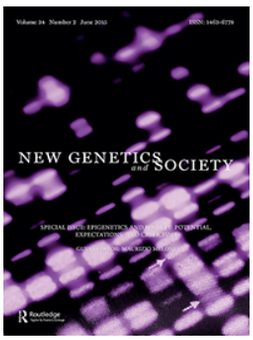

New Genetics and Society

ISSN: 1463-6778 (Print) 1469-9915 (Online) Journal homepage: http://www.tandfonline.com/loi/cngs20

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To cite this article: Maurizio Meloni (2015) Heredity 2.0: the epigenetics effect, New Genetics and Society, 34:2, 117-124, DOI: 10.1080/14636778.2015.1036156

To link to this article: http://dx.doi.org/10.1080/14636778.2015.1036156

New Genetics and Society, 2015
Vol. 34, No. 2, 117–124, http://dx.doi.org/10.1080/14636778.2015.1036156

Routledge
Taylor & Francis Group

EDITORIAL

Heredity 2.0: the epigenetics effect

The reasons for a special issue of *New Genetics and Society* dedicated to epigenetics seem so obvious as to not to deserve a long explanation from a guest editor.

Epigenetics, the "collective heritable changes in phenotype due to processes that arise independent of primary DNA sequence" (Tollefsbol 2011), has taken central stage in biological research. Not only has the number of publications about epigenetics skyrocketed, but it has also increasingly been honored with many "catchy" and bombastic definitions, for instance that epigenetics has become the "new molecular and medical genetics" (Tollefsbol 2011). Many authors have written of an "era of epigenetics" being "upon us" (Hurd 2010) or asked whether we find ourselves in the "decade of the epigenome" (Martens, Stunnenberg, and Logie 2011; see for an analysis, Meloni and Testa 2014). This new cycle of excitement already provides more than enough material to make epigenetics a huge case study for the sociology of expectations: it would be enough to look at the pace at which this new wave of enthusiasm has buried the previous cycle of hype generated, only a few years ago, by the Human Genome Project.

However, paying attention to this roller coaster of hopes, enthusiasm, and hyperboles would be just one among many possible points of entry to the epigenetic archipelago. Looking at the novel epigenetic landscape from any direction would work equally well, and likely generate rich material. For instance, one could take the scientific and evolutionary controversy; or the ontological implications: is epigenetics the missing link between the social and the life-sciences?; or the public health and public policy repercussions; and, finally, the commercial translations and exploitations: for instance, which will be the impact of epigenetic knowledge for potential clinical applications?.

The heredity of epigenetics

However, before turning to the presentation of the papers composing this special issue, I would like to call attention to one crucial dimension of epigenetics that remains rather underestimated so far. I refer to the *cultural and historical* significance of epigenetics for the century-long struggle about what counts as inheritance in evolution.

My argument here is that epigenetics, understood as the culmination of a heretic line in the history of biology, and the history of inheritance in particular, uncovers forgotten, marginal, and even disgraced traditions in biological thought.

Epigenetics possesses a unique heuristic value in bringing back to center stage views that were buried in the twentieth century by the triumph of hard-heredity and the exclusion of non-Mendelian forms of inheritance. And this historical and diachronic reading of epigenetics has implications also on the present, synchronic level, that is, the global, non-Western reverberations of epigenetics.

The restricted or hard view of inheritance (i.e. impermeable to environmental inputs) that culminated in the central dogma of molecular biology (information can never go back from protein to DNA) acted like a cork that kept many alternative and unconventional views in the bottle of heredity. Some of these views, often gathered under the label of soft-inheritance (i.e. "influenced by the environment or phenotype of the parents:" Bonduriansky 2012), are once again today spilling onto the floor, to the discomfort of the orthodox geneticists. Perhaps a psychoanalytic metaphor would be more apt here: epigenetics appears to be the return of the repressed of twentieth-century mainstream biological views of heredity.

On the basis of contemporary epigenetic findings, an increasing number of articles have recently appeared on the supposed scientific rehabilitation of some real ghosts of twentieth-century biology like Viennese neo-Lamarckian Paul Kammerer (1880–1926) (Vargas 2009; see Pennisi 2009; Wagner 2009; responses in Weissmann 2010; Gliboff 2010), and Russian plant breeder Ivan Michurin (1855–1935) (Liu and Wang 2011). Even the mythical notion of telegony (offspring inheriting a feature of the mother's *previous* mate), which was rather widespread in the nineteenth century, has recently been revisited, always in the context of novel findings circa non-genetic mechanisms of inheritance (Crean, Kopps, and Bonduriansky 2014).

Finally, of course, there is the ghost *par excellence*, the disgraced Trofim Denisovich Lysenko (1898–1976), the man who "destroyed" genetics in the Soviet Union, to which historians are looking today with somehow new eyes (Roll-Hansen 2011), or are simply impressed by the resurgence of his themes in Putin's Russia (Gordin 2015). Loren Graham, the eminent historian of Soviet and Russian science, is just publishing a book on the impact of epigenetics in revitalizing nationalist views of science in contemporary Russia (personal communication), and there is reason to believe that the controversy on what kind of heredity implies epigenetics will further escalate when the global dimension of the phenomenon is fully appreciated in the (often parochial) West.

Epigeneticists may think that it is unsound to present epigenetics along with these disgraced frameworks, since this would give ammunition to people who claim that with epigenetics we are witnessing a potential return to Lysenko (Maderspacher 2010). In introducing a special issue on epigenetics, would it not be sounder to sweep this scabrous heredity of epigenetics under the carpet so to speak?

My point is that these are false worries on the side of epigeneticists. Papers arguing that we are back to Lysenko are based on a naïve historiography that is

as totalitarian as Lysenkoism or, better, that is actually the complement of Lysenkoism, the bitter fruit of the same cold war mentality.

Only a substantial dose of historical ignorance may bring people to propagandize (or fear) that anything that is not the Central Dogma of molecular biology is Lysenkoism. Such a view simply ignores the facts that the environmental regulation of gene expression and the search for non-Mendelian or cytoplasmic mechanisms of inheritance have a longer and honorable story in biological thought (for instance: Sapp 1987; Jablonka and Lamb 2014) of which Lysenko is nothing but a modest component.

The interpretive suggestion to approach epigenetics would be, therefore, to use its findings today to break this spell, and show that there is much more, actually an *entire continent*, between narrow genecentrism and Lysenko. But what kind of continent?

Here an answer should probably be in two steps. With epigenetics, we are somehow touching the tip of the iceberg of a new, and richer, conceptual framework for biology and genetics, in which the genome appears as "a highly sensitive organ" (McClintock 1984; see Keller 1983), a "reactive genome" (Gilbert 2003; Keller 2011; Griffiths and Stotz 2013), or a "developing genome" (Moore 2015), subject to time and space, biography and milieu (see a powerful description of this richer framework, although in a different terminology, in Lappé and Landecker's article; see also the notion of local biology in Niewöhner's article).

However, and the second step, how much of this novel continent will be translated and consolidated into a new view of inheritance, which we might possibly call soft inheritance 2.0 (given how it modifies the term of the soft versus hard-heredity debate, as suggested by Moore 2015) or postmodern heredity (because of its contingent features, more local than universalistic in nature) remains still to be seen.

Epigenetics between "degeneration" and "regeneration"

But, of course, as Italians would say "non c'e' rosa senza spine": "every rose has its thorn." As a social theorist concerned with the politics of biology, my own suggestion for the curious reader interested in the return of forgotten heredities in our epigenetic *zeitgeist* would point to a more perplexing scenario; perplexing, but helpful in keeping together the always difficult mixture of science and society that is at stake in this special issue.

My suggestion would be to look at the fact that current debates on the public health implications of epigenetics are, unknowingly, allowing the re-emergence of older 1910s–1920s' debates on the toxic or regenerative effects of the environment upon what was then called the germplasm, and what today we would call the genome.

Before now, the period between 1910 and the 1920s was one of the last moments at least in Europe and North-America, when explicitly soft-hereditarian views were still applied to public health and public policy debates, before hard-heredity put to rest all these alternative views. One way to look at how these soft-hereditarian

views circulated in public health is to comprehend them under what can be called *the degeneration–regeneration* dialectics (Meloni, forthcoming).

The first line was represented by authors who mostly saw the *degenerative effects* of pathogenic environments on human germplasm. Many things could poison heredity: alcohol, sexual diseases, and moral and physical squalor of the slums. For all of the nineteenth and the early twentieth centuries, doctors, educators, and social reformers were obsessed by the transgenerational perpetuation of these toxic environments and bad habits upon poor families and dangerous groups. Indelible scars were left on the germplasm not only of the exposed but also of the unexposed generations.

In opposition to this degenerationist line of thought, which even called for a loss of citizenship for these poisoned social groups, a leftist regenerationist line of thought emerged. This second line of thought claimed that heredity, in Paul Kammerer's words, was "soft wax in our hands" and that it was finally possible to make it "comply with our wishes" (1920; quoted in Gliboff 2005), by recurring to various techniques (many of which we would find very questionable today!).

In a spirit that resonates with today's popular hypes on the way we can change our genes via food or behaviors, newspapers of the 1920s celebrated Kammerer's findings, the men who had re-growth "eyes in sightless animals," with bombastic titles (for instance in the British *Daily Express*) that a "race of supermen" could be finally bred.

I have no intention of over-playing these historical analogies. 2015 is not 1920 and what happens now with epigenetics does not mark the return of medical degenerationism or Kammerer's regenerative eugenics *as such*. However, there is a sense in which these two parallel ways of politicizing soft-heredity, the first looking at the scars left by the environment on the germplasm, the second looking at the reversal of these scars through various techniques, have been *reactivated* today.

The contemporary and epigenetic version of the first line of thought is not truly "degenerationist" because it is mostly moved by a compassionate wish to highlight how various historical and psychological traumas are "real" as they leave (epigenetic) marks on the present and future generations. From the Dutch Hunger Winter of 1944 to 9/11, from the effects of bad parenting to smoking, we witness today an increasing number of claims that exposed and unexposed generations may be biologically damaged by certain historical events that occurred in a near past.

Similarly, the contemporary version of the second line of thought is not truly "regenerationist" because Kammerer's framework was mostly utopian, collective, and socialist, whereas today the ethos of epigenetic advice to take care of our own epigenome is fully neoliberal: epigenetic claims of "regeneration" are mostly mobilized as individual techniques of taking better care of ourselves, from athletic exercise, to eating properly, or stopping smoking.

Nonetheless, there is a sense in which a reactivation of the old debate under mutated circumstances is occurring; something literally unthinkable within a

hard-heredity framework. So it happens today that we have magazine and newspaper headlines that proclaim that heredity is "poisoned," or babies are born "damaged" (references given in my article in the special issue). Or, alternatively, on the regenerationist side, we have headlines about exercise and physical training activating or deactivating gene expression, thus providing a cheap and accessible way to health and quality of life (Reynolds 2014)

Presenting this special issue: epigenetics for the social sciences

This dialectic of regeneration and degeneration is behind many of the reflections that I advance in my article on the social theory implications of epigenetics (*Epigenetics for the social sciences: Justice, Embodiment, and Inheritance in the Postgenomic Age*). I look in particular at two sites where epigenetics has deep reverberations for social theory: (a) the blurring of the boundaries between natural and social inequalities in theories of justice and their possible implications for public policy and public health; (b) a deepening of the notion that the constitution of the body is dependent on its material and socially shaped surroundings, in what he calls "embodied constructivism." My conclusion is deliberately ambivalent: in principle, epigenetics represents genuine progress from dichotomous frameworks that opposed, in the first site, natural and social inequalities or, in the second site, social constructionist and biomedical views of the body. Epigenetics represents a blurring of the line between body and society. The way this will be turned into politics remains difficult to assess, however. The optimistic regenerationist view can be always turned into a darker degenerationist view in which the overexposure to toxic environments has been so detrimental to certain social groups as to make them too damaged to be rescued. Politics, not science, will decide whether this is eventually the case. And politics is not always, or not necessarily, our restricted Anglo-American, liberal-democratic, human rights framework.

In a conceptually vibrant and thought-provoking article, Lappé and Landecker's (*How the Genome Got a Life Span*) inject temporality not only into the epigenome but in the genome itself. They understand the relevance of epigenetics as the fact that "the human genome has come to be seen within the parameters of the human life span"; the genome has now gotten "an early life and an old age, and to a more limited degree, an adolescence, middle-age, and other stages." As they claim this is an impressive shift from the broader picture of the "genomes, human and otherwise, that came into being through the massive sequencing efforts of the 1990s and 2000s" in which genomes were understood as "the same in every cell of the body for all of that body's life." The most ambitious part of the paper is probably where the authors question the partition between a genome as fixed and an epigenome as temporally contingent that is becoming mainstream in epigenetics. They claim that this distinction (the "mantra of separateness") is "something to understand and analyze, not to accept as a given framework for our inquiry." Their argument is that "thinking through a genome with a lifespan"

and in particular looking at the "intimate connections between the state of chromatin and the state of the DNA sequence itself" will challenge:

> the oft-repeated definition of epigenetics as being changes to gene function in the absence of DNA sequence change. There are many examples in which change to the epigenome over time is also change to the genome over time. The genome too has a life span.

Waggoner and Uller (*Epigenetic Determinism in Science and Society*) pose the question of "the extent to which epigenetics research and discourse engages or engenders deterministic views." Drawing on an analysis of popular and scientific portrayals of epigenetics, they "highlight three features of epigenetics research and discourse that reveal deterministic approaches: the notion of genetic control of epigenetic regulation, the concept of developmental programming, and the discussion of transgenerational epigenetic inheritance." Their careful and fine-grained analysis is that we are seeing the rise of what they call "epigenetic determinism," or "the belief that epigenetic mechanisms determine the expression of human traits and behaviors." They perceive, however, a sign of optimism in the fact that not the whole of epigenetic research is caught in this narrow understanding of epigenetics: a minority is increasingly resisting highly deterministic notions like epigenetic control in favor of a more contingent view of development and evolution. Whether this richer understanding of epigenetics will prevail, however, still remains doubtful given "the perceived explanatory sufficiency" with which more traditional lines of research counter these less deterministic views, they argue.

Nerlich and Stelmach (*Metaphors in search of a target: The curious case of Epigenetics*) analyze in detail the linguistic repertoire that is taking prominence with the rise of epigenetics. While, at the peak of its iconic relevance, genetic research was framed in terms of metaphors such as "information," "code," "letter," or "book," with epigenetics a new language is becoming popular. As the authors claim, "instead of grand genomic metaphors of the 'book of life' type" epigenetics seems instead characterized by the proliferation of smaller and semantically more various metaphors to convey the dynamism of epigenetic phenomena. These metaphors comprehend the mechanistic vocabulary of "switching" or "marking/tagging," as well as more temporally inflected repertoires of connected to ideas of memory, such as "remembering," "poisoning," "cursing," and even "a time bomb in your genes." As they claim in the conclusion, at present epigenetics remains very much a field in flux, in itself possessing a plasticity that just reflects the plastic processes that epigenetics aims to depict.

Finally, Jörg Niewöhner (*Epigenetics: Localising Biology Through Co-laboration?*) looks at the significance of environmental epigenetics from the point of view of anthropology. As he claims, environmental epigenetics is "producing results that are good to think with for anthropology and social science as well as for interested scientists within biology." In particular, environmental epigenetics

may be helpful in challenging "established notions of the body and of biology as a science of nature clearly separated and separable from culture." For Niewöhner, the situatedness of biological knowledge (or "local biology") that is emerging via epigenetic research is the key concept with which to rethink biological categories as "part of the social fabric within any given society," that is, "part of the way bodies are known and treated by their owners and by medical practitioners and through infrastructures." In particular, Niewöhner proposes the concept of *collaboration* to highlight the novel "non-teleological, experimental practice" that epigenetic knowledge may contribute to recent debates on inter-disciplinarity. Collaboration would amount to a new form of "joint epistemic work on [. . .] localizing human biology," going beyond classical inter-disciplinary or ethical legal and social implications (ELSI) approaches to biological knowledge. Niewöhner's point seems to be that the conceptual discontinuity introduced by local biology and environmental epigenetics requires a novel attitude from the social sciences in relation to the production of biological knowledge.

These five articles do not aim to exhaustively draw out the multifarious connections that epigenetic knowledge may create between the new twenty-first-century biology and the social sciences. All the authors seem to be aware that the terrain under our feet is changing rapidly, that previous well-established notions of what "the biological" is and what "the social" is are continuously shifting. This is extremely exciting for social scientists who want to work in the novel biosocial paradigm that is taking shape in this century. At the same time, however, the quick-pace changes of the current scenario are also a warning to the fact that any cartography or ontology of the contemporary remains precarious, unstable, and less universalizable than the great narratives of science and society in the last century would have probably liked.

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