The Nature/Culture of Genetic Facts*

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Abstract

This review aims to explore the relationship between anthropology and genetics, an intellectual zone that has been occupied in different ways over the past century. One way to think about it is to contrast a classical "anthropological genetics" (Roberts 1965), that is to say, a genetics that presumably informs anthropological issues or questions, with a "genomic anthropology" (Pálsson 2008), that is to say, an anthropology that complements and relativizes modern genomics (on the model of, say, medical anthropology and legal anthropology).[1] This review argues that a principal contribution of anthropology to the study of human heredity lies in the ontology of genetic facts. For anthropology, genetic facts are not natural, with meanings inscribed on them, but are instead natural/cultural: The natural facts have cultural information (values, ideologies, meanings) integrated into them, not layered on them. To understand genetic facts involves confronting their production, which has classically been restricted to questions of methodology but which may be conceptualized more broadly. This review is not intended as a critique of the field of anthropological genetics, but as a reformulation of its central objects of study. I argue for reconceptualizing the ontology of scientific facts in anthropological genetics, not as (value-neutral) biological facts situated in a cultural context, but instead as inherently biocultural facts.

[1] "Genetics" ought technically to refer to the transgenerational study of biological features, and "genomics" to the study and manipulation of DNA. In practice, they overlap considerably, with genetics connoting classical twentieth-century breeding studies and genomics connoting the application of modern cellular and biochemical technologies (Barnes & Dupré 2008).

INTRODUCTION

Anthropology is such an intellectually broad field that it is subject to unique centrifugal forces: Biological anthropologists migrate to biology, archaeologists to art history, social anthropologists to cultural studies, and linguistic anthropologists to cognitive science. What connects them as anthropologists is an appreciation for the biocultural nature of human existence. The premodern view that human physical and cultural differences need to be studied simultaneously was eventually superseded by appreciating the notion that the relationship between them is correlational, not causal. They can indeed be studied separately, and although the microevolutionary and historical processes that determine their patterns occasionally converge, most often they are phenomenologically separate and distinct. Biological difference can therefore generally be taken as a constant, or at least as an irrelevant variable, in explaining the origin and diversity of human social forms.

The fields of anthropology and human genetics have been at odds, to a large extent, for a full century, since Franz Boas and Charles Davenport published their fundamental works in each area. Boas's (1911) *The Mind of Primitive Man* and Davenport's (1911) *Heredity in Relation to Eugenics* were both published in the same year and sought to explain the same phenomena: why some groups of people were civilized and powerful, and others were not. Boas paradigmatically answered the question in terms of history and circumstances, that is to say, in terms of culture. Davenport, on the other hand, answered it in terms of hypothetical alleles for feeblemindedness, that is to say, in terms of genetics.

Davenport was regarded as the leading human geneticist in America.[2] Davenport had, in fact, been a founding member of the American Association of Physical Anthropologists, as well as a founding member of the editorial board of the *American Journal of Physical Anthropology*. His scientific empire began to crumble only in the late 1930s; by 1939, he was marginalized from American biology and lost the long-standing funding for his Eugenics Record Office in Cold Spring Harbor (Kevles 1985). He died in 1944 as the sitting president of the American Association of Physical Anthropologists.

ANTHROPOLOGY AND THE BIOCULTURAL "BRAND"

The term pseudoscience is difficult to apply rigorously because it is generally a label assigned in retrospect. It usually connotes, however, the inappropriate application of scientific authority, which is precisely what the genetic view of human history is, even though the people promoting it have often themselves been scientists. The earliest textbook of Mendelian genetics, for example, by R.C. Punnett in 1905, concluded in a crassly self-interested vein, "As our knowledge of heredity clears and the mists of superstition are dispelled, there grows upon us with an ever increasing and relentless force the conviction that the creature is not made but born" (p. 60). Nearly a century later, stumping (successfully) for the Human Genome Project, James Watson tells *Time Magazine*, "We used to think our fate was in the stars. Now we know, in large measure, our fate is in our genes" (Jaroff 1989).

But this is not what the science of genetics tells us. The science of genetics is about how biological heredity works, not about adherence to a tenet that it governs the course of our lives. If it were, then genetics would be a faith-based initiative, like creationism, and should not be taught in public schools.

And yet, because genetics is manifestly science and geneticists are manifestly scientists, to reject their assertions is effectively to take an "antiscience" position (Gross & Levitt 1994). Yet

[2] British eugenicists challenged his work in scholarly and public forums in 1912–1913, but to little avail.

sometimes smart people do say stupid things, or more specifically, otherwise reputable scientists say bizarre or wildly inaccurate things about human origins and diversity. Why? Anthropology is positioned to try to explain why groups of scientists do and say the things they do, in parallel with why groups of natives do and say the things they do (Franklin 1995). The basic explanation lies in a significant contribution of twentieth-century anthropology, namely, the discovery that human facts are fundamentally biocultural (McKinnon & Silverman 2005, Hayden 2009). Consequently, we are now understanding the facts of human biology not so much as facts of nature, but as facts of "nature/culture" (Franklin & Lock 2003, Goodman et al. 2003), following the work of culture theorists, and highlighting the falseness of the dichotomy between natural and cultural facts (Haraway 1991, Latour 1993). Where the gene exists as a "cultural icon" (Nelkin & Lindee 1995), the boundary between genes as natural facts and as cultural facts becomes increasingly difficult to maintain. After all, "innate" and "learned" are not antonyms, for the most fundamentally hard-wired human adaptations—walking and talking—are actively learned by every person, every generation.

