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Recovering the Body

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Abstract

The Anthropocene has been officially declared as a new geological epoch owing to the lasting impact made by humans on environments, negatively affecting the health and even survival of human populations. Furthermore, over the past decade, molecular science has shown that the human genome is reactive to environments that are external and internal to the body. Hence, environments impact directly on individual bodies by bringing about epigenetic changes in the genome. Following a discussion of human exceptionalism and its limitations, I argue that an anthropology of embodiment should be situated in time and space, and recognition given to local biologies as a subcategory of situated biologies evident globally. Examples are then given of the intergenerational transmission of epigenetic effects due to environmental toxic exposures with a concluding call for anthropologists to engage with the worldwide challenge.

[T]hey create a desolation and call it progress.

–With apologies to Tacitus (98 CE)

PREAMBLE

The geological epoch known as the Holocene, which commenced 11,700 years ago following the last major ice age, has been eclipsed. As of September 2016, we have been living in the Anthropocene. Designation of this new epoch was initiated in the 1980s by the ecologist Eugene Stoermer, and it was taken up again in 2000 by the atmospheric chemist and Nobel Laureate Paul Crutzen at a meeting in Mexico. By 2013, more than 200 peer-reviewed articles had been published that aired debates about the looming, epochal transition, and Elsevier had launched a journal titled *Anthropocene*, followed by an e-journal *Elementa: Science of the Anthropocene*.

The historian Dipesh Chakrabarty highlights the peculiarity of the current epoch: "[T]he Anthropocene spells the collapse of the Kantian distinction between natural history and human history" for we are now in the first geological epoch in which the force transforming the globe—human-initiated activity—is supposedly self-conscious about what it is doing, with profound implications for politics and the allocation of responsibility (Chakrabarty 2009, p. 3). The Hall of Biodiversity in the American Museum of Natural History contains a plaque that states, "Right now we are in the midst of the Sixth Extinction, this time caused solely by humanity's transformation of the ecological landscape" (Kolbert 2014, p. 267); for an account of the significance of the Anthropocene for the United States, see Jedediah Purdy's (2015) *After Nature*.

Following three years of heated exchanges, the notoriously conservative International Union of Geological Sciences (IUGS) convened a group of scholars in 2013 to decide if the Anthropocene should be officially recognized. In a recommendation presented to the International Geological Congress in Cape Town, they declared that this was indeed the case. Geologists had shown little opposition to the position that humans have replaced nature as the dominant environmental force on earth, but as to when, exactly, this took place, for this force to be recognized as a valid geological turning point, caused dispute (Biello 2015). For a decade or more, arguments have been made about whether the Neolithic revolution, or perhaps even earlier changes brought about by humankind, evinced the beginning of the Anthropocene.

The ecologist Erle Ellis and colleagues (2015) argue that the Anthropocene commenced 10,000 years ago, when land clearance for agriculture and irrigation began to have a global effect on vast swaths of land. In recent centuries, colonization has further reduced the planet's biodiversity to a fraction of what it was formerly, as Annie Proulx's (2016) latest novel, *Barkskins*, graphically depicts for Canada. Others argue that the Industrial Revolution, which commenced in the late 1700s, epitomized by the steam engine, was the singular moment (Jørgensen & Jørgensen 2016). Humans have manufactured numerous mineral compounds, including more than 500 million metric tons of pure aluminum since World War II, much of which has sedimented into earth's layers. Even more striking are "mineraloids"—glass and plastics—300 million tons of which are made annually and are present on the earth's crust and in all the oceans. Concrete, a rock of our own making, encases much of the globe today. Our chemical footprints are everywhere, principally in the form of CO_2, nitrogen fertilizer, pesticides, and diesel fuel, which have accumulated as toxic waste distributed globally. James Lovelock (2006) argues in his book *The Revenge of Gaia* that human overpopulation is the most significant threat that we must confront today.

The majority of earth's inhabitants recognize that we now live with dramatic global warming manifest in rising sea levels, extreme temperatures, drought, floods, and famine. The environment—nature—is exhibiting all the signs of stress, trauma, toxicity, and abuse that are usually associated with suffering human bodies; "capitalist ruins," as Anna Tsing (2015) puts it, are all too evident in vast swaths of the globe. But geologists need hard evidence of an irreversible transition to identify a new epoch. Their decisions are pegged to a so-called golden spike—a marker that appears in ice cores, the oceans, lake sediments, and soils, where recognizable fossilized strata appear, which can be hammered, sampled, and/or dug up. Such changes are known as a time-rock unit. The IUGS eventually agreed that July 16, 1945, the day when the first nuclear device exploded, leaving rare isotopes of plutonium distributed worldwide, including Antarctica and Greenland, constituted such a spike (Zhorov 2016).

