Comprehending the Body in the Era of the Epigenome

by Margaret Lock

This paper suggests that it is urgent for anthropologists to respond to a current move in epigenetics in which nature and nurture are no longer understood as dichotomous elements. It is argued that a neobiological reductionism is currently taking shape due to molecularization of the environment by epigeneticists. Anthropological concepts of embodiment should be retheorized in light of this development. The formation of epigenetics as a discipline is discussed, then the habitual black-boxing of the post-Enlightenment material body is noted. Five illustrative examples are given of recent epigenetic findings: the impact of maternal stress on fetal dysfunction, social deprivation and epigenetic changes, food as molecularized epigenetics, aging and epigenetics, and toxins as epigenetic triggers. “Embedded bodies,” “local biologies,” and “biosocial becomings” are introduced as concepts that enable the insertion of an anthropological perspective into this emerging debate. A brief account of historical trauma and its ongoing effects as experienced by First Nations and Inuit of Canada are given in conclusion. It is argued that historical and ethnographic accounts are indispensable if epigenetic findings are to avoid neoreductionism and contribute to policy changes to improve human well-being.

Transcending Reductionist Biology

For more than a decade, rapidly accruing knowledge in the burgeoning field of molecular epigenetics has brought about a partial shake-up of “normal science” (Kuhn 1962) in the world of biology. Numerous epigenetic findings demand recognition of and further inquiry into the way in which the biology of living entities is continually modified throughout their existence by environmental stimuli, external and internal to the organism. Seemingly, these insights should be of great interest to those anthropologists whose research is concerned with the body and embodiment, but caution is advised: evidence of neoreductionism is already apparent in the practice of environmental epigenetics in which the majority of researchers are busy tracking molecular pathways conceptualized as mediators between nurture and nature. In these carefully controlled experiments, “miniaturized environments” (Landecker and Panofsky 2013) proximal to the body are in effect recognized as equivalent to the nurture concept.

In Reassembling the Social (2005), Bruno Latour argued that we should abandon beliefs about the unity and objectivity of the sciences (of all kinds) on the one hand, and the multiplicities and symbolic reality of the social sciences on the other. He insisted that we must actively recognize highly complex and controversial sets of mediators between these stark divisions, and that we should focus on “matters of concern” that arise in the messy arena where assumed facts and relevant symbols jostle for attention. In the age of epigenomics, involved researchers recognize multiplicities of nature/nurture and declare that bodies are no longer genetically determined. Darwinian principles of evolution are not, however, challenged by epigenetic findings, although a second form of adaptation is recognized. This is a process in which the body, understood as coalesced inseparably with environmental forces (macro and micro) from the moment of conception throughout life, is ceaselessly modulated. Such adaptations do not involve DNA modifications and are frequently of relatively short-term duration and often reversible. But modifications can last a lifetime and, at times, are possibly transmitted intergenerationally (Rando and Verstrepen 2007). This mutable body clearly poses a challenge to the reductionism of Enlightenment sciences, and hence is a matter of concern.

1. A shorter version of this paper was delivered as the 8th Eric Wolf Lecture at the Austrian Academy of Sciences, Vienna, October 2013.
2. Epigenetics is the study of modifications in gene expression brought about by mechanisms other than changes in DNA itself. The most researched aspect of epigenetic marking is known as DNA methylation, involving the addition of a methyl group, a so-called chemical cap, to part of a DNA molecule, thus preventing the expression of a gene or genes. See "http://www.livescience.com/37703-epigenetics.html#sthash.wSSAYnI0.dpuf.
3. Epigenomics is the study of the complete set of epigenetic modifications on the genetic material of a cell. These modifications are known as the epigenome.
Independently of developments in epigenetics, certain social scientists and philosophers of science have been arguing for many years that reductionistic representations of the material body, even though they have brought about significant advances in medical sciences, do not suffice: rather, the body should be conceptualized as situated in time and space, allowing recognition of the way in which environmental, historical, political, and sociocultural variables influence representations of the body and, further, meld with the material body directly and indirectly (see, e.g., Hacking 1999; Haraway 1991; Ingold 2004; Lock 1993, Lock and Nguyen 2010; Young 1995). Arguments such as this signal the importance of understanding epigenetic findings as embedded in environment writ large, that is, in historicized and politicized contexts. Such a move has significant implications for our understanding of what it is to be human in the present epoch trendily labeled “anthropocene” (Pálsson, forthcoming; Stromberg 2013).

When bodies are situated in time and space, not only do the limitations of environmental epigenetics as it is currently practiced become apparent, but so too does the stance taken by numerous cultural and social anthropologists. Undeniably the majority of us have for many years stowed the material body in a black box, assuming erroneously that it falls fully into the realm of the biosciences. If social scientists are to engage with the processes of lifelong biological transformations now recognized by epigeneticists, then the hoary debate about the concepts of nature and nurture and their interrelationship must be addressed yet again (Lock 2005; Meloni 2014a; Meloni and Testa 2014). Furthermore, epigenetic findings strongly suggest that the common practice of rather rigidly partitioning biological and sociocultural/political arguments among subdisciplines should be reconsidered.

It must be recognized that although media coverage of epigenetic findings is extensive these days, it should not be naively assumed that it has or will usurp genomics. The expectation for widespread personalized medicine in the near future in the form of whole genome mapping is very high indeed; see, for example, Manolio et al. (2013) and Collins (2014). Nevertheless, epigenetic findings provide a cautionary tale for genomic medicine, even though remarkable breakthroughs, especially in connection with cancer, are currently taking place based on genotyping. In practice, genomic medicine furnishes a static reading of a DNA profile, thus providing a decontextualized snapshot assumed to be stable through time. In contrast, epigenetic findings have the potential from which to create dynamic, fluid images, recognized as inherently unstable, that demand contextualization in time and space, with implications for population research, public health, and individual well-being.

This paper opens with a short account of the formation of molecular epigenetics and its current claims. A review then follows, necessarily truncated, of the ways in which representations of nature and nurture, notably those made by cultural anthropologists, have influenced theorizing over the past century, and with what consequences. Next, drawing on clusters of environmental epigenetic findings as illustrative examples, a discussion ensues of the manner in which “nurture” is, in effect, miniaturized and molecularized for the purposes of this research. Although involved epigeneticists acknowledge in principle social, economic, and political variables that contribute to the unequal distribution of health and illness, many, but not all, essentially set these variables to one side in order to conduct, standardize, and regulate their laboratory work. Hence, the consolidation of a newly assembled neo-reductionistic approach to the human body is in the making. In conclusion I argue, paradoxically, that these same epigenetic findings may provide incentive for better recognition by policy makers of the extent to which discrimination, violence, abuse, and trauma result in crippling consequences for human health, and for economies at large. Social science and epidemiological researchers have, of course, long since documented the shocking effects of violence, poverty, and discrimination, but these findings are, almost without exception, based on correlations, supplemented at times by ethnographic findings. Epigenetics is beginning to make manifest the molecular pathways internal to the body by means of which external de predating situations literally transform the material body—findings such as these are regarded by many nonscientists as “hard” data, tout court.

In closing the paper I introduce the concepts of “embedded bodies,” “biosocial becomings,” and “local biologies”; already in wide use, each of these concepts is designed to erase nature/nurture dichotomies and assist anthropologists in challenging molecular reductionism. Concurrently, these concepts confront the anthropological propensity to set an interiorized body to one side. Following a descriptive account of the continuing effects of colonization on Canadian First Nations peoples for illustrative purposes, the paper concludes that the findings of environmental epigenetics should be contextualized historically, politically, and ethnographically if the dangers associated with neoreductionism are to be avoided, and the full import of these research findings is to be comprehended.

The Epigenetic Explosion

The term epigenetics was introduced more than 70 years ago by C. H. Waddington, who is described in the Encyclopedia Britannica as an embryologist, geneticist, and philosopher of science. While teaching at Cambridge University, he taught himself paleontology and eventually become known as the founder of systems biology. His book Organisers and Genes published in 1940 described “the epigenetic landscape” in which human development is likened to a river flowing from a mountain to the sea that splits off into branches during the course of its journey. Waddington makes clear that this metaphor has limitations (1940:92), but even so this image is usually taken as the starting point for a genealogy of epigenetics. In the preface to the first edition of the book, Wad-
dington notes that his greatest debt goes to the biochemist Joseph Needham, who was also an extraordinarily influential sinologist best known for his monumental seven-volume work on the history of science in China. It is just possible that the image of the epigenetic landscape was inspired by discussions with Needham, who in the 1940s was teaching himself Chinese, and would have been well acquainted with classical understanding of disease causation in China; this is an approach that embeds bodies in encapsulating spheres of mind, society, environment, and cosmos. This type of thinking persists in modified form to the present day in the practice of TCM (Traditional Chinese Medicine; Farquhar 1994).

Over the intervening decades, as a result of numerous technological innovations, epigenetics has expanded into an enormous field of inquiry that includes stem cell biology, cancer biology, investigations into genome instability, DNA repair, and so on. Further, certain orthodoxies in evolutionary biology are severely challenged by epigenetic findings, as the singularly important book Evolution in Four Dimensions published nearly a decade ago (2006) by Eva Jablonka and Marion Lamb makes clear. Of direct interest to anthropologists is the subfield of environmental epigenetics, a term used to cover investigations into subjects as wide ranging as toxic exposures, malnutrition, and abuse. Disagreements among practitioners of this subdiscipline are evident, and the presumption that one or more teams of researchers represent the entire field is a mistake.

Arguments made by environmental epigeneticists have been described on occasion as "neo-Lamarckian"; this label was first created in 1885 by scientists countering a Darwinian position (Jablonka and Lamb 2006:21), used over the twentieth century in a number of ways, and has recently regained visibility. Although the belief was abandoned years ago that use or disuse of body parts brings about evolutionary change, certain researchers have continued to propose from Lamarck's time that forces internal and external to the body, in addition to genes, contribute to the phenotype of the next generation, and possibly several generations, a position supported today by a good number of environmental epigeneticists. Work with single-celled organisms, nematodes, rodents, and primates supports this position; some researchers remain less than confident about the evidence among humans, while others are convinced that this is indeed the case (Champagne 2008).

The assertion that multiple mechanisms of inheritance exist, and that variation in genomic sequences alone cannot account for phenotypic differences (Ramírez-Goicoechea 2013:66–67) inevitably raises ontological concerns similar to those apparent in the days of Lamarck, regardless of the question of intergenerational inheritance. If the gene is no longer understood as the fundamental force of human life and is not "part physicist's atom and part Platonic soul," as the philosopher of science Evelyn Fox Keller put it (2000:47), then the concepts of nature and nurture and their relationship have to be confronted head-on. Barry Barnes and John Dupré in their 2008 book Genomes and What to Make of Them use the term "astrological genetics" to describe what they insist has been a fetishization of DNA that must now be overcome. Central to this new understanding is recognition, partly as a result of findings made while carrying out the human genome project, that genes, in and of themselves, although essential in the creation of the form and structure of life, determine very little indeed of its functioning. Genes must be activated (switched on) and, when appropriate, deactivated (switched off) by means of complex processes bringing about differentiation that takes place at the cellular level throughout the life cycle, a process that Waddington termed "canalization." What has emerged is a "reactive genome" (Griffiths and Stotz 2013:66).

Ramírez-Goicoechea (2013:66) argues: "cellular differentiation is governed by the epigenetic landscape, a complex panorama of networks and feed-forward loops that determine whether or not stem cells go into a lineage. As a developmental process, epigenesis is highly context-specific, following a chronological and topological logic." DNA methylation, currently receiving a great deal of attention, is just one of several epigenetic mechanisms that control gene expression in cells. It is of note that several timescales are affected by methylation processes—evolution, transgenerational inheritance, individual lifetimes, life-course transitions including adolescence and menopause, and seasonal change modifications. The effects of these passages of time become miniaturized in the bodies of individuals and hence are researchable at the molecular level (Landecker and Panofsky 2013).

Epigenetic researchers are usually careful to point out that the identification of mechanisms that transmit signals from social environments resulting in changes in DNA methylation have yet to be fully worked out. But it is incontrovertibly demonstrated that methylation (a highly conserved process found widely in both animal and plant worlds) functions so that any given genome is able to code for diversely stable phenotypes. In other words, although every cell is potentially the same, methylation brings about cell differentiation among, for example, what will become liver as opposed to neuronal cells. Furthermore, such changes do not take place only in utero and early postpartum years, as was believed until recently, but continue throughout the life span (Meaney 2010).

An additional hypothesis that attracts environmental epigeneticists posits that DNA methylation and other related mechanisms have a second very important function, namely that these processes are not solely the result of endogenous stimuli, but are also direct responses to environmental signals external to the body that modulate patterns of cellular activity; a substantial body of research of this kind now exists (Cortessis et al. 2012; Feil and Fraga 2012). One approach that has attracted considerable media attention used models of maternal deprivation created in rodents, on the basis of which biological pathways have been mapped that result in disadvantageous infant phenotypes that can persist into adulthood (Meaney et al. 1996). With respect to humans, a
large literature has accrued since the 1990s showing a strong relationship between “childhood maltreatment” and negative mental health outcomes ranging from aggressive and violent behavior to suicide. Current investigations are beginning to expose the pathways of the implicated epigenetic processes regarded as “crucial mediators of . . . long-term biological embedding of childhood maltreatment” (Tureki et al. 2012). The conclusion drawn from these studies is that the “epigenome is responsive to developmental, physiological and environmental cues” (Lutz and Tureki 2014).

In late 2011, Moshe Szyf, well known in the world of epigenetics, titled a presentation he gave at a Montreal gathering: “DNA methylation: A molecular link between nurture and nature.” At the time this talk was given, evidence for this link accrued primarily from animal research and from one human study based on a sample of 25 individuals who had suffered severe abuse as children and later committed suicide. At autopsy, the donated brains of these individuals showed a significantly different pattern of DNA methylation than did those of a control group of 16 “normal” individuals. A second control group of 20 individuals who had committed suicide but where no known abuse had taken place was also included in the study. The findings are presumed to substantiate a mechanism whereby nature and nurture meld as one. In this particular case, childhood adversity is associated with sustained modifications in DNA methylation across the genome among which are epigenetic alterations in hippocampal neurons that may well interfere with the processes of neuroplasticity (Labonté et al. 2012).

The researchers acknowledge that the sample is small, and that the study cannot be validated. The absence of a control group that experienced early life abuse and did not die by suicide is another shortcoming. Furthermore, the abuse that the subjects experienced was exceptionally severe (G. Tureki, personal communication, 2012). Szyf and colleagues readily agree that understanding of these processes is rudimentary. More recent work has established that specific regions of DNA methylation-induced tissue changes are not limited to brain tissue alone, but can also be shown in white blood T-cells. This is potentially good news for researchers who may now be able to make use of blood samples procured from living subjects, rather than be limited to the use of donated brains, although this method is not as yet validated. A review article in Neuroscience, part of a special issue titled Epigenetics in Brain Function (Lutz and Tureki 2014), brings the literature on childhood maltreatment and DNA methylation up to date.

Moshe Szyf insists, with justification, that he is not a biological reductionist, but his presentation to an audience composed largely of molecular biologists made it easy for them to walk away with the idea that such findings are sufficient to settle the nature/nurture puzzle once and for all. He did not venture into the social and political aspects of child abuse, nor present data about the histories of the involved families, include narrative evidence from families, discuss what is known of the lives of the individuals who had committed suicide, or elaborate on the lives of the control groups. This is perhaps not surprising given the audience to whom he was speaking and the imposed time limitation and, further, that Szyf makes it clear that he has no expertise in the social sciences (personal communication, 2013).

Epigenetic findings of this kind have certainly opened doors to what has been described as “an explosion of interest in so-called epigenetic mechanisms of gene regulation in the brain” (Miller 2010:24), but cultural anthropologists will be wary that we may be entering an era bent on embracing a new round of somatic determinism, this time with attention directed at the cell as the site for primary attention. As noted above, the contribution of environments—social and environmental—to human development, health, and illness are not denied by epigeneticists, but there is a distinct danger that the molecular endpoints that these variables bring about, and very little else, may well receive undue attention.

Research concerning abuse of humans is fraught with difficulties due to ethical issues and, further, “abuse” is not amenable to measurement. Even so, these epigeneticists, and others whose work is noted below, have thrown down the gauntlet to genetic reductionists. However, the manner in which historical, social, economic, and political variables impinge on human experiences and behavior, and in all likelihood contribute indirectly or directly to epigenetic changes, remains distinctly shadowy. These variables are likely to go largely unexplored if research is left up to environmental epigeneticists alone. One dramatic example is already in existence of the way in which epigenetic findings about abuse and violence can be taken up in the media in a very disturbing manner. A video was recently distributed widely on the internet with the title: “The New Theory that Could Explain Crime and Violence in America: forget what you’ve heard about guns and drugs. Scientists now believe that the roots of crime may lie deep within our biology.” This video cites extensively the research of the Montréal group, and also that of a Zurich-based researcher working with mice.

At the beginning of the twentieth century, Franz Boas argued that adult phenotypes are dependent upon environmental exposures during human development, but this insight has been largely forgotten among cultural anthropologists. Developments in epigenetics have now brought us to a juncture where I believe it is necessary to reconsider Boas’s insights, and turn our attention to the specifics of how life events and environmental exposures become literally embodied, and with what consequences for health and illness, possibly over ensuing generations.

Beyond Nature and Nurture

In the late nineteenth century, Francis Galton set himself the task of investigating the origins of “natural ability” and gave

the name “eugenics” to the program he devised. The ultimate objective of this archetypal Enlightenment endeavor was, no surprise, human improvement, and Galton drew on what he knew about animal and plant breeding that had already long prevailed in husbandry. “Undesirables” would be eliminated by means of the removal of “inferior germ plasm,” and efforts would be made to permit the multiplication of “desirables”—approaches that he labeled negative and positive eugenics, respectively. It was Galton who first formally coined the phrase “nature and nurture,” thus setting up a marked disjunction between these entities. From classical times, ideas about “nature/nature” had been blurred and left indistinct; it was only after Galton that these diffuse ideas were transformed into distinct entities by the deliberate introduction of the conjunction “and.” With this move, Galton set up the body alone as the source and vehicle of inheritance, thus making theories about heredity “both nominalized and interiorized” (Keller 2010:21).

Keller has argued that the very creation of the idea of nature and nurture introduces a “mirage of space” and insists: “it is a mistake to think of the development of traits as a product of causal elements interacting with one another.” Indeed: “the notion of interaction presupposes the existence of entities that are at least ideally separable.” She argues that the terms nature and nurture are not in any way separable; to insert the “and” is to make them into a false dichotomy. She adds: “entanglement between genes and environment is the product of “an immensely complex web of interactions between environmental stimuli (both internal and external to the cell) and the structure, conformation, and nucleotide sequence of the DNA molecule” (Keller 2010:7). In addition, RNA activity must be accounted for among yet other exchanges taking place ceaselessly inside every cell of the body. This cellular environment is itself endlessly modified by signals emanating from other cells, the organism as a whole, and environmental sources external to the body.

Recent work has also demonstrated that bacterial cells outnumber human cells by 10 to 1 in the human body, and 3.3 million genes from more than 1,000 species of microbes are present in the human digestive tract, a good number of which function positively to enhance the immune system, among other activities. Jennifer Ackerman argues: “Our individual fates, health and perhaps some of our actions may have much more to do with variation in the genes found in our microbiome than in our own genes” (2012:39). The microbiome, then, continually interacting with stimuli originating from both external and internal environments is integral to the human self.

The Culture Concept and the Super Organic

As is well known, Alfred Russel Wallace introduced a concept of natural selection several years before Darwin’s publication of the Descent of Man, but Wallace communicated with Darwin in 1869 to say that he had revised his opinion. Based on his experience of living in South America and Southeast Asia in intimate contact with local peoples, Wallace came to the conclusion that the human brain is so powerful that it overrides natural selection because its capacity is such that humans are not subject to pressure from environmental variables in the same way as are other living organisms. His position, one of human exceptionalism, profoundly influenced Franz Boas, and inspired the first anthropological postulation of the culture concept, the most extensive elaboration of which appeared in The Mind of Primitive Man (Boas 1911).

Boas’ research in the first decade of the twentieth century involved measuring the cephalic indexes (the ratio of the length to the width of the head) of several thousand immigrants and their children living in New York. The findings of this study surprised him when it was made clear that the cephalic indexes of the children of immigrants differed from those of their parents. Boas’ conclusion was that the head shapes of immigrants converged to a common type as a result of similar environmental pressures, so that: “we are necessarily led to grant . . . the great plasticity of the mental make-up of human types” (Boas 1911:64–65). Boas was also at pains to emphasize that the organization of the brain is basically the same for all mankind: “There can be no doubt that in the main the mental characteristics of man are the same all over the world,” but equally he acknowledges a “diversity produced by the variety of contents of the mind as found in various social and geographical environments” (1911:104).

George Stocking, historian of anthropology, suggests that ultimately Boas ended up as an agnostic in the nature/nurture debate (Stocking 1974). Although the validity of Boas’s research on the cephalic index has been questioned, such critique merely sidesteps the ontological questions that are at stake. He was writing after the rediscovery and publication of Mendel’s work on genetic inheritance and, no doubt very struck by this publication, he insisted throughout his life that the influence of heredity was probably more important than that of the environment. Even so, Boas continued to be a firm believer in the contribution the environment makes to human developmental processes, and he argued that the concept of race should be abandoned, working tirelessly against racial prejudice in the United States to considerable effect (Degler 1991). Even so, Boas persisted in his belief that the “highest culture” was to be found in Europe (Stocking 1968: 231–232) although, with the right conditions, he argued, such a status could be attained among people anywhere. Based on the emphasis Boas gave to the “plasticity” of the human brain in response to environmental influences, he can perhaps be labeled a proto-epigeneticist.

Alfred Kroeber, in contrast to his mentor Boas whose early training was in science, was initially schooled in literature and language; even so, Kroeber found justification for making a strong claim for recognition of a marked dichotomy between nature and nurture by drawing on the genet-
icist Weismann. He insisted that Weismann had proved beyond doubt “the Lamarckian structure . . . to be absolutely hollow.” Kroeber was especially struck by Weismann’s argument that a wall exists between “gamete and zygote” (the unfertilized sex cell and the fertilized cell; Kroeber 1916:26–27), and he inferred from this that biology cannot in any way explain the achievements of human society. Even so, Kroeber agreed with Galton’s theories about the inheritance of intelligence because he firmly believed that “characters of mind are subject to heredity much like traits of the body” (1952:39). As is well known, Kroeber’s essay “The Superorganic” published in 1917 became the canonical argument explaining why biology has no place in anthropology. Herbert Spencer had first made use of the term superorganic, but Kroeber reworked the concept and, in effect, turned its original intended meaning on its head (Degler 1991:90). For Kroeber, above all else, it is the possession of values (morals) that sets humans apart from animals. Notably, Kroeber chas- tised sociologists, historians, anthropologists, and other theorists for having simply “imitated” biologists. He insisted, in contrast to Boas, that in order to understand social phenomena it was essential to “disregard the organic as such and to deal only with the social.” (Kroeber 1952:34–35). Kroeber’s arguments were so successful that in an introduction in 1952 that preceded a reissue of “The Superorganic,” Kroeber was able to write: “For many years now, the article has excited little stir among anthropologists, presumably because its conten- tions have largely passed into their common body of as- sumptions” (Kroeber 1952:22).

Toward an Anthropology of Nature/Nurture Reunification

One result of a “disregard of the organic” has been that body interiority has been “black-boxed” by cultural anthropolo- gists. Our assumption has usually been that the body of modernity resides in the domain of biology and, further, that body interiority is for all intents and purposes universal, although, inarguably, bodily subjectivity and discourse are highly varied. The philosopher Russell Keat commented on this phenomenon long ago when he noted that a good deal of time had been spent in the social sciences and humanities in discussing the distinctiveness of human beings, while at the same time holding to an assumption about the “non-distinctiveness of the human body” (Keat 1986:24). Without doubt reluctance to engage with body difference has been reinforced by a fear that this gives support to a racialized bi- ology.

The outcome of disembodying anthropological subjects has been that the “body proper”—the body that has enabled singular advances in the biosciences—has been left largely untroubled by thoughtful critique (Lock and Farquhar 2007; Lock and Nguyen 2010). Ultimately, many medical anthropologists, even though we condemn the social inequalities that give rise to poor health and premature death, and the political injustices so often associated with the implementa- tion of medical practice, have been less adept at addressing fundamental matters of onto/epistemology—matters of concern—that inform the production of biomedical knowledge, although this situation has changed considerably in recent years. The intent in addressing the truth-claims of biomed-icine is not to dismiss outright the standardized “universal” body (an entity that is indispensable to contemporary medical practice), but rather to contextualize and embed bodies in time and space and bring to the fore the coalescence of history, the social/political, and the material body. Examples of anthropological research that have approached the nature/ nurture problem in this manner include Fulwiley (2011), Hamdy (2011), Ingold (2004, 2013) Koch (2011), Lock (1993; 2001), Montoya (2007), Nguyen (2010), Pálsson (2013) Rapp (2011), and Yates-Doerr (2011), among yet others.

Politics and Embodiment

Certain epidemiologists, one or two influenced by anthropo- logical work, have written about embodiment for some time. In 2004, Nancy Krieger and George Davey-Smith, cri- tiquing the reductionism of so much biomedicine, wrote: “mending the mind/body rift long characteristic of biomedici- cine is not sufficient”; it is “equally critical,” they insist, “to recognize that in addition to being mindful, bodies also are literally corporeal” (Krieger and Davey-Smith 2004:92). Their essay illustrates the way in which societal conditions “shape the expression of biologic traits, population distributions of disease, and social inequalities in health,” and they cite the classic Engels text on this matter: “common observation shows how the sufferings of childhood are indelibly stamped on the adults” (1845 [1968]:118–19). These are arguments that have been made again and again by social epidemiologists over the years. Quantitative research has shown robustly the effects of poverty, inequality, social discrimination, lack of social support, and racism on the health of individuals and populations, as the work of Richard Wilkinson (2005), among many others, makes startlingly clear. Such findings demand that bodies be situated in context in order to account for the vagaries of disease.

Unfortunately, this line of work is frequently labeled as the “social determinants” of health and illness, with a subtext of “Why do some people get sick and others not?” (Evans et al. 1994). The majority of researchers have adhered to the basic working assumption of biomedicine, namely that body interiority is in effect everywhere the same, and that social determinants account fully for difference in ways that can be standardized and measured (with some allowance made for genetic predispositions). The conjunction “and” remains in place in most health-related epidemiological work. Obvi- ously such research is invaluable but, given advances in epigenetics, refinement is now required, as Kreiger and Davey- Smith (2004), among others, are well aware. A recent issue of the American Journal of Public Health is devoted to the
manner in which epigenetics influences phenotypic expression. Moshe Szyf was asked to make a contribution to this issue and acknowledged that the manner in which DNA methylation "participates in a sculpting genome function in response to signals from the environment" remains to be fully elucidated (Szyf 2013:S9).

What follows are several examples of subject matter being investigated by environmental epigeneticists. These illustrations cover a wide range of issues, and are set out here in the hope that they will encourage anthropologists to contemplate how best we may contribute to enlarging the arena of investigation urgently needed to complement the findings of epigeneticists.

Epigenetics and the Life Course

It has been demonstrated repeatedly that prenatal exposure to maternal stress, anxiety, and depression can have lasting effects on infant development linked to the appearance of psychopathology later in life. A review of 176 articles, based on both animal and, to a lesser extent, findings from human research, notes: "the in utero environment is regulated by placental function and there is emerging evidence that the placenta is highly susceptible to maternal distress and is a target of epigenetic dysregulation" (Monk, Spicer, and Champagne 2012:1361), added to which a large body of research suggests that postnatal maternal care can induce further disruptions. Such findings are based largely on correlations; although researchers are beginning to map segments of the pathways whereby environmentally induced epigenetic marks are apparently associated with behavioral outcomes pre- and postnatally (Monk, Spicer, and Champagne 2012). Antenatal depression and anxiety symptoms are picked out for particular attention as signs of an in utero environment bringing about dysregulation. In other words, the environment is effectively scaled down to molecular activity inside a single organ of the body—the uterus and its fetal contents.

In an article published in BioSocieties, Ilina Singh comments on a warning sent out to its members by the American Academy of Pediatrics in 2011 cautioning about the harm caused to children by "toxic stress." Singh interprets this warning as a move toward increased monitoring of families, notably pregnant women and young mothers who, she suggests, are likely to be further targeted for observation—their behavior subjected to surveillance designed to avoid fetal and infant stress. Medical and social support for young childbearing women is to be lauded but, as Singh states, the possibility that newly revamped home visits to pregnant women, such as those being carried out through a partnership of nurses and family practitioners in New York, might well become, in effect, "womb visits." The poverty and often violent living conditions of many mothers-to-be may well be virtually ignored, and attention light almost exclusively on the pregnant belly and its contents (Singh 2012). Research findings from the Mapping of the Human Brain project are providing remarkable insights into the singularity and complexity of genes that appear to put a fetus at risk for autism following birth. It is evident that epigenetic changes in utero are implicated. As this research unfolds, the womb and its environments will be monitored ever more closely (Semeniuk 2014).

One of the most cited studies in which the fetal environment has become an object of study is in connection with pregnant women affected by the so-called Dutch Hunger Winter; research has been followed up over two ensuing generations. Thirty thousand people died from starvation as a result of a food embargo imposed by the Germans in World War II that brought about a complete breakdown of local food supplies, adding to the misery of an already harsh winter. Birth records collected since that time have shown that children born of women who were pregnant during the famine not only had low birth weights but also exhibited a disproportionately high range of developmental and adult disorders later in life including diabetes, coronary heart disease, and breast and other cancers. Furthermore it has been shown that the second generation, even though prosperous and well nourished themselves, produced low-birth-weight children who inherited similar health problems thought to be incited by epigenetic effects (Heijmans et al. 2008). Furthermore, exposure to severe food deprivation during the first trimester of pregnancy showed a substantial increase in hospitalized schizophrenia for women once adult, but not for men. These findings give plausibility to the proposition that early prenatal nutrition can have a gender-specific effect on risk for schizophrenia (Susser and Lin 1992; space does not permit further examples of gender-specific epigenetic changes).

Obviously fetal malaise and that experienced by young children is at times caused directly by parental and step-parental behavior. Such behavior is frequently aggravated by the socioeconomic status of the family and may be exacerbated by substance abuse. However, it is clear that history, politics, social environments, racism, chronic discrimination, war, and other major social disruptions must be given consideration equal to that of immediate family circumstances when attempting to account for epigenetic effects. Such research will raise challenging questions about the distribution of responsibility for ill health over time and space among individuals, families, communities, bureaucrats, politicians, capitalists, and others. It is noteworthy that the Dutch Hunger study is one of two or three sets of findings often cited as examples of intergenerational transmission of epigenetics effects. These claims have not yet been satisfactorily substantiated however.

Social Deprivation

Research carried out with Romanian children living in orphanages makes clear that a paucity of social relations can bring about significant lifelong harm that may well have in-
tergenerational effects (Nelson et al. 2013). A randomized clinical trial was carried out in which over 60 orphans ages 8 and 9 were moved into good foster-care homes, at the expense of the involved researchers from the United States, while a control group of similar size was left to languish in the orphanage. The study demonstrated, perhaps not surprisingly, that foster care was much more effective for the well-being and development, mental and physical, of these young children than was the orphanage setting in which a single adult may be responsible for 12–15 children. But of particular interest were findings that, as compared with never-institutionalized children, the orphaned children exhibited less development in both the grey and white matter in their brains. Foster placement quickly improved development of white matter, although grey matter development did not recover. Furthermore, the majority of institutionalized children showed shorter telomere lengths. As Elizabeth Blackburn, who has worked her whole life on telomeres, has argued: short telomeres “powerfully quantify life’s insults” (Blackburn and Epel 2012:170). These findings were communicated to the Romanian government in the hope, one assumes, that the government will work harder to foster the many children still living in orphanages as a result of the Ceaușescu regime. Efforts to map the molecular epigenetics pathways of these findings, and those obtained from other orphanages, are now under way with some success (Nau-mova et al. 2012). Longitudinal ethnographic research could enrich these findings greatly, and has the potential to influence policy making.

Food as Environment

Globally, nearly 2 million children die from malnutrition each year. Recent research has revealed remarkably interesting findings about biological differences between infants who suffer from marasmus as opposed to kwashiorkor (Forrester et al. 2012). This impressive study was carried out in Jamaica, commencing in 1962 and continued for 30 years; during this time over 1,100 infants with severe acute malnutrition were admitted to University Hospital, Kingston. It was found that those infants diagnosed with kwashiorkor had considerably higher birth weights than did infants diagnosed with marasmus. The authors concluded that mechanisms associated with physiological “plasticity” are operative in utero and that these children have distinctively different types of metabolism. Of the two conditions, children more often die from kwashiorkor, associated with edema, although less wasting takes place as compared to marasmus. Children diagnosed with marasmus do not become edematous but endure much greater wasting of their flesh, although their survival rates are better than those of children with kwashiorkor. Researchers characterize marasmus as “metabolically thrifty,” and kwashiorkor as “metabolically profligate.” They propose that in the case of children with marasmus, when the maternal diet is low in nutrition, fetal metabolism in utero in effect anticipates a postnatal environment of scarcity, and low birth weights are assumed to be evidence of this process designed for survival. The authors argue that this finding provides the first direct evidence in humans in support of the fitness-enhancing effects in childhood of “anticipatory responses” in utero. Hence, the distinctly different phenotypes of children with kwashiorkor and marasmus are understood as the endpoints of epigenetic activity on genotypes in utero.

Nutritional epigenetics is a field attracting a great deal of attention in part because it is hoped that it will throw light on the so-called obesity epidemic currently affecting many countries, whether affluent or not. The same team that carried out the research reported above argues that growing evidence exists of “developmentally plastic processes” (Forrerest et al. 2012) that, in addition to lifestyle and individual genotypes, contribute significantly to obesity. No claim is being made that such developmental pathways, in which methylation processes are involved, cause obesity directly, but that the risk of genetically predisposed individuals for developing obesity in later life is increased. Based on a hypothesis known as the “mismatch pathway,” it is posited that “evolved adaptive responses of a developing organism to anticipate future adverse environments” can have maladaptive consequences if the environment is not what has been “biologically anticipated” (Gluckman and Hanson 2008:124). In other words, if fetuses and young infants are exposed to nutritionally deprived diets, their bodies may be epigenetically prepared to deal with deprivation as they mature, as the marasmus study suggests, a situation that can cause havoc in energy-rich environments. In addition, maternal diabetes, maternal obesity, and infant overfeeding are associated with increased risk of obesity in adult life (Gluckman and Hanson 2008).

Clearly this account resembles the thrifty gene hypothesis put forward in 1962 by James Neel, an argument now outmoded in the postgenomic era; discussion about thrifty phenotypes has superseded it (Watve and Yajnick 2007). Animal research into epigenetics, and recent findings with humans, is showing how “evolution has equipped organisms with mechanisms to respond specifically and efficiently to certain critical novel experiences . . . and to transmit this information effectively to their offspring without the need for the typically slow process of natural selection” (Szyf 2014:4). It may well be that—given the inordinate rate of global change currently being brought about by human activities, environmental and social, much of it involving extraordinary violence and dislocation of one kind or another—mismatches will commonly exist between environments to which human populations are reasonably well adapted biologically, and the lived environments in which millions of people are forced to exist. Data based on the Dutch Hunger Winter and

5. Marasmus and kwashiorkor are two common forms of serious protein-energy malnutrition.
similar studies in which starvation is implicated appear to be recent historical examples of this process.

Hannah Landecker argues that food is currently understood by researchers as an epigenetic factor that functions in the regulation of gene expression, in turn, linked to several medical conditions including cancer, metabolic syndrome, obesity, and diabetes. In other words, food is a form of “environmental exposure” (Landecker 2011:167) in which the environment is molecularized as food chemistry so that “the body’s molecules [are] hung in the same network of interactions as environmental molecules, a network anchored and organized through the temporarily sensitive interface of metabolism” (176). Landecker argues this is a model “for how social things (food, in particular) enter the body, are digested, and in shaping metabolism, become part of the body-in-time, not by building bones and tissues, but by leaving an imprint on a dynamic bodily process,” namely, the expression of genes (177). She notes that, in a sense, food enters the body and never leaves it, and what is taking place is “a very specific form of naturalization of social change that recasts suffering as molecularly heritable, the past borne forward into the future via a metabolic interface” (179). Without doubt this is a research area that will incite interest among anthropologists who—using historical accounts and ethnographic and survey methods—clearly have the potential to greatly complement the work of basic scientists.

Epigenetics and Aging

Research into the epigenetics of Alzheimer’s disease (AD) is under way. One study has showed links between memory formation and epigenetics (Wang et al. 2008). In another project, an analysis of DNA methylation across what are considered to be 12 genome susceptibility loci for Alzheimer’s was carried out. It was found that age-specific epigenetic drift from a previously established norm was apparent in brain tissue taken from individuals who had been diagnosed with AD prior to death, as compared to normal controls. The authors of this study argue: “The epigenome is particularly susceptible to deregulation during early embryonal and neonatal development, puberty, and especially old age” (Wang et al. 2008). They also found that certain genes known to be of significance in Alzheimer’s development showed “significant inter-individual epigenetic variability.” Another study revealed that brain tissue obtained from identical twins had markedly different levels of DNA methylation. One twin had been diagnosed with AD at age 60 and died 16 years after the diagnosis, and the other died at age 79, with no signs of dementia. The individual who was demented had significantly lower DNA methylation in his brain tissue than did his twin and had been exposed extensively to high pesticide levels in connection with his earlier employment, a factor considered to be highly significant (Mastroeni et al. 2009).

Wang’s team also noted that epigenetic modifications may exert only subtle effects on the regulation of specific genes. Thus, it is plausible that abnormal DNA methylation results in a disease phenotype only when several loci are affected at the same time. These researchers argue that late-onset AD “may represent merely an extreme form of normal aging, which would imply that every human being has a certain predisposition to developing Alzheimer’s” (Wang et al. 2008). They conclude: “epigenetic effects can accumulate throughout life, especially from the time-point when the epigenetic machinery suffers from old age, but also from early embryonal stages or even trans-generational [effects], influenced by epigenetic events in the parents” (Wang et al. 2008). These findings, and many others from epidemiology and neuroimaging findings in connection with AD, challenge the dominant approach taken by the medical world to Alzheimer’s, that is, approaching this phenomenon as a burgeoning epidemic of a readily diagnosable, uniform disease for which a cure can be found, despite the fact that billions of dollars have already been spent fruitlessly in such a search (Lock 2013).

Exposure to Toxic Chemicals

For a decade or more, certain researchers have been working to elucidate the effects on neurodevelopment of exposure to neurotoxins in utero and early life. Recent work has highlighted epigenetic effects and an apparently intergenerational aftermath of such exposures. A recent review of an array of 201 neurotoxins, ranging from arsenic to benzene and PCBs, concluded that exposure to hundreds of industrial chemicals can be potentially damaging to the developing brains of children worldwide (Grandjean and Landrigan 2006), although it is noted that both timing and the amount of exposure are significant. A more recent review (Lifang et al. 2011) notes that every year more than 13 million deaths worldwide are due to environmental pollutants. Evidence links environmental pollutants to epigenetic marks associated with a range of disease endpoints. It is emphasized that these changes have been shown to be reversible and hence preventive measures are feasible. Lead is the most closely researched toxin to date; it has been shown repeatedly that there is no safe level of exposure during the early years of human development and that it brings about many epigenetic effects (Senut et al. 2012). Decreased brain volume is recognized as a lead-related brain atrophy and is most pronounced in males (Cecil et al. 2008). Research has also shown negative effects of lead exposure on language function (Yuan et al. 2009).

The ongoing lead paint scandal in the United States that has been unfolding over the past half-century is graphically described by Markowitz and Rosner (2013). Over the years, millions of children have been exposed in their homes to potential lead poisoning, although reliable numbers are not available. It is estimated that today over 500,000 children between 1 and 5 years old have lead levels above that which policy makers currently regard as a safe level. Reminiscent of
the infamous Tuskegee experiments conducted on African Americans, 100 children, mostly African American, some less than a year old, living in poor family dwellings where lead paint had been used, have been systematically studied for the effects of lead exposure on their development. A judge presiding over a pending lawsuit has described these young research subjects as “canaries in the coalmine.”

It has been shown that lead released from a woman’s bones during pregnancy can increase risk for preterm deliveries and low birth weight and, further, affect gene expression in infants involving changes to DNA methylation that may well have lifelong effects (Pilsner et al. 2009). One researcher is quoted as stating: “lead exposure, rather than a poor social environment, is a key contributor to . . . subsequent cognitive and behavior problems” (Radiological Society of North America 2009). Such a claim prioritizes one variable over another, causing a distortion. It is highly likely that lead exposure does irreparable harm to all humans, but those individuals who are at the greatest risk of being exposed are almost exclusively economically deprived.

The effects of toxins such as dioxin and PCBs in the Arctic are more devastating than elsewhere. Legislation against these chemicals is not effective in the extreme north as yet because toxic residues slowly drift toward the Arctic and accu-mulate there, making it one of the most contaminated places on earth. The body fat of seals, whales, and walruses hunted for food is highly contaminated, as is the breast milk of many Inuit women. An Inuit grandmother, politically active in circumpolar meetings, is quoted as stating: “When women have to think twice about breast feeding their babies, surely that must be a wake-up call to the world” (Johansen 2003: 479). The situation is exacerbated because the cost of store bought food is beyond the reach of many Arctic residents.

A recent article in the New Yorker (Aviv 2014) about Tyrone Hayes, a biologist working at the University of California, Berkeley, tells a very disturbing story about one of the world’s largest agribusinesses, Syngenta. Sales of the herbicide atrazine made by Syngenta are estimated to be around $300 million a year. Hayes’s research findings about the toxic effects of atrazine resulted in what appears to be a systematic effort on the part of Syngenta to debunk his findings and destroy his career. See also Kolbert (2010), who writes about the attempts of the American chemical industry to quash the findings of biologist Frederick vom Saal on bisphenol A. And the present partisan government in Canada refuses to legislate effectively against asbestos, although it is the top workplace killer (Galloway 2014). Clearly, efforts to rid the environment of such chemicals are fraught with dangers other than their toxicity.

The following section explores directions anthropologists are beginning to follow in explicitly addressing some of the concerns raised by environmental epigenetics as it is currently conducted.

Embedded Bodies

Several years ago, the Berlin-based anthropologist Jörg Niewöhner carried out research in the laboratory headed up by Moshe Szyf. Niewöhner argues that environmental epigenetic interactions such as those researched by Szyf’s group highlight the significance of attending to different temporal horizons and spatial scales. He notes: “In epigenetic research, interpretations of findings often combine evolutionary time, transgenerational or biographic time and the ‘real’ time of cellular activity in order to construct a plausible argument” (Niewöhner 2011:285). The discourse of environmental epigenetics of this kind produces an “embedded body.” Such a body, Niewöhner writes, is “heavily impregnated by its own past and by the social and material environment within which it dwells. It is a body that is imprinted by evolutionary and transgenerational time, by ‘early-life,’ and a body that is highly susceptible to changes in its social and material environment” (289–290). Group discussions in the laboratory make use of the idea of a “molecular biology of social position” in which attention is paid not only to the social and material environment relevant for human development, but also to the “interpretation of these environments by its inhabitants” (286). Niewöhner makes clear how significance is not produced through a single statistical measure, but instead is built up in “layers of analysis and interpretation” (288) resulting in what he has come to think of as “thick significance.”

This sounds promising to anthropologists, but in practice, Niewöhner argues, a “pragmatic reductionism” (Beck and Niewöhner 2006) prevails in connection with the projects carried out in the laboratory, and efforts are made to “operationalize instances of social change according to criteria taken directly from the practice of molecular biological research, resulting in the ‘molecularization of biography and milieu’ ” (Niewöhner 2011:291). Events of significance in people’s lives are researched and documented, to some extent standardized, and then systematically examined for associations with bodily epigenetic changes. Niewöhner concludes that, in this kind of research, aspects of the social world are situated by environmental epigeneticists in a “quasi-natural experimental system” (291). In other words, subjective knowledge and meanings attributed to events are ultimately ignored, washed out, and rendered insignificant.

The concepts of embedded bodies and also that of local biologies (Lock 1993, 2001) are designed to highlight inextricable multiplicities among material bodies and environments past and present: historical/socio/political variables, and subjectivities. The embedded body provides a vehicle by means of which the molecularized biology of epigenetics can retroactively be contextualized with respect to both individ-
ual experience and variables of all kinds external to the body. Recognition of local biologies, on the other hand, suggests that body interiority should not be hastily reduced to the universal standards of biomedicine, for the very reason that, in everyday life, bodies are not skin-bound, individualized entities but active at the hub of extraordinarily complex shifting processes external and internal to the body. As Ramirez-Goiocochea argues: "Phenotypic differences in local biologies are mainly due to the presence or absence of a resource at a specific time and place in a network of biochemical interactions. Compared with the genome, the epigenome—the epigenetic state of a cell at a particular moment is highly dynamic and in constant flux" (2013:66).

Anthropologists have, of course, long carried out extensive research in connection with the relationship among culture, self, and the body that illustrates how discursive practices and symbolic systems serve to cement bodies in context. However, an embedded body embraces broader dimensions of space and time, history and politics, and enlarges the very scale of what constitutes self and other by situating individuals simultaneously as part of families, groups, and populations that have all too often been exposed to hugely disruptive events. This entails a major shift away from the standardized bodies of the biosciences. For more than 2 decades, Tim Ingold has been tussling with the biological reductionism adhered to by evolutionary biologists and psychologists and is particularly critical of the inability of the neo-Darwinian paradigm to account for phenotypic variability. Ingold argues that “process” should take priority over “form.” In a recent essay he insists that we must think of “humans, and indeed creatures of all other kinds, in terms not of what they are, but of what they do.” In other words, we should understand ourselves “not as beings but as becomings . . . not as discrete and preformed entities but as trajectories of movement and growth” (Ingold 2013:8). In a similar vein, Gösta Pálsson argues: “humans may usefully be regarded as fluid beings, with flexible, porous boundaries; they are necessarily embedded in relations, neither purely biological nor purely social, which may be called ‘biosocial’; and their essence is best rendered as something constantly in the making.” Pálsson characterizes this situation as “ensembles of biosocial relations” (2013:39).

Epigenetic findings confirm what has long been known on the basis of statistical associations, and certain epidemiologists now work together with epigeneticists to make these correlations incontrovertible, in other words, to “prove” the fact of “biological embedding” on the basis of molecular measurements (Hertzman 1999). These epidemiologists and the molecular biologists with whom they work are aware that the molecularized “nurture” of their models relies on the creation of decontextualized entities that are then “boxified” (Kaufert 1990) in order to facilitate research. If the ceaseless cascades of miniscule biological changes are to be elucidated, such an approach is unavoidable, but anthropologists and most epidemiologists cannot sit comfortably on the margins; we must work to pry the molecularized environment open, to grow it again, and approach both macro and micro environments that together account inseparably for the protean fuzziness of this concept. Only thus can the reality of human life always already embedded in nature/nurture be better apprehended.

The illustrations set out thus far in this paper have shown how the body is commonly conceptualized as interacting with miniaturized environments by epigenetic researchers. One brief illustration must suffice to highlight the impoverishment of these findings when viewed from a broader historical and anthropological perspective.

Colonization and Historical Trauma

Canada is home to roughly 1.2 million individuals who endorsed the category “Aboriginal” in the 2006 Canadian census. The majority of these people live in communities that continue to contend with the devastating legacy of settler colonialism, including entrenched poverty and invidious discrimination manifested in so-called mental health problems of many kinds. These include substance dependence, depression, violence, and extraordinarily high rates of suicide, especially among young people, estimated in some Inuit communities to be six times the rate in other parts of Canada (Kral 2012).

Independently, mental health professionals and individuals living in First Nations communities have consistently associated these high rates of pathological distress with the experiences of colonization that commenced 5 centuries ago. A concept of “historical trauma” has been adopted to call attention to the collective, cumulative, and intergenerational psychosocial effects that resulted from past colonial subjugation and persist in abated form to the present day (Niezen 2013). Among the early travesties was the introduction of infectious disease. Measles, to which indigenous peoples had never previously been exposed, was inadvertently transmitted, but the claim has long been made that smallpox was spread by means of blankets deliberately distributed to indigenous populations to assist with “the extirpation of this execrable race” (Haida Laas 2009:15). This history is possibly contestable (Houston and Houston 2000), but undeniably the mortality rate from infectious disease was extraordinarily high—on Haida Gwaii, for example, it is documented that between 1700 and 1900, smallpox, measles, dysentery, TB, influenza, and other communicable diseases wiped out many thousands of people. The Haida nation, with whom Boas worked for some time, went from an estimated population of 20,000 prior to 1770 to less than 600 by the end of the nineteenth century (Haida Laas 2009).

This decimation was followed by extensive efforts to “whiten” the Indians, among which was the establishment of residential schools created expressly to “kill the Indian and save the child.” Young children were rounded up by school administrators, RCMP (Royal Canadian Mounted Police)
agents, and agents attached to the despised Bureau of Indian Affairs to be sent great distances from their homes, in order to be housed in institutions where they were not permitted to speak their own languages or participate in anything regarded as cultural practice (Carr 2013). Today, the residential schools, the last of which were closed down only in the 1990s, are regarded among First Nations and Inuit communities as the primary source of their current malaise. It recently came to light as part of the ongoing Truth and Reconciliation Commission of Canada that repeated sexual abuse took place in these schools, one of which was characterized by an investigating Supreme Court Justice as practicing “institutionalized paedophilia” (Carr 2013:19). Systematic nutritional medical experimentation was also practiced on some of the students resulting in malnutrition in many, and death for many more. TB was rampant, and few attempts were made to curb it. In one notorious school, the death rate of children was apparently 75% in the first 16 years of the school’s operation (Carr 2013; Niezen 2013). The majority of individuals who grew up in these conditions, now middle aged and older, have until very recently been unwilling to ruminate about their younger lives, but many freely admit to being unable to adequately parent their own children.

Despite major changes for the better in recent years, racism and discrimination continue to be blatantly evident against First Nations. Shocking poverty persists on many reservations, a good number of which have no running water and where toxic contamination is frequently found; schools on reservations are poorly provided for compared with schools elsewhere in Canada, the education gap has increased between First Nations children and other Canadians (Friesen 2013), and alcohol and drug abuse and violence against women and children are extraordinarily high.

Two points must be noted: first, not all reservations exhibit high rates of illness and suicide. Some survivors report that they enjoyed school, and others became devout Christians—a conversion that apparently assisted in their survival. Clearly, appreciating differences among First Nations is of the utmost importance when attempting to account for malaise. Second, ongoing land claim settlements have improved the lot of some First Nations communities, but settlements have not been made with many communities. And third, the establishment of healing programs and suicide prevention gatherings conducted by First Nations peoples that make use of indigenous healing practices together with biomedicine exist in certain communities and receive some government support. Such changes are regarded as a positive form of empowerment by many First Nations leaders, but are not as yet broadly entrenched (Niezen 2013).

First Nations received a formal apology from the prime minister of Canada 2 years ago, but since that time the budgets of 12 government-funded programs for First Nations have been cut, and nine of these programs are now closed (Bennett 2013). And suicide rates, substance abuse, and the disappearance and death of young First Nations women continue to be extraordinarily high (Leblanc 2014). If the concept of “historical trauma” is to be taken seriously, then a great deal more than an apology and a reconciliation commission are needed to counter the crudely racist attempts to obliterate the Indian—the effects of which are being played out among third and fourth postcolonial generations. It is not known if intergenerational transmission of DNA modification has taken place. Very understandably, First Nations individuals are reluctant to donate tissue for postmortem analysis; but obviously, demonstration of epigenetic changes are not required to verify the extent and depth of this ongoing abuse that a good number of survivors of residential schools and their offspring describe as genocide (Niezen 2013).

Conclusion

To date, it has been shown that by far the majority of epigenetic effects on gene function are limited to short stretches of time or the lifetime of individuals. Furthermore, research suggests that effects of apparent transgenerational inheritance of epigenetic changes are not highly uniform, and not all offspring are inevitably affected. Clearly, research should continue apace. In addition, changes brought about by RNA may prove to be of even more significance in connection with intergenerational effects than are effects brought about by DNA methylation. Despite large gaps remaining in the foundational knowledge of environmental epigenetics, it is increasingly recognized that, from the time of conception and throughout the lifespan of individuals, intrasomatic, cellular environments, and extrasomatic environments, physical and social, should be conceptualized as together bringing about transformations in material bodies. It remains an open question whether or not these interactions result in intergenerational transmission of effects. But sufficient evidence exists to argue that the body should not be conceptualized as a clearly bounded predetermined entity from birth.

With respect to ontology, molecular demonstrations of nature/nurture multiplicities are no doubt “real,” but the biological anthropologists Ken Weiss and Anne Buchanan caution that although a very small fraction of DNA-related causality is highly predictable, recent technological developments are “enabling us to see that, in important ways, life might not be law-like in the Enlightenment sense, or even that we may not know when we have found such laws” (2011:769). In the world of biology, they argue, we must supplement linear thinking by conceptualizing interrelated, overlapping cycles and, further, acknowledge the frequency of stochastic, random happenings. Such a shift challenges the tendency, visible already in epigenetic research, to proceed rapidly toward systematized reductionism. Of course, even if good will exists, poverty will not be eradicated globally, but it can be greatly reduced through investment in local communities to support
grassroots changes. Horrific violence will not be alleviated without extraordinary political will, and clearly, at present, it is on the increase globally. However, much more stringent regulations can be set in place worldwide to lower exposures to toxic environments, although these moves will be successful only if their implementation is monitored, corruption is hounded out, and scientists are not discredited and their findings are not falsified or denied. Similarly, recognition of the direct impact of climate change on human survival is unlikely to be successful if the denial position pervasive among many politicians persists.

Post-Enlightenment thinking has driven us to assume that a chemical fix is the easiest and most efficient way to solve medical problems of all kinds. Moshe Szyf, trained in pharmacology in addition to genetics, is currently working on development of drugs that might effectively reverse harmful methylation. Meantime, for many researchers, recognition of probabilistic associations between molecularized environments and DNA methylation changes in individuals may well be as far as the majority of scientists are willing to go when thinking about causation and the lifelong effects of “nurture debilitated” (as I’ve come to think of it). The majority will resort to standardized concepts of “stress” or PTSD (post-traumatic stress disorder) as the entities to be targeted in order to minimize effects of toxic exposures, social and environmental. And when it comes to prevention, monitoring the fetus and the behavior of pregnant women and, more generally, food intake, are likely to be given prominence. Attention will be diverted from the repeated dereliction of fundamental human rights that takes place when individuals, communities, and whole populations are repeatedly violated by those in power.

It is feasible that epigenetic data could be presented to governmental bodies and courts as rigorous scientific evidence of the harm that toxic and abusive environments cause to human well-being. Such molecularized findings may well add considerable weight in the minds of those in power to submissions of epidemiological or social science findings based on correlations alone. If so, this could be a positive move, but only if it is acknowledged that “fixing matters” should involve making changes of a much greater order than tinkering with individual bodies.

Franz Boas was never able to satisfy himself about the relationship among history, culture, and biology, try as he might. And over the course of the twentieth century, molecular reductionists have time and again made scientific headway by setting the social to one side. Epigenetics has the potential to change this situation, but it remains to be seen whether or not its approach will transcend the hegemony of molecularized biological determinism. As for anthropologists, one can hope that the indivisibility of nature/nurture will become glaringly apparent to large numbers of us—so much so that we will no longer insist that the sociocultural and political can readily be investigated divorced from the biological. Only when epigenetic findings are firmly embedded by means of ethnographic investigation in histori-}


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and studied. For example, the PHenX Toolkit (Hamilton et al. 2011) has been developed to catalog an array of phenotypic and environmental measures that can be used across studies, with the goal of expanding evaluation of environmental factors and making data from different studies easier to compare (see https://www.phenxtoolkit.org/index.php?pageLink = browse .protocols&id = 211300). The consensus-based catalog leverages impressive efforts to define and measure the environment. Many measures relate to personal behavior, diet, and physical exposures, but the toolkit also incorporates measures of social conditions. It includes “neighborhood concentrated disadvantage,” a measure utilizing neighborhood-level population characteristics to identify the concentration of poverty in a particular neighborhood, and “family interpersonal relationships,” a questionnaire that assesses “each family member’s perception of the cohesion (support and commitment), expressiveness, and conflict associated with his or her family.” Measures of this kind have been crucial in establishing the importance of social determinants of health, including the profound impact of poverty, childhood maltreatment, and other social disadvantages—yet they have limited ability to illuminate the complex social forces that shape worldviews, behaviors, and life chances.

Perhaps more important, many studies utilizing environmental measures are selective in what they choose to study, often focusing on behaviors such as diet, smoking, and activity level without probing how social conditions influence these behaviors or condition their effects. As an example, a recent environment-wide association study of type 2 diabetes utilized more than 300 medical and environmental measures; most of the latter assessed personal behaviors (Hall et al. 2014). In this context, Professor Lock raises appropriate concern about a neoreductionist movement that seems intent on bypassing the very complexity to which epigenetics calls attention—and worse, generates data implying that health solutions beyond medical care are primarily a matter of behavioral change.

The problem involves more than an overreliance on reductionist science. The difficulty also lies in the limited scope of translational science. The prevailing view defines translation as the use of scientific knowledge to produce better medical interventions (Collins 2011). Helping people to stop smoking fits into this rubric, but efforts to improve childhood nurturing or the social capital of people living in poverty do not. As a result, even when social determinants of health are recognized, they are typically viewed by biomedical researchers as “not my job.”

The interdisciplinary collaboration that Lock proposes is fundamentally a call to redirect biomedical research toward health, instead of health-care products. This shift is needed if we are to address the profound health disparities present among human populations. Can epigenetics help to achieve this goal? It certainly produces powerful narratives that link molecular biology with lived experience. The question is whether we can use these narratives to help the biomedical sciences escape from their narrow confines and embrace a larger mission.

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There is a great deal to welcome in Margaret Lock’s paper. That there is no sharp divide between nature and nurture cannot be said too often, and Lock says it well. It is also true that there is a real danger of simply modifying traditional reductionist models of human development and human inheritance in epigenetic terms, and this is something that we are already seeing, for example in the growing popularity of the term “epigenetic code.” It is easy to imagine this as just an addition to the genetic code, punctuation perhaps, that actually reinforces ideas of an inherited blueprint or recipe in the genome. This is a tendency that must be strongly resisted.

I would like to comment briefly on Lock’s somewhat cautious attitude to transgenerational epigenetic inheritance. First, I read the evidence as being somewhat stronger than Lock suggests. Lock doesn’t cite, for instance, the work by Marcus Pembrey and colleagues on human male line inheritance, sometimes missing a generation, which seems especially compelling. More important, however, is to note that epigenetic inheritance doesn’t require transmission through the germ line. This is a very important implication of the much-discussed work by Michael Meaney and colleagues on the effects of maternal care on the development of rat brains (Champagne and Meaney 2006; Weaver et al. 2004). Maternal licking of rat pups appears to cause epigenetically modulated changes in their developing brains, the upshot of which is a calmer, less fearful adult that, if female, is more likely to lick its own pups. Within the context of the developmental system there are various pathways by which traits can be transmitted between generations, and in which epigenetic changes play a crucial role.

On the issue of emerging reductionism, an important question is where exactly the reductionism is coming from. Lock is surely right to point to the dangers that the findings she describes will be interpreted in terms of a reformed nature/nurture distinction, with “nurture” reduced to a molecular context for a mechanistically understood body, “nature.” But though some of the scientists involved in the relevant research may well adhere to such a view, there is no reason that they need to do so. Given the complexity of the processes of human development, any attempt to understand the role of epigenetic changes must begin with highly sim-

7. See Grossniklaus et al. 2013 for a summary and references. The various perspectives in this paper also make clear, however, that, as Lock suggests, there is still considerable debate on the topic.
plified models that abstract from many crucial and variable features of the process. It is a potentially useful epidemiological finding, for instance, that epigenetic variation explains (in the precise technical sense defined by statistical methods such as analysis of variance) part of the variation in developmental outcomes.

The problem, as has become so familiar with parallel findings about genetic factors, is that both are liable to be grossly misinterpreted. Causal inferences from statistical data are notoriously tricky. With great care it may be possible to infer that an epigenetic factor is a probabilistic cause within a particular population, a factor that increases the probability of a developmental outcome. But this says nothing about its causal role in any particular case. Yet the further one moves away from the technical context in which such statistical data are produced, the more likely one is to hear that “the cause” of some phenotypic trait has been discovered. The widest significance of epigenetic factors is to demonstrate one pathway from (causally) distant features of the environment to individual developmental outcomes. This, in turn, shows how exceptional are the circumstances in which it will make sense to distinguish any factor as the cause.

Lock perfectly summarizes a more general conclusion from current biology: “bodies are not skin-bound, individualized entities but active at the hub of extraordinarily complex shifting processes external and internal to the body.” In addition to epigenetics, she might have mentioned here the growing understanding of the complexity of symbiotic relations that sustain what we think of as individual organisms, noting for example the trillions of microbes, ten times as many as human cells in a human body, that are involved in sustaining a human life (Xu and Gordon 2003). In the philosophy of biology, insights from these fields have led to an explosion of interest in the question of individuality, questioning whether there is any unique way of drawing boundaries around discrete individuals within the complexity of biological interdependences (Bouchard and Huneman 2013; Dupré 2012, esp. chaps. 5 and 11). At any rate, it is to be hoped that the attempt to address such questions through a sharp distinction between nature and nurture will soon be of only antiquarian interest.

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I read this article as symptomatic of the phenomenon of epigenetics at the same time that it performs analysis of the field. It oscillates between acerbic critique of old reductionism in new bottles and careful enthusiasm that cultural anthropologists could think newly about bodies and their own refusal to take on biology if they were to engage with epigenetics. We turn from the sense that surely the molecular can’t harness human suffering and historical injustice—to the hope that it can nonetheless help with political action in an age of somaticization of human rights and identity. We hear that molecular biologists don’t know anything about society, but also that their work is interesting and thought provoking.

Some of this multiplicity of positioning derives from the demands of writing about a field of knowledge that makes its arguments via biochemistry and genetics, placing the erstwhile analyst and critic also in the position of expert and explainer, facing down a skeptical readership that may or may care to tell a methyl group from a macromolecule. And the expert position isn’t at all settled, as epigenetics is of decidedly indeterminate definition; its own practitioners and proponents often disagree about fundamentals such as the significance of persistence of epigenetic phenomena across generations, with observers acting as if this uncertainty is a sink-or-swim condition for all of the research bearing the word “epigenetic.”

Indeed, we live in the time of scientific confidence with requisite waiver—after the overpromising of various mega-projects from the war on cancer to the human genome project, the favorite rhetorical form in these sciences is “this may solve obesity (but-not-anytime-soon-and-this-is-only-in-animals—so don’t extrapolate even though I just did).” There is something of a phenomenon of agreeing to agree that the problem with new scientific fads such as microbiome science and epigenetics is that they are being overhyped and irresponsibly communicated (Hanage 2014; Saini 2014). Participants in epigenetic discourse are attracted by the promise and afraid of the hype, practicing qualified exuberance and hedging their bets; social scientists included.

But it has never been the role of the cultural anthropologist to occupy the safe position and ask the same questions that other kinds of observers are asking. It has never been our job to weigh in on who’s right or wrong in a knowledge system under study, nor to call the hype/real game except perhaps to study the social function of hype itself (Pickersgill et al. 2013). It has not and should not be the cultural anthropologist’s responsibility to determine whether epigenetic phenomena are really heritable over generations of individual organisms or not. It is however our responsibility to ask what definition is given to both “really” and “heritable” in these formulations that makes this such a fraught question today, that produces talk of “soft” inheritance and other non-reflexive discussions of how inheritance can really only be “cleanly” demonstrated through the male line in experimental animals.

There is a gendered politics of legacy being played out inside and outside this scientific area in which “genetic inheritance” is partitioned off as the hard stuff, leaving other phenomena such as the effects of lead or maternal depression as “soft” subjects, seen as “exposures” that affect the next generation or two directly in utero. Why should genet-
ically heritable qualify for a different status, one that is linked to the legitimacy of epigenetics as a scientific endeavor? And yet one also has to eye the cramming of poverty and depression and all of their manifest embodied cultural complexity into “exposure” to particular substances made amenable to experimental measurement with an equally critical eye.

As I said, the critical position becomes a source of some circumlocution for observers of epigenetics. It almost makes one long for the good old days, when reductionism in genetics was an easier target. Almost, but not really: circumspect uncertainty is a necessary feature of occupancy of the terrain of health biomedicine today, and for the asking of questions that other kinds of commentators cannot. Some of these questions are embedded in Lock’s different varieties of incisiveness around environmental epigenetics: How is this molecular and epidemiological work generating new concepts of persistence and legacy in the “epistemic space” of heredity for the twenty-first century, in a time when suffering must have a molecular profile to participate in law and policy (Müller-Wille and Rheinberger 2012)? How is the time of the human life span and human experience and human history being newly folded into understandings of bodies and embodiment? What can we say with this resolutely unpoetic language of histone acetylation and gene expression about human experience—and what can we not say? These questions go far beyond “epigenetics” per se, even as they are opened out by engagement with it.

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How is biographical specificity and dynamism realized in flesh? How are the scars of social experience incorporated into persons as they unfold over the life course? How do historical experiences of poverty, violence, discrimination, or for that matter love and respect get inside the human body and the bodies of humans yet to come? Is there an inside and an outside for that matter? In other words, where, if at all, does the environment end and the body begin? What makes us singularly human amid a wide range of corporeal form?

In this essay, Margaret Lock brings such fundamentally anthropological questions to bear on the emergent field of molecular epigenetics. Her answer—at once remarkably measured and yet nonetheless cautionary and urgent—is a product of decades of careful work to remove the human body from its black box. Lock argues, as she has since she first developed the concept of local biology that prefigured epigenetic reasoning, that human beings cannot be reduced to a set of biochemical processes any more than our bodies can be disregarded as ephemeral to implicitly disembodied yet meaning-laden, socially constructed lives. Just as it is impossible to unscramble an egg, so too a human being cannot be sorted into a set of binaries: mind/body, self/society, nature/nurture, nor can a person or a population be held still in time. Neither biology nor culture is epiphenomenal; it is impossible to ever fully peel them apart. Epigenetics, therefore, would seem to be an affirmation of and a prompt for yet deeper anthropological research.

Anthropologists who have read Fassin (2007) or Montoya (2011) or Bledsoe (2002) (among many others) will not be surprised to hear that the politics of the body are heritable, even as they will learn from Lock about the details by which epigenetics establish new grounding for the material stakes of the biopolitical environment. Yet, reductionist reasoning is seductive, and the nature/nurture framework has proven remarkably persistent, hence Lock’s cautionary tone about “the molecularization of nurture” now underway. The modern fantasy in which complex political and economic problems are solved by narrow, if innovative, technologies is alive and well. Such fantasies are stoked by the threat of a limited epigenetic imagination focused on a narrowly conceived environment (e.g., lead paint as pathogen rather than public housing as historically embedded context). Already Lock suggests how epigenetics, like the genetics that precedes it, might be enfolded into our techno-salvific narratives, even as epigenetic research raises more questions than it answers (See Wailoo and Pemberton 2006). Equally tenacious are the epidemiological models designed to assess risk factors, thus cleaving experience into a set of linear trajectories rather than the multifactorial and multitemporal scales necessary to capture the dynamism of human life.

Perhaps the most pressing set of questions called forth by epigenetics concerns our uneasy relationship with and yet reliance upon the universal body. For biomedicine, this enables a standard universal organism, with standard symptom constellations, that will respond in predictable ways to standardized therapies, whose efficacy is tested in standardized trials. For humanists and social scientists, including anthropologists, the universal body that emerged in the twentieth century has been the necessary grounding for an egalitarian politics of race, gender, sexuality, and capacity.

Epigenetics, as Lock explains, presents a paradigm shift that will require anthropologists to articulate a dynamic corporeality, conceptualizing the body as universal in its unfolding process rather than as a normative container—body as time rather than as private property. Such articulation and elaboration of a temporal body are necessary to stave off a far horizon of personalized medicine for the wealthy and molecularized eugenics directed toward the poor. But doing so will mean thinking far more seriously about questions of time than we have thus far. As Lock suggests, epigenetic time
is hard to hold onto, and its inherent complexity defies the modeling capacity of epidemiology. It is layered, accelerant, recursive, contingent, scalar, linear, and circular all at once. If we are to insist on an expansive conceptualization of environment, one that pays careful attention to political economy and power as Lock rightly calls for, we will need ways of thinking and talking about time that allow for its embodied florescence.

As we work through new issues of temporality, we might also note that epigenetics is of a piece with a larger erosion of linear narratives of causation in scientific and epidemiological logics of human and population health. We might thereby extend Lock’s call, adding yet more momentum to the mutable body as “matter of concern” by placing the dynamic, embedded body she describes in conversation with epigenetics alongside the scalar interspersed body of the microbiome, to articulate a new and more expansive biopolitics.

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Toward a Biology of Social Experience?

Margaret Lock is surely right to highlight the long-term significance of work in environmental epigenetics for anthropology and the social sciences more generally, as it looks set to rework a series of important categories, concepts, and boundaries. However, before considering the issues raised in her important article, it is worth first reflecting on the nature of the field of epigenetics, which spans a number of scientific disciplines and technological applications. While its origins are in developmental biology, the main focus of contemporary research is in cancer, with ~70% of all publications in this area. Already epigenetics has contributed to understanding internal mechanisms of oncogenesis and helped develop new diagnostic tools and anticancer therapies. The subfield of environmental and social epigenetics, which unravels the interaction between the epigenome and its external milieu, are not central to these endeavors, but are expanding areas of inquiry. Epigenetics therefore has multiple meanings, and an entirely internal approach with a focus on the mechanics of gene regulation may remain the dominant locus of the field for the foreseeable future.

Despite this, expectations of environmental epigenetics are high with it holding the promise of a major reworking of some of the foundations of modern biology. This is deeply troubling for much of established evolutionary theory, and the claims of epigenetics are likely to remain controversial and at time fiercely contested, particularly on the extent of intergenerational transmission in humans. Despite a number of important scientific and clinical applications, in fields such as oncology, the immediate impact of epigenetics seems likely to be conceptual (Jablonka and Lamb 2006). In particular, epigenetics may form the cornerstone of a critical post-genomic science that could provide much more nuanced and complex understandings of disease etiology that relocate established notions of causation within networks of interaction between the body and its broad physical and social environment. In doing so, this may fundamentally undermine the dominant paradigm of genetic causation and help address the problem of so-called missing heritability in many common diseases.

A second way in which epigenetics is reworking fundamental concepts is in relation to the dominant understanding of the human body. Again Lock makes important points about somatic change and plasticity. However, this must be seen as part of a broader trend within the biosciences that constructs human anatomy as increasingly dynamic and shaped by a range of biological, environmental, and behavioral factors. For example, work in stem cell biology highlights the extent to which the body at both the (epi)genomic and cellular level is highly responsive to external and internal signals. Where previously tissues such as the brain were seen as largely fixed, the discovery of neural stem cells and neurogenesis points to how the body is constantly being renewed, adapted, and altered.

Lock also points to the increasing dominance of the molecular vision of the world over processes, objects, and domains that were previously understood as social or environmental. For example, describing eating food in terms of molecular epigenetics. However, this must not distract from the parallel process of what might be thought of as the socialization of nature, in which closed biological processes are now being opened up to the imprint of society. Lock’s suggestion of the possible link between individual and collective historical experience of trauma and violence, and epigenetic changes that can be reproduced across generations, outlines an important new field for investigation. However, this can be extended still further to consider broader questions of the possibility of a biology of social experience that operates in multiple temporal and spatial dimensions. These might include, first, the experience of social deprivation, such as the effects of loneliness, isolation, and exclusion, all of which are linked to adverse health outcomes. Second, such a biology could explore the effects of social position in class-based, gendered, or racial hierarchies of oppression or domination. Already epigenetic studies are exploring the biological and health consequences of socioeconomic inequalities (McGuinness et al. 2012). Third, it may also be possible to examine the somatic effects of symbols, language, and mean-

8. I am endebted to Rayna Rapp for this point.
ing mediated by affective systems, such as fear, grief, or anger. For example, work on the placebo effect clearly demonstrates how our beliefs about the therapeutic worth of a sugar-coated pill can relieve pain and how this is biologically mediated in the brain (Benedetti, Carlino, and Pollo 2011). This latter point may seem highly speculative, but anthrop-ology has long studied the impact of symbolic violence and the power of culture and experience to shape societies and individuals. As Lock suggests, there is no reason why this can’t be investigated through some sort of postmaterialist social etiology of disease based on environmental epigenetics.

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I agree on some of the most important points of Lock’s paper: (1) the significance of epigenetics for rethinking key concepts in biology and in the wider society; and (2) the need for anthropologists to open up the “miniaturized” and “molecularized” view of the environment that is currently taking stage in epigenetics.

Where my view differs is on a sort of broader context in which Lock’s assumptions seem to be situated. In a nutshell, I don’t believe, as she seems to, that the molecularization of nurture and the rise of a new wave of “somatic determinism” is the most worrying aspect of epigenetics to which social scientists need to be alerted, and this is for two reasons.

First, I can’t see how much more epigenetics can do to contribute to a reductionist or deterministic understanding of the sociocultural world. It seems to me that this process is already well underway, and has been so for the last 2–3 centuries so to speak, particularly after WWII and most significantly in the Anglo-American academic world. There are plenty of technological, political, and cultural reasons for various streams of reductionism, determinism, mechanism to being winning trends, also and increasingly so in explanations of the social world.

However, honestly, I don’t see how for instance, some sort of economical-financial view of the social world (health, education as mere market variables), or a political science understanding of election process as consumerist choice between products should be much worse than the scaling down to the molecular level of the socio-environment in an epigenetic lab. These all seem to me variations on a basic reductionist ethos that characterizes modern science, and I would not feel fair blaming epigeneticists for this.

Moreover, one can add, at least in epistemically alerted researchers, nurture is certainly made mechanistic but with an understanding of the notion of mechanism that is much more sophisticated than in vulgar determinism. I refer for instance to the way Griffiths and Stotz (2013) understand the mechanistic rendering of nurture in postgenomics as a multilevel and emergentist notion, expanding on philosophers like Bechtel (2008; see also Meloni 2014b).

However, and I come to my second point, I think that where epigenetics can have a significant impact on the social world, and I mean significant because it introduces a real difference with previous trends (which it does not in relation to determinism, as I have tried to say above), is in offering “hard data,” as Lock says, for the biological evidence of the effects of social insults. However, whether this will be used, as Lock auspices (as I do), to “provide incentive for better recognition by policy makers” of the extent to which social traumas matter for human health, or instead for reproducing and consolidating structural differences in society (class, rank, race, gender), it is still too early to say.

To cut a long story short, my concern is that, with the return to neo-Lamarckian ideas of past socio-environmental experiences being passed on transgenerationally, a new rhetoric may arise that singles out specific “risky” groups, identified by abnormal methylation marks for instance, who are therefore different from the rest of the population (Meloni and Testa 2014).

The often unnoticed problem with Lamarckianism is that there is in it a dialectics (see, e.g., Bowler 1984) that we find reproposed exactly in epigenetics today. It is true that often Lamarckianism is superficially associated with ideas of social reform, because, of course, differently from genetic determinism, you can do something now to change your biological endowments (habits can be turned into instincts, or, as one would say today, “change your genes with diets, exercise,” etc.).

However, this is a double-edged sword. If habits can become instincts, also bad habits can become bad biology, and the indelible scars of past environmental exposures can give rise to ideas of specific groups being “too damaged” (because of persisting bad social experiences) to be rescued.

This was the argument against Lamarckianism by Soviet eugenist I. Filipchenko, an argument tragically defeated afterward in the Soviet Union (Graham 1978). Some recent studies on different levels of methylation between the rich and the poor, and the way they have been received in the wider society, can in my view give rise to ideas about stable biological differences between social groups, an idea that biology after the horrors of Nazism had tried to fight against with its view of a universal human nature.

Social historian Michael Katz has often written about a return to a biologically based class racism, a trend that he calls “the biological inferiority of the undeserving poor” (2013). Whether or not epigenetic studies will resonate with this deeply entrenched tendency to make the poor a biologically separate group is something which social scientists need to be alerted to. Unfortunately, not always good scientific ideas, as epigenetics definitely is, produce good social results.
Margaret Lock manages to outline many of the key issues of the rapidly growing field of epigenetics, fleshing out what they mean, why they matter, and what they imply for both academia and biopolitics. Her article provides a meaningful and timely take on themes of profound relevance for anthropology and several other fields. Epigenetics is clearly opening a new space for both rethinking the nature-nurture debate, beyond traditional divides of the academy, and for addressing human health and well-being. Much depends on how it will be developed and practiced.

According to environmental epigeneticists, food transforms the organism, leaving an imprint on the body. This raises fundamental questions about governance and policy, highlighting the need to align public and private interests. These questions are likely to be central concerns in the near future in a variety of disciplines, including anthropology and environmental history. Ethnographic case studies informed by biosocial theory, as Lock suggests, should facilitate a broad notion of biopolitics that is pertinent for the modern world, abandoning a narrow conceptualization of “life itself.” Recently, the notions of “biology” and “the body” have been radically socialized. At the same time, the concept of “social theory” has been thoroughly materialized. The deep-rooted antagonism of the social and the life sciences, each of which has sought to debunk or colonize the other, has somewhat surprisingly and rather quietly given way to an open collaborative zone that renders the nature-society divide utterly trivial and out of place. Lock has been a key player on this front.

C. H. Waddington suggested the useful metaphor of “canalization” of “epigenetic landscapes” for understanding the complexities of development and heredity. Lock speculates that the development of the metaphor was informed by Chinese theories of disease causation. Taking the metaphor further, we may ask: What are the epistemic and historic forces that have canalized the recent biosocial turn across the academy, especially the current fascination with environmental epigenetics? The anxieties of the Cold War fueled excessive interest in nature-nurture theorizing, the role of instinct, and the importance of motherhood for raising healthy citizens. It may be too early to make strong claims about the genealogy of environmental epigenetics. Indeed, it can canalize into two radically different directions: one reductionist, extending earlier dualisms into the molecular world of bodies, another genuinely biosocial. It may be time, however, to start exploring the possibility that the epigenetic bent, including its concern with pregnancy and the responsibility of mothers, is similarly related to anxieties, this time with concerns for the global environment. Molecular reductionism at least may resonate with the geological reductionisms of the so-called Anthropocene.

Boa’s early conclusions about environmental influences on cephalic proportions were debated and eventually more or less forgotten. Recently, however, as Lock points out, in the wake of developments in epigenetics, they have been brought back to the agenda and reconsidered. Clearly, the epigenome has a “social” aspect, embodying context and historical practices, much like phenotypic markers such as cephalic indexes and skin color. Given the growing evidence of epigenetics, the body is inevitably embedded in context. To some extent, the idea of the relational supra-organism envisioned by studies of epigenetic processes is echoed by recent ethnographies of chronically unstable bodies. It also resonates with pre-Enlightenment views of porous bodies, open to influence through social practice. The commonsense view of the body as a natural, physical object eventually dressed up in “culture” is not only a historical product, emerging with the body as machine in the sixteenth century, it is also seriously flawed and incomplete in that a universal “natural” body doesn’t preexist the “social” body. It no longer seems to make sense to imagine “bare life” as a biological substrate infused with social relations; the “local” doesn’t get into bodies or the biological domain. As Lock has been arguing, it is always necessarily there.

Epigenetic processes and connections are not new phenomena; the evidence, however, still debated and scanty, is relatively new. At the same time, we have become acutely aware that human activities increasingly refashion the structures of bodies and genomes, human and nonhuman, the ecosystem of the planet, even life itself. As a result, environmental epigenetics poses fundamental challenges nowadays. Given the intimate relations of porous bodies and molecular environments, how should human-environmental relations be conceptualized and refashioned? Might we benefit from applying the same theoretical and political frameworks to the nano-world of bodies and the giga-worlds of the globe? How can we meaningfully address the molecular pathways of epigenetics by means of biosocial theory that goes beyond the tired nature-culture divide? Lock’s work on epigenetics, health, local biologies, and the body—nicely illuminated by the present paper—is leading edge, raising the key questions that need to be asked and indicating where we should be moving.
ments. Her review of the epigenetic literature demonstrates the materiality by which environmental assaults may produce methylation and other marks on genome expression that sometimes endure through the life cycle not only of cells and individual organisms, but possibly across generations as well. Lock herself concludes, “sufficient evidence exists to argue that the body should not be conceptualized as a clearly bounded predetermined entity from birth.”

While the paradigm shifts embedded in epigenetic understandings of plasticity and variability are potentially quite exciting, Lock also alerts anthropologists to the reductionism by which “nurture” is, in effect, miniaturized and molecularized for the purposes of this research. Increasingly, biomedical researchers believe that the epigenome may well be implicated in what appears as large-scale rapid change in the prevalence of disease and disorders: those examining autism, diabetes, cardiovascular disease, and more are beginning to use this paradigm. As understandings of chronic diseases/disorders become more complex, biomedical scientists increasingly explore the enduring, time-sensitive mediation of environments as they affect disease at the level of cells and their DNA (and RNAs, microbiomes, etc., as the life sciences open up new and profitable toolkits to investigate complexity.)

But Lock’s analysis of the methodological and disciplinary pressure to reduce that complexity to experimentally bounded design shows how the terrible costs of social inequity are too often excluded in favor of close examination of the epigenetic marks impressed on the DNA of individuals and populations. This leaves anthropologists and allied social science researchers with substantial translational work to do. Much of our mission consists of working at what David Hess (2009) calls the “undone science,” showing that social structure, too, is deeply embodied. As Lock insists, “we must work to pry the molecularized environment open, to grow it again, and approach both macro and micro environments.” Epigenetic studies may help us to show how structural violence sometimes encodes damage at the level of DNA expression, but we cannot begin or end our analytic interpretations there.

Lock has done us a great service by showing her anthropological audience how life scientists are using molecularized modalities to understand this nature-culture coproduction in diverse contexts, while providing a primer against any too-easy belief that the epigenetics buzz will likely heal longstanding theoretical divides. But I believe she has done more. In bringing us back to Boas, Lock indexes his venerable struggle against murderous stereotyping of racial/ethnic vulnerabilities as pathologies, while acknowledging his profound ambivalence about the importance of embodiment (now read by her through theories of local biology, embedded bodies, bi-social becomings).

Researchers in medical anthropology, science studies, environmental, global, food studies, and more are now benefitting from forging and using new/old coalitions and paradigms, perhaps the very ones of which Boas was both a champion and a critic. Among our biological anthropology colleagues, for example, one might attend to the critiques and revisions of genetics/epigenetics central to the work of, for example, Augustin Fuentes and Catherine Panter-Brick on health and adversity (2008), Alan Goodman on genetics/race (2011), Daniel Londe and Gary Downey on neurogenetics (2012), Jonathan Marks on eugenics and genetics (2013), Debra Martin on gender violence (2008), and many others, to disentangle any too-simple slide from population risks to individual ones. All take seriously the problem of phenotypic variation in contexts of profound social inequality. Additionally, I want to highlight a “politics of hope,” slim as that may be, to which Lock also points. Resilience theory, currently under bioanthropological scrutiny, tries to show how and why communities of people living under conditions of extreme difficulty nonetheless manage to take care of body and soul, enabling some parents to protect their kids (Panter-Brick 2014). Resilience theory highlights community strategies that are broadly protective (rather than individual; e.g., our science media delights in reporting how many cups of coffee may protect each of us against diabetes, but usually misses the larger questions of labor, distribution, and corporate intervention in food chains).

We want to keep the complexities of social organization, political power, and inequitable cultural resources squarely at the center of analysis: sometimes, but not always, we can increasingly track how such social relations seem to be expressed in the body epigenetically. The life sciences may currently be fascinated by molecularization, but our job remains classic: the burdens and benefits of social life and political-economic history cannot be reduced to biochemistry, although we welcome epigenetic evidence that these large-scale structural processes may be materially expressed in these terms. In this recognition, we may perhaps forge a bridge back to Boasian ambivalence, participating again and again in Anthropology and Modern Life (Boas 1928).

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Nature and nurture are having another roll in the hay. The horrors of eugenics, Nazi racism, and Soviet Lamarckism are disappearing in the rearview mirror. Once again with similar luscious prurience science is peering into people’s true nature, with the stainless-steel tools of technology and a wise “Aha!” confidence. Geneticists, of course, are getting another blank check.

One doesn’t know whether to be Chicken Little and proclaim the imminent descent of the heavens, or to shrug and say that this time it will cycle harmlessly through. But would
that vote of confidence be warranted? Reaction to reports of epigenetically induced changes in gene expression can indeed be overreaction, but not because the science is telling us anything fundamentally new, but because the nature/nurture divide is still so polarized.

We have long known that the environment leaves its signature on our bodies: our adaptive immune system responds to invading organisms with permanent cellular changes; our lung cells may respond to cigarette smoke with permanent changes, as might cells in numerous other tissues; we host a dynamic and essential environmentally derived bacterial microbiome in and on every millimeter of our bodies; what we eat may make us chronically ill; and so forth. Indeed, cell differentiation is a context-specific change in gene usage in response to conditions external to the cell, if not the organism.

So epigenetics is not a fundamentally new finding. What is new is an understanding of some mechanisms that translate experience into cell-specific change. This could have useful applications, plausibly relieving people of disease via epigenetically targeted approaches, in the same sense that surgery and drugs can. But it doesn’t fundamentally change the known fact of gene-environment interaction.

Nor does epigenetics pose any real threat to the important realization that culture is largely superorganic. Even if speaking Chinese versus English, being Hindu versus Catholic, or eating with forks versus chopsticks leave specific epigenetic imprints, culture is the driver, not inherited DNA sequence.

Lock considers the reductionistic thrust of enthusiastic new attempts to unify nature and nurture that come from having sexy, expensive new technical toys to play with, to locate environmental effects as epigenetic changes in DNA. Technology clearly has constructive uses, but while the focus on molecular reductionism is good for the science business, it diverts resources from the sociocultural factors causing the problems in the first place.

Lock cautions that an infatuation with eugenics in anthropology may lead the field to lose sight of its longstanding acceptance of nature and nurture as interacting partners in contributing to who we are. As advancing technology enables the discovery of further instances of epigenetic changes associated with environmental conditions, she warns, the focus on DNA can lead environmental variables to go unexplored, to the detriment of our understanding of the role of social factors in the human condition.

As a warning light, consider why, as in the past, there is so much interest in molecularizing the most sensitive aspects of human social behavior: Is the recurring drive to see such traits as inherent a coincidence? Indeed, the nature-nurture water is muddied when the further claim is made that epigenetic changes are inherited. If it turns out that such changes are lifelong, rather than easily reversible, and sometimes transmitted through open-ended numbers of generations, they will simply join natural selection as another factor in long-term evolution. But that’s premature at best, because it still seems that epigenetic traits, by their essential relation to fundamental cell biology, are reversible in ways DNA sequence isn’t, so that epigenetic nurture is not the same as classical nature.

Ironically, fervent genomic reductionists dismiss epigenetics as a trivial or unproven threat to the view that genes determine who we are. It’s a threat because epigenetics in this context means who you are is due to the environment, not inborn, so can be seen by genetic determinists as deplorable blank-slatism and even (Zounds!) cultural relativism!

On the other hand, some who believe the environment does have a large role in shaping who we are also see epigenetics threatening to swing the nature-nurture pendulum back in a reductionist direction that ignores the holism of cultural experience. No matter that epigenetic changes are induced by environmental factors; they’re genetic reductionism by another name, a kind of technophilic coup d’état.

Knowing how DNA methylation reversibly regulates gene expression doesn’t change what we knew about the role of the environment. It is the stress given by contentious worldviews, whose current swing back to nature as our explanation, that is threatening because of its distraction from sociopolitical issues and its historic potential for societal harm. Lock makes the challenges clear.

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Reply

I am very pleased that the editors of Current Anthropology chose to approach experts from six different disciplines in North America and Europe when soliciting commentaries for “Comprehending the Body in the Era of the Epigenome.” These insightful, astute, occasionally provocative responses, nine in all, make for stimulating reading, and it is clear that my position, namely that anthropologists cannot ignore the challenge posed by epigenetic research findings, is shared by others whose opinions I value. Not surprisingly, these comments are partly informed by disciplinary concerns, making it apparent that cross-disciplinary engagement in response to the epigenetic turn will be fruitful and potentially enriching. I have no idea whether or not an epigeneticist was asked to comment. If this is indeed the case and the request was declined, this is unfortunate.

Epigenetic insights mean that we must now ask, as Hannah Landecker puts it: “How is the time of the human life-span and human history and human experience being newly folded into understandings of bodies and embodiment?” Similarly, I argued in the paper above, and elsewhere (Lock 2005), as has Tim Ingold (2013), that sufficient evidence now exists that bodies should no longer be conceptualized as clearly bounded predetermined entities from birth. These insights, made glaringly apparent as a result of epigenetic research, demand an ontological shift: individual bodies are not mere containers stuffed with biological entities that age and die over a lifetime; rather, they are products of human evolution; the longue durée
of history; environments expansive and local; the communities that people live in; the diets they eat; the toxins, insults, and abuses they are exposed to; and the good times too. In short, individual bodies harbor the effects of both past and present experiences and exposures and, further, contribute to generations that follow, not merely by passing along DNA but also by the epigenetic transmission of the biological residues of life experiences and, at times, those of generations who have gone before. The individual is radically decentered to become a distributed entity.

Intergenerational transmission may involve germ-line reproduction of epigenetic marks (this is still contested by some scientists with respect to humans, although the work of Pembrey noted by Dupré suggests strongly that humans are not exempt). More frequently it is achieved by means of what has come to be termed rather disparagingly as “soft inheritance,” that is, the transmission of heritable phenotypes resulting from changes in chromosomes without alterations in DNA sequences. The durability of soft inheritance is not well established as yet, is variable among species, and no doubt depends greatly on environments and other extenuating circumstances. Durable or not, there is no doubt that epigenetic marks, even if wiped out at transmission, are recreated from scratch very frequently indeed in subsequent generations as a result of human behaviors and environmental exposures. Furthermore, accumulating knowledge about the microbiome has shown irrefutably that over ten thousand unique species of microbes contribute a hundred times more genes to our genome than do human genes, with the result that we are forced to reflect on what is meant by bodily environments; inside and out and self and other, indeed, what it means to be human.

But caution is called for, of course, because a paradox is at once apparent: it is clear that the basic biological processes associated with human reproduction over time are remarkably stable and predictable. As Evelyn Fox Keller observed at the turn of the century: “in each generation the fertilized egg grows, with astonishing dependability, into an adult that is still clearly recognizable as a member of that species (2000: 105).” This process depends upon the intergenerational transmission of DNA and on developmental processes. This is all the more remarkable because DNA itself is not inherently stable and mistakes are made regularly; even so, the fidelity with which human bodies are reproduced is “the product of remarkable biological dynamism . . . biologically we appear to be characterized by images of constancy and phenomenal flux” and live in a state of “hyper-dynamic stability” (Newton 2010:203). Julie Livingston pushes this matter further when she writes in her commentary that the challenge is to determine how “biographical specificity and dynamism [are] realized in flesh.”

Wiley Burke notes that although scientists have long recognized gene-environment interactions and their joint role in human biology, “genes are now easy to study, while the environment remains a complex and messy entity.” It is very tempting, then, for epigeneticists to reduce the environment to small quantifiable components that can be readily manipulated in laboratory settings, a process that is aided by the production of at least one toolkit that facilitates the amassing of an array of environmental and phenotypic measures across numerous studies. Burke warns us about the neoductionism evident in this kind of approach in which the very complexity that epigenetics calls to attention is immediately sidestepped. As does Rayna Rapp, Burke makes it clear how enormous issues are already evident in connection with translational science because epigenetic findings are in effect reduced, to be imbibed by the monster. As Dupré notes, we already have an “epigenetic” code in addition to a “genetic code” that serves to reinforce the inappropriate, misleading idea that inheritance is undoubtedly blueprinted, recipe-like. The epigenetic input cannot be completely ignored, but it can be tamed and cut down to size to fit scientific modeling. Not all scientists are happy with this by any means, but the majority, no doubt, remain relatively untroubled, and funding agencies have not, to my knowledge, shown evidence as yet of a newfound flexibility in approving grants that eschew the blueprint approach.

Paul Martin is perhaps more optimistic than other commentators when he points out that as the dominant paradigm of genetic causation becomes increasingly dented, including the question of so-called missing hereditablity, epigenetics may form the “cornerstone of a critical postgenomic science that could provide more nuanced and complex understandings of disease etiology.” For the time being, however, conceptualizing a postgenomic science is limited primarily to social scientists, philosophers of biology, and a few biological anthropologists (see, e.g., Gilbert 2002; Griffiths and Stotz 2013; Lock 2005; Marks 2013; Meloni 2014b; Moss 2001; Oyama, Griffiths, and Grey 2001). As Martin stresses, the recognition of biological plasticity, particularly with respect to the brain, has inserted a time trajectory into the research scenario so that lifelong processes of renewal and adaptation must now be taken into account. These are singular insights that spotlight an arena where social scientists and neurobiologists might fruitfully engage.

Pálsson argues that we should now abandon the narrow conceptualization of “life itself”; both biology and the body have been “radically socialized”; reciprocally, social theory has been “thoroughly materialized.” He suggests that deep-rooted antagonisms have quietly given way to open collaborative zones. I fear that we are not at this juncture yet, with one or two possible exceptions, and, if indeed such zones open up, it will be among relatively few groups of similarly inclined individuals across the disciplines. The most promising arenas to date are those involving biological and sociocultural anthropologists, and Rayna Rapp’s referencing is very helpful here. But, even so, turf wars between biological and cultural anthropology persist, and does harm. Zones of engagement with epigeneticists are a different matter. Even though certain anthropologists and sociologists are busy
creating explications about what epigenetics in all its varieties encompasses (and my paper was one more example of this), no turf wars are in sight and nor are readily visible collaborative endeavors—anthropologists and epigeneticists have different objectives in their research endeavors and, as Landecker points out, to stitch methylation, acetylation, and chromatic markers into a seamless account with abuse, poverty, stigma, violence, wars, and so on, is perhaps not feasible at all, except in terms of very general correlative inferences. The one case I know of where an anthropologist is working as part of an epigenetic research project has turned out to be the situation that medical anthropologists fear most—being metamorphosed into a handmaiden. On the other hand, Jörg Niewöhner’s (2011) work in an epigenetics laboratory as an anthropologist of knowledge production is exemplary.

This is not to suggest for a moment that hard-won collaborations may not be path-breaking and richly fruitful if we can bring them about, but, as both Wiley Burke and Hannah Landecker make clear, we must first struggle with the massive difficulties of translation across domains, thus confronting embedded unexamined concepts; assumed norms; what is taken to be “natural”; what is understood by “culture” or, indeed, if we need a culture concept at all; and so on. As Fassin (2009) argued: to enrich our understanding of life-as-such we must undertake an interrogation of values and meanings and how they become manifest in the body itself—a task to which numerous medical anthropologists have contributed since the time of the prolegomenon written nearly 3 decades ago by Schepfer-Hughes and Lock (1987). Recent remarkable examples include ethnographies by Angela Garcia (2010), Seth Holmes (2013), and Kimberly Theidon (2012).

Rayna Rapp notes and elaborates on my plea to return to the insights of Boas. She reminds us of his “venerable struggle against murderous stereotyping” in which differences among so-called racial and ethnic groups are brought into stark relief and labeled as pathologies. I would like Boas to be required reading once again in the social sciences. Maurizio Meloni similarly comments that a “new rhetoric may arise that singles out specific "risky groups" that will be identified by methylation marks. The video that I reference in footnote 4 of my paper is an extremely frightening example of the directions that might be taken on the basis of epigenetic findings, spurred on by media hype and inflation. It is inarguably the case that biological reductionism has been around for several centuries, as Meloni points out, but my position is that if epigenetic findings are made use of in law courts, at public hearings, and by certain clinical psychologists in a reductionistic fashion, they can readily be taken up for neo-eugenic purposes in the wrong hands—the very concern that troubles Meloni. Furthermore, in contrast to earlier forms of genetics, by definition epigenetics is not wedded to reductionism alone, thus sounding a clarion call to anthropologists. One task, together with motivated epigeneticists and epidemiologists, is to repeatedly make public the bigger picture of how and why so many human bodies harbor the marks of generations after generations of violence and discrimination. Medicating methylation changes may only add to the abuse.

I share Rayna Rapp’s sentiment in that I would like to see a good portion of anthropological research turn to the question of resilience in the face of massive disruptions and oppression that often have long historical trajectories. This is one means of countering reductionism that requires bracketing causation (temporarily) and instead inquiring into the sources of prevention. I have found this orientation productive when investigating Alzheimer’s disease (Lock 2013). Taking resilience seriously makes it possible to “redirect biomedical research toward health, instead of health-care products,” as Wylie Burke puts it. And ethnography becomes doubly powerful when one elicits not only accounts of suffering but, equally, of resilience.

Turning to the question of environment, as Ken Weiss and Anne Buchanan stress, “we have long known that the environment leaves its signature on our bodies. . . . So epigenetics is not a fundamentally new finding.” But the claim of many epigeneticists is that they are now demonstrating molecular causality and hence by extension we will be able to dispose of correlative thinking. John Dupré exposes the depths into which we so easily descend when pushing for causal inferences. Where exactly do such pathways begin and end? Dupré suggests that if we demonstrate causal features in the environment that are spatially “distant” (and also temporarily distant I would add), it becomes clear how “exceptional are the circumstances in which it will make sense to distinguish any factor as the cause.” This takes us to the article written some years ago by Weiss and Buchanan (2011) titled “Is Life Law-Like?,” which I cited in my article. Their conclusion is worth repeating: “Much of life seems to be characterized by ad hoc, ephemeral, contextual probabilism without proper underlying distributions” (761). The regularity of causal effects is at issue here and, as Dupré suggests, the further afield we go, the less likely it is that we will be able to specify causality. But, I suggest, with a judicious use of both quantitative and qualitative data, we may well be able to isolate clusters of contributory factors that make individuals vulnerable, especially when certain susceptibility genes are in play. We may also be able to detect clusters of variables that contribute to resilience. Pálsson reminds us that “the ‘local’ doesn’t get into bodies or the biological domain”; it is already always there, and, as every anthropologist who has engaged in ethnographic research knows all too well, the local must be taken seriously.

I first posited the concept of “local biologies” in Encounters with Aging: Mythologies of Menopause in Japan and North America (Lock 1993:39). Certain anthropologists have portrayed this concept as a precursor to epigenetic theorizing. Based on comparative ethnographic and statistical findings in Japan and North America, I was attempting to move anthropological analyses of the body beyond social construc-
tionism and, further, signal that while well-demonstrated population-based differences in biology are indeed “real,” interpretations of local/regional phenomena should include accounts about subjective bodily experience. Furthermore, I explicitly argued that the assumption of a universal biological body was a serious error leading to inappropriate practices of standardization—a claim demonstrated earlier and in subsequent years by other anthropologists (see, e.g., Adams 2013; Erikson 2012; Farquhar 1991). I adopted the term “local biologies” to gloss what I was trying to get at:

The embodied experience of physical sensations, including those of well-being, health, illness, and so on, is in part informed by the material body, itself contingent on evolutionary, environmental, and individual variables. Embodiment is also constituted by the way in which self and others represent the body, drawing on local categories of knowledge and experience. If embodiment is to made social, then history, politics, language and local knowledge, including scientific knowledge to the extent that it is available, must inevitably be implicated. (Lock 2001:484)

This statement is radically different from the position taken by most epigeneticists. Paying serious attention to language, subjective experience, and symptom reporting allowed me to postulate that, even though the end of menstruation is universal, the experience of menopause is markedly different for the majority of Japanese women than that reported by women in the United States and Canada. This is not what behavioral epigenetic methodology is about. Rather, research is motivated by a desire to translate demonstrated epidemiological correlations into cause and event molecular pathways. Such pathways are usually first modeled in animals and then adapted for use in human populations. The subjective view of embodiment is absent, as are accounts of local histories, everyday life, experiences of stigma, discrimination, and so on. And this is exactly where the challenge lies for anthropology. While the “local,” in the form of environments, cannot be ignored in epigenetics, ultimately many (but not all) researchers are striving for universal causal explanations, after funneling and canalizing variation into specific channels.

Julie Livingston reminds us most forcibly how time, secreted away in reductionistic approaches to the body, is now front and center: time is “layered, accelerant, recursive, contingent, scalar, linear, and circular all at once,” she states. The mind boggles! What to do? Clearly we need to transcend straightforward linear narratives—and many ethnographic accounts, especially from societies that until recently were nonliterate, show us how, as does literature such as that written by Amitav Ghosh and Joseph Boyden among others, and, on occasion, that of psychoanalytic literature.

Hannah Landecker pointed out in her commentary that my paper “oscillates between acerbic critique of old reductionism in new bottles and careful enthusiasm that cultural anthropologists could think newly about bodies and their own refusal to take on bodies if they were to engage with epigenetics.” She makes clear that I had more than double duty to do: explicating the field of epigenetics while simultaneously critiquing it constructively and, at the same time, praising it for its uses as a stimulant for anthropology. My hope is that this uncomfortable position will resolve itself when it is no longer necessary to convince numerous anthropologists that the time is long overdue to open the black body box.

—Margaret Lock

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