Chapter 9
Behavioural and Cultural Epigenetics: Social Biologisms Refuted by Developments in Biology

Marco Celentano

Abstract Developments in evolutionary studies, focused on the discovery of epigenetic inheritance and the social-environmental factors influencing it, have led to epochal turning points in the last three decades. Faced with these important changes, we can now consider the genocentric models that guided evolutionary studies from the last decades of the nineteenth century to the early '70s of the twentieth as obsolete. In fact, today we can demonstrate that, in the course of phylogenesis, at least three other kinds of selection, heredity and variation, respectively *epigenetic, behavioural and cultural,* operated alongside the slow processes of genetic variation, producing adaptive or maladaptive effects in a much more rapid way than that implicated by genetic mutations. Thanks to very young research areas such as behavioural and cultural epigenetics, we can now *refute old and new social biologisms*, ancient, ever re-emerging forms of biologistic determinism, *with the tools of biology itself*. We can indeed show that, through the *methylation and demethylation processes*, a lot of socio-environmental factors contribute to inhibit or re-activate gene expression, influencing fundamental aspects of the individual's health, emotional, social and cognitive development with effects that are often transmitted to descendants for several generations. This essay discusses some of the most recent and representative results of these emergent areas of the epigenetic research and eco-evo-devo studies. This analysis reaches the conclusion that it is now anachronistic to hypothesize "human nature" being rigidly codified at the genetic level and substantially unchangeable in its fundamental mental and behavioural propensities.

9.1 Introduction

Within the theoretical framework of the "synthetic theory" developed in the first half of the twentieth century (Huxley 1942), it was excluded that living conditions and social context could, over a few generations, cause hereditary modifications of the phenotype and of its physiological, psychic and behavioural propensities. In fact, the phenotypic conformation was considered as the result of a faithful execution (except for "random transcription errors") of a program entirely written in DNA and scarcely modifiable by the environment. Significant phenotypic changes were

R. Marchesini and M. Celentano, *Critical Ethology and Post-Anthropocentric Ethics*, Numanities - Arts and Humanities in Progress 16,
https://doi.org/10.1007/978-3-030-74203-4_9

considered, therefore, possible only in the long time required by significant genetic or even genomic mutations that were estimated as millions of years (Riedl 1980).

However, different kinds of phenomena verified by the biological and behavioural sciences remained difficult to explain within this theoretical framework: the ability of organisms to adapt to rapid environmental changes, the evident influence of environmental and social stimuli on cognitive and relational development of human beings and other animals, the problem, discussed since the days of Darwin, of explaining the surprising speed with which the evolutionary process took place after the appearance of the metazoans. According to the most accredited theories, in fact, the differentiation of organisms began very slowly but, as of the last phase of the pre-Cambrian, underwent a strong acceleration. In other words, as Steven Jay Gould wrote, for about 2.5 billion years, "the seaweed carpets remained carpets of algae" (Gould 1977: 114; 121), then, within about a billion or at least 600 million years, the evolutionary process led to the appearance of the incredible variety seen in past and present multi-cellular species. In 1867, F. Jenkin had already pointed out that the solution proposed by Darwin to explain this process, the slow accumulation of random favourable hereditary variations produced by natural selection, hardly justify the genesis of a so wide flowering of phyla, species and varieties and the appearance of complex organs such as the eye or the brain in such a short time (Jenkin 1867). All the subsequent reformulations of the Darwinian theory cantered on binomial mutations-selection, "chance and necessity", proposed from then on have been dragging behind this problem.

But as I have briefly reconstructed in the Sect. 2.8 of this volume, the birth of the evo-devo approach and the turning towards an "extended synthesis" of the Darwinism have led, in recent decades, to a substantial overcoming of the theoretical framework of modern synthesis and to a solution of this problem. Developments in these research fields have in fact shown that three other kinds of hereditary transmission have cooperated with the genetic one in determining the effects and times of phylogenesis: epigenetic, behavioural and (at least among "higher animals") cultural inheritance. Three forms of inheritance the effects of which manifest themselves much more rapidly than those implied by genetic mutations.

These changes of perspective have considerable repercussions on at least three issues that have crossed the entire history of post-Darwinian biology:

- the aforementioned debate on the "dilemma" of the speed of evolution;
- the problem of explaining the ability to quickly adapt to environmental changes that all organisms capable of associative learning manifest;
- the *vexata questio* on the degree of influence that, respectively, genes and socio-environmental stimuli have on human experiences, activities and propensities.

As I recalled in the second chapter, the new version of Darwinism emerging from the extended synthesis implies, in fact, that any drastic change in living conditions can trigger "large amounts of [...] hereditary variations" (Jablonka and Lamb 2005: 443), that "some hereditary variations are non-random in origin" and that some acquired information can be inherited. In other words, it implies that evolutionary change can result "from instruction as well as from selection" and that genetic changes can often come as "followers" of evolutionary divergences started at the epigenetic and ethological level (Jablonka 2006; Callebaut et al. 2007; Pigliucci and Müller 2010) and, therefore, that in various cases the "evolution can be very rapid" (Jablonka and Lamb 2005: 442; 443).

