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Mutable environments and permeable human bodies*

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Geologists have declared an epochal transition to the Anthropocene, formally recognizing humans as the driving force of destructive global change; a distinction can no longer be made between human history and natural history. Certain commentators argue that Capitalocene better characterizes the situation, given that the effects of planetary decimation and global warming are not equally distributed among humans. A second conceptual change has recently taken place in which genomes are recognized as reactive to environmental stimuli both external and internal to the human body. In the post-genomic era, genes neither initiate life nor drive human development. The science of the bourgeoning field of behavioural epigenetics is introduced, followed by illustrative examples of environmentally caused epigenetic changes that impact negatively on health. Epigeneticists routinely delimit their attention to detecting measurable changes at the molecular level. It is argued that anthropological contributions that incorporate subjective accounts of embodiment involving past and present events are crucial in order to better situate and account for biological differences and health outcomes historically, ecologically, and politically. Discussion of the microbiome provides a cautionary reminder that microbes are the ultimate driving force of health and illness. In conclusion, the Earth Optimism movement is briefly introduced, as is the concept of resilience, but alone these positive moves will not curb unremitting global warming.

The Holocene, which commenced 11,700 years ago following the last major ice age, has been eclipsed. The historian Dipesh Chakrabarty insists that the Kantian distinction between 'natural history and human history' no longer exists (2009: 201). Moreover, this is the first epoch in which the primary force transforming the globe is self-conscious about what it is doing (or some of us are, at least), with profound implications for politics and the allocation of responsibility.

Christopher Rapley, a climate scientist at University College London and former director of the Science Museum in London, states:

> The Anthropocene marks a new period in which our collective activities dominate the planetary machinery. Since the planet is our life support system – we are essentially the crew of a largish

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> spaceship – interference with its functioning at this level and on this scale is highly significant. If you or I were crew on a smaller spacecraft, it would be unthinkable to interfere with the systems that provide us with air, water, fodder, and climate control ... [T]he shift into the Anthropocene tells us that we are playing with fire, a potentially reckless mode of behaviour which we are likely to come to regret unless we get a grip on the situation (Carrington 2016).

Martin Rees, the Astronomer Royal of the United Kingdom, and former President of the Royal Society, insists: 'The darkest prognosis for the next millennium is that bio, cyber or environmental catastrophes could foreclose humanity's immense potential, leaving a depleted biosphere'. An atheist, he adds more optimistically a vision of the future:

> Human societies could navigate these threats, achieve a sustainable future, and inaugurate eras of post-human evolution even more marvellous than what's led to us. The dawn of the Anthropocene epoch would then mark a one-off transformation from a natural world to one where humans jumpstart the transition to electronic (and potentially immortal) entities, that transcend our limitations and eventually spread their influence far beyond the Earth (Carrington 2016).

Evidence of certain changes, many of which are irreversible, is already overwhelming. The science writer Owen Gaffney has used mathematical models to formalize Anthropocenic markers, and concludes that the ever-increasing impact of humans on earth over the past 7,000 years has 'ejected Earth from the interglacial envelope' and we are now heading into 'uncharted waters' (2017: 24). 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: 267).[1]

Discussion about the need for a declaration of a new geological era has been in the air for many years. The atmospheric chemist and Nobel Laureate Paul Crutzen suggested as early as 2000 at a meeting in Mexico that a new epoch should be recognized, and proposed that it be called the Anthropocene. By 2013, over 200 peer-reviewed articles had appeared on the topic. Elsevier launched a journal in 2013 titled *Anthropocene*, followed by an e-journal *Elementa: Science of the Anthropocene*. The International Union of Geological Sciences convened a sub-committee of Quaternary stratigraphy in 2013 to decide if the Anthropocene should be formally recognized. A heated debate persisted for some years until it was declared in a recommendation presented to the August 2016 International Geological Congress in Cape Town that '[h]umanity's impact on the earth is now so profound that a new geological epoch ... needs to be declared' (Carrington 2016). Among geologists there has been little opposition to the position that humans have replaced 'nature' as the dominant force on earth transforming environments everywhere, but as to when, *exactly*, this took place – thus making it a valid *geological* turning-point – has been the cause of extensive dispute.

Since the start of the millennium, arguments had been made as to whether the Neolithic revolution, or perhaps even earlier changes brought about by humankind, evinced the beginning of the Anthropocene (Ellis, Maslin, Boivin & Bauer 2015). Alternatively, was the industrial revolution that commenced in the late 1700s, epitomized by the steam engine, the singular turning-point (Jørgensen & Jørgensen 2016)? In recent years, environmentally orientated biologists and chemists have incrementally put forward other plausible markers of more recent origin. They have documented how humans have manufactured numerous mineral compounds, including more than 500 million metric tons of pure aluminium, since the Second World War, much of which

has sedimented into earth's layers. Even more striking are 'mineraloids' such as glass and plastics – 300 million tons of which are currently made annually, and are present everywhere on the earth's crust and in all the oceans. By 2050, plastic debris is likely to be more numerous than fish in the oceans (Kaplan 2016). Concrete, a rock of our own making, now encases much of the globe. Our chemical footprint is everywhere, most notably as CO_2, nitrogen fertilizer, pesticides, and toxic waste.

Until recently, the assumption has been that minerals, by definition, are part of the 'natural' world, but the mineralogist Robert Hazen and colleagues have made a tally of 208 minerals 'mediated' by humans. Such minerals occur in human-made mines owing to humidity or fires, deep in the oceans as a result of shipwrecks, or in the form of human-fashioned materials such as rubies, diamonds, ceramics, bricks, cement, batteries, and components of cell phones. Hazen stresses that humans are profoundly changing the sedimentary horizon in which we now live at an increasingly rapid speed (S. Hall 2017). Annual global production of plastic has increased from 200 million to 300 million tons since the 1950s and continues to rise (Klein 2017). Recently, a tiny South Pacific island, 5,000 kilometres from the nearest human habitation, was found virtually buried under layers of washed-up plastic rubbish (Lavers & Bond 2017).[2]

The majority of people throughout the world most probably recognize that we now live with dramatic global warming manifest as rising sea levels, ocean acidification, extreme temperatures, drought, floods, and famine. The environment – nature – is exhibiting all the signs of stress, trauma, toxicity, and abuse usually associated with suffering human bodies; the 'ruins of capitalism', as Anna Tsing (2015) puts it, are all too evident in vast swathes of the globe. Law professor Jedediah Purdy insists that 'the familiar divide between people and the natural world is no longer useful or accurate' (2015: 2) and Marshall Sahlins (2008) reminds us that such a divide is not universally recognized, but rather is derived from our own 'folklore' of the past few centuries. 'Nature' perforce responds to human-made perturbations with the result that, in addition to the environment out there, our own bodies are implicated in the brunt of the debris of capitalistic production. Put another way, humans shape 'natural' history to a far greater extent than ever before, with colossal repercussions for both environments and humankind itself.

However great these changes are, for geologists the singular question remains: if and when we destroy ourselves, which of these human-made marks will last for ever? In 100,000 years' time, the rare plutonium isotopes produced by nuclear bombs will have decayed to a layer of uranium 235 that will permanently become part of the earth's crust, hence geologists eventually were able to agree that the first nuclear explosion was the deciding event that created a new epoch.

