which to grow and freeze cells and the cell lines themselves. Now publicly listed, the company strategy is an explicit one: move deeper into the biologicals market. An ampoule of human aortic endothelial cells, for example, goes from $455 to $1,300 USD, depending on its characteristics. So one can indeed order biological products in exactly the same way, and in many cases from exactly the same companies that used to supply chemical reagents. In other words, the link is not metaphorical, or simply a question of biochemists seeing the world as one big mass of chemical reactions, but a new and growing infrastructural characteristic of doing research with living things, in which they very literally come in different packages than they used to. For my interlocutor, trained a generation ago in the specialized and demanding task of actually coaxing
cells to live in the laboratory after excising them from the guts of laboratory animals such as rats or dogs, cell lines come first packaged as organs in organisms. For many others, these days, cell lines come as small ampoules in a Fedex package, smoking with dry ice.

[Cells in culture] change over time. We grow old – so do they. The first and most important characteristic that Elliott saw as being lost in the cell-as-reagent way of doing things was the sense of how cells live in time. As she put it, a cell in passage 10 is not a cell in passage 100. ‘Passage number’ here refers to the number of times that a cell population has been removed from the culture vessel and subcultured, in order to keep the cells at a sufficiently low density to stimulate further growth. It is a rough marker of in vitro age – indicating how long a cell population has been kept continuously dividing. And, I speculate here that this was also an invocation of a generational issue (at other times in the conversation she referred to the post-docs down the hall who were actually doing the transfection experiments as ‘kids’). She seemed to feel that her way of doing biology was aging along with her and her cells, despite the renewed interest in in vitro cell techniques due to transgenics and stem cell research.

When I asked Elliott what an example might be of this attitude to cells as reagents, she told me a story about mycoplasma.

They [the molecular biologists’ cultures] had mycoplasma – and just doused them [the cells] with antibiotics. I don’t work with antibiotics because I want to know right away if my technique is sloppy. I say, assume nothing. Look at your culture, it’s a living system, like watching a child grow. Each cell line has a phenotypic characteristic, you have to observe them when they’re happy, because if you don’t know what a good culture looks like, you can’t recognize when something goes wrong. I like to do the tissue culture work at the end of the day (you know, like splitting and feeding), just close the door and everything’s quiet.

The second thing she saw as lost along with care for one’s cells was actually a certain level of precision or complexity, gained by observing one’s cultures and building up a feel for whether they are ‘happy’ or not, and how they respond to the ‘technique’ applied to them. In other words, interacting with the cells with some sense of give and take – she put great emphasis on the word ‘look,’ stressing the necessity to see the cultures as living beings, to spend time simply observing them. I want to stress here that this was not some abstractly moral or empathetic or caring thing to do, but was in her eyes simply the right technique as opposed to sloppy technique, an attitude to cells that was not separable from a definition of good science. Forgetting something is alive is not good science. Forgetting that something ages and therefore changes over time and between experiments is not good science. Infection, such as with mycoplasma or other contamination, spoils experiments because it means what is in the petri dish is no longer a
controlled situation, ‘your’ DNA is not the only ‘foreign’ DNA in the mix, and you are not the only parasite around. Mycoplasma is particularly insidious – a form of bacteria but lacking a cell wall, it is very hard to get out of one’s cultures once it is in them, and the molecular biologist’s cultures infected her cultures, ruining months of work. Elliott explains:

In graduate school I grew African violets, then I got interested in orchids. And of course then, orchid cell culture - you can regenerate full plants, they’re much more flexible than animal cells. Anyway, I told them to just get a clean culture from ATCC [American Type Culture Collection], because it hadn’t occurred to them to freeze some down, but they don’t listen. They forget that the things they’re working with are living beings. I won’t let them store stuff with my cultures anymore, I just can’t take the risk.

At first it seemed extraneous that a comment on gardening should be sandwiched in here between doing tissue culture work at the end of the day and complaints about colleagues’ sloppy technique, but then I realized she was sorting biologists into types – or cultures, perhaps: are you a gardener, or are you a shopper? If you weren’t going to grow your own, you should call up the American Type Culture Collection (ATCC) – a central repository for all kinds of cell lines - and get a culture certified to be ‘clean’ of contamination. If you didn’t know enough about working with cells to know that you should freeze a ‘seed’ stock at the outset, in case you needed to recover from infection or mislabeling, or because you realize that cells age in culture, and you wanted to grow up a culture from frozen stock each time you needed them instead of working on sequentially cultured passages and therefore do your experiments on older and older cells, then you should recognize your lack of technique, and buy what you need from people who know what they’re doing. Even here, the assumption that the place you would naturally turn to buy your cell lines is the ATCC, a public, non-profit, government institution – rather than, say, Cambrex corporation – speaks to a mode of practice that probably differs from that which happens in the laboratory down the hall.

