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Economic Development in the Anthropocene: Perspectives on Asia and Africa
The 2014 Pierre du Bois Conference, Gareth Austin, Convenor
The Graduate Institute of International & Development Studies
Geneva, 26-27 September 2014

Historians, Biologists and the Problem of Defining Who is Threatened by Climate Change

Under the threat of climate change, culture and nature seem to converge. Ethicist Clive Hamilton argues that "humans have become a 'natural' planetary force."[1] Historian Dipesh Chakrabarty insists that anthropogenic climate change "spells the collapse of the age-old humanist distinction between natural history and human history."[2] As the divide between the humanities and the sciences melts in the heat of global warming, humanists and scientists might be expected to envision the endangered human figure in similar terms. When asked who is threatened, all disciplines might now reasonably be expected to answer in chorus, producing an understanding of the embodied mind, a naturalized history, a cultured nature, and a figure of the human recognizable in all corners of the university. The unprecedented and enormous threat of anthropogenic climate change would seem to demand the dissolution of artificial barriers between forms of knowledge revealing deep complementarity. With the challenges of intense heat, wilder weather, acidic oceans, increasingly virulent diseases, chemical pollution, decreased biodiversity, failed crops, rising political tensions, revolutions and wars, greater inequality and injustice, massive migration, and strains on practices dedicated to knowledge and beauty, a conjoint understanding of the human-at-risk might seem inevitable and desirable. Indeed, attempts at such harmony have been made by both historians and biologists, two disciplines central to this essay. Historians such as Ian Morris and biologists such as E.O. Wilson have tried to reconcile disciplinary differences and create consilience across the divides.[3] But, as I will argue, we are nowhere near achieving a rapprochement and its benefits themselves are doubtful.

As this essay will demonstrate through a brief tour of paleobiology, microbiology, and biochemistry, humanists trying to come to grips with climate change and to think somatically cannot rely on our scientific colleagues to define "the endangered human" for us. Instead, biology's many branches have produced throngs of radically different figures of the "human," not all of them endangered by anthropogenic environmental change according to the criteria crucial to humanists. Instead of simplifying the picture and defining the endangered "we," engaging with biologists complicates the view of who is threatened. Although this essay celebrates the increasingly sophisticated conceptualization of human reality and endorses efforts by humanists and biologists to pool their resources in the face of global danger, I will argue in the end that it is impossible to treat "endangerment" as a pure scientific fact. Instead, endangerment is a question of value and a question of perspective. What we value, what we are in danger of losing under the pall of global climate change, is most fully articulable not through science but in the humanities.

I. Paleobiology: Masters of the Planet

From certain vantages in the age of the Anthropocene, the human figure appears gigantic, best understood not as an individual or even as a group but as the whole of the species over millennia. Paleoecologist Curt Stager describes our species' greenhouse gas emissions as transforming the planet not just for the next several centuries, but even deeper into the future. Stager argues that "we" as "species" have decisively prevented the next ice age, previously "scheduled" for 50,000 years from today. "Thanks to the longevity of our greenhouse gas pollution," Stager argues, "the next major freeze-up won't arrive until our lingering carbon vapors thin out enough, perhaps 130,000 years from now, and possibly much later."[4] The human species operates on a truly geological scale. Likewise, historian Dipesh Chakrabarty argues that *the* outstanding challenge to his discipline is to understand this new figure of the human: this immense, baleful, aggregate entity now undermining the earth's life-support systems through a whole array of activities from agriculture to industry, from transportation to communication.[5] Chakrabarty draws on the work of climate scientists, particularly Paul Crutzen and Eugene Stoermer who in 2000 declared "mankind" a "major geological force," to point to our collective "agency in determining the climate of the planet as a whole, a privilege reserved in the past only for very large-scale geophysical forces."[6] This version of the species pumped up for

action on a global scale is, as Chakrabarty urges us to see, what climatologists and paleobiologists are positing in contrast to humanistic understandings of the human figure.

Up to this point, Stager and Chakrabarty describe the planetary situation in homologous terms and name the human species as the culprit of climate change. Looking only this far, it is possible to think that we have arrived at a figure of the human – the species – shared by historians and biologists alike. But here the similarities end. For Stager, thinking in terms of the species is easy – he is, after all, a trained biologist – and his general argument is that most species, including ours, will survive pretty well, especially if we allow for migration. Looking back on the Eocene era 55 million years ago which produced temperatures 18-22°F higher than today's, Stager maintains that PETM or the Paleocene-Eocene thermal maximum was not so very terrible: "On a relatively bright note, we also know that many plants and animals, including our own primate ancestors, made it through PETM just fine."[7] This depends, of course, on how you define "fine." Looking forward into the deep future, Stager explores two climate change models, the "moderate" one projecting a rise in atmospheric carbon concentrations to 550-600 ppm (well above the 350 ppm that climatologist James Hansen and environmental activist Bill McKibben see as safe) with globally averaged temperature increases of 3 to 7°F (2 to 4°C) and the "extreme" one of 2000 ppm with temperature rises of "at least 9 to 16°F (5 to 9°C)."[8] Either way, Stager argues, the human species is here to stay, however uncomfortably, and he even hints that a new "ethics of carbon pollution" may credit us with having rescued our distant descendants from "ice age devastation" formerly projected for 50,000 years from now.[9] For Stager, then, the human species is not endangered and global warming may even have some benefits.

On the other hand, when Chakrabarty weighs the viability of the concept of "the species" for historians, he finds it wanting. This is not because it falsely attributes responsibility to humanity or because climate change is not a threat. Instead, the species is not, argues Chakrabarty, something humanist historians can *understand* through self-reflection in Dilthey's sense where historical consciousness is "a mode of self-knowledge" or in Collingwood's sense where historical comprehension rests fundamentally not on reconstructing the past but on reenacting "in our own minds the experience of the past."[10] While "species" may work for paleobiologists collating, say, the fossil records of Eemian biota from 130,000 years ago against modern organisms,

theirs is a labor of reconstruction as opposed to one of self-reflection or mental re-enactment. The scale both temporally and spatially on which these types of biologists work disallows the tools of intellectual and emotional imagination honed by historians attempting to penetrate evidence produced by particular minds in the rich context of particular cultures. For most historians, it is only on this smaller and more particular scale that judgments regarding ethical actions can be made. For one thing, sheer biological survival is not the ultimate value or highest ethical good of every individual or every culture. The concept of species remains for humanist historians such as Chakrabarty a galvanizing flash, important in illuminating the new landscape but unable to provide sustained light. What appears most endangered in this strobe light flash are our structures of knowledge, the figure of the individual capable of understanding his or her predicament.

Chakrabarty's brilliant double move, both toward the sciences and back again to theoretical reflection on history, can be performed with other biological sciences. Through this dialectic, Chakrabarty demonstrates the impact of scale in distinguishing between history as a description of past events (something we share with many biologists) and history as the formation of self-knowledge. Climatologists and paleobiologists put "species" on the historian's map in unprecedentedly difficult ways because of the macroscales involved, but other types of biology compound our difficulties by looking at the human on a microscale. Microbiology and biochemistry contort "the human" into yet other forms, blurring and even undermining the very notion of "species" and raising other perplexing questions about how humanists might think biologically.