In late January 2017, atomic scientists portrayed what they believe lies in the future for humankind. They reset their 'Doomsday Clock' (a symbolic clockface maintained since 1947 by atomic scientists at the University of Chicago). The clock presently stands at two minutes and thirty seconds to midnight (Clarke 2017). Humankind is closer to midnight, that is, to Doomsday, than it has been since 1953. Such a state of affairs was last declared when the original arms race between the United States and the Soviet Union was underway. Catastrophe is at hand.

Efforts to precisely date the beginning of the Anthropocene epoch do not concern me deeply, although it is important to recognize on what grounds such arguments are made. Above all I am concerned with the increasingly damaging effects on human health and well-being that these rapid, destructive environmental changes are bringing

about, and particularly the way in which these effects are not uniformly distributed across populations. Anthropologists can without doubt make a major contribution to systematic analyses of Anthropocenic changes to populations, communities, and individuals globally, employing both ethnographic and, where realistic, quantitative methods. Such findings will make clear the extent of the impact of human-produced environmental changes on human well-being and hopefully incite national and global policy changes. Moreover, such findings will shore up emerging scientific understanding that rather than genes determining individual human biology, human bodies are subject to restless, mutable environments. What is more, human bodies are extremely permeable to environmental stimuli via both skin and gut, and recent research makes clear that microbial populations largely mediate this permeability (Yong 2016).

In what follows, I set out themes that have emerged in recent scholarly articles and in the media about the Anthropocene and its probable effects. The positions taken respectively by Donna Haraway and Bruno Latour as to what the Anthropocene means for humankind are then briefly considered. Turning to the molecular level, the concept of the 'reactive genome' is introduced. In the burgeoning field of epigenetics, environments internal and external to the body have come to be regarded as the primary driving forces for human development and bodily change over lifetimes, with the result that the gene has undergone demotion to a role informed by environmental stimuli. The challenge to anthropology posed by growing insights into microbiome functioning in connection with body boundaries, self and other, is then presented. A call is made for anthropologists to rigorously address these shifts in scientific thinking in connection with epigenetic and microbiome findings. In addition to a constructive critique, an active contribution by anthropologists to multidisciplinary research teams is important. This will provide significant insights into environmental, sociopolitical, and economic effects on human well-being in the current era, and will greatly enhance the significance and interpretation of findings at the molecular level. In the concluding section, five illustrative examples are presented.

Predicting Anthropocenic fallout

To date, many publications about the Anthropocene have focused on the effects of human activity in altering earth's landscapes, oceans, atmosphere, and ecosystems over a range of scales in time and space. Not surprisingly, one detects a certain outrage in these articles (see, e.g., Lorimer 2015; Yusoff 2017). But it is above all the destruction of earth itself that is lamented by such authors, more so it seems than the ruination of human lives, with which I am primarily concerned here (as are Kirksey & Helmreich 2010; Ruddick 2015; Weisman 2007).[3] I am, for course, deeply concerned about the destruction of wildlife and of environments that sustain life of all kinds. However, owing to limitations of space, I have reluctantly created an artificial fissure between Anthropocenic effects on humans and on wildlife, and give priority to humankind.

Climate change, driven by human activities, directly accounts for rapidly accumulating human displacement worldwide. A report in *Scientific American* states that in 2015 alone, 28 million people were internally displaced, in addition to the 15 million forcibly driven beyond the borders of their respective countries, less than 1 per cent of whom are resettled in a new home each year (Fischetti 2016). The original uprising in Syria that ignited the current war there is directly associated with the internal displacement of 1.5 million people owing to drought. Recently a crowdfunding campaign was set up to combat the potential starvation of 150 Maasai families and their

cattle in Kenya, where the land has repeatedly become parched over the past years owing to lengthening of the dry season, resulting in prolonged droughts.

Responsible media of all kinds are documenting the traumatic effects of climate change resultant from human activities on ourselves and on our surroundings, including the release of pathogens from melting permafrost, the global spread of antibiotic-resistant bacteria, the reduction of arable land, famine, the increasing intensity of wars, genocide, and slavery, all of which bring about escalating inequality and poverty virtually everywhere. But media reports have for the most part an ephemeral life. We need data of substance with time depth, including ethnographic findings in which people recount their lived experiences, to fully appreciate the extent to which the rapaciousness of certain individuals is affecting not only our survival but that of earth itself. Of course, numerous anthropologists have long made forays in this direction in which they have documented an interpenetration of cultural and biological variables (see, e.g., Dressler 2009; Goodman & Leatherman 1998). More recently, the biosocial approach, spearheaded by Tim Ingold and Gísli Pálsson, has argued for the inseparability of the social and the biological, and for recognition that human bodies are 'neither genetically nor culturally configured' but rather are 'emergent outcomes of the dynamic self-organization of developmental systems' (Ingold & Pálsson 2013: 20). Eugenia Ramírez-Golcoechea (2013) argues cogently for an approach to epigenetics (see below) that situates the human body in biocultural environments. The current decimation of the globe demands that we build on these insights when tracking the effects of Anthropocenic changes on humankind.

Several recent conferences, keynote talks, and publications in Europe and North America have taken the position that research into the effects of Anthropocenic fallout on human existence is now urgent. Donna Haraway (2015: 159) reminds us that a major question must be: 'when do changes in degree become changes in kind', and with what effects? Haraway readily acknowledges that bacteria and other microbes have had the greatest influence on earth over time (see also DeLong & Pace 2001, among others). Even so, she insists, human influence has been of long duration, is very widespread, and such processes have had planetary effects 'in inter/intra action with other processes and species for as long as our species can be identified'. Erica Oberndorfer, an ethnobotanist who lives in Labrador and works among the Inuit, notes: 'The Arctic is a peopled place and ... the plants of the North ... carry the legacy of human activity over generations' (Semeniuk 2017; see also Oberndorfer *et al.* 2017). Oberndorfer has spent years recording Inuit knowledge transmitted orally from generation to generation about changes over time in Arctic ecology that have been brought about by human behaviour.

Haraway's concern is with establishing an 'inflection point of consequence' (2015: 159) such as the widespread physical destruction created by human activities set out above. She cites Anna Tsing's (2015) argument that massive changes were wrought on earth in colonial days, but, even so, abundant places of refuge remained, which is now no longer the case. The Anthropocene marks 'severe discontinuities', Haraway insists, and our task is to make this epoch as 'short and thin' as possible by working hard to 'replenish refuge' (2015: 160). Re-wilding projects are an important step in the right direction; as are the efforts of organizations such as the law charity Ecojustice. But Haraway also charges us to 'make kin' and not settle simply for traditional ancestry or genealogy – kin should be stretched and recomposed as 'assemblages' of multiple kinds. Trump's America, a 'rogue state' (Stiglitz 2017), does not encourage this, but elsewhere

changes are being made on this front (in Canada, for example, among the principal sponsors of Syrian refugee families are synagogue- and church-based groups).

Haraway further insists that we should 'make kin, not babies!' (2015: 162). But anthropologists know all too well that in situations where most offspring die young owing to unremitting poverty, racism, and violence, numerous pregnancies are desired, in the hope that some infants may survive to adulthood (Briggs & Mantini-Briggs 2016). We cannot set aside the significance of politico/economic variables, of impoverished environments, or unremitting racism and discrimination when considering the Anthropocene, the very designation of which highlights destruction caused by humans, but which glosses over massive differences in effects among humankind.

Bruno Latour, in his 2014 distinguished lecture at the American Anthropological Association, sets out his 'personal view' of what the Anthropocene means for anthropological research. He insists that because human agency is clearly significant, anthropologists are well positioned to contribute to a conversation that must now consider the moral dimensions of a newfound relationship between what he terms 'physical' and 'cultural' anthropology, and the various ways humans have of inhabiting the earth. Latour argues that humans are not merely the 'bag of proteins, computerized neurons, and selfish calculations' that we have heard about repeatedly over the past decade and more. On the contrary, the 'anthropos' pushed to centre-stage by geologists is endowed with a moral and political history. Humankind as posited by geologists of today has 'exited' natural history, he notes, and the idea of 'one human' has been exploded (as social and cultural anthropologists have always already known). Human agency is as important as ever, Latour insists, but is now 'redistributed' and in theory, at least, no longer individualized.

Latour (2014) further posits that, in contemporary society, the notion of territory is back, but this time round as an unbounded network of attachments and connections. There can be no 'otherness'. In sum, Latour insists (as does Haraway) that we are not post-human; rather we should concentrate on connections among humans when investigating the Anthropocene. Of course, this is not to dismiss inquiry into the relationships among multi-species and human/nonhuman ecologies. Latour concludes that in this environment there is no time for 'leisurely in-depth ethnographic research' – politically relevant action is needed right away. Anthropologists will surely take issue with this statement; our position being that one cannot discern what would be relevant political action without having first carried out ethnographic investigation.

Turning briefly to recent publications on the subject of the Anthropocene in popular intellectual magazines, Benjamin Kunkel, an American novelist, titled his review published in the *London Review of Books* 'The Capitalocene' (2017). Jason Moore (2015), the author of one of the books under review, argues that the locution 'Capitalocene' is more apropos than that of 'Anthropocene' because it makes clear how unequally distributed among humans are the effects of planetary decimation. Kunkel (2017), broadly in agreement with Moore, argues that the ecological predicament with which we are landed must be confronted politically. He reminds readers that the majority of people who inhabit the world are poor by North American and European standards, and already fare badly owing to the abuse of planetary resources by the well-off. Such people should not be made the first in line to apply ecological constraint, Kunkel insists. He bolsters his argument by citing Purdy, who insists that Anthropocene democracy will emerge as a 'self-aware, collective engagement with the question of what kinds of landscapes, what kind of atmosphere and climate and what kinds of world-shaping

habitation to pursue' (2015: 50). Writing in a similar vein, the political activist George Monbiot titled his recently published book *How did we get into this mess?* He insists: 'We are being parasitized from above and not below' (2017: 284). Monbiot is writing about the United Kingdom, but his argument has worldwide relevance.

The accumulating reflections on the Anthropocene are thoughtful and challenging. Two dominant themes emerge: first, assemblages of politicized individuals must mobilize to work together to arrest earth's destruction.[4] And, second, Anthropocenic effects are unequally distributed among people and hence, by implication, have a differential impact on health and illness. This applies not only to the so-called 'developing world', but equally nearer to home. The 2016 film *I, Daniel Blake*, directed by Ken Loach, hammers this point home, as did the catastrophic fire in June 2017 that struck Grenfell Tower, situated in impoverished North Kensington but surrounded by some of the greatest wealth in London.

In what follows, I elaborate on how, for more than a decade, we have been living not only with the imploding effects of climate change but also with another fundamental transformation known as the 'post-genomic' era. The human genome is no longer recognized as the driving force of life, but rather as 'reactive' to environments external and internal to the body (Gilbert 2003). In other words, 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. These insights at the molecular level inform the burgeoning field of epigenetics. In summary, consideration of the planetary effects of global warming and the concomitant spread of gruesome pollution cannot be sundered from the findings of diminished human well-being exposed by research in environmental epigenetics. Human embodiment in the Anthropocene is mutually informed by stimuli that are at once global and local.

The reactive genome

DNA is among the most non-reactive, chemically inert molecules in the world, with no 'power to reproduce itself' (Lewontin 1992). Even so, following the announcement in 2001 that the human genome had been mapped (which was not yet strictly speaking true), one journalist reported that it 'was like [completing] God's own jigsaw puzzle' (J. Hall 2013), although others were more skeptical. Some insisted that the map resembled a list of parts for a Boeing 747, but to a person with no idea as to how the parts go together, and no knowledge of the principles of aeronautics (Abernethy 2000). 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 *C. elegans* has about the same number as ourselves. 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 per cent of DNA segments actually code for proteins, and the remaining 98.8 per cent were initially labelled disparagingly as 'junk' (Carey 2015).

Although non-coding sections of the genome appeared to have no obvious function, and are frequently remnants of bacterial and viral genomes, they separate out the coding parts of the genome, thus inhibiting unwanted mutational changes during DNA transmission between generations. Moreover, numerous non-coding DNA sequences

are highly conserved, which is to say that they may well have been present in genomes for hundreds of millions of years, suggesting, as research is currently confirming, that they are crucial both to the processes of life and to evolutionary change (Mattick 2004).

Furthermore, it is well established that the activities of non-coding 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), and the occurrence of cancer and other complex ailments. These insights relate to the structure and function of the genome itself, but over the past decade the findings of molecular epigeneticists have added to this already complex picture (Mattick 2004).

Epigenetics literally means 'over or above genetics', but its precise meaning changes in context and as new discoveries come to light. A few years ago, scientists in the expanding sub-field of behavioural epigenetics claimed that they had tracked the molecular links *between* nature and nurture and had 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 throughout mind and body (which must be isolated and made separable for experimental purposes). These stimuli influence how DNA functions during the course of embryonic development and on throughout life, with profound effects on human behaviour and well-being, including mental illness and suicide rates (Labonté *et al.* 2012).

The epigenetic mechanism best researched to date is methylation, a process initiated by enzymes in which DNA sequences themselves are not changed, but simply one nucleotide (cytosine) is transformed, altering the nucleotide base, thus rendering a portion of DNA inactive (Meaney 2010). Animal research has shown definitively that methylation modifications can be transmitted inter-generationally, and some findings strongly suggest that this is also the case among humans (Pembrey, Saffery & Bygren 2014). Epigenetic regulation of chromatin structure is of crucial importance in these processes (Lappé & Landecker 2015).

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 described in the mid-twentieth century as the epigenetic landscape – a complex panorama of networks and feed-forward loops that determine whether or not stem cells go into a lineage (Waddington 1940). The majority of scientists also agree not only that these changes take place inside the body, but also that external environments interact directly with individual genomes, bringing about epigenetic changes. Such changes are often reversible, while others apparently are not.

As the philosopher of science Evelyn Fox Keller puts it, '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' (2014: 2425). We live now with a 'reactive genome' (Gilbert 2003). Furthermore, if genes are conceptualized as in effect 'real' entities, then they must be understood as composite rather than as unitary objects, and 'objects only in the way that the solar system is an object, or a forest is, or a cell culture', as sociologist of science Barry Barnes and philosopher of science John

Dupré suggest (2008: 53). A dynamic epigenetic network with a 'life of its own' – a context-dependent reactive system of which DNA is just one part is now exposed. Thus, contingency displaces determinism.

In summary, over the past decade, a profound shake-up of knowledge about genes and how they function has taken place. The consolidation of the field of molecular epigenetics has brought about a demotion of the gene, and challenges the unexamined assumption held by many geneticists, researchers in human development, certain social scientists, and members of the public that genes determine who we are (Lock 2015; Meloni 2015). However, numerous geneticists continue to set to one side these scientific findings in their research programmes.

Two decades ago, the neurobiologist Steven Rose (1997) argued that we must be concerned above all with the dynamics of life, that is, with process, including the continuous interchange between organisms and their environments. He argued that our 'lifelines', constituted by life processes, generate our sense of self. Rose insists that we are defined by our histories at least as much as by our molecular constituents, and individual histories comprise lived experience in environments natural and social.

The preceding discussion strongly suggests that in order to better comprehend the effects on human well-being of human-made environments created in the Anthropocene, in addition to the research findings of epigeneticists and other scientists, it behoves us to pay attention to historical, sociopolitical, and environmental variables. Furthermore, Marilyn Strathern (1995) has alerted us to shifts in scale made by researchers that demand attention. Reconciling the claims made about global Anthropocenic effects and those about molecular changes in individual bodies as a result of environmental stressors is clearly challenging. No doubt, like it or not, we must settle for 'partial connections' (Strathern 2004) and for less than certitude. Nevertheless, anthropological analyses should make every effort to 'get under the skin', as the Berlin-based anthropologist Joerg Niewöhner (2011) has put it, and go further than the all-important documentation of emerging networks of affiliated humans across boundaries. The degree to which human activity and associated epigenetic effects internal to the body are affecting the expression of genes is increasing, contributing to a concomitant increase in inequality.

Black-boxing the body

Over much of the past century, a dominant ideology has prevailed that our genes determine who we are. Of course, the majority of anthropologists agree that poverty, discrimination, racism, and stereotyping contribute greatly to both economic and health inequalities. At the same time we are, not surprisingly, very wary about the possibility that recognition of inherent biological difference among people may exacerbate such matters. Clearly, such arguments bolstered eugenics in the past, and support racist assertions today, so evident in the 2016 American election campaign, recent Brexit negotiations, and in other parts of Europe in connection with immigrants and refugees.

Hence, following Kant, the interiority of the material body has been normatively 'black-boxed' by anthropologists on the assumption that this is the domain of biologists and physical anthropologists and beyond the purview of social scientists (Lock 2015). Research into the social and cultural construction of discourse about embodiment, both medical and popular, and about subjectivity, self, and identity, is without doubt valuable and enlightening. But, as the philosopher Russell Keat put it three decades ago,

a good deal of time has 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' (2013 [1986]: 276).

A major outcome of disembodying anthropological informants has been that the 'body proper' – the body that has enabled singular advances in the biosciences – has not been exposed sufficiently to thoughtful critique (Lock & Farquhar 2007). Nor have fundamental matters of 'onto/epistemology' (Barad 2007) in connection with the production of biomedical knowledge been routinely addressed. Critically assessing the truth-claims of biomedicine does not entail dismissing outright the standardized 'universal' body (an entity indispensable to good biomedical practice); rather, it systematically exposes the unexamined assumptions embedded in biomedical knowledge and practice, including those of gender and ethnicity, made clear in the work of numerous anthropologists.[5] Similarly, the sociologist Steven Epstein (e.g. 2007) has long been concerned with biological variation and the political implications of ignoring such difference. Paying attention to biological variation is also at the forefront in several medical disciplines today, notably population genetics, the transplant world, and so-called 'personalized' or 'precision' medicine.

In addition to clinical medicine, there are, of course, other important ways of scientifically representing bodies, including epidemiology, life-cycle analyses, and forensics. But for anthropologists the most important task is to situate bodies in time and space, thus bringing to the fore the coalescence of history, social/political variables, medical knowledge of all kinds, and the material body. On the basis of findings using this approach, I reached the conclusion in the early 1990s that part of our task is to account for local biologies, that is, for biological difference among humans that is habitually glossed over in virtually all discussion about the Anthropocene (Lock 2001; Niewöhner & Lock 2018).

Epigenetic research reveals how environment(s) impact differentially on bodies, frequently bringing about changes, temporary or permanent, in individual biology. But epigeneticists, almost without exception, choose to delimit 'environment' to factors proximate to the body, including maternal care and poor nutrition. The undoubted effects of more distal environmental factors are acknowledged, but a reductionistic approach is nevertheless taken in order to strive for scientific accuracy. In practice, environment is deliberately 'miniaturized' expressly to achieve standardization in research projects. Social theorist Maurizio Meloni and molecular biologist Guiseppe Testa point out the dangers associated with this move:

> Epigenetics' materialization of novel links between the genetic and the social, its making the body porous and permeable to the world *is exactly the channel* by which the capture of the body in molecular terms is possible. The openness of the genome to the social is thus always on the verge of collapsing the social onto a mere source of differential genetic expressions (Meloni & Testa 2014: 449, original emphasis).

Clearly, attention to the effects of shifts in scale is demanded when assessing possible bias in research findings associated with epigenetics.

Reductionism in environmental epigenetics

The concept of environment, having been rendered essentially of no importance in hard-line deterministic genetics, has been resuscitated, taking on singular importance in the sub-field of 'environmental epigenetics' – a term used primarily to gloss investigations

into the lasting effects on individuals and their families of toxic exposures, malnutrition, abuse, social isolation, and other troubling events.

Disagreements among practitioners in this sub-discipline are evident, and the presumption that one or more teams of researchers represent the entire field would be a mistake, but, even so, findings in environmental epigenetics are of singular interest to anthropologists. Debates about the locus of responsibility for malaise and disease, policy-making relating to human well-being, and discussion about social justice in connection with healthcare are increasingly taking epigenetic findings into consideration, a move that will have wide-ranging social and political consequences.

The field known as the 'developmental origins of health and disease' (DOHaD) focuses on the idea of a 'foetal environment'. Research projects have shown repeatedly that lasting effects on infant development, often culminating in psychopathology later in life, are initiated by what is described as 'maternal stress, anxiety, and depression'. A review of nearly 200 articles based on research with animals, supplemented by a small amount of human research, concluded: '[T]here is emerging evidence that the placenta is highly susceptible to maternal distress and is a target of epigenetic dysregulation' (Monk, Spicer & Champagne 2012: 1361), added to which another body of research strongly suggests that postnatal maternal care can induce further disruptions (Jawahar, Murgatroyd, Harrison & Baune 2015).

Such findings are based on correlations, although researchers are beginning to map segments of pathways whereby epigenetic marks are linked directly with behavioural outcomes pre- and postnatally. In other words, the environment in this type of research is effectively scaled down to molecular activity inside a single organ of the body – the uterus and its foetal contents. Maternal bodies have become 'epigenetic vectors', in the words of the historian of science Sarah Richardson (2015), and a mother-to-be who is anxious and/or depressed is the source of this so-called 'dysregulation'.

As epigenetic changes *in utero* become increasingly implicated in neurodevelopment (including brain structure) and a range of medical conditions from autism to diabetes, the womb and its environments will be monitored ever more closely. Perceived threats to the unborn are extremely potent signifiers: a warning sent out to its members by the American Academy of Pediatrics in 2011 cautioned that the harm caused to children by 'toxic stress' can result in damaged 'biological memories', added to which is the well-substantiated evidence that poor diet, smoking, and excess alcohol consumption in pregnant mothers negatively affects the foetus. Medical and social support for childbearing women is to be lauded, but, as the anthropologist Ilina Singh (2012) has written, the ever-increasing poverty and often-violent living conditions of many women is liable to be ignored, and attention lights almost exclusively on the pregnant belly and its contents.

The contribution of the environment writ large to human development, health, and illness is rarely denied by epigeneticists, as noted above, but a danger exists that miniaturization, although it exposes what has taken place at the molecular level with respect to epigenetic marks, supposedly owing to the behaviour of pregnant women, blots out most of the story. Focusing exclusively on proximate variables, scientifically valuable though they are, has grave limitations, as the examples that follow illustrate.

Eliminating stunting

The President of the World Bank, Jim Yong Kim, a physician/anthropologist, announced that he will 'name and shame' countries that fail to tackle the malnourishment and

poor growth of their children. Kim is clear that 'stunting', that is, children with height considerably below the average for their age, is not only a humanitarian disaster but also an economic one. His position is that foetal malnutrition during pregnancy and early childhood leads to serious neurological deficits, particularly in toxic environments, where recurrent infections are common, and when infants are given little or no stimulation. Kim stresses that stunted women frequently give birth to children who become stunted, with the result that '[i]nequality is baked into the brains of 25% of all children before the age of 5'. Crude estimates suggest that stunted children in India approach 40 per cent, in the Democratic Republic of the Congo 43 per cent, and in Pakistan 45 per cent, hence, Kim insists, 'the most important infrastructure we can invest in is grey matter' (Boseley 2016). He seeks to rid the world of stunted children by 2030 by donating conditional cash transfers to mothers of stunted children, thus enabling them to feed and stimulate their children through play. It is reported that a trial run in Peru worked well (Boseley 2016). Kim plans to bring up 'this stain in our collective conscience' repeatedly at World Economic Forums in the coming years, and indeed did so in the 2017 Forum.

There is no question that a project focused on mothers and their offspring is an important intervention, but key socioeconomic variables have been set to one side, including, in the case of Peru, unequal distribution of land resources, effects of climate change, increasingly toxic environments, and the violence and counterinsurgency so evident in that country, ably documented by anthropologist Kimberley Theidon (2013).

Apparent deficits in maternal behaviour are often assumed by researchers to be 'in-bred', although this is rarely stated outright. Well-substantiated work by epidemiologists in the United States counters such assumptions. Robust findings show that the disproportionate number of low-birthweight infants born to African Americans is closely correlated with the subjective experience of racism while pregnant, and associated epigenetic changes during pregnancy have been documented (Krieger & Davey-Smith 2004). These infants are twice as likely as are white infants to die in their first year of life, and have a greater burden of disease and abnormalities throughout life. The so-called 'Glasgow Effect' highlights dramatic class differences in disease incidence and life expectancy within that city, in which epigenetic changes are also implicated (Ash 2014).

Among policy-makers, molecular findings, biomarkers, and neuroimaging tend to carry more weight than do correlations, and emerging epigenetic findings are likely to garner considerable attention. The challenges for social scientists and epidemiologists today are, first, to expose the limitations of the miniaturized findings of epigeneticists and, second, to counter the tendency of researchers and policy-makers to create apparently easy targets for behavioural changes, all the while ignoring the broader sociopolitical origins of by far the majority of health and illness differentials.

Mismatch theory

On a much broader scale than that of the family and its immediate environment, the next illustration highlights increasingly pernicious Anthropocenic changes involving epigenetic effects. Globally, nearly 2 million children die from malnutrition each year, a number that is rising. Research has revealed remarkable findings about biological differences between infants who suffer from marasmus (severe malnourishment) as opposed to those who have kwashiorkor (severe protein-energy malnutrition with oedema). An investigation has been carried out in Jamaica that commenced in 1962

and continued for thirty years. During this time, over 1,100 infants with severe, acute malnutrition were admitted to University Hospital, Kingston. It was hypothesized that when the maternal diet is low in nutrition, foetal metabolism *in utero* in effect anticipates a postnatal environment of scarcity, and low birthweights are evidence of this. However, the research in Jamaica showed that those infants diagnosed with kwashiorkor had considerably higher birthweights than did infants diagnosed with marasmus, but they die more frequently at a younger age. In contrast, those with marasmus endure greater wasting of flesh, but many survive to adulthood (Forrester *et al.* 2012).

Researchers characterize marasmus as 'metabolically thrifty' and kwashiorkor as 'metabolically profligate', and conclude that mechanisms associated with physiological 'plasticity' are operative. Their findings, they argue, are direct evidence of so-called 'anticipatory responses' *in utero*, and the distinctly different phenotypes of children with kwashiorkor and marasmus are interpreted as endpoints of environmentally driven epigenetic activity on different genotypes.

This striking example of nutritional epigenetics is just one in a field attracting a great deal of attention because it is hoped that it will throw light on the so-called 'obesity epidemic' currently affecting many countries, whether affluent or not. The global cost of obesity is reckoned to be approaching $1.2 trillion per year (Boseley 2016). 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 & Hanson 2008: 62). In other words, the bodies of foetuses and young infants exposed to nutritionally deprived diets may be epigenetically prepared to deal with deprivation, but this can cause havoc in energy-rich environments, resulting in obesity, especially if they are over-fed.

Given the inordinate rate of human displacement across the globe, it is likely that mismatches will 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.

The following examples focus on just two of the ubiquitous epigenetic effects on local populations created by human-made toxic environments.

Inter-generational transmission of toxins

Based on many years of fieldwork that commenced in 2003 in Hanoi, Vietnam, the Danish anthropologist Tine Gammeltoft (2014) documented the devastating effects on reproduction that persist more than forty years after the war caused by the chemical defoliant Agent Orange. The Vietnam War lasted from 1962 until 1971, during which time the US military conducted an aerial defoliation programme that was part of a 'forced urbanization' strategy designed to force peasants to leave the countryside, where they helped sustain the guerrillas, and move to the cities, which were dominated by US forces. Nearly 20 million gallons of chemical herbicides and defoliants was sprayed onto 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 living in Vietnam today to be increasing in the population over time. It is estimated that

at least 3 million citizens in Vietnam suffer from serious health problems owing to exposure to defoliants, and the rate of severe congenital abnormalities in herbicide-exposed people is reckoned to be 2.95 per cent higher than for unexposed individuals (Gammeltoft 2014: 46). Animal research has shown that, following foetal exposure, dioxin reprogrammes epigenetic developmental processes, the effects of which may become manifest throughout life. Cases of third-generation Agent Orange victims have been reported in which individuals exposed during the war have produced apparently healthy children, but whose grandchildren are born severely disabled.

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: 10-12). Making the decision to have an abortion if a deformity is detected by ultrasound is not easy. Many affected families think of abortion as 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 it 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. A few women discover very late in a pregnancy that their foetus is not normal, and some opt for a late termination, to the great discomfort of their doctors (Gammeltoft 2014: 111-13).

Gammeltoft's moving interviews with affected families make clear that many individuals choose not to entertain the idea that an anomalous foetus detected by ultrasound, or the birth of a horribly deformed child, is due to Agent Orange (2014: 77). They are all too well aware that the stigma attached to Agent Orange families ensures that finding marriage partners for healthy members of the family would be virtually impossible. Better 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: 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, following extensive lobbying over many years, in 2014 the US Congress passed a five-year aid package of $21 million that amounted to a modest sum for each Vietnam War veteran. These cases were settled out of court and no legal liability has ever been admitted (Gammeltoft 2014: 46-7). The official position to this day is that the government was in effect prodded into settling these legal suits and that no evidence exists that Agent Orange caused harm, a position supported by its principal makers, Monsanto and Dow Chemical companies. Children born to Vietnam War veterans with severe birth defects, including hydrocephalus and spina bifida, have received no compensation (Gammeltoft 2014: 49).

In Vietnam, officials were reluctant to press complaints about Agent Orange because uppermost were concerns 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, and eventually Vietnamese citizens filed a class action suit in the US District Court in New York. Although this was abruptly dismissed, demands for responsibility are increasingly being heard, spearheaded by nongovernmental organizations (Gammeltoft 2014: 44-6).

Toxic water supplies

A second 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 forty years ago when a paper mill was forcibly shut down after dumping about 9,000 kilograms of mercury into the downstream river. Today mercury levels in the fish near Grassy Narrows are fifteen times the safe consumption limit, and forty times the limit for children, pregnant women, and women of child-bearing age. The Grassy Narrows people have fought for fifty years for a clean-up of the river. The Ontario Minister of Environment, after wavering, reiterated in May 2016 that a clean-up is not necessary, despite a report by experts stating that the river remains badly contaminated (Mosa & Duffin 2017). Two generations of people from Grassy Narrows and Wabaseemoong First Nations today exhibit the symptoms of mercury poisoning, including loss of muscle co-ordination, numbness in the hands and feet, hearing loss, speech damage, and tunnel vision. Foetuses are particularly vulnerable to cognitive damage. Extreme cases result in paralysis, insanity, coma, and death.

Mercury poisoning has been officially recognized in Japan since the 1950s. What first came to attention were local cats that appeared to go crazy, some of which 'committed suicide' by 'falling' into the sea. Thereafter, humans started to report numbness in their extremities, accompanied by tremors, difficulty walking, and, in some cases, signs of mental illness. By 1959, it was definitively established that mercury poisoning was implicated. A large petrochemical plant, Chisso Corporation, 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 was 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. Japanese experts in mercury poisoning were summoned to Grassy Narrows and reported that up to 90 per cent of the people there show signs of mercury poisoning that is being inter-generationally transmitted (Mosa & Duffin 2017).

The legacy of colonialism

It is evident that to come to grips with changes brought about by human activity on earth, we must take history into account, long before the newly declared era. This final illustration is a greatly truncated narrative about the experience of First Nations in Canada.

Canada is home to roughly 1.2 million individuals who endorsed the category 'Aboriginal' in a recent Canadian census. Well over half live in communities that continue to contend with the devastating legacy of settler colonialism, including entrenched poverty, toxic and septic environments, and invidious discrimination, manifested as so-called 'mental health' problems, including 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).

Mental health professionals and individuals living in First Nations communities explicitly associate these remarkably high rates of pathology with toxic exposures. In addition to tons of plastic, residues of dioxin and polychlorinated biphenyls (PCBs) drift towards the Arctic and accumulate 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. A politically active Inuit grandmother declared: 'When women have to think twice about breast feeding their babies, surely that must be a wake-up call to the world' (Johansen 2002).

But First Nation leaders are also acutely aware that colonization of their lands that commenced five centuries ago has had an enduring effect. Independently, mental health professionals and individuals living in First Nations communities have consistently associated these high rates of pathology with colonization. The concept 'historical trauma' has been adopted to call attention to the collective, cumulative, and intergenerational psychosocial effects resultant from past colonial subjugation that persist in abated form to the present day (Niezen 2013). Among the early travesties was the introduction of infectious disease. Tuberculosis has been documented as present throughout the Americas before the arrival of the colonists, and numerous other infectious diseases were also present, but populations were isolated, and hence epidemics could not take hold. With colonization, population density increased considerably along the major trails created for the transportation of goods for exportation, facilitating the rapid spread of disease. Measles, to which indigenous peoples had never been exposed, was inadvertently transmitted and proved deadly, but the claim has long been made that smallpox was deliberately spread by means of contaminated blankets distributed explicitly to assist with 'the extirpation of this execrable race' (Churchill 2009: 14). This history is contested (Houston and Houston 2000) but the cumulative evidence is impressive.

Amherst College in Massachusetts recently disposed of its century-long icon, Lord Jeffery Amherst, together with its 'rouse song' that calls on his name. Among other highly questionable activities, Amherst was known as a perpetrator of 'germ warfare and implicit suicide against the Woodland Indian tribes of the eastern Great Lakes' (Fernandez & Herzog 2014: 8). He is on record as stating that Indians 'are more nearly allied to the Brute than to Human Creation', and he expressed the hope that they be 'extirpated root and branch' (Long 1933: 186). To this end, he had blankets infected with the smallpox virus handed out to indigenous populations (Churchill 2009: 15).

The mortality rate from infectious disease between 1700 and 1900 was extraordinarily high. Smallpox, measles, dysentery, tuberculosis, influenza, and other communicable diseases wiped out many thousands of people. The Haida nation, among whom Franz Boas worked, went from an estimated population of 20,000 prior to 1770 to less than 600 by the end of the nineteenth century. The effects of population decimation are rarely fully appreciated: given the climate and an economy based on hunting, the ability of those who survived to procure sufficient food was effectively destroyed, and hence individuals 'with the dubious good fortune of living through the initial sickness die of hunger' (Daschuk 2013: 12).

Population 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'. School administrators, members of the Royal Canadian Mounted Police, and agents attached to the despised Bureau of Indian Affairs rounded up young children 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. As part of the Truth and Reconciliation Commission of Canada that met from 2008 until 2015, it came to light that repeated sexual abuse took place in these schools, one of which was characterized by an investigating Supreme Court Justice as practising 'institutionalized paedophilia' (Carr 2013: 19). Systematic nutritional medical experimentation was also carried out on some of the students, resulting in malnutrition in many, and death for many more. Tuberculosis was rampant, and few attempts were made to curb it (Stevenson 2014). In one notorious school, the death rate of children was apparently 75 per cent during the first sixteen years of its 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 freely admit to being unable to parent their own children adequately.

