The New Biology

with Fraser Watts and Michael J. Reiss, "Holistic Biology: What It Is and Why It Matters"; Michael Ruse, "The Christian's Dilemma: Organicism or Mechanism?"; David J. Depew and Bruce H. Weber, "Developmental Biology, Natural Selection, and the Conceptual Boundaries of the Modern Evolutionary Synthesis"; Ilya Gadjev, "Epigenetics, Representation, and Society"; Harris Wiseman, "Systems Biology and Predictive Neuroscience: A Double Helical Approach"; Richard Gunton and Francis Gilbert, "Laws in Ecology: Diverse Modes of Explanation for a Holistic Science"; and Niels Henrik Gregersen, "The Exploration of Ecospace: Extending or Supplementing the Neo-Darwinian Paradigm?"

EPIGENETICS, REPRESENTATION, AND SOCIETY

by Ilya Gadjev

Abstract. In recent decades, advances in the life sciences have created an unprecedentedly detailed picture of heredity and the formation of the phenotype where clusters of simplistic reductionist and deterministic views and interpretations have begun to lose ground to more complex and holistic notions. The developments in gene regulation and epigenetics have become a vivid emblem of the ongoing 'softening' of heredity. Despite this headway, the outlook and rhetoric widely popular in the twentieth century favoring the 'gene' in the 'gene↔genetic plasticity↔phenotype↔environment' tetrad have not been successfully tackled but continue to exist in parallel with a new, equally monochromatic, viewpoint championing genetic plasticity. An examination of epigenetics and its presentation in the public sphere, open to a conversation with the social disciplines and philosophy, could address this dichotomy and contribute to the discourse. This article outlines key biological aspects of epigenetics and discusses the language, presentation and wider resonance of this field of life science research.

Keywords: Epigenetics; 'hard' inheritance; representation; science and society; 'soft' inheritance

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Over the last few decades, advances in the life sciences have drawn an unprecedentedly elaborate picture of heredity and the formation of the phenotype. In this emerging vision, clusters of simplistic reductionist and deterministic conceptions and interpretations, circulating in the scientific

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and the wider public space, have begun to lose ground to more complex notions and approaches. Despite this progress, the outlook and rhetoric widely popular in the twentieth century, separating the hereditary material from the environment and positioning the gene at the center of the way the living world is understood, have not been successfully tackled but continue to play a distinctive role in the scientific and popular discourse. Phenotypic variation, behavior, and social achievement are often perceived, studied and explained through a markedly gene-centric lens.

The burgeoning fields of epigenetics, gene regulation and developmental biology have refined our understanding of heredity and revealed an elaborate network of links between the environment, individual or collective experience, and the genetic system. This broadened, systems-oriented comprehension, however, has not been satisfactorily explored, developed and assimilated into a wider, integrated, balanced view but has become somewhat isolated and polarized. Curiously, the 'old' deterministic outlook, strongly favoring the '*gene*' in the '*gene↔genetic plasticity↔phenotype↔environment*' tetrad, has not lost much ground but continues to exist in parallel with a 'new'—equally monochromatic—viewpoint championing 'soft' genetics and phenotypic plasticity. The current scene is marked by a maelstrom of opposing extremes where constructive integration between genetics and epigenetics, 'hard' and 'soft' inheritance, the biological and the sociocultural, *nature* and *nurture* gives way to injurious polarization (Crews et al. 2014, 42, 51). The media and the public sphere abound with clashing statements ranging from examples such as "the infidelity gene" to slogans like "the victory over the gene" (*Der Spiegel* 2010; Carter 2015). Seen as representing the reductionist, rigid, biological end of the scientific spectrum, the 'gene for' language is thriving alongside 'environment rules' (or experience- and culture-centered) rhetoric, popularly understood as a domain of the more permeable and all-embracing sphere of the humanities. This baffling dichotomy could be viewed as a reflection (or extension) of the broader *nature vs. nurture* debate and is indicative of the complex relationship between science and society. The far-reaching demarcation lines separating the *internal-hereditary* and the *external-environmental-experiential*, drawn with the rise of 'hard' genetics (as fashioned by Francis Galton and August Weismann in the second half of the nineteenth and the start of the twentieth centuries) and permeating not only the life sciences but also the social sciences and the humanities, have begun to be reevaluated in light of contemporary developments in biology (Meloni 2016, 61–78). This reconsideration, however, has—perhaps—not reached its fullness yet but is waiting to be better understood and adequately realized in all spheres.

The current, confused, and polarized situation raises important questions about the wider presentation, and public understanding of science; it calls attention to the role of biology in the human imaginary and society. It invites an inquiry into the rhetorical dimension of the biological sciences: the world of metaphors and symbols—their potential to influence the discourse and the scientific endeavor at large, their intricate life and resonance. More broadly, the ongoing confrontation between 'soft' and 'hard' heredity challenges science's perceived neutrality, its separation from nonepistemic values and the wider complexity of the human world. A detailed analysis of the relevant developments in the life sciences and their presentation, open to a conversation with the social disciplines and philosophy, could contribute to the discussion and elucidate these problems. An undertaking of this kind could unmask the hostile extremes and reveal their incongruity, pointing toward a middle path between (or beyond) this division, a comprehension not only in greater tune with the broad philosophical tradition but also more adequately reflecting the reality of both science and the human situation.

Such, both novel and classical, synergistic understanding and presentation of the *nature/nurture* (or *genome/environment*, *genetics/epigenetics*, *hard/soft heredity*, *biological/sociocultural*) duality has, in part, started to take shape, substantiated by a rapidly increasing body of research from different branches of the biological sciences. The picture that arises is particularly clear in the realm of the plant sciences, where the examples of genetic plasticity, environmental epigenetics, and epigenetic inheritance are most abundant and have been studied in greatest detail over many years (Heard and Martienssen 2014, 95). Research on animals and humans is also gaining considerable momentum—outstripping plant biology in some ways and producing striking and widely discussed results.

Seen as exemplifying 'soft' inheritance and biological flexibility, epigenetics and various aspects of gene regulation have begun to attract considerable interest from the humanities and the social disciplines. The ongoing advances in heredity, driven by a complex matrix of factors within the field of biology but also outside of it (in social, cultural, commercial, and other sectors), have started to dissolve the confines separating the life sciences from the social sciences and the humanities. This situation could allow the epigenetic domain and the related fields of research to serve as hubs where different spheres of knowledge and investigation could fruitfully communicate.

Despite the numerous problems, gray areas, and general confusion characterizing the whirlpools of hype and heightened media attention around epigenetics, the discipline's place in the study of nature and life cannot and should not be written off. The biological, social, and philosophical potential of this research field needs to be disclosed, thoroughly studied, understood in its many facets, and (where possible) carefully actualized. Such efforts will be beneficial, not only to clarify the issues surrounding biological inheritance, but also to better understand the broad *nature vs. nurture* debate. Examination and interpretation of the developments in heredity and their popular perception could provide a valuable insight into the problem of widespread dissociation, and enmity, between 'hard' and 'soft' inheritance and shed some light on the complex relationship between science and society. This sort of inquiry could help alleviate the heated bipolar model of genetic versus environmental determinism, genetic rigidity versus the influence of the environment, or 'the biological' versus 'the social' and lead to a more balanced, multilayered and integrative concept with effects restricted not only to the presumed confines of the life sciences but felt also in the areas of sociology, philosophy, education, law, and politics. Neither haughty rejection nor glamorization of the advances made in epigenetics will be conducive to the realization of these possibilities.

This article summarizes some emblematic advances in environmental epigenetics and discusses their wider resonance, influence, and significance in the biomedical sciences and beyond. An examination is provided of the public understanding of these developments, their ethical dimension, the language which shrouds and permeates them, and their capacity to address the *nature/nurture* dichotomy in a constructive and synergistic fashion.

Epigenetics in Biology

Phenotypic variability is not always clearly attributable to genetic factors in a narrow sense, that is, primary DNA structure, which calls for a widening of the current coverage of the terms *genetics* and *heredity* through the inclusion of other inheritance mechanisms (Schaefer and Nadeau 2015, 403). DNA sequence variation cannot successfully explain the heritability of complex phenotypes: genome-wide association studies in humans have been able to demonstrate only a limited linkage between various multifactorial characteristics and the underlying genetic architecture in terms of DNA sequence specificity. This "missing heritability" could in part be associated with other structures and dimensions of heredity such as epigenetics (Maher 2008, 21; Day and Bonduriansky 2011, E34). Furthermore, genetic changes including mutations and chromosome rearrangements are not sufficient to satisfactorily explain the occurrence of rapid phenotypic changes and the formation of new heritable characteristics (e.g., stress tolerance and adaptation to new environmental conditions) in one or many generations (Laland et al. 2014, 161–64; Skinner 2015, 1296). 'Hard,' DNA-centered inheritance, where phenotypic variation is strictly understood as produced by DNA sequence alterations, has long been viewed as a limited system and an inadequate source of adaptation in rapidly changing environments. In plants, mutation rates are too low to be recognized as the only reason behind the stunning phenotypic plasticity occurring in time-spans of one or ten generations (Boyko and Kovalchuk 2011, 261). Epigenetic phenomena have been suggested as a possible source and mechanism for comparatively quick and frequent phenotypic variation which in some cases might have adaptive effects to changes in the environment. These effects could remain within the limits of a generation or cross the generation barrier.

What is epigenetics?

It is widely accepted that the term *epigenetics* was originally coined by the British polymath C. H. Waddington to describe "the branch of biology that studies the causal interaction between genes and their products, which bring the phenotype into being" (Jablonka and Lamb 2014, 83). Although the neologism was devised before the discovery of the DNA double helix and the ensuing molecular insights into gene regulation, gene networks, and various genetic interactions, the theoretical framework behind it presupposes the existence of such dynamic systems (Jablonka and Lamb 2014, 83; Jablonka 2012, 1–4). Furthermore, the term and the discipline which it describes are also resonant with the issues surrounding the sharp separation between genotype and phenotype, pioneered by Wilhelm Johannsen at the start of the twentieth century, as well as the soma-germline distinction introduced by August Weismann some years earlier. Waddington addressed these problems by incorporating a "whole complex of developmental processes" named "epigenotype" into the multidimensional relationship between the sphere of the genotype and that of the phenotype (Waddington 2012, 10). Thus, epigenetics was designed as a window onto a wide biological universe where the gene-based aspect was important but represented just one of many interlaced facets and dimensions. Subsequently, this broad, network-oriented, developmental and philosophical conception was redistilled and narrowed (in a molecular way) to emphasize cellular heritability and address gene expression.

Currently, epigenetics is perceived as a discipline studying the changes in the expression and realization of genetic information which are not caused by alterations in the underlying DNA sequence: the arrangement of nucleotides making up the DNA double helix remains unchanged but the biochemical context around the core DNA molecule becomes modified. Although the exact coverage of the term is surrounded by a degree of opacity, there is a general scientific consensus that the epigenetic traits are heritable, stably transmitted during cell division—via mitosis or, in some instances, also via meiosis (Berger et al. 2009, 781). The best known epigenetic modifications are DNA methylation (covalent addition of a methyl group, usually to a cytosine nucleotide); covalent changes to histone proteins including methylation, acetylation, phosphorylation, ubiquitination, and sumoylation; and the roles of various noncoding RNA molecules. It is widely accepted that the epigenetic effects (mitotically and/or meiotically heritable) are potentially reversible and often have a relatively short life span and influence limited to a generation or a developmental phase, yet in some cases they can be passed on to the progeny, become 'stabilized' and persist for many generations. The transgenerational dimension of epigenetics has lately become a focal point of great scientific and wider popular interest but this aspect did not receive such emphasis in Waddington's original vision of epigenetics and the epigenome.

Epigenetic modifications have important roles in gene regulation, genetic stability, genomic defense, differentiation, development, and interaction with the environment. Genomic DNA is relatively static and virtually identical in each cell of a multicellular organism, yet the organism's body comprises a wide array of cell types, tissues and organs. Epigenetics is a significant player in the differential actualization of the common genetic potential leading to this stunning diversity of form and function. Epigenetic factors are involved in paramutation, parent-of-origin-dependent genomic imprinting, control over transposable genomic elements, and many other phenomena. The formation of epigenetic marks could be genetically driven or could result from the effects of the macro- or micro-environment and experience. A broad gamut of published research casts light on the relationship between the environment and the epigenome. Numerous abiotic, biotic, behavioral, and social factors have been reported to promote epigenetic changes in microorganisms, fungi, plants, animals, and humans. Moreover, it has also been proposed that in certain instances the epigenetic features do not only interfere with the functioning of the genome but can also influence its structure, modifying it, and even, reportedly, eventually becoming 'translated' and 'assimilated' into more stable genetic marks (Koonin 2014, 238; Schaefer and Nadeau 2015, 391). The genetic and epigenetic foundation of the assimilation and accommodation of environmentally induced phenotypic variation and similar plastic responses, however, remains to be elucidated (Schlichting and Wund 2014, 656–66). In a sense, the epigenome can be viewed as a dynamic mediator and repository of environmental information and stimuli—a kind of biological interface-and-depot. It 'senses' and responds to a wide variety of biotic and abiotic factors and then retains, 'internalizes,' for a shorter or longer period of time, the environmental information depending on factors such as type of organism, developmental stage, and signal characteristics. Yet, this system is not only receptive to environmental signals but is also dependent on the genetic foundation upon which it 'resides.' The specificity of the DNA structure and code directly influences the epigenome in terms of dynamics, potential for modifications, stability, and so on. Thus, the epigenome could be pictured as positioned between the genome and the environment, being co-dependent on both. Influencing the realization of the genetic information, the epigenome also occupies a place between the genotype and the phenotype, bridging the two or, perhaps, stretching beyond the two.

Some mechanistic aspects of the relationship between the environment, the phenotype, and the hereditary apparatus have been known for a considerable time (McClintock 1984, 792–801). More generally, the study of 'soft' inheritance—routinely connected with Lamarckism and the work of the infamous chief biologist in Stalin's USSR Trofim Lysenko—has an even longer and more tumultuous history. The beginning of the twenty-first century has seen a reinvigorated interest in Lamarck's intellectual legacy and 'soft' heredity (Gadjev 2015, 242–47). This revival is no doubt driven largely by progress in molecular biology and specifically epigenetics, but the broader dynamics, transformations, and interactions within and between the life sciences, the social sciences, and the public sphere have also played an important role.

Viewed through the angle of studies in gene regulation, the novelty of epigenetics could become somewhat blurry and a matter of debate. The term, with its inherent ambiguity, has accommodated many phenomena, which have been known and discussed in the life sciences for a long time. Despite these issues and concerns, the formation of the field—its differentiation, popularization, and powerful allure—asks for serious and focused consideration. Epigenetics precipitates significant interest which leads to a constantly growing body of research and a lively debate regarding the way heredity is understood not only in the realm of science (with respect to meaning, mechanism, development, and the environment) but also in the broader human world. The developments in the field have a wide-reaching resonance and raise pressing questions with important ethical, legal, social, and other implications.

Epigenetics in Society

The understanding that phenotypic variation is dependent on more than the fundamental influence of the genome is not a novelty in the scientific arena. Since the dawn of genetics, the cause and expression of the phenotype have been apprehended with a fluctuating degree of complexity related to genes, nongenetic factors, and environmental effects. During the last century, the richness and symmetry of this outlook have wavered, at times reaching contrasting extremes: from many-sidedness and great flexibility to rigid geneticization. Galton's, Weismann's, and Johannsen's work and views of separation between the internal, inflexible, deeper and the external, weaker, shallower, together with the later amalgamation of genetics and Darwinism, played an important role in the 'rigidization' of heredity, influencing the dynamics not only within the biological sciences but also within the social sciences and anthropology (Meloni 2016, 66). The discovery of the double helix in the 1950s and the following advances in molecular biology, among other aspects, further affected the tides and currents in and around genetics and strengthened the 'hard inheritance' outlook. Consequently, areas of the scientific as well as the broad social, political, and philosophical discourse began to see the complex, multidimensional understanding of heredity gradually waning in favor of a dominant molecularized gene-centric interpretation (Noble 2015, 7). Despite this enduring tendency, the views and studies on biological inheritance over time have not irrevocably fallen into a narrow, unidirectional rut but in recent decades have begun to expand and ardently branch out again. The ongoing boom in epigenetic research generously offers 'new,' 'solid,' 'concrete,' 'unquestionable,' and 'objective' (we are made to believe) evidence *against* the 'hard,' DNA-sequence–centered model, and *for* the standpoint championing flexibility, vigorous environmental receptiveness, and many-sidedness of the hereditary apparatus. In a dramatic fashion, the 'soft' face of genetics is fervently returning to the scientific stage, emerging opposite its well-established 'hard' counterpart. Now, close to each other, are these two faces really confronted or connected—Janus-like?

The dynamics in the field of inheritance are multifaceted and indicative of the complex interplay between the perceived fortress of science and the wider human cosmos. Transgenerational environmental epigenetics and other related phenomena strike a resonant chord with problems pertaining to the wider kaleidoscope of the human situation and universal human narratives are easy to discern in the epigenetic discourse. Human biology is producing a fast-growing body of captivating publications in the field, yet much of the groundbreaking and widely presented research in epigenetics comes from work on plants and animals. Although enticing, extrapolation of research data from different organisms to humans and the human sphere could be inadequate and must be done with extreme care and proportion. Nevertheless, epigenetics is gaining speed and continues to vividly interact with the public interest and imagination. The discipline demands multilateral attention and acquaintance with its structure, development, potential and far-ranging effects. Knowing the name is what every familiarization usually begins with.

What is in a Name?

Waddington created the catchy neologism *epigenetics* through amalgamating Aristotelian *epigenesis* with modern *genetics.* Over the centuries, *epigenesis* (the classical view that biological structures and organisms come into existence and develop gradually, as a result of a succession of numerous steps and interactions from a relatively formless state to a formed one) has been contrasted with *preformationism* (an outlook where the individuals and their parts are seen as *pre*formed or *pre*determined) (Müller and Olsson 2003, 114–23; Speybroeck, Waele, and Van de Vijver 2006, 7–34). This antagonism has mutated and surged under different insignia—not necessarily confined to the field of embryology: for instance, 'soft' inheritance and environmental plasticity versus 'hard' inheritance and genetic determinism or—more popularly—biology versus upbringing and experience. The nuanced etymology, semantics, and resonance of the name coined by Waddington reflect the overarching duality embedded in the expansive *nature/nurture* conflict with its numerous manifestations but, transcending the limitations of such high-contrast polarity, they offer a powerful synergistic perspective. In its wholeness, the term could be viewed as an invitation for a constructive dialogue between the seemingly opposing camps in this many-faced dichotomy.

Although modern epigenetics is often related primarily to the influence of environmental conditions, most of the causes driving and actualizing Aristotelian *epigenesis* towards the final end, the *telos*, are internal (pertaining to the nature of the organism and its potentiality), rather than explicitly external (macro-environmental). 'Canonical' *genetics*, on the other hand, focuses on the inner and the inherent, the genes, but this aspect, although sometimes heavily emphasized in the wider discourse, cannot be viewed as drastically isolated from the outer, the environment. Reflecting this intricacy, Waddington's symbolically rich understanding (and presentation) of epigenetics is positioned within a broad developmental context. This notion is often associated with the image of a complex multidimensional *landscape* and the presence of an elaborate *network* of interacting elements (genetic and others). The landscape 'canalizes' development along one valley or another where some valleys are deeper and more difficult to leave than others. Thus, the realization of the genetic information and the actualization of the developmental potentiality, which will "bring the phenotype into being," can follow various trajectories (leading to different ends) depending largely on the interaction between the internal, biological factors, but also on the influence of the external, environmental ones (Gilbert 1991, 137–52; Jablonka and Lamb 2014, 83–95). The external and the internal or the apparently dynamic and the seemingly static do not exist in hostile isolation but effectively communicate and merge. Despite being somewhat vague and metaphorically overcharged, such an inclusive vision successfully highlights the complicated nature of the relationship between genotype and phenotype, drawing an elaborate tableau where different biological elements are perceived as connected not only with each other but also with the environment and experience—an understanding in harmony with the currently unfolding dynamics in the biological sciences.

Evidently, Waddington's theory (and associated lexicon) is not one of confusing *nature/nurture* antagonism and acute separation between *preformationism* (understood as 'conservative' genetics) and *epigenesis* (seen as gene expression, development and receptiveness to the environment) but one of compatibility and coexistence (Deans and Maggert 2015, 887–88). Without negating gene-centered inheritance, epigenetics invites a wider integrative perspective on development and heredity. A sense of this intricate connectedness can be discerned not only in the term itself but also in its author's work and outlook as a whole. Classical philosophy plays a vivid role in Waddington's thought and in this spirit, if Aristotle's *meta*physics is viewed as following, or going beyond, his physics, perhaps *epi*genetics could be seen as concerned with the horizon stretching 'beyond' what is perceived as the limited realm of 'hard' genetics.

Subsequently, David L. Nanney and other researchers underlined the mitotic stability of the epigenetic effects and redistilled the broader Waddingtonian meaning of the term, concentrating it on gene expression (Nanney 1958, 712–16; Deans and Maggert 2015, 888–89). The emphasis gradually moved from development to cellular heritability and biochemical structure. This narrower, molecular-biological understanding of epigenetics differs in many points from Waddington's and is more closely related to the definition(s) in highest circulation nowadays. Notwithstanding this specification and molecularization (or in some aspects because of it), the term hasn't lost its complexity and ambiguity (Deans and Maggert 2015, 887–94). A plethora of very diverse biological phenomena, accompanied and influenced by throngs of much wider problems looming from the puzzle of the human condition, have been ushered and accommodated in this biomedical Tower of Babel. The welcoming flexibility of the term has been identified as one of the reasons for the success of epigenetics in the scientific and popular arenas (Meloni and Testa 2014, 432). This ambiguity is not only linguistic but reflects the fluidity of epigenetic research and its objectives. Epigenetics' slippery semantics and general elusiveness make it approachable and accommodating but they also pose serious epistemological and ontological problems and provide ample opportunities for confusion and abuse. The epigenetic label communicates with its signified content in a complicated fashion marked by a degree of tension between the broad coverage of the name (as originally conceived by Waddington) and the narrow spectrum of molecular phenomena it has come to describe. Confusion surrounds also the emphasis on epigenetic *heritability* (mitotic or transgenerational), its coverage, focus, and underlying causes and mechanisms. Naturally, the considerable attention on the resonance of the epigenetic domain with many aspects of human life also adds to the tension between the name (which becomes ever so noticeable) and what it denotes (which becomes ever so expansive and difficult to delineate).

Echoing the Platonic distinction between true reality and representation, at the start of the scientific revolution Galileo Galilei stated that "names . . . must be accommodated to the essence of things, and not the essence to the names, since things come first and names afterwards" (Galilei 1957, 92). What the essence of epigenetics is and whether the term adequately reflects it remains to be elucidated. This growing branch of biology, however, provides a vivid illustration of the creative power of language in science. Here, the chosen symbolic representation is not an inert tag, a passive reflection and an external element in the dynamic mosaic of the research field, but it *participates* in the life of the discipline influencing its future and contributing to its growth and development. The name and the constellation of terms gravitating around it are charged, they have gravity and emanation which actively attract, filter and repulse facts, intentions, beliefs and outlooks—creating a vibrant metaphorical landscape with its own multidimensional features. The rhetorical dimension, *the name*, in a sense, 'canalizes' the development of epigenetics itself.

Epigenetic Paradoxes and Reflections

Presenting and elucidating in molecular detail a 'soft,' complex, and dynamically receptive to the environment side of *nature* and heredity, the studies in epigenetics have obtained an emblematic position in reference to the problems of genetic determinism and reductionism in biology and medicine. Certainly, the developments in the field and their interpretation possess the capacity to confront the deterministic-reductionist outlook and contribute to a more pluralistic view of heredity. This capacity has, in some measure, galvanized the current vitalization of the *genetics–environment* discourse which has become richer, more welcoming, widespread and open to a fruitful dialogue with the social disciplines and the humanities. It seems that epigenetics has somewhat liquefied not only the well-guarded frontiers between the individual sciences, but also the wall separating the scientific domain from the humanities, allowing the biological and the sociocultural to productively meet. Alongside this optimistic openness, however, modern-day epigenetics (and its broad understanding and presentation) suffers from a number of inherent problems. The departure from its original definition and the striking molecularization and digitization of the phenomena studied and classified under this term are some of the reasons for these issues (Meloni and Testa 2014, 435–51). On the one hand, epigenetics has retained its terminological breadth and ambiguity, yet on the other hand it has lost its rather broad and loosely deterministic Waddingtonian coverage and become more narrowly deterministic, synonymous with a specific set of induced, heritable biochemical processes and structures. These constrained, molecularized, reductionist standpoints and rhetoric are, surely, not restricted to epigenetics—they have spread to the presentation and understanding of *nature,* the living world (and to an extent the human condition), the role of the environment and *nurture*. Arguably, although associated with numerous disadvantages, this novel 'molecular-epigenetic reductionism' is still more refined and open-framed, allowing for greater complexity and flexibility, than the well known gene-centric one, because it includes and/or depends on a gamut of interconnected elements such as various biological components, the many-sided role of the environment, experience, upbringing, behavior, and choice. Yet, this new molecular biologization may become an important component in outlooks where complex characteristics (especially in the human sphere) are treated in a dangerously simplistic fashion. Diagnostics of and solutions to multifaceted problems, where biological, environmental, social, and other factors act in concert, could be sought within unwarrantably narrow biochemical confines (Tamatea 2015, 640). The ongoing molecularization beneath the broad umbrella of epigenetics, with all its accompanying problems, is somewhat redolent of the movement from the initial, rather general, Mendelian and Johannsenian understanding of the *gene* to the much narrower molecular and digital modern-day concept. In the original sense, the word *gene* refers to all or any factors that cause a heritable phenotype (no narrow specialization; wide causation), whereas in the modern sense *gene* signifies a specific DNA sequence (narrow biochemical specialization; higher level of direct causation). Evidently, the exchange of the wide, multifactorial definition for a more focused, mechanistic one has been accompanied with a dramatic change in the understanding of the nature, degree, and span of causality and determinism in biology (Noble 2015, 7–13). In parallel with genetics, the molecularization of epigenetics has led to great advances but its consequences are not-one-sided and need to be examined in their entirety. A rethinking of the modern concept of a *gene* can be beneficial in light of its more inclusive, original definition—not as a specific DNA sequence but as a *unit of heredity* (complex and multilayered, in this case)—where the epigenetic dimension can also find a place.

It comes as no surprise that in an environment where destiny is becoming increasingly biologized (or biology depicted as destiny), epigenetics could be apprehended as offering an antithetical perspective: one against the views of genetic and biological predestination. This conception is not uncommon but rather widespread and graphically reflected throughout the media, including *Time Magazine*'s cover article "Why Your DNA Isn't Your Destiny" and *Der Spiegel*'s "The Victory over the Genes. Smarter, Healthier, Happier: How We Can Outwit our Genome" (Cloud 2010; *Der Spiegel* 2010; Maderspacher 2010, R835). The 'gene for' approach in explaining crime, well-being, social and educational achievement, psychological health, religion, sexuality, and so on is richly documented, widely publicized, and deeply engrained in the public consciousness. Not infrequently, genetics is fathomed and popularized as central to personal or collective destiny and genetic analyses are believed to objectively disclose ancestral secrets from the past (inherited health problems and strengths, ethnic and national origin, relatedness to famous people) and things to happen in the future (disease, behavior, social achievement, well-being, happiness). The discoveries in various domains of epigenetic research have the potential to guide critical attention toward the problems of sharp geneticization and reductionism, which have colonized our treatment of development and organism–environment interactions as well as the human situation at large. Meloni and Testa point out that "epigenetics may introduce a strong discontinuity with this stereotypical thinking" and lead "to a new relationship between biological and social events" (Meloni and Testa 2014, 446). In addition to the relatively rich spectrum of publications on plants, over the past years several widely discussed studies have shed light on the link between the experience of unfavorable environmental conditions and transgenerational epigenetic effects in mammals (e.g., Weaver et al. 2004; Anway et al. 2005; Dias and Ressler 2014; Radford et al. 2014; Yao et al. 2014). Furthermore, a number of highly visible reports have demonstrated associations between stress exposure or the specificity of socioeconomic status and the long-term epigenetic profile of studied groups of people. Insightful discussion of the results and their implications has also been provided (e.g., Heijmans et al. 2009; Kuzawa and Sweet 2009; McGowan and Szyf 2010; McGuinness et al. 2012; Pickersgill et al. 2013; King, Murphy, and Hoyo 2015; Yehuda et al. 2015). Epigenetics highlights the complex nature of development, disease, behavior, and other aspects of life and the human situation. That, as well as the far-reaching charm and potential of epigenetics to stimulate cross-disciplinary, multilateral, critical thinking targeting the views of biological predestination, could contribute to the *nature/nurture* debate and deserve to be considered in the spheres of science, healthcare, law, and education. Yet, the advances in this bio-discipline and the great enthusiasm that surrounds them need to be approached with a considerable degree of caution, so that the unwarranted biologization of destiny does not become exchanged for radical environmentalization or a new form of 'plastic' molecular biocentrism.

Epigenetics and genetic determinism relate to each other in highly charged and complicated ways. The ever-increasing amount of information which supports the emerging 'soft,' multidimensional view of heredity has sometimes been interpreted rather monochromatically as deconstructing or even destroying genetic determinism at large—in all its aspects and manifestations. It looks as though the data springing from this enchanted fountain of scientific research promise quick and directed liberation from the yoke of the gene and signal the dawn of a new era where the environment, experience, and choice are to be celebrated as the chief artificers of biological, behavioral, and social characteristics. In this vision, the determinative power of the gene dissolves to disclose a shifting landscape of countless potential forms and opportunities. Environmental change, chance, and free will are the main drivers of this fleet-footed transformation. At times, it seems that the excesses of the view of rigid genetic determinism, notoriously popular in the nineteenth and twentieth centuries, have been dethroned and replaced by the extravagance of the overarching softness of epigenetics. Not only has *nurture* returned to the debate but, having received great impetus and ambition, it has once more been pitted strongly against *nature*, threatening to invalidate and oust it. The deterministic outlook has been challenged only to change shape: biological determinism risks becoming a different, closely molecular version of itself. It can also mutate into environmental, cultural, or other types of determinism and/or into a system centered on malleability, behavior, choice, and will. Furthermore, broad genetic biologization could be exchanged with or could begin to exist alongside no less reductionist epigenetic biologization which approaches complex features through a narrow biochemical perspective.

Although portrayed as antagonistic, epigenetics and genetics are connected not only biologically but also in terms of representation: the striking language of modern epigenetics and neo-Lamarckism is interwoven with and dependent upon the language of 'hard' inheritance and neo-Darwinism. The symbolic arsenal is largely shared. Moreover, in both cases, the interpretation and exposition of the research data are taken as truthfully mirroring and accurately describing the underlying experimental evidence. The characteristic rhetoric of representation in epigenetics as in genetics, however, is not necessarily reflective of the scientific reality that it denotes but often rises above the underlying experimental results and takes on a relatively independent, pervasive, and widely influential existence. In this process, sacred utterances from the sanctum of the modern oracle of science are received, interpreted, fashioned, and brought to the attention of the public by the priests of the mass-media. Indeed, these present-day 'oracular mediators' occupy a key place in the creation of the scientific narrative, its resonance and influence. When assessing the dynamics in the field of heredity, it is of great importance to carefully fathom the creative relationship and the apparent distinction between the scientific base and the heavy rhetorical cloud around it. Language is an active player in the scientific arena: the enmity between epigenetics and 'hard' genetics is—to a great extent—symbolic, and the rhetorical aspect is a central factor in the polarization of the debate. The metaphors, which the scientists apply and use, have a capacity (restrictive or welcoming) to shape the development of the field that they are associated with. Absorbed in the communication media, these metaphors become more visible, additionally charged, extended and located within broader narratives.

On the whole, the paradoxical dichotomy between 'conservative' and 'new' heredity has to be apprehended in the light of a complex web of interactions between the human realm and science. The wall of the scientific sphere is not impermeable to nonepistemic values. Archetypes, expectations, beliefs, fears, and hopes pervade it and leave deep traces in what it encircles. As outlined above, under the shroud of charged language, much of the research in epigenetics indeed supports the critique against the rigid form of biological determinism and the view of genetics as destiny, but it does that in a balanced way: it attacks the often automatically and unconsciously perpetuated 'gene for' outlook, but it does not profess a radical split between soft/epigenetic and hard/genetic inheritance. On the contrary, it indicates interdependence between the two. A multidimensional view of heredity does not exclude genetics but presupposes that epigenetics and genetics, *nature and nurture,* are intertwined. The potential of this powerful, moderating side to epigenetics is waiting to be identified and channeled by the scientific and educational establishment.

The discoveries in epigenetics communicate with both the human fear of change and the human need for it. They are often understood and/or presented in the public space as giving an objective promise for the possibility of transformation and renewal. Yet, these scientific advances are also surrounded by a degree of fear related to the sense of biological impermanence and environmental vulnerability which they evoke. Such narratives are easy to locate in the media. In addition to *Der Spiegel*'s and *Time*'s cover stories cited above, examples include titles such as *The Telegraph*'s "Epigenetics: How to Alter Your Genes," *Newsweek*'s "Epigenetics: It's All in the Packaging. Roll over, Mendel. Watson and Crick? They Are So Your Old Man's Version of DNA. And That Big Multibillion-dollar Hullabaloo Called the Human Genome Project?," *The Economist*'s "Grandma's Curse," *Nature*'s "The Sins of the Father" and many more (*Newsweek* Staff 2010; *The Economist* 2012; Bell 2013; Hughes 2014). Interestingly, although epigenetics is hailed for promising boundless plasticity, the most widely discussed examples in the field, the ones considered most striking, are those of transgenerational epigenetics, especially the long-term, rather 'permanent' ones. This paradox of change and permanence is particularly strong in reference to studies reporting transgenerational epigenetic inheritance in mice and humans. Heredity is multilayered, receptive to the influence of the environment, and capable of prompt internalization of environmental signals, but the instances that grab the popular attention most profoundly are those where this internalization has become stabilized in the progeny. The presence of interweaving narratives of genetic flexibility and hereditary permanence is another symptom of the complex relationship between 'hard' and 'soft' inheritance as well as between science and the broader human world.

The rhetorical scenery around epigenetics (*receptiveness, softness, plasticity, malleability,* etc.) is closely connected to the celebrated promise for transfigurative change sought in this discipline and epitomized by it. The epigenetic language impinges upon a web of fundamental philosophical notions such as *nature (φύσις)*, *essence (τὸ τί ἦν εἶναι; οὐσία)*, *substance (οὐσία; ὑπόστἄσις)* and *existence (εἰναι)*. Modernity has a complicated relationship with these gnarled, deep-rooted terms, as clearly seen in the treatment of *essence*. From Descartes' plurality, Spinoza's singularity and Locke's distinction between nominal and real *essence*, via Santayana's elevated primacy of the *Realm of Essence* to the demotion of this concept or its outright rejection by some existentialists and postmodernists, *essence* has seen it all during the ages. Lamarck recognized the presence of a certain inner, *essential* principle, but he was not optimistic about deciphering it. *Essence* in Darwin's work is no less elusive; there are universal, typical aspects to life, but other, presumably *essential* elements, look impermanent, changeable. "This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species" affirms the conclusion of *On the Origin of Species* (Darwin, 1859, 485). Despite this bold statement, the debate about essentialism (of different forms: nature, type, life-force, etc.) in Darwinian thought is far from settled. Modern science is generally suspicious of such—redolent of idealism—terms and concepts, yet they (and the idealistic overtones they carry) have not disappeared but continue to exist under different guise in biology. Returning to the plane of heredity with full awareness of the pitfalls around crude associations between philosophical outlooks and scientific discoveries, it can be suggested that if the environment, experience, behavior, and choice can induce long-term epigenetic modifications, connected to phenotypic variation, which persist for many generations, if these acquired modifications and their effects can become stabilized, internalized and even genetically assimilated—then these changes may, perhaps, influence (or question) the very *essence* or *nature* of a living being. In this light (beyond the entangled essentialist dispute in biology), a creature becomes strikingly moldable, plastic: holding, exercising and also subjected to the potential to swiftly become something different—purposefully or accidentally. Current epigenetics, on a certain level, powerfully communicates with the phenomenological understanding of *essence* through the perspective of experience and the existentialist or postmodernist view underlining the precedence of *existence* over *essence*. This well known outlook is commonly positioned within a Western, mostly atheist framework, but it is also found in a different, theistic, context (e.g., to an extent in Søren Kirkegaard's thought or in the works of the sixteenth–seventeenth century Persian philosopher Mulla Sadra, where—along Neoplatonic contours—much attention is given to existence, becoming, change, and individuation with respect to *essence*). Indeed, Jean-Paul Sartre's assertions that man "will be what he makes of himself," "he is what he wills" and defines himself as man only after he "exists, encounters himself, surges up in the world," bear strong resonance not only with the general spirit of 'soft' neo-Lamarckian thought but, more concretely, with the public image of the discipline of epigenetics and the widespread presentation of its transformative potential (Sartre 1988, 349). How deep and profound is the epigenetic change? Does it reach and transmute the core, the *essence* of an organism, its *nature* (substantial or other)—in narrow-biological or other terms? How do the developments in the field address the problem of essentialism in the life sciences? If the shifting epigenetic landscape could obtain a level of permanence, the biological 'identity' of the individuals and the groups would relatively quickly and continuously change—randomly or in a directed fashion. Could this 'identity' become seen not as reflecting typical, inherent, or essential principles but as something fully emergent? If so, what would ensue from this notion? Through the perspective of overarching epigenetic malleability, what could the repercussions for biology, taxonomy, systematics, the concept of 'species,' and also for human identity, race, ethnicity, gender, health, crime, and law be? How could or should society channel or control the actualization of this kaleidoscopic potential? What are the ethical implications? Without doubt, more needs to be understood about these problems.

Fueled by the developments in epigenetics, the *nature vs. nurture* debate has begun to boil with renewed vigor. 'Hard' genetics is confronted with 'soft' inheritance; the perceived flexibility of molecular neo-Lamarckism is stood against the rigidity of the genomic neo-Darwinian synthesis; the 'inspirational' hot line between the environment and the hereditary apparatus is opposed to the 'hopelessness' of genetic determinism. The heat of the debate, however, could trick us into instinctively attending to the outward enmity between *nature* and *nurture*, but could also prevent us from delving deeper and gazing at the inner unity and co-dependence of the two. Permeating the information media, industry, and academia, the rhetorical and symbolic palette of epigenetics has largely grown in reaction to the excesses of the gene-centric outlook. Paradoxically, this palette has not blotted out or even softened the sharp symbolic and linguistic arsenal of 'hard' genetics but now exists in parallel with it, often along equally drastic lines. The dialectical coincidence of these opposing extremes is clearly visible in the mass media where "the happiness gene," "the bargain-hunting gene," "the God gene," "the binge-drinking gene" and "the infidelity gene" share space with "the victory over the gene," "it's all in the packaging," "how to alter your genes," "why everything you've been told about evolution is wrong," and "why your DNA isn't your destiny" (Langone 2004; Burkeman 2010; *Newsweek* Staff 2010; Coghlan 2011; BBC 2012; Bell 2013; Hirshmiller 2013; Carter 2015). The language, symbols, and metaphors of 'hard' inheritance and neo-Darwinism have not simply remained antagonistically situated in the picture but in one way or another have become absorbed into the epigenetic sphere. These forms of representation, however, do not necessarily truthfully depict the intricacy of the scientific and experimental reality but often conceal it. Epigenetics is impregnated with the metaphorical charge of 'hard' inheritance and shrouded by a similar thick veil of scientifically and experimentally unwarranted rhetoric (Noble 2015, 7).

Whether epigenetics lies between *nature* and *nurture*, within this dyad, or beyond it remains to be understood, but under the arresting veil of flamboyant language, the developments in plant and animal epigenetics (along with plentiful data from other branches of the biological sciences) clearly support and articulate not the disjunction but the unity of *nature and nurture*. The discoveries in gene regulation and epigenetics have enlivened the evolutionary discourse and stimulated the development of various ambitious integrative outlooks. Unified views of the theory of evolution including both neo-Darwinian and neo-Lamarckian elements have been proposed and widely discussed (Koonin 2014; Skinner 2015; Jablonka and Lamb 2002). A lively, expanding dialogue between the biological sphere, the social disciplines, and the humanities has been established. Although still contentious, the role of epigenetics as a connector, but not a disruptor, awaits to be explored, channeled, and incorporated in the way we regard the *nature/nurture* dyad.

The Ethical Dimension

The fact that the environment and various aspects of individual or collective experience can induce measurable epigenetic effects influencing the development health, and well-being of individuals across a generation and in the next generation(s) makes epigenetics a natural focal point where biological, social, ethical, and legal perspectives coincide and interlink. Epigenetics has been described as "one of the most scientifically important, and legally and ethically significant, cutting-edge subjects of scientific discovery" (Rothstein, Cai, and Marchant 2009, 1). The effects of the advances in this field of research do not stay confined to the academic discourse and the province of science but resonate broadly, communicating with the human condition on many levels and raising numerous practical philosophical questions.

The vibrant epigenetic narrative, with its wide presence, penetration, and influence, plays a pronounced role in the relevant ethical, legal, and social debate (Juengst et al. 2014, 428; Meloni and Testa 2014, 441–42). Experience, behavior, the power of choice, and will are heavily emphasized in the fora of science dissemination. Through the angle of transgenerational environmental epigenetics, a great many of our decisions (from the global to the local, most common and ostensibly innocuous ones—related to different forms of pollution, various environmental influences and effects, diet, psychological, physiological, and other types of pressure and trauma, and so on) become ever so significant to the health and well-being of the next generations of humans and other life forms. The stress on the combination of inherent biological plasticity, transformative potential, environment, long-term inheritance, and choice brings the problem of responsibility center-stage, somewhat echoing Sartre's claim that "if . . . it is true that existence is prior to essence, man is responsible for what he is" (Sartre 1988, 349). It seems that "man is responsible" not only for what "he is" but also for what individuals and populations of many other species are. The weight of collective and individual responsibility and accountability, however, is unevenly distributed. Although the foci of interest are widening and merging, females (actual or potential mothers) alongside various social, ethnic, and racial groups (e.g., working-class British citizens or African

Americans) receive a disproportionally large amount of biological, social, ethical and broad popular attention. On the one hand, the research, presentation, and public understanding of epigenetics highlight plasticity and the role of free will, but on the other hand they bring a new deterministic angle to the discourse where factors such as social class, gender, and race play a key role and attract a lot of multidirectional scrutiny and judgment (Mansfield 2012, 352–69; Juengst et al. 2014, 427–28; Meloni and Testa 2014, 437, 446). This is another indication of the issues surrounding a possible switch from one form of determinism (genetic) to another (gender, racial, or environmental) where the prominent biological/biochemical component remains constant. The influence of the ongoing developments in heredity (and their interpretation), however, is remarkably extensive and complex, operating beyond superficial binomial confrontations and simplistic divisions and contradictions. It not only prompts questions about racial or gender determinism and bias, but also reaches deep into the very perceptions and discourse about race, ethnos, and gender, which are beginning to be seen as distinctly plastic.

The impact of epigenetics is not limited to various developmental, physiological, hereditary, and other phenomena but extends to the biological dimension of animal and human behavior (van Dongen et al. 2015, 686–95; Lenkov et al. 2015, 1–9; Simola et al. 2016, 42). In this regard, focused elaboration on biological/biochemical causation can be of great benefit but it can also become misguiding and lead to accentuated biologization of complex, multifactorial features such as behavior, psychology, and well-being (Baselmans et al. 2015, 710–17; Tamatea 2015, 629–40). Epigenetics, with its wide connectedness, however, offers a richer panorama: not only can it stimulate biomolecular reductionism, but it also harbors the potential to challenge this undue limitation, inviting a broader, not narrowly biological perspective. The wider compass of general ethical aspects surrounding the problem of behavior and free will, related to epigenetic research and presentation, is of notable relevance for the sphere of law and legislation. Here, again, an intricate duality may be discerned where, on the one side, the widely publicized advances in epigenetics underline the importance of free will, choice, and individual and collective responsibility, yet on the other side, the epigenetic marks and modifications may also be understood as effectively modifying behavior, limiting free will and introducing another dimension of reductionism and determinism. In addition to law, these issues have a pronounced bearing on psychology, education, philosophy, and theology which expects to be addressed and fathomed.

Following in the footsteps of genetics, the employment of epigenetic markers in behavioral science and criminology and in testing for addiction or use of various substances is mired in ethical, legal, and scientific problems (challenges to individual autonomy and privacy, discrimination and stigma, environmental bias, reduction of multifaceted problems such as crime, addiction, and social success to the presence or absence of certain biomolecular features) which need to be approached promptly and seriously (Erwin 2015, 662–72; DeLisi and Vaughn 2015, 623). Furthermore, the translation and incorporation of epigenetic research conducted on plants and animals into human healthcare or applied social science holds many risks. It is not only the extrapolation itself that is problematic but, alongside the need for a solid evidence-based approach, it is also troubling that the focus of attention falls on individuals or groups of people who are "sensitive, and even vulnerable, to health advice that carries the authority of science" (Juengst et al. 2014, 428).

Sensitivity and openness to the effects of the environment are two key characteristics of the epigenetic landscape. Another of its attributes is its intimate and dynamic connection with the genome. The epigenome not only influences the function and activity of the genome; it may also impact the underlying genetic structure. More needs to be understood about the nature, generation, retention, stabilization, frequency, persistence, and inheritance of the acquired epigenetic modifications, but there is a general perception that various plastic effects can become 'internalized,' 'solidified,' and genetically accommodated/assimilated. This plasticity could be celebrated for the desired changes it could bring about (spontaneously or in a directed fashion) but it could also be feared for giving rise to undesired modifications leading to undesired phenotypic effects. The evoked fear could become more expansive, spreading also to the general lack of stability and perpetuity for characteristics or systems of features deemed essential or necessary. The receptiveness of the epigenome to environmental influence, its potential to absorb and 'internalize' this information, along with the problem of narrow molecularization, pose salient questions: how to defend the (epi)genome from adverse or unwanted environmental effects; how to retain—or even augment—the positive epigenetic marks, and how to reduce or eliminate the negative ones; are there any epigenetic standards and what are they? Individuals and groups of people, especially from vulnerable sections of society, could be encouraged or required to improve or protect their epigenetic profile in accordance with an 'unquestionable' scientific touchstone or framework. In this context, there is a great risk of embracing the notion of 'purity' in the same monochromatic 'scientific' way in which it has influenced the development and public understanding of genetics (Meloni and Testa 2014, 445). An urge to protect, retain, or solidify the individual or collective epigenome could lead to a new form of biological engineering analogous to eugenics—*euepigenics* or *epieugenics* (Juengst et al. 2014, 428). Resembling genetic discrimination, epigenetic discrimination may be reflected in the delineation of an epigenetic underclass of 'burdened' citizens (Tamatea 2015, 636). Epigenetic markers may come to be viewed as a tell-tale sign of moral, intellectual, or psychological weakness (Erwin 2015, 672). Such biodeterministic oversimplification of the complexity of life and the human situation cannot but engender controversy and dire consequences. What would the repercussions of the softness, malleability, and receptiveness of the epigenome be in terms of our individual or collective identity—racial, ethnic, or even national? Could epigenetics become a (key) identifier of what we are? Targeting the problem of race, Becky Mansfield writes:

> My question, then, is what happens to race if biology is no longer something pre-determined but is quite plastic? My argument is that even as it erodes notions of essentialized difference, an epigenetic understanding of life does not eliminate but rather transforms notions of biological race and can intensify racialization, simultaneously producing race as a category and ascribing causality for phenomena to racial difference. This is particularly so when the plasticity of the body is tied to processes of normalization such that race is seen as an emergent quality of the body rather than an essential one. (Mansfield 2012, 353)

The array of contentious points around epigenetics could potentially be exploited by the political system, industry, or unscrupulous scientists. Moreover, the effects of environmental pollution on the epigenome, in light of various transgenerational health issues in humans and other species, deserve to receive greater and immediate scientific and legal attention (Schaefer and Nadeau 2015, 387). These and many other related problems need to be addressed multilaterally and ecumenically before the new understanding of biology becomes firmly established in our global outlook.

Conclusion

The advances in epigenetics and gene regulation have attracted a lot of academic and popular attention to the complex, multidimensional nature of heredity. Careful scrutiny of published research, juxtaposed with relevant concepts and narratives from the information media and the wide social discourse, can bring valuable insights into the structure and dynamics of this fast-growing field of biological research, its resonance, presentation, pervasion, perception and influence. More broadly, such an analysis could potentially open a window into science–society interactions and could even be viewed as a possible model in the study of these interrelations.

Epigenetics has become a focal point in which various interests meet and communicate. It provides a valuable zone of contact between the sciences, the social disciplines, politics, legislation, and the humanities where they can converse and cooperate. Such a multidisciplinary dialogue could contribute to the establishment of an integrated, holistic understanding of inheritance, the role of the environment, the relationship between the biological and the socio-cultural and—generally—the wide-reaching *nature/nurture* dichotomy. It could offer many benefits to the life sciences and their liaisons with other branches in the tree of knowledge. Despite the great interest in the epigenetic sphere, however, its potential—in reference to heredity, evolution, development, healthcare and education, as well as to the social, legal and other domains—hasn't been maturely and efficiently studied, tapped, and utilized. Epigenetics has become enveloped, consumed, and inflated by a cycle of hypes. It has been enthusiastically embraced by the proponents of 'soft' inheritance, pitted against 'traditional' genetics, and advertised as an example and a source of incredible biological transformation. Consequently, the 'hard' gene–centered, reductionist outlook has been challenged only to a limited extent and now exists alongside equally extreme views and rhetoric of 'soft' epigenetic change and malleability. Such a polarization does not only reflect but also fuels the age-old *nature vs. nurture* antagonism, posing many scientific, philosophical, theological, social, legal, and educational problems. Over the last two centuries, this dichotomy has had well known, sometimes disastrous, effects on the way we view, study and treat ourselves, each other, and the organic world at large. The full capacity of the advances in epigenetics to moderate this dangerous confrontation through an integrative, cross-disciplinary dialogue needs to be revealed, better examined, interpreted, and embraced.

Evidently, the rhetorical and symbolic cloud around epigenetics plays an important role in the life, growth, and success of this field of biological endeavor. Definitions and language are not passive elements in the structural and dynamic mosaic of epigenetics but actively influence the development of the discipline, its high-contrast image, and its part in the *nature/nurture* debate. To better understand epigenetics is not only to go beyond the veil of representation but also to gain a more detailed perception of this veil's complex fabric of different strands and interactions as well as of the shaping power of language, metaphors, and symbols.

Epigenetics is surrounded and permeated by a multitude of problems which demand critical assessment. The discipline, in all its dimensions, however, deserves not to be automatically sentenced or repudiated but taken seriously and approached in a 'medicinal' way—it should be carefully studied and, in a sense, 'restored' to take its place in biology and beyond. Surely, being fetishized, heavily charged with expectations and ideologies, and dressed in flamboyant rhetorical attire which does not fairly represent the scientific base indicates that epigenetics requires serious critical scrutiny and refinement; yet, this kaleidoscope of problems also discloses a certain appreciable potential that needs to be channeled and employed but not dissipated. Not only can what has become known as epigenetics shed light on heredity and other biological aspects, but it can also provide insights into science-society interactions, the public imaginary, and the psyche. This multidirectional epigenetic potential is still waiting to be located, studied, understood, and actualized.

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