In this chapter, I will discuss the results of numerous studies which demonstrate that ontogenetic development of mind and behaviour, in humans and other social animals capable of learning, is decisively influenced, through epigenetic inheritance and cultural tradition, by early and subsequent experiences, social context and living conditions. Mental and behavioural propensities and preferences can therefore develop significant, useful or harmful changes in the rapid times in which social and cultural selection operate. Therefore, to "explain the socio-behavioral status quo in terms of genes" appears, within this new theoretical framework, incorrect and anachronistic (ibid.: 473). In short, according to the emerging perspectives, environmental stimuli, social constraints and cultural heritage channel and largely constrain the gene expression: the exact opposite of what the genetic determinists have always supposed and supported.

9.2 From the "Selfish Gene" to the "Altruistic" One: Moral Innatisms and Evolutionary Psychology

In the fourth chapter of *The Descent of Man* (Darwin 1871), like the third dedicated to a comparison between the human mental faculties and those of other animals, Darwin exposes his conception according to which human morality sinks its remote roots in the social instincts of the higher animals, especially primates. The great naturalist introduces here an approach that could be defined proto-ethological, then developed in the work *The expression of emotions in animals and humans* (Darwin 1872), starting to locate a series of emotional, cognitive, behavioural and expressive patterns that our species shares with others.

In the final pages of the chapter, there is a passage quoted from the letter that Hebert Spencer had written to John Stuart Mill, and that Alexander Bain had published in his *Mental and Moral Science* (Bain 1868): "Our great philosopher, Herbert Spencer, has recently explained his views on the moral sense. He says: «I believe that the experiences of utility organised and consolidated through all past generations of the human race, have been producing corresponding modifications, which, by continued transmission and accumulation, have become in us certain faculties of moral intuition»" (Darwin 1871: 102). Darwin initially seems to align himself with Spencer's moral innatism and intuitionism: "There is not the least inherent improbability, as it seems to me, in virtuous tendencies being more or less strongly inherited" (*Ibidem*). In the following passages, however, he raises perplexities, essentially dictated by the fact that the moral traditions have often preserved and handed down norms which, in his eyes, appear neither useful nor adaptive: "My chief source of doubt with respect to any such inheritance, is that senseless customs, superstitions, and tastes, such as the horror of a Hindoo for unclean food, ought on the same principle to be transmitted" (*Ibidem*: 103).

In other words, it would be necessary to admit, *as Nietzsche was later to do*, that, for millennia, social and cultural selection has in many cases rewarded, preserved and venerated even the "un-adapted", here understood as a melting pot of beliefs and behaviours that damage those who enact them, reducing their vital chances.

The theoretical oscillations between concessions to the moral innatism and critical reservations against it, emerging in this Darwinian text, will cyclically recur in the subsequent biological and philosophical debate, up to our days.

In the last twenty years, in particular, two different models of "moral Darwinism" (Pennock 1995; Wiker 2002; Attanasio 2010; Hodgson 2013; Ruse 2017) have emerged, in which this polarity returns to show itself.

The first model, which I would call "strong", postulates the existence of a series of "innate" instincts, principles and moral judgments, dependent, more or less directly, on our genetic code. This model found some of its best-known supporters in evolutionary psychologists[1] as Jonathan Haidt, Steven Pinker and Marc Hauser, and in the biologist and science popularizer Richard Dawkins.

The second model, which I will define "weak", is instead centered on the hypothesis that "we are not born with any specific moral norms in mind, but with a learning

[1]Evolutionary psychology was born in the early nineties of the twentieth century. Its approach was outlined in the collective volume *The Adapted Mind* (1992), edited by Jerome Barkow, Leda Cosmides and John Tooby. As the title of the work suggests, the first assumption of this branch of psychology is that the human mind and brain are, in their basic architecture and mechanisms, products of the adaptation of the human species to the environment in which it has evolved. The second basic assumption of evolutionary psychology is that the human mind and brain function, according to the model suggested by Fodor, in a modular way (Fodor 1983), that is: through cognitive and physiological circuits which are *mutually independent*. Evolutionary psychology is presented by its supporters as an area of research aimed at finding a mediation between the reductionist and deterministic positions of the genocentric sociobiology and the culturalist approach of the traditional sociology (Adenzato and Meini 2006: XIII). Indeed, it advocates, at least in theory, the overcoming of every innate/learned dichotomy (Cosmides and Toby 2006). However, the positions of its best-known exponents often appear more as a diplomatic and rhetorically "soft" repurposing of sociobiological genocentrism than as a theoretical or experimental overcoming of it. Ultimately, according to their approach, it is possible to explain the origin and motivation of every human psychological attitude, including moral, religious and political ones by discovering the genes they depend on.

These psychologists like to call themselves "Darwinians", but their beliefs diverge profoundly from the Darwin's one. In the concluding chapter of *The Descent of Man*, Darwin stated that "the moral qualities are advanced, either directly or indirectly, much more through the effects of habit, the reasoning powers, instruction, religion, &c.", which means through a social and cultural selection, rather "than through natural selection" (Darwin 1871, II: 404). Therefore, the moral innatism promoted by the main exponents of contemporary evolutionary psychology supports a thesis opposite to that of Darwin. It is no coincidence that it refers to two theoretical models that are *extraneous to Darwinism*: Chomskyan linguistic innatism, which still lacks any adequate genetic and/or neurophysiological evidence from the 1950s to the present day, and the modularistic approach launched by J. Fodor in the 1980s. Moreover, in the new millennium the latter approach underwent extensive criticism and revision by its own author, who has argued that the thesis according to which the human cognition is mostly or totally modular is "devoid of empirical plausibility" and borders on "incoherence" (Fodor 2000).

agenda that tells us which information to imbibe" (de Waal 2006: 166). This leads us to "internalize the moral fabric of our native society" (de Waal 2006: 166; Simon 1990) and rework it according to our experiences. From the 1990s onwards, ethologist and primatologist F. de Waal has offered the most consolidated and documented exposition of it.