As I will discuss in the next section, some microbiologists now describe "the human" as a coral reef of many "species," mostly microscopic, evolving at different rates and in different ways. From the microbiological perspective, the very solidarity of the human species is eroded. In the third section, I will turn to yet another science, biochemistry and its revelations about the industrial toxins that since World War II have flooded our environments and infiltrated our bodies, including our brains. These powerful chemicals, including endocrine disruptors, transform human beings both brutally and subtly, raising questions about the continuity of "the human" in the ways we think and respond to the world. Climatology, microbiology, and toxicology reveal three distinct human figures. As environmental concerns compel humanists to grapple with the biological sciences what emerges is not a single, shared human figure

understood to be endangered in the same way by all disciplines but new conceptions of the human that challenge the understanding, solidarity, and continuity that serve as the foundation of humanist inquiry.

II. Microbiology: The Body Multiple[11]

Biologists work not only with the grand scale of species over hundreds of millennia, but also with minute organisms where mutations and adaptations are measured in minutes. For those of us wishing to understand who is endangered by climate change, this microbiological scale needs to be considered alongside the macrobiological scale of species.

Microbiology is a rapidly changing field. Back in 1969, W.H. Auden wrote "A New Year Greeting" to the "Bacteria, Viruses, Aerobics and Anaerobics" inhabiting his ectoderm. These denizens of "Middle-Earth" were invited to:

> . . . settle yourselves in the zone
> that suits you best, in the pools
> of my pores or the tropical
> forests of arm-pit and crotch,
> in the deserts of my fore-arms,
> or the cool woods of my scalp.
>
> Build colonies: I will supply
> adequate warmth and moisture,
> the sebum and lipids you need,
> on condition you never
> do me annoy with your presence,
> but behave as good guests should,
> not rioting into acne
> or athlete's-foot or a boil.

This invitation to microbes to live where they chose as long as they minded their manners was congruent with the scientific view forty odd years ago that microbes were mere "passive riders" on our bodies as microbiologist Bonnie Bassler recently put it.[12] Auden was in fact responding to an article on the passive microbial inhabitants of the human skin in *Scientific American.*[13] Accepting this view, historians ignored the well-behaved "guests," focusing instead on the badly behaved "parasites" as in William McNeill's path-breaking *Plagues and Peoples* which traced the effects of illnesses on political, economic, social, colonial, and intellectual developments.[14] Historians of medicine continue to do incisive work on the rampaging ingrates infecting our bodies with new diseases like AIDS.[15]

But the science has now changed dramatically. The relationship between "ourselves" and microbes is not best described as one between genial host and guests, well-behaved or otherwise. According to very recent studies, we are *mostly* bacteria if one counts sheer numbers of cells. With the completion of the Human Microbiome Project in the summer of 2012, the estimated number of bacteria was put at 100 trillion for healthy human adults.[16] "Going strictly by the numbers," says science writer Valerie Brown, "the vast majority–estimated by many scientists at 90 percent–of the cells *in what you think of as your body* are actually bacteria, not human cells."[17] Put a different way by the National Institutes of Health, "The human body contains trillions of microorganisms – outnumbering human cells by 10 to 1."[18] But this figure, jaw dropping though it may be, hardly conveys the drama of the new findings. After all, microbial cells are so very tiny compared with human cells that merely counting them reveals less than may appear. Bacteria make up only 1 to 3% of the normal adult body weight, usually a mere two to six pounds.[19] More to the point than their sheer numbers, the Human Microbiome Project reveals that these microbes are neither our "passive passengers" nor our incidental allies aiding digestion and the like. Instead they are actually, inseparably, "us" by almost any calculation. The Human Microbiome Project concludes that on a genetic level, "this plethora of microbes contribute [sic] *more genes* responsible for human survival than humans contribute. Where the human genome carries some 22,000 protein-coding genes, researchers estimate that the human microbiome contributes some 8 million unique protein-coding genes or 360 times more bacterial genes than human genes."[20] Not only do bacteria participate in our physical processes but also in our mental ones (assuming this distinction still holds), producing "some of the same types of neurotransmitters that regulate the function of the brain."[21] For all practical purposes, then, the distinction between "us" and "them" within microbiology has eroded away.

The current biological understanding of "the human" on this scale, as Stanford microbiologist David Relman describes it, is that we are "like coral, 'an assemblage of life-forms living together.'"[22] Harvard systems biologist Peter Turnbaugh and his colleagues speak of the "human 'supra-organism'," "a composite of microbial and human cells, the human genetic landscape as an aggregate of the genes in the human genome and the microbiome, and the human metabolic features as a blend of human and microbial traits."[23] A person is not an individual but congregation.[24] Analogously, the research done to establish these and other findings was also communal,

coordinated among 200 scientists and 80 institutions, the data generated so vast that a single mammoth computer would still not suffice.[25] The host and his company played by Auden and his microbes in the poem "A New Year Greeting" are, from the microbiologist's point of view today, indistinguishable: everyone prepares the meal, pours the wine, joins in the laughter, and scrubs the dishes.

Furthermore, our microbes, like our friends, are not definitively categorizable as "good, healthy, and helpful" while others are "bad, disease-causing, and unwelcome." Just as an assembled company may be surprised when the loutish drunk digs everyone's car out of the snow, scientists have been surprised to discover the "genetic signatures of disease-causing bacteria in everyone's microbiome. But instead of making people ill, or even infectious, these disease-causing microbes live peacefully among their neighbors."[26] We are good and bad, diseased and healthy, not in essence but in relation to particular situations, not genetically but epigenetically.[27]

Microbiology's description of "us" as the "body multiple," as a "coral reef" or "supra-organism," begs two major questions for humanists in the age of the climate change: how might this inflect our understanding of human solidarity and what light does this perspective shed on who is endangered. As Chakrabarty has shown, analysis on the macrobiological level presents the human species as a distinguishable, discrete, and immense entity: "mankind" in the word of Crutzen and Stoermer. On this macroscale, there are humans and non-humans, with the human species now emerging as a global agent, the master of the planet. But, through the lens of microbiology, "the human species" is dramatically less coherent. Humanists attempting to grapple with the microbiological view of the human must try to comprehend not just the diseases whereby parts of ourselves sometimes rebel against the symbiotic harmonies of our communal life, but to grapple with the idea that each "individual" can be understood as a collectivity of "species" and "humanity" seen as an archipelago of multiple life forms. Although the findings of the Microbiome Project are far too recent to have been absorbed into the literature and thinking of scientists let alone historians, this figure of the human can already be seen to pose grave challenges to most humanists' ideas. "We" in this microbiological assemblage differ from "one" another more than imagined. While we share about 99.9% of our human DNA, our microbial cells may have as little as 50% of their genetic profile in common.[28] From the perspective of human solidarity, this finding is disturbing. If 90% of my cells are bacterial and half of those have a different DNA sequence than yours, then on a cellular level it is not as

clear that we are "the same species" as other branches of biology or as the humanities have hitherto defined "species," a problem that micobiologists are well aware of. Self-reflection and mental reenactment as empathetic historical practices assume a cohesion to "the human" not apparent on this cellular level. For the humanities, it would seem just as difficult to think with microbiology's view of the human as it is to think with paleobiology's, yet the difficulties are different.