Despite major changes for the better in recent years, racism and discrimination against First Nations continue to be blatantly evident. Shocking poverty persists on many reservations where 40 per cent of First Nations live, a good number of which have no running water and where serious toxic contamination is evident. Schools on reservations are poorly provided for compared with those elsewhere in Canada, and the education gap has increased in recent years between First Nations children and other Canadians (Friesen 2013). Increasing concern about this situation is being voiced and it is claimed that 'Ottawa continues to fail Indigenous children' (Picard 2017).

Alcohol and drug abuse is endemic in indigenous communities and violence against First Nations women and children is extraordinarily high. Indigenous people make up 4.3 per cent of the Canadian population but comprise 25 per cent of homicide victims and 26.4 per cent of federal prison inmates. Among female prisoners, 37.6 per cent are indigenous, and those with mental health problems are routinely incarcerated in prisons without facilities to care for them (Stone 2017).

Two points must be noted. First, not all reservations exhibit high rates of illness and suicide, and the majority of First Nations people live today in metropolitan areas where some fare well, but many do not. Some survivors of residential schools report that they enjoyed school, among them individuals who became devout Christians – a conversion that apparently assisted in their survival. Clearly, accounting for differences among individuals is of the utmost importance when attempting to explain persistent malaise. Second, ongoing land claim settlements have improved the lot of a few First Nation communities, but settlements have not been made with the majority, among them, notably, those where oil reserves have been found. And, third, the establishment of healing programmes and suicide prevention gatherings conducted by First Nations themselves that make use of both indigenous healing practices and biomedicine exist in certain communities with government support. These programmes are regarded as a positive form of empowerment by many First Nations leaders, but are not as yet broadly entrenched (Niezen 2013).

In 2008, Stephen Harper, the then Prime Minister, delivered a formal apology to all First Nations throughout Canada. However, since that time, the budgets of twelve government-funded programmes have been cut, and nine of these programmes have now closed (Bennett 2015). Suicide rates, substance abuse, and the disappearance and

death of young First Nations women continue to be extraordinarily high (Galloway 2017; Leblanc 2014).

Recent reports make clear that First Nations women undergo extraordinary abuse at the hands of provincial police, notably in the province of Saskatchewan, a situation documented by Human Rights Watch (*Globe* Editorial 2017). Sexual abuse and victimization of young indigenous people continues at a shockingly high rate, much of it carried out by foster parents and/or fostered children preying on younger children Two in every three victims of sexual abuse in Canada are indigenous girls (Picard 2017). These children have usually been removed from their homes owing to what is described by social workers as neglect, while the impoverished environments in which their families live remain unaddressed. There are more indigenous children in state care today than there were in residential schools at their peak (Picard 2017). Despite claims by Canada's current 'sunny' liberal government that it is addressing First Nations problems, the list of missing and murdered children grows ever longer as investigations intensify. This sad state of affairs is not confined to the young. Recently, the highly acclaimed indigenous artist Annie Pootoogook, exhibited internationally, was found drowned in an Ottawa river. The cause of death has not been definitively established, but it sent shock waves across Canada.

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 inter-generational transmission of DNA modifications has contributed to this situation. But it is likely that at the very least such modifications are re-created anew in each generation, given the extent of the involved trauma and toxicity. Understandably, there has been reluctance on the part of many First Nations individuals to donate tissue for analysis, although this is changing.

From local to situated biologies

Epigenetic marks have histories that demand investigation, and epigeneticists routinely combine evolutionary time, transgenerational time, biographic time, and the 'real' time of cellular activity to construct their arguments (Niewöhner 2011). These findings highlight possible origins of material bodily changes, but they do not constitute local biologies. My argument has always been that subjective accounts about embodiment involving past and present events must be taken into account to effectively situate biological difference historically, ecologically, and politically in specific times and places. Only then can the extent of the changes in mind and body resulting from violence, poverty, discrimination, and racism be fully appreciated. In the era of the Anthropocene, biological changes in individual bodies are becoming increasingly frequent, mobile, unpredictable, and rapid, in large part owing to dramatic environmental transformations forced on people across large swathes 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. Adopting a second concept of 'situated biologies' in part addresses concerns raised by certain colleagues about local biologies, namely that use of the word 'local' might inadvertently reinforce a false belief about inherent biological difference among humankind. The above examples make clear that this is not so because environmental variables – dietary, toxic exposures, climate change, and so on – have clearly been causal in bringing about biological difference.

The concept of local biologies highlights how and when such transformations come about, but it is useful to recognize the overarching concept of situated biologies, which reinforces an awareness of the ubiquity, mobility, and mutability of local biologies.

Elizabeth Roberts has introduced 'bio-ethnography' as key to understanding the integration of 'biological and ethnographic data about the larger histories and life circumstances that shape health' (2015: 4). Her objective is to make clear how difficult it is to collect all-important ethnographic data effectively because one is dealing with 'complex, conditioning entanglements' that are extraordinarily dense. Such entanglements interact in turn with situated biologies that when analysed constitute a 'bio-ethnographic' approach (Roberts 2015: 4).

The microbiome

Brief mention must be made of burgeoning knowledge about the microbiome – the entity that affects human health and illness to a greater extent than any other aspect of the material world. The microbiome is the genetic component of all the micro-organisms that typically inhabit a particular environment. In the instance of the human body, the skin and the gastrointestinal tract are of singular importance. The science writer Ed Yong (2016) argues that we live in the Microbiocene, which started at the dawn of life itself, and will continue to its extinction. This emerging microbial knowledge provides a lens that exposes the inexhaustible extent of the mutability and permeability of human bodies. The genomes of bacteria, viruses, and plasmids are also present in the body, and vastly outnumber the genetic contribution made by the human genome. The relationship of humans and their genomes is not one-to-one, and the genome of any given organism, including humans, is not equivalent to the organism itself. Tightly bounded, autonomous humans simply do not exist, and microbial activity orchestrates the entanglement between the natural and social worlds. To think of micro-organisms as germs to be eradicated is to completely underestimate their worth.

The majority of these microbial residents live in the intestine, but they are also present in the mouth, scalp, on the skin, in all the crevices and orifices of the body, and envelop us externally in clouds. These commensal bacteria, which add approximately 3 million genes to our bodies, work on our behalf, while ultimately working for their own benefit. The resultant 'metagenome', composed of well over 98 per cent microbial genes and less than 2 per cent human genes, is exquisitely sensitive, and responds to new stimuli rapidly within two or three days (Barnes & Dupré 2008).