The facts of human biology are, of necessity, facts of human culture in three ways. First, our evolutionary lineage has been coevolving with technology for millions of years, and consequently the environment into which our own species evolved and adapted was necessarily a cultural one; culture is an ultimate evolutionary cause of human biological facts. Second, as individuals we develop within environments that are profoundly cultural, ranging from uterine conditions to postnatal nutrition, exercise, social stimulation, child-rearing practices, and personal experiences; culture is a proximate physiological cause of human biological facts. And third, these facts have always been produced in a context of conflicting interests of patronage, political ideologies of diverse kinds, professional aspirations, and cultural expectations, and they still are (Jasanoff 2004).

This of course does not mean that there is no reality. Archaeological facts are often produced in the service of nationalism or other political ideologies, for they may authorize the historical identity of a nation (Abu El-Haj 2001; Meskell 2002, 2011). Physical anthropologists have long known that taxonomic judgments in paleoanthropology are likewise significant compromises with reality, with authoritative estimates of species diversity among the hominids (or perhaps the hominins) presently ranging from less than 10 to more than 20 (Cartmill & Smith 2009). The number of extant primate species has doubled over the past generation, as a consequence not of new discoveries, but of conservation-driven "taxonomic inflation" (Marks 2007, Strier 2011). The very facts of genetics themselves may have locally situated meanings that differ transnationally (Taussig 2009). The problem is not that culture corrupts our understanding of nature; it is that culture is integral to understanding nature (Franklin 1995, 2003). One literally cannot understand natural facts any way other than culturally,[3] and particularly so for the natural facts of human biology, which are what concern physical anthropologists.

RACE AS A SET OF NATURAL/CULTURAL FACTS

Aside from implementing the applied human genetics program of the eugenicists, the 1920s also brought the application of allele frequency data to the central problem of physical anthropology, the delineation of the human races. Unfortunately, there was little relationship between the entities that the genetic data were seeming to reveal and the racial units of the human species of interest to physical anthropologists. Earnest Hooton's (1931) textbook reviewed the area and concluded that

[3] As a human activity, the attempt to understand natural facts is a cultural activity. A chimpanzee's understanding of nature is only arguably cultural and certainly much less accessible (Povinelli 2000).

"the fact that some of the most physically diverse types of mankind are well nigh indistinguishable from one another [serologically] is very discouraging" (p. 490). Likewise, Alfred Kroeber's (1933) general textbook notes, "It is clear that we have in these blood group occurrences an astonishing set of data which may yet profoundly modify the current ideas of race relationships, but which for the present are more provocatively puzzling than illuminating" (p. 12).

In fact, through the 1960s, genetic (serological) data would be interpreted as revealing the "true" races (Boyd 1963) and would not be reinterpreted as undermining the existence of human races until Richard Lewontin's famous 1972 paper, which followed two decades of physical anthropologists criticizing and gradually abandoning the very concept of race as a natural analytic unit (Washburn 1951, Weiner 1957, Hulse 1962, Livingstone 1962). Lewontin's conclusions have stood up remarkably well, across diverse kinds of genetic markers, but this produces an odd paradox. When the genetic data were expected to yield races, they did so, from roughly 1918 to 1972; and when the genetic data were expected not to yield races, they also did so, from roughly 1972 to the present. There is some considerable disagreement among geneticists even today about the relationship between genetic data and race (Abu El-Haj 2007, Bliss 2012), and indeed there are sometimes even mixed messages in the same work (Cavalli-Sforza et al. 1995, Rosenberg et al. 2002).

Such context dependence and multivocality on the fundamental question of race certainly does not suggest that race is an objective entity, out there to be either discovered or denied by the collection of the appropriate genetic data. Race, we must rather conclude, is underdetermined by genetics (Morning 2011). That is to say, it is genetically real when geneticists who believe it is real brandish their particular genetic data and statistical analysis (Risch et al. 2002, Edwards 2003), and it is unreal when geneticists who do not believe it is real brandish their genetic data and statistical analysis (Templeton 1998, 2013; Long & Kittles 2009). Genetics, as seemed clear in the 1930s, does not have privileged access to race (Santos et al. 2009).

Why not? Race is what allows us to see most strikingly the ontological point that frames this review. Race is not a fact of nature, but a fact of nature/culture. That is, race does not inhere in the objectively measurable data of difference, but rather in a constant negotiation between that difference and its meaning, or how much difference and what kinds of difference are taxonomically salient. Thus, the number of races of Europeans, say, may range from one (on the latest US Census, in 2010) to three (Ripley 1899) to five (Boyd 1963) to twelve (Coon 1939). None of these conclusions is more right than any of the others, for they are all coproduced by the natural facts of difference and by the cultural facts of classifying. Neither is it a case of objective data situated in a subjective or cultural context, for the data themselves are collected, analyzed, and presented culturally; thus culture pervades the facts of race (Wade 1993; Mukhopadhyay & Moses 1997; Hartigan 2008).

