Chapter 2
From Evolutionary Epistemology to an Extended Evolutionary Synthesis

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Abstract The first part of this essay reconstructs the scientific and philosophical paths that led, between the 1940s and the late 1990s, to the formulation and development of Evolutionary Epistemology (EE). This was an "open theory" and a research program aimed at studying analogies and differences between biological and social and scientific human evolution focused on the hypothesis that both can be considered as effects of a "cognitive increase", or a process of knowledge. Konrad Lorenz, Karl Popper, and Donald Campbell were the promoters of this approach and the Altenberg Circle (*Altenberger Kreis*), animated by scholars such as Rupert Riedl, Erhard Oeser, Franz M. Wuketits, was its forge. The second part of the essay shows how the EE project continued to develop under different forms over the last decade, despite being partly shipwrecked. In fact, thanks to its critical reworking and scientific update promoted by members of the Konrad Lorenz Institute For Evolution and Cognition Research such as Werner Callebaut, Karola Stotz, Massimo Pigliucci, Gerd Müller, it acted as a basis for the formulation of a new scientific project: that of formulating an "extended synthesis" of the Darwinian theory of descent with modifications able to take into account the most important discoveries of the last decades pertinent to developmental processes and epigenetic forms of inheritance.

2.1 Introduction

The two initial sections of this chapter examine the short but intense collaboration between the young ethologist Konrad Lorenz and the philosopher Eduard Baumgarten from which arose, between 1940 and 1941, a fruitful attempt to rework the Kantian doctrine of knowledge in the light of the Darwinian theory of natural selection.

The third section focuses on the "natural history of human knowledge" which Lorenz proposed in his book *Behind the Mirror* (Lorenz 1973), developing the hypothesis that every adaptation of organisms to their environment is the result of a "cognitive process" (Lorenz 1973, 1983). The following three parts analyze three main developmental stages of Evolutionary Epistemology: its foundation, by Konrad Lorenz, Karl Popper and Donald Campbell, in the 1970s; the birth of the

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Altenberg Circle, and later of the Konrad Lorenz Institute; the "constructivist turn" of EE promoted in the 1990s by Rupert Riedl.

The seventh section focuses on the impact the reformulations by Riedl of the "body plan" concept from pre-Darwinian morphology in an evolutionary and systemic key in the context of contemporary evolutionary biology.

The following section illustrates the contributions some of the members of the Konrad Lorenz Institute gave to a critical re-examination of EE and shows that, since 2007, this project has been merging with the attempt to reach an "extended synthesis" of the Darwinian theory, capable of integrating the most important discoveries emerging in contemporary eco-evo-devo (ecological, evolutionary, developmental) biology.

The tenth section attempts to clarify, in a nutshell, how the anti-mechanistic and *etho-centric* model that emerged in the field of evolutionary and ethological studies presented in the previous sections allows both an anti-deterministic and anti-biologistic approach to the study of human behaviour and social evolution and a critical reflection on their effects.

Finally, in the brief open conclusions, I propose some reflections oriented to the elaboration of a post-anthropocentric and a post-genocentric, inter and trans-specific concept of knowledge.

2.2 The Meeting Between Lorenz and Baumgarten and the Project of a "Darwinian" Re-formulation of the Kantian Apriorism

On September 2nd of 1940, Konrad Lorenz arrived in Königsberg, Immanuel Kant's hometown. He had been offered to chair Comparative Psychology at the Albertus Universität, where the great Illuminist philosopher had taught for almost fifty years. Lorenz's major sponsor there was Eduard Baumgarten, full professor of Kantian Philosophy and pragmatically oriented thinker, follower of John Dewey and expert in the work of Ralph Waldo Emerson, Nietzsche, and Max Weber. He was interested in a critical reworking of Kantian philosophy and went looking for "a second teacher with gnoseological interests, but at the same time endowed with a solid biological background" (Wuketits 1990: 60).[1] In Königsberg, he "brought together very bright scientists and men of letters for evening discussions, with the ambition of paving the way to a theoretical and methodological synthesis of the two fields" (ibid.). In the Institute he co-directed with Lorenz, "philosophical anthropology was combined with comparative behavioural research" (Lorenz 1992: 75). At that time, they both were active members of the *Kant Gesellschaft Königsberg* where they promoted heated debates.

[1] This and all the other quotations taken from essays that do not have an English translation, contained in this chapter, are my translations.

Lorenz remained in Königsberg only thirteen months, after which he enlisted in the army.[2] In his brief time there, however, together with Baumgarten he sketched a phylogenetic and "non-transcendental" revision of Kant's theory of knowledge set to become, in the second half of the twentieth century, the first pillar of Evolutionary Epistemology. Lorenz summarized this theoretical position in the essay "Kants Lehre vom Apriorischen im Lichte gegenwärtiger Biologie" (Lorenz 1941), originally published in the *Blätter für deutsche Philosophie*.[3]

As Donald Campbell remarked later, in writing "Kant's Doctrine of the A Priori in the Light of Contemporary Biology", "the young Lorenz creatively solved a major epistemological puzzle" (Campbell 1974: 96) and, as Lorenz remarked in turn, this puzzle had been evidenced by Kant himself:

> «If one were to entertain the slightest doubt that space and time did not relate to the Ding-an-sich but merely to its relationship to sensuous reality, I cannot see how one can possibly affect to know, a priori and in advance of any empirical knowledge of things, i.e. before they are set before us, how we shall have to visualize them as we do in the case of space and time» (section 11 of *Prolegomena to the critique of pure reason*)
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> Kant was obviously convinced that finding an answer to this question in terms of natural science was impossible. He found clear proof that our forms of ideation and categories of thought, in contrast with what Hume and other empiricists claimed, are not the products of individual experience; they are logically necessary a priori, and therefore cannot have 'evolved' (Lorenz 1973: 9).[4]

But building on Kantian premises, i.e. on a pluralistic realism acknowledging the reciprocally independent existence of "external" entities and of a "subjectivity" that experienced them, and on a theory of knowledge founded on the acknowledgment of "a priori forms of sensibility" as conditions of possibility of experience, Lorenz intended to demonstrate that a consistent response to Kant's problem was made possible by the Darwinian theory, or more precisely, by a specific interpretation of it. The ethologist in fact wrote:

> The system of sense organs and nerves that enables living things to survive and orientate themselves in the outer world has evolved phylogenetically through confrontation with an adaptation to that form of reality which we experience in phenomenal space. This system thus exists a priori to the extent that it is present before the individual experiences anything and must be present if experience is to be possible. (ibid.)

In other words, organisms are pre-adapted, already from birth, to the interaction with a given environment, and the human mind itself is pre-adapted to this interaction, but this condition is an a priori only for the individual, not for the species.

As noted by Franz M. Wuketits, Lorenz was attempting, with this first strategic move, "a synthesis between Kant's theory of knowledge and Darwin's theory of

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[2]Lorenz went to Königsberg on September 2, 1940 and joined the army on October 10, 1941.

[3]The essay was first translated in von Bertalanffy and Rapoport, A. (Eds.) General Systems, Yearbook of the Society for General Systems Research, vol. III, 1962: 23–35, and later reprinted in Evans (1975: 181–217).

[4]The quotation by Kant, contained in the Chapter 11 of Prolegomena to the Critique of Pure Reason (1783) is extracted from the 1973 English edition of Lorenz mentioned in the References.

evolution" (Wuketits 1990: 83). A deep understanding of anatomy and behaviour of organisms allowed him to provide new empirical foundations for a concept already brought to philosophical clarity by Nietzsche: the true possibility of experience is not to be found in a (non-existent) transcendental structure of reason, immutable and free from historical and empirical influences, as maintained by the Kantians. The real subject of experience is the human body, as a product of natural, social, and individual history (Nietzsche 1882).

According to the philosopher Aldo Masullo this conception was already present in the confutation of Idealism attempted by Kant in the second edition of the *Critique of Pure Reason* (1787). Kant's transcendental idealism was primarily aimed at undermining the "immaterialism" and "spiritualism" upheld by Berkeley and Descartes. It was meant to overcome that form of idealism which frames the knowing subject in an incorporeal dimension and defines the known object as "mere subjective representation". In this sense, "if never explicitly […] the theme of corporeality of subjects constitutes the unifying focus of Kantian theoretical thought" (Masullo 1986: 34).

However, Kant's failure to make this theme completely explicit had important theoretical consequences, highlighted by Lorenz in his 1941 essay:

> The only thing we can assert about the thing-in-itself, according to Kant, is the reality of its existence. The relationship which exists between it and the form, in which it affects our senses and appears in our world of experience […] is determined by the ideal forms and categories of intuition. (Lorenz in Evans 1975: 182)

But these forms, in a Kantian theoretical horizon, cannot be related "to the laws inherent in the «thing-in-itself» by abstraction or any other means" (ibid.).

