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Race in an Epigenetic Time: Thinking Biology in the Plural

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A substantial body of literature in sociology and anthropology successfully challenges the naïve optimism whereby the completion of the human genome project assigns race and racialized categories to the status of relics. (Duster 2006; El-Haj 2007; Bolnick 2008; Roberts, 2011; Montoya, 2011; M'charek, 2013; Kahn 2013; TallBear 2013; Fullwiley, 2014; Bliss, 2015). As Troy Duster has urged in this journal, new postgenomic developments, in disciplines ranging from forensic science to pharmacology, "have actually served to re-inscribe race as a biological category" (2015).

This critical literature has been hugely helpful in describing how race is constructed molecularly in light of today's understandings of biology. But we should question the narrative of *re*-inscription and the future visions it yields. When addressing the biological race concept, these texts speak of "return" (Frank, 2015), "resurgence" (Wailoo, Nelson, and Lee 2012; Frank, 2015), "redemption" (Morning, 2011), and even "resuscitation" (Duster, 2015). On this way of thinking, something—race as a biological concept—was "buried alive" (Duster, 2001), i.e. "not

decisively finished off" (Morning, 2011) and is today recreated or "repackaged" (Roberts, 2011). We have failed to "move beyond all that" (Morning, 2014) and are therefore "back to the future" (Frank, 2015).

From this diagnosis, a certain prognosis follows. If "race as a fixed genetic characteristic" (Morning, 2014) and a "geneticized conceptualization of race" (Frank, 2015) have been restored to sociology, we should expect "*sociobiology* [to gain] a larger foothold in [the] discipline." (Morning, 2014, my italics)

This assumption that a putative renewed genetic fixity leads to a surge in sociobiological thinking reflects a mostly American tendency to identify racism and eugenics with ideas of genetic stability. This seems natural not only given the persisting allure of the gene in American culture but also the specific hard-hereditarian form the eugenic movement took in the USA. But eugenics, racism, and other oppressive biologistical projects have also drawn on *the science of unfixed characteristics*, where biology and heredity are seen as plastic and profoundly shaped by environmental influences. The reason why I mention this is less philological, and more concerned with the present. I want to raise the possibility that in this postgenomic moment history can be less unilinear that this 'resuscitation-of-the-past' view of history fears

My argument in this article is that the real "postgenomic surprise" to use Duster's term, is less a return to a *geneticized* conceptualization and more the coming to the fore of an alternative view of race, heredity and biology. This latter view is *no longer based on the seducing power of a 'gene for' worldview*; it depends

rather on a complex entanglement of environmental and biological factors in which the human body and its genome become a *porous and impressionable material*, shaped by all sorts of social pressures originating in society at large.

However, in order to fully appreciate these changes, it is important to understand exactly what happens in our postgenomic moment and how discontinuous it is from deeply established models of genetics. Indeed, some responses to Duster have highlighted this potential discontinuity of the present landscape, emphasizing how "genetics is a diverse field" (Friese, 2015) and how "the paradigm of stability [has] given way to the dominant notion of malleability" (Prainsack, 2015).

It is important to expand on these insights and show how a *continuist view of postgenomics* as a *mere prolongation of the old genomics business* conveys only a partial picture of what has been occurring in biology over the last decade. In so doing it misses some important points in the current remaking of race.

My argument will develop in three steps:

1) Recent findings in postgenomic biology, with epigenetics as a key-case, look very much like a paradigm-shift, or at a minimum, a "profound disturbance" (Lock, 2015) of the dominant understanding of biological heredity.

2) This shift has important implications in the conceptualization of race. In particular, in thinking of human heredity as plastic and unfixed, it shows the pluralistic way in which race and its social construction may be biologically framed.

3) The scenario emerging from this shift is disconcerting. On one side the novel epigenetic biology of race is fulfilling some of the desiderata of social scientists. It is a view of biology that is less genecentric, more plastic and sensitive to contextual factors. However, this shift does not always come with pleasant sociopolitical consequences. It may even imply a more pernicious potential for racialist discourses than genomics had in a recent past.

Postgenomics as a (nearly) paradigm-shift[1]

There are several parallel and coexisting meanings of postgenomics. The most widespread use of the term is merely temporal, to reflect a period inaugurated with the completion of the human genome project in 2003. Whatever occurred in genomics after this period is called 'postgenomic'. Other authors, more profoundly, focus not only on flat chronology. Some look at postgenomics as the emergence of a unifying framework for the many –omics (nutrigenomics, transcriptomics, metabolomics) that expand existing genomics (Richardson and Stevens, 2015). For others, postgenomics is characterized by the availability of new sequencing technologies by which large-scale maps and databases are obtained (Ankeny and Leonelli, 2015). Finally some scholars have looked at the political and moral economy of this novel scenario, largely coinciding with the neoliberal era (Abu El-

[1] This and the following section (until p. 16) are a condensed (and very simplified) excerpt of Chapters 7 and 8 of my Political Biology (2016).

Haj, 2007), where individual risk (Rose 2007) and self-optimization are emphasized (Mansfield, 2012).

I'd like instead to suggest a different reading of postgenomics as a different "style of reasoning" (Hacking 2002) compared to genomics. Postgenomics means an unprecedented temporalization, spatialization, permeability to material surroundings, and plasticity of genomic functioning. It refers to a radical rethinking of the ontology of the genome and even a dismissal of its role as the prime mover in biological processes (Griffiths and Stotz, 2013). It is the emergence of what has been called the "postgenomic genome": "an exquisitely sensitive reaction mechanism", whose borders with the environment are increasingly porous, and almost impossible to establish (Keller, 2015).

There are many entry points to distinguish between genomics and postgenomics but I take growing claims of a return of soft-heredity (Hanson, Low, and Gluckman, 2011), driven by the ascendancy of epigenetics, as the clearest marker for a postgenomic paradigm-shift. A little terminology is helpful. Hard heredity is the idea that the hereditary material is impervious to environmental signals. Twentieth century genetics has been largely the story of the consolidation of hard heredity (with genetics), and the disproof of any formative environmental influence on the gene (Meloni, 2016). The Central Dogma (i.e. information going one way from DNA to protein and never in reverse) was constructed by molecular biologists in the 1950s to convey exactly this meaning: there is "no direct route by which the environment could imprint on DNA" (Lappé and Landecker, 2015).

Soft heredity (a contested and somehow imprecise term) is for brevity the opposite, heretic, view: it refers to the idea that the hereditary material is affected by the parents' or grandparents' lifetime experiences, not fixed at conception (Bonduriansky, 2012; Jablonka and Lamb, 2005). This view, largely popular until the rise of genetics, was repeatedly challenged and nearly forgotten in the twentieth century for both scientific and political reasons. Its incompatibility with the notion of a stable genetic material seemed obvious (Meloni, 2016).

However, the quest for mechanisms of nongenetic inheritance was never completely discontinued during the century of the gene, no matter the difficult context in which it was pursued (Sapp, 1987). The current return of interest in epigenetics is the last episode of this troubled history, in which many non-mainstream authors have thought of biological heredity as more than the mere transmission of nuclear DNA.

Today, epigenetics is conventionally defined as "the study of changes in gene function that (….) do not entail a change in the sequence of DNA" (Armstrong 2014), or also phenotypic variation not depending on genetic changes (Haig, 2012). DNA methylation, a simple addition of a methyl group to DNA that can silence gene expression, is the best-known epigenetic phenomenon. Directly driven by environmental signals (toxins, nutrition, stress, socio-economic status, maternal care, parental and grandparental lifestyle) methylation is one of the mechanisms that illustrate how biological information moves two ways: not only from DNA to the cell, but also from the environment to DNA expression.

In order to argue for the emergence of a different style of reasoning via epigenetics, it is important to insist on the "exceptionalism" (Rothstein, 2013) of epigenetics compared to genetics. This exceptionalism has several dimensions, but three stands out here:

1) A new synchronism of history and the molecular

While the genome is *unresponsive* to the environment in the short term, the epigenome is a mechanism for *flexible and dynamic responses* to a changing environment, especially in certain critical windows of plasticity. For humans, the history that is impressed on their biology is not only the *longue durée* history of evolutionary time, or the signatures of macro historical events (rise of empires, huge human migrations, diasporas etc. occurred some hundreds or thousands of years ago) that today genomic admixture studies claim to detect (Hellenthal et al., 2014)[2]. The epigenome is a much more fine-grained molecular archive that synchronizes human biology to a very peculiar micro-history made of local and extremely recent events, such as diet (famine, obesity), habit (smoking, alcohol), and in general lifestyle of our most direct ancestors (parents, grandparents), or even our own social position (and variation in it), stress exposure or psychological traumas.

2) Reversibility of effects via social intervention

[2] I am not discussing here the methodological validity of these studies when they aim to make an objective history based on DNA, nor their persisting use of racial categories, see Morning 2013 for a critique.

Whereas human actions can affect genes only over a long evolutionary timescale, as in gene-culture coevolution (e.g., lactase persistence in human populations with extended milk consumption), epigenetic effects are deemed to be potentially reversible in a very limited timespan by social intervention. Many of the best-known experiments in epigenetics (Weaver *et al.*, 2005) highlight exactly this reversibility of the induced phenotype through practice or therapy. How this is operationalized in policy will be discussed later.

3) Broad unit of inheritance

While in genomics the unit of inheritance is narrow (i.e. only the nucleotide sequence is inherited), in epigenetics the whole cellular architecture, including epigenomic regulation of gene expression, is believed to be maintained for a few generations. This implies that also biological material whose functioning encodes social signals reflecting very recent micro-historical events can make its way to the next generation.

These are very important changes with profound implications for the notion of heredity. If, as some claims, we have now "a solid molecular basis for understanding how environmental influences can affect the phenotype of the next generation, or even those which follow" (Hanson, Low and Gluckman 2011) how shall we re-conceptualize inheritance in the postgenomic age? And what happens to race in this scenario? If the human genome (via epigenome) is sensitive to short historical

episodes, how is this new synchronization of history and biology reflected in the understanding of race? Regardless of the final validation of this knowledge, wider social implications are already considered.

When Race is soft: Pluralizing the meaning of Race

My point of entry to look at the present postgenomic remaking of race via epigenetics are two articles that, though speculative, may be seen as exemplar (in Kuhn's sense) of the new way of framing racial disparities in health beyond the two poles to which explanations have typically aligned so far: the genetic vs. the environmental model. These two polarized models had more in common than they believed: both thought that *biology equated with 'genetics'* and therefore *fixed and insensitive* to lifetime changes, and both believed that genes or environment were the only two explanatory cards left on the table. Both these assumptions are increasingly untenable in new epigenetic approaches.

Fragments of a new epigenetic scenario I: Multigenerational[3] effects of slavery

In 2009, the *American Journal of Human Biology* published a study on the persisting Black-White divide in mean birth weight, with African-American women

[3] There is a technical distinction in the literature between intergenerational (or parental) and transgenerational effects, with the former being shorter and limited to two generations, and the second spanning multiple generations. However, the use of transgenerational is loose, even in studies that are technically restricted only to two generations. Since usage blurs the two (see also Jasienska), I have preferred to use the less specialist term 'multigenerational'.

"twice as likely as European American women to deliver children with weight below 2.5 kg" (Jasienska, 2009). The subject is pretty common in epidemiology, but the originality of the study was in its explanatory strategy. It looked at a specific historical event, slavery, as a cause for this present racial divide:

> Since neither genetic factors nor current socioeconomic determinants can adequately explain the existence of birth weight variation between "races," other environmental, social, and historical reasons must be considered. The following observation points to slavery as the factor of potentially profound importance: contemporary black women who were born in African countries ancestral to slave populations, but who live in the United States, give birth to children with significantly higher weight than black women in the United States who have slave ancestry (16)

A connection between slavery and LBW (low birth weight) at the time seems of course plausible: maternal undernutrition and intense physical labor are obviously potential causes for smaller babies (22).

However, where is the evidence for the causal link between these past events and current racial gap in LBW? It is important to note here that the article does not claim that slavery *has been simply the initiator* of a causal process then reproduced by racist discrimination in the post-slavery period. While recognizing the influence

of contemporary conditions, the article follows a different line: life conditions in the slavery period are responsible for LBW of African Americans today. (22).

Jasienska recognizes that the specific physiological mechanisms of this long term effects "are unknown at present" (22) or "not well understood" (16). Epigenetics is flagged as the possible pathway by which "intergenerational information about environmental quality *can be passed* to next generations" (16, my italics).

Although the article's grounds may seem problematic, its claims are strengthened by two contextual factors. Firstly, its collocation in a well-established theoretical model on human plasticity in which current birth weight in human populations is seen as the effect not only of present maternal conditions, but also of "the influence of intergenerational life conditions, i.e. influences *integrated across several generations*" (16; see Kuzawa, 2005).

Secondly, the analogy established with a much more recognized empirical study of multigenerational effects with measurable impact on LBW: the Dutch Hunger Winter. The Dutch case refers to the catastrophic famine caused by the Nazi occupation in 1944-1945, and is the most well-known epidemiological study of the multigenerational effects of disease susceptibility. Health implications of the Dutch Famine are recorded up to the second generation (Painter et al. 2008) and include metabolic disorders and mental health issues.

It is mostly by referring to the Dutch case, where "women suffering from famine during the last trimester had babies with almost 300 g reduced birth weight

in comparison with babies born after the famine", that the slavery argument, inferentially, works. If a relatively-short event as the Dutch famine had consistent multigenerational effects, Jasienska, notices, how much deeper should this be for African Americans who "suffered much longer-lasting nutritional deprivation", and extreme level of energy expenditure (21-22)?

Leaving aside the scientific plausibility of these claims, my interest is here on their general narrative, intellectual context from which they take legitimacy, and some of their sociopolitical reverberations. In particular, three points stand out.

Firstly, this is not the first time that a scientific hypothesis about the effects of slavery has been recruited to explain racial health disparities. The so-called "Slavery Hypothesis" was firstly advanced as a genetics (i.e. non-epigenetic) theory to explain present US black/white disparities in hypertension (Wilson and Grim, 1991). The theory, widely criticized by historians and social scientists (Curtin, 1992; Kaufman and Hall, 2003), maintained that a selective process took place during slave transport that favored "individuals with an enhanced genetic-based ability to conserve salt" (Wilson and Grim, 1991). Only this group survived the brutal effects of the Middle Passage characterized by "salt-depletive diseases such as diarrhea, fevers, and vomiting" (ibid.,).

Second the attractive force of the article, given the paucity of its evidentiary terrain, lies in its context. Until a few years ago such claims for biological but non-genetic multigenerational effects would have seemed audacious but today they gain traction from a growing body of scholarship that has looked at how of various life

events travel inter-generationally via epigenetic mechanisms. Epidemiological studies include not only the Dutch famine, but also cases as diverse as the multigenerational effects of nutrition in North Sweden (Bygren et al., 2001), and epigenetic effects on offspring of 9/11 and the Holocaust (Yehuda et al., 2005; Yehuda et al. 2014).

Thirdly, in terms of its politics, the article confers a great emphasis to the *persistence of traumatic events*. The author is adamant on the fact that slavery effects may be very "recalcitrant" or "resistant" to present changes and not amenable to policy reform:

> "several generations that have passed since the abolition of slavery in the United States (1865) has not been enough to obliterate the impact of slavery on the current biological and health condition of the African-American population." (16)

Slavery is still, biologically, with us. As we can read further:

> *Even when the mother is well nourished herself*, an intergenerational experience which may be integrated in her own maternal physiology and anatomy, may cause her organism to follow the physiological strategy, which results in a reduced birth weight of her children (my italics).

This brings us Jasienska to some pessimistic conclusion on the lack of malleability of low birth weight. As she writes:

> "too few generations have elapsed with improved energetic status to counteract the tragic multigenerational effects of nutritional deprivation on birth weight of children". (23)

We shall return later to this dialectics between change and stabilization in plastic view of biology.

Fragments of a new epigenetic scenario II: Race as the Embodiment of Racism

A better known epigenetic approach to racial health disparities is Kuzawa and Sweet's article "Epigenetics and the Embodiment of Race" (2009). Like the previous study by Jasienska, the article takes its cues from the epidemiological puzzle of a racial gap in health between African Americans and US whites, with a focus this time on cardiovascular disease (CVD). As the previous study, it highlights the insufficiency of either the genetic or the "social forces" model. The critique of genetic explanations is particularly explicit. There is, however, a remaining aspect of a genetic model that needs clarification, in alternative (epigenetic) terms: why, despite the recognized importance of social factors, "self-identified race (…) remain[s] a significant predictor of disease outcomes in epidemiological studies, even after lifestyle and SES factors have been adjusted for statistically"?

To explain the biological significance of self-identified race however Kuzawa and Sweet don't look at genes nor at nineteenth century slavery, but at the embodiment of contemporary racism and its negative impact on maternal biology. Stressful conditions are transmitted via intrauterine environment to the next

generation programming the fetus for a higher CVD risk. Racism goes under the skin and becomes literally the biology of future generations, reproducing biological differences over time. As they write:

> social environments, defined along lines of constructed and socially imposed racial identities, can drive developmental processes, thereby becoming embodied as biological patterns that influence health and disease (11).

The key notion of the article, i.e. that racism, institutional or perceived, can harm health is far from new. There is a long tradition of biopsychosocial research on the effects of perceived racism as a key stressor producing health disparities (Clark et al. 1999). Race as a social construction has been increasingly explored as producing real biological consequences in the bodies of oppressed groups (Krieger, 1999, 2003; Bonilla-Silva, 2003; Dressler et al., 2005).

Sociologists have also been well aware of the multiple links between institutional racism and racial disparities in health (Williams and Sternthal, 2010), a topic that has witnessed a significant return in the last two decades (Williams and Collins, 1995; Massey, 2004; Williams and Sternthal, 2010). More recently, the idea of an inheritance of 'poverty', 'neighborhoods' and 'contexts' has powerfully returned in American sociology to account for the multigenerational legacy of racism, in particular in the work of New York-based sociologist Patrick Sharkey (Sharkey 2008; Sharkey and Elwert, 2011).

However, it would be wrong to equate Kuzawa's and Sweet's epigenetic approach with the notion of multigenerational effects elaborated by sociologists like Sharkey. Between the two models, developmental-epigenetic and sociological, there is certainly proximity but also some significant discrepancy.

Firstly, in epigenetic models the 'environment' is a different construct than in the sociology of institutional racism proposed by sociologists like Sharkey. Since what a fetus experiences is not the present environment but, in Kuzawa's words, "an expression of maternal phenotype", the physiology of each generation is less shaped by present environment than an average of present and past cues "sampled over decades and generations" (Kuzawa, 2005: 12-13). Plasticity does not respond to "current ecological signals, but to parental cues, which tend to integrate past environmental experience." (Kuzawa and Bragg 2011). The lingering effects of phenomena going back to previous generations *are* the present environment.

Secondly, the epigenetic or developmental approach proposed by Kuzawa is social constructionist but with an important biological counterpart. The arrow *is not only one-way from the social to the biological*: the mechanism is bidirectional. What Kuzawa and Sweet emphasize is the reciprocal interaction of social factors on biology and biological ones in shaping the milieus of future generations. The original starting point is purely environmental, but after a certain threshold biological factors become self-replicating. Biological cues arisen in response to past exposures "form part of the milieu in which the next generation develops"

(Landecker and Panofsky, 2013). Once again, this inertial model "greatly extends the 'reach' of past environments" (Kuzawa and Eisenberg, 2014).

I am not saying that sociology is unaware of the inertial weight of phenomena that are passed down through generations, cultural memories, identities, social inequalities and institutions. As Bourdieu famously wrote "the social world is accumulated history" something "not to be reduced to a discontinuous series of instantaneous mechanical equilibria" (1986; Bourdieu and Passeron, 1979).

However, this does not fully represent what is meant by an epigenetic-developmentalist model. Even when sociology moves away from a "single point in time" methodology and confronts the perpetuation of neighborhood stratification with metaphors such as "inheriting" or "lingering" onto the next generation (Sharkey and Elwert, 2011; Sharkey, 2008, 2014) it is clear that it is using a metaphorical repertoire. What multigenerational sociology describes are mostly the perpetuating effects of non-biological phenomena such as "*social* and *psychological* ties to places, discrimination, informal intimidation and individual preferences" (Sharkey, 2014, my italics). True, the "inheritance of ghetto" (ibid) can be embodied and have physiological effects. However, since these cumulative effects are given by a continuity of social signals, moving out of the ghetto (i.e. interrupting the signal) is enough to reverse their course. What parents pass to their children is still *a social context* (i.e. peers with different social opportunities: aspiration to college vs. fear of prison), not *an actual physiology* marked by the legacy of past events.

In an epigenetic approach instead the style is profoundly anti-metaphorical. Epigenetics seems to prefer a metonymy in which the abstract is turned into the physical, incorporated into the bodies of people and bequeathed to succeeding generations. It is not merely collective memories, forms of identity or cultural capital that is passed down, but a "somatic capital" or even a "metabolic ghetto" shaping the development of future generations (Wells, 2010). In epigenetics, the fact that mechanisms for persistence *are explicitly identified* makes of lingering and inheriting much more realistic notions. People are here not so much stuck in place (Sharkey, 2014) but *trapped in bodies*, an entrapment that seems more obdurate compared to other "sources of persistence" explored by sociological models.

Race is in the Plural: Reflections on a New Epistemic Scenario

The emergence of a new biological but non-genetic (i.e., epigenetic) language has the potential to reconfigure scientific investigations of race. But what about its social circulation? Although I have insisted previously on the epistemic discontinuity of postgenomics, it is obvious from the above analysis that an epigenetic view of race intersects with and perhaps radicalizes existing trends in society.

Epigenetics, by virtue of its association with studies of racial differences in health, is itself becoming racialized, like genomics before. Epigeneticists no longer look at 'genes for' to explain racial gaps in health, but sociohistorical conditions materialized in the bodies of specific groups. However, race remains an important organizing principle, as we saw above (see also at an empirical level: Zhang et al,

2011). This approach to race and disease clearly resonates with the emergence of a thought-style binding disease, risk and ancestry (Rose, 2008).

More broadly, at a cultural level, these epigenetic connections of slavery or other historical traumas to present etiologies resound with attempts at reconfiguring the genealogical past using genomic signatures (and their objectivistic allure) as evidentiary documents of human history (Sommer, 2008; El-Haj, 2012), although here there is a *sui generis* synchronization between history and the epigenetic archive, as said above.

Finally, through its investments of race, epigenetics participates in an ongoing process that "disrupts the dualisms between the social and the biological and the natural and the cultural that have been so important to the sociological account of race" (Skinner, 2007). In inhabiting a zone of passage between the social and the biological, the molecular and the molar, epigenetics further complicates questions about the biological meaning of race that persist even when race's socially constructed nature is accepted (Montoya, 2011).

However, it would be wrong to believe that epigenetics merely adds a layer of complexity to established trends and questions. New phenomena, such as the epigenetic transcription of race, always carry some of the weight of existing patterns in society, but they can also reshape these patterns. The extent to which epigenetics will alter conceptual frameworks about biology and race, biology and the social, is an open question. The problematic alignment of scientific concepts and social practices is a further problem in anticipating future directions. To gain a sense of

where we might go, and what is at stake for sociology, I will consider four different axes of race in epigenetics: ontology, epistemology, politics, and phenomenology (i.e. the lived experience of race). Given the provisional and speculative nature of much of epigenetic findings, these reflections are indicative, impressionist sketches, in a way. But they are necessary, I believe, to developing tools for an updated cartography of the postgenomic moment.

Ontology of Race

Race's ontology is caught in a curious paradox in epigenetics. On the one hand, it seems to fit more comfortably a constructionist rather than realist or naturalistic framework (in Morning's terms, 2011). Rather than "a genetically justified criteria for classifying human variation" race, in epigenetics, is "a socially constructed category" (Kuzawa and Sweet, 2009). The reason is obvious: epigeneticists look at gene expression and biology in general as effects of social structures (Landecker and Panofsky, 2013). This implies that the biology of epigenetics is not one of fixity and being but of becoming (Ingold and Palsson, 2013), routes more than roots (Wade, 2005). It is not by chance that Kuzawa frames this dynamic materialization of race using a terminology of process and emergence, such as "embodiment." Biology is the *outcome* of racialization rather than the *underpinning* of race, as a longstanding sociological and epidemiological literature claims (see Bonilla-Silva, 1999; Ossorio and Duster, 2005; Krieger, 2005).

Does epigenetics therefore vindicate a constructionist race ontology? Not completely, as we observed above. Epigenetics describes inertial phenomena of plasticity across time in which heritable effects incorporated from the environment may become *relatively stable* biological characteristics of future generations. Plasticity, after all, as in the case of sculpted marble, implies the capacity to "*retain an imprint* and thereby *resists endless polymorphism*. (..) Once the statue is finished, there is *no possible return* to the indeterminacy of the starting point" (Malabou, 2008, my italics). The one-way metaphor—from indeterminacy to closure—aptly describes how the sculpting by social events (racism, slavery) becomes durable in people's bodies. So what is race in epigenetics? A mobile social construct but one that is hardened into a biological reality. Rather than vindicating biologistical or constructionist views, epigenetics breaks apart this dichotomy. In epigenetics it is the ethnic fact – a certain commonality of cultures, material practices and historical events – that is turned into the bios of people. This is a bio-ethnical notion, but not in the sense of Montoya (2011) where biomedical *discourses* produce (conscribe) race. It is probably more similar to a certain minority tradition that saw race as the exposure to a common history of social hardship (El-Haj, 2013). These racialized events are then perpetuated by the transmission *neither of genes nor social communication*, but very material *biological memories* (Slavet, 2008). This heretic notion may not necessarily replace constructionist or genetic view of race. As in the case of the epigenetics of slavery, it may simply supplement existing genetic hypotheses (selection during the Middle Passage) on the significance of

racial differences. But it will likely add a third possible and non-oppositional card in the articulation of the biological and the social in race debates.

Epistemology of Race

How do we know race, given that the hybrid biosocial language of epigenetics upsets the social-scientific notion of opposition between race as a performative fiction and race as biology (Hobbs, 2015)? The impact of this biosocial language on the sociological imagination, and the sociology of race in particular, remains unappreciated.

A good point of entry is recent debate on the crisis of social constructionist views of race (Skinner, 2006, 2007; Hartigan, 2008; Rose, 2007; Schramm, Skinner, and Rottenburg, 2012). If constructionism's strength was in its capacity to disentangle the biological from the social, then this alleged authority is not only in general on the vane (Schramm, Skinner, and Rottenburg, 2012) but is obviously disrupted by the biosocial language of epigenetics.

Constructionism's appeal for sociology lied in an ethos of "unmasking," to paraphrase Hacking (1999; Schramm, Skinner and Rottenburg, 2012)—that is, in the case of race, in exposing the degree to which cultural or extra-scientific motives acted behind the supposed objectivity of 'biological types' or 'natural populations'.

This unmasking has occurred in several ways. First, constructionist critics have typically argued that, in accepting biological explanations of race, people neutralize or elide— "naturalize"—deeper sociopolitical factors. This implies an

opposition between genetic theories of life outcomes and theories invested in broader political context.

A second modality of constructionist critique exposes the imprint of the investigator's biases on the research material itself. In Kim TallBear's words, "The populations and population-specified markers that are identified and studied mirror the cultural, racial, ethnic, national, and tribal understandings of the humans who study them" (2013). As a result, race studies themselves reveal "the fundamentally social nature of both our perceptions and our measurements" of racial signification (Morning, 2011).

Neither of these modalities is obviated by epigenetics. Instead, though both remain important, we must recognize that they are partial and need to be recalibrated. In an epigenetic mode "histories of politics" will still "inhere in the sample" as in genetics (TallBear, 2013). The nature of this inherence differs, though, from that of the genomic, or hard-heredity, mode. In genomics, the inherence of politics can be produced via the mirroring of nationally specified ideological sources of taxonomic schemes into the classification of groups (for Canada, Hinterberger, 2012); or, through the specific history of oppression that produces distinctive populations and hence their apparently natural clustered DNA (for Native Americans, TallBear, 2013). All of these hard-hereditarian modes of inherence concern however the *form* of the genetic material[4].

[4] Even when fine-scaled genomic admixture studies measure the length of DNA segments as a way to infer historical events (Hellenthal et al., 2014) they are not claiming a *direct*

In a soft-heredity—epigenetic—mode instead, the history of oppression is believed to penetrate the *content* of the sample. The DNA of oppressed groups is not only carved out externally by a specific history of subjugation but it is also rendered internally different, at least at the level of its expression and regulation, by coercive effects (from famine to slavery). Again, these claims remain contested and so far speculative, but this is the direction in which the soft-heredity modality points. Epigenetics points to a more radical level of *conflation* of genetics, politics and history than genomics (Wailoo, Nelson, and Lee, 2012) and its effects on the politics and lived experience of race are of the utmost significance.

Politics of Race

There is a double tension in the politics of epigenetics, visibly emerging also in debates on race. The first is about the individual and the collective level of analysis. In the specific political-economy of twenty-first life sciences, epigenetics is often promoted at as the ultimate layer of personalized medicine, one that not only will tell something unique on our individuated nutritional or even psychological story but that can be also changed by social intervention, behaviour, drugs, or lifestyle. But this neoliberal and consumerist presentation is obviously in tension

relationship between those events and DNA material, but an *indirect* dating via measurement of the size of chromosome segments. The length of "uninterrupted DNA" is a measure for the distance in time of the admixture event from the present generation (ibid.) not a mark of its social impact on the present generation. To use a simplified language: in genomic studies, we can know that, as a consequence of the Arab slave trade, a certain admixture was produced at a specific time (ibid.), but not speculate on how slavery as an event has modified genetic functioning in people with long lasting consequences.

with the population logics by which many of the studies in social epigenetics have operated so far. It is often social groups (racially or class- defined) that are presented with distinctive patterns of methylation, and our two racialized cases do not escape this model (for class, see Meloni, 2016). And it is at this level of governing populations with different epigenetic markers (because of their unique history of social exposure) that we should expect the second characteristic oscillation of epigenetic science: the one between change and stability. No matter the promissory discourse of 'you can now change your genes' in popular epigenetics and the liberal interpretation of reversibility favoured by most epigeneticists today, the history of soft heredity claims in public policy is in fact much more complex and ambiguous (Meloni, 2016). Claims of degeneration of specific populations for their too long exposure to pathogenic environments have been a significant part of the eugenic experience. There is no way out of this 'racial poison' argument in epigenetics: if the epigenome is open to environmental effect, it can get the good and the bad from it. If it is closed, as in genetics, it is shielded from improvement but also disruption. Moreover, the translation of soft-heredity claims into politics will once again entirely depend on the political agenda of various stakeholders. The epigenetic slavery hypothesis can obviously be used to make claims for a better and stronger investment into the healthcare system, "providing people with special diets or other treatments that will counteract their epigenetic heritage", paraphrasing Jablonka and Lamb (2014). But it can also (and, there is no reason to doubt, it will

also) be used by racist groups to make claims about the acquired inferiority of specific populations.

Phenomenology of Race

A similar tension is reflected in the lived perception of race in epigenetics. Obviously, the impact of what I have described so far is too fragmented and embryonic to have immediate and profound impact on the wider society. We well know for instance from Morning analysis (2011) how the notion of race as a fixed genetic characteristic is still dominating education, the media, textbooks, and forensic practices. After all, it has taken decades for genetics to gain widespread currency and shape the popular imagination, so we can only conclude that more time must pass before the "epigenetics revolution" shows its greatest effects.

When this happens, when epigenetic ideas penetrate deeply public discourse, we may find they reconfigure the lived experience of race. The question is who is going to take advantage of these ideas and how. But even now we are seeing the initial "looping effect" (Hacking) of epigenetic findings on public perception.

First, as sociologists and anthropologists have noticed of genetics, the new knowledge gains "plausibility, not through any inherent power of science, but by reinforcing already-existing cultural and political forms" (Montoya, 2011; TallBear, 2013). For instance, epigenetics, by emphasizing transmission of experience effects across generations, fortify some established ways of thinking genealogical relations at the popular level (for the case of post-socialist Russia, see Leykin, 2015). Second,

as in the case of genetics, we can expect a dialectics between poison and cure (Pollock, 2012), victimization and agency. In the case of genetics, the strategic embracement of scientific data to argue for reparation or equality of opportunity, albeit problematic (Fullwiley, 2007, TallBear, 2014), has made more complex the feared passivity and oblivion of the social dimension that a "geneticization" model should imply. Genetics has also turned into "a medium through which the 'unsettled past' can be reconciled" as in the plaintiff's failed attempt to obtain reparations for the "hereditary injury" suffered by her enslaved genetic ancestors (Nelson, 2012). Such *reparative mode* is central to epigenetic knowledge, where only a few months ago the first "conclusive study" on altered methylation levels in descendants of Holocaust survivors has been published (Yehuda et al., 2014).

A significant literature in legal scholarship has already theorized the importance of thinking in terms of multigenerational epigenetic harms (Rothstein, 2009; Khan, 2010). The first epigenetic petitions for reparations have appeared. Curiously, alongside one from descendants of slaves trafficked to the Caribbean, white American southerners have also lodged an epigenetic claim to victimization by the U.S. federal government during Reconstruction (a claim that has circulated on violently racist websites). Similar claims have been made for the long-term effect of the Dutch famine and for Native populations in Canada. A report by Canada's Truth and Reconciliation Commission on decades of abuse in the country's Indian

Residential Schools, has the CBC asking, "Can Trauma Have Genetic Effects Across Generations?"[5]

Although these claims to reparation are arriving forcefully, it is impossible to know just where they will lead, whether popular understanding of epigenetics will buttress successful court challenges or inspire changes in police. And we can only speculate about how histories of political oppression will be mobilized by different stakeholders. Who, after all, is historically oppressed? As the divergent claims of slave descendants and southern whites suggest, the future of epigenetic allegations of victimhood, their impact on the self-fashioning of social groups, is unpredictable.

Conclusions: thinking race and biology in the plural

It may be time to give up debates about *race and biology* as if biology, genetics, and heredity were monolithic. Epigenetics returns us, in the language and complexity of twenty-first century molecular biology, to marginalized views of biological heredity. In light of this, all the research communities engaged in debates on race and racism, sociologists, anthropologists, biologists and bioethicists, should recognize the need to think in the plural, in terms of not of biology but *biologies*, and about

[5] See for the Caribbean petition:http://www.tribune242.com/news/2015/nov/16/caribbean-reparations/; for American southerners: https://www.change.org/p/united-states-congress-reparations-for-hereditary-trauma-dueto-us-reconstruction;for Canada: http://www.cbc.ca/radio/day6/episode-236-transgender-parenting-trauma-and-genetics-bobby-baun-gun-lobbyists-vs-bill-c-51-more-1.3098757/can-trauma-have-genetic-effects-across-generations-1.3098819

different models of genetics and heredity. As Skinner rightly notes, confronting racism means not a "denial of biology but a struggle over it" (2007). However, the struggle *is not only over biology: it is also within biologies,* i.e. alternative and often conflicting epistemologies in the life-sciences. As I have argued, this alternative understanding of the biological that comes via epigenetics will not necessarily replace more established and still pervasive genomic models. But it may add a significant diversification to the mainstream way in which biology and society have interacted. Crucially, it may also add an important variation in the way in which oppressed groups, but also racist ones, may draw on the conceptual and rhetorical repertoire of biology. This reminds us once again that it is clearly faulty to believe that biology is settled once and for all, as an extra-temporal notion, and that the biopolitical implications of any one ascendant epistemology are fixed. If social scientists are to reasonably conceptualize their prospects, they will need to be open to the possibility of a range of social impacts resulting from the same data and to the possibility that that the science producing that data is precarious. Many turns and wrinkles of biological knowledge and notions of heredity were conveniently forgotten during the century of the gene. Today, their recovery enables our visions of a contested future.

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REFERENCES

Abu El-Haj, N. 2007 'The Genetic Reinscription of Race', *Annual Review of Anthropology* 36 (1): 283-300

Abu El-Haj, N. 2012 *The Genealogical Science: The Search for Jewish Origins and the Politics of Epistemology*. Chicago: University of Chicago Press

Ankeny, R and Leonelli, S. 2015 'Valuing Data in Postgenomic Biology' **in** Richardson and Stevens (eds.) *Postgenomics*. Duke UP

Bliss C., 2015 'Defining Health Justice in the Postgenomic Era' in Richardson S. and Stevens H. (eds.), 2015, *Postgenomics*. Duke UP

Bolnick, D. 2008 'Individual Ancestry Inference and the Reification of Race as a Biological Phenomenon' in Barbara A. Koenig, Sandra Soo-Jin Lee and Sarah S. Richardson (eds) *Revisiting Race in a Genomic Age*, Piscataway NJ: Rutgers University Press

Bonduriansky, R. 2012. 'Rethinking Heredity, Again', *Trends in Ecology and Evolution* 27 (6): 330–337.

Bonilla-Silva, E. 2003 *Racism without Racists: Color-Blind Racism and the Persistence of Racial Inequality in the United States.* Lanham, MD: Rowman and Littlefield

Bourdieu, P. 1986 The forms of capital. In J. Richardson (Ed.) *Handbook of Theory and Research for the Sociology of Education* (New York, Greenwood), 241-258

Clark R, Anderson NB, Clark VR, Williams DR. 1999 'Racism as a stressor for African Americans. A biopsychosocial model', *Am Psychol.* 54(10):805-16.

Curtin, P.D. 1992 'The Slavery Hypothesis for Hypertension among African Americans: The Historical Evidence' *American Journal of Public Health* 82(12):1681–1686.

Dressler W. W. Kathryn S. Oths, and C. Gravlee 2005 'Race and Ethnicity in Public Health Research: Models to Explain Health Disparities', *Annual Review of Anthropology* 34: 231-252

Duster, T. 2001. 'Buried Alive: The Concept of Race in Science.' *The Chronicle of Higher Education* 48(3):B11-12.

Duster, T. 2006 'The Molecular Reinscription of Race', *Patterns of Prejudice* 40: 427–41.

Duster, T. 2015 'A Post-Genomic Surprise: The Molecular Re-inscription of Race in Science, Law, and Medicine', *British Journal of Sociology* 66(1): 1–27.

Emanuel, I. 1986 'Maternal health during childhood and later reproductive performance' *Ann N Y Acad Sci.* 477:27-39.

Fullwiley, D. 2007 'The Molecularization of Race: Institutionalizing Human Difference in Pharmacogenetics Practice',
Science as Culture 16(1): 1–30.

Fullwiley, D. 2008 'The Biologistical Construction of Race: Admixture Technology and the New Genetic Medicine', *Social Studies of Science* 38(5): 695–735.

Fullwiley, D. 2014 'The "Contemporary Synthesis": When Politically Inclusive Genomic Science Relies on Biological Notions of Race', *ISIS, Journal of the History of Science Society* 105(4(December)): 803–14.

Frank, R. 2015 Back to the Future? The Emergence of a Geneticized Conceptualization of Race in Sociology. *The ANNALS of the American Academy of Political and Social Science* September 661: 51-64

Gravlee, C. 2009. 'How Race Becomes Biology: Embodiment of Social Inequality.' *American Journal of Physical Anthropology* 139: 47–57.

Griffiths, P., and K. Stotz. 2013. *Genetics and Philosophy*. Cambridge: Cambridge UP.

Hacking, I. 1999 *The Social Construction of What?* Cambridge, Mass: Harvard University Press

Hacking, I. 2002 *Historical Ontology*. Cambridge, Mass.: Harvard University Press, 2002

Hanson, M., Low F., and Gluckman, P. 2011 'Epigenetic Epidemiology: The Rebirth of Soft Inheritance', *Ann Nutr Metab* 5 (8; suppl 2):8–15

Hartigan Jr, J. 2008 'Is Race Still Socially Constructed? The Recent Controversy over Race and Medical Genetics', *Science as Culture*, 17:2, 163 — 193

Hellenthal, G., J. Busby, G. Band, J. F. Wilson, C. Capelli, D. Falush, and S. Myers. 2014. "A Genetic Atlas of Human Admixture History." *Science* 343:747-51

Hertzman, C. 2012 'Putting the concept of biological embedding in historical perspective' *Proc Natl Acad Sci* 16(109): 17160-7.

Hinterberger, A. 2012 'Investing in Life, Investing in Difference: Nations, Populations and Genomes' *Theory Culture and Society*. 29 (3): 72-93

Hobbs A. 2015 'Rachel Dolezal's Unintended Gift to America', *New York Times*, Op-Ed Contributor, June 17

Ingold T and Palsson G (2013) *Biosocial Becomings: Integrating Social and Biological Anthropology*. Cambridge: Cambridge University Press.

Kahn, J. 2013 *Race in a Bottle: The Story of BiDil and Racialized Medicine in the Genomic Age*, NewYork: Columbia University Press.

Kaati, G., Bygren, L. Edvinsson, S. 2002 'Cardiovascular and diabetes mortality determined by nutrition during parents' and grandparents' slow growth period.' *Eur J Hum Genet* **10** (11): 682–8.

Keller, E. F. 2015 'The Postgenomic Genome' in Richardson S. and Stevens H. (eds.), 2015, *Postgenomics*. Duke UP

Khan, F 2010 'Preserving human potential as freedom: a framework for regulating epigenetic harms'. *Health Matrix Clevel* 2010; 20: 259-323

Krieger, N. 1999. Embodying inequality: a review of concepts, measures, and methods for studying health consequences of discrimination. *Int. J. Health Serv.* 29:295–352

Krieger, N. 2003 'Does racism harm health? Did child abuse exist before 1982? On explicit questions, critical science, and current controversies: an ecosocial perspective'. *Am. J. Public Health* 93:194–99

Krieger, N. 2005 'Stormy weather: race, gene expression, and the science of health disparities,' *American Journal of Public Health*, 95(12), pp. 2155–2160.

Kaufman, J.S., and S.A. Hall 2003 'The Slavery Hypertension Hypothesis: Dissemination and Appeal of a Modern Race Theory'. *Epidemiology* 14(1):111–118.

Kuzawa CW., 2005. 'Fetal origins of developmental plasticity: are fetal cues reliable predictors of future nutritional environments?' *Am J Hum Biol* 17:5–21.

Kuzawa C.W., Quinn E.A. 2009 'Developmental origins of adult function and health: Evolutionary hypotheses', *Annual Review of Anthropology*, 38: 131-47.

Kuzawa C.W. & Sweet E. 2009 'Epigenetics and the embodiment of race: developmental origins of US racial disparities in cardiovascular health'. *Am J Hum Biol* 21:2–15.

Jablonka, E., and M. Lamb. 1995 *Epigenetic Inheritance and Evolution. The Lamarckian Dimension*. Oxford: OUP.

Jablonka, E., and M. Lamb. 2014. *Evolution in Four Dimensions. Second Edition*. Cambridge, MA: MIT Press

Jasienska, G. 2009 'Low Birth Weight of Contemporary African Americans: An Intergenerational Effect of Slavery?' *Am J Human Biology* 21:16–24

Lappé M. and Landecker H. 2015 'How the Genome Got a Life Span, New genetics and society', 2/2015

Landecker, H., and A. Panofsky. 2013. 'From Social Structure to Gene Regulation, and Back: A Critical Introduction to Environmental Epigenetics for Sociology.' *Annual Review of Sociology* 39: 333–357.

Lock M. 2015 'Comprehending the Body in the Era of the Epigenome', *Current Anthropology*, 56/2, online first

Malabou, C. 2008 *What Should We Do with Our Brain?* New York: Fordham University Press.

Mansfield, B. 2012. 'Race and the New Epigenetic Biopolitics of Environmental Health.' *BioSocieties* 7 (4): 352–372.

Massey, D., 2004. 'Segregation and Stratification. A Biosocial Perspective', *Du Bois Review*, 1 (1) 7–25.

M'charek, A. 2013 "Beyond Fact or Fiction: On the Materiality of Race in Practice." *Cultural Anthropology 28: 420–442*

Meloni, M. 2016 *Political Biology: Science and Social Values in Human Heredity from Eugenics to Epigenetics.* Palgrave: London and New York

Morning, A. 2011. *The Nature of Race: How Scientists Think and Teach about Human Difference*. Berkeley: University of California Press.

Morning, A. 2014. 'And you thought we had moved beyond all that: biological race returns to the social sciences'. *Ethnic and Racial Studies*, 37:10, 1676-1685

Morning, A. 2015. 'Scientific racism redux? The many lives of a troublesome idea'. *Du Bois Review* 21 (1): 187–211.

Montoya, M. 2011 *Making the Mexican Diabetic: Race, Science, and the Genetics of Inequality*. University of California Press.

Nelson, A. 2012 'Reconciliation Projects: From Kinship to Justice' in Wailoo. K., Nelson, A, and Lee C. (eds.) *Genetics and the Unsettled Past: The Collision of DNA, Race, and History*. New Brunswick NJ: Rutgers UP

Ossorio, P., & Duster, T. (2005). Race and genetics: Controversies in biomedical, behavioral, and forensic sciences. *American Psychologist*, 60, 115–128.

Painter, R., et al. 2008. 'Transgenerational Effects of Prenatal Exposure to the Dutch Famine on Neonatal Adiposity and Health in Later Life.' *BJOG: An International Journal of Obstetrics and Gynaecology* 115: 1243–1249

Reardon, J. 2005 *Race to the Finish.* Princeton, NJ: Princeton University Press.

Richards, E. J. 2006. 'Inherited epigenetic variation – revisiting soft inheritance.' *Nature Reviews Genetics* 7: 395–401.

Richardson, S. 2015 'Maternal Bodies in the Postgenomic Order: Gender and the Explanatory Landscape of Epigenetics' in Richardson & Stevens (Eds) *Postgenomics*. Durham: Duke Univ Press

Richardson S. and Stevens H. (eds.), 2015, *Postgenomics*. Durham and London: Duke UP

Roberts, D. 2011 *Fatal Invention: How Science, Politics and Big Business Recreate Race in the 21st Century*, New York: The New Press.

Rose, N. 2007 *The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the Twenty-First Century.* Princeton NJ: PUP

Rose, N. 2008 'Race, Risk and Medicine in the Age of 'Your Own Personal Genome' *BioSocieties*, 2, 221–237

Rothstein, M. 2009 'The ghost in our genes: legal and ethical implications of epigenetics'. *Health Matrix Clevel* 19: 1-62

Rothstein, M. 2013 'Epigenetic exceptionalism'. J Law Med Ethics. 41(3):733-6.

Sapp, J. 1987. *Beyond the Gene: Cytoplasmic Inheritance and the Struggle for Authority in Genetics*. New York: Oxford University Press.

Schramm, K. Skinner, D. and Rottenburg, R. 2012 *Identity Politics and the New Genetics Re/ Creating Categories of Difference and Belonging*. Berghahn Books.

Sharkey, P. 2008. 'The Intergenerational Transmission of Context.' *American Journal of Sociology* 113:931–69.

Sharkey, P. and Elwert F 2011 'The Legacy of Disadvantage: Multigenerational Neighborhood Effects on Cognitive Ability' **A***merican Journal of Sociology* 116: 1934-1981

Sharkey, P. *2014 Stuck in Place: Urban Neighborhoods and the End of Progress toward Racial Equality*. Chicago: UCP

Skinner, D. 2006 'Racialised Futures: Biologism and the Changing Politics of Identity', *Social Studies of Science*,

Skinner, D. 2007 'Groundhog Day: The Strange Case of Sociology, Race and Science', *Sociology* 41 (5): 931-943

Slavet E. 2008 'Freud's 'Lamarckism' and the Politics of Racial Science'. *Journal of the History of Biology*, Vol. 41, No. 1, pp. 37-80

Sommer, M. 2008 'History in the gene: Negotiations between molecular and organismal anthropology'. *Journal for the History of Biology* 41/3: 473–528.

Stevens, H. and Richardson, S. 2015 'Approaching Postgenomics' in Richardson S. and Stevens H. (eds.), 2015, *Postgenomics*. Duke UP

Sullivan, S. 2013 'Inheriting Racist Disparities in Health: Epigenetics and the Transgenerational Effects of White Racism', *Critical Philosophy of Race* 1(2):190-218

TallBear, K. 2013 *Native American DNA: Tribal Belonging and the False Promise of Genetic Science*, Minneapolis, MN: University of Minnesota Press.

Wade, P. 2005 'Hybridity Theory and Kinship Thinking', *Cultural Studies*, 19:5,602 — 621

Wailoo. K., Nelson, A, and Lee C. 2012 Genetics and the Unsettled Past: The Collision of DNA, Race, and History. New Brunswick NJ: Rutgers UP

Wells, J. 2010 'Maternal Capital and the Metabolic Ghetto: An Evolutionary Perspective on the Transgenerational Basis of Health Inequalities'. *American Journal of Human Biology* 22: 1-17

Weaver, I., et al. 2005. Reversal of Maternal Programming of Stress Responses in Adult Offspring Through Methyl Supplementation: Altering Epigenetic Marking Later in Life. The Journal of Neuroscience, 25, 11045–11054.

Williams, D. and Collins, C. 1995. 'U.S. Socioeconomic and Racial Differences in Health: Patterns and Explanations.' *Annual Review of Sociology* 21:349–86.

Williams D., and Sternthal, M. 2010 'Understanding Racial-ethnic Disparities in Health Sociological Contributions' *Journal of Health and Social Behavior 51* (1): *15-S27*

Wilson, T.W., and C.E. Grim 1991 'Biohistory of Slavery and Blood Pressure Differences in Blacks Today. A Hypothesis'. Hypertension 17(1) 122–I-128.

Yehuda R et al., 2005 'Transgenerational effects of posttraumatic stress disorder in babies of mothers exposed to the World Trade Center attacks during pregnancy', *J Clin Endocrinol Metab.* 90(7):4115-8.

Yehuda R et al., 2014 'Influences of maternal and paternal PTSD on epigenetic regulation of the glucocorticoid receptor gene in Holocaust survivor offspring', *Am J Psychiatry* 171(8):872-80

Zhang et al. 2011 Significant differences in global genomic DNA methylation by gender and race/ethnicity in peripheral blood. *Epigenetics*. 6(5): 623–629.