Given that the microbial ecosystem plays an indispensable role in the functioning of the human immune system, and hence serves to distinguish self from non-self and, further, produces beneficial compounds that we cannot make for ourselves, we are not merely host to our microbiomes; rather, these commensals are integral to 'us'. The human microbiome – me, self, and us – weighing in at about a kilogram, is perhaps best thought of as an organ, albeit a rather odd one (Barnes & Dupré 2008: 136). Our permeable skin-bound selves comprise a collection of miniaturized communities – ecosystems that are products of our evolutionary past, more recent historical events, and social and political contingencies of many kinds. The microbial mix at work today in North America and Europe in connection with nutrition copes primarily with the digestion of sugars, fats, and proteins. In contrast, people living in countries such as Malawi and Bangladesh, and the Yanomami in Venezuela, Hadza in Tanzania, and Matsés in Peru, have microbes in their digestive tracts that 'fit' with their local diets and environments (Yong 2016: 13). It is possible that our early ancestors harboured an even

greater variety of micro-organisms. In addition to effects on the immune system, the microbiome has powerful effects on the neurological system (Smith 2015). The complex ecosystem of the human microbiome is tuned to continuously adapt to the vagaries of human life, but may be in a losing battle, given the environmental havoc we are currently wreaking, with horrifying consequences: a World Health Organization fact sheet (2017) states that worldwide obesity has nearly tripled since 1975 and documents that in 2016 1.9 billion people aged 18 years and over were overweight. Among these individuals, 650 million are obese. The number of people around the globe with diabetes has quadrupled since 1980 and its prevalence continues to increase in all regions (World Health Organization 2016). Martin Blaser (2014) has amassed data to show that current overuse of antibiotics in part fuels these 'modern plagues'.

Conclusions

As noted above, Marshall Sahlins argued that conceptualizing an opposition between nature and culture is distinctive of our own folklore (2008: 2). Molecular findings, both epigenetic and microbial, challenge complacency about this folklore. On a broader scale, the examples given above make clear that environmental stimuli, created in large part by socioeconomic, political, and cultural variables, work on the next generation prior to conception and throughout life. These stimuli do not *determine* biology, but deeply inform it, as the 'reactive genome' makes evident.

The contribution of anthropologists in moving us beyond misguided folklore is already considerable, among which are the findings documented above. The significance of this singular contribution lies, of course, in use of the ethnographic method, in which informants have been asked to focus on the perceived effects of environmental stimuli impinging upon them, as, for example, when they have been forced to physically relocate or flee from traumatic and/or toxic conditions. Resultant accounts of a heightened awareness of transformed embodiment make clear that individuals, families, and larger groups are keenly aware that the environments in which they live impact greatly on their health.[6]

Several books and articles have appeared lately arguing that Marx is back. They suggest that capitalism must be dismantled and that we should invest in new forms of social arrangements in order to diminish social inequalities (Menand 2016; Piketty 2014). This is a laudable Anthropocenic task, but equally urgent is the repair of environments in which we live, vast swathes of which are unproductive and/or outright toxic. We are indeed playing with fire, literally and disastrously. The new epoch is appropriately named – human activity brought it about and marked it indelibly into earth's stratigraphy, and humans must now remake the globe into a space equitably habitable for everyone.

The story is not all doom and gloom. A group that goes by the name of Earth Optimism was established in 2008 to shift the usual accounts about destruction of the earth to one in which biologists disseminate accounts of conservation success stories. Its goal is to foster understanding that seemingly insurmountable environmental problems can be fixed. This group reports that the rate of deforestation in the Brazilian Amazon has decreased in recent years; the coal industry appears to have peaked and is now in decline; and worldwide greenhouse gas emissions have diminished. Earth optimists believe that the tide is turning, but perhaps they do not pay sufficient attention to the fact that East and Southeast Asia, Africa, and parts of Central and South America are far from 'developed' to the same extent as are Europe and North America.

Humankind is extraordinarily resilient, and, as Roberto Barrios (2016) makes clear, the voices and behaviour of affected people, whatever the issue at hand, should be given priority in spearheading change. The actions and voices of Rohingya, Syrians, Chechnyans, and numerous other people facing unremitting extreme violence and discrimination reveal extraordinary resilience. So, too, did the internationally recognized Canadian indigenous artist Daphne Odjig, who received the Order of Canada and died in 2016 at 97. She is among thousands of indigenous people worldwide whose resilience is phenomenal. Amartya Sen has argued that above all else the importance of human lives, experiences, and realizations must come first, and only then can justice come about (2009: 18). Anthropologists have much to offer in making this possible; it is of urgency that we work both in the field and at home towards the curbing of global warming. Much of this work may be as part of interdisciplinary teams who in effect compromise assemblages of politicized individuals with the ultimate objective of influencing both national and global policy-making.

NOTES

[1] For an account of the significance of the Anthropocene for the United States, see Jedediah Purdy's *After nature* (2015). A professor of law, Purdy makes it explicit in his book that use of the term 'Anthropocene' 'is an attempt to do what the concept of "the environment" did in the 1960s and early 1970s; that is, join problems as disparate as extinctions, sprawl, litter, national-parks policy, and atomic fallout into a single challenge called environmental crisis. Such a term is pragmatic' (2015: 4).

[2] One hopeful sign is that bacteria in the ocean may be evolving the ability to break down plastic (Le Page 2017).

[3] See also Simon Dalby (2017), who emphasizes the impact of these changes on human security.

[4] A recent article in the *Guardian* about mobilization of indigenous people across Mexico illustrates this point well (Tucker 2017).

[5] Including Brotherton (2012), Garcia (2010), Hamdy (2012), Hyde (2007), Kaufman (2015), Lock (2013), Nading (2014), Nguyen (2010), Petryna (2002), Roberts (2012), Stevenson (2014), and Street (2014), among yet more others.

[6] See also accounts of 'structural violence' (e.g. Farmer 1992).

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Environnements mutables et corps humains perméables

Résumé

Les géologues ont défini une transition d'ère vers l'Anthropocène, reconnaissant ainsi formellement le rôle moteur des humains dans les changements destructeurs à l'échelle mondiale : il n'y a désormais plus de distinction entre histoire humaine et histoire naturelle. Certains commentateurs estiment cependant que le terme de « Capitalocène » décrit mieux la situation, puisque les effets de la décimation planétaire et du réchauffement climatique ne sont pas également répartis entre les humains. Un deuxième changement conceptuel s'est récemment produit, avec la reconnaissance du fait que le génome réagit à des stimuli environnementaux extérieurs aussi bien qu'intérieurs au corps humain. Dans l'ère postgénomique, les gènes ne sont pas à l'origine de la vie et ne sont pas non plus les moteurs du développement humain. L'auteure présente ici le domaine naissant de l'épigénétique comportementale, qu'elle illustre d'exemples de changements épigénétiques néfastes pour la santé causés par l'environnement. Les épigénéticiens limitent habituellement leur objet à la détection des changements décelables au niveau moléculaire. L'auteure avance que l'apport anthropologique de récits subjectifs d'incorporation, relatifs à des événements présents et

passés, est indispensable pour mieux situer et expliquer les différences biologiques et l'évolution des paramètres de santé du point de vue historique, écologique et politique. La discussion du microbiome rappelle que les micro-organismes sont, en dernier recours, la force qui fait la santé et la maladie. En conclusion, l'auteure présente rapidement le mouvement « Earth Optimist » et le concept de résilience, tout en précisant que ces mouvements positifs ne suffiront pas à enrayer l'implacable réchauffement climatique.

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