What derives from this approach is a radical dualism, according to which the value of a priori forms of reason is considered "in principle independent from the laws of real nature, based only on the faculties of the subject, while the thing in itself appears in principle unknowable" (1975: 183). For Lorenz, this approach generates some questions that biologists "have to ask" Kant:

> Is not human reason with all its categories and forms of intuition something that has organically evolved in a continuous cause-effect relationship with the laws of the immediate nature? Can an organ that has evolved in the process of continuous coping with the laws of nature have remained so uninfluenced that the theory of appearances can be pursued independently of the thing in itself, as the two were totally independent from each other? (ibid.)

Lorenz's second step was to translate the Kantian concept of "a priori form of sensible intuition" in that of a historical state of pre-adaptation of the organs, produced by selection and heredity (the "experience of the species"), which is a necessary condition for both existence and experience for each and every individual. This means that, to Lorenz, the conception of the "a priori" as an organic function "means the destruction of the concept: something that has evolved in evolutionary adaptation to the laws of the natural external world has evolved a posteriori in a certain sense" (ibid.).[5]

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[5]Lorenz's formula "what is a priori for the individual is a posteriori for the species" was not an absolute novelty in the post-Darwinian debate. In a 1876 anthology of earlier journal articles, St.

The third theoretical step, in the final section of the essay, consists in an attempt to demonstrate that some categories, or central conceptual nexuses such as causal relation, may have also originated from genetically and physiologically based learning programs, i.e. the conditioned reflex. In fact, for Lorenz, human understanding "does not prescribe the laws of nature" (1975: 186) because, quite like a horse's hoof, it continually stumbles over "unforeseen changes in its task, highlighting the inadequacy of its hypotheses" (ibid.):

> [...] the fundamentals of pure reason are just as imperfect and down to earth as the band saw, but also just as real. Our working hypothesis should read as follows: everything is a working hypothesis. This holds true not only for natural laws which we gain through individual abstraction a posteriori from the facts of our experience, but also for the laws of pure reason. The faculty of understanding does not per se constitute an explanation of phenomena, but the fact that it projects phenomena for us in a practically usable form onto the projection screen of our experiencing is due to the formulation of working hypotheses; developed in evolution and tested through millions of years! (ibid. 199)

According to Lorenz, precisely the fact that human beings, since they exist have had to interact with beings and phenomena that do not passively submit to their efforts to "shape" them, precisely the experience of these "resistances" from the external environment, accumulated in the biological and cultural patrimony of our species ensure that we can indeed rely on the capabilities we possess, albeit within our species-specific and historical limits.

Despite the unbridgeable gap introduced by these theoretical shifts, Lorenz did not ignore many points of a substantial convergence between Kant's transcendental idealism and his own genealogical materialism. Like Kant, he opted for a "critical realism", while distancing himself from any form of "naïve realism":

> [...] we are perfectly aware that what exists in itself will never be completely at hand, except within the limits imposed even to theoretically higher living forms by the categorical forms of our thought, [...and] even if we as natural scientists are in a certain sense naïve realists, we still do not take the appearance for the thing in itself, nor the experienced reality for the absolutely existent! (ibid. 191)

Compared to the Kantian model, Lorenz's approach both strengthened and weakened human pretensions in the cognitive field. Whereas Kant's transcendental idealism stated the impossibility of a positive knowledge of real aspects or features of things, according to Lorenz's hypothetical-critical realism "evolutionary success does not entail that all our innate hypotheses be true, but only that they cannot be completely false" (Vollmer 1983: 49). As Riedl later remarked, no organism could survive if its sensory organs and relational modalities did not put it in the condition of detecting any real feature of the elements it really deals with in its own environment (Riedl 1980:

George Mivart wrote, criticizing Scottish sensism: "in this way Mr. Spencer conceives that what is a priori to the individual is but a posteriori to the race and he thus claims to have reconciled the two schools of thought, namely, those who assert and those who deny the derivation of our ideas exclusively from sensation and experience". He went on: "As it is manifest, however, he gives the substantial victory entirely to the sensists, and denies to all ideas any higher origin than mere incipient sentiency" (Mivart 1876: 425).

56). In this perspective, the very fact that organisms can interact with other entities in a way that is functional to their survival demonstrates a positive know-ability of real entities or processes and an actual capacity of knowing, present in different forms and degrees in every living being. About human knowledge, it shows that the relation "between the real within and the real outside ourselves" is "explorable in principle", but always and only indirectly, through an understanding that is constantly putting to test *vis à vis* every day acting and living, and which is not absolutely true or false, but rather more or less useful to face the needs, the circumstances and perils of life.

2.3 Toward a "Natural History of Human Knowledge"

It was only a quarter of century later, with *Behind the mirror* (Lorenz 1973), that Lorenz tackled again the question of the genesis of animal and human forms of knowledge. In this work, the genealogical approach to the theory of knowledge was recast in a model comprising, besides the phylogenetic version of apriorism, a critical interpretation of Darwinism and neo-Darwinism: a re-formulation of the problem of understanding, but also of the theory on the origin and transformation of the species. In the "Epistemological Prolegomena" which opened the work, Lorenz subtly criticized the position expressed a few years earlier by Jacques Monod in *Chance and Necessity* (Monod 1970) by observing how "it is undeniably true, yet at the same time misleading, to say that living organisms are at the mercy of purely random changes and that evolution only takes place through the elimination of the unfit" (Lorenz 1973: 27). In his polite rebuttal of Monod's claims, Lorenz was marking his own distance from a specific interpretation of the neo-Darwinian canon, linked to the then dominant approaches in molecular biology. In a nutshell, the interpretation consists in the idea that evolution is essentially based on the interaction between two factors: "chance", embodied by favourable genetic mutations, and "necessity", embodied by external selection. Lorenz, instead, stressed a third factor, namely, the "extremely active" care of their living conditions which all the organisms manifested through their behaviour and physiology.

In other words, his interpretation implied that living beings search in an "eminently active" way and tend to accumulate "both a fund of energy and a stock of knowledge, the possession of the one being instrumental to the acquisition of the other" (ibid.). According to Lorenz the lack of appreciation for this "exploratory" aspect of behaviour makes it impossible to account for two fundamental features of the evolutionary process, its "speed" and its "directness", without resorting to metaphysical and finalistic hypotheses. If evolution "depended simply on the random elimination of the unfit, then the period of a few thousand million years which has been calculated by physicists as a few thousand million years based on the rate of decay of radioactive substances would hardly be enough for man to have evolved from the most primitive organisms" (1973: 28). By the same token, the appearance of beings endowed with a growing degree of organic complexity and behavioural capacities, which Lorenz considered an established fact, can be explained, without resorting to teleology and ultimately to theology only by acknowledging that life is also a process of acquisition of "information".

The history of living systems can be described as a process of knowledge acquisition, meaning that in order to survive and reproduce, organisms have had to learn to distinguish the things that have an impact on their physiological condition and their likelihood of survival so as to exploit or avoid them. This means organisms have turned their own living conditions and the factors influencing them into objects of knowledge, however indirect, without this process implying any form of predestination. Organic evolution "does not follow a predetermined plan" but derives its direction from the reciprocal selection among organisms, from their attitude to explore both the external environment and their behavioural capabilities, from their active search and construction of specific internal and external conditions.

Lorenz's organic history can thus be understood without reference to any kind of determinism, be it finalistic, genetic or environmental. In *Behind the Mirror*, the ethologist was therefore proposing a general reinterpretation of Darwinism in which differentiation and preservation of living species are conceived as effects of a "process of acquisition of knowledge" in the sense of an increase, selection, and differentiation of "information" embodied and potentially embeddable in organisms themselves, and usable to the survival of individuals and species.

From this perspective, whatever its level of internal complexity may be, a living organism can never be considered as an entity simply undergoing an external selection: it must at the same time be considered a selecting agent.

The behaviour of organisms must be therefore analyzed as both a product of phylogenetic, social and individual history and as one of the main selecting factors orienting phylogeny itself and the history of the species with it.

2.4 The Project of an "Integrated Theory" of Evolution

The earliest version of Evolutionary Epistemology sprang from the integration of three independently developed approaches, those of K. Lorenz, K. Popper and D. Campbell. The latter, back then less known than the others, was a psychologist interested both in the theoretical aspects of Lorenz's approach and in the evolutionary reinterpretation of the falsificationism propounded by Karl Popper since the 1960s. It is to him that we owe the invention of the formula "Evolutionary Epistemology" (Campbell 1974). Campbell conceived EE as a research program targeted to an "integrated theory", whose was to identify analogies and differences between biological and socio-cultural human evolution, biological adaptation and scientific progress. In the perspective of its founders, EE implied first of all "the hypothesis that biological evolution in itself represents a cognitive process, independent from the appearance of the human species" (Somenzi 1996: 238) and the conviction that the human condition is a "product of biological and social evolution" (Campbell 1974: 413). The common denominator among processes of such diverging order, complexity, and origin is to be found, according to EE, in a process based on "trials" and selective preservation of efficient solutions, which underlies both natural selection and individual associative learning. This process would have its most meaningful precedent and functional analogue (not teleologically oriented and not responding to any conscious immanent or transcendent design) in the "positive" interaction between genetic variance and environmental selection, which neo-Darwinism took as the moving force of biological evolution. The process of natural selection, favoring in terms of differential reproduction the organisms best fitted to their environments, produces effects analogous to a learning process, unrolling through trials and errors. In other words, natural selection and descent, without being pre-oriented in any direction, have de facto triggered a process leading to the elimination of errors, seen as inefficient solutions to the problems of survival and reproduction, and to their replacement with more efficient forms of behaviour and internal organization. According to Lorenz, Campbell and Popper, in the course of phylogeny, all individual learning configurations, from the simplest to the most complex, have developed and differentiated starting from this first form of "learning of the species".

But despite these important points of convergence, and Campbell's attempt to mediate them, Lorenz and Popper's theoretical positions presented irreducible differences (Stanzione 1984; Celentano 2000, 2011). Popper's approach to Evolutionary Epistemology was founded on "genetic dualism", a theoretical formulation admittedly very close to "a mind-body dualism". It presupposes the possibility of identifying, even in "very simple organisms" and a fortiori in more complex ones, an organization based on "two distinct parts: roughly speaking a behaviour-controlling part like the central nervous system of higher animals, and an executive part, like the sense organs and the limbs, together with their sustaining structures" (Popper 1972: 273). Each organism, then, would be divided into an "aim-structure" and a "skill-structure" and, according to Popper, in the course of phylogeny, the development of teleological structures has preceded and favoured that of performative structures, thus endowing evolution with a course ever less subject to happenstance and progressively characterized by orthogenetic developments.

> Once a new aim or tendency or disposition, or a new skill, or a new way of behaving, has evolved in the central propensity structure, this fact will influence the effects of natural selection" and this, to Popper, meant "that the evolution of the executive organs will become directed by that tendency or aim, and thus 'goal-directed'. (1972: 278)

Lorenz's mastery of comparative anatomy made him aware that this hypothesis was untenable in the case of "lower" organisms, devoid of a centralized nervous system. Popper's dualism arbitrarily extends to all or almost all living organisms a model, derived from the neurophysiologic organization of 'higher' animals endowed with a central nervous system (a level of organization arising only in a very advanced phase of phylogeny). Cognitive performances of some complexity are, instead, observable in the protozoans or lower metazoans, whose physiological organization shows no trace of the division between two different mechanisms devoted to central coordination and executive performances, adumbrated by Popper.[6] But, according to Lorenz, even for "higher" organisms Popper's dualistic model was valid only in part. In almost

[6]In coelenterates (medusa) we find groups of cells with specialized perception, sensitive to light and to position equilibrium. A type of cephalic specialization, still very far from a centralized nervous

all his works, Lorenz remarked how nervous structures originated from the integration of "already functioning" parts, with a certain degree of reciprocal autonomy, and that the integration is only partial at each stage of evolution and never devoid of dysfunctions.

Popper instead opted for the inclusion of all animals in the genetic-dualism model, to the point of denying the distinction, at the time common among biologists, between the capacity to react to stimuli, or "excitability"[7] considered present in all living cells and "sensation", traditionally restricted to the animal world. One must admit, considering present developments in plant ethology, that Popper was ahead of his time on this point when he observed that plants "do have something like sensations or perceptions" (Popper 1990: 35).[8] However, the point at stake here is mainly philosophical. Even though he was not arguing for "conscious" knowledge processes in other organisms, Popper, following Kant, maintained that interpreting the behaviours of living beings "as if" they acted according to patterns of finalistic reasoning, analogous to that of humans, was the only way to underscore the active and selective character of those behaviours. On the contrary, in all his works, Lorenz tried to interpret the sequences that, in many different animal species, lead from appetitive behaviours to the execution of a "consummatory act",[9] taking into account the fact that, to the animal, each and every phase of the sequence is "self-compensatory" and acts as a sort of "present aim" (Lorenz 1937: 298).

2.5 The EE and the Debate on Similarities and Differences Between Natural and Social Selection

Even sharper were the differences between Lorenz and Popper's approaches in the interpretation of organic and human social evolution, and of the effects of modern science and capitalistic economy. Lorenz was highly critical of the idea of an evolutionary process generally following "the direction of a greater completeness of adaptation" (Lorenz 1983: 40) and offered a lot of empirical evidence against it. Despite

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system, appears in the phylogenetic line with anellids. In these animals it is possible to observe "a metameric system, with groups of nerve cells (ganglia) organized in pairs, in every ring" anterior to the sense organs. In insects "besides metameric groupings, made more numerous by the fusion of metameres […] it emerges a very advanced specialization of the system of cephalic ganglia, anticipating the future development of a brain" (Fancello 1985: 110–111).

[7]"The capacity to react to stimuli (excitability) is a basic property of all living organisms, including plants" (*Nuovo Atlante Biologico*, Milano, Garzanti, 1989: 339).

[8]For an updated overview of the sensory and perceptual plant systems see Baluška et al. (2007), Mancuso (2018).

[9]A "consummatory act" is defined as the final sequence of a hereditary motor co-ordination, as distinct from "appetitive behaviour" (active search of triggering stimuli) preceding it and "in natural conditions, it leads to the disappearance of the pulsion" (Craig 1918). In complex motor sequences, however, "an act may represent at once an 'appetitive behaviour' for what follows and a 'consummatory act' for what precedes" (Heimer 1977: 32).

his intention to correct some "mistakes" of neo-Darwinism, Popper instead found himself in a general agreement with the idea that organic evolution was explainable as a gradual and progressive emergence of "the fittest", and extended this model to the interpretation of human social, scientific and political evolution. For Popper (and Campbell's position was similar on the subject), the "evolution of scientific knowledge is, in the main, the evolution of better and better theories" (Popper 1984: 395) and this is in every aspect "a Darwinian process. The theories become better adapted through natural selection: they give us better and better information about reality. They get nearer and nearer to the truth" (Popper 1984: 396). With these passages, Popper let his original falsificationist position "slip", as he put it, from the methodological to the theoretical domain, making it a model for the interpretation of the whole history of Western science as a gradual progress towards better theories. Unfortunately, history does not seem to confirm this hypothesis: for centuries competition among scientific theories led to outcomes far different from those imagined by Popper. The fact that some scientific theories hindered an adequately critical study of empirical phenomena, instead favouring superstition and social privileges, has in many instances been the very reason of their success. On the contrary, the fact that certain theories offer tools for validating truths towards which mass media controllers are hostile lead even today to their boycott, as shown by numerous sources. Popper's model, therefore, seems highly simplified and idealized, inasmuch as it arbitrarily removes the processes of conscious and unconscious manipulation of information and processes of social selection of knowledge not aimed at the critical development of knowledge itself, but rather subordinated to other individual or collective goals, such as social control or profit.

After all, Popper extended his optimistic model of organic evolution and modern scientific progress to the political sphere: taking the US system as a model, he maintained that we are actually living in the best possible world, and that "democracies are always open to ideas, especially those coming from the opposition. Far from being masked dictatorships, democracies are always open to self-doubting" (Popper in Arrigoni 1991: 226).

Lorenz dissented from this idyllic approach, which in the last years of his life the same Popper had doubted (Popper and Condry 1994), arguing that human sociocultural evolution, especially in the age of advanced capitalism and triumphant technocracy, was led by selective processes different from those regulating organic evolution. In *The Waning of Humaneness*, he elaborated a perspective in which the "creative selection" underlying organic evolution "has ceased to influence humans. Creative selection has been replaced by intra-specific selection" (Lorenz 1983: 12). It is intra-specific, social selection, Lorenz argued, namely the selection of man by man, that now determines the "direction of development" of human evolution, and it is "our present technocratic world order" that sets this social selection (1983: 13). For these reasons, to Lorenz, not just dictatorial regimes, but also the present democratic systems were taking on "more and more totalitarian aspects" (1983: 187) and the increasingly pervasive power to manipulate individual and mass behavior offered to the powers in force by today's technologies represents one of the most serious dangers that humanity has to face.

2.6 Riedl's "Constructivist Turn"

The developments of EE can be divided into three main phases.

The first lasted from the mid-1970s to the late 1980s and includes the constitution and developments of the Altenberg Circle (*Altenberger Kreis*), around the ethologist K. Lorenz, the biologist R. Riedl and the philosopher O. Oeser. This circle was an ever-growing interdisciplinary group of scholars, who regularly met at Lorenz's house in Altenberg, to discuss the theoretical implications and possible developments of the "evolutionary and cognitive" approach.

The second phase began after the death of Lorenz (1989), covered the 1990s and marked the transition to the foundation of the Konrad Lorenz Institute for Evolution and Cognition Research (1990–1991), culminating in the turning point toward a "constructivist extension of EE" propounded by its first director, Rupert Riedl (Riedl 1995). These developments contributed to introduce EE in the contemporary international debate about the "naturalistic" approach in epistemology, and about the emergent eco/evo/devo (ecological, evolutionary and developmental) approach in biology. On the other hand, they opened the theory to many different explanatory models and presumptive domains of application causing a considerable weakening of its internal consistency between basic assumptions and developments.

The third period started with the new millennium but was anticipated by the new research project expressed in the programmatic paper *Lean Evolutionary Epistemology* (1998) in which philosophers Werner Callebaut and Karola Stotz attempt a radical reform of EE and a more rigorous formulation of its basic assumptions. This project in the following years converged into an even more ambitious one: that of an "extended synthesis" of the contemporary theory of evolution, aimed at going beyond the Modern Synthesism and integrating the recent results of disciplines as molecular archaeology, genetics, epigenetics, neurophysiology, cognitive and cultural ethology in a systemic eco/evo/devo approach (Pigliucci and Müller 2010). An attempt which is still in progress. After having analyzed the first phase of this process in the previous sections, we will now describe and discuss the other two.

Towards the mid-1970s, the time was ripe for the convergence program, of widely diverging perspectives, interests and theoretical orientations in the EE research program. In 1975, only a year after Campbell's programmatic essay *Evolutionary Epistemology*, German physicist Gerhard Vollmer,[10] in his *Evolutionäre Erkenntnistheorie* (Vollmer 1975), tried to "design the structure of an «Evolutionary Epistemology» with a view to the whole" (Riedl 1980: 3).

According to EE, "evolutionary success does not entail that all our innate hypotheses be true, but only that they cannot be completely false" (Vollmer 1983: 49), because neither the human being nor any organism could survive if their sensorial organs and their relational modalities did not grasp any real aspect of the elements with which they have to deal with in their own environment. Both the EE founding

[10] Born in 1943 in Speier, Rheinland, Vollmer studied mathematics, physics and chemistry in Munich and Berlin. After an early career in theoretical physics, he moved on to linguistics and philosophy, focusing on logical and gnoseological issues.

fathers and the members of the Altenberg Circle shared this hypothesis, but Vollmer reworked it in a way that aroused some perplexity among the Circle. According to Vollmer, the cognitive modalities that we have inherited from our phylogenetic past prove to be valid in the "world of medium dimensions" (*Welt der mittleren Dimensionen*), or "mesocosm", that would correspond to the environment with which man has had to deal with during his prehistory. Developing this approach, Vollmer ended up supporting an adaptationist justification of both human common sense and scientific knowledge, on the basis of the assumption that our hereditary cognitive apparatuses are well adapted to the world of average conditions, against which they were refined during phylogeny, and only fail when they are taken away from such a world. In other words, they prove inadequate only when our experiences look beyond the threshold of the mesocosm, as happens, for example, in sub-atomic physics experiments. Science, however, through its means of research, verification and control, may overcome these inborn limitations of the cognitive apparatuses, allowing us to "know something not only about ourselves, but also about the world (the thing in itself). This is the reason why objective knowledge is actually possible" (Vollmer 1975: 189).

This stance delved into a subtle, but theoretically not irrelevant, divergence between Vollmer's approach and that of the Altenberg Circle. In fact, it risked nullifying the differences between a traditional "objective realism" and the "critical-hypothetical realism" that Lorenz, Popper, and Campbell had considered a theoretical pillar of EE, according to which to every representation of reality that we enact, from the perceptive to the theoretical one, from an epistemic point of view we can only assign, the value of a "working hypothesis". Therefore, Vollmer's position exposed itself to the already mentioned criticisms that Lorenz had addressed, in 1941, in perfect agreement with Kant, to every "naïve" realism: "even if we, as natural scientists, are in a certain sense naïve realists, we still do not take the appearance for the thing in itself, nor the experienced reality for the absolutely existent" (ibid.). In fact, the EE approach, as originally conceived, implies the idea that *the relationship* between our phenomenal representation and the external reality is *a real interaction between real entities* (human beings and their environments), and that it is "by principle investigable", but does not allow the belief that the scientific study can be resolved, to a certain degree of its development, in an objective mirroring of the studied entities, process or events.

The philosopher Erhard Oeser and the biologist Rupert Riedl, two scholars at that time very close to Lorenz, would have contributed in the following years to relaunch, in a constructivist key, this approach, the development of which continued, after the death of the ethologist (1989), through the foundation of the Konrad Lorenz Institute for Evolution and Cognition Research, currently based in Klosterneuburg, near Vienna.

In that same year, a criticism of the adaptationist approach, prevalent in the first formulations of the EE and particularly in Vollmer's version of the same, was exposed by the philosopher Eve Marie Engels in the book *Erkenntnis als Anpassung? Eine Studie zur Evolutionären Erkenntnistheorie* (Engels 1989). Engels argued for the impossibility of explaining the complexity and variety of the mental, social and cultural human evolution through the biological concept of "adaption". This criticism led the promoters of the Altenberg Circle to clarify the non-exclusively adaptationist assumptions implicit in the EE that some years later would have found a programmatic expression in Riedl's paper "Deficiencies of Adaptation in Human Reason" (Riedl 1995). In that essay the author explicitly called for a "constructivist extension of Evolutionary Epistemology", aimed at:

a. integrating the concept of external selection with that of self-organization, and the adaptationist approach with the systemic-constructive one;
b. offering an evolutionary explanation, not only of the resources, but also of the limitations and "deficiencies" of our cognitive apparatuses, clarifying that those defections occur because we live in an environment which is now profoundly different from the one in which our species evolved, that is to say, in an almost totally anthropized world.

Not by chance, Riedl had been the first, within the Altenberg Circle, to try a *rapprochement* between selective and constructivist models and, more precisely, between the concept of "natural selection" introduced by Darwin and the hypothesis of an "internal selection" (*innere Selektion*), a kind of selection which is intra-specific and intra-organismic, relatively independent from the inter-specific one, already introduced by heterodox scholars such as Lancelot Whyte and Sewall Wright (Riedl 1975). Species are at first transformed in response to changes in the environmental contexts in which they live, and therefore under the pressure of "natural selection", understood as a set of selective processes that take place in a given ecological context (of which each species, group, individual is both an object and an active participant). Instead, according to Riedl, the selective pressures that lead to the *stabilization and conservation* of species-specific characteristics, or of those of larger taxonomic groups, although conditioned by a wider ecosystem context, depend to a large extent on processes of *intra-specific trans-generational self-regulation.* Processes in which each species draws information from itself and becomes a selective environment for itself. In other words, in Riedl's model, if the external environmental selection is the main cause of the transformations that the species have undergone in the course of their history, "internal selection" is, on the contrary, the main cause of the stability of their anatomical and morphological basic characters, of their preservation over time, and of the resistance to changes that phylum, classes, genera and species manifest. According to his hypothesis, in fact, the basic characteristics of taxonomic groups are fixed "more by the internal systemic conditions of the organism than by the external environment" (Riedl 1975: 297) and are protected by constraints which make drastic changes of their load-bearing structures during embryonic development extremely improbable. "The order of the living", that is the stability of the taxonomic groups that organic evolution has produced and the irreversibility of the process that led to their differentiation, depends on these constraints.

To clarify the nature and functions of internal selection, Riedl took up and reworked, in a systemic-evolutionary key, a concept strongly rooted in the tradition of pre- and post-Darwinian German biology from Goethe, to Haeckel, to Uexküll: that of a body's "structural", "anatomical", or "development plan" (*Bauplan*) which guides the development of each individual organism. As Günter Paul Wagner was later to write, according to Riedl's approach the structural plan is something like a "spectrum of adaptive degrees of freedom within the plan itself" (Wagner 1996: 20), the genesis of which must be explained in a historical phylogenetic, anatomical-morphological and probabilistic perspective. This means that the stability of the basic structures that characterize each clade depends on the role of conditions of possibility of all the further stages of development they played during the evolution and still play in every process of ontogenesis. In other words, during the course of evolution, the development of these structures has become a *conditio sine qua non* for the formation of an ever-greater set of characteristics and functions, in turn indispensable for the further development and operation of organisms. This has made any modification of these first, crucial phases of cell differentiation more and more unlikely, because, given the enormous complexity of the inputs and processes that depend on them, every slight variation from their stabilized pathway could cascade over all others, compromising performance.

As an instance of Riedl's evolutionary and systemic concept of *Bauplan*, Günter Paul Wagner refers to the structural organization of vertebrates being completely disposed (*gruppiert*) around the spinal cord. This conformation has a specific counterpart in the process of embryonic development: all the signals "that are necessary to the development of axial organs" and thus for the rest of the body, in fact depart from the construction of the spine. As Wagner writes the spinal column "is a structural plan, in that nearly all the other characteristics of a vertebrate depend on its presence" (ibid.).

As Waddington had already shown (Waddington 1975) the crucial development phases of these load-bearing structures are encoded allowing them to be restored in their course even after disturbances or anomalies, provided that these are not too drastic. As Riedl argued, these resetting mechanisms have the important function of protecting species, populations, and individuals from genetic mutations or changes in the epigenetic regulation of genetic expression that would affect a large number of the functions of an organism, with likely drastic or lethal consequences. Or, as Gerd Müller wrote in the early 1990s: "In the case of vertebrate limbs, where most of these mechanisms were studied, it is difficult to imagine any kind of novelty that could not be readily and automatically integrated by the epigenetic cascade" (Müller 1990: 119).

2.7 The Concept of "Body Plan" Today

Riedl's conception of "internal selection" as a function that presides over the stabilization of body plans and regulates the process of development, limiting "the ability of the phenotype to evolve" and binding it "to follow a determined path", was taken up and reworked by many researchers in the ensuing years. Only four years after the first edition of *Die Ordnung des Lebendigen*, the two eminent scholars Stephen Jay Gould and Richard Lewontin, in the well-known essay *The Spandrels of San Marco* *and the Panglossian Paradigm: A Critique of the Adaptationist Program* (Gould and Lewontin 1979), praised Riedl's "integrative" model as a useful attempt to overcome the unilateral adaptationism of modern synthesis and widen the horizons of evolutionary theory. Later, numerous scholars engaged in different research areas contributed to test and develop concepts such as "body plan" and "internal selection". The geneticist Wallace Arthur, the physicist-philosopher-engineer William C. Wimsatt, the social psychologist Jeffrey C. Schank, the cell biologist Stuart Newman, the evolutionary geneticist Günter Paul P. Wagner, the expert of vertebrate limb development and evolution Gerd Müller, the philosophers of science Werner Callebaut and Massimo Pigliucci are just some of the best known.

Wimsatt and Schank, already since the 1980s, had reworked Riedl's notion of *Bauplan* by developing the concept of "generative entrenchment" and defining it as follows:

> The generative entrenchment of an entity is a measure of how much of the generated structure or activity of a complex system depends upon the presence or activity of that entity. It is argued that entities with higher degrees of generative entrenchment are more conservative in evolutionary changes of such systems. (Schank and Wimsatt 1986: 33)

In the 1990s Arthur proposed a model in which internal selection is considered a "selection for co-adaptation" which "presides over the co-evolution of genes and their products, in order to select genes «downstream» according to their ability to adapt to those «upstream» in the morphogenetic process" (Caianiello 2013: 115). In his picture, "the reason that some character combinations are fitter than others may sometimes be determined primarily by the prevailing environmental" but "often the «internal selection» that drives co-adaptation is also important" (Arthur 2004: 285).

Newman, professor of cell biology and anatomy at the *New York Medical College* and editor-in-chief of *Biological Theory*, the Konrad Lorenz Institute for Evolution and Cognition Research scientific journal, has taken up once again the problems faced by Riedl, studying development and evolution in systemic terms. That is, as multilevel phenomena that must be analyzed with a multi-scalar approach. Particularly interesting it is the fact that Newman, documenting the relevance of environmental and epigenetic factors in evolutionary processes, uses the anti-genocentric perspective, which Riedl introduced to explain *the stability* of morphological and anatomical structures, to explain *evolutionary changes* instead. In fact, the biologist, starting from an analysis of the physical-chemical constituents of organisms, and of the constraints that their characteristics impose on both individual and species-specific morphogenesis, attempted to reconstruct the processes that led from the explosion of biological forms, peculiar of the Cambrian, to that bottleneck narrowing which later led to the circumscribed number of body plans existing now (Newman 2014). According to Newman, this process was influenced more by changes in the epigenetic structure (phenomena concerning the regulation of gene expression that in no way modify DNA sequences) than by genetic mutations, as the Synthetic Theory argued. In fact, as Newman writes and as it is today demonstrated, "heritable morphological changes were seen to be capable of occurring abruptly with little or no genetic change" (Newman 2014: 2403). We know that they require a "significant involvement of the external environment and, in several documented cases, appear to be not purely happenstance as the neo-Darwinian approach predicted, but oriented in preferred directions" (ibid.).

Gerd Müller, who along with Newman has produced important and innovative essays (see, among others, Müller and Newman 2003, 2005; Newman and Müller 2010), observes in this regard: "the majority of novelties arise as secondary by-products of epigenesis that appear when quantitative modifications of developmental processes reach a threshold of the affected system" (Müller 1990: 124).[11] Some of the consequences of this approach appear relevant for a consistent overcoming of the genocentric one:

> If morphological novelties are initially epigenetic by-products, which arise as a consequence of threshold properties in development, it follows further that it is not necessary to evoke new genes for their origin, as had been proposed on previous occasions [...]. Rather, we may find at the genome level an epigenetically induced, modified activation of existing genes. This does not exclude the possibility of later genetic assimilation of the new character [...] and its exposure to natural selection, but genetic mechanisms will not of necessity have to be held responsible as initiating causal agents. In addition, it is noteworthy that the three properties of development discussed - threshold phenomena, intermediate structures, and sequential transition of mechanisms - share the capacity to produce discontinuity within brief periods of time. (Müller 1990: 123)

Müller, who had already anticipated these ideas in the early 1990s when epigenetics and the evo-devo approach were in their infancy, in the following decades, together with scientists-philosophers such as Werner Callebaut and Massimo Pigliucci, gave important contributions to the most ambitious tasks that contemporary life science had set itself: to insert the new concepts and discoveries emerging from fields such as "molecular biology and evolutionary developmental biology, the recognition of ecological development, niche construction and multiple inheritance systems, the '-omics' revolution and the science of systems biology" in a "renewed and extended theoretical synthesis" (Müller 2017: 1) of the theory of descent with modifications.

2.8 The Project of an Extended Synthesis

Werner Callebaut was born on October 7, 1952 in Mechelen, Belgium, and in 1983 obtained his degree in philosophy at Ghent University. Three years later, he became one of the protagonists of the international debate on Evolutionary Epistemology by organizing an important workshop in Mechelen connected to the one promoted two years earlier in New York by Donald Campbell and Alex Rosen. Together with Rik Pinxten, he was later become editor of the collective volume which contained the proceedings of that meeting: *Evolutionary Epistemology: A Multi-paradigmatic Program* (Callebaut and Pinxten 1987).

[11] G. Müller, *Le origini della novità morfologica*, cit. p. 270.

In the following years, Callebaut worked at the universities of Brussels, Limburg, and Ghent where he became professor of philosophy in 1995. Then, after two periods as "visiting professor" at the Konrad Lorenz Institute for Evolution and Cognition Research, in 1999 he became, its scientific manager and later, its scientific director.

What sort of contribution was the philosopher giving to the EE debate in those years?

During the 1990s, as a diversity of interpretative models proliferated under the "umbrella" of Evolutionary Epistemology, the conceptual vagueness of its theoretical core (the idea of an indissoluble relationship between "life" and "knowledge" and between evolution and cognitive increase) became ever more apparent with a lack of a rigorous set of procedures for the control and falsification of assumptions and the inadequacy of the EE approach to the study of human social, cultural and scientific evolution. This situation convinced Werner Callebaut that EE needed to be radically re-founded. He worked on the project with the philosopher Karola Stotz and in 1998 they published "Lean Evolutionary Epistemology" (Callebaut and Stotz 1998): a sort of manifesto-essay conceived as a comprehensive review of the potentialities and limits of EE and a revision of its main theses.

Presenting EE as a *descriptive*, rather than normative, theory, and as an *open research program* based on a "multi-paradigmatic" approach and a methodological pluralism, the authors declared the dual intent to both go back to its roots and to renew it. Summarizing these goals in the introductive section of the essay, they wrote:

> What we recommend instead is a critical reflection on the naturalistic roots of EE (the quest for a scientific, that is, anti-transcendent and anti-transcendental epistemology for limited beings) which we hope may inspire a version of EE apt to face the future. (Callebaut and Stotz 1998: 11)

In fact, Callebaut and Stotz deemed it necessary to clarify and re-assert the cornerstones of the earliest versions of EE, proposed by the founding fathers Popper, Lorenz and Campbell, but also to overcome them towards a naturalistic but not genocentric, modular but not only adaptationist, selectionist and at the same time constructivist model of the evolutionary processes. Therefore, they proposed the rejection of every dichotomy between internal and external causes in favour of an integration between "interactionism" and "constructivism", or selectionism and self-organization-based models, already attempted by Riedl, enriched with the new discoveries about epigenetic inheritance systems acquired in the 1990s. In a far-sighted way, they emphasized the importance of the then very recent discovery that what distinguishes the morphology of a fish from that of an insect or amphibian is not the presence of class-specific or species-specific genes, but rather the way in which the expression of some genes which are common to all these classes and species is regulated trough processes of methylation and de-methylation (Callebaut and Stotz 1998: 19). A key point in their approach was the acceptance of a fundamental, although never absolute, *autonomy of the epigenetic and social evolutions, changes and developments* from the genetic mutations.

The authors' orientation towards an overcoming of the genocentric approach clearly emerged also in their critique of the apodictic and popularized version of the "central dogma" of molecular biology, according to which the phenotype is a faithful execution of a program already entirely written in the genotype. Referring, back then, to important studies by Jablonka and Lamb (1995), Müller and Newman (1999, then in press) and others, Callebaut and Stotz explicitly affirmed the centrality of the interaction between the cellular system and the external, environmental stimula for the modulation of gene expression during embryonic development and in the later stages of the life cycle.

This way they offered a model of both evolutionary and developmental processes which "treats non-genetic developmental resources as equally important to the course of evolution as genetic resources" (Callebaut and Stotz 1998: 19), and that is grounded in a "«constructivist interactionist vision of ontogeny and phylogeny»" (Oyama 1999 quoted in Callebaut and Stotz 1998: 20).

In short, the critical review of EE proposed by Callebaut and Stotz gathered several important questions that would become crucial to the bio-evolutionary research of the following two decades. However, at first their invitation to a collective re-elaboration of the EE program obtained a scarce echo and in the following years the project seemed destined to fail. With the death of Riedl in 2005, and the coeval closure of the six-monthly scientific journal *Evolution and Cognition*, official organ of the Konrad Lorenz Institute, a cycle seemed to be closing and the reworking of EE seemed to stall. However, the most active members of the Institute did not give up and produced an important breakthrough to their scientific activities. They began to converge towards a complete reworking of the theory of descent with modifications capable of taking into account what, in those years, was being discovered on the interactions between development and evolution, internal regulatory factors and environmental influences, selective and constructive processes, both in the biological and social sphere. In a few years, in fact, important steps forward had been made in this field.

In 2005, Eva Jablonka and Marion Lamb had published their revolutionary book *Evolution in four dimensions*, prompting a wide debate (Jablonka and Lamb 2005). The book appeared aimed at enhancing, in all their theoretical scope, the discoveries and "conceptual changes" which had deeply renewed almost all the branches of biology in the previous decades, in view of an overcoming of the "genocentric" approach. Discoveries and changes that the two authors summarized, in the prologue of the work, in four points:

- there is more to heredity than genes;
- some hereditary variations are non-random in origin;
- some acquired information is inherited;
- evolutionary change can result from instruction as well as from selection. (Jablonka and Lamb 2005: 1)

The new outlook that they introduced was relevant and able to solve the aforementioned classic "Darwinian dilemma" (Celentano 2013) already formulated in 1867 by Fleeming Jenkin (also known as Lord Kelwin): the hypothesis advanced by Darwin in *The Origin of Species* (1859) that the slow accumulation of random hereditary favourable variations produced by natural selection is the "main" spring of evolutionary changes can hardly explain the origin of complex organs such as the eye or the brain, at least because the time since the emergence of life on earth to today would be too short (Jenkin 1867; Lorenz 1973).

Jablonka and Lamb documented the fact that, in the course of phylogeny, alongside the slow processes of genetic variation, three other kinds of selection, heredity and variation, respectively defined epigenetic, behavioural and cultural, cooperated with the first reciprocally producing phenotypic adaptations independently of genetic or genomic mutations. In Chap. 4, they described four different kinds of Epigenetic Inheritance Systems ("Self-sustaining loops" or "memories of gene activity", "structural inheritance" or "architectural memories" and "cell structures"; "Chromatin marking systems" or "chromosomal memories"; "RNA interference" or "Silencing of the Genes") which have in common the ability to transmit from mother to child cells information "that is not related to DNA" (Jablonka and Lamb 2005: 402). Already present in the protozoa, fundamental to the evolution of multi-cellular organisms, EIS are indispensable to every kind of organisms in dealing with rapid changes and contiguous variations of their living and social environments. They are triggered by behavioural habits and/or environmental stimuli, and can preserve or modify, within very few generations, food preferences, immune systems, cognitive abilities, psychophysical and emotional attitudes. The book reported a rich documentation on cases of transmissions of food preferences taking place before and independently of any form of induction or imitation learning, in animals as rabbits, rats and humans (Jablonka and Lamb 2005: 203–207), also illustrating cases of epigenetic transmission of the effects of stress and traumatic experiences and immune deficiencies through cellular memory. It also describes cases in which new phenotypes are produced in the absence of any DNA modification (Jablonka and Lamb 2005: 339) and cases of no random genetic mutations whether induced by stress or changes in the environment (Jablonka and Lamb 2005: 97, 99, 109, 115–116).

The rapidity with which the process of differentiation and stabilization of the body plans took place, still a mystery within the theoretical framework of the "new synthesis", according to which evolutionary changes depend almost exclusively on slow accumulation of random favourable genetic mutations then "rewarded" by natural selection is in this way finally explicable.

Not surprisingly, in the concluding dialogue of the work, Mistabra, the imaginary interlocutor with whom the authors discuss at the end of each chapter, observes:

> But of more general interest are the implications your version of Darwinism has for the dynamics of evolutionary change. It implies that evolution can be very rapid, because often an induced change will occur repeatedly and in many individuals simultaneously; there is also a good chance that such a change will be of adaptive significance, since it stems from already-evolved plasticity. Even without selection, evolved plasticity will bias the direction of evolution, simply because induced variations are non-random. However, as I see it, one of the most important implications of the version of Darwinism that you have espoused is probably that when the conditions of life change drastically, it may induce large amounts of all sorts of heritable variations. The genome, the epigenome, and the cultural system (when present) may all be restructured, with the result that there can be rapid evolutionary changes in many aspects of the phenotype. (Jablonka and Lamb 2005: 350, 351)

As of 2006, the research project carried out by the Konrad Lorenz Institute for Evolution and Cognition Research, previously focused on a critical redefinition of

Evolutionary Epistemology, has increasingly come to converge with this project of a post-genocentric synthesis of Darwinian genealogical theory, and several members of the Institute have given significant contributions to this collective effort. In addition to the aforementioned biologists Gerd Müller and Stuart Newman, the protagonists of this phase were two philosophers of science such as Werner Callebaut, scientific director of the institute, who unfortunately died in 2014, and Massimo Pigliucci, professor of philosophy at the CUNY- City College of New York. In 2006, together with Müller, Callebaut founded the scientific journal *Biological Theory* and became "an early supporter of the extended version of evolutionary theory currently in the making, having himself contributed to it with his conceptualizations of biological modularity (Callebaut and Rasskin-Gutman 2005) and the organismic Systems Approach (Callebaut et al. 2007)" (Müller 2015: 2). In July 2008, Pigliucci, Müller and Callebaut organized an important international workshop in Altenberg, involving "a group of 16 prominent evolutionary biologists" (Pigliucci and Müller 2010: VII) in the discussion of the ambitious project. The proceedings of the meeting would be published a couple of years later, in the collective volume edited by Pigliucci and Müller, *Evolution—The Extended Synthesis* (Pigliucci and Müller 2010).

The evolutionary model they proposed presents some notable differences if compared to the classical Neo-Darwinian one.

To highlight only a couple of the qualifying points:

- it envisages a both functional and evolutionary autonomy of each level of the biological organization and evolution, particularly of the epigenetic, behavioural, social and ecological level from the genetic one. Therefore, this model imposes the need to study changes that occur, or have occurred, in each level (from the molecular to the social) using the spatial and temporal scales appropriate to it (Callebaut 2009, 2012);
- it does no longer place genes and genetic mutations in the role of unique or principal driving forces of evolution, but in the role of "followers" of evolutionary divergences that start from the epigenetic and ethological spheres. That is, from the differentiation of environmental contexts, uses, and habits between individuals and between populations of the same or related species, in biologically relevant contexts such as diet, explored and frequented niches, mating rituals, communicative traditions (Jablonka 2006; Pigliucci and Müller 2010).

In this regard, in the book Pigliucci wrote that today "genes could come to be seen as «followers» rather than leaders in the evolutionary process" (Pigliucci in Pigliucci and Müller 2010: 370) and "the pre-eminent role that behaviour plays in directing evolutionary changes" (2010: 371) is now undeniable.

In short, if the mechanistic model of development proposed in the late nineteenth century by Haeckel and re-proposed in the following century with updated languages by different versions of genetic determinism affirmed that "phylogenesis is the mechanical cause of ontogeny",[12] the approach of contemporary scholars such

[12]E. Haeckel, *Anthropogenie, oder Entwickelungsgeschichte des Menschen. Engelmann*, Leipzig 1877, ed. or. 1874, p. 7, my translation.

as Callebaut, Müller, Pigliucci and Newman, as noted by Salvatore Tedesco, comes rather to the opposite hypothesis: "ontogenesis creates phylogenesis".[13]

Meanwhile the work aimed at offering a "postmodern" synthesis of the Darwinian theory of descent with modifications has become a *collective international enterprise* in which the efforts of many scholars specialized in different disciplines, and living in different countries, are converging.

2.9 Towards a Post-Genocentric Conception of Human Behaviour and Social Evolution

The post-genocentric approach nowadays prevailing in both ethological and evolutionary studies offers innovative answers to another *vexata quaestio* that accompanied the history of Darwinism and evolutionism:

To what extent are human mind and behaviour the product of inherited adaptations fixed in an irreversible or scarcely modifiable way in all members of our species?

To what extent, are they instead influenced by economic, social and cultural selection, by tradition, institutions and communication, and can therefore develop significant, useful or harmful, changes in the rapid times in which these kinds of social factors operate?

The old question now seems through the developments of genetics and epigenetics, molecular and developmental biology, cognitive and cultural ethology, *to the detriment of the genetic determinism that dominated the theories of inheritance and evolution in the twentieth century*. The reasons for this change are easily understandable even to non-experts. The theoretical framework of the "modern synthesis" suggested that social environment and cultural influences had not been able to make significant modifications in the human phenotype and in its physiological, psychic and behavioural propensities. The phenotypic conformation was, in fact, considered the result of the faithful execution (except for random errors) of a program entirely written in the DNA and hardly influenced by the environment. Therefore, significant phenotypic modifications were considered possible only in the long times required by relevant genome mutations, that is, over millions of years. The empirical and experimental evidence discussed in this essay instead allows the corroboration of opposite approaches and conclusions: as Darwin and Lorenz had already guessed, in human social evolution, the influence of selective pressures exerted by social environment on individual mental and behavioural orientations has been growing over the years, to detriment of the influence of the selective pressures exerted by the natural environment and the inter-specific context. The social selection of behaviours and propensities has increasingly replaced that interaction "of everything with everything" through which natural selection in a Darwinian sense is regulated. The environment in which the selection of human behaviour takes place has already for

[13] S. Tedesco, *Introduzione*, in A. Pinotti, S. Tedesco, *Estetica e scienze della vita*, Parte seconda, *Evo-Devo e morfologia*, Raffaello Cortina Editore, Milano 2013, p. 188.

millennia been and become an increasingly *anthropic* environment. An environment in which the conditions for survival and success are socially produced by our species. Today the developments of epigenetics enable us to demonstrate that, generation after generation, this social context in which experiential and selective dynamics take place selects orientations and contents of emotions, sensations and propensities, cognitive and health resources and deficits, paths of mental and behavioural development, not only in the individual, but also in their immediate descendants, thus triggering the inhibition and/or reactivation of the expression of certain genes (Jablonka 2006, 2013, 2017). Thus, we can now affirm that:

- for millennia, the most important biological modifications taking place in the human organism, those that channel and guide the development of main aspects of the emotional, cognitive and social attitudes, are shaped by inter-specific selection, by the social environment, and by the rules and living conditions that they impose, more than by "natural selection" understood in the Darwinian sense;
- the effects of these ethogenetic and epigenetic inheritances are transmitted not with the slowness of genetic modifications that require millions of years to set new characters, but with extreme rapidity. In fact, as we shall see in greater detail in the final essay of the volume, it is today possible to demonstrate that the experiences and lifestyles of every single generation have an immediate impact on morphogenesis and organization (micro-geography and functionalities) of the brain's and organic apparatuses in immediately ensuing generations.

In other words, today biology and ethology themselves show that our "inside", understood both as organic profile and subjective experience, is to a large extent a *social product*, a product of the human, social, economic and cultural system in which it takes shape. As Jablonka and Lamb pointed out in their book, this makes *anachronistic* every claim to explain the "social-behavioural status quo" of contemporary humanity as an expression of innate tendencies irreversibly fixed in our genetic code millions of years ago (Jablonka and Lamb 2005: 424–427).[14]

After all, in the last fifteen years, the developments of this field of research made increasingly evident the close correlation between EIS (Epigenetic Inheritance Systems) and BIS (Behavioral Inheritance Systems), leading to the birth of a new scientific discipline or sub-discipline: behavioural and cultural epigenetics (Jablonka 2013, 2017; McGowan and Szyf 2010; Champagne and Rissman 2011). Its task is "the investigation of the role of behaviour in shaping developmental-epigenetic states and the reciprocal role of epigenetic factors and mechanisms in shaping behaviour" (Jablonka 2017: 42). This development of behavioural and cultural epigenetics open the possibility of a social history of human biological evolution and condition based on an anti-separatist but at the same time anti-deterministic approach.

They invigorate and raise the need of that two-stage evolutionary model that had already been introduced in 1987 by the philosopher Erhard Oeser (1987) in the context of EE, according to which behavioural and perceptive habits, mental categories and expectations, interactive modes and evaluative criteria develop in

[14]*Ivi*, p. 473.

the human individual, over the course of life, thanks to so-called "open programs", that is to say innate learning programs, of which Lorenz and Mayr had already spoken.[15] In other words, through a series of sensitive phases of biological and cognitive maturation, marked by species-specific forms of *active research of the stimulus* leading individuals to assimilate mental and behavioural models from society, from the behaviour and teachings of con-specifics, from the parental and socio-cultural figures of reference through some key phases of psychic development. According to this perspective, cerebral and cognitive formation of every human being starts, inevitably, from an assimilation and a re-elaboration of inputs, models, behavioural patterns, emotional reaction norms, drawn from the social environment, which in the first years of life take place in a largely unaware form. The brain and psychic development is thus configured as a "biographical path" that leads to the structuring of "a hierarchy of dynamically interdependent layers, in which the component of mere adaptation progressively decreases, giving way to constructive elements that take over in an ever more incisive manner" (Oeser 2000: 338). Callebaut and Stotz also referred to this model in their aforementioned 1998 essay, framing human thought and behaviour as socially produced and individually learned and re-elaborated expressions, starting from an interactive cultural and linguistic environment that exercises training functions on them. As we have seen, today studies aimed at the formulation of an "extended" or "post-modern" synthesis of Darwinian theory, reaching a full recognition of the autonomy of socio-cultural evolution and individual behaviours from direct and binding genetic influences. Moreover, the research of contemporary ethologists such as Frans de Waal, who for over twenty years investigated the phylogenetic and historical origins of "morality", also led to a similar recognition. In fact, the long de Waal study confirms the decisive influence of social factors and early experiences on the development of moral codes and ethical choices (de Waal 1996, 2006; Celentano 2013) and clarifies an important concept: in our species, the innate components which guide the development of ethical evaluations and choices manifest themselves not as innate rules or principles as some evolutionary psychologists have recently argued (Hauser 2006; Pinker 2008), but as learning programs. Not by chance, on this matter the ethologist writes:

> We are born not with any specific social norm, but with a learning agenda that tells us which information to imbibe and how to organise it. [...] In a sense, we are imprinted upon a particular moral system through a process that, though hundreds of times more complicated than the imprinting of birds, maybe just as effective and lasting. (de Waal 1996: 36)

So, in a nutshell, today it is exactly the same sciences that every genetic determinism has traditionally used to argue the (still unproven) hypothesis that human behaviours are prescribed in a binding way by our genes that contribute decisively to proving the opposite. They thus prepare us for a task from which contemporary culture can no longer escape, if not at the risk of compromising its own ability to produce critical

[15] See K. Lorenz, *Evoluzione e modificazione del comportamento*, tr. it. Boringhieri, Torino, 1971; E. Mayr, *Behavior Programs and Evolutionary Strategies: Natural selection sometimes favors a genetically "closed" behavior program, sometimes an "open" one, American Scientist*, 62, 6, 1974, pp. 650–659.

self-reflection: understanding what consequences have derived and are deriving from the fact that the society, and no longer nature, in its inter-specific wealth, produces the environment in which the "human" is selected and cultivated, in an increasingly pervasive way.

This target implies a triple commitment that, in my opinion, should today concern transversely all the scientific disciplines:

- to contribute to understanding the ways in which intra-specific selection and social context impose developmental constraints and directions on the biological, behavioural and cognitive expressiveness of individuals, populations, and species, i.e., to develop a comparative, synchronic and diachronic study of the "canalizations" (Waddington 1975) that social evolution imposes on biological evolution;
- to contribute to explain how human biological history has evolved and is evolving *within* human social history and under the dominance of intra-specific human selection. Trying to understand which transformations social life has inscribed and is inscribing in physiological, sensory and cognitive activities, as well as in the "appetences" and propensities of humans. To develop a synchronic and diachronic comparative study of the structural constraints and evolutionary orientations that currently dominant development models in human social organization are imposing on humans themselves, on almost all the other organisms and on our and their living environment (Jablonka and Bronfman 2014; Jablonka 2017);
- to contribute to the scientific identification and concrete social removal of all those forms of discrimination, exploitation and social manipulation of human beings, and of other sentient beings, which, as we know today thanks to cultural epigenetics, leave scars, wounds and traumatic effects not only in those that suffer them in a direct way, but also in their descendants.

2.10 Genealogical Perspectivism: Towards an Ethological Conception of Knowledge

Like fish capable of exploiting undulating motions of water so as to move and live in it, or birds, able to fly, hunt and sometimes sleep gliding over air currents, we only possess *knowledge without "truth"*. We can elaborate complex forms of schematization of the "entities", "elements", "processes" or "events" with which we interact. These allow us to survive in the environments we colonize, as the fish does in water and the bird in air, but we hold no "truths", if we intend them in the traditional, strong and emphatic sense of the term, that of metaphysical laws, or laws of nature that are universally valid in space and time. The "knowledge" we incorporate through inheritance and learning never translates into statements that can be considered unquestionably true or exact from any point of view and that remain so over time. Our cognitive activity, not unlike that of any other body, is never resolved into an objective and neutral reflection of what we come into contact with. Rather, it manifests itself always and exclusively as a production of behaviours, of forms of assimilative, exploratory, transformative and self-regulating interaction with what coexists with us.

As some prominent contemporary scholars have reiterated, this limitation concerns not only the ability of discernment of other living beings and our common sense, but also our *scientific* knowledge. In fact, even the latter cannot overcome these limits. This finding led contemporary scholars like Ronald Giere and Werner Callebaut to assume an epistemological position they called *scientific perspectivism* (Giere 2006; Callebaut 2009, 2012; Celentano 2018). Its basic theses can be summarized as follows:

- Each detection system, whether biological, technological, or hybrid, responds only to a particular and limited set of signals. Like our organs, scientific "instruments are sensitive only to a particular input and blind to everything else; and their output is a function of both their input and their internal constitution" (Callebaut 2012: 76).
- No system, whether organic or artificial, offers a mere neutral mirroring of data, because all the detection systems process the collected data according to criteria intrinsic to their own structure, and not (or not only) to the entities or processes they detect.
- Different sensor organs and instruments receive and represent the same phenomena in different ways.
- The scientific hypotheses and theories are "models of aspects of the world", and the so-called natural laws are highly generalized models "that characterize a scientific perspective" (ibid.).
- "As a consequence, we cannot transcend our human perspective" (Brandon 2007).

Starting from them, I would like to propose, in these concluding pages, some reflections on the possibility to elaborate an ethological conception of knowledge and to clarify the basic concepts of a perspectivism that is not only scientific, but also *genealogical*. Or rather, of an ethological and genealogical approach to the problem of knowledge which affirms, not only that every human and not human form of knowledge is based on a limited perspective and makes only certain aspects of reality perceptible, or conceivable, but also that these limits are essential to make this knowledge useful for the survival and for the modification of the living conditions of the organisms. This approach radically modifies the concept of "knowing", which was intended since the age of Aristotle until the contemporary one. In fact, it sets the evaluation parameters and criteria for putting to test our knowledge, no longer with the pretense of progressively approaching the formulation of alleged immutable "natural laws", or to chase an impossible exact representation of the "in itself", but solely in its concrete, practical effects. That is, in the qualitative and quantitative modifications, in the protection or in the worsening, of the living conditions of acquaintances and known subjects that this knowing produces.

Cognitive activities are always simultaneously self-regulative interactions, forms of energetic and informative exchange with the species-specific and inter-specific environment, and exploratory behaviours or forms of testing and implementation of the practical skills of an organisms.

The forms of the perceptive, mental and symbolic representation of the reality we elaborate, may be more or less functional to the resolution of practical, individual and collective problems, more or less useful to develop certain systems of representation of reality that we use in our forecasting and calculation operations, but not absolutely true.

In fact, as Nietzsche pointed out, the existent does not, in itself, have an aspect. It can take on an aspect, it can present itself under certain forms and characteristics, only in relation to a living being that perceives it and to the different situations in which this happens. Therefore, we don't have to establish a difference between the way we perceive something and the way that something would appear "in itself". Rather, we must take note that every existing "x" must necessarily appear in as many different ways as they are the organs, apparatuses or instruments engaged in understanding and interacting with it and the different circumstances in which this interaction takes place.

Every existing entity, or ongoing process will thus necessarily appear differently to the many species of organisms that will interact with it because each species (and to a lesser extent each population and individual) has developed different perceptive and cognitive apparatuses in relation to particular vital needs and evolutionary contingencies.

A similar argument also must be applied to human abilities: our cognitive organs developed their skills over the course of phylogeny and of social, cultural and individual history. This means that they acquired and modified their shape not only through a mental representation of the external environment, but also through *a material interaction with it*.

Consequently, we need a complete overcoming of the traditional concept of knowledge as a form of compliance of human ideas to external things, or *adaequatio rei et intellectus*, and of the idealistic conception of the cognitive apparatus as a set of functions delegated to perform *a mere mental representation* of the external environment.

The brain, or eye, as the fin of a fish, rather than merely representing an external environment, serve to move in it, to interact with it, to implement vital and social functions in a determined (but changing) ecological context. In this sense, we can affirm that a cognitive activity primarily manifests itself in all living beings as the ability to *produce body plans and behavioural forms* suitable enough to guarantee their survival and reproduction as an individual, populations or species. This is the core of an ethological conception of knowledge. We can today recognize that not only human beings, but all organisms, in order to stay alive and reproduce need to carry out and exercise cognitive activities within the limits imposed to them by their own evolutionary and ontogenetic history. These cognitive activities manifest themselves as a production of physiological and behavioural forms and activities which place crucial self-regulating functions and are capable of implementing qualitative changes in the physiological states and life conditions of an organisms.

But to what extent is it possible to affirm that organisms are capable of acquiring and transmitting, in ways that go from the genetic to the cultural heritage, information that is useful to the survival or to the qualitative improvement of their living conditions?

From a genealogical point of view, we could answer that the cognitive endowments of the organisms have proved to be useful enough to ensure that life, for more than three billion years (that is from the moment of its appearance until today), has not died out. We could not allow more than this, with regard to their degree of reliability, but it would be difficult to deny them at least this degree of "utility". The organisms "know" some factors of the real world just enough to survive and reproduce in some of its areas. This is what we can say about the "validity" of the systems of codification and decoding of reality developed both by other living beings and by ourselves.

This also means that, even though we cannot reach absolute certainties, each of our cognitive resources, from sensation to emotion, from perception to imagination and theories, just like the skills of other organisms, can be put to the test. In fact, we could test their real effectiveness on the condition that we modify as a yardstick of our knowledge, by placing it no longer on the horizon of an alleged progressive approach to the perfect correspondence between things as they actually are and their scientific representation, but rather exclusively in terms of its practical effects. That is, in terms of the damages or benefits it entails. Knowing serves to live, to face life. We can't demand more.

The first consequence of this approach is that claiming a cognitive methodology is more valid than any other, and therefore preferable under all circumstances, is as vain as expecting a microscope to be equally useful for observing microorganisms as to avoid the dangers of a car-filled street and studying the stars. In fact, the utility of a presumed knowledge or methodology is detectable only in relation to the specific area of problems that they are called upon to face and resolve.

In conclusion, genealogical perspectivism is based on an ethological conception of knowledge according to which cognitive processes are not reducible to mere processes of assimilation of information or mere activities of perceptive, mental or symbolic representation of known "objects". In fact, they always imply an effective interaction between the knowing subject and the known "object" (which of course may also be one or more other living beings) that transforms them both and that is indispensable for the environmental monitoring, self-monitoring and self-regulation that every organism must perform to keep itself alive.

Moreover, according to an ethological conception of knowledge, as the fathers of the Evolutionary Epistemology already guessed, we can include in the cognitive activities not only processes that allow individual organisms to monitor the environment and interact with it, but also those that regulate morphogenesis, ontogenesis, and phylogeny. Living being learn while taking shape, both physically and mentally in the first place. Organisms acquire knowledge by transforming themselves and the context in which they live, and this is true both for the homeorhetic processes (Waddington 1975), or the vital parabola of individuals as well as for trans-generational processes that allow the species to preserve and/or change. Therefore, development and evolution are both cognitive processes, inextricably intertwined, in which living beings play an eminently active role, contributing with their intelligence to shape themselves shaping and to the evolution of the environments in which they live.

References

Arrigoni, Ermanno. 1991. *"L'uomo a una dimensione" di Marcuse e l'alienazione dell'individuo nella società contemporanea secondo gli autori della Scuola di Francoforte.* Torino: Paravia.

Arthur, Wallace. 2004. The Effects of Development on the Direction of Evolution. *Evolution and Development* 6 (4): 282–288.

Baluška, Frantisek, Stefano Mancuso, and Dieter Volkmann. 2007. *Communication in Plants: Neuronal Aspects of Plant Life.* New York: Springer.

Brandon, Ed. 2007. Ronald N. Giere: Scientific Perspectivism. *Metapsychology: Online Reviews* 11 (41).

Caianiello, Silvia. 2013. L'interno della selezione. In *Confini Aperti: Il rapporto esterