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*DOI:*

[10.1080/0731129X.2024.2376444](https://doi.org/10.1080/0731129X.2024.2376444)

*Publication date:*

2024

*Licence:*

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*Document Version*

Publisher's PDF, also known as Version of record

[Link to publication in Discovery Research Portal](#)

*Citation for published version (APA):*

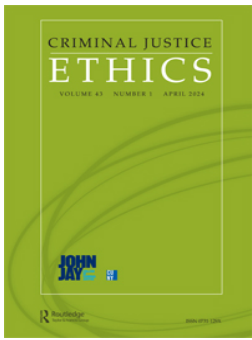
Vecellio Segate, R. (2024). Exposing, Reversing, and Inheriting Crimes as Traumas from the Neurosciences to Epigenetics: Why Criminal Law Cannot Yet Afford A(nother) Biology-induced Overhaul. *Criminal Justice Ethics*. Advance online publication. <https://doi.org/10.1080/0731129X.2024.2376444>

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**To cite this article:** Riccardo Vecellio Segate (24 Jul 2024): Exposing, Reversing, and Inheriting Crimes as Traumas from the Neurosciences to Epigenetics: Why Criminal Law Cannot Yet Afford A(nother) Biology-induced Overhaul, Criminal Justice Ethics, DOI: [10.1080/0731129X.2024.2376444](https://doi.org/10.1080/0731129X.2024.2376444)

**To link to this article:** <https://doi.org/10.1080/0731129X.2024.2376444>



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Published online: 24 Jul 2024.



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ARTICLE



# Exposing, Reversing, and Inheriting Crimes as Traumas from the Neurosciences to Epigenetics: Why Criminal Law Cannot Yet Afford A (nother) Biology-induced Overhaul

RICCARDO VECELLIO SEGATE 

*In criminal proceedings, offenders are sentenced based on doctrines of culpability and punishment that theorize why they are guilty and why they should be punished. Throughout human history, these doctrines have largely been grounded in legal-policy constructions around retribution, safety, deterrence, and closure, mostly derived from folk psychology, natural philosophy, sociocultural expectations, public-order narratives, and common sense. On these premises, justice systems have long been designed to account for crimes and their underlying intent, with experience and probabilistic assumptions shaping theoretical discourses on the nature of crimes and offenders' punishability. As scientific discoveries, inventions, and methodologies progressively developed to refine such doctrines and displace long-held assumptions, criminal courtrooms have increasingly witnessed counsels and judges relying on scientific evidence to submit, dispute, or validate claims. For instance, over the last century, criminal courtrooms have selectively admitted neuroscientific models, exams, and insights claiming to revolutionize our understanding of who is culpable and deserving of punishment. Most recently, advancements in epigenetics have promised even more profound challenges to long-standing criminal law doctrines. This article examines the reasons reversibility and inheritability of epigenetic markers might warrant revising culpability and punishment and concludes that epigenetic findings are not yet robust enough to justify such revisions.*

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**Keywords:** epigenetics ELSI, folk psychology, neuroscientific evidence, reversibility and inheritability of epigenetic markers, standard of proof in criminal proceedings, theories of culpability and punishment

## 1. Introduction

*Epigenetics is the coffee stain on the page that gets copied when you photocopy the book, and [then] someone photocopies your copy.<sup>1</sup>*

The revolutionary *potential* of epigenetics (or epigenomics)<sup>2</sup> is so disruptive that debates thereabout are unfolding on a scale which is arguably unprecedented for “unsettled” science. Despite this branch of knowledge being relatively recent and far from settled, strictly scientific literature on epigenetics from clinicians as well as evolutionary, molecular, and computational biologists is already so extensive that attempting a comprehensive review here would exceed the scope of this paper. While the reader is invited to engage with it directly,<sup>3</sup> I will just offer a couple of paragraphs to delineate a few selected aspects of special relevance for our ensuing discussion here.

Cells can be said to keep a record of their (stressful) events, understood as mechanical and metabolic solicitations translated into signals that can be “decoded” by a cell.<sup>4</sup> Such “memory” is enabled by and stored into biochemical markers which are capable of switching on or off the expression of that cell’s genetic information. We can define such dynamic, cell-type-specific markers as epigenetic markers. These play a role in pluripotent cell structural and functional differentiation,<sup>5</sup> oncogenesis and mutagenic disease onset,<sup>6</sup> aging<sup>7</sup> (and its partial reversal?),<sup>8</sup> and most importantly here, indeed, in gene expression. The process does not

alter the genotype *per se*, nor necessarily the phenotype; it is more of a gene regulation mechanism that may alter phenotypical expression.<sup>9</sup> Each human cell contains 2.2 m of DNA, coiled and wrapped around proteins, with  $2 \times 3$  billion letters encoded therein;<sup>10</sup> zooming out, the human body counts approximately 40 trillion cells. Epigenetic mechanisms (agents and signals) that can activate or deactivate (i.e. silence) the expression of specific regions of this genome (i.e. the total DNA of a living organism) are, *inter alia*: DNA methylation; chromatin remodelers; histone modifications; and non-coding RNAs. For the sake of this paper, it is not essential to understand the difference among them; what matters instead is to recognize that “epigenetics” is a sophisticated universe of different elements, not all of which act in the same way or bear the same effects. Policy-wise, the relevant quest is for at least one of the elements (assuming it could be managed in isolation from the others) to deliver on the promise which will be recounted below. Going back, briefly, to the science, it shall be noted that for a long time, and until recently, epigenetics had been concerned with cells’ “signaling memory” as opposed to their inheritability across cell generations and eventually organism generations. Currently accepted definitions extend to “regulatory processes that involve molecules known to participate in epigenetic inheritance, even when

not addressing the epigenetic memory function per se."<sup>11</sup>

Intuitively, in a popular sense, epigenetics might be said to "captur[e] the molecular signatures of social experiences,"<sup>12</sup> including suffering, stressors, and trauma; it might also be metaphorically grasped as wrapping one's sites of struggle around that person's genome, or as embedding one's personal history into the genes. This may occur within a person's lifetime as much as intergenerationally, through a variety of markers that could seemingly be "reversed" to different degrees.<sup>13</sup> In a more scientific register, "epigenetics refers that molecular modifications on DNA that can regulate gene activity are independent of DNA sequence and mitotically stable,"<sup>14</sup> and the epigenetically marked genome is called epigenome. DNA methylation, for instance, is accepted as an epigenetic biomarker for one's actual aging, which accounts for "[p]sychosocial exposures, traumas and adolescent adversity," to track and somehow "explain" associations "with mortality, cancer, and cognitive impairment."<sup>15</sup> However, as recalled earlier, epigenetics embraces a number of other techniques and phenomena which "are all correlated and intertwined," although "we must absolutely resist the temptation to equate them all mechanistically:"<sup>16</sup> alongside DNA methylation, histone modifications are mitotically stable and inherited transgenerationally, influencing gene expression and regulatory RNA production. As a working definition for this paper's purposes, I will accept that epigenetics represents the universe of physio-chemical mechanisms through which the expression of our genes is activated or silenced by regionally altering the

shape and folding of those genes themselves, but without impacting their overall morphology (i.e. nucleotide sequence).<sup>17</sup>

Epigenetics, concerned not so much with genes per se as with their expression patterns, fits within the overarching scholarly endeavor to finally sophisticate the gene-intensive (or even gene-siloed) understanding we have long held of ourselves, and to decode the actual multifactorial sources of our being, relating, behaving, and choosing. There is one paradigm-change potential that sits right at the root of epigenetics: its reversibility. Epigenetics' most powerful message is that the way our genes are expressed can be reversed so as better to align with social expectations and therefore enhance one's fitness for "social success." When this is coupled with epigenetic markers' claimed inheritability, implications extend even farther, and have been duly captured by social scientists from a variety of perspectives.

As for lawyers, they have been walking down a very similar path for some time already. Four decades ago, the epigenetic wave started traversing the entire spectrum of scholarly knowledge production and consumption, with a broad range of (more or less grounded) revolutionary perspectives. In this article, I seek to explain why criminal law, too, has been affected by epigenetics to its core, and address the risks of turning this preliminary influence into evidentiary material that courts would rely upon in adjudicating defendants. Epigenetics' impact on criminal law draws on this logic: if our behaviors are also explained by epigenetic factors that can switch off or on the expression of our genes, and if such factors are influenced by the exposure (especially via

“substandard” upbringing) to certain long-term environmental conditions, then not only can criminal behavior be “excused” as contingent on such conditions; it could also be “treated” through the removal or alteration of such factors, i.e. their optimization for “prosocial”<sup>18</sup> as opposed to “anti-social” behavior.<sup>19</sup>

Claims (or expectations) I just outlined notwithstanding; reality is admittedly not as simple. Can gene expression be “undone” by removing the markers? And how direct and immediate would the effect on behavior be? Also, how are epigenetic traits inherited? Is there a scientific way to demonstrate said inheritance, to an extent that would be deemed trustworthy by a court of law and satisfy criminal-law standards of proof? Taking stock of the above, this paper provides the first assessment of epigenetics research readiness from a criminal-law perspective; even more specifically, it expounds the policy-legal reasons that epigenetics research (and even more so, epigenetic records of individuals based thereon) is not yet ready to be tendered as evidence in criminal proceedings with the aim of displacing traditional paradigms of culpability and punishment.

To deliver on its stated ambition, the paper will proceed as follows. Section 2 provides a relatively succinct overview of the claims advanced in social science scholarship regarding the implications of epigenetics for our social living. It recalls the reasons social scientists have enthusiastically (and perhaps to some extent uncritically and/or prematurely) embraced the perspective that epigenetics will increasingly contribute to explaining—and, to some extent, justifying—social phenomena such as crime,<sup>20</sup> disadvantage, and

inequality, both over the course of one’s lifetime and intergenerationally.

The paper then delves more specifically into epigenetics’ legal implications, especially for criminal justice. In Sections 3 and 4, it unpacks in further detail the two claims that might more prominently enter the courtroom, and comment on the existing legal literature surrounding those claims.

The first potential claim it focuses on is that epigenetic markers are inherited—or at least, that they *may* be inherited; if this was true, it could help explain the intergenerational transmission of “bad” (i.e. socially unfit, or even prone-to-crime) genes (that is, their expression), but also the legal significance of subjecting one to inappropriately violent and/or socially extractive environments that may “settle” into genes and be transmitted.<sup>21</sup> Along similar lines, the legal implications of traumatizing someone are amplified with epigenetics. The neurosciences had already rudimentarily suggested that “[w]hile violence leads to trauma, trauma also leads to violence,”<sup>22</sup> but this had been statically addressed within the scope of one lifetime only. Indeed, with some minor exceptions that transcend the scope of this paper, criminal law is currently “intergenerationally neutral” vis-à-vis trauma inflicted onto others, in the sense that trauma is assessed “monogenerationally” for its exclusive effects on the immediate victim’s living. Epigenetics would overturn this monolithic conception, and reconceptualize trauma more dynamically as intergenerational harm, which, if proven, could well become an aggravating factor at sentencing for those who inflict it, and

an exculpatory/mitigating factor for defendants who suffered it.

The second potential claim lawyers would probably endeavor to submit is that differently from the genome, one's epigenome can be "reprogrammed" or "reversed" more easily—and perhaps one day more cheaply, too.

In Section 5, I explore the potentially transformative power of epigenetics for the detention system and, relatedly, for the four main rationales for culpability and punishment.

In Section 6, I make conjectures about the reasons legal counsels might be tempted to try to tender epigenetic evidence as a mitigating or exculpatory ground for crimes—especially violent ones. I specify why this move seems problematic at this stage, and what the risks are in terms of evidentiary inaccuracy but also cognitive biases for the parties involved.

In Section 7, I draw a parallel between the premature acceptance of neuroscientific evidence in criminal proceedings and the potential for a specular maneuver with epigenetic findings.

In resuming the discussion around epigenetics, Section 8 briefly shifts the focus onto medical practices, theories, and standards. Drawing on essential outlines of the current state of biomedical research on epigenetics, and touching upon directions, open problems, and "schools of thought," I posit that the science is not yet ready to validate the (expected) lawyering claims from a medical perspective. I will introduce the reader to the inconsistency and weakness of current evidence, and further specify what exact benchmarks those shortcomings are assessed against, that is,

what would be required (or "what is missing") for such claims to be considered "valid." Against what theory of causal inference in medicine could lawyers assess the "readiness" of scientific claims for being introduced at court? I will recapitulate the relevant standards of proof in criminal law, contrasting them with the ones applicable for tort claims, arbitral proceedings, and so forth. A thorough examination of the conditions that, once evidence is deemed to rest on medically validated research (if ever), would enable lawyers to satisfy the beyond-reasonable-doubt evidentiary standard, requires an analysis of its own. More modestly, Section 8 confines itself to sharing with the reader a high-level overview of these methodological interfaces between medical and legal standards.