The second question is about how this coral reef entity might be endangered by climate change. Here too microbiology offers a picture at odds with paleobiologists and climate scientists. Not only is "the species" *not* the coherent, planet-altering agent it is to those working on the larger scale, it is also *not* the victim of these changes in the same way. Back in 1969, when Auden, with piquant playfulness, questions his own microbiome as to their perspective on the hurricanes, dousings, and heatwaves of life on the Audenesque ectoderm, he can separate himself and his activities of dressing and bathing from his bacteria. He politely hopes that "he" makes "a not impossible world" for these tiny guests, but muses that his " . . . purposive acts, //may turn to catastrophes there." Auden's description of the havoc wrought by his daily activities conveys something of the magnitude of microbial death rates as it was understood forty years ago, but today's understanding of the horrific slaughter of "ourselves" in our digestive tracts (where half the weight of our feces are not undigested food but extruded microbes) and in other arenas of "our" bodies might give rise not to light verse but to epic dirge.[29] But the more important point about these deaths is that they allow for more births and rapid evolution. While Auden muses on the deaths of bacteria, he does not mention their fecundity: the high death rate of parts of our supraorganism is matched by the equally high birth rate.[30] The microbial part of us reproduces with such astounding rapidity that the number of bacteria, in the right conditions, can double every twenty minutes.

Not only that, but these high birthrates are accompanied by a different evolutionary style. These simple prokaryotic cells, without nuclei, mitochondria, or smaller organelles, can conjugate, technically, with any other bacteria creating an interactive web of information evolving in many directions at once. Compared with the laborious process of sexual reproduction embraced by eukaryotes, which results in (fairly) linear evolution, a process often represented by the branching tree of life, prokaryotic cells are like sports cars with the capacity to turn on a dime. Their apparent ability to conjugate with "anyone" means that the concept of distinct species

among bacteria is extremely flexible. As the new studies show, "bad" human-disease-causing bacteria exist with "good" bacteria throughout a healthy body so that differentiating them is, as I have suggested, less a matter of ontology than of situation. The consequence of this rapid reproduction coupled with differences in evolutionary strategy is that the microbial part of us evolves at different rates and in a different way from the non-microbial part of us and can therefore respond more quickly to environmental changes. That a part of us might be capable of coping with more acidic water, drier climates, and higher temperatures than other parts of us produces a strikingly different version of what might be endangered. Understood in this way, the body multiple is not an *entity* to be protected but a *system*, an interactive process of life and death combined. As such this "supraorganism," this coral reef, is not threatened by climate change in the same way other branches of knowledge have imagined "the human" to be threatened when they talk of rising oceans advancing on coastal cities, wars for natural resources, and environmental injustice perpetrated on the poor.[31]

My point here in underscoring the wildly variant visions of "the human" in paleobiology and in microbiology is to show that defining what is endangered by climate change cannot be left to biology. There is more than one biology and these biologies produce human figures of variable vulnerability. The question is how to think with these new biological figures about "our" past and "our" possibilities under the threat of climate change, and the answers are far from clear. Who is this "we" that is endangered?

III. Biochemistry: Toxic Beings[32]

"Minamata, 1970" with the kind permission of Kuwabara Shisei

The wizened, claw-like hand of the Minamata-disease victim in Kuwabara Shisei's photograph curls in an impossible shape, more reminiscent of Karl Blossfeldt's furled ferns than human digits.[33] This nearly abstract representation of a portion of a body exposed to methylmercury from the Chisso chemical plant in Minamata Japan is politically potent precisely because it divides the normal from the diseased, the healthy from the ill. Kuwabara's photograph documents the effects of a corporation's criminally inhumane actions and demands redress. If ever there were an instance of "no caption needed," the provocative title of a book on photography by Robert Hariman and John Louis Lucaites, this image is it, proclaiming at a glance that *this should not be* even before the context is made clear.[34] In *Toxic Archipelago,* historian Brett Walker describes to devastating effect how Minamatabyō, this "industrial disease," affected the body and mind of one of its victims, a fisherwoman who had lost everything, including her unborn child, to its predations: "In only four years, methylmercury had destroyed enough cells in Sakagami's brain to deprive her of control of herself almost entirely: mercury devours the brains of adults and stops the development of fetal ones."[35] Walker then details a horrific scene in which Sakagami, in her confusion, imagines that the oily fish on her hospital dinner plate is her by-then-aborted fetus. She tries to eat it in order to save it from the excruciating pain caused by methylmercury, only to have it flop from her chopsticks to the floor where she chases it, stuffing it into her mouth with her spasmodic hands.

Methylmercury does not only affect human beings. One of the earliest signals of the community's poisoning was that Minamata's cats "danced" crazily just before they died, leading to an explosion of mice that damaged the fishing nets.[36] Unquestionably, introducing methylmercury into bodies harms and sometimes destroys life, mental and physical, economic and social, in the womb and out of it, human and otherwise. What Kuwabara's image, Walker's prose, and the death of a hundred convulsing cats clearly show is a situation that "should not be."

However, the divide between the body and its non-organic chemical infiltrators is not as clear as the black-and-white photograph or the heart-wrenching stories of Minamata suggest.[37] As scientists, historians of medicine, and others have come to realize, we must cast aside what Steve Kroll-Smith and Worth Lancaster have dubbed "the Enlightenment-inspired idea that bodies and environments are genuinely discrete realities."[38] In many cases, there is not even a threshold between "us" and "outside of us," let alone a stalwart barricade preventing penetration by dangerous substances. The new chemical compounds being pumped out in the millions of tons annually, particularly the endocrine disrupters, enter our bodies through multiple and little-understood pathways as the work of ecologists and historians such as Nancy Langston, Sandra Steingraber, and Florence Williams has shown.[39] As Langston explains, "Since World War II the production of synthetic chemicals has increased more than thirtyfold. The modern chemical industry, now a global enterprise of $2 trillion annually, is central to the world economy, generating millions of jobs and consuming vast quantities of energy and raw materials. Each year more than seventy thousand different industrial chemicals annually make their way into our bodies and ecosystems. Americans are saturated with industrial chemicals . . .."[40] In the same vein, historian of science Michelle Murphy speaks of our "chemical embodiment" and states plainly and powerfully, "in the twenty-first century, humans are chemically transformed beings."[41] Of the more than 70-80,000 chemicals in commercial use in the United States, notes an editorial in *Scientific American*, "the EPA has been able to force testing for only around 200."[42] Even those of us who have escaped the horrific deformations visible in Kuwabara's photographs appear biochemically altered when examined by other means of imaging and analysis.

As before, scale is crucial here: exponentially more chemicals have been introduced globally throughout the planet more quickly than ever before: greater amounts; vaster coverage; shorter time. This point about scale is important because

even before the industrial revolution, some people lived in chemically altered local environments where such things as lead, mercury, coal, ergot poisoning, and even wood smoke harmed human health and altered human brains and bodies. However, after the Second World War, the new industrial substances infiltrating our bodies became more plentiful, more potent, and more complex by many orders of magnitude. By 1986, the substances that became part and parcel of every single American included measurable amounts of styrene and ethyl phenol in 100% of the population, toluene in 91%, polycholorinated byphenols in 83%. "Virtually every person who has lived in the United States since 1951 has been exposed to radiological fallout," as the Environmental Protection Agency admits, and "'all organs and tissues of the body have received some radiation exposure.'"[43] The toxic load carried by almost every human being includes phthalates (a toxin derived from plastics) and mercury, the substance responsible for Minamata disease.[44] Of particular concern are the endocrine disruptors such as the synthetic estrogen used in cattle feed, putting "masculinity at risk" and raising the rates of intersex conditions and reproductive cancers in human beings and in other creatures. (Surveys of many British streams discovered that "more than 30 percent of the fish . . . are now intersex."[45]) With these endocrine disruptors, scale is an issue in two ways. Not only is there concern about the massive amounts of these products in the environment at large, but, contrary to original assumptions, when it comes to altering body chemistry, tiny amounts can be even more dangerous than large doses in the effects they trigger. Today, not only the planet but also we ourselves have been fundamentally transformed by the energy- and resource-intensive activities of agriculture and other industries altering the earth.

What this "chemical embodiment" means, in short, is that there is not one group of healthy human beings living without toxic – or potentially toxic yet untested – chemicals and another group of unhealthy (and unlucky) human beings living with them. Our chemical environment *is* us, not just in those extreme cases such as Minamata, but everywhere and with everyone.[46] The old idea that a line between "the body" and "the environment" could be carefully policed by governments reigning in corporations or by individuals making healthy choices no longer pertains as we have come to understand the interpenetrability of bodies and environments. Since the environment is now radically altered through the various industrial processes polluting and warming the planet, the body too is radically altered. As Langston argues, "Bodies are, in effect complex ecosystems made up of a dynamic interweaving of material and

cultural feedbacks that are themselves subjects and sources of environmental degradation. Whatever humans do to the natural world finds its way back inside our bodies, with complex and poorly understood consequences. And in turn, what happens inside our bodies makes its way back into the broader world, often with surprising effects."[47] This conception of our bodies' embeddedness in the surrounding environment resembles the nineteenth-century idea that individual health could only be attained in a healthy climate. Illness was not understood as a pathology existing exclusively within the compromised individual, but instead as a disorder arising between individuals and their surroundings.[48] A century ago, it might have been possible for people to move to truly healthy climates; now the possible range of habitats extends only from the not-immediately-harmful to the deadly.

Much of the insightful and impassioned research tracing the processes responsible for our toxic bodies and our toxic landscapes has been done by historians, so it would be perverse, ungenerous, and simply wrong to suggest that science alone has contributed to the recognition of this chemically altered human figure. Nevertheless, at the theoretical level, those in history and the humanities have not yet grasped the challenge posed by humanity's unprecedentedly rapid biochemical transformation. History relies, as Reinhardt Koselleck, Dipesh Chakrabarty and many others argue, on the assumption of a certain continuity of experience that permits us to understand not just what happened, but also how and why it came to pass. This continuity is at root physiological. The figure of "the human" in biochemical terms remains, it has been always assumed, recognizable. Daniel Smail puts it this way: "The existence of brain structures and body chemicals means that predispositions and behavioral patterns have a universal biological substrate that simply cannot be ignored. . . . Basic social emotions are almost certainly universal. Nonetheless – the point is almost too obvious to bear repeating – they do different things in different historical cultures."[49] But, the rapid introduction of hither-to-unknown industrial chemicals affecting our bodies including our brains, as illustrated in the extreme example of Sakagami's hallucinations of her dinner being her suffering child, threatens this continuity. Humanists (and biologists) are now confronted with the problem of how the postwar biochemical revolution affects the continuity of our "universal biological substrate."

At the usually less-than-toxic levels at which every person is now imbued with industrial toxins, it is hard to imagine that there are not subtle – and perhaps not so

subtle – changes in our thought processes. If history involves self-reflection in order to understand the existential human condition yet that self and that condition have been chemically altered, how do we proceed? How could we even measure these effects, given the wide range of human abilities and talents? Can we articulate the way contemporary brains differ in perception and function from those of Auden's generation? In asking these questions, we emphasize what we may be losing in terms of human continuity. On the other hand, if we *are* our chemically altered environment, then who is the "we" endangered by the industrial processes producing climate change? From this perspective, there may be no endangerment.

A thorough embrace of the understanding of the human organism as part and parcel of its environment might view adaptation to new chemicals as yet another life process, neither good nor bad. In fact, in corporate circles, the malleability of human physiology is presented as a reason to dismiss climate concerns. In 2009 the U.S. Chamber of Commerce advised the Environmental Protection Agency that should the predictions of global transformation be correct, "populations can acclimatize to warmer climates via a range of behavioral, *physiological* and technological adaptations."[50] Bill McKibben wryly observes, "As radical goes, demanding that we change our physiology seems right up there."[51] Trying to understand what it means to be human, based on what toxicologists are telling us, presents dizzying, even sickening questions.

With both paleobiology and microbiology, we remain essentially organic, "natural" in the sense of being constituted of organic cells created with simple non-organic molecules including water (65%), carbon (19%), hydrogen (9.7%), nitrogen (3.2%), and calcium (1.8%). Even though the microbial part of ourselves reproduces differently and evolves by different pathways, it has done so in relation to the human cells, a coevolutionary pattern with its origins at the beginning of life. We and they–or the "us" that is the human body from this perspective–have shared for millennia the same molecular compounds and a joint history that we can reconstruct, even if we cannot reenact it in our minds in Collingwood's fashion. However, the swift introduction of hitherto unknown industrial chemicals and hormone disruptors into our bodies is unlike the earlier co-evolutionary processes absorbed for historians through the work of Edmund Russell.[52] Like "the species" of climate change and the "coral reef" of microbiology, the "toxic self" challenges the historians' tools and craft, but even more so. From the perspective of biochemistry, we look back at an historical

"us" abruptly discontinuous with the toxic beings we have become, and it is very hard to know how we might begin to grapple with the transformation. Here is a "we" already lost, not endangered but extinct, if "we" assumes a continuity of organic biology.

Conclusion: A Critical Friendship

Geneticists Craig Venter and Daniel Cohen declare that "the 21st century is the century of biology."[53] What is needed for other branches of knowledge in relation to these life sciences is what sociologist Nikolas Rose calls a "critical friendship" centering around "the vitality of the living body."[54] In this concluding section, there are two points I want to make about this "critical friendship," the first having to do with reality and the second with values.

First, reality may be described truthfully and cogently in many ways. Manifold biologies produce manifold descriptions of the human. Each of the biological sciences in my limited sample—paleobiology, microbiology, and biochemistry – has defined "us" in a different way and each one poses a different challenge to historians. The human defined as a species defies historical understanding; the human as multi-species coral reefs undermines solidarity; a toxified humanity undermines temporal continuity. Despite these tensions, for those concerned with climate change, these various biological understandings enrich and broaden our conception of what is at stake. They confirm our embeddedness in the global environment on different scales: as an increasingly domineering species operating over vast eons of time, as a coral reef of many species spreading out in awkward archipelagos of co-dependent beings, and as a semi-industrialized product of the last, brief half century. In doing so, they usefully defamiliarize "the human" as portrayed by most humanists.

In the sense of defamiliarizing the present, biology contributes to the humanist's project of creating a critical distance on the status quo as well as to our fund of information about climatic conditions, disease patterns, and coevolution. Thinking with biologists reminds us of the biological foundation of all that we are and do. With biologists, we go deeper, beyond the old materialism of the economic "base" to a new, and far richer, biological materialism.[55] With them, we trace the limits of our age of abundance and grasp the scale of our exorbitant use of fossil fuels and its implications for life.[56] With them, we learn to think somatically through the body, like Auden thinking through his bacteria-laden epidermis or Kuwabara thinking with

images of malformed hands. Biologists work on many scales, and in engaging with them, we fruitfully learn to see the human on different scales as well: as species over eons, as amalgamated with microbes, and permeated by our industrial products. Reality may be accurately described in many ways.

But these engagements also remind us of the limits of biological description. When it comes to climate change, according to most of the work in paleobiology, microbiology, and biochemistry, human beings in one form or another will continue. If our species survived horrifically hot temperatures in the Eocene era, we are likely, Stager says, to do so again. The vicious struggles for natural resources and high death rates evoked by environmental journalist Mark Lynas in *Six Degrees: Our Future on a Hotter Planet* will not necessarily wipe us out entirely.[57] Our microbiome's capacity for rapid evolution also suggests that some of us will resist new diseases and be able to adapt to extreme environmental conditions, avoiding the extinction that worries *Scientific American* editor Fred Guterl in *The Fate of the Species: Why the Human Race may Cause its Own Extinction and How We Can Stop It.*[58] Our biochemistry's mirroring of environmental toxins will produce deformities and cancers, but still allow for adequate reproduction rates so that, as a whole, humans are unlikely to disappear.

And yet this is hardly what most people mean in expressing concern about environmental dangers. It is not mere survival that the humanities teach us to value, nor description that humanistic disciplines teach us to practice. When ethicist Clive Hamilton mourns our inevitable losses in *Requiem for a Species*, it is not our sheer physicality over which he grieves.[59] Ideas about value are another type of knowledge, rooted in cultural genealogies, conversations and controversies, and true to the extent that they are persuasive rather than provable.

Scientists do not address the questions of value that are central to the humanities. As the late biologist Stephen Jay Gould argued, "the factual state of the universe, whatever it may be, cannot teach us *how we should live* or *what our lives should mean* – for these ethical questions of value and meaning belong to such different realms of human life as religion, philosophy, and humanistic study. Nature's facts can help us to realize a goal once we have made our ethical decisions on other grounds . . .."[60] When humanists turn to science for answers to questions of value and meaning, they often stumble. In response to philosopher Thomas Nagel's wistful insistence on a natural teleology culminating in human consciousness, evolutionary geneticist Allen Orr points out the greater success of fungi, observing that "if nature

has goals, it certainly seems to have many and consciousness would appear to be fairly far down on the list." Biology, as Orr suggests, has no special fondness for philosophers, poets, photographers, or historians. Nor a penchant for justice, peace, or decency. Nor any particular desideratum. If nature "is trying to get somewhere," Orr asks, "why does it keep changing its mind about the destination?"[61] What conversations with biologists demonstrate first and foremost for historians and others in the humanities is that biology is not going to ease our burden of responsibility for crafting an understanding of the human figure currently threatened by climate change. Instead, the humanities must bear the responsibility of defining and defending threatened commitments to justice, decency, and beauty and to imagining a human figure capable of embracing and sustaining them. Biologists can help us understand our predicament, but they cannot provide the cultural, social, and political imagination to resolve it.

Political theorist Wendy Brown is particularly eloquent in celebrating humanistic approaches. She sees the rush to embrace scientific models of knowledge as part of the reduction of human experience to "the one dimensional rationality of *homo economicus*" celebrated in neoliberal regimes. Arguing against "the convergent challenges of scientization and neoliberalization within and outside the academy" whereby all knowledge becomes "marketable, immediately applicable, or scientific in method," she defends the humanities: "They speak to, cultivate and elevate precisely what a neoliberal rationality would extinguish in us individually and collectively – not only historical, philosophical and literary consciousness and viewpoints, not only notions of the political exceeding interest and featuring shared power and purpose, but the play of ambiguity, vulnerability, awe, ambivalence, psychic depths, boundary, identity, spirit, and other elements foreign to neoliberal rationality."[62] These humanistic qualities and modes of understanding are particularly threatened in the coming world of duress and hardship. They define what is most endangered which is not our fragile bodies but the even frailer edifices of decency, justice, playfulness, and beauty. In what Nikolas Rose describes as the epistemic shift in both the human and the biological sciences whereby "personhood itself is becoming increasingly somatic," biology is crucial, but only the humanities can articulate the value of what is endangered and produce the wisdom, grace, and humor, the cultural, political, and social resources available in our records to begin to address the problem.[63]

In short, "in the moment of danger that is climate change" as the figures of the species, the microbiome, and the toxic body flash before us, the most important scale for exploring the human figure remains the one that comes most readily to hand for most humanists, the scale in time and space where individuals and communities have political agency, the scale, in other words, that has long framed our studies. But now there is a difference. In the age of biology, this figure's biological being, its somatic form takes equal weight with its conscious actions. Indeed, the two are imbricated with one another. We must not only be "historians of mind" in Collingwood's terms where mind and body can be neatly separated, but also historians of the eating, sleeping, making love, and much else besides that he dismisses.[64] In so doing, we are politicizing passivity, politicizing the received nature of our environment and bodies without letting go of the need for mindful action.[65] For historians, mindful action occurs in the archives tracing not only exponential expansion of populations and economies founded on fossil fuel since the eighteenth century but also the byways taken by those not pursuing the illusion of limitless growth. In revealing multiple viable ways of life, we can offer a somatic politics that counters neoliberalism's naturalization of growth. Biology underscores human malleability, but history and other humanistic disciplines provide a forum for deliberating how we might direct this malleability. Engaging with biology reveals a multiplicity of human figures and delimits the possible answers to humanistic questions of value but it cannot decide them. Ultimately, defining what is most endangered by climate change is the role of the humanists.