For more than a decade, we have been living with another fundamental change known as the postgenomic era, in which the human genome is no longer recognized as the driving force of life, but rather as reactive to environments that are external and internal to the body (Richardson & Stevens 2015). The very nature of what it is to be human has been revised on the basis of knowledge brought to light when mapping the human genome, with enormous consequences for understanding human development, health, ill-health, and possibly our very survival.

In sum, a new geological epoch exists because humans are making over nature writ large to such an extent that it is irreparably transformed. At the same time, molecular science has shown that the human genome does not determine who we are; on the contrary, the environment that we are constantly remaking is in the driver's seat, bringing about increased inequalities and, for many, intensified misery.

HUMAN EXCEPTIONALISM

Alfred Russel Wallace, the nineteenth-century naturalist and anthropologist, came to mind when I was in Malaysian Borneo a couple of years ago admiring orangutans, pygmy elephants, scarlet-rumped trogons, and other remarkable wildlife, usually while I was perched precariously in a small boat. Wallace is best known, of course, for independently postulating a theory of evolution through natural selection, and he was coauthor with Charles Darwin on several papers. He was also a social activist and was opposed to the effects of capitalism that he observed taking place in nineteenth-century Britain, among them a troubling negative impact on the environment (Shermer 2002).

On the basis of long sojourns in South America and Southeast Asia, Wallace came to the conclusion, contrary to Darwin, that the human brain is so powerful that it overrides natural selection. His adherence to a form of spiritualism drove him to argue that humans are not subject to pressure from environmental variables in the same way as are other living organisms (Wallace 1911). Wallace's assumption of human exceptionalism profoundly influenced Franz Boas, inspiring him to postulate a concept of culture elaborated in *The Mind of Primitive Man* (Boas 1911).

Throughout the first decade of the twentieth century, Boas was busy measuring the cephalic indexes (the ratio of the length to the width of the head) of several thousand immigrants and their children who lived in New York. He was surprised by his findings, because the indexes of the children of immigrants differed from those of their parents. Boas concluded that the shapes of immigrants' heads converged to a common type as a result of similar environmental pressures, and he noted that "we are necessarily led to grant . . . the great plasticity of the mental make-up of human types" (Boas 1911, pp. 64–65). Boas was at pains to emphasize that the organization of the brain is basically the same for all humankind, but diversity arises, he suggests, because of "the variety of contents of the mind as found in various social and geographical environments" (p. 104).

Although the validity of Boas's research on cephalic indexes has been questioned, such critique sidesteps the ontological questions at stake. Boas was writing after the rediscovery and publication, in 1900, of Mendel's work on genetic inheritance; no doubt quite struck by these findings, he insisted that the influence of heredity was probably more important to human development than the influence of the environment. Nevertheless, he insisted that an environmental contribution is significant, leading George Stocking (1974) to suggest that Boas ultimately remained agnostic on this matter. One of the abiding concerns of Boas, an assistant editor of *Science* from 1887, was to question whether the cultural character of a race is determined by its physical characteristics. On the basis of his research, he concluded that the answer was negative and worked tirelessly against racial discrimination in the United States to considerable effect (Degler 1991).

Alfred Kroeber, in contrast to his mentor Boas, justified a marked dichotomy between genes and the environment by drawing on the insights of the geneticist August Weismann. Kroeber, who described himself as "a humanist and a natural historian, or natural scientist" (Steward 1961, p. 1), was struck by Weismann's argument that a wall exists between "gamete and zygote" (the unfertilized sex cell and the fertilized cell), and he inferred from this that biology cannot in any way explain the achievements of human society (Kroeber 1916, pp. 26–27). As is well known, Kroeber's essay "The Superorganic" has become the canonical argument for why biology has no place in anthropology. Herbert Spencer had first made use of the idiom superorganic, but Kroeber in effect turned its original intended meaning on its head (Degler 1991, p. 90). A diligent empiricist, Kroeber regarded anthropology as the most humanistic of sciences, and he argued that the possession of culture comes about through shared values and styles that set humans apart from the rest of the animal kingdom. He was uncomfortable with structural/functionalism and chastised social scientists and historians for having simply followed biologists. Although oriented toward the biological sciences, he nevertheless insisted that to understand social phenomena one must "disregard the organic as such and to deal only with the social" (Kroeber 1952, pp. 34–35).

Emphasis on the significance of cultural relativism was particularly strong among anthropologists in the years leading up to World War II; however, following The Universal Declaration of Human Rights by the United Nations in 1948, its championing became questionable. When he gave a talk at the University of California in 2002, Karl Kroeber, an historian and Alfred's son, explicitly noted "your profession's midlife crises at the end of World War II" (Kroeber 2003, p. 141). As Kurt Vonnegut put it in the introduction to *Slaughterhouse-Five*, "I went to the University of Chicago for awhile after the Second World War. I was a student in the Department of Anthropology. At that time they were teaching that there was absolutely no difference between anybody. They may be teaching that still" (Vonnegut 1968, p. 8). Anthropological theorizing and practice have flourished exponentially since the middle of the last century, and ethnographic writing of one kind or another is central to the work of perhaps most of us. But the bifurcated orientation toward the human mind and body set out by Kroeber continues to retain a strong hold in many quarters.

OPENING THE BLACK BOX

For more than a century, a widely held assumption that our genes determine who we are has persisted among both geneticists and the majority of the public at large. Of course, anthropologists have long argued that poverty, discrimination, racism, and stereotyping, and not genes per se, contribute greatly to economic and health inequalities. We are, justifiably, wary about the possibility that a belief in inherent biological difference among people may exacerbate racism and discrimination. Galtonian eugenics, founded in 1883, was based on a desire to improve the human race through a breeding program, and, like Kroeber, Galton was impressed by the work of August Weissman (Galton 1876). Active in the late nineteenth century, he was able to correspond with Weissman, and they were duly impressed by each other's ideas. But Galton's plans for human breeding were not driven primarily by race; rather they were directed first at transforming the poor and destitute in England of the day. It was not until his ideas were taken up in the United States that racism became dominant in eugenic discourse, following which it infected Europe.

Charles Davenport, an American biologist, made clear that "biological and cultural degradation" follows "interbreeding between white and black populations" (Davenport 1910, p. 207). The Eugenics Records Office in Cold Spring Harbor Laboratory, where Davenport was the director, expressed anti-immigrant sentiment and sent warnings to Ellis Island where more than one million passengers were processed in 1907 alone. Clearly, racist assertions, at no time fully put to rest, are markedly on the rise today, seemingly worldwide, and the dramatically increased movement of peoples precipitated by violence, climate change, and starvation has contributed to its resurgence.

Anthropologists are right to be concerned about the politicization of biological difference. Hence, following Kant, it seems appropriate that the interiority of the material body be black-boxed and given over to biologists and physical anthropologists for scientific investigation. Research about the social and cultural construction of discourse about embodiment (both medical and popular), about subjectivity, and about self and identity has been, and continues to be, undeniably valuable and enlightening. But, as the philosopher Russell Keat put it two decades ago, a good deal of time has been spent in the social sciences and humanities in discussing the distinctiveness of human beings, while also holding to an assumption about the "nondistinctiveness of the human body" (Keat 1986, p. 275). Perhaps now, when post-truth is bursting out all over, the moment has come to pry open the black box in search of something resembling a fact or two.

One major outcome of disembodying anthropological informants has been that the body proper—the standardized biological body that has enabled singular advances in the biosciences—has not been sufficiently exposed to thoughtful critique by anthropologists. Until recently, we have not routinely addressed fundamental matters of onto/epistemology, as Barad (2007, p. 44) puts it, in connection with the production of biomedical knowledge. Critically assessing the truth claims of biomedicine does not entail dismissing outright the standardized universal body (an entity indispensable to good biomedical practice) but, rather, requires systematically questioning unexamined assumptions embedded in biomedical knowledge and practice. See, for example, Garcia (2010), Hamdy (2012), Lock (2002, 2013), Nading (2014), Nguyen (2010), Roberts (2012), Stevenson (2014), and Street (2014).

In addition to clinical medicine, there are, of course, other ways of scientifically representing bodies, among them epidemiology, biological anthropology, and forensics, all specialties that, in contrast to biomedicine, mark out biological difference among individuals and populations. Along these lines, anthropologists of embodiment should, I believe, seek to situate bodies in time and space, thus bringing to the fore the inevitable coalescence of material bodies in environments, histories, social/political variables, and medical knowledge of all kinds. On the basis of such an approach, I reached the conclusion in the early 1990s that part of our task is to recognize "local biologies," that is, biological difference among people that results from bodily responses to differing environments over time and across space. Such differences are not genetically determined, and a great number are of no consequence, although some bear profoundly on health and illness.

EPIGENETICS AND THE REACTIVE GENOME

DNA is among the most nonreactive, chemically inert molecules in the world, with no "power to reproduce itself" (Lewontin 2000, p. 141). Even so, following the announcements in 2001 that the human genome had been mapped (which was not at that time, strictly speaking, true), one journalist reported that it was like completing God's own jigsaw puzzle, although others were more skeptical. Some insisted that the map resembled a list of parts for a Boeing 747 but offered no idea as to how the parts go together and no knowledge of the principles of aeronautics. Furthermore, many surprises came to light, some of which scientists had predicted prior to embarking on the Human Genome Project but that had been ignored.

Mapping made clear that humans have approximately 20,000 genes, and not 100,000 as had been predicted. Numerous plants have many more genes than do humans, and the diminutive worm *Caenorhabditis elegans* has about the same number as humans do. The size of a genome bears no relationship to its complexity, and the genome is not a template for the organism as a whole. Only approximately 1.2% of DNA segments actually code for proteins, and the remaining 98.8% was initially labeled disparagingly as "junk" (Carey 2015, p. 5).

Although noncoding sections of the genome appear to have no obvious function, and are frequently remnants of bacterial and viral genomes, these noncoding sections separate out the coding parts of the genome, thus inhibiting unwanted mutational changes during DNA transmission between generations. Moreover, numerous noncoding DNA sequences are highly conserved, implying that they have been present in genomes for hundreds of millions of years, which strongly suggests that they are crucial to both evolutionary change and the processes of life. Furthermore, the activities of noncoding RNA (ncRNA) comprise a comprehensive regulatory system that functions to create the architecture of organisms, without which chaos would reign. To this end, ncRNA profoundly affects the timing of processes that occur during development, including stem cell maintenance, cell proliferation, apoptosis (programmed cell death), the occurrence of cancer, and other complex ailments (Mattick 2004).

These findings relate to the structure and function of the genome itself; over the past decade, the research of molecular epigeneticists has added further insights to this already complex picture. Epigenetics literally means "over or above genetics," but its precise meaning changes as new discoveries come to light. A few years ago, scientists in the expanding subfield of behavioral epigenetics claimed that they had tracked the molecular links between nature and nurture, thus providing sound evidence that nature/nurture is not divisible (Labonté et al. 2012). This assertion was based on research demonstrating how environmental stimuli and stressors originating both externally and internally to the body initiate trains of molecular activity that modify how DNA functions, often with lasting effects on human behavior and well-being, including, at times, increased mental illness and suicide rates.

To date, the most well-researched epigenetic mechanism is methylation, a process initiated by enzymes in which DNA sequences are not altered; rather, one nucleotide, cytosine, is transformed, which changes the nucleotide base and renders a portion of the DNA inactive. Animal research has shown definitively that methylation modifications can be transmitted intergenerationally; some work strongly suggests that this process also occurs among humans (Pembrey et al. 2014), although certain researchers argue that this fact has not been irrevocably established. Szyf et al. (2008) demonstrated that the epigenetic regulation of chromatin structure is of crucial importance in these processes. This emerging knowledge makes clear that the task of the genome is to respond to the environment during the course of human development from the moment of conception and throughout life.

Today, the majority of biologists, whatever their specialty, accept that cellular differentiation is governed by something akin to what the developmental biologist, embryologist, and philosopher Conrad Waddington (1940) described in the mid-twentieth century as the epigenetic landscape. This landscape is a complex panorama of networks and feedforward loops triggered by environmental stimuli internal to the body, which determine how embryonic cells, with the potential to become any kind of mature cell, are transformed, for example, into kidney, nerve, or epithelial cells. These changes are essential for human development. In addition, environments both external and internal to the body can induce epigenetic alterations in the genome independently of normal development that may be deeply involved with health and illness throughout life. Based on the emphasis he gave to the plasticity of the human brain in response to environmental influences, Boas can perhaps be labeled retroactively as a proto-epigeneticist.

With the advent of epigenetic insights, philosopher of science Evelyn Fox Keller (2014) notes, "The role of the genome has been turned on its head, transforming it from an executive suite of directional instructions to an exquisitely sensitive . . . system that enables cells to regulate gene expression in response to their immediate environment" (p. 2425). Biologist Scott Gilbert (2003), elaborating on Waddington, characterizes this situation as one in which the genome is best understood as "reactive" (p. 92).

Furthermore, if genes are conceptualized as, in effect, real entities, then they must be understood as composite rather than as unitary, somewhat analogous to "the solar system, or a forest, or a cell culture," as Barnes & Dupré (2008, p. 53) put it. In sum, a dynamic epigenetic network with a life of its own has been exposed, which can best be understood as a context-dependent reactive system of which DNA is just one part. Thus, contingency displaces determinism.

Gene regulation—above all how, and under what circumstances, genes are expressed and modulated—is at the heart of epigenetic investigation, and whole cells, rather than DNA segments, are the primary targets of inquiry. Effects of evolutionary, historical, and environmental variables on cellular activity, developmental processes, health, and disease are, in theory, now central to the research endeavor, although, to date, this is by no means the case in most basic science investigations (Lock 2015, p. 154). Notably, biologists agree for the most part that epigenetics does not overturn the Darwinian theory of natural selection, although epigenetic research has been characterized by some as neo-Lamarckian. Of course, long since abandoned was the notion that use or disuse of body parts brings about evolutionary change; epigeneticists recognize, however, an important aspect of Lamarck's thinking with which Darwin agreed, namely that forces internal and external to the body contribute directly to the makeup of future generations (the concept of a phenotype was not available to either Lamarck or Darwin).

Given the bourgeoning effects of human activities on the environment sufficient to herald a new geological epoch, combined with the relegation of genes to a reactive function in response to environmental stimuli, the time is ripe, it seems, for cultural and social anthropologists to reassemble mind and body. Our task, or part of it at least, must surely be to assess the lasting effects of the dominant values and desires of our era on the state of the planet itself and, by extension, on the health and well-being of humans and other life forms.

LOCAL BIOLOGIES

In recent years, anthropologists writing about environmental effects on embodiment, ranging from toxicity to deprivation, violence, and migration, have made extensive use of the concept of local biologies. I created this concept in the late 1980s in an attempt to account for significant differences among women in Japan and North America when reporting symptoms experienced at menopause. The findings from this three-site project were based on comparative statistical analyses of respondents aged between 45 and 55 years inclusively in the United States (8,000), Canada (1,300), and Japan (1,300). Preliminary ethnographic investigation was key to creating the questionnaire and interpreting the findings in Japan (Lock 1993). Japanese reporting of the characteristic symptoms of menopause was low; experiences of so-called hot flashes were approximately one-third of those reported by US and Canadian women; reporting of night sweats was extremely low and was not associated with menopausal status. Only 19% of Japanese women in the study had experienced a hot flash at some time in the past, and reporting of both frequency and intensity was much lower than among US and Canadian respondents, among which nearly 60% had experienced hot flashes. Subsequent research involving biological measurement in addition to verbal reporting has substantiated the Japanese findings: Melissa Melby, a biological anthropologist, concluded that the metabolism of phytoestrogens is almost certainly implicated in the Japanese experience of this midlife transition (Taku et al. 2012).

The concept of local biologies was not designed to draw attention to the discovery of menopause by the medical sciences in the nineteenth century, although this is indeed the case. Nor does it refer to measurable biological differences across human populations, although such findings contribute to the present argument. Rather, the notion of local biologies refers to the manner in which biological and social processes are permanently entangled throughout life, ensuring a degree of biological difference among humans everywhere that typically has little or no significance but at times bears profoundly on well-being. Nguyen and I refer to "biosocial differentiation" to suggest the continual interactions of biological and social processes across time and space that sediment into local biologies, in effect precipitating artifacts—snapshots of ceaseless entangled change (Lock & Nguyen 2010, p. 90). In summary, the material and the social are both contingent—both local (Lock 2001, p. 483).

No simple relationship exists among local biologies and nation-states, social groups, ethnicities, communities, or even families. Local biologies are not uniform across groups of people nor are they fixed in place and time. Nevertheless, they are readily detectable on the basis of biological and/or ethnographic investigation and are often clustered in specific locations. They do travel, however, and may be transformed owing to new environmental influences. Menopausal symptom reporting by Hawaiian Japanese resembles that in Japan; in contrast, Japanese Americans in California experience an increase in symptoms that approaches, but remains lower than, that in the United States (see Melby et al. 2005 for an extensive review).

In the examples of local biologies that appear below, I confine discussion to epigenetic effects that result from exposure to toxic and/or nutritionally impoverished environments to emphasize the impact that massive environmental destruction coupled with increased social inequalities are having on human bodies everywhere. Epigenetic findings limited to the effects of exposure to traumatic and stressful events on fetal and early life (for example, Grandjean & Landrigan 2006; Hertzman 1999; Lock 2015, p. 157; Monk et al. 2012), startling though they are, are set aside, owing to space limitations. However, it is important to note that "environments," the boundaries of which must be delineated for research purposes, whether by epigeneticists or anthropologists, are, in reality, not isolable. For instance, exposure to malnutrition may well happen simultaneously with trauma in early life.

INTERGENERATIONAL TRANSMISSION OF TOXINS

Based on many years of fieldwork that commenced in 2003 in Hanoi, Vietnam, Danish anthropologist Tine Gammeltoft has documented the devastating effects that the chemical defoliant Agent Orange continues to have on reproduction more than 40 years after the war (Gammeltoft 2014). The Vietnam War lasted from 1962 until 1971, during which time the US military conducted an aerial defoliation program that was part of an urbanization strategy designed to force peasants to leave the countryside, where they helped sustain the guerrillas, and move to the cities dominated by US forces. Nearly 20 million gallons of chemical herbicides and defoliants were sprayed on Vietnam, eastern Laos, and parts of Cambodia, destroying all plant material in two days. In some areas, toxic concentrations in soil and water became hundreds of times greater than the levels considered safe in the United States.

Agent Orange contains the highly toxic chemical dioxin, known to have long-lasting effects on the environment and human tissue. Gammeltoft documents a widespread fear about the so-called dioxin gene, widely believed by many people who live in Vietnam today to be increasing in the population over time. Studies estimate that at least three million citizens in Vietnam suffer from serious health problems due to exposure to defoliants, and the rate of severe congenital abnormalities in herbicide-exposed people is 2.95% higher than in unexposed individuals (Gammeltoft 2014, p. 46). The mass media has reported cases of third-generation Agent Orange victims, in which individuals exposed during the war have produced apparently healthy children whose grandchildren are born severely disabled. Animal research has shown that, following fetal exposure, dioxin reprograms epigenetic developmental processes; the effects of these changes may manifest over the life course.

Vietnam was given membership in the World Trade Organization in 2007, one result of which was heightened concern by the Vietnamese government about the international visibility of the health of the population as a whole. It was at this juncture that extensive use of ultrasonography was introduced—a political tool designed to ensure the birth of healthy children. One result has been that ultrasound is now used repeatedly during pregnancy as part of antenatal care, even though the Vietnam Ministry of Health does not recommend this practice (Gammeltoft 2014, pp. 10–12). Deciding to have an abortion if a deformity is detected by ultrasound is not easy. Many affected families think that abortion is an evil act. Furthermore, everyone involved knows that it can be difficult to assess the extent of the deformity from ultrasound images, although it is equally the case that frequently the severity is all too evident. Some families, reluctant about abortion and longing for a healthy child, are raising three or four children with deformities, the most common of which is hydrocephalus (water on the brain), which causes severe retardation. Some women discover very late in pregnancy that the fetus is not normal, and some opt for a late termination, to the great discomfort of their doctors (Gammeltoft 2014, pp. 111–13).

Gammeltoft's (2014) moving interviews with affected families make clear that many people choose not to entertain the idea that an anomalous fetus detected by ultrasound, or the birth of a horribly deformed child, is due to Agent Orange (p. 77). They are all too well aware that the stigma attached to Agent Orange families ensures that finding marriage partners for healthy family members would be virtually impossible. It is more socially acceptable to claim publicly that the anomaly resulted from a cold that the mother had or the heavy work that she did while pregnant.

A range of severe illnesses are associated with dioxin exposure, including deadly cancers, Parkinson's disease, and spina bifida, in addition to those associated specifically with pregnancy (Gammeltoft 2014, p. 55). Vietnamese researchers have reported these findings, but the official US position is that there is no conclusive evidence that herbicide spraying caused health problems among exposed civilians and their children. However, in 2014, following extensive lobbying over many years, the US Congress passed a five-year aid package of $21 million, which amounted to a modest sum for each Vietnam veteran. These cases were settled out of court, and no legal liability has ever been admitted (Gammeltoft 2014, pp. 46–47). The official position to this day is that the government was, in effect, prodded into settling these legal suits and that no evidence has shown that Agent Orange caused harm, a position supported by the chemical's principal makers, Monsanto and Dow Chemical companies. Children who have severe birth defects, including hydrocephalus and spina bifida, who were born to Vietnam War veterans have received no compensation (Gammeltoft 2014, p. 49).

In Vietnam, officials were reluctant to persist with complaints about Agent Orange because their utmost concerns were about the economy as a whole, notably a desire not to damage the marketing of numerous agricultural and aquacultural products made in Vietnam. In the mid-1990s, Vietnamese writers and artists finally began to express concern about Agent Orange, and eventually Vietnamese citizens filed a class-action suit in the US District Court in New York, which was abruptly dismissed. But demands for responsibility are increasingly being heard, spearheaded by nongovernmental organizations (Gammeltoft 2014, pp. 44–46).

A further example of toxic local biologies is furnished by the mercury contaminated Grassy Narrows' Wabigoon River system in Ontario, Canada. The government claims that defilement of the river stopped 40 years ago, when the paper mill was forcibly shut down after dumping about 9,000 kg of mercury into the downstream river. Today, mercury levels in the fish near Grassy Narrows are 15 times the safe consumption limit and 40 times the consumption limit for children, pregnant women, and women of childbearing age. The Grassy Narrows people have fought for 50 years for a cleanup of the river. The Ontario Minister of Environment at first wavered but then reiterated in May 2016 that a cleanup is not necessary, despite a report by experts who stated that the river remains badly contaminated (Mosa & Duffin 2016). Two generations of people from Grassy Narrows and Wabaseemoong First Nations today exhibit the symptoms of mercury poisoning, including loss of muscle coordination, numbness in the hands and feet, hearing loss, speech damage, and tunnel vision. Fetuses are particularly vulnerable to cognitive damage. Extreme cases result in paralysis, insanity, coma, and death.

Mercury poisoning has officially been recognized in Japan since the 1950s. At first, there were only reports that local cats appeared to go crazy, and some "committed suicide" by "falling" into the sea. Thereafter, humans started to report numbness in their extremities, accompanied by tremors, difficulty walking, and, in some, signs of mental illness. By 1959, mercury poisoning had been definitively established. A large petrochemical plant, Chisso Corporation, which was active in Minamata, the affected fishing village, was immediately suspect. Chisso denied involvement, even when it was shown that an estimated 27 tons of mercury compounds were present in Minamata Bay. Protests began in 1959, but it was 1968 before the company finally stopped dumping. Close to 3,000 people contracted what came to be known as Minamata disease, more than half of whom have died (Kugler 2016). Japanese experts in mercury poisoning have been summoned to Grassy Narrows and report that up to 90% of the people there show signs of mercury poisoning that is being intergenerationally transmitted (Monk et al. 2012).

Further examples of local toxic biologies include setting fires to numerous oil wells and a sulfur plant in Mosul, Iraq, by Islamic State supporters, killing several people and causing hundreds to be exposed to toxic fumes, the effects of which are likely to cause lasting damage. Likewise, a second generation may be affected once women who were pregnant during exposure give birth (*New Scientist* 2016). Chlorine gas attacks by government troops in Syria are equally devastating and may well have intergenerational consequences.

MISMATCH THEORY

At the present time, nearly 2 million children die from malnutrition each year worldwide, a number that is rising. Research has revealed remarkable findings about biological differences between infants who suffer from marasmus (severe malnourishment) compared with those who have kwashiorkor (severe protein-energy malnutrition with edema). An investigation into malnutrition, which was carried out in Jamaica, commenced in 1962 and continued for 30 years. During this time, more than 1,100 infants with severe, acute malnutrition were admitted to University Hospital, Kingston. Investigators hypothesized that 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 evidence of this. The research in Kingston showed that those infants diagnosed with kwashiorkor had considerably higher birth weights than did infants diagnosed with marasmus, but frequently these infants die very young; in contrast, those with marasmus endure greater wasting of flesh, but many survive to adulthood (Forrester et al. 2012).

Researchers characterized marasmus as "metabolically thrifty" and kwashiorkor as "metabolically profligate" and thus concluded that mechanisms associated with "physiological plasticity" are operative (Forrester et al. 2012). Their findings are assumed to be direct evidence of "anticipatory responses" in utero, and the distinctly different phenotypes of children with kwashiorkor and marasmus are interpreted as end points of environmentally driven epigenetic activity on different genotypes (Forrester et al. 2012).

This striking example of epigenetics is just one in a field that is attracting much attention because researchers hope that it will throw light on the so-called obesity epidemic currently affecting many countries, whether affluent or not. On the basis of a hypothesis known as the "mismatch pathway," investigators posit 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 & Hanson 2008, p. 12). The bodies of fetuses and young infants exposed to nutritionally deprived diets may be epigenetically prepared to deal with deprivation, but this preemptive adjustment can wreak havoc in energy-rich environments, resulting in obesity, especially if children are overfed.

Given the inordinate rate of human displacement across the globe, due in large part to environmental destruction and violence, mismatches will likely become increasingly evident between environments to which human populations are biologically adapted and the lived environments in which millions of people are now forced to exist.

SITUATED EMBODIMENT

In the era of the Anthropocene, biosocial differentiation is becoming increasingly complex, mobile, unpredictable, and rapid, in large part because of dramatic environmental changes forced on people in large swaths of the globe. As a result, local biologies increasingly travel and may well be modified as people try to subsist in new, often impoverished environments. Anthropologists are now employing a second concept, that of situated biologies, in part to address concerns raised by certain of our colleagues about local biologies, namely that this concept may inadvertently reinforce a false belief about inherent biological difference among humankind. The examples above make clear that this is not so because environmental variables—dietary, toxic exposures, climate change, and so on—clearly bring about biological difference, following Darwinian logic. The concept local biologies highlights how such transformations come about, but it is useful to conceptualize local biologies inserted under an overarching concept of situated biologies.

At the molecular level, epigenetics is beginning to spell out how human biology is everywhere an expression of the effects of environments small and great over the entire life course. On another level, epidemiology and public health practitioners produce correlative findings, based primarily on socioeconomic status, gender, and ethnicity, that reveal differences in incidence of ill-health among these specified groupings. Situated biologies, in contrast, highlight the potential impact on the health of everyone, of increasingly pervasive human-induced toxic environments, including pervasive poverty that can impair neurodevelopment from birth (Hamzelou 2016), famine, war, genocide, mining, terrorism, oil extraction, radioactive waste, dams, dysfunctional nations, and antibiotic resistance. When such mass exposures are examined in situ, local biologies become apparent beneath the "noise" of Anthropocenic destruction.

Ayo Wahlberg (2016), whose current research site is China, suggests that "exposed" biologies is yet another useful concept (Waddington 1940). Dietary changes associated with urban living, chain smoking, a perpetually harried lifestyle, and factory emissions and car exhaust, which contribute to the toxic smog that coats much of urban China today, are associated with the rise of "cancer villages," estimated to be about 460 in number (Kaiman 2013). Respiratory problems are rampant, and infertility rates are supposedly soaring (Kaiman 2013). India has recently admitted that their urban pollution resembles that of China, and increased respiratory problems and purportedly rising infertility rates are documented there. Other cities around the world come to mind, including Cairo, Dhaka, Lagos, and Mexico City, to name a few.

In 2015, 205 billion liters of raw sewage were pumped into Canadian rivers, lakes, and coastlines (Thompson 2016). Canadian photographer Edward Burtynsky, having documented similar worldwide destruction for more than three decades, describes "hypercrucible[s] of globalism" (Khatchadourian 2016). There is more: The exploding worldwide prevalence of diabetes and obesity indicates that rates of dementia will increase—and so it goes. Welcome to the Anthropocene—anthropologists have work to do!

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