Lastly, Section 9 will insist on parallelism from neurosciences, in order to inspect not the scientific underpinnings of a potential criminal-justice overhaul, but its social attainability and policy desirability. Most radically, it interrogates the reasons that, despite significant evidence to the contrary, humans find it attractive to cultivate the belief that their actions depend on their rational choice and not that they are predetermined (or at least lie at the confluence of predetermined variables). Is believing in free will a necessary and somehow "inalienable" precondition for the orderly conduct of human societies? Does it define our "being together" to such an extent that whatever the scientific findings on the matter, we should keep pursuing the comforting idea that criminals could have effectively chosen to act against it? Put differently: to what extent should even the soundest of the natural science

be translated into fundamental rethinking and reorganization of the way criminal justice is administered? Section 10 offers a conclusion.

It is probably worth emphasizing from the outset that although I repeatedly caution courts here against taking a similar turn as with neuroscientific evidence (until the science grows stronger), I do hope epigenetics will overcome its current limitations and be peer-validated up to the point of contributing to

society also via a rethinking of the entire justice system. As will become clearer throughout the paper, the extremely powerful message announced by epigenetics is that, in principle, any offender could enjoy at least one chance to be rescued. We just need to make sure that this message is delivered when the transmitting device (research), the audience (society), and the message's content itself (science) are all ready to hear and be heard.

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## 2. Social Implications Broadly Construed

Epigenetic research is widely known for sparking controversy and stirring debate, swinging between extreme excitement and cautious conservatism. Because of the potentially subversive momentum it solicits both conceptually and among social practitioners, as well as its promise of empowering individuals and social groups, epigenetics is redefining the epistemology of anthropology,<sup>23</sup> and has become an “object of speculation for policymakers, including speculations about new ways of envisioning links between nature and nurture, about eliminating poverty, abuse, violence, mental illness, cancer[,] and much more.”<sup>24</sup> The controversial nature of epigenetic research spans medical specialties, and extends to the social sciences. Here I explore legal implications in particular and reviews that have flourished lately, to try and systematize all the claims put forward.<sup>25</sup>

The broader context of this research is clear. On the one hand, genetics has long advised us that illness and health are almost never dependent on genes alone. Even what was supposed to be the most

“environment-independent” genetic domain—i.e. genetic diseases—is now attributed to the environment to an appreciable degree. For instance, on a population level, one may think of penetrance, whereby the penetrance rate of certain recessive but also autosomal dominant traits depends on other gene variants but also—and not necessarily to a lesser extent—on environmental variables.<sup>26</sup> This is one of the reasons why ethical, legal, and social implications (ELSI) literature has blossomed around an issue such as genetic testing and its wider socio-legal context.<sup>27</sup>

No wonder that warnings against “serving epigenetics before its time”<sup>28</sup> have been issued: social-science related claims surrounding epigenetics have increased in scope and number, and been widely popularized in the media, but in keeping with the culinary metaphor, they seem disjointed from the actual state of “ripeness” of the underlying science. Indeed, it was contested that

*[ELSI] scholarship in epigenetics ... anticipate [s] troubling uses of epigenetics, offering an*



*unlikely and at times overly deterministic vision in which a multitude of environmental and lifestyle factors can be clearly associated with specific epigenetic changes.<sup>29</sup>*

This is no surprise: social scientists have been misappropriating the epigenetic discourse for at least three decades, focusing on Lamarckian (as partly “opposed” to neo-Darwinian) inheritability of epigenetic markers as if scientists had shared this understanding of the epigenome with conviction,<sup>30</sup> and as if the science had been settled to the extent that most social dynamics could be immediately reshuffled to accommodate it. Regrettably, the scientific underpinnings of epigenetics are mostly correlational rather than causal; and even so, correlations are far more uncertain, weak, and inconsistent than what these social scientists believe or purport to believe. In fact, partly out of a sense of qualitative vindication against the science-driven peripheralization of the “social” in quantitatively explaining human behavior,

*social epigeneticists make far-reaching claims by selecting elements from research labelled epigenetics in biology while ignoring widely confirmed scientific facts in genetics and cell biology, such as the dependence of epigenetic marks on DNA sequence-specific events, or the lack of evidence for the lasting influence of the environment on epigenetic marks or the epigenome.<sup>31</sup>*

What is more, juxtaposing Darwinian and Lamarckian insights out of epigenetic epiphany is misleading, and the reiteration of a long-standing sterile debate under an epigenetic guise.

*In fact, scientists have long accommodated the role of “habits” within “broadened” approaches to evolution operated via natural selection, and this is not the same as to claim*

*that any acquired characters can be transmitted ipso facto, or that this makes them the driving force of evolution. More accurately, Darwin’s flexible and pluralist approach to habits throughout his scientific activity [...] might have let him easily and profitably to integrate within his theory even those mechanisms that go today under the label of epigenetic inheritance and, strictly connected to that, phenotypic plasticity.<sup>32</sup>*

Perusing this complexity does not equate to rehabilitating Lamarck. Epigenetic variation does not drive unlimited change, and “transgenerational epigenetic inheritance [...] can be understood as] an obligatory emergent feature of evolution, [...] instead of] a property inherent in living matter itself.”<sup>33</sup> Furthermore, coevolutionary dynamics that partly “dethroned the genome” by focusing on parasitic transposons had already been embraced in biomedical science prior to the epigenetic turn and were already displacing any rigid interpretation of Darwin’s legacy.<sup>34</sup>

This “state of the field” prompts us to deviate from an ELSI approach to epigenetics in order to advance our criminal-justice claims; rather, I will survey ELSI’s “ethical” and “social” components to set the landscape for my contribution, and then turn to the law separately, with specific focus on the doctrines and procedures of culpability and punishment in criminal proceedings.

The socio-ethical discourse builds primarily on human rights (HR) theories. In equality and HR literature, which does involve (international) publicists but mostly pertains to political scientists, the reversibility of epigenetic markers is most often considered under a positive light, to the extent that if the technology to undo negative markers becomes widely accessible, this might lessen the

influence of “bad genes” and optimize everyone’s genetic expression—in other words, it would decrease the importance of genes per se and enhance that of their expression, which could however be controlled more than genes per se could be. And yet, scholars question whether this stands, in essence, similar to several quasi-eugenic trends whereby one “societally suboptimal” deserves no place—or at least no good place—within society; indeed, the claim would become that if one could optimize themselves epigenetically but does not do so, their marginalization would be their fault. And on a more macroscopic take, [w]hat if epigenetic discourses on different levels of methylation between social groups are used to underwrite new discourses on “the biological inferiority of the poor” or on incapacity of the poor seriously to take care of themselves?<sup>35</sup>

Of course, one could cynically rebut that even without epigenetics—and even without genetics, for that matter—those who are for any reason considered “suboptimal” by “dominant” groups in society would not join the highest ranks of that society, however those ranks may be defined. They would not be selected for them, coopted into them, and even if they aspired to or “applied” for them, they would face rejection. This has always been the case with humans, and will probably always remain, regardless of genetics or epigenetics. This is obviously not a good reason, however, to dispel at least the idealistic tendency towards more inclusive societies. The current trends towards idealistic perfectionism—from neuroenhancement<sup>36</sup> to cosmetic surgery, from discourses around transhumanism to debates

on genetic editing—are closely tied to extremist stances on epigenetics which should be carefully isolated and problematized.

One extremization to be problematized concerns pregnant women, who might be blamed for having provided their fetuses with suboptimal environmental conditions which would be then reflected in their children’s “fitness for life,” including their mental and physical health.<sup>37</sup> This is not merely about “methylation epigenetics;”<sup>38</sup> for instance, epidemiologists lamented “the shortage of studies that assessed how early-life exposures in utero and during childhood were associated with non-methylation epigenetic changes, particularly histone PTMs and ncRNAs.”<sup>39</sup> Mother-blaming arguments might carry some degree of scientific truth, but fair opportunities to provide otherwise seem exceedingly difficult for anyone to assess, to the extent that in social and legal practice, blaming pregnant women for their life choices seems unhelpful. In the least, it is increasing the already existing “surveillance” on their behaviors because of epigenetics. My argument is not that maternity should not be a forum for epigenetically informed debate merely because feminists cannot accept the maternal body being a site for enhanced epigenetic scrutiny compared to the male body.<sup>40</sup> I am rather reasoning simply on the grounds of unpreparedness of the underlying science, and on the consequent meaninglessness of constructing socially perilous discourses and practices referring to such science. For example, in reviewing “how DNA methylation dynamically changes in blastocyst formation and gastrulation and its function in

transcriptional regulation lineage-specific genes," it was accepted that "lineage-specific interactions and interaction activity may contribute to different lineage specification... [but] the understanding regarding the properties and functions of chromatin structure on lineage specification remains superficial."<sup>41</sup>

If simplistic implications were not eradicated, one could already foresee that in not so distant a time, mothers could be summoned by courts to respond for (part of) their offspring's crimes. This would drastically revolutionize the core criminal-doctrine assumption<sup>42</sup> that criminal liability is strictly individual unless proven otherwise. This assumption stems from the common-law principle of individual autonomy, which "subjectivizes" criminal liability by informing it not only with an act listed as "criminal" by positive law (*actus reus*), but also with considerations around guilt (*nullum crimen sine culpa*), mental capacity and awareness (*mens rea*),<sup>43</sup> and thus eventually intention to commit a *dolus malus*.<sup>44</sup> In plain language, criminal law is premised upon convicting individuals who had a fair opportunity to decide otherwise, and the reader will recognize here the same expression I deployed *supra*. Epigenetics is still rudimentary science, but it might end up complexifying the boundaries of such "opportunity" remarkably. Upon committing a criminal offence, defendants may argue that their epigenome contributed to them not having a "fair opportunity" to decide otherwise, because the way their genes are expressed can explain their criminal tendencies. Defendants' mothers, in turn, could refuse to accept liability on the grounds that the epigenome they

"transmitted" to the defendants records the best environmental conditions they could afford to provide the fetuses with at the relevant time. These arguments read as grossly overstretched today, and they indeed are, but one shall not forget that certain neuroscience-grounded arguments could have read just as overstretched one century ago, while they are nearly mainstream in criminal proceedings nowadays.

Along somewhat similar lines, there are many other claims around "epigenetic disruption" that may read as misguided or overbold. For instance, it is often repeated that with epigenetics, "the blame shifts from the bad genes, for which our ancestors cannot directly be blamed, to a bad epigenome, for which they can be blamed, as it may be the outcome of a bad lifestyle or traumatic life."<sup>45</sup> However, if one thinks more closely about it, this statement makes no sense. First, ancestors can be blamed for genes, too, insofar as the former are aware of the potential genome they are going to transfer to their offspring, including genetic diseases and other "disadvantages" that appear as evident from the phenotype; second, even accounting for several "circumstantial" conditions, the "range" of "lifestyles" we can adopt, pursue, and "choose," still depends largely on the genome we inherit. Moderation is always warranted before claiming that someone can be "blamed" for one's epigenome more than they could already be blamed<sup>46</sup> for their genome! If something must be blamed on one's disadvantages in society, the genome comes first; one issue with intergenerational trauma literature building on epigenetics is that it seeks to displace the "genome" component of

the “epigenome.” Socially, “externalized blame” is also risky, insofar as it is deployed not merely to *explain* one’s attitudes and fragilities, but to justify them a priori—de-responsibilizing individuals always makes for a disempowering move. Retrospective analyses seem helpful for contextualizing traumas but should not be allowed to shield individuals from the responsibility to strive for an after-trauma future of independence and healing. Epigenetics should not force individuals to undergo re-traumatization, and most of all, it should never be turned against them if they decide to leave the epigenetic markers of their traumas unexplored and unaddressed. “[T]rial processes are often liable to exacerbate rather than ameliorate trauma amongst a broad constituency of victims,”<sup>47</sup> and epigenetics’ emphasis on (intergenerational) trauma bears the potential to upscale the magnitude of this long-standing, precarious tradeoff between victims’ protection and comprehensive disclosure in legal proceedings.

Whatever their reception in the courtroom, equality and disadvantage are mostly shaped intergenerationally via cumulative effect, which is exactly why the social science debate around epigenetics is particularly interested in the potential inheritability of epigenetic markers,<sup>48</sup> and more specifically in two distinct epigenetic transgenerational effects:

*germ line inheritance ... where the epigenetic signature is not entirely cleared in gametogenesis and can be transmitted through the germ line ... [and] non-germ line, experience-dependent epigenetic inheritance ... where the epigenetic signature is re-established in each successive generation by the reoccurrence of the “behaviour or*

*environment that induces the mark,” also known as “niche recreation.”<sup>49</sup>*

In considering these factors, one of the obvious risks is a descent too deep into determinism. Our bodies, minds, behaviors, relationships, and achievements are far more and else than what our genes and epigenetic markers can explain, disclose, or predict—there are chance, chaos, luck, serendipity, and probably a spiritual dimension that could never be encoded in biologically explainable growth and maturity. There are social variables that act on large numbers and whose effects can only be conceptualized macroscopically via models such as game theory. In fact, “[n]either the material effects of social differentiation nor the material contributions to practices of social differentiation can be adequately understood within ... biological methodologies alone,”<sup>50</sup> and therefore any attempts at completely outsourcing the site of our responsibility might well prove frustrating and disingenuous.

Not only are behaviors and skills too complex to be biologically reduced, but even clinically relevant phenomena that were once addressed as purely biological start acknowledging their extra-biological charge. One example thereof comes with genetic diseases, thanks to the aforementioned variable of penetrance, but also due to a variety of other extra-genetic factors. This multifactorial complexity has eventually filtered through the medical discourse, “and more recently this approach has gained recognition in medicine and mental health research and practice,”<sup>51</sup> but the interesting point here is that against this biology-resizing backdrop, epigenetics somehow

features biology back into the picture, from the backdoor. Granted: epigenetics is all about valuing extra-genetic factors that depend on actions, choices, surroundings, traumas, environments; nonetheless, it refers them back to biology insofar as those extra-genetic factors “written” as epigenetic markers influence the expression of our genes. To some extent, epigenetics can be said to “rebiologize” environmental factors, whose influence can be thus tracked, measured, and even “reverse-engineered.” If one’s predisposition to, say, neuropsychiatric disorders depended on their inherited epigenome as opposed to one’s life choices (or at least, on one’s epigenome also as a result of their life choices), then disorders’ relapses could be explained far more easily than they are now, together with pharmaceutical ineffectiveness and psychiatric demographics.

I shall also mention that even assuming the science surrounding “epigenome’s reversibility” was validated enough, ethical and epistemic issues would still complexify the automatic application of epigenetic editing techniques—just like in genomics, where the scientific robustness of CRISPR gene-editing techniques does not automatically qualify them for wider clinical (and *a fortiori* non-clinical) application. Among the drawbacks of widely applying epigenomic editing techniques even upon scientific validation of their technical viability one could list at least the

underrepresentation of certain fractions of the population in correlation studies between epigenetic markers and their behavioral effects; the complex dynamic nature of epigenetic editing in living systems; as well as the potential for unfulfilled therapeutical promise across a wide spectrum of psychiatric, neurological, and metabolic disorders.<sup>52</sup> In this respect, given that my article focuses on crime, I should recall that the stereotypically gendered criminal—for the general public, but most relevantly here for judges and even more for jurors—is male.<sup>53</sup> Worse yet, women “tend to be sentenced to prison far less than men, and for shorter periods of time. Even when they commit a crime with a male partner, women tend to be less severely punished than their male counterparts.”<sup>54</sup> This implies *inter alia* that epigenetic editing aimed at “reversing” or “off-switching” gene expressions which might enhance one’s propensity for crime will be tailored to the male physiology, metabolism, genetics, and psychiatric sphere. This gendered automatism would work to the detriment of both genders: to men, as it would reiterate the stereotype that they are most likely to be criminals; and to women, as they would not optimally benefit from these techniques if they were convicted (however leniently) for a crime that could be “explained” in part (or whose relapse rate would be drastically reduced) by epigenetic editing.

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### 3. Legal Implications and Lawyers’ Standpoint: Inheritability

What about interpersonal harm and the potential role of epigenetics in quantifying the scope and impact of

emotional distress? One may *prima facie* observe that if traumas can be “written” on us to the extent of

regulating the expression of our genes, and especially if they can be passed onto the next generations via epigenetic regulation, then those who cause traumas should receive more severe punishment—assuming they were aware of the way epigenetics works. The potential for epigenetics to “encode” such traumas would suffice, even in the absence of specific evidence that such trauma altered exactly such fractions of the victim’s epigenome (although the two crimes, of course, would be distinct, just like what distinguishes “murder” from “manslaughter,” for instance). But let us assume that the exact trauma-to-marker link could be identified, and consequently also reversed feasibly and affordably; in that case, in the event the victim chooses not to undo it, would liability shift onto her? Would she be deemed responsible for not doing everything in her power to break the cycle of violence and undo the markers of her

suffering, which could easily turn in the future into similar harm inflicted on others?

Inheritability-related implications are indeed numerous. Think about the so-called “white torture,”<sup>55</sup> that is, torture which is inflicted against the mind and leaves only minor surface evidence—if any at all—on victims’ bodies.<sup>56</sup> To begin with, “[i]f torture left marks in the DNA, ... [t]orturers would find it much more difficult to evade accountability and potential perpetrators would be more likely to refrain from torturing.”<sup>57</sup> Moreover, when it comes more specifically to the inheritability of epigenetic markers, it

*would show that torture affects our very biological essence, the DNA carrying the genetic information that makes us human. This would lend further support to the absolute prohibition of torture and perhaps ... help ... refine the definition of torture on the basis of scientific evidence.*<sup>58</sup>

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#### 4. Legal Implications and Lawyers’ Standpoint: Reversibility

If such extensive interest has gathered from social scientists, regulators, and policymakers, but especially lawyers, it is because differently from genes, which can be edited at high cost and spelling deep ethics controversy,<sup>59</sup> epigenetic factors can be *purportedly* “undone” or “removed” more easily, recalibrating *the expression of* our genes in order to pursue socially rewarded—or at least more acceptable and thus not punished—behavior.

I have posited *supra* that epigenetics should never make traumatized individuals undergo re-traumatization by forcing them to screen and reverse the epigenetic

markers of the suffering they once endured. But is this always true? From a legal perspective, not quite so, but “forced re-traumatization” should remain an exception, to be pursued only in the wake of overwhelming social benefits that balance it out. Suppose that a serial offender has finally been handed over to the court, where she faces trial for multiple (not overly severe, but still very much disruptive of the social order) crimes that could award her a cumulative prison term of eight years. Suppose further that she regrets none of her actions, and that she would probably leave the prison worse than she entered it,

thus reiterating her crimes upon release. It is a typical case of criminal recidivism, whereby crime relapse stems from unhealed traumas that contribute their fair share to making the offender insensitive both to the suffering of her victims and to the consequences of her actions more broadly. The third supposition suggests that one could reverse at least part of such criminogenic traumas via clinical epigenetic intervention. Should we legally oblige the offender to undergo such treatment? Most arguments seem to favor such a solution: her victims would fare better, taxpayers' money otherwise spent on prison management and court proceedings would be saved, and she herself would probably recover from part of her motivation to commit crimes, possibly smoothening her antisocial attitude as a consequence. Against this backdrop only, it seems fair to admit that forcing epigenetic screening and treatment onto individuals might be an option; nevertheless, before enforcing new epigenetically explained legal obligations onto individuals, the underlying science should prove solid enough, which is not yet the case. This is precisely why my study is dedicated to illustrating why epigenetic science has not yet been validated enough for the purpose of establishing the just-mentioned legal obligation, and what is missing for it to be ready for such a criminal-law revolution.

Epigenome's reversibility is a cause of concern across a number of other domains, too. One of those is individuals' degree of risk-aversion, which might be drastically compressed as soon as "resetting" one's epigenome becomes widely acceptable or even standard practice. This is

because individuals currently expect dangerous activities to trigger, deepen, or confirm anxieties, fears, traumas, and dependencies that would likely impact their profound "being" for a long time; think about drug abuse, or exposure to bullying, or participation in riots, hostilities, and even full-fledged conflicts. However, if a significant fraction of this "being" was characterizable as the epigenome, and the epigenome could be "overwritten," then some individuals might feel more incentivized to "give things a try" and "live dangerously," so to write—at least for a little while. What does the law have to do with this? If one's behavior does not align with reasonable expectations of prudence and standards of care, "living dangerously" might be legally framed as negligence or recklessness in relevant circumstances and give rise to liability.

Risk-taking and risk-averting attitudes may also be shaped by epigenomics' expected ability to design personalized risk scales for individuals epigenetically at lower risk to contract a disease compared to others classes of population—the so-called "epigenetic stratification" of such disease.<sup>60</sup> No externality exists for this particular deployment of epigenetics as a risk-taking encouragement, but if one translates the same potential into the domain of, say, crime, then potential misalignments between predictive assessments and the actual outcome might prove devastating for third parties and indeed cause externalities that make such "personalized risk assessments" less convenient for society to support. Indeed, if one behaves more dangerously in pursuance of acts that might endanger one's own health,

and this is done on the basis of epigenetic predicaments, and externalities on the wider society come only in the form of increased public-health costs where applicable. However, if one behaves more dangerously along the perimeter with criminal behavior, and restraint is not as optimally exercised as the epigenetic forecasts predicted, then epigenetics-backed risk-taking attitudes turn into violence and eventually

crime which would have been avoided otherwise.

As the reader may appreciate, a range of legal claims can be built on or supported by epigenetics, especially if the epigenome can be “inherited” but also “reset;” these embrace several legal domains, including civil-law tort claims. From here on, the paper will exclusively deal with—and dig even deeper into—epigenetics’ criminal law implications.

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## 5. From Detention to Rehabilitation: Epigenetics as Catharsis?

For at least a couple of decades now, “humanization”-oriented, situationist research streams have been pursued and clearly valued within the realm of criminal justice:<sup>61</sup> emotions and extra-mechanical considerations around “the human” have always been surreptitiously factored into sentencing, but are now mainstreamed as a fundamental variable of context-aware, root-informed criminal—their actors, procedures, claims, dynamics, intended “audience,” and outcomes.<sup>62</sup> It all started with the refashioning of the long-held assumption that committing crimes depends on one’s will. In harmony with folk psychology, criminal law’s theory of retribution had long relied on the premise that because we are conscious of our actions and can decide how to act or refrain therefrom, in acting contrary to the law we implicitly accept and deserve to be punished. In fact, differently from tort or contract law, there is no such doctrine as responsibility-free or faultless liability in criminal law: blameworthiness is a precondition for criminal liability, which is, in turn, a precondition for deserving punishment.<sup>63</sup> One

century ago, the discussion turned to genes<sup>64</sup> and neuroscience, in a preliminary, rudimentary attempt to demonstrate that we are somehow subjected to decisions exercised by our brain “autonomously from us,” in accordance with our genetic instructions and mechanistic, consent-independent, will-free brain.<sup>65</sup> Genetic—and generally biologic—reductionism was thereby inaugurated. But challenging the foundations of retribution was still long out of hand, and a third stage of intellectual (but also technoscientific) progress was desired. Debunking retribution only started to feel within reach once the narrative turned multifactorial, to encompass a wider range of influences and causes to explain crime, including indeed “the environment.” Initially proposed as exculpatory or at least “mitigating” grounds thanks to neuroscientists’ arguments establishing that connection, it was then termed a “generic partial excuse,” on the hypothesis that a disadvantaged upbringing and being raised in a violent context may frequently lead to “no fair opportunity to do otherwise” (that is, to deciding not to react violently



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and commit crimes).<sup>66</sup> It is precisely at this juncture that epigenetics creeps in.

Currently, for well-researched reasons having to do with our essentially tribal nature as well as with how our brain is wired and rewired, inmates who are released from prison are often worse off compared to when they entered, and the reoffending rate is high.<sup>67</sup> Even when this proves initially untrue, life with a criminal record is fraught with a host of informal and formal “collaterals”<sup>68</sup> that may push frustrated society’s “re-entrants,” however initially well-intentioned, into reoffending. These bureaucratic and factual impediments might contribute to explaining why “[t]he likelihood of former prisoners being arrested outside the [S]tate where they were released increase[s] with a longer follow-up period.”<sup>69</sup> Furthermore, prisons themselves are overcrowded, and their management proves financially and demographically unsustainable across a majority of jurisdictions. One day, epigenetics might solve all these issues at once, or at least become part of the solution. It will be making the administration of justice more sustainable both outcome-wise and from a wider “urban” and “demographic” perspective, not merely because prison facilities are overwhelmed, but more importantly here because urban “crime hotspots” are first and foremost ghettos of structural—most often intergenerational—disadvantage and exclusion.<sup>70</sup>

If offenders can be rehabilitated, they can somehow be “saved,” eventually fulfilling the spirit of reconciliation and social catharsis that justice has long strived for, but never accomplished. At the same

time, the security-based public policy rationale for punishment will be hopefully accommodated through epigenetic reprogramming. The reasoning is as follows: as things currently stand, the argument that the environment exposes individuals to higher propensity to crime, up to the extent that the latter is “encoded” in them, would paradoxically work against releasing defendants. This is because, if prison is not rehabilitating and actually worsens criminals’ brain, as confirmed by neuroscientific research, then prioritizing the *ordre public* would lead to the absurd paradox that anyone who cannot be rescued should be condemned for life, i.e. permanently removed from society. Epigenetics lights the way as a flame of hope that disrupts this dichotomic conundrum: it is indeed true that negative environmental exposure is partly what makes an individual a criminal, as it is equally true that prison terms would generally not improve and, if anything, worsen such condition, this would no longer imply that the only solution safe for society is to remove those “environmentally afflicted” humans from the rest of humanity. Rather, they could be rehabilitated.

The emancipatory, disruptive magnitude of this concept is hard to overstate, especially insofar as the State-citizen dialectic is concerned. Providing “security” is a cardinal way for the State to assert its authority over citizens and pretend to address their concerns while largely leaving the structural causes of crime and disorder unaltered.<sup>71</sup> If accessible to all and not misappropriated by the élites for perpetuating their exclusive privilege, epigenetics could mark an important step

towards a social focus shifting onto crime's long-term interrelated root causes (political violence, segregation, structural disadvantage, inherited poverty, fear, precarity, loneliness, marginalization, broken social elevators, and so on), warranting a debunking of the State's pretention to act as a security guarantor in everyone's interest using cursory and/or inconclusive repressive tools such as criminal records, "wars on drugs," overregulation, and detention. Epigenetics could help make this empty power ostentation redundant, by demonstrating that most humans in similar protracted circumstances would have acted alike. Further, it could help socialize responsibility within relevant communities, with crime remaining individual, while the burden of addressing and redressing gets shared. These ideas read doctrinally heretical now, but they are worth considering in a long-term rebalancing of the role of criminal law in making our societies fairer, safer, and more functional. Whereas today it is largely with the defendant alone that the expectation lies to "make efforts at repairing and restoring the pre-crime state of affairs,"<sup>72</sup> epigenetics' powerful message is that society (the ways in which it is designed, run, and policed) shall be formally implicated in the process, too. It is less about surveilling ex-offenders,<sup>73</sup> and more about uplifting their life context and social engagement with it.<sup>74</sup>

"Over the last four decades, the number of incarcerated Americans has increased by 500%. In 2017, there were 1,097,083 arrests made in California alone, while an estimated total of 6,613,500 American citizens were on parole, probation, in jail, or

in prison."<sup>75</sup> Forensic experts are keen on identifying the culprits, but policymakers may welcome epigenetics if that helps them relieve society from some of its burdens, including the incarceration rate, jail terms, and prison overpopulation. Suppose that (every other variable being equal) a set of epigenetic traits can be solidly correlated with crime propensity and violent behavior, that reversing those traits is clinically feasible, and that it would lead to the suppression of (or at least appreciable limitation to) the expression of perpetrators' relevant genetic underpinnings of violence. This would prove exceedingly helpful policy-wise.

First, jail time has long proven unsatisfactory in reducing one's propensity to crime; in most cases, if their criminal behavior is genetically and epigenetically elicited as opposed to socially encouraged, convicted individuals will leave prison worse than they entered it (especially if they were placed in solitary confinement),<sup>76</sup> in that their motivation to offend would stay unchanged while their isolation will have negatively contributed to their neuropsychiatric wellness and stability. If crime-related markers can be reversed, then prison time becomes superfluous and criminals could be rehabilitated rather than jailed, improving in this way their own lives and making society effectively safer. Taxpayers' money would be spared, too, making justice more sustainable logistically and economically, not merely thanks to decreased prison populations, but equally in terms of building management and long-term urban sustainability. Prison guards, who are currently ill-trained and overburdened with unmanageable

workloads and overcapacity numbers, would experience less work-related stress, eventually decreasing their exposure to overreaction, psychiatric illness, and discomfort-dependent absenteeism.

Second, rehabilitating rather than jailing would turn the criminal justice system into a social elevator (allowing blame-free readmission into society), thereby removing the stigma associated with the operation of detention facilities. As it stands, the criminalization of poverty and structural disadvantage looks more like an apartheid system enforced by the wealthy using law's securitization, than like a viable policy solution to the problem of violence among the most disadvantage-exposed segments of society. Compellingly enough, it conceptually resembles the system of "climate apartheid" that the wealthy are gradually yet inevitably heading to in the face of climate change;<sup>77</sup> indeed, the concept is similar: wealthy individuals create "safe" spaces through law, settle themselves therein, and fail to address any structural issue they leave at the periphery; worse yet: when problems erupt from the periphery, the pretense of solving them they enforce through "security" measures and regimes of emergency-phrased exception, which only work in the short run, and only for them. Among such measures, oppression and detention schemes devised by the privileged in onshore and offshore facilities are increasingly common and normalized. If the emergency is climate change, *de facto* climate apartheid occurs if the wealthy keep behaving as usual and fence away those who escape from climate-induced disasters, conflicts over resources, polluted soil and air,

and displacement;<sup>78</sup> if the emergency is, say, street violence, *de facto* urban crime apartheid occurs when the root causes are left unattended and the issue is institutionally "solved" through the (often privately outsourced) enforcement of detention (i.e. social removal and *de facto* class-based ghettoization).<sup>79</sup> It is true that this cannot be generalized to all such policies, but it is frequent enough to be taken seriously, and what is worse, one can trace a worrisome normalization trend.<sup>80</sup>

Third, detention facilities should be restructured as mental-health facilities where offenders-patients are rehabilitated in balanced and humane ways into full living, instead of abandoned to their crime-detention spiral as they so often are today. Studies on the "institutionalization effect," grounded in US data but presumably generalizable to any context where similar trends are evidenced, have demonstrated that not only are imprisonment rates inversely correlated to the availability of public mental-care facilities (i.e. the more facilities are discontinued, the higher the detained population), but also that psychiatrically ill individuals are far more likely than the general population both to commit and to fall victim to violent crimes;<sup>81</sup> in particular, former detainees who are mentally ill exhibit a high likelihood of falling victim of or committing violent crimes soon after they are released from detention facilities, feeding a spiral of crime and mental illness that resolves the "institutionalization" problem in the wrong way—i.e. through their removal (institutionalization of punishment) rather than rehabilitation (institutionalization of care). Ideally, if one conceptualizes crime and

illness—at least to some extent—as expressions of deviant genes but also epigenomes, the latter’s reversibility might in the future contribute towards breaking this cycle and displace the need for long-term institutionalization altogether.

Fourth, this operative but also conceptual overhaul would finally liberate criminal justice from its misplaced retributivist tone and align it with the social imperative it should fulfill first: public safety. After centuries of burning debate, criminal justice still purports to justify punishing individuals on four main grounds: retribution (“those who breach social trust through crime deserve to be punished”); safety (“punishing crimes removes the source of crime—understood as the criminal—from society”); deterrence (“punishing crimes will disincentivize others from taking similar paths, if they want to avoid the same consequences”); and closure (“once a criminal is punished, the victims or their survivors will find relief”). As currently phrased, none of these four grounds is meaningful or true.

The retributivist ground presupposed that the “trust” to be breached exists, but criminals’ life experience is often such that they stand to be disenchanting about the system’s ability and willingness to handle disputes equitably, protect the weak, and preserve their interests and dignity. Most crimes arise from (aware or subconscious) mistrust in lawful paths available in society for addressing their own aberrations, inequities, and distortions;<sup>82</sup> they are a logical, naturally encoded way to respond to systemic asymmetries. The safety ground presupposes that

the source of crime are individual criminals instead of the systemic reasons they commit crimes, so that the simplistic conclusion can become that the more numerous the criminals who are removed from society, the lesser the threat of experiencing new crimes. This is patently disproven by the fact that no matter how many criminals are “removed,” crime remains a constant across any society. The deterrence ground builds on the assumption that criminals can rationally assess the benefits and drawbacks of committing crimes; yet if that were true, crime would be nearly absent from any society where the certainty of punishment is upheld. And finally, the closure ground draws from general wisdom and folk psychology, but it has been scientifically debunked as self-convincement (autosuggestion).

Scientifically validated, epigenetics could help reject all these grounds as unpersuasive—or at least contribute to their reframing. Retribution would be either dispelled or revolutionized: if it is the genome and the epigenome that drive serious crime rather than one’s choice, then no one deserves to be punished; at best, one would “deserve” punishment if negligently resisting any offer to “improve” their epigenome, and public authorities would hold a corresponding obligation to make such improvement accessible and timely. Safety, too, would need to be thoroughly rethought: what would make societies safer is treating crime-inclined epigenomes, as opposed to jailing those who carry them. As for deterrence, it would be deprived of any justification, as the site of crime, the main “criminogenic” factor,

would reside in genetic information and its epigenetic expression, rather than (solely) in lucid calculations on expected gains and potential losses. Finally, closure may plausibly be satisfied with victims' and survivors' awareness that the actual, deepest cause of crime has been removed: today, remorse is considered a leniency factor in sentencing, and is therefore mostly disingenuously "compelled" onto perpetrators.

Again, it seems worth emphasizing that this is the conceptual landscape that would be prospected if epigenetic science were robust enough to sustain them, which it is not yet. In other words, I am not suggesting that the four grounds for culpability and punishment have already been satisfactorily overhauled by studies of the epigenome; what I am submitting is that those four grounds, already detached from real-life experience as well as doctrinally untenable, might find in epigenetic research one further, remarkable source of disruption and rearrangement around alternative, more realistic sets of premises, values, nexuses, and data. While we should devote reasonable hope to this future scenario, a reminder is due on the risk of swinging from one extreme to the next: discussions are already vibrant around the ethical dimension of epigenetics within widening trends of personalized medicine and care,<sup>83</sup> and perpetrators' hospitalization as opposed to incarceration would, to some extent, fall within the same trend. The risk of "hypermedicalizing crime" and of the attendant abuses is round the corner,<sup>84</sup> but I am still persuaded that the paradigm-shift from seclusion and removal to rehabilitation

and readmission is well worth exploring. Once the science turns robust enough, it will be for the policymakers to identify the right balances between traditional doctrines and procedures and the novel room for rehabilitation.

In any case, it seems of the essence to stress here that what I am discussing is *post factum* treatment and not prediction. Not only do I stand by the general tenet that presumption in criminal profiling should be against predictive capacity;<sup>85</sup> I also reckon, more specifically, that epigenetic science is so fragmented and controversial that the way to go before relying on its capacity to predict crime (e.g. by deploying AI to extract correlations between certain epigenomes and the tendency to unleash violent reactions) is tortuous and fraught with ethical dilemmas.

Indeed, even with regard to the neuroepigenetic hypothesis that "epigenetic modifications of DNA expression in neurons are fundamental to the wiring and rewiring of neural circuitries responsible for learning and memory,"<sup>86</sup> my interest within the realm of criminal law focuses on the implications of such hypothesis for the assessment of crime, never for its prediction. For instance, if neuroepigenetics ever becomes robust enough to explain to satisfaction a defendant's unstable behavioral oscillations in terms of neurobiological control of neural plasticity, then the perimeter of one's "opportunity to decide otherwise" might account for patterns of behavioral instability which would not currently meet the threshold for relevant psychiatric disorders and mental insanity.

## 6. Epigenetics Evidence in the Criminal Courtroom

Thus far, I have addressed the most profound social implications of a potential future mainstreamed recourse to epigenetics in criminal law and criminology. In this section, I will articulate the reasons why epigenetic research, on the medical side, has not gathered sufficient consensus and validation to match the criminal-law standard of “beyond reasonable doubt” (and its equivalents) to prove and disprove one’s intent (*mens rea*) to commit crime. If it did, all claims and assumptions as portrayed within social-science literature on epigenetics, which have been discussed above, could have found accommodation and transformed the justice system as described above.

Introducing epigenetic evidence into criminal courtrooms at this stage of scientific research would harm the justice system irremediably. Yet, as unreasonable as it may sound (given the relatively poor state of the underlying science), attempts at “appropriating” epigenetic clues for forensic purposes have been circulating for years among prosecutors and law-enforcement agencies, as well as forensic scientists. This is why surveys have been conducted among researchers to gather their views, some of which make for rather alarming reading. While respondents generally acknowledge that epigenetic evidence should never be “stand-alone indicting” but at best corroborative or circumstantial, that such evidence should be handled carefully from a statistical perspective, and that non-validated science-intensive evidentiary toolsets

are not infrequently abused by prosecutors and unappreciated by jurors, judges, and forensic consultants, a considerable fraction of them do tend to assume that epigenetics should be a factor to consider in refining criminal profiles.<sup>87</sup> They are not the majority, but compared to the underlying science, this seems disquieting enough.

Furthermore, the inaccurate “popularization” of epigenetic research in media reports and policy outputs has been extensively studied, reporting that biomedical and clinical research which is already fraught with caveats undergoes further levelling and simplification when adapted for mass-media or political purposes, to the extent that the—already exception-filled—underlying science is communicated as quasi-certain while in reality it barely explores its hypotheses.<sup>88</sup> On the one hand, epigenetic milestones such as the developmental origins of health and disease (DOHaD) theory are largely ignored by the public which tends to treat genetic and epigenetic phenomena as non-interactive and mutually discrete. On the other hand, when these nuanced theories are popularized among the public by mass media, the latter tend to overemphasize their scientific robustness and omit all caveats and limitations customarily attached to bioscientific literature, even the most macroscopic ones.<sup>89</sup>

One could argue that courtroom evidence is filtered through expert scrutiny before being tendered to judges, but this is far from accurate in most instances, both because of

budget constraints and owing to expert disagreement as well as relaxed admissibility standards. Moreover, it has long been ascertained that judges are not abstracted from their wider context, including media pressure (a fortiori towards “high-profile” cases) and commentaries from popular news agencies, which again may sound “scientific” while in fact reporting gross simplifications of scientific tenets. These ideas are brought with judges into courtrooms and eventually make their way into their verdicts, risking

a propagation effect especially in those common-law jurisdictions where even lower-court decisions can be immediately cited by “peer” as well as upper courts. Once ideas find their way into the minds of judges, rejecting evidentiary material that confirms such ideas just because such material does not stand up to admissibility standards might no longer prove sufficient: what the judge has heard and seen will anyway influence judicial holdings, however implicitly that might occur.<sup>90</sup>

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## **7. The Courtroom Deployment of Neuroscientific Evidence as Precedent-setting**

My concern is that epigenetics might be gradually and somehow surreptitiously introduced into courts on a wave of pretentious, trendy claims previously materialized with the neurosciences, whose admissibility is now seldom questioned by judges in principle. In fact, as a result of several decades of “neuroexuberance,”<sup>91</sup> courts’ reliance on neuroscientific evidence is mainstreamed today, while the underlying technologies (and doctrines) are still in their infancy, though far more advanced and consensus-validated compared to epigenetics ones. Such discussion will be mainly grounded in Anglo-Saxon common law as a matter of convenience (U.S. lawyers pioneered the tendering of neuroscientific evidence, and US/UK universities today are leading in epigenetics research—together with Germany’s), but in fact the dilemma is common to most jurisdictions worldwide—and indeed, I

will draw appropriate comparisons and analogies from around the globe.

Comprehensive reviews about neurolaw, neurorights, and especially the reliance on neuroscientific evidence in criminal trials are already numerous, extensive, and compelling;<sup>92</sup> this is why I will confine myself to a rapid sketch of their main observations here, in the interest of assisting the reader in reasoning by analogy with us vis-à-vis epigenetics.

Historically, the enthusiasm for neuroscientific evidence originated in the early twentieth century but remained relatively peripheral for quite a few decades. It later steadily expanded because of the broadened scope of evidentiary techniques and material it supplied, but also owing to its increased social-judicial acceptance, or at least to its gradual and mostly unresisted “normalization.” A widened range of claims depending thereupon soon surfaced,

stemming from related refinement in sociolegal doctrine but also from psychiatry, neurology, and clinical psychology literature. Enhanced focus was placed on empathy networks, emotion regulation systems, and signaling pathways for aggression and violence.<sup>93</sup> In harmony with these developments, expertise rapidly underwent a process of sophistication: definitely on the part of expert witnesses and sometimes even on the side of jurors and judges, but also on the side of defendants and prosecutors themselves, who demonstrated their eagerness for exploiting the influence reportedly exerted by this type of evidence onto the mind of justices.<sup>94</sup>

As for the technology solutions turned into evidence, electroencephalography (EEG) was first accepted as early as the 1930s, especially in cases of epilepsy; magnetic resonance imaging (MRI) scans on humans were introduced in the 1970s; computed tomography (CT) followed suit, famously relied upon in the 1981 case of attempted assassination of President Reagan; and positron emission tomography (PET) scans appeared one decade later, e.g. in *People v. Weinstein*.<sup>95</sup> In tracing the history of neuroscience as court evidence, it is important to distinguish neuroscientific records from psychometric assessments and surveys which are common standard in clinical psychology practice, as they raise an entirely different set of issues that will not be discussed here. What I mean by “neurosciences” here more narrowly encompasses assessments of morpho-functional structures underpinning our brain activity, including the neuropsychiatric perspective but excluding psychology. This is mindful of the

distinction between *psychological* and *psychiatric* evidence: while the two might indeed be tendered together, in that psychiatric diagnoses tend to rely on psychological interviews and self-assessment as well,<sup>96</sup> “[a] strategy for dealing with malingering...and thus overcoming the intrinsic limitations of the clinical psychiatric assessment...would be the validation of the reported symptoms with an objective anatomico-clinical correlation,”<sup>97</sup> which may indeed include neuroscientific examinations, especially neuroimaging.<sup>98</sup>

The admissibility of new types of evidence does not necessarily imply that its impact is momentous:<sup>99</sup> their mitigating effects on sentencing might eventually prove moderate. After all, “[w]here the traditional input of behavioral experts is considered soft science, the hardness of neuroscientific contributions also appears overestimated.”<sup>100</sup> Yet, the risk of ill-conceived evidence filtering through and deeply impacting verdicts remains high. Indeed, the U.S. rule for evidentiary credibility has long been that only evidence “generally accepted by the scientific community” should enter the courtroom, but it is exactly with a neuroscientific case, *Daubert*,<sup>101</sup> that the Supreme Court first lowered the standard by applying new legislation in the matter:

*almost two decades before Daubert*, Congress had passed the Federal Rules of Evidence (FRE), which offered a more liberal standard for allowing scientific testimony to enter trial. Rather than requiring “general acceptance” of the scientific technique for admissibility, the standard set by the FRE deemed such an assessment to be only one of a number to consider, along with whether or not the methodology is testable, whether it has



been subjected to peer review, and its known or potential error rate.<sup>102</sup>

This contributes to neuroscience being deployed today to prove or disprove a wide range of matters, including

*to support or cast doubt on the testimony of an expert, to support or rebut a medical diagnosis, to corroborate a defendant's testimony about his frame of mind at the time of the crime, to establish that a defendant's conduct caused severe harm, or used demonstratively to help the judge or jury understand some other kind of evidence.*<sup>103</sup>

The most immediate claim is that neuroscientific evidence would be able to “certify” neuropsychiatric conditions that make a defendant “not guilty by reason of insanity,”<sup>104</sup> with the effect of, say, turning a charge for murder into one for manslaughter.<sup>105</sup> Other times insanity will be only partially upheld, but the mental disorder will be acknowledged—this is the “guilty but mentally ill” outcome. I will define these claims as “fact-specific,” i.e. dependent on a specific crime and perpetrator. But as I hinted at in the Introduction, there are also crime-independent arguments that draw on the neurosciences to credit all defendants with a “generic partial excuse”<sup>106</sup> based on the assumption that, at least in part, if they ended up committing crime that must have been due to structural disadvantage they acquired at birth, and/or which was enforced on them over the years in the form of unstimulating environments, rejection, violence, and social exclusion.

There is one more crucial observation to make, and it relates to the limitations of neuroscientific evidence when it is confronted with public-order grounds for punishing,

as opposed to closure, retribution, and/or deterrence.<sup>107</sup> Indeed, there are trials where neuroscientific evidence did prove its point on the merits and succeeded in mitigating blameworthiness, but the ensuing sentencing was not affected because the “safety” rationale prevailed regardless. One case from Canada is informative in this respect:

[I]n *R. v. Zaakir*, the judge sentenced a 20-year-old offender with brain damage due to [Fetal Alcohol Spectrum Disorder (FASD)] for several offenses including theft. The judge noted that FASD contributed to his behavioral problems and his lack of success in treatment, but considered that there is no cure for FASD and that the protection of the public required incarceration. Zaakir’s lawyer argued against incarceration on the ground that it would not serve the goal of specific deterrence due to the offender’s difficulty in learning from the consequences of his actions due to FASD. The judge responded [in the negative].<sup>108</sup>

What can we learn from this passage? One could *prima facie* contend that no matter how robust the underlying science is, scientific evidence might fail to impact sentencing because of public-order rationales.<sup>109</sup> Yet, my reading is that this only holds true insofar as we consider neuroscientific evidence, while epigenetic evidence could potentially prove revolutionary precisely because it would displace such rationales as well. If specific epigenetic markers can be removed or altered to the effect of neutralizing offenders’ risk for public safety, then it would be more convenient to *treat* them (and the root causes) rather than have them serve jail terms which would only worsen their conditions and likely enhance their danger to society once released.

To put it differently, if epigenetic science ever grows robust enough, its link with doctrines of culpability and, in this case, punishment will be much deeper and influential than that with the neurosciences. Introducing weak neuroscience at trial is, at worst, ineffective; in a few cases, it might slightly lower the quality of the justice system, but no fundamental danger is present. Contrariwise, introducing weak epigenetics would put the justice system in far deeper jeopardy. First, because public order would no longer be tenable, and offenders would be released on the basis of questionable therapy and poor science. Second, because the potential disruptive magnitude of epigenetics on reform-warranting criminal law doctrines would be wasted and dissipate before having a chance to properly fulfill its promise. This is plausibly one of the key take-home points from this article, which is why I would like to reiterate its grounding. The above paragraphs align with a general (albeit admittedly preliminary) sense that, differently from the neurosciences, epigenetics might prove more deeply unsettling and revolutionary for criminal-law scholars and practitioners in the long run. Why is this so? Even assuming that behavioral sciences can supply solid evidence from a scientific standpoint, their impact on sentencing is far less clear and consistent. Their challenge to legal doctrines and procedures seems profound but not foundational, and in most cases the findings of behavioral science are added to traditional findings as corroborative.<sup>110</sup> It is rather rare to witness arguments entirely built on behavioral science. In potential, epigenetics is more deeply foundational.

Its outlook is to propose a new consistent approach to culpability and punishment altogether, with a clear spillover into public policies around incarceration and urban policing; and its biological underpinnings, if ever proven and alterable on a large scale, it could well turn out to be more robust, trackable, measurable, and reversible than behavioral ones. The latter are too mediated by metaphysical theories<sup>111</sup> to be concretely adopted by lawyers for rethinking millennia-old ideas around who is culpable and what punishment is.

To account for the merits, too, of neuroscientific evidence, it is noteworthy that it initiated a fertile (if complex) dialogue between brain sciences and the law; a journey towards reflecting upon the relationship between scientists and legal philosophers on defining how we are and how we act, up to reexamining the fundamentals of criminal law—a journey yet to unleash its full momentum. To be sure, my point is not that neuroscience today should be totally excluded from courts. Over time, some of it has become solid science and should be valued, though procedural rules should accommodate it more properly in order to enhance trust, enhance consistency, and dispel bias. Instead, what I argue is that when it was first introduced and in its yearly years, neuroscience evidence was not mature enough to shape criminal proceedings to the extent it did; and again, even today, one shall distinguish between meaningful and unhelpful neuroscientific evidence. This is to reason by analogy and conclude that epigenetic evidence should not be allowed to enter

either, because there is as much left to know about epigenetics today as there was about neuroscience then, and possibly more.

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## **8. On Biomedical Benchmarks, Missing Causation, and Research Unreadiness**

As previous sections have hoped to clarify, it all boils down to two fundamental questions: (a) whether the epigenome can be inherited; and (b) whether it can be “reversed” or “corrected,” and even then, what “correcting” would stand for exactly. How would it translate into actual behavioral change? Of course, one shall be wary of the hype surrounding epigenetics tales. To begin with, hypermedicalization, i.e. the idea that most “deviations from normalcy” are symptomatic of “conditions” that should or even “can” be treated, is controversial. Medicalization can be a promising prospect in lieu of detention, but it also carries the seeds of perilous tendencies that echo eugenics conceptual premises and might aspire in the long run to suggest again selective inbreeding and other similar ideas. Also, proving causal explanations differs from observing correlations, especially between given sets of markers and specific behaviors. And the risk of turning all policing exercises into more and more deeply technology-sustained networked biopolitics seems to be around the corner, too.<sup>112</sup>

Beyond their far-reaching transformative potential in the realm of criminal law, the background deficiency of these questions lies with the scientific uncertainty underpinning them. If one contrasts the potential lawyering claims with the unsettled science underlying them,

no doubt is left that so long as the latter is so unsettled, the former are to be cautioned against. And yet, what is the applicable benchmark? In other words, considering that most biomedical research (and certainly that on epigenetics) is by its own nature probabilistic rather than deterministic, against what benchmark of “validity” should lawyers reject or accept a given degree of uncertainty in biomedical research, before drawing implications from it? Relatedly, it is worth pondering whether epigenetics in itself represents a challenge to theories of causality and inference in medical research which already admit a margin of error and room for exceptions. This is not the focus of this paper and will therefore not be addressed exhaustively here, but limited preliminary remarks are due, at least about when one could reasonably expect the science to settle enough for lawyers to build more solidly upon it. To put it straight, what is missing for scientific research on epigenetics to become “trustworthy enough” for lawyers to rely on it in deconstructing the long-lasting theories of culpability and punishment?

I will (re-)start with the inheritability issue. “There is a trend for those outside the field of molecular biology to assume that most cases of transgenerational epigenetic effects are the result of transgenerational epigenetic inheritance, in part

because of a misunderstanding of the terms.”<sup>113</sup> The scientific debate may read extremely convoluted and obscure to non-experts and would itself deserve a few hundred pages of diagrams and narrative to be addressed properly. I can try to summarize it here in the following plain terms like this: what we satisfactorily know (in essence), and what we might soon know better (also in essence). What we already know is that to differentiate from a fertilized egg into a functionally complex human being, cells’ DNA binds to regulatory proteins called transcription factors, mainly contributed by the mother, that activate or repress the transcription of specific genes. What we aspire to understand soon is the extent to which some of the mentioned transcription factors, beyond controlling cell differentiation, can regulate post-transcriptional gene expression in response to extracellular signals, including signals from other cells in the wider extracellular environment.<sup>114</sup>

The reprogramming effects<sup>115</sup> and intergenerational fixation of these regulatory actions (usually termed epigenetic); necessary molecular bindings; a comprehensive “library” of signals that can indeed trigger this transcription factor-mediated response; and how specific and consistent their action should be—these are all active and exceedingly complex biomedical and computational research fields.<sup>116</sup> For the time being, despite encouraging progress (in epigenetics generally, and even in personalized epigenomics)<sup>117</sup> and highly popularized results, no pretention should be made to hold a granular view of how this works in detail, especially of how this is “memorized” by cells across cell

generations, or, even more complicatedly, across human generations. As for our species, for the time being, the closest approximation to truth is that transcription factors binding can somehow predict histone modifications (which are, as stated in the introductory section, an epigenetic mechanism).<sup>118</sup> We still cannot tell how often predictions can be made, how permanent those modifications are, how many generations they will last, and essentially why. A fortiori, we cannot tell how to demonstrate the causal link in each given case, or whether predicting the process could help us “do” and “undo” it at will.

More generally, one of the greatest challenges in contemporary epigenetics is not the paucity of datasets but their overabundance and poor leverage,<sup>119</sup> meaning that patterns of correlation among biochemical mechanisms are so numerous that even with the assistance of computational tools, isolating causal chains from correlational data tangles is an arduous enterprise. Clinical scholarship frequently speaks of “mutual influence” and “interrelation,”<sup>120</sup> but we are fairly far from validating causal nexuses between specific epigenetic factors and precise phenotypes expressed as behavior. To dig deeper into biochemistry for just a moment, the reader is advised that clinical scholarship on epigenetics frequently refers to “multivalent interactions” as well;<sup>121</sup> technically, those are tangles of bonds between proteins and carbohydrates, which while not being equivalent to the less technical meaning of “interrelation” or “correlation” in a general sense do represent yet another complexity multiplier in this domain.

Furthermore, it is precisely human epigenetics that warrants refinement and will take a long time: experimental generalizability and reproducibility are extremely problematic in biomedical research on humans, and these well-known general limitations are mirrored in scientists' experience with handling experimental findings from non-human animals in epigenetics as well. As a recent experiment report lamented, "[w]e need to come to terms with the possibility that epigenetic epidemiology is not yet well matched to experimental, non-human models in uncovering the biological embedding of [victimization, crime, and] stress."<sup>122</sup> The same shortcomings compared to research on non-human animals are faced by studies on the relationship between adverse early-life events and adults' antisocial behavior.<sup>123</sup> While correlations are many (even too many) and evident,<sup>124</sup> their patterns are not necessarily consistent, and their causality even less so, and the relatively small size of participant pools is

challenging to scale up and generalize from.<sup>125</sup> While "findings in animal models implicating epigenetic mechanisms in the transmission of stress effects through germ cells have created much excitement for the possibility that similar mechanisms might be operating in humans,"<sup>126</sup> it would be irresponsible at this stage to take it for granted that it will ever happen, or to let hubris obfuscate the actual state of biomedical research in this realm.

Yet another challenge, and the last one I will mention here, is that there is no "normalcy" standard against which to assess "violence-expressive" or "crime-inducing" epigenetic markers. In other words, there is no "normal" epigenome we can speak of, none yet. This limitation is all the more important if one considers that epigenetic markers can be cell-type specific but also individual specific.<sup>127</sup> By all means, the epigenome is better conceptualized as a behavioral mediator between the genome and the environment than as a "cause" *tout-court*.

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## **9. Would an Epigenetics-substantiated Criminal Justice System Without Free Will Prove Attainable and Desirable?**

Until this juncture, the paper has illustrated the advancements and uncertainties in epigenetic science, cautioned against simplistic social-science claims based thereupon, and proposed a few momentous transformations that criminal justice systems could consider undergoing in the event that the advancements are confirmed and uncertainties overcome. Still, one of my underlying assumptions until this point has

been that as soon as the science is validated, societies should consider revolutionizing their criminal justice systems accordingly. In this respect, this last section before the Conclusions will introduce further caveats aimed at questioning the automatic transposition of epigenetic scientific achievements into criminal justice overhauls, even if the former were demonstrated and consolidated.

The additional caveat could be summarized in these terms: even assuming that epigenetic science is validated, and even accepting that its potential implications for criminal justice could indeed be the ones described in the preceding sections, it would not necessarily follow that said legal implications are also imperative or desirable from a wider political perspective, in light of the fundamental assumptions around which our societies have built at least minimal degrees of public order. The challenge is not merely about policing how we are, but just as significantly, it is about addressing how on average, ordinarily we understand ourselves to be in order to function (and potentially “prosper”) as a species on a collective level, within so-called “organized societies” for which the justice system is a fundamental pillar.

Just as above, I will turn to neurosciences yet again to draw what I hope is a helpful parallel with the debates and solutions devised when neuroscience was at this precise juncture rather than epigenetic science, with presumed potential to revolutionize the values and procedures on which criminal justice has been standing for centuries. Just like with epigenetic science, and perhaps even genetics more generally,<sup>128</sup> the most fundamental challenge launched by neuroscientific findings against the foundations of criminal justice was free will.<sup>129</sup> To put it simply, if human action is determined by humans’ nature rather than their will, no meaningful intent drives criminal action, and therefore no perpetrator could “choose to do otherwise” and deserves to be punished. The scientific basis for such a foundational rethinking of criminal

law would have been the sweeping wave of neuroscientific findings that could essentially confute the existence of appreciable margins of free will, if not by each singular action,<sup>130</sup> then at least from a systemic perspective.<sup>131</sup> The claim could have been that because one is unable to account for the combined effect of chance, chaos, luck, hormones, endured abuses, and so on in every specific action they commit, there would be little point in charging any specific action criminally as if it could stand in isolation from its “broader life” perimeter. The extent to which even the most radical determinism would automatically defeat free will has long been a subject of contestation. For present purposes, let me even assume that we stand at a juncture where the scientific community has reached ultimate consensus around determinism being irreversibly, uncontestably incompatible with free will. Even then, philosophers, cognitive psychologists, anthropologists, and legal thinkers found it necessary to make a number of observations that could equally be applied to epigenetics. I will summarize the two most effective of those observations.

First, they argued that we do not punish only out of retribution, but in light of security concerns as well —this is indeed also emphasized in the sections above. One implication is that even if an individual did not choose to commit a crime, we might still prefer to make sure that they are not placed in the conditions to harm again. We shall realize that determinism does not necessarily displace free will,<sup>132</sup> or that if it does, the lack of free will does not necessarily displace punishment. Contemporary legal thinking has

emphasized blameworthiness to such an extent that the security ground for punishing has slipped down the ranking, while it did play a prominent—and often understated role in human history. The debate on free will is also, at its core, metaphysical;<sup>133</sup> one that long predates modern science, which means that even ancient societies where blameworthiness was not taken for granted, did punish on standalone no-harm grounds. Strikingly similar discussions have been entertained vis-à-vis nonhuman animals.<sup>134</sup> To simplify again, if we learn that a panther has attacked a child, we will try to cage her so as to disable her from attacking more children, regardless of the panther's "wanting" to attack children or her access to feeding alternatives.<sup>135</sup> Humanists would find it questionable to police humans and nonhumans alike, yet perhaps the time will come when we will be forced to accept that we had severely overstated our ontological distance from all other species; after all, this already happened once with humans realizing that many mammals and probably insects, too, are conscious and self-aware.<sup>136</sup> Along somewhat cognate lines, one could elaborate on the agency of robots,<sup>137</sup> and from there extrapolate policy implications with regard to their "punishability."<sup>138</sup> This was all to confirm that with humans, other animals, or even non-living objects, punishment can be disconnected from free will, so long as legal theories of criminal liability are correspondingly redefined.

Second, they argued that no matter how "proven," "valid," or "true" the inexistence of free will, human belief in merit and demerit,

in culpability and retribution will serve the purpose of functional societies,<sup>139</sup> and, with it, the (dys)functional élite-legitimizing neoliberalism.<sup>140</sup> Not even anarchists ever go so far as to advocate for a punishment-free society, and arguably treat free will as a given. Even in extremely corrupt societies, where poverty is prevalent and very few people could truly "do otherwise," belief in free will—though delinked from moral judgement—supports the need for criminal punishment.<sup>141</sup> One of the most popular—and debated—philosophical accounts on the matter, Strawson's, concludes that we should probably stop trying to "justify" punishment, and instead accept it as inherently human, that is, "given with human society, not something for which there are or need to be reasons."<sup>142</sup> I am not confident this sounds too helpful intellectually (or practically), but it does testify to our apparent inability—or unwillingness—to imagine societies and criminal law doctrines purified of the free-will socio-anthropological substratum. In other words, humans appear to know no other way of *being together* other than believing that aside from a specific and limited number of exceptional circumstances, criminal action could have been spared if the perpetrator had truly so decided.

Needless to stress, the above does not imply that because humans are unaware of social structures that could build around the lack of free will, then such arrangements must not exist. They might in fact exist; it is just that we might have not yet appropriately conceptualized them. Furthermore, the reform called upon by epigenetics would be far more specific, profound, stable and

“sustainable” than the one explored when neuroscience seemed to be almost on the verge of promising fundamental reshuffles. Epigenetics is more sustainable because its two cardines introduced here, i.e. inheritability and reversibility, would be independent from the strenuously complex mind–body problem that makes it so daunting for neurobiology findings to be translated into reliable predictions and explanations for human behavior. “The mind,” as a mid-step between “the physical brain” and “behavior,” arguably remains an insurmountable obstacle epistemically because its scientific inspection is limited insofar as we cannot easily observe ourselves from our own conscious standpoint. Inheritability and reversibility, and the intergenerational momentum of their combination, are farther ahead than anything neurosciences could suggest: they make the dialectic between brain and mind redundant.

Surveying general public opinion about these conundrums and their ethical implications (not least for criminal justice) seems at present impractical. I kept repeating the word “science” because if one places religion aside, the debate mainly takes place within educated, erudite, specialist circles. It is not all about biology; in fact, it rests on the surface of a physics conundrum between Heisenberg, Bohr, and Einstein on relativism, determinism, and probability,<sup>143</sup> a debate that has never come to be settled and is being revived in terms of the “quantum structure of cognition.”<sup>144</sup> But this is different from suggesting that criminal law should depend on its outcome. After all, current criminal-law doctrines build on “science,” or at least on what we

understand to be “natural” or “hard” science, only to a rather limited extent. Human societies have crafted them this way gradually, and overall accepted them because they “worked” better than many alternatives, not because they found them “scientific.” This is not to posit they shall not be available for reform, but it does mean that the latter will stem from human experience and any reform is likely to be more efficient if it emanates from and is embedded in social need, rather than in a scientific narrative (or even scientifically validated discoveries) detached from it. Legal doctrines and social customs arise together, but it is more for the law to crystallize what society accepts, than vice versa. Humans are prone to polarization, tribal protection beliefs,<sup>145</sup> contested leadership, and nonevidential ideology, to a degree that makes it unadvisable to have unfiltered scientific findings guide social action without many qualifications and strings of caution attached. Some will find these new truths liberating and compassion-calling, others will deem them repulsive and subversive of the social order.<sup>146</sup> The leap is not merely from the “natural” to the “social” sciences, but farther, up to abstractly valid scientific discourse and social design, and then from there to its practice, including its enforcement on actual humans and their particular lives. In the wrong hands (or algorithms), potentially revolutionary scientific findings of the sort described in this article might well be misappropriated and manipulated in either “just” neo-eugenic pursuits<sup>147</sup> or, at the other extreme, for undesirable and oxymoronic absolute moral relativism. Punishment



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grounded in security alone can easily turn dangerous, as the concept of public order is prone to political abuse: any political regime could preemptively designate someone as a threat to society and convict them on that basis. This is already happening under authoritarian and repressive regimes, but should not be normalized, at least across liberal societies and democracies.

Another premise worth recalling here has been that scientific inquiry and its (temporary) truths are something external to us. Yet they are not completely independent from human agency.<sup>148</sup> One endo-poietic component persists: serendipity aside, we do choose the overarching questions and theoretical premises that guide research towards new discoveries.<sup>149</sup> This, too, might legitimately be perceived as an exercise of free will. If our science is methodologically sound, we will not get to choose the answer, but we will retain preponderant ownership of the questions, which means that in selecting what is worth asking, we decide to take something in and leave something else out. One ensuing possibility is that no picture of human agency will ever be complete through scientific prisms considered in isolation from the way we can conceive of ourselves socially. A society without blame is also one without praise, and with them we would also lose one of the residual distinctions we place between us and other species: they reward “prosocial” behavior out of instinct, not morality. Is our urge to “believe in free will,”

then also an irreducible, irremovable, inalienable instinct—the one that characterizes our species?

In sum, it seems fair to posit that centuries after the debate erupted, upholding willful “illusionism,”<sup>150</sup> i.e. functionally ignoring the alleged lack of free will, remains one of the options and the only immediately applicable one. The causal effect between (1) validating the science, (2) appreciating its potential implications for criminal law doctrines and procedures, and (3) reforming criminal justice systems accordingly, is not and shall never become automatic. Both these steps (between 1 and 2, and between 2 and 3) must be given appropriate consideration, and exploring the second is just as essential as problematizing the first. Yet, in the abstract, one could well accept that potential forms of punishment-free (or punishment-endowed but free-will-refuting) societies could exist, as they are not absolutely absurd. It is just that they would not function so far as we can tell from the evolutionary and institutional human experience thus far. Perhaps they could work with other (or more) intelligent species,<sup>151</sup> or somewhere else across the cosmos, and astrobiology pursuits will enlighten us more in decades to come about further potential ways to live and relate collectively while not abdicating what natural science seems to suggest we are.<sup>152</sup> That is, however, material for another paper some thousand years from now.

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## 10. Conclusions

The novel foundational contribution of this paper resides in its linking biomedical, clinical psychology and social science literature on

epigenetics with theories of culpability and punishment in criminal law. If one had to summarize the original findings of this work in one single takeaway paragraph, one could say that:

*In principle, the combined effect of the prospected reversibility and inheritability of epigenetic markers bears the potential to revolutionize long-standing criminal law doctrines of culpability and punishment, to the effect of providing offenders with a chance for redemption grounded in a generic partial excuse and the opportunity for voluntary treatment. Nevertheless, the underlying science is not yet robust enough to validate the inferences that lawyers may draw from it; more specifically, evidence based on such inferences would not satisfy the applicable standard of proof, so that courts for the time being should refrain from upholding any such arguments if they were submitted.*

In epigenetics research, like generally, asking the “right” questions drives the type of answer scientists are encouraged to seek.<sup>153</sup> In this respect, if legal researchers frame potential epigenetic evidence in terms of criminal law standards, scientists from the life sciences might be incentivized to provide clearer and policy-deployable guidance for the statistical robustness of epigenetic research and particularly about the correlations between epigenetic markers, their inheritability, their reversibility, and socioeconomic phenomena such as poverty, disadvantage, trauma, exclusion, hierarchies of dominance, and particularly violence and crime. As the science stands, it seems legitimate to state that while epigenetic markers do influence evolution by natural selection in a variety of ways,<sup>154</sup> it is too early to affirm that they can be “inherited” as such, and even more premature to speculate that said potential

inheritability can last for several generations. This is probably what Huang and King meant when they stressed that “the potential of epigenetic research is more likely to inspire novelty in biomedical interventions than in moral and ethical obligations”<sup>155</sup> for the time being. This is why Science and Technology Studies scholars have scrutinized the circulation of epigenetic knowledge from the life sciences to the social sciences and back, in order to expose the “intrinsic biases and limitations of research practices of epigenetics that may produce a controversial uptake of this science in society.”<sup>156</sup>

When it comes more specifically to situating crimes as intergenerational traumas and drawing on legal and medical standards of causal inference, I have tried to illustrate why the science is not ready yet—but also how revolutionary it could prove to be once it becomes ready to do so. And even within the course of one’s lifetime, interpreting crimes as an epigenetically explainable consequence of trauma would lead to broad justifications which society is probably not yet ready to cater for.

In illustrating the just mentioned unreadiness, I have also reasoned analogically from the neurosciences. In fact, this is the first work to reason by analogy from neuroscientific research in order to illustrate why we are at a critical juncture when it comes to epigenetics and criminal law theory, and why we should learn from neurosciences how to preserve the good practices while refraining from reiterating the questionable ones. Any novel medical domain of this sort seems to be generating similar waves of enthusiasm and counterreaction that insist on a

consistent aspiration towards shifting crime from a terrain of “blame” to one of “rehabilitation.”<sup>157</sup> Whereas offenders’ behavior, just like that of any blameworthy citizen more broadly, is often perceived to be socially dysfunctional and aberrant,<sup>158</sup> epigenetics offers the redemptive tale that renders such behavior functional for its circumstances, so it could adhere to “normal” social expectations if society itself offered substantially improved conditions in which to live and thrive. If circumstances are wired into the epigenome—so to write—then they could rewire it, too.

In particular I have endeavored to demonstrate that courts seem right on the verge of accepting epigenetic tests as evidence in favor or disfavor of criminal defendants, and I have cautioned against adopting an overly liberal approach to that end. I have justified my cautionary tale via (admittedly rudimentary) references to standards for and narratives of medical causality as well, arguing that while epigenetic evidence might and should find its way into courts as soon as its scientific limitations are clarified, it is currently unsettled to a degree that would make it unreliable in proving or disproving the neurobiological underpinnings of violent behavior. It would delay trials and overburden the courts procedurally and budget-wise, without providing any reliable added value in the overall cause of justice.

In epigenetics and beyond, “scientific research articulated through a regime of epistemic modesty is perhaps less attractive to social scientists than that situated in a regime of epistemic ostentatiousness.”<sup>159</sup> This seems all the more problematic when such research, or the misleadingly confident way in which it is presented, finds its way into courts of law and influences criminal sentencing. We have been there with neurosciences, but we are not there yet with epigenetics, and my concern is that this might be happening soon.

Mine is a call for prevention but not a moratorium manifesto: once science has identified a few narrow claims whose implications for social scientists could be relied upon, this evidence not only could but should be given consideration, potentially to become, in shorter or longer term, standard reference in criminal proceedings. Incorporating epigenetic science into criminal justice will depend on social preparedness, but it is worth considering. Social sustainability of detention and treatment; mental health rehabilitation of those who stand at the most disadvantaged edges of society; and the distancing of justice from its traditional (and much questionable) discourse around “deserving” punishment, could all greatly benefit from bringing epigenetic insights into the courtroom.

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## Notes

[**Disclosure Statement:** No potential conflict of interest was reported by the author(s).]

[I am grateful to the Journal’s Editor-in-Chief, Professor Jonathan Jacobs, for his patience throughout the extensive revision process, as well as to this paper’s three

anonymous peer-reviewers (two in criminal justice, one in medical biology). I further acknowledge the salience of countless afternoon conversations around epigenetics

with Dr Gabriele Schweikert from the University of Dundee, where most of the present work was conceived and first drafted in early 2023. The ethical and legal implications of those discussions fall entirely within the perimeter of my responsibility, as do any potentially outstanding scientific inaccuracies on the biomedical side. While most of my background (LLM, PhD, three PostDocs) is in law, I have recently embarked on a BSc in Medical Biotechnologies at the University of Ferrara, which also contributed via its unit on molecular biology to inspiring this paper].

1 Joseph Boyle, as quoted in Stelmach and Nerlich, "Metaphors," 201.

2 Epigenomics is the study of epigenetics applied to the entire genome (sum of all genes) of an individual or a species, and for the purpose of this paper, the two terms ("epigenetics" and "epigenomics") will be treated as synonyms unless otherwise specified.

3 For a selection of the most comprehensive, up-to-date, and authoritative compendia of epigenetic science, see: Tollefsbol (ed), *Handbook of Epigenetics*; Mai (ed), *Chemical Epigenetics*; Chadwick (ed), *Epigenetics*; Allis et al. (eds), *Epigenetics*; Tollefsbol (ed), *Transgenerational Epigenetics*; Wei (ed), *Computational Epigenetics and Diseases*; McCulley, *Epigenetics and Health*; Yasui et al. (eds), *Neuropsychiatric Disorders and Epigenetics*.

4 For examples, refer to Weiner et al., "High-resolution Chromatin Dynamics; Hoffmann, "Chronically High Stress Hormone Levels."

5 See e.g., Zenk et al., "Single-cell Epigenomic Reconstruction."

6 See e.g., Paro et al., *Introduction to Epigenetics*, 151 et seq.; Bailey et al., "Comprehensive Characterization"; Esteller, "CpG Island Hypermethylation and Tumor Suppressor Genes"; Bedogni et al., "Rett syndrome"; Connolly and Zhou, "Genomic Insights into MeCP2 Function."

7 See e.g., Dupras et al., "Potential (Mis)use of Epigenetic Age Estimators."

8 See e.g., Zhang et al., "The Ageing Epigenome."

9 Refer to Shema et al., "Single-cell and Single-molecule Epigenomics."

10 See e.g., Alberts et al., *Molecular Biology of the Cell*, 189 et seq.

11 Cavalli and Heard, "Advances in Epigenetics." See also, most recently, Díez-Villanueva et al., "Identification of Intergenerational Epigenetic Inheritance."

12 Cerdeña, "Epigenetic Citizenship and Political Claims-Making," 632.

13 See also Relton, Hartwig, and Smith, "From Stem Cells to the Law Courts," 1083.

14 Li, "Modern Epigenetics Methods," 104.

15 Dhingra et al., "DNA Methylation Age," 317.

16 Deans and Maggert, "What Do You Mean," 894.

17 Refer also to Kitazawa et al., "Morphology-oriented Epigenetic Research."

18 "Prosocial" is the behavior that maximizes the return on the social capital invested in behaving a certain way rather than another.

19 See also Glenn and McCauley, "How Biosocial Research Can Improve Interventions"; Wilson and Scarpa, "Criminal Behavior."

20 Refer e.g., to Machado and Granja, *Forensic Genetics*, 33–44.

21 This is for the reader to acquire a general sense of the process. Technically, however, this expression is inaccurate, as the pathways through which genes and epigenetic patterns are (or could be) inherited are different. There always is some residual inexactitude in translating extremely complex and exception-filled biological processes into a "policy-viable" and "digestible-by-lawyers" lexicon. Mine here is simply an attempt to approximate reality, with no claim of textbook-faithful representation of these biomechanisms.

22 Liebert, "Trauma and Blameworthiness," 237.

23 Refer extensively to Silva, "Old and New Perspectives."

24 Stelmach and Nerlich, "Metaphors," 197.

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- 25 See e.g., Dupras, "Epigenetics, Ethics, Law and Society."
- 26 See e.g., Heinzel et al., "Clinical Relevance;" Goodrich et al., "Determinants of Penetrance"; Cooper et al., "Where Genotype is not Predictive"; Kingdom and Wright, "Incomplete Penetrance"; Shawky, "Reduced Penetrance"; Li et al., "Incomplete Penetrance"; Coll et al., "Incomplete Penetrance."
- 27 Refer e.g., to Ascencio-Carbajal et al., "Genetic/genomic Testing."
- 28 Juengst et al., "Serving Epigenetics."
- 29 Joly et al., "Epigenetics ELSI," 591.
- 30 Further reading in Loison, "Lamarckism and Epigenetic Inheritance."
- 31 Deichmann, "The Social Construction of the Social Epigenome," 1.
- 32 Portera and Mandrioli, "Who's Afraid of Epigenetics?" 19.
- 33 Loison 2018, cit., 1.
- 34 Refer e.g., to Linqvist and Fullerton, "Transposon Dynamics" 137–154. Read further Pievani, "How to Rethink Evolutionary Theory," 447.
- 35 Meloni, "Epigenetics for the Social Sciences," 142 (in-text citations omitted).
- 36 See Vecellio Segate, "Neuroenhancement Patentability."
- 37 Refer extensively to Turkmendag and Liaw, "Maternal Epigenetic Responsibility"; Lapehn and Paquette, "The Placental Epigenome"; Salmeri et al., "Epigenetics Beyond Fetal Growth Restriction."
- 38 See e.g., Mortillo and Marsit, "Select Early-Life Environmental Exposures."
- 39 Schrott, Song, and Christine Ladd-Acosta, "Epigenetics as a Biomarker," 615.
- 40 Refer e.g., to Lappé, "The Paradox of Care in Behavioral Epigenetics," 698 fn. 1.
- 41 Fang, Luo, and Lin, "Epigenetic Reorganization," 379; 384.
- 42 See e.g., Hallevy, *The Matrix*, 1–61.
- 43 See also Denno, "Neuroscience," 365–370; 381.
- 44 Refer further to Peno and Bogucki, "Principles of Criminal Liability," 570.
- 45 Stelmach and Nerlich, "Metaphors," 207.
- 46 See e.g., Vecellio Segate, "Shifting Privacy Rights," 84–94.
- 47 Ellison and Munro, "Taking Trauma Seriously," 183.
- 48 See e.g., Ramo-Fernández et al., "Epigenetic Alterations."
- 49 Meloni, "Epigenetics for the Social Sciences," 128 (in-text citations omitted).
- 50 Niewöhner, "Epigenetics," 232.
- 51 Uller and Waggoner, "Epigenetic Determinism," 180.
- 52 Refer extensively to Huerne et al., "Auditing the Editor."
- 53 See e.g., Shapiro, "Gender Stereotypes;" Sorby and Kehn, "Juror Perceptions;" Smalarz et al., "The Perfect Match"; Estrada-Reynolds et al., "I Don't Like the Cut."
- 54 Philippe, "Gender Disparities in Sentencing," 1058.
- 55 Refer e.g., to Mohammadi, *White Torture*, 8; Pérez-Sales, *Psychological Torture*.
- 56 See further Reyes, "The Worst Scars"; Mausfeld, "Psychologie, weiße Folter"; Cakal, "Debility, Dependency and Dread"; Sveaass and Woolf, "Human Rights"; O'Mara, "Interrogating the Brain," 208 et seq.
- 57 Suárez-López, "The Potential of Epigenetic Methods," 30.
- 58 Philippe, "Gender Disparities in Sentencing."
- 59 In this respect, it is worth recalling the distinction between somatic gene editing, which is a therapy based on altering specific genes but cannot be inherited by next generations of individuals, and germline gene editing, which alters the genome of an embryo at its earliest stages and will be passed down to the offspring. Literature in this respect abounds, but a particularly helpful essential table may be found in Bergman, "Perspectives on gene editing."
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60 Loi, Del Savio, and Stupka, "Social Epigenetics," 147.

61 See e.g., Coppola, "Valuing Emotions"; Coppola and Martufi (eds.), *Social Rehabilitation and Criminal Justice*; Manikis, "The Principle of Proportionality," 597.

62 Refer extensively to Vecellio Segate, "Navigating Lawyering"; Bystranowski et al., "Uncertainty and Condemnation."

63 See Hage and Waltermann, "Responsibility, Liability, and Retribution."

64 Refer extensively to Part II ("Genetics and Crime") in Beaver and Walsh (eds), *Bio-social Theories of Crime*.

65 See e.g., Lavazza, "Free Will and Neuroscience"; Mele, "Free Will and Neuroscience"; Nahmias, "Is Free Will an Illusion?"; Razeev, "The Problem of Free Will."

66 See also Lambert, "A Way Out"; Kennefick, "Beyond Homicide?"

67 See e.g., Wallace and Wang, "Does in-prison Physical and Mental Health Impact Recidivism?"; Bullock and Bunce, "'The Prison Don't Talk to You'."

68 See further Ewald, "'You Can't Punish People for the Rest of Their Life"; Harding et al., "Making Ends Meet After Prison;" Miller, *Halfway Home*.

69 Alper et al., "Update on Prisoner Recidivism," 12.

70 Refer also to Leshem and Weisburd, "Epigenetics and Hot Spots of Crime."

71 See also Vecellio Segate, "The Distributive Surveillant Contract," 683–684.

72 Günther, "The Productivity of Guilt," 105.

73 See also Doleac, "Study after Study."

74 For examples, see La Vigne et al., "How Do People in High-Crime," 15.

75 Aono et al., "Neuroscientific Evidence in the Courtroom," 1 (in-text citations removed).

76 See Coppola, "The Brain in Solitude"; Coppola, "Humanizing Prison"; Coppola, *The Real Pain of Punishment*; Manikis and

Doiron, "Solitary Confinement as State Harm."

77 Refer for instance to Brisman et al., "Climate Apartheid;" Tuana, *Racial Climates*; Rice et al., "Against Climate Apartheid."

78 See e.g., Vecellio Segate, "Persecution and Labor Migrations."

79 See also White, *The Politics of Private Security*.

80 Refer e.g., to Verkaik, "British Plans"; Jefferies, "'Offshore Processing" in Guatemala"; Collyer and Shahani, "Offshoring Refugees;" Gleeson and Yacoub, "Cruel, Costly and Ineffective;" Matera, Tubakovic, and Murray, "Is Australia a Model."

81 Refer extensively to Harcourt, "An Institutionalization Effect."

82 See also Varghese et al., "Injustice in the Justice System"; Lo Iacono, "Law-breaking, Fairness, and Generalized Trust"; Slobogin and Brinkley-Rubinstein, "Putting Desert in Its Place."

83 Refer e.g., to Santaló and Berdasco, "Ethical Implications of Epigenetics."

84 See also Lara-Millán, *Redistributing the Poor*.

85 See also Harcourt, *Against Prediction*.

86 Tramacere and Bickle, "Neuroepigenetics in Philosophical Focus."

87 Refer extensively to Dupras et al., "Researcher Perspectives," 9.

88 Read extensively Dyke et al., "Communicating Science."

89 See Lynch et al., "Public Knowledge."

90 Refer e.g., to Vecellio Segate, "Cognitive Bias, Privacy Rights, and Digital Evidence," 271; Degenshein, "Finding the Criminal Within," 5; Solomon, "One Image," 384.

91 Morse, "Neuroscience and Criminal Law," 473–475.

92 Ibid.

93 For a more recent example of such studies, refer to Klasen et al., "Serotonergic Contributions."

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- 94 See further Church, "Neuroscience in the Courtroom," 1850.
- 95 156 Misc. 2d 34, 591 N.Y.S.2d 715 (Sup. Ct. 1992).
- 96 See e.g., McWilliams et al., "The Use of Neuroscience;" Meixner, "Neuroscience and Mental Competency," 1000.
- 97 Scarpazza et al., "The Role of Neuroscience," 85.
- 98 See Moriarty and Langleben, "Who Speaks for Neuroscience?," 792-795.
- 99 See e.g., Berryessa, Coppola, and Salvato, "The Potential Effect of Neurobiological Evidence."
- 100 Noyon et al., "Integrating Neuroscience in Criminal Law," 289.
- 101 *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 113 S. Ct. 2786, 125 L. Ed. 2d 469 (1993).
- 102 Aono et al., "Neuroscientific Evidence in the Courtroom," 2.
- 103 *Ibid.*, 3.
- 104 Refer further to Meynen and Bijlsma, "Culpability and Accountability."
- 105 See e.g., Catley and Claydon, "The Use of Neuroscientific Evidence," 526-527. In some civil-law jurisdictions, the distinction between murder and manslaughter can be more nuanced, but of interest here is that at some trials, neuroscientific evidence is introduced to plead a reduced sentence below the minimum threshold for either crime, instead of seeking the conversion of one crime into the other. For instance, in Slovenia, "neuro-evidence [has often been] the basis for a reduction of a prison sentence even below the statutorily prescribed minimum for murder or manslaughter," in Hafner, "Judging Homicide Defendants," 239.
- 106 Refer extensively to Coppola, *The Emotional Brain*, section 5.V.
- 107 See also Linden, "Possibilities and Limitations," 9-10.
- 108 Chandler, "The Use of Neuroscientific Evidence," 569 (notes omitted).
- 109 See also Romanowicz, "Neuroscientific Evidence in Courtroom," 243.
- 110 See e.g., Morse, "The Promise of Neuroscience for Law," 87-88.
- 111 See Roskies, "What Kind of Neuroscientific Evidence?"
- 112 See e.g., Pickersgill et al., 441.
- 113 Youngson and Whitelaw, "Transgenerational Epigenetic Effects," 233.
- 114 See further Ptashne, "Epigenetics: Core Misconcept."
- 115 See also Takahashi and Yamanaka, "A Developmental Framework."
- 116 Refer also to Huang et al., "Personal Transcriptome Variation."
- 117 Refer e.g., to Deasy et al., "Generalising Sequence Models."
- 118 See Benveniste et al., "Transcription Factor Binding."
- 119 See further Lukauskas et al., "DGW."
- 120 For a relevant example, refer to Rose and Klose, "Understanding the Relationship."
- 121 Refer e.g., to Schmidt, Zhang, and Cardoso, "MeCP2," 19.
- 122 Marz et al., "Analysis of DNA Methylation," 517; 526-527.
- 123 See e.g., Neumann et al., "Effects of Adverse Early-Life Events."
- 124 Refer e.g., to Kim et al., "Epigenetic Alterations of the BDNF Gene."
- 125 Refer e.g., to Canli, "Molecular Psychology," 7-8.
- 126 Yehuda and Lehrner, "Intergenerational Transmission," 252.
- 127 See also Hawkins-Hooker et al., "Getting Personal with Epigenetics."
- 128 See e.g., Onay, "The True Ramifications"; Jones, "Overcoming the Myth," 1044.
- 129 Refer e.g., to Mudrik et al., "Free Will Without Consciousness?"
- 130 See Lavazza, "Why Cognitive Sciences Do Not Prove," 10.
- 131 See Sapolsky, *Determined; Pereboom, Living Without Free Will*.

- 132 Read e.g., Krishnan, "How Can Determinists Believe."
- 133 See extensively Pleasants, "Free Will."
- 134 Refer e.g., to Chiesa, "Punishing without Free Will," 1448.
- 135 See Daly, "Free Will is No Bargain," 1022.
- 136 Check most recently Yokose, Marks, and Kitamura, "Visuotactile Integration"; de Waal, *Are We Smart Enough*; Andrews, "All Animals are Conscious"; Nussbaum, *Justice for Animals*.
- 137 See e.g., Vecellio Segate and Daly, "Encoding the Enforcement of Safety Standards," 24–25.
- 138 Refer e.g., to Lee et al., "People May Punish"; Simmler and Markwalder, "Guilty Robots?"; Danaher, "Robots, Law and the Retribution Gap"; Keijsers et al., "Teaching Robots a Lesson"; Lima et al., "Will Punishing Robots Become Imperative"; Abbott, *The Reasonable Robot*, 111–133; Nagenborg, "Can We Forgive a Robot?"; Zając, "Punishing Robots"; Rossmly et al., "Punishable AI"; Cogley, "Reasons to Punish Autonomous Robots"; Mulligan, "Revenge Against Robots."
- 139 Refer e.g., to Quinton, Trafimow, and Genschow, "The Role of Free Will Beliefs"; Feldman, "Making Sense of Agency."
- 140 See Mercier et al., "Does Belief in Free Will."
- 141 Martin, Rigoni, and Vohs, "Free Will Beliefs Predict Attitudes."
- 142 Hieronymi, *Freedom*, 105.
- 143 See Balaguer, "Why the Classical Argument."
- 144 le Mouël, "Self and the Paradox of Free Will."
- 145 Read e.g., Newberg and Waldman, *Born to Believe*.
- 146 See Burkeman, "The Clockwork Universe."
- 147 See further Meloni, "If We're Not Careful"; Rothstein, "The Ghost in Our Genes," 58–61; Mansfield and Guthman, "Epigenetic Life"; Saldaña-Tejeda and Wade, "Eugenics."
- 148 Read also Bedessem and Ruphy, "Scientific Autonomy"; Hanna, "The Scope and Limits."
- 149 Refer e.g., to Wong and Hodson, "From the Horse's Mouth," 120.
- 150 Miles, "Irresponsible and a Disservice," 207.
- 151 See Robinson, "Criminal Law's Core Principles," 216.
- 152 Further reading in Cockell, *Interplanetary Liberty*; Cockell (ed), *Human Governance Beyond Earth*.
- 153 Read also Hendrickx and Van Hoyweghen, "An Epigenetic Prism."
- 154 For an overview of these ways, refer to Ashe et al., "How Does Epigenetics Influence."
- 155 Huang and King, "Epigenetics Changes Nothing," 77.
- 156 Chiapperino et al., "Epigenetics and Society," 2.
- 157 See also Coppola, "We are More Than our Executive Functions"; Coppola, "Social Vulnerability on Trial."
- 158 See also Dean, "Poverty and Social Exclusion."
- 159 Pickersgill, "Epistemic Modesty," 200.

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