[1] Clive Hamilton, *Requiem for a Species: Why We Resist the Truth about Climate Change* (Washington, D.C.: Earthscan, 2010), 9.
[2] Dipesh Chakrabarty, "The Climate of History: Four Theses" *Critical Inquiry* 35 (Winter 2009), 201.
[3] See, for instance, Ian Morris, *Why the West Rules--for Now: The Patterns of History and What They Reveal about the Future* (New York: Picador, reprint edition, 2011) and Edward O. Wilson, *Consilience: The Unity of Knowledge* (New York: Vintage, 1998).
[4] Curt Stager, *Deep Future: The Next 100,000 Years of Life on* Earth (New York: St. Martin's Press, 2012), 11.
[5] Systems analysis, pioneered in the 1972, reminds us that it is not only fossil fuel burning that is responsible for climate change but the whole panoply of human activities including agriculture, demographic rates, transport systems, and many other things. See Donella H. Meadows, et al., *The Limits to Growth: A Report for the Club of Rome's Project of Mankind* (New York: Universe Books, 1974) and Donella H. Meadows, Jørgen Randers, and Dennis L Meadows, *The Limits to Growth: The 30-Year Update* (White River Junction, Vt.: Chelsea Green Publishing Company, 2004). The attempt to call people's attention to the problem has taken many forms, including a wildly successful one-man play, "Ten Billion," written and performed by Stephen Emmott, head of computational science at Microsoft Research in Cambridge and professor of computational science at Oxford, which essentially consisted of his reading data in sold-out London performances during the summer of 2012. Reviewing the play, Ian Jack writes, "food production already accounts for 30% of greenhouse gases – more than manufacturing or transport; more food needs more land, especially when the food is meat; more fields mean fewer forests, which means even more carbon dioxide in the atmosphere, which means an even less stable climate, which means less reliable agriculture." Ian Jack, "The implications of overpopulation are terrifying. But will we listen to them?" *The Guardian*, Friday August 3, 2012. Regrettably, some people continue to believe that laptops, mobile phones, ipads, and other devices enabling electronic communication and supposedly cutting down on paper use (as in books) is ecologically sound. On the contrary, tantalum also known as 'coltan' as well as other rare minerals necessary for these devices are mined in terrible conditions with great harm to the environment. See Michael Nest, *Coltan* (Cambridge, UK: Polity Press, 2011)
[6] Dipesh Chakrabarty, "Postcolonial Studies and the Challenge of Climate Change," *New Literary History,* 2012, 43, 9. Paul J. Crutzen and Eugene F. Stoermer, "The 'Anthropocene'," originally published in *International Geosphere-Biosphere Programme Newsletter*, no. 41 (May, 2000) and republished in Bill McKibbon, ed., *The Global Warming Reader: A Century of Writing about Climate Change* (New York: Penguin Group, 2011), 72. Crutzen and Stoermer date the beginning of the Anthropocene to the "latter part of the eighteenth century, although we are aware that alternative proposals can be made (some may even want to include the entire Holocene)." p. 71. The ramifications of this periodization has been discussed from a number of angles by historians. See, for instance, Will Steffen, Paul J. Crutzen, John R. McNeill, "The Anthropocene: Are Humans now Overwhelming the Great Forces of Nature?" *Ambio: A Journal of the Human Environment*, 36:8 (2007) and Dipesh Chakrabarty, "The Climate of History: Four Theses" *Critical Inquiry* 35 (Winter 2009). Ruddiman, W.F., *Plows, Plagues, and Petroleum: How Humans Took Control of Climate* (Princeton: Princeton University Press, 2005) argues that the anthropocene began with agriculture and should be dated to 8,000 years ago. Responses to Chakrabarty include, Ian Baucom, "The Human Shore: Postcolonial Studies in an Age of Natural Science," *History of the Present*, Vol. 2, No. 1 (Spring 2012), 1-23 and Simon During, "Empire's Present," *New Literary History* (2012) 43:331-340.
[7] Stager, *Deep Future*, 84-85.
[8] Stager, *Deep Future*, 34 and 41. In relying on a projected high of 600 ppm, Stager is following climatologist David Archer's prediction. Bill McKibben's standard for survival is 350 ppm, pushing us back down from our current level of almost 400 ppm. Bill McKibben, "Global Warming's Terrifying New Math: Three simple numbers that add up to global catastrophe - and that make clear who the real enemy is," *Rolling Stone* (2 August 2012) According to the Potsdam Institute for Climate Impact Research and Climate Analytics in their report for the World Bank, "By the time the concentration reaches 550 ppm (corresponding to a warming of about 2.4°C in the 2060s), it is likely that coral reefs in many areas would start to dissolve. The combination of thermally induced bleaching events, ocean acidification, and sea-level rise threatens large fractions of coral reefs even at 1.5°C global warming. The regional extinction of entire coral reef ecosystems, which could occur well before 4°C is reached, would have profound consequences for their dependent species and for the people who depend on them for food, income, tourism, and shoreline protection." Potsdam Institute for Climate Impact Research and Climate Analytics, "4°: Turn Down the Heat: Why a 4°C Warner World Must be Avoided," Executive Summary, Report for the World Bank, (November 2012), 5. See also Mark Lynas, *Six Degrees: Our Future on a Hotter Planet* (Washington, D. C.: National Geographic Society, 2008) and David Archer, *The Long Thaw: How Humans Are Changing the Next 100,000 Years of Earth's Climate* (Princeton: Princeton University Press, 2010).
[9] Stager, *Deep Future*, 11.

[10] Dipesh Chakrabarty, "The Climate of History: Four Theses" *Critical Inquiry* 35 (Winter 2009), 220.
[11] The phrase "the body multiple" is used as the title of anthropologist Annemarie Mol's fascinating *The Body Multiple: Ontology in Medical Practice* (Durham and London: Duke University Press, 2002).
[12] Gina Kolata, "In Good Health? Thank Your 100 Trillion Bacteria," *New York Times*, 13 July 2012 (accessed on line 18 July 2012.)
[13]A microbiologist working in New Zealand, Mary J. Marples published a nearly thousand page book *The Ecology of the Human Skin* (Springfield, IL: Charles C. Thomas, publisher, 1965). This pioneering effort applied the term "ecology" to the study of skin for the first time.
[14] See, for instance, William McNeill, *Plagues and Peoples* (New York: Anchor Books, Random House, 1977), Alfred W. Crosby *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Cambridge: Cambridge University Press; 2 edition, 2004) and *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Greenwood, 1973), and in my own field of Japanese history, William Wayne Farris, *Population, Disease, and Land in Early Japan, 645-900* (Cambridge, MA.: Harvard University Press, 1985)
[15] See, for example, John Engel, *The Epidemic: A Global History of AIDS* (Washington, D.C.: Smithsonian, 2006), Christopher Hamlin, *Cholera: The Biography* (Oxford: Oxford University Press, 2009), and William Johnston, *The Modern Epidemic: A History of Tuberculosis in Japan* (Cambridge, MA.: Harvard University Asia Center, 1995).
[16] In June 2009, the estimate of unique bacterial genes in each human gut was about 9 million. Valerie Brown, "Bacteria 'R'Us," Smart Journalism. Real Solutions. *Miller-McCune* 2 December 2010. (accessed December 28, 2010) http://www.miller-mccune.com/science-environment/bacteria-r-us-23628/#. The NIH newsletter reports that: "In a series of coordinated scientific reports published on June 14, 2012, in *Nature* and several journals in the Public Library of Science (PLoS), some 200 members of the Human Microbiome Project (HMP) Consortium from nearly 80 universities and scientific institutions report on five years of research. HMP has received $153 million since its launch in fiscal year 2007 from the NIH Common Fund, which invests in high-impact, innovative, trans-NIH research. Individual NIH institutes and centers have provided an additional $20 million in co-funding for HMP consortium research."
[17] Valerie Brown, "Bacteria 'R'Us," *Miller-McCune* 2 December 2010. (emphasis mine.)
[18]NIH News, National Institutes of Health, U.S. Government, press release Wednesday, June 13, 2012, contact Raymond MacDougall, NHGRI, "NIH Human Microbiome Project defines normal bacterial makeup of the body: Genome sequencing creates first reference data for microbes living with healthy adults" (accessed June 19, 2012)
[19]Valerie Brown, "Bacteria 'R'Us," *Miller-McCune* 2 December 2010.
[20] NIH News, National Institutes of Health, U.S. Government, press release Wednesday, June 13, 2012, contact Raymond MacDougall, NHGRI, "NIH Human Microbiome Project" (emphasis mine.)
[21] Valerie Brown, "Bacteria 'R'Us," *Miller-McCune* 2 December 2010.
[22] Quoted in Gina Kolata, "In Good Health? Thank Your 100 Trillion Bacteria," *New York Times* 13 July 2012 (accessed on line July 18, 2012) The coral reef metaphor works well. Another used by biologist David George Haskell musing on the microbes in our guts and the mitochondria in our cells is that of Russia dolls: "We are like Russian dolls, our lives made possible by the other lives within us." *The Forest Unseen: A Year's Watch in Nature* (New York: Viking, 2012), 4.
[23] Peter Turnbaugh, et. al., "The Human Microbiome Project, *Nature* (vol. 449, no. 18) October 2007, 804.
[24] For an elaboration of earlier research, see Lynn Margulis, Dorion Sagan, and Lewis Thomas, *Microcosmos*: *Four Billion Years of Microbial Evolution* (Berkeley and Los Angeles: University of California Press, 1997).
[25]Gina Kolata, "In Good Health? Thank Your 100 Trillion Bacteria," *New York Times,* 13 July 2012.
[26] Gina Kolata, "In Good Health? Thank Your 100 Trillion Bacteria," *New York Times*, 13 July 2012.
[27] See, for instance, Nessa Carey, *The Epigenetics Revolution: How Modern Biology is Rewriting Our Understanding of Genetics, Disease, and Inheritance* (New York: Columbia University Press, 2012)
[28] Peter Turnbaugh, et. al. point to some of the challenges of answering the question: "How similar are the microbiomes of between members of a family or members of a community, or across communities in different environments?" in "The Human Microbiome Project, *Nature* (vol. 449, no. 18) October 2007, 804.
[29] Gina Kolata, "In Good Health? Thank Your 100 Trillion Bacteria," *New York Times* 13 July 2012. "The gut is not jam-packed with food; it is jam-packed with microbes," Dr. Proctor. "Half of your stool is not leftover food. It is microbial biomass."
[30]The reproductive powers of microbes are such that their numbers, in the right conditions can double every twenty minutes which allows them to survive the attacks of viruses. In the oceans, daily, viruses kill half of all the bacteria only to have them regenerate. And they invade a microbe host 10 trillion times a second around the world. Carl Zimmer, *A Planet of Viruses* (Chicago: University of Chicago Press, 2012). An imagination less

imbued than Auden's with Christianity's focus on death and more inflected by Buddhistic views of reincarnation and the multiplicity of life forms might have celebrated the sheer vitality.

[31] The term "environmental justice" seems to have particular resonance in writing about the United States where the concept is enshrined in the directives of the Environmental Protection Agency with the intention of protecting poor communities from becoming sites for contaminated waste and other problems. See, for instance, David Schlosberg, *Defining Environmental Justice: Theories, Movements, and Nature* (New York: Oxford University Press, 2007). From a global perspective, the concept applies to the way the wealthy countries of the northern hemisphere (roughly speaking) use a disproportionate amount the earth's natural resources and produce a disproportionate amount of the pollution. For this perspective, see, for instance, Vandana Shiva, *Earth Democracy: Justice, Sustainability, and Peace* (New York: South End Press, 2005) and *Soil Not Oil: Environmental Justice in the Age of Climate Change* (New York: South End Press, 2008).

[32] On remaking human bodies, see Jody A. Roberts and Nancy Langston, "Toxic Bodies/Toxic Environments: An Interdisciplinary Forum," *Environmental History*, Vol. 13, No. 4 (2008): 629-703 and the related articles; Sarah A. Vogel, "The Politics of Plastics: The Making and Unmaking of Bisphenol A 'Safety'," *American Journal of Public Health* 99 (2009): 559-566; and Nancy Langston, *Toxic Bodies: Hormone Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010).

[33]See Kuwabara Shisei, *Kuwabara shisei shashin zenshu,* Vol. 1, *Minamata* (Tokyo: Kusanone Publishing Company, 2004), 118. See Karl Blossfeldt, *Karl Blossfeldt Photography*, ed. Ann and Jürgen Wilde, (Ostfildern-Ruit, Germany: Cantz Verlag, n.d.)

[34] Robert Hariman and John Louis Lucaites, *No Caption Needed: Iconic Photographs, Public Culture, and Liberal Democracy*, (Chicago: University of Chicago Press, 2007)

[35] Brett L. Walker, *Toxic Archipelago: A History of Industrial Disease in Japan* (Seattle: University of Washington Press, 2010), 140.

[36] Timothy S. George, *Minamata: Pollution and the Struggle for Democracy in Postwar Japan* (Harvard East Asian Monographs), 3. See also Ui Jun, *Kōgai no seijigaku: Minamatabyō o otte* (Tokyo: Sanseidō, 1968) and Frank K. Upham, *Law and Social Change in Prewar Japan* (Cambridge, MA: Harvard University Press, 1987)

[37] Such industrial diseases, as Brett Walker carefully reminds us, are the "result of hybrid causation, because of complex and largely unanticipated interrelationships among advanced technologies, idiosyncratic social practices, and naturally occurring agencies." Walker, *Toxic Archipelago*, 139.

[38] Kroll-Smith, Steve and Worth Lancaster, "Bodies, Environments, and A New Style of Reasoning," *Annals of the American Academy of Political and Social Science* 584 (2002): 204.

[39] Sandra Steingraber, *Having Faith: An Ecologist's Journey to Motherhood* (Cambridge, MA: Perseus Press, 2001); Nancy Langston, *Toxic Bodies: Hormone Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010); and Florence Williams, *Breasts: A Natural and Unnatural History* (New York: Norton, 2012). See also, Theo Colborn, Diane Dumanoski, and John Peterson Myers, *Our Stolen Future: Are We Threatening Our Fertility, Intelligence, and Survival? A Scientific Detective Story* (New York: Penguin Books, 1997).

[40] Nancy Langston, *Toxic Bodies* (New Haven: Yale University Press, 2010), 17. See also Jody A. Roberts and Nancy Langston, "Toxic Bodies/Toxic Environments: An Interdisciplinary Forum," Environmental History, *Vol. 13, No. 4 Italic (2008): 629-703* and the related articles in that issue; and Sarah A. Vogel, "The Politics of Plastics: The Making and Unmaking of Bisphenol A 'Safety'," *American Journal of Public Health* 99 (2009): 559-566.

[41]Michelle Murphy, "Chemical Regimes of Living," *Environmental History,* 13 (October 2008)

[42] Quoted in Fred Magdoff and John Bellamy Foster, *What Every Environmentalist Needs to Know about Capitalism*, (New York: Monthly Review Press, 2011), 24. Editors, "Chemical Control,"*Scientific American* (April 2010). Magdoff and Foster write, "The United States continues to have one of the worst records among industrial countries concerning protection of its citizens from toxic chemicals found in products in everyday use—from cosmetics to food containers to denture cream." (24)

[43] Steve Kroll-Smith and Worth Lancaster, "Bodies, Environments, and a New Style of Reasoning," *Annals: American Academy of Political and Social Science (AAPSS)*, 584 (November 2002), 205.

[44] Florence Williams, *Breasts: A Natural and Unnatural History* (New York: Norton, 2012). As reviewed by Elizabeth Kolbert: "One in 17 women had enough mercury in her blood to risk causing learning disabilities in her children. The Environmental Protection Agency expressed concern that even low-level exposure to perfluorooctanoic acid, used in the manufacture of Teflon, could potentially lead to developmental problems. Flame retardants known as PBDEs, which were known to cause brain damage in rats, were increasingly showing up in human breast milk." Kolbert, *Onearth* (Summer 2012), 54.

[45] Langston, *Toxic Bodies*, 143. Alarms over the feminization of the human species as expressed in the title "Masculinity at Risk" from a science article are discussed on page 135.

[46] Human bodies are not the only ones affected by the soup of synthetic chemicals. Reproduction in wildlife worldwide is affected. Just to take a few of the most startling examples provided by Nancy Langston, "Male alligators exposed to DDT in Florida's Lake Apopka developed penises that were one-half to one-third the typical size, too small to function. Two-thirds of male Florida panthers had cryptorchidism, a hormonally related condition in which the testes do not descend. Prothonotary warblers in Alabama, sea turtles in Georgia, and mink and otters around the Great Lakes all showed reproductive changes. Male porpoises did not have enough testosterone to reproduce, while polar bears on the Arctic island of Svarlbard developed intersex characteristics. In one particularly disturbing example, Gerald A. LeBlanc of North Carolina State University in Raleigh found that more than a hundred species of marine snails were experiencing a condition known as imposex, a pollution-induced masculinization. Affected females could develop a malformed penis that blocked their release of eggs. Engorged by eggs that could not get out, many snails died." Nancy Langston, *Toxic Bodies* (New Haven: Yale University Press, 2010), 4.
[47] Nancy Langston, *Toxic Bodies* (New Haven: Yale University Press, 2010), 136.
[48] Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley and Los Angeles: University of California Press, 2006.)
[49] Daniel Lord Smail, *On Deep History and the* Brain (Berkeley and Los Angeles: University of California Press, 2008), 114.
[50] Quoted in Bill McKibben, "Global Warming's Terrifying New Math," *Rolling Stone* (2 August 2012), 8. (accessed online July 23, 2012)
[51] Bill McKibben, "Global Warming's Terrifying New Math," *Rolling Stone* (2 August 2012), 8.
[52] Edmund Russell, *Evolutionary History: United History and Biology to Understand Life on Earth* (Cambridge: Cambridge University Press, 2011) and Edmund Russell, "Evolutionary History: Prospectus for a New Field," *Environmental History,* Vol. 8, No. 2 (April 2003), 204-228.
[53] Craig Ventor and Daniel Cohen, "The Century of Biology," *New Perspectives Quarterly* (Vol. 21, Issue 4, Fall 2004), 73.
[54] Nikolas Rose, "The Human Sciences in a Biological Age," *Theory, Culture, & Society* 30 (1) (January 2013), 3-4.
[55] Julia Adeney Thomas, "Atarashii Busshitsu Shugi," (The New Materialism) preface to *Kindai no saikochiku: Nihon seiji ideorogii ni okeru shizen no gainen*, (Reconfiguring Modernity: Concepts of Nature in Japanese Political Ideology) (Tokyo: Hosei University Press, 2008).
[56] There is a dispute between deep historians who have argued that the intensive use of fossil fuel since the 18th century is the unremarkable continuation of millennia-old patterns of resource exploitation and those who see not only an abrupt quantitative change but a qualitative change as well. For the former position, see Andrew Shyrock and Daniel Lord Smail, *Deep Histories*. For the latter argument, see for instance Edmund Burke who refers to modernity as "deeply aberrant." Edmund Burke III, "The Big Story: Human History, Energy regimes, and the Environment" in Burke and Kenneth Pomeranz, eds., *The Environment and World History* (Berkeley and Los Angeles: University of California Press, 2009), 49. For an excellent exposition of the stakes of this debate, see Fredrik Albritton Jonsson, "Review: The Industrial Revolution in the Anthropocene,"*The Journal of Modern History*, Vol. 84, No. 3 (September 2012), 679-696.
[57] Mark Lynas, *Six Degrees: Our Future on a Hotter Planet* (Washington, D.C.: National Geographic Society, 2008)
[58] Fred Guterl, *The Fate of the Species: Why the Human Race may Cause its Own Extinction and How We Can Stop It* (New York: Bloomsbury, 2012)
[59] Clive Hamilton, *Requiem for a Species: Why We Resist the Truth about Climate Change* (Abingdon, Oxon, U.K.: Earthscan, 2010)
[60] Stephen Jay Gould, "Introduction," in Carl Zimmer, *Evolution: The Triumph of an Idea* (New York: HarperCollins, 2002), xxxvi.
[61] H. Allen Orr, "Awaiting a New Darwin," *New York Review of Books* (7 February 2013), 28. A review of Thomas Nagel's *Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature is Almost Certainly False* (Oxford: Oxford University Press, 2012)
[62] Wendy Brown, "Interventions: Neoliberalized Knowledge," *History of the Present: A Journal of Critical History*, Vol. 1, No. 1 (Summer 2011), 126-127. For an expanded discussion on the ideas framing knowledge in the last few decades, see Daniel T. Rodgers, *Age of Fracture* (Cambridge, MA.: Harvard University Press, 2011).
[63] Nikolas Rose, "The Human Sciences in a Biological Age," *Theory, Culture, & Society,* 30 (1) (January 2013), 7.
[64] R.G. Collingwood, *The Idea of History* (Oxford: Oxford University Press, 1946), 216.

[65]See my argument in Julia Adeney Thomas, "From Modernity with Freedom to Sustainability with Decency: Politicizing Passivity," *The Future of Environmental History: Needs and Opportunities*, edited by Kimberly Coulter and Christof Mauch (Rachel Carson Center Perspectives, University of Munich: March 2011)