From this brief encounter, a whole set of questions opens up about science as consumption, the arrangement of gardeners and shoppers. In terms of the commodification or capitalization of biological matter, or nature, what do we know about the market that is scientific research itself? Scientists and laboratories, whether university, pharmaceutical industry, biotech start-up or whatever, increasingly purchase rather than make the infrastructure of their research, from machines to chemicals to reagents to datasets to assays to tissues to animals – to cells. Various configurations of all these products often come bundled together as kits designed to make particular procedures as rapid as possible.

While the commodification of human biological matter has received much attention (Scheper-Hughes and Wacquant, 2003), one important but
unstudied part of this story is the market in all kinds of biological matter that is research science itself. When scientists decide to work on cells, those cells have to come from somewhere. While sometimes they just use their own body as a source, or extract them from patients or laboratory animals, these days they are just as likely to order them from a catalog, whether that of a non-profit cell bank such as the ATCC or a commercial source. Just as novel entities such as cloned animals or embryonic stem cells can be reconnected to the conditions of their emergence, research as a market in itself is an important condition for the production of biological entities as generators of value in the present moment. It is becoming increasingly clear that large twentieth century chemical companies are becoming early twenty-first century biologicals companies (Boyd, 2003; Plotkin & Swanson, 1999).

The scale implied by the involvement of these companies speaks to the industrialization of biotechnology’s interventions in temporality and plasticity as ‘biologicals’. The ability to make cells live differently in time, so important to changing concepts in cell biology, connects at this juncture with the infrastructure of exchange through which the material base of research gets spread around the world. The techniques exploiting the malleability of biological time, which treat a living cell population as a thing that can be expanded in space and suspended in time, literally get packaged and delivered into disparate laboratories at disparate times, yet they can all say they are working on ‘the same cell.’ What is a narrative of loss for Rita Elliot is from another perspective the efficient collapse of years of conceptual and technical work into the condensed form of a tool that makes the kind of work and the scale of work being done today possible.

Thus it is not just that the idea of the cell has reemerged with all its fundamental-unit-of-life gravity, but that a very particular kind of cell – a plastic, temporally adjustable, highly autonomous cell – is readily at hand to work with as experimental subject and substrate, one that often comes packaged with the conditions of its own in vitro existence. This is not to deny that many scientists are also continuously still working to establish (make) their own cellular research objects when they have particular problems or questions to answer, or that they don’t continuously tinker with given conditions. The industrial scale of cells as biologicals is however one constitutive condition of this work today, both as a source of materials or as a potential goal for materials being developed.

The importance of the biologicals industry to the nature of the objects being produced has very recently been underscored by the finding that most human embryonic stem cell lines in use today have incorporated a significant amount of a cell surface molecule called sialic acid Neu5Gc from the kind of media they have been cultured in, and the cells they have been cultured with, most of which are of animal origin (Martin et al., 2005). The use of so-called ‘feeder layers’ of irradiated, non-replicating cells is part of growing embryonic stem cells, and these are most typically made using mouse cells. The media they are bathed in are also animal-derived. Human embryonic
stem cells grown using this ‘xenogenic culture methodology’ would cause an immune reaction if used therapeutically in the human body, because humans do not make Neu5Gc and have antibodies specific to it. A human body would recognize them as foreign animal cells and reject them. The authors writing this report tested the commercial serum replacement media that they termed ‘standard’ to human embryonic stem cell culture techniques, explicitly naming it KnockOut serum replacement and measuring its levels of Neu5Gc. Since the techniques of standardized media and feeder layers emerged in the 1950s, and were developed using animal cells, it is not surprising that the standardized tools that many scientists draw upon (i.e. buy) to work with human cells are of animal origin, and that the ‘human’ cells produced thereby have adopted, to their cultivators’ dismay, some of the characteristics of their animal culture environment. Only when a problem arises does this infrastructure become visible.

Many of the research questions suggested by this interview – such as the nature of research science as a market - are just that, open questions which represent research directions rather than detailed answers. How does the market that is scientific research itself fit into the more general capitalization of biological things? At what points do things exit ‘raw’ nature and enter the condition of ‘product’, and in what forms? Are there intermediary forms as tools, before things become therapies (antibodies come to mind as a good example of this) (Cambrosio & Keating, 1995)? Does the laboratory or research market work the way other markets do? What is its scale in comparison to the market of the general public, for the end-products of research – genetically modified foods, drugs, etc.? What is the role of the laboratory market in making possible the longer-term development of these end-products for a mass market?

In addition to understanding the infrastructural and economic role of the scientific market, we may also understand the gardener, the shopper, and the perfect parasite as ethical or political modes of practice. Kim and Michael Fortun have proposed attention to ‘care of the data’ in doing ethnographic study of scientific practice, invoking Foucault’s The Care of the Self and the idea that practical works dealing with acts of everyday life reveal generally accepted principles that organize ethical experience, even though they are not works of moral reflection or prescription and make no explicit moral judgments on those acts (Fortun & Fortun, in press; Foucault, 1986). They have shown how subject formation in the sciences may be followed and analyzed via attention to the way new scientific machines and processes are connected to new articulations of what ‘good science’ is and how a ‘civic science’ grows out of such practical projects. Their ethnography follows scientists in the field of toxicogenomics, paying close attention to what these scientists themselves articulate as worthy of care and ethical attention. Taking this approach as a guide, it becomes clear that there are many different modes of caring (or not caring) for cells currently at play in biological research, and that these are intimately related to the question
raised above, of the nature of research science as a market in which scientists are also consumers as well as hopeful patent-holders or industry participants.

My interlocutor’s enthusiastic emphasis on good science as synonymous with ‘care of the cells’ - including respect for their existence as temporal beings - and her contrasting marked disinterest in any of my questions about the sameness or difference of working with human materials as opposed to any other kind of biological materials – suggests that attention to laboratory manuals, protocol books, the training of young scientists on how and where to ‘get’ their materials and how to maintain them, how to operate in relation to other scientists’ materials and techniques, will often be more productive than explicitly moral or political questions in revealing the attitudes to the living that characterize biotechnology. We cannot stop at the laboratory door and engage only in explicitly political questions of regulation or prohibition. As years of science studies literature have demonstrated, technical practices are not abstract, but occur in social settings, like a row of laboratories located on the same hallway. Conflicts over the right way to do things are also about the power relations between different constituencies and generations battling over the design and performance of experiments, the purpose of those experiments or their ownership. 10

Conclusion

Speaking both of her refusal to share her tissue culture facilities and the changing economic conditions in which cell lines were increasingly privately sold and controlled rather than shared via ATCC, Elliot said: ‘[shrug] You do what you’ve got to do.’ These mostly unprompted comments – coloured as they are by a gentle nostalgia for previous times and one individual’s disgust for certain colleagues – are not meant to mourn the loss of a way of doing science or champion this particular perspective. Rather, they are offered as an example of the kind of empirical work that will delineate changes in those imperative but not necessarily explicit conditions for ‘what you’ve got to do’ in the life sciences today. A focus on technique, either in the contemporary or the historical sense, is one useful tool for characterizing the conditions of production of new biotechnical objects. Here it has revealed the importance of practices of plasticity and temporality to the formation of the technical cellular objects occupying so much attention today.

The dreams of synthetic biology aside (to make organisms from scratch), biotechnology depends fundamentally on the cultivation of self-reproducing, productive life forms, and the harnessing of their life courses to human intention. These components of the biotechnological touch cross between individual instances of biotechnology, and between particular objects such as stem cells, transgenic organisms, or cloned animals (as well as the much more numerous unknown, unheralded objects that escape public attention). Attention to these components opens up a set of empirical research
questions about scientific research as a market, the interpretation of laboratory practices in the life sciences as ethical and political practices, and about the material techniques of caring for, exchanging and using biological matter that characterize contemporary attitudes to the living.

Perhaps most importantly, this methodological focus on genres of technique and infrastructures of research allows room for the vast realms of contemporary biological practice and biotechnological intervention that are not based directly on human matter or health or reproduction. We thus gain better access to the question of how, specifically, altering any kind of biology – yeast, fruit fly, nematode, slime mold – is to alter what it is to be biological, without having to assume that their cultural significance derives only from their direct, one-to-one relation to human health and wealth. Gillian Beer writes of Darwin’s *Origin of Species by Means of Natural Selection*, as a text that spoke of

> survival and descent, extinction and forgetfulness, being briefly alive and struggling to stay so, living in an environment composed of multiple other needs, coupling and continuing, ceasing to be: all these pressures, desires and fears are alerted in this work without any particular attention being granted the human person. (Introduction, ix)

Similarly, the contemporary texts of biotechnology, particularly the materials and methods sections of its thousands of constitutive publications, speak of mutation and revision, senescence and parasitism, multiplicity and infinitude, living in an environment composed of multiple other technologies, profit and proliferation, totipotency and replication, also without necessarily granting centrality to the human person. Certainly the focus is often on the implication for human health, and this is accentuated by the funding and investment structures of contemporary research. However, must the observer of the life sciences exclusively focus only on how biotechnology is always directly about human biology and human nature? My argument is that to do so is paradoxically to lose sight of much of its power in contemporary culture. Once we have a more specific grasp on how altering biology changes what it is to be biological, then we may be more prepared to answer the social questions that biotechnology is raising: What is the social and cultural task of being biological entities – being simultaneously biological things and human persons – when ‘the biological’ is fundamentally plastic?

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Notes

1 ‘Characterization is a feature of biological practice itself, as it seeks to bring an unknown entity into view at that peculiar point of not knowing yet what it is, therefore necessitating the development and negotiation of tools of characterization themselves at the same time as trying to characterize the unknown thing (Rheinberger, 1997).

2 ‘Reproduction in mammals normally involves contemporaneous and contiguous action on the part of the two sexes. The advent of artificial insemination abolished this requirement in principle, but in cattle at any rate the practicability of effectively using semen long-stored in the frozen state has enormously extended the scope of the technique. It may be said, in fact, that we have abolished time and space in cattle breeding’ (A.S. Parkes, 1956; quoted in Smith, 1961: 38).

3 A good point of comparison here is the work of Alberto Cambrosio and Peter Keating, who in writing about contemporary biomedical practice have developed the idea of the ‘biomedical platform,’ looking at the practices which link different laboratory, clinical and public spaces together, and keep bodies of patients, samples derived from them, test results, and clinical entities functioning coherently across diverse disciplinary, technical, and architectural spaces. Methodologically, the focus on practice, or on ‘activities that seek to stabilize existing practices and the entities they produce,’ allows them not to address single novel objects or events, but to ‘outline conditions for the production of novelty and routine’ within any given situation, and also to avoid the trap of always having to explain everything as a ‘paradigm-ordered or theory-driven activity’ (2003: 3).

4 My complaint with always only choosing human things for study as examples, or leaving their relevance to human life unproblematic, is sympathetic with, but not the same as the call first put forth by Bruno Latour to include non-human actors in stories of the history and sociology of science as a means of avoiding the assumption that all scientific or technical change springs from human thought. Human genes are also non-human actors in his sense, as they are not (usually) endowed with thought. I wish to specify only that human biology and medicine is a subset of how the life sciences function, and is therefore not representative of the vast amount of non-human biological work in the past and present that forms the possibilities and concepts of action with human matter today.

5 A good example of this kind of work is that of Stefan Helmreich, who shows how molecular evolutionary theory has been altered by techniques of sequencing and large-scale computerized sequence comparison, practiced in large part on micro-organisms that live in extreme environments such as deep sea vents. Further, he demonstrates that these changes and
arguments over the shape of evolutionary trees (to the extent that they are no longer trees at all), connect with particular practices in the bioprospecting and valuing of marine microorganisms, via the linguistic and legal configurations of patenting (Helmreich, 2003).

6 As Andrew Lakoff and Stephen J. Collier have observed of the growth in anthropological studies of scientific, technical and administrative systems and their political regulation, these investigations are clearly not ‘to understand technical developments, per se,’ but the question does then arise of what draws these studies together (2004: 419). The same query may be posed to anthropological, sociological, literary, historical and other critical studies concerning life science. Lakoff and Collier argue that what binds diverse studies of different instances of scientific and technical transformations, what makes them ‘anthropological’ questions, is a common interest in how, ‘in relation to these technical and political developments, ‘living’ has been rendered problematic.’ That is, technical change and technical reason problematize what individual and collective life is or should be, raising questions of ‘what is human life becoming? What conventions define virtuous conduct in different contexts?’ (2004: 419). Therefore, they suggest, anthropological methods should be directed at elucidating the elements of the problematization of ‘living’ in different localities traversed by global technological and scientific developments. The empirical study of ethics then is a Foucauldian one, directed at elucidating these elements - techniques, subjects and norms – through which the question of ‘how to live’ is posed.

7 Many of the prize-winning microphotographs in the Nikon Small World Competition involve multiple labeling of cell components; see the beautiful example at http://www.microscopyu.com/smallworld/gallery/ (last accessed October 22, 2004).


9 These comments also raise the interesting question of what consumerism looks like in the laboratory, among scientists. A flip through any life sciences journal will indicate the advertising strategies designed to shape laboratory consumers. Just registering for a meeting such as the Society for In Vitro Biology has been enough to produce an absolute flood of offers for probes, machines, and biologicals, as well as telephone calls from various salespeople, slightly bemused when they find out they’ve called a Cultural Anthropology department and found someone more interested in asking them questions than placing an order for the newest apoptosis assay. Who buys what, and how does that affect the knowledge they produce?

10 In a different kind of paper, the local conditions around this particular case could be explored in much more detail, including the institutional and economic hierarchy between different kinds of life science being done in the
same complex, and the dynamics of age of gender at work in the relationships being reported here from a single perspective.

References