We will start our analysis by examining the positions of some supporters of the "strong" model, according to whom moral principles oriented to favour the conservation of "altruistic" behaviour are innate in our species or even fixed on a genetic level. Among these, I will first mention an apparently "unsuspicious" scholar to whom, a few decades ago, no one would have attributed the defence of this model: Richard Dawkins. When he published his bestseller *The Selfish Gene* in 1976, Dawkins seemed to have questionable but *very clear* ideas about our hereditary inclinations: "*If you wish*, as *I do*, to *build* a *society* in which *individuals cooperate generously* and unselfishly towards a *common good*, *you* can *expect little help* from *biological nature*. Let *us try* to *teach generosity* and *altruism*, *because we* are born *selfish*" (Dawkins 1976: 3). These statements did not leave much room for doubt regarding their interpretation: they asserted that our innate tendencies lead us to be *selfish and not generous*. They echoed, renewing its form but not its substance, the position assumed in the previous century by Thomas Huxley in which "altruistic" choices contrast with a natural tendency to protect one's own survival and an unyielding part of our ereditary kit. However, about thirty years later, in the volume *The God Delusion* (Dawkins 2006), he went to reverse this position, though without explicitly admitting it. Indeed, in the sixth chapter of the book, entitled *The Roots of Morality: Why Are We Good?* he wrote: "Where does the Good Samaritan in us come from? Isn't goodness incompatible with the theory of the 'selfish gene'? No. This is a common misunderstanding of the theory - a distressing (and, with hindsight, foreseeable) misunderstanding" (Dawkins 2006: 215). This very self-denial, which Dawkins minimized by presenting it as a simple misunderstanding, had precise historical and cultural causes. In those years, in fact, the hypothesis that some altruistic behaviour has a very strong innate basis in our species had found wide diffusion in a new field of research born in the nineties: evolutionary psychology.

One of the best-known popularizers of this approach had been the cognitive psychologist Steven Pinker. Based on the model of Chomskyan linguistic innatism, and on the neo-intuitionist approach proposed by psychologist Jonathan Haidt, Pinker had launched, in the volume *The Blank Slate: The Modern Denial of Human Nature* (Pinker 2002), the idea of a "Darwinian moral innatism", then re-proposed in the paper *The Moral Instinct* (Pinker 2008).[2] This approach had been then reworked and developed by Marc Hauser, also an evolutionary psychologist, who in the essay *Moral minds. How nature designed our universal sense of right and wrong* (Hauser 2006) had proposed the hypothesis that our "moral sense" is inscribed in the human brain, based on a "universal moral grammar" and determined to a large extent by genetic factors. According to Hauser, it is therefore correct to talk about a very

[2] As he himself affirms, Pinker adopts a "weakened", or semi-strong, version of the moral innatism, believing that in our brain there is likely no list of "you must", but only some "if-then" rules.

“moral instinct” which is innate and “immune” to the conditioning of social and cultural factors as authorities and religions (Hauser 2006: xviii).

Hauser’s approach, in turn, referred to the Haidt’s one which in the article *The emotional dog and its rational tail: a social intuitionist approach to moral judgment* (Haidt 2001) had hypothesized the existence of two separate systems of evaluation that guide the human mind: “moral intuition”, phylogenetically older, and the younger “moral judgment”, which appeared only after verbal language was affirmed. Indeed, his “intuitionist social model” postulates that it is the phylogenetically older brain functions that are at the basis of the intuitive, quick, automatic and emotional responses we give to questions of a moral nature. According to this approach, therefore, reasoned ethical judgments play, in the mental processing of our ethical choices, only a secondary role, used more to construct a posteriori rational justifications for our evaluations than to identify the conclusions they reach. This way, while not being able to deny that moral judgments are individual re-elaborations of values transmitted by a specific cultural tradition, Haidt tends to minimize the effects of our cultural formation on our emotions, and those of reasoning on the moral judgments, substantially equating both to a posteriori justifications of innate behavioural patterns.[3]

For its part, Hauser, referring to the Chomskyan innatist model, Haidt’s intuitionism and John Rawls’s neo-transcendentalism, had proposed the hypothesis that there is a “universal moral grammar”, based on a “moral instinct”, which matures naturally in the brain of each child (Hauser 2006: xvii).

While not going as far as denying the undeniable, that is the influence of cultural differences on the codes of conduct and values internalized by individuals, he postulates the existence of universal “innate principles” of moral judgment only our species is endowed with.

In short, Hauser’s theses outline, albeit with some caution, a very strong model of moral innatism, stating that we possess an “innate moral faculty”, characteristic and exclusive to our species, that there is a “universal moral grammar”, analogous to the universal grammar that Noam Chomsky postulated to explain the learning of verbal language, and finally that these innate devices are impervious to conditioning from social, political and religious authorities.