For example, the geneticist can measure the patterns of similarity among a sample of Irish, Armenians, and Ethiopians but cannot say whether they constitute one kind of people, two kinds of people, or three kinds of people. The information that there are three kinds of people to be sorted by the study is loaded into the sampling. The samples themselves are coded by nationality, which is itself a cultural category, raising questions of inclusion. How Armenian do you have to be to be noticed by the geneticist? A similar issue exists for other cultural categories of people: In 1950, Kluckhohn & Griffith observed that a genetic study of Navajos highlighted the genetic purity of the people sampled, whereas a knowledge of the ethnohistory of the specific community and the families showed quite the opposite. Furthermore, what does it mean to identify differences between two groups of people? If one looks closely enough at any two groups of people, one can characterize and tabulate their average genetic difference; but the ability to do so says nothing about race. And finally, we come to the question of representation: What is each sample sampling (Braun & Hammonds 2008)? Are the Ethiopians intended to stand for "Africans"? Is that reasonable?

What kind of sample would be adequate to represent "Africans"? Twenty African Americans (Cann et al. 1987)? Ninety-five pygmies (Bowcock et al. 1991)?

The point, once again, is that race is nature/culture. Another way of saying it is that just as protons are facts of nuclear physics, and amino acids are facts of biochemistry, races are facts of anthropology. The 200-year mistake, from roughly 1760 to roughly 1960, was to think that human races were biological facts, like salamanders, rather than anthropological facts, like mother-in-law avoidance. Indeed, recent work is showing that the most productive anthropological context for understanding race may lie in the domain of kinship, the constructed knowledge of relatedness, a classical locus of nature/culture, of interwoven biological and nonbiological information (Wade 2002, 2007; Palmié 2007; Zerubavel 2011; Fields & Fields 2012).

GENOMICS AND OUR PLACE IN NATURE

Not only is race understood as nature/culture, but so is another of the most well-known facts of "molecular anthropology": that of our intimate genetic similarity to the apes. In its strongest form, this genetic similarity to the apes means that we are apes (Diamond 1992) and, indeed, that chimpanzees should be classified in the same genus (*Homo*) as humans (Wildman et al. 2003). In the area of primate genetics, where the connection to anthropology may sometimes appear to be tenuous, normative research continues to be carried out on questions of systematics (Steiper & Young 2006, Jameson et al. 2011, Perelman et al. 2011, Scally et al. 2012), microevolution (Newman et al. 2004, Locke et al. 2011), demography (Bradley et al. 2005, Hernandez et al. 2007), speciation (Zinner et al. 2011), and evolutionary morphology (Willmore et al. 2009). The cultural issues of taxonomic inflation and conservation notwithstanding, however, the closer one gets to humans as scientific objects, the more biocultural the endeavor becomes.

Of course, all peoples theorize themselves in relation to the animals they know. The intimate similarity of the form of human and ape was familiar to European scholars well before Darwin but was not considered to be the result of genealogical descent until the nineteenth century. Today, our "place in nature" is often given with reference to the discovery in the 1980s that we are apes genetically, a fact deduced from data that had actually been known in one form or another for about a century (Nuttall 1904, Hussey 1926). The data showing that we are apes genetically, however, had previously been balanced by the recognition that we are not apes ecologically, anatomically, or behaviorally. In other words, our place is established dialectically, being both "apes" and "not-apes" simultaneously (Marks 2002). As Thomas Huxley (1863) put it in the very first book on the subject, we may be "from" the apes without necessarily being "of" them (p. 130).

The idea that our place in some natural order ought to be understood solely by reference to our blood (more or less equivalent to our genes and our DNA) was a fringe perspective in the 1960s (see Simpson 1963, Buettner-Janusch & Hill 1965), which had gradually become acceptable as a scientific description of human identity by century's end (Diamond 1992), justified by the reductive technical and rhetorical successes of molecular genetics. Thus, we were not always apes; in a significant sense we became apes as the Human Genome Project ascended. To understand our place in nature entails confronting the historical and theoretical conceptions of "nature" that underlie establishing "our place" within it.

Epistemologically, our identity as apes hinges on privileging the genetic similarity over the ecological difference. Who would say "nature" is reducible to "genetics" (aside from self-interested geneticists)? Certainly not the evolutionary "synthetic theorists" of the mid-twentieth century (Huxley 1947, Simpson 1949). If "evolution" refers to the naturalistic production of difference, then to say that we are apes is equivalent to denying that we have evolved. Or to put it another way, if evolution is descent with modification, then our ape identity implies descent without modification.

Unsurprisingly, a backlash has been forming within the scientific community, emphasizing in part whether the 98–99% genetic similarity is too high, perhaps by failing to account for insertions and deletions and repetitive DNA, which may cause the familiar anatomical differences (J. Taylor 2009, Cohen 2010). Actually, the problem lies not with the accuracy of the number itself, but with linearizing biological relationships through DNA similarity, privileging genetic relationships over other kinds of relationships, and privileging ancestry (which genetics reveals efficiently) over divergence (which it does not). That is, there is far more evidence for the genetic proximity of humans to the African apes than there is for the genetic basis of bipedality or language, which we do not really know how to access (King & Wilson 1975). In other words, "we are apes" is a natural/cultural fact, not a natural fact.

HUMAN POPULATION GENETICS

The phrase "anthropological genetics" was coined by Derek Roberts (1965) to refer to the study of the microevolution of traditional, "anthropological" peoples, with a theoretical grounding in population genetics. Although some early genetics researchers believed that human behavioral diversity indeed had a large genetic component, they did not think that they were actually studying it; rather, they were studying surrogate genetic variations or genetic markers. The interpretation of the patterns of variation in these genetic markers in extant human populations remains the primary research area of anthropological genetics (Crawford 2007), although they are rapidly being augmented by studies of ancient DNA and whole genomes.

Some famously high-profile conclusions from human population genetics have not been very well substantiated: for example, the origins of Native Americans in three separate waves of migration (Greenberg et al. 1986),[4] full species differentiation of Neandertals (Cann et al. 1987), and microcephaly genes explaining the purported cognitive deficits in Africans (Mekel-Bobrov et al. 2005). In some cases, alternative historical processes yield predictions about human diversity that differ only subtly from one another and consequently require esoteric statistical treatments to identify the potential signals of evolutionary history (Sabeti et al. 2002, Wang et al. 2006, Williamson et al. 2007). For example, the crude observation of reduced allelic variation is a prediction of both genetic drift (as founder effect, yielding nonadaptive change in the genome) and natural selection (as a selective sweep, yielding adaptive change in the genome). The subtleties of the patterns in the data and in the predictive models and interpretations create epistemological issues that are not easily resolved, resulting in conclusions that are not so much probable as plausible. Thus, evidence of human-Neandertal admixture (Green et al. 2010) may also be explicable in other ways (Eriksson & Manica 2012). Jobling (2012) complains of "historical cherry-picking" (p. 794) in the ways that population geneticists often invoke history to explain genetic patterns, a process that produces consistency arguments rather than strong conclusions (see also Egorova 2010, Thomas 2013).

Some recent work, combining genomics and bioinformatics, has revisited classic themes in biological anthropology, such as the origin of the Eurasian gene pool (Henn et al. 2011), prehistoric demography (DeGiorgio et al. 2009; Li & Durbin 2011), and the origins of Neandertals, Native Americans, and Jews (Reich et al. 2010, 2012; O'Rourke & Raff 2010; Behar et al. 2010). Most normative anthropological research in this area, however, tends to focus on questions of local

[4]Reich et al. (2012) recently inferred at least three waves, not independent of one another, from a sample consisting almost entirely of South American Indians.

microevolution and its increasingly explicit biocultural aspects (Kaestle 2003, Bolnick & Smith 2007, Clark & Cabana 2011, Gokcumen et al. 2011, Vitti et al. 2012).

BEHAVIORAL GENETICS

In contrast with discussions in the previous section, the field of human behavioral genetics has existed largely independently of anthropology since Earnest Hooton's poorly received work on "criminal anthropology" (Merton & Montagu 1940) and "constitutional anthropology" (Seltzer 1950, Rosenbaum 1995, Rafter 2004). This field is now principally an outgrowth of psychology, and unlike other areas of genetics, its methodologies are not so much mechanistic as correlational. These tend to be dominated by three epistemologically problematic approaches. The first approach is the inference of an innate genetic cause for cognitive differences between groups, based on the measurement of heritability, which is a descriptive statistic of a single population and is thus spurious as an explanation for the difference between populations (Jensen 1969, Lewontin 1970, Block 1995, Rushton & Jensen 2005, P.J. Taylor 2009, Stenberg 2013). The second approach is twin studies, which have proven to be far more valuable to epidemiology than to psychology; psychology has been dominated by the infamously fraudulent (Burt 1966) and the anecdotal and flatly incredible (Holden 1987, 2009; Joseph 2002).[5] And third is the invocation of an unrealistic model of human biology, in which the influence of genes is a subtractive residual, a result of holding environmental variables presumably constant and attributing the remaining phenotypic variation to heredity. In practice, this approach has tended to involve defining the scope of relevant environmental variables too narrowly, failing to confront developmental subtleties, and attributing spurious genetic effects to the remaining vacuum. This practice has been criticized in both behavioral and epidemiological contexts (Gravlee & Mulligan 2010, Keller 2010). Consequently, much of the work in this area does not meet the standards of reliable inference presumed in mainstream science (Kaplan 2000, Moore 2002, Wensley & King 2008, Charney & English 2012). This creates a paradox: In an era of intense reaction against a perceived antiscience attitude among the public, many geneticists nevertheless reject much of the basic epistemology of human behavioral genetics (Lewontin et al. 1984, Beckwith & Alper 2002, Coyne 2009, Rosoff 2010).

The paradox is resolved by recognizing that the problem, once again, lay in imagining that this work consisted of "natural" facts that were being discovered and injected into a "cultural" framework. By regarding human behavioral genetics instead as a set of natural/cultural facts, that is, with cultural values and issues loaded into the science—into the production of the facts themselves—we can make sense of scientists' apparent rejection of this science. The facts do not just appear; they are produced, and their production becomes a relevant aspect of the facts themselves. Indeed, how any scientific facts are produced is the crucial determinant of their truth-value. That involves an evaluation of methodology: For example, was the appropriate statistical test used?

Narrowly defining the variables relevant to the production of genetic facts, however, places the onus on the skeptic, where it should not reside in the scientific process. It should never have been up to the critics of *The Bell Curve* (Herrnstein & Murray 1994), for example, to determine

[5] Most influential has been the Minnesota Study of Twins Reared Apart, which publicized the amazing similarities of reunited twins—marrying women with the same name, divorcing them, and doing it again, or both being firefighters, etc. Nevertheless, these data, even if naively taken at face value, have nothing whatsoever to do with the twins' genetic similarity. The psychology researchers, however, have been reluctant to acknowledge this fact (e.g., Segal 2012). Heavily subsidized by the notorious Pioneer Fund (Tucker 2002), this misdirection allowed the twin study to advance a racist goal with nonracist data, by purporting to show that (decontextualized) "intelligence" is strongly influenced by genetics and thus by implying that differences between populations in test scores must be facts of nature (Rushton & Jensen 2005). Bound up with right-wing ideologies, and a thoughtless approach to genetic inferences, ultimately the scientific value of this body of work is very unclear.

precisely what was wrong with the study. That represents a frightful waste of time, energy, and resources. And because most of its arguments were recycled from the previous generation, there were really only two things in its favor: the short memory of the public, even the scholarly public; and the political resonance of its message (Marks 2005).

The science of human behavioral genetics is inherently politicized in a critical way. There are two polar explanations to the question that people have asked since the emergence of large-scale social inequality, about 10,000 years ago: Why is there large-scale social inequality? One answer might be that the inequality is the result of injustice: a long history of institutionalized evils, in consequence of which one might choose to work in the service of social justice (Marx 1867). Another answer, however, might be that the inequality is real, but not unjust. The haves have more than the have-nots because they deserve more, and they deserve more because of their inherent virtues (Gobineau 1853). In this scenario, the consequence is to search for the nature of those inherent virtues. To the first answer, genetics is irrelevant; but to the second answer, it may well be relevant.

It is hardly a profound revelation that finding a positive result for an interested party necessarily calls the quality of the scientific result into question; at the very least, that is why epidemiologists and psychologists try to do double-blind experiments (Goldacre 2009). Thus, whether the work in human behavioral genetics is funded by a politically interested party (Lane 1994, Lombardo 2002, Tucker 2002) ought to be just as relevant for evaluating the credibility of a scientific claim as is the choice of appropriate statistical test. In the case of human behavioral genetics, it is not a case of politicizing naturally unpolitical facts; it is that the science itself is inherently politicized (Fujimura 2006). A recent study indeed suggested that judges reduce sentences by about one year if they believe there is a biological cause of the crime (Aspinwall et al. 2012). The facts, once again, are natural/cultural.

GENOMICS AND BIOETHICS

The facts of anthropological genetics are politicized in a fashion different from those of human behavioral genetics, which became clear in the 1990s. The collection of blood from native peoples had been proceeding on a small scale for decades; however, in the wake of the Human Genome Project, human population geneticists attempted to recruit support for a large-scale program to collect and analyze the DNA of indigenous peoples, the Human Genome Diversity Project (HGDP) (Cavalli-Sforza et al. 1991). Unfortunately, it came at a time in which the ownership of the body parts of indigenous peoples was being actively contested; the Native American Graves Protection and Repatriation Act (NAGPRA) was passed the year before the HGDP proposal.

The politics of collecting, of objectification, and of exploitative colonial practice, which had long been invisible to scientists, were now casting large shadows in the light of NAGPRA. The HGDP protested that others were politicizing the project, resisting acknowledgment of the highly political nature of the project they were proposing (Gutin 1994, Barker 2004, Small 2006). Intellectual issues ranged from the reification of tribe and race (Reardon 2004), through the commodification of the body (Lock 1994, Cunningham 1997, M'Charek 2005), and into fundamental bioethical issues of consent by individuals and the groups they represent (Greely 1998, Juengst 1998).

Although many genetic and medical researchers have worked closely and conscientiously with native peoples, few formal guidelines existed in anthropological genetics in the 1990s, and even other scientists were privately scornful of those who seemed to fly in, say anything to collect samples, and fly out again (Anderson 2008). The scientific practices were explicitly called into question in the early 2000s, when the Havasupai sued Arizona State University over the use of blood samples collected with the understanding that they were to be used to search for a cure for diabetes. The samples, however, were piggybacked onto other research projects (notably, on

studies of schizophrenia and population structure) without the tribe's knowledge or consent, which they maintained they would not have given if they had been informed. The principal investigator maintained that she was merely following standard scientific practices in this area. The case was settled out of court in 2010 and is not a legal precedent, but it is a bioethical precedent: The scientific practices of the 1960s, which framed the HGDP proposal in the 1990s, do not stand up in the twenty-first century (Marks 2010, Reardon & TallBear 2012).

The failure to acknowledge the nature/culture of this scientific work is what ultimately undid the Diversity Project; it attempted to maintain a separation between the natural facts and their ostensibly political context, and it wanted to work with the former but not with the latter. It could not; for again, the science is nature/culture. The HGDP's perceived bioethical design flaws that prevented it from receiving federal funding apply less to the Genographic Project, which is privately funded but is still saddled with unresolved questions about consent, disclosure, obligation, and exploitation (Harmon 2006, Nicholas & Hollowell 2009). The principal operational innovation of the Genographic Project is the development of a marketable product, namely, ancestry (Wald 2006, TallBear 2007).

The biocultural facts of ancestry form the basis of the oldest research problem in anthropology, namely, kinship, newly revitalized in the age of genomics (Strathern 1992, Franklin & McKinnon 2001, Carsten 2011). Among the most interesting aspects of genomics is the manner in which its scientific authority is mobilized to reify, naturalize, and retail ancestry (Bolnick et al. 2007, Lee et al. 2009, Fujimura & Rajagopalan 2011). A racialized ancestry in particular is at the center of ancestry informative markers, or AIMs, which provide a series of reference points by which to compare the client's DNA to a panel of geographically identified DNA samples. By assuming the genetic purity of the samples, the client's geographical "ancestry" can be statistically estimated as a function of its similarity to the reference samples (Fullwiley 2008). Within limits, the technology can be creatively applied to the study of admixture in human populations. But a company such as "23andme" can also market "your continental origins revealed" as, say, 64% European, 33% African, and 4% Asian (**https://www.23andme.com/ancestry/origins**). These conclusions depend crucially on cultural assumptions about the naturalness of the continents, the sampling of the reference populations, the demographic history of ancient populations, and the particular algorithm used. In short, there is no reason to think that the racialized results, which are highly culturally meaningful, are readily scientifically meaningful (Koenig et al. 2008, Tattersall & DeSalle 2011) or that they yield a more accurate view of one's ancestry than may be gained by looking in the mirror.

Another market for ancestry involves exploiting the clonal inheritance of mitochondrial DNA (mtDNA) and Y-chromosome DNA (the nonrecombining part of the Y, or NRY). Unlike most chromosomal DNA, the client is not a genetic mixture of both parents for these two small bits of DNA, but is, instead, genetically identical to one parent and unrelated to the other. Rather than estimate the client's similarity to reference samples, the client's DNA can be directly matched to the reference samples. A match of your mtDNA to that of an Italian might mean that your mother's mother's . . . mother came from Italy. But the inference of genetic ancestry on the basis of this match depends on the exclusivity of the match—that ancestor might have been from Tunisia or Greece, whose gene pools extensively overlap those of Italians. More interestingly, from the standpoint of kinship, is that the genetic trail is present only in one ancestor every generation. In other words, from the standpoint of mtDNA, you are a clone of your mother and unrelated to your father, but your mother was also a mitochondrial clone of her mother and unrelated to her father. Thus, in your grandparental generation, you are unrelated to three grandparents and are a clone of the fourth. Likewise, you are a mitochondrial clone of one great-grandparent and unrelated to your other seven.

Clearly, this is not ancestry in any meaningfully naturalistic sense, aside from a bit of genomic arcana, a tiny and trivial portion of DNA used as a genetic marker, an estimator of ancestry (Bandelt et al. 2008). Given that its meaning vertically or transgenerationally is far from transparent—with only one mtDNA ancestor per generation—then what might it mean horizontally, to share the same mtDNA with someone alive today? The attribution of meaning to a DNA match can be considered a form of biosociality (Rabinow 1992, Gibbon & Novas 2008) and has proven to be marketable as an indication of membership in a fictive descent group from a 20,000-year-old European "clan mother" (Nash 2004); as fictive African tribal membership for African Americans (Nelson 2008); or as descent from "Genghis Khan, President Jefferson, and other historic personalities" (**http://www.rootsforreal.com/service_en.php**).

The Y chromosome of the Cohanim is particularly interesting in this context because it reflects the similarity of Y chromosomes of a sample of Jews who claimed to be scions of the ancient Jewish priestly line, often expressed by the surname Cohen or its cognates. The initial publications (Skorecki et al. 1997; Thomas et al. 1998, 2000) traced the origin of the lineage through its biblical account to Aaron, the brother of Moses (whose Y chromosome he would naturally have shared).[6] Yet it is a classic fact of human biology that people who tend to have similar surnames tend to be more genetically similar to one another, a situation known as isonymy, a noninvasive estimate of inbreeding (Swedlund 1975). Moreover, the characters of Exodus would certainly seem to be a weak basis for a DNA source. Interestingly, the Cohanim Y chromosome would also be that of the Genesis patriarchs, through the genealogy given in Exodus 6, and would even be the Y chromosome of Adam, from the genealogies in Genesis 5 and 11. Thus, leading science journals interpreted genomic data casually as validating a biblical origin myth, and apparently nobody noticed or cared: nonsense as science (Zoossmann-Diskin 2000, 2006), fascinating as science studies, sensible to both as a set of natural/cultural facts. The Cohanim Y chromosome has also been used to assert the crypto-Jewish origins of the South African Lemba people (Parfitt & Egorova 2005, Abu El-Haj 2012).

The popularity of *The Immortal Life of Henrietta Lacks* (Skloot 2010) called attention to the nature of consent and the exploitation of people's bodies by biomedical interests. The HGDP raised parallel concerns regarding indigenous people (Greely 2001). Was there any benefit to the participant for participating, or was this science for the exclusive benefit of scientists (Annas 2001, 2006)? If the participants do not benefit from the science, then who does? And if there are profits, how is science advanced by not sharing them with the participants? Is the DNA of native peoples just another natural resource to be transformed technologically into something valuable for somebody else? And is a standard consideration of individual risk and benefit adequate to speak to this larger issue of social objectification and exploitation?

The normative practice of sharing genetic materials among laboratories, and of piggybacking different kinds of studies on a common set of samples, to which the donors had not consented and of which they had not been apprised, was called into question most recently by the Havasupai case (see above). Biological anthropologists, and particularly human biologists, who have strong and long-standing relationships with other peoples, are the vanguards of a reconceptualized and renegotiated ethical practice in the genetic/genomic studies of human populations (Turner 2005, Marks & Harry 2006, Pálsson 2008). This issue will, of course, become increasingly collaborative, as people once construed as isolated or indigenous gain increasing access to cyber-literacy and develop an interest in tracking the results of their research participation.

[6]"The priestly caste of the Cohanim are thought to have the same Y chromosome as the biblical Moses, because Aaron, Moses' brother, founded this priesthood, whose duties traditionally pass from father to son" (**http://www.rootsforreal.com/dna_en.php**).

HEALTH AND GENOMICS

The field of health and genomics is particularly known for extravagant promises (Brown 2003, Fortun 2008, Pang & Weatherall 2012). In the absence of viable systems of "gene therapy," the contribution of genomics to health is most significant at the diagnostic level. The diagnostic tools, however, are commonly privatized—most notably, Myriad Genetics's test for the alleles associated with elevated risk of breast cancer, *BRCA* (or *BRAC*) *1* and *2* (Cook-Deegan & Heaney 2010).[7] It would be highly misleading, at least from an anthropological perspective, to observe the DNA breakthrough without noting the poor relationship between diagnosis and cure, confronting the economic and medical consequences of monopoly, and questioning the distribution of benefits of the breakthrough. And that is without even considering the paradoxical public identity of breast cancer as a "genetic disease," when only a small proportion of cases are in fact attributable to genetic causes at present (Gibbon 2002).

Human biology, since at least the work of Franz Boas, has taken note of the influence of the conditions of life on the form of the body. Indeed Boas's German mentor, Rudolf Virchow, studied the influence of the conditions of life on the body and consequently pioneered work in pathology, epidemiology, and public health. Although genotype is indeed a predictor of many health risks, the conditions of life—nationality, income, occupation, education, clean water, fresh air, exercise, hygiene—predict much more (Fullerton et al. 2012). To the extent that racial disparities exist in health-related measures, such as life expectancy, these are easily attributable in the main to social disparities (Goodman 2000, Outram & Ellison 2006).

In some cases, however, the attribution is less obvious. The best controlled and most rigorously interpreted work points toward subtle, sometimes multigenerational, effects of the conditions of life (i.e., nongenetic etiologies) on those health risk disparities, such as low birth weight and hypertension (Kaufman & Hall 2003, Dressler et al. 2005, Deo et al. 2007, Kaufman 2008). In classic human biology, this measurement would be an expression of "human adaptability" (Kaplan 1954, Lasker 1969); in evolutionary genetics, it is "developmental plasticity" (Bateson et al. 2004, Gluckman et al. 2007); and in epidemiology, it is "embodiment" (Krieger 2005, Gravlee 2009, Kuzawa & Sweet 2009). What all three concepts express is the overwhelming effect of the environment (broadly defined) in explaining significant biological differences among human groups.

In the context of racial differences in health risks in the United States, the known genetic disparities are so rare that one can say quite reasonably that the only legitimate reason to use race in the biomedical contexts is to try to address issues of racial justice.[8] There are, however, conflicting interests in the convergence of race and medicine that need to be recognized, for they tend to favor the act of naturalizing racial differences as genetically based, when in fact they may not at all be genetic (Fullwiley 2007, Rose 2008).

The first such conflict is political: To acknowledge racial health differences as social in cause, the result of inequalities, rather than as genetically caused, the result of differences of nature, is to suggest a source of blame and a course of action. The innatist explanation, on the other hand, lays the blame for the problem of racial disparities at nobody's feet and indeed may deny that there is a problem at all—simply unfortunate facts of life (Leroi 2005). Thus, no solution may be called for. The naturalized explanations for racial health disparities may consequently be convergent with a conservative social and political agenda (Satel 2002).

The second conflict is economic. Race provides a commonsensical "niche market" for pharmaceutical interventions (Duster 2007). The reality is that the kinds of genetic polymorphisms that

[7] The Supreme Court unanimously ruled against Myriad's patents in June 2013.

[8] J. Kahn, personal communication.

might render people more or less susceptible to the activity of a drug are not patterned racially. That is, such an allele would not be present in 100% of Koreans and 0% of Senegalese but rather might be present in, say, 23% of Koreans and 51% of Senegalese. Any relevant intervention would have to be predicated on the individual's genotype, for which race would inevitably be a very poor predictor, because someone in either population can have a good chance of having either allele (Cooper et al. 2003). Racialized medicine is thus not a step toward individualized medicine (Root 2003, Fujimura et al. 2008); for a patient, race (or more broadly, ancestry) is at best a diagnostic aid, as a statistical indicator of certain elevated health risks for diseases such as cystic fibrosis, thalassemia, sickle-cell anemia, or familial dysautonomia (Wailoo & Pemberton 2006). The introduction and marketing of BiDil in 2005, as a cardiovascular intervention for black patients, was not at all a philanthropic public health measure. Its racial aspect served as the basis on which to extend its patent protection; there was never any epidemiologically valid evidence that it worked better or differently in blacks than in anyone else; and it drove its owners to financial ruin not because they were giving it away but because they grossly overpriced it (Roberts 2011, Kahn 2012).[9]

Like other genetic facts, then, genetic facts in health care need to be regarded as natural/cultural facts and, thus, subject to different standards of validation than, say, ordinary facts of nature.

EPIGENETICS

By the late 1930s, the developmental geneticist C.H. Waddington (e.g., 1938, p. 156) was formalizing a distinction between the kind of information in a human cell that distinguishes one person from another (genetic) and the kind of information that distinguishes one cell type from another, with identical DNA sequences (epigenetic). Both kinds of information are stably transmitted across cell generations. But unlike the nature of epigenetic information, the nature of the genetic information began to be revealed in the 1950s in the structure of DNA.

A generation ago, the Human Genome Project's interest in DNA sequence was accompanied by crude reductive hereditarian "geno-hype" (Holtzman 1999). Although that interest has hardly abated, epigenetics reminds us that nucleotide sequence is not all there is (Bonduriansky 2012). Epigenetics examines the effects of environmental stresses upon the expression of DNA and the stable transmission of those effects. Epigenetics, like other aspects of human heredity, is biopolitical, and to understand the pendulum swing toward it, one must view it in the context of the anthropology of kinship. The central question is, what is the relationship between you and your ancestors? The stronger and more deterministic that bond is perceived to be, the greater validity the ancient social inequalities—whether based on race, ethnicity, caste, or lineage—will seem to have. This was indeed a lesson implied, either directly or indirectly, by James Watson and Reginald C. Punnett (quoted above), and by many other geneticists of different generations, making "objective" inferences about the role of the science of heredity—or in contemporary terms, DNA sequence—in modern life (Nelkin & Lindee 1995).

In what ways are your own possibilities not constrained, channeled, or determined by your ancestors? Here, the science has traditionally been aligned with more progressive politics (Bowler 1989, Müller-Wille & Rheinberger 2012). To some, this freedom from one's ancestors could be approached scientifically through the study of culture (Tylor 1871). To others, it came from the

[9]Although they are tangential to anthropological genetics, the problematic Malthusian arguments supporting genetically modified foods can certainly be seen as a health issue. Like the case of BiDil, the public good would be the ostensible motivation for supporting practices that are actually intended to boost corporate profits. Nevertheless, the actual need for the corporate product is unclear (Stone 2002, 2010), in a world of obesity, farm subsidies, and differential access to existing resources.

inheritance of acquired characteristics, or neo-Lamarckism (Bowler 1983, Koestler 1971, Vargas 2009). And to still others, it came from the study of human adaptability. In the twenty-first century, epigenetics focuses on externally stimulated modifications to DNA structure, which affect gene expression and consequently are expressed phenotypically but are inherited stably. Consequently, they can produce multigenerational physical changes in direct response to the conditions of growth and development. In short, descendants can be quite physically different from ancestors, even over a scale of one or a few generations (Bateson et al. 2004), without a concurrent change in the gene pool. Of course, anthropologists have known for more than a century that it happened (Shapiro 1939); epigenetics tells us how it might be happening biochemically.

CONCLUSIONS

The collection and analysis of genetic data have been augmenting anthropological knowledge for several decades. The development of new technologies, such as ancient DNA analysis, promises a long and continued synergy for the two fields. The purpose of this review has been to bring genetic facts within the purview of anthropological knowledge and theory and to help situate and comprehend them within anthropology, rather than attempting to apply them to anthropology as if the facts of human genetics/genomics could be segregated as value-neutral and noncultural.

Anthropology has always been fundamental to understanding human genetics. For example, the Manoilov Blood Test, which could purportedly determine sex, race, and sexual preference and was written up quite credulously in mainstream journals in the 1920s (Satina & Demerec 1925, Manoiloff 1927, Poliakowa 1927), was dismissed out-of-hand by physical anthropologist Earnest Hooton on the simple grounds of its impossibility. Hooton wrote in his 1931 textbook, "The results of the Manoiloff test do not inspire confidence. . . . It is inconceivable that all nationalities, which are principally linguistic and political groups, should be racially and physiologically distinct" (p. 491). The test defied the patterns of human variation, and thus could not be real, although Hooton (e.g., 1926) would certainly have been the first to welcome a foolproof test of racial diagnosis. By contrast, a genetics textbook published the same year casually told students, "According to Manoiloff, the oxidizing process in a certain blood reaction occurs more quickly in Jewish blood than in Russian blood; tests of race based on this difference proved correct in 91.7 per cent of cases" (Schull 1931, p. 299). To see the Manoilov Blood Test as a set of natural facts is to miss what was really significant about it (Naidoo et al. 2007): that the test identified patterns imagined to exist in the blood (e.g., Jewish versus Russian identity, homosexual versus heterosexual) with the same facility as it identified patterns that indeed might be hematologically discernible (e.g., male versus female).

To evaluate genetic anthropological facts involves interrogating and comprehending not just their materials and methods, but also their source in relation to other kinds of knowledge and manipulations of heredity: folk, religious, political. Even the boundaries of the human species itself are increasingly being challenged genetically (Cavalieri & Singer 1993, Rossiianov 2002, Alter 2007). There are multiple cultural meanings and vested interests in genetic facts, and to confront their concealment is the start of an anthropological understanding of the science of human heredity (Martin 1990).

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