What kinds of data supports these theses?

Hauser examines the contributions of various disciplinary fields, but the argument he considers decisive does not derive from genetic, neurophysiological, ethological, or historical evidence, but from a study which consisted in administering a “Moral Sense Test” via Internet (see: http://www.moralsensetest.com) to more than 60,000 volunteers from 120 different nations. The test related on some “moral dilemmas” and mental experiments that Hauser himself, along with two of his collaborators, had instructed.

[3]In more recent years Haidt has argued that also political and religious preferences are attributable to genetic factors. See Haidt (2012).

Both Hauser and Dawkins interpret the results obtained from this telematic test—that is, the fact that most of the interviewed people provided similar answers, regardless of their culture of origin, religious affiliation and social status—*as an indication of the universality of basic human moral principles and of their substantial impermeability to social and cultural influences.*

This procedure has raised several criticisms aimed to emphasize an evident inconvenience and disproportion between the poor reliability of the data collection method used by Hauser and collaborators, the kind of data analyzed, and the extreme generality of the conclusions which the author claimed to have been able to reach.

Even a scholar like Philip Lieberman who has made important contributions in both cognitive psychology and studies on human psychic evolution, has attacked the exasperated "adaptationism" that characterizes the approach of these evolutionary psichologists, denouncing the spread of research based on data collected, exclusively or almost, among the WEIRDOs. The acronym indicates the "people of Western cultures, educated, industrialized, rich and democratic" that constitute the majority of "the subjects who played the highly constrained mind-games experiments that form the «empirical» data of *Moral Minds*" (Lieberman 2013: 182) and of its "Toy Experiments".

The result that Hauser and Dawkins interpret as a proof of the existence of an innate universal morality appears, according to Lieberman's pertinent observations, more credible as an indicator of the high degree of *cultural homologation* now achieved in a globalized world, within a circle of people which is westernized enough to be familiar with telematic questionnaires and online games. In any case, it certainly cannot refute the results confirmed by all the countless archaeological and historical studies which had attest to very profound differences developed by past and present human cultures in terms of moral rules and lifestyles in a period that covers (and most likely exceeds) the last ten thousand years.

But, as we have already shown in the previous chapters with specific examples and as this final section will further demonstrate, the developments reached in the past three decades by an emerging discipline such as epigenetics, and the profound renewal it has brought to the field of evolutionary studies finally allow us to dismiss "strong" moral innatism as a dogmatic doctrine now refuted by an increasing amount of experimental results and statistical analyses of historical and empirical data.

9.3 Experience *Creates* Difference: Studies on Monozygotic Twins

Physical and behavioural similarities between monozygotic twins (MZ) have always been among the arguments that the supporters of genetic determinism try to exploit in favor of their own thesis. For example, evolutionary psychologist Steven Pinker, in an article entitled "Why nature & nurture won't go away" (Pinker 2004), tried to prove, drawing on some studies on mono-ovular twins, a thesis characterized by extreme biologistic determinism: "Setting aside cases of extreme neglect or abuse, whatever experiences siblings share by growing up in the same home in a given culture make little or no difference to the kind of people they turn into" (Pinker 2004: 15); "the shared family environment has little to no lasting effect on personality and intelligence" (ibid.).

A thesis that has always been disputed by the psychic and social sciences and that received, the following year (2005), a resounding denial precisely in the research areas to which Pinker most insistently appealed: behavioural genetics and the study on the development of epigenetic characteristics in mono-ovular twins. This refutation was offered by an article published in PNAS, the magazine of the American Academy of Sciences (Fraga et al. 2005). The paper, signed by twenty researchers operating in different countries, was based on a research project coordinated by Manel Esteller and focused on the study of 80 monozygotic male and female twins aged 3–74. It showed that the perfect genetic and epigenetic identity as found in MZ twins immediately after their birth does not prevent the punctual maturing in them, over the course of their lives, of significant epigenetic, attitudinal and behavioural differences. Differences deriving from their lifestyles, from the different environments they have lived in, or different roles they have occupied in a common environment, from biographical circumstances or pathologies which involve the regulation, and therefore the expression, of their genes. The authors of the study found the most significant differences in terms of immune system, organic function, brain micro-conformation and behavioural propensities precisely between monozygotic twins raised in different environments and when different pathologies changed the "epigenetic landscape" of a sibling. "We also established", they wrote, "that these epigenetic markers were more distinct in MZ twins who were older, had different lifestyles and had spent less of their lives together" (ibid.: 10608). Conclusions that, contrary to those taken from Pinker, fully confirmed "the significant role of environmental factors in translating a common genotype into a different phenotype" (ibid.) and the relevance that the life context has for the dynamics of the brain development and personality formation.

For these reasons, according to Esteller and his collaborators, "MZ twins are an excellent example of how to genetically identify individuals can exhibit and therefore provide a unique model for the contribution of epigenetic modifications in the establishment of the phenotype" (ibid.).

Another paper, published in *Science* in 2013, shows, instead, that *even mono-ovular twins grown in the same environment develop, from early childhood, different preferences, attitudes and abilities, and related differences in the respective brain micro-geographies*, if the environment in which they live is sufficiently stimulating (Freund et al. 2013). Particularly interesting is the fact that the study reveals these differences not in human beings, which many scientists consider as the species endowed with the greatest cerebral and behavioural plasticity, but in a model species such as the mouse.

In fact, it offers an experimental account of the development of different behavioural propensities and corresponding differences at the level of neural networks in 40 monozygotic mouse twins raised in a "large enriched environment" which gave them the opportunity to differentiate their activities. Monitored 24 hours a day by a microchip for three months, the twins developed different propensities, attitudes and abilities. The use of imaging diagnosis showed that their brains also underwent different kinds of micro-modifications. The mice had in fact increased the number of neurons in different areas of their hippocampus (an area of the brain that is very important to the learning ability, procedural memory and the encoding of information), and the mice "who explored their habitat more broadly also grew more new neurons" (ibid.: 758) in this area.

Experiments like these show that, to adequately appreciate the incidence of the social and natural environment on the formation of cerebral, psychic and behavioural differences in monozygotic twins, both environmental and biographical differences must be taken into account. They demonstrate that, even in genetically identical individuals, experience creates differences, not only on a cultural but also on a biological level, by modifying their self-regulation systems.

9.4 Experience *Transfers* Difference: Influences of Maternal Lifestyles and Parental Care on Descendants

The developments of behavioural and cultural epigenetics, a research area "which includes both the investigation of the role of behavior in shaping developmental-epigenetic states and the reciprocal role of epigenetic factors and mechanisms in shaping behavior" (Jablonka 2016: 47) already allow, about twenty years after its birth, to corroborate the following statements:

- It is established that a mother's diet, experiences and lifestyle influence embryonic development from its earliest stages and that parental care plays a no less crucial role in the development of the mental and behavioural attitudes of children.
- The effects of these embryonic and childhood experiences persist, in forms that are modulated by subsequent experiences, throughout children's and adults' lives and can be transmitted for some generations to their descendants even in the absence of a reiteration of the external stimuli that caused them.
- These influences, both in human beings and other social mammals, invest all main aspects of development: from the immune system to resistance to stress, from levels of neophobia or exploratory propensity to the development of psychic, cognitive and relational attitudes.
- They induce a series of experimentally verifiable changes in the epigenetic regulation of genetic expression and cerebral microcircuits.

As found in various animal clades, the effects of a mother's diet on her offspring's preferences appear particularly significant in placental mammals, where the zygote lives its prenatal development constantly immersed within the maternal uterus. Bilkó and some collaborators, in a well-known study (Bilkó et al. 1994) fed pregnant, laboratory-grown female rabbits with juniper berries obtaining the development of a clear preference for this food both in offspring bred by their natural mother and in those entrusted to adoptive mothers early. Similar effects on food preferences have produced experiments in which adoptive mothers fed with these berries suckled puppies born of mothers fed with normal laboratory feeds (Jablonka and Lamb 2005). In both cases the preference for that food was then passed on to the next generation.

Does maternal diet also have direct influences on the dietary orientation of human children? Experimental evidence has been accumulating over the past few decades. Often cited are the studies coordinated by the biopsychologist Julie Mennella that demonstrated the transmission of a preference for carrot juice in children of women who had drunk it regularly during pregnancy, or just during its first two months (Mennella et al. 2001). More recently, other studies have clarified that the diet followed by a mother during her pregnancy influences a wide range of organs and systems in offspring and can also affect the biological and health profile of their descendants. Finally, a very recent study deals with a topic to which we will return in the concluding pages of the chapter: the trans-generational effects of undernourishment (Aiken et al. 2016).

But it is now known that the uterine environment not only influences food preferences, but also other temperamental and behavioural traits. For example, in a rodent such as the Mongolian gerbil, the period in the maternal uterus can exert strong inheritable effects on the development of the female offspring. In this animal species, in fact, "a male-biased sex ratio and aggressive female behavior is perpetuated, probably because the mother's phenotype reconstructs a testosterone-rich uterine environment that induces the same hormonal and behavioral state in her daughters" (Jablonka and Lamb 2007: 359)

There are thus many studies on animal models that highlight the direct influence between mother/offspring, or reference adults/offspring and interactions on the latter's psychic and relational development. Lorenz and his collaborators already showed decades ago that it is enough to deprive an anatidae chick of the "greeting" ritual to make it an asocial adult, unable to weave "normal" relationships with conspecifics (Lorenz 1988). More recently, a series of experiments with rats coordinated by Frances Champagne (Weaver et al. 2004; Champagne and Rissman 2011) testified that puppies raised by mothers who donated a low quantity of licking and grooming subsequently showed lower levels of stress resistance, and a higher propensity to neophobia, than those who received greater amounts of care. The females raised this way, when becoming mothers, enacted behaviours similar to those received, obtaining the same effects, which were thus perpetrated from generation to generation (Weaver et al. 2004). Champagne and her collaborators found that these trans-generational effects depended on the fact that the donation and the non-donation of care triggered, respectively, methylation or de-methylation processes of certain portions of DNA.[4]

[4]Methylation is an epigenetic modification of DNA that allows the formation of a bond between a methyl group and a nitrogenous base (one of the bases of which the DNA and RNA nucleotides are composed). In mammals, methylation plays a fundamental role in the development of the zygote, making possible the formation of the chromatin, and therefore of the chromosomes, and then the

They have indeed detected "that increased pup licking and grooming (LG) and arched-back nursing (ABN) by rat mothers altered the offspring epigenome at a glucocorticoid receptor (GR) gene promoter in the hippocampus. Offspring of mothers that showed high levels of LG and ABN were found to have differences in DNA methylation, as compared to offspring of 'low-LG-ABN' mothers" (ibid.: 847). In simpler words: the pups that had received scarce care presented, in the successive phases of their development, a tendency to stress and a neophobia significantly greater than those raised with more care. The females bred by mothers who gave little care also presented "the same epigenome as the mothers and therefore reproduced the same 'unloving' behavior with their children" (Bottaccioli and Bottaccioli 2012: 331).[5] In fact, the methylation process induced by the lack of parental care prevented the development and functioning of an adequate number of glucocorticoid receptors, hormones that allow individuals to adapt to stress, alleviate anxiety and to relax. Individuals who had undergone poor treatment ended up becoming perpetually stressed subjects and females raised in such conditions procreated offspring with similar propensities. Therefore, the greater or lesser donation of parental care was revealed, in this case, as a factor capable of inducing epigenetic modifications that have significant effects from an emotional, psychic and clinical point of view, for both first generation children and their descendants.

Subsequently, to demonstrate even more rigorously that these effects were mainly due to the behaviour of the mother, and not to her genes, Champagne and her colleagues had mothers who gave abundant care bred rat pups born of mothers who gave them few and vice versa. The causal links suggested by the results of the first experiment found full confirmation in the second one: the pups born to "caring" mothers but raised by inattentive mothers developed in their hippocampus low levels of glucocorticoid receptors and behaved more anxiously. Those born to inattentive mothers but bred by mothers who gave wide care showed high levels of glucocorticoid receptors and a more sociable and relaxed behaviour (Iversen 2014).

9.5 Trans-Generational Effects of Traumatic Experiences, Privations and Social Inequalities

Several experiments have proved that also in human beings, "psychic stress has trans-generational effects" (Jablonka 2016: 49). For example: "using blood cells, a study in Gambia found that individuals conceived during the nutritionally-stressful

gene transcription and the differentiation of cells, tissues and organs. The DNA methylation allows the cells to regulate the gene expression by silencing certain genes, i.e. inhibiting their expression. De-methylation is instead a process that has the opposite effect: it fixes, so to speak, the gene in an "ON" position and therefore allows it to perform its functions. Both these processes are strongly influenced by environmental stimuli.

[5]This and all the other quotations from essays contained in this chapter that have not been translated into English are my translations.

rainy season had significantly higher methylation at several important gene loci than individuals conceived during the more plentiful dry season" (ibid.).

More generally, over the last twenty years, the cross results of many studies have shown that for us as for other animals, "stressful or traumatic experiences such as social defeat, a strong or enduring mental shock, physical and emotional abuse, or deprivation of early parental care can have deleterious longterm, trans-generational effects that are mediated by molecular epigenetic mechanisms" (ibid.). In other words, according to the new insights of behavioural epigenetics, "traumatic experiences in our past, or in our recent ancestors' past, leave molecular scars adhering to our DNA. Jews whose great-grandparents were chased from their Russian shtetls; Chinese whose grandparents lived through the ravages of the Cultural Revolution; young immigrants from Africa whose parents survived massacres; adults of every ethnicity who grew up with alcoholic or abusive parents - all carry with them more than just memories" (Hurley 2015).

In 2008, neurobiologist Michael Meaney and molecular biologist Moshe Szyf published, together with other researchers, the results of a study in which they compared the brains of 13 people who had been sexually abused and died by suicide with those of people who died suddenly due to other causes. The former presented an excess of methylation (silencing) of the hippocampal genes, a region of the brain that plays a fundamental role in stress regulation, but also in the fixation of mnemonic data and in spatial orientation (McGowan et al. 2008).

Then, in 2012, Szyf and his collaborators published the results of a study based on the analysis of the methylation rates of most of the genes present in the genome (obtained from blood samples) of 40 people born in England in 1958 (Borghol et al. 2012). These were people who had lived, from childhood, or from a certain phase of their life onwards either in conditions of extreme poverty, or in conditions of great wealth. Overall, Szyf and his colleagues analyzed the methylation status of about 20,000 genes. "Of these, 6,176 genes varied significantly depending on poverty or well-being. The most surprising thing, however, was to notice that methyl changes were more frequently found if the impacting event" that had drastically changed the economic life of those people had occurred "in the early childhood rather than as adults" (Iversen 2014).[6] The authors, presenting the study, wrote: "We aimed to establish whether childhood SEP" (socio-economic position) "was associated with differential methylation of adult DNA" (Borghol et al. 2012: 62). Their conclusions were equally clear: "Disadvantaged socio-economic position (SEP) in childhood is associated with increased adult mortality and morbidity" (ibid.).

In another study, published in the same year, Elena L. Grigorenko, Moshe Szyf and other researchers compared the overall methylation levels of 14 children raised in Russian orphanages with those of 14 Russian children who grew up with their natural parents (Naumova et al. 2012). The experiment confirmed that in the orphans many genes involved in important functions, such as the neuronal communication

---

[6]This and all the other quotations from essays that have not already been translated into English in this chapter are my translations.

and the brain function development, had a level of methylation, and therefore of inhibition, significantly higher than those found in the control group.

"The study of social and cultural epigenetics is still in its infancy, so we do not have detailed studies of the relations between socio-cultural conditions and epigenetics. It is well established, however, that social inequality (e.g., poverty) in geographically, politically, and economically diverse populations is correlated with an increased risk of cardiovascular diseases, cancer and psychological disorders, and that all these deleterious conditions have epigenetic underpinnings. [...] The disposition to develop such deleterious effects can be transmitted to the next generation and contribute to the difficulty of escaping poverty" (Jablonka 2016: 50), thus triggering a "vicious cycle of political-social action" (ibid.). Very clear, in this sense, is the data on the trans-generational effects of social catastrophes such as wars, famines and persecutions. "A 2008 study was first to show in humans that early-life environmental conditions can cause epigenetic changes that persist for life. It investigated long-term effects of the Dutch hongerwinter (hunger winter) of 1944–1945, a seven-month famine imposed by Nazi rationing" (Powledge 2009: 738; 739). The study (Heijmans et al. 2008) showed that individuals conceived during this period, in which the Nazi occupiers reduced daily food rations to less than 700 kilocalories per person, "had, 6 decades later, less DNA methylation of the imprinted *IGF2* gene compared with their unexposed, same-sex siblings" (ibid.). This led, for them, to an increased incidence of diabetes, obesity, schizophrenia and coronary heart disease, significantly higher than that of the siblings of the same sex born in less hard times. A study published by Yehuda and some collaborators (Yehuda et al. 2015) illustrates, instead, the trans-generational effects of different kinds of traumatic events, showing that the experiences of war, segregation, degradation and humiliation influence the disposition of descendants to develop several neurophysiological and psychological pathologies. Indeed, all 22 children of the 32 Holocaust survivors examined were more likely to develop post-traumatic stress disorder (PTSD) than control groups, related to the methylation of the cytosine within the gene encoding the FKBP5 protein, which plays an important role in controlling stress sensitivity.

9.6 Conclusions

Summarizing what has been discussed in this chapter, developments in evolutionary biology and behavioural sciences have now proved that the ability of organisms to adapt to rapid changes in the environment depends, to a significant extent, on epigenetic regulatory mechanisms capable of deactivating or reactivating certain genes, or their influence over certain processes, and that these forms of self-regulation are transmitted to descendants through the epigenetic inheritance. According to these emerging models, biological evolution is based not only on the slow processes of accumulation of genetic mutations and natural selection, but also on these rapid changes in epigenetic regulation, behaviour and survival strategies, which allow living beings to cope with the changes that continually arise in their environmental and social contexts.

This also means that, particularly among animals as the social mammals and birds, the development of individual and collective reactivity, preferences, attitudes and capacities is mainly regulated by inputs coming from the *intraspecific* environment, that is, from the social context in which individuals live. We already knew that this happens through training and learning processes, but we can now state that it is also through epigenetic inheritance. This means that the effects of the experiences of immediate ancestors are transmitted to descendants not only because they take relatives and parents as a model, and/or react to their behaviour, but also because each parent transmits to their children an entire functional and self-regulatory structure that works, above all, at a cellular level and this structure, as we have seen, regulates a lot of aspects related to health, behaviour, cognitive activity and social relationships.

This is all the more true for humans, who live in an environment which, even from a material point of view, is almost entirely anthropic, or built and regulated by humans themselves. This means that the biological history of man is also a *social history*, that its developments, ever since ancient times and even more so today, are channelled towards certain directions by the ways in which human relations are organized within the society. This is true both for aspects relating to emotional and physiological self-regulation, as well as for those relating to psychic, attitudinal and intellectual development.

Furthermore, a wide range of studies attests that every form of traumatic or stressful experience and any kind of social discrimination leave in our minds and bodies molecular and cellular "scars" which cause physical and psychic discomforts and can be transmitted to our descendants. What these studies bring to light is, therefore, a vicious circle, existing for millennia, in which social discrimination produces, through inhibitory, stressful or disabling effects that are transmitted from generation to generation, a continuous strengthening of inequalities. They demonstrate, in other words, that *social discrimination produces biological discrimination* and tends to perpetuate the conditions of their arising and increasing.

But, fortunately, these studies also demonstrate the possibility of the reverse effect. They show in fact that:

- the inclusion of subjects with previous deficits or disorders, caused by epigenetic inheritance or individual experiences, in a social and material environment which is appropriate to them, enriched, stimulating, and non-stressful, can produce considerable compensatory effects and forms of rehabilitation (McGowan et al. 2008; Freund et al. 2013; Ball et al. 2019);
- such improvement effects can concern both the health profile and the management of emotions, the social relationships and the learning abilities (Schneider et al. 2006; McGowan et al. 2008; Freund et al. 2013; Ball et al. 2019);

- in some cases, these positive effects also occur in individuals who have inherited from their parents *genetic* anomalies that hinder learning, emotional management and social relations (Arai et al. 2009; Arai and Feig 2011).[7]

What are the meta-ethical repercussions of these discoveries on theories regarding the innate or learned, genetically or socially transmitted nature of moral imperatives, prohibitions and orientations in human beings?

In short, the thesis of both old and current *genetic determinism* according to which organisms are essentially mere executors of instructions encoded in their genes, and the current human moral and socio-economic systems ultimately the effects of an almost unmodifiable "human nature" produced by natural selection, are now proving, *thanks to the progress and tools of genetics and epigenetics, developmental biology and evolutionary studies themselves, groundless and anachronistic.* What has been discovered in the last decades on the processes of epigenetic inheritance and on the trans-generational effects of personal and historical experiences, allows us to understand that human *social* history has shaped, and is still shaping, not only the psyche and behaviour, but also the biology of human (and not only human) beings, and the self-regulating systems of every individual.

In other words: *biologisms have been refuted by biology itself*.

The data discussed in this essay may be useful to highlight at least three aspects related to this issue:

- the endless disasters produced, since the dawn of "civilization", by the processes of social manipulation of the human propensities and reactivity, implemented by every political and economic regime based on the coercive induction of behavior, the monopoly of information, the gender, class and ethnic discrimination, the thirst for power, conquest and profit;
- the enormous power of mind and behaviour manipulation that the current biological and media technologies and the enormous inequality in the access to the resources that characterize our societies deliver into the hands of restricted economic groups and political institutions. A power of manipulation that is fuelling processes of degradation of the human critical capacity and ethical sensitivity in an increasingly penetrating, incisive and pervasive way;
- the beneficial effects that any attempt to let the forms of human and animal sociality mature from below, creating non-oppressive living environments, capable of offering to everyone a range of life chances, development and expression, could produce if it were socially supported.

Today we can say that the epigenetic landscape that humans inherit from their closest ancestors and develop throughout their lives is, like every other aspect of the human

[7]For example it has been proved that a stimulating environment "can compensate for a learning-deficiency in mutant mice" and "also improves learning in the F1 offspring that inherit the deleterious gene" (Jablonka 2016: 50). Of course, if these forms of compensation are possible for the mice, there is no reason to think that it wouldn't be the same for human beings, all the more so if supported by their social context and by the means it can offer, provided the political wish of the leading class to do so.

world, to a large extent, a *social product*. In our species, moreover, innate behaviour patterns often manifest not as a set of rigid sequences of movements, but as a set of learning programs: "we are born not with any specific social norm, but with a learning agenda that tells us which information to imbibe and how to organize it" (de Waal 1996: 36). That leads us to assume behaviour patterns and reaction norms from the environment in which we live, initially in a completely unconscious way, interiorizing emotional patterns and customs, values and traditions. Epigenetic regulation of gene expression plays a key role in this process because it makes inheritable some effects of experience and propensities. Social learning, and especially early learning experiences, have in turn very strong long-term effects, and may therefore play a role that is even more important than that of epigenetic inheritance in shaping human personality.

Genetic, epigenetic, behavioural and cultural inheritance cooperate, thus, among themselves and with the experience and environmental stimuli to construct the whole neuro-physiological condition, the patterns of reaction, the preferences and propensities which every human being develops over a lifetime.

In short, social life, from the most embryonic of its phases, the one that a fetus spends in the maternal body and in symbiosis with it, moulds individual biological and behavioural expressiveness, inhibiting or enhancing its potential and attitudes and, just like a gardener with their plants, can make them flower or wither.

References

Adenzato, Mauro, and Cristina Meini. 2006. *Psicologia evoluzionistica*. Torino: Boringhieri.

Aiken, Catherine, Jane Tarry-Adkins, and Susan Ozanne. 2016. Trans-Generational Effects of Maternal Diet on Metabolic and Reproductive Ageing. *Mammalian Genome* 27 (7–8): 430–439.

Arai, Junko, and Larry Feig. 2011. Long-Lasting and Trans-Generational Effects of an Environmental Enrichment on Memory Formation. *Brain Research Bulletin* 85 (1–2): 30–35.

Arai, Junko, Shaomin Li, Dean Hartley, and Larry Feig. 2009. Trans-Generational Rescue of a Genetic Defect in Longterm Potentiation and Memory Formation by Juvenile Enrichment. *Journal of Neuroscience* 29 (5): 1496–1502.

Attanasio, Alessandra. 2010. *Darwinismo Morale*. Torino: Utet.

Bain, Alexander. 1868. *Mental and Moral Science*. London: Longmans, Green and Company.

Ball, Natalie, Eduardo Mercado, and Itzel Orduña. 2019. Enriched Environments as a Potential Treatment for Developmental Disorders: A Critical Assessment. *Frontiers in Psychology* 10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6414413/.

Barkow, Jerome, Cosmides Leda, and Tooby John. 1992. *The Adapted Mind*. New York: Oxford University Press.

Bilkó, Ágnes, Vilmos Altbäcker, and Robyn Hudson. 1994. Transmission of Food Preference in the Rabbit. *Physiology & Behavior* 56 (5): 907–912.

Borghol, Nada, Matthew Suderman, Wendy McArdle, Ariane Racine, Michael Hallett, Marcus Pembrey, Clyde Hertzman, Chris Power, and Moshe Szyf. 2012. Associations with Early-Life Socio-Economic Position in Adult DNA Methylation. *International Journal of Epidemiology* 41 (1): 62–74.

Bottaccioli, Francesco, and Anna Giulia Bottaccioli. 2012. La rivoluzione epigenetica. *Sistema Salute* 56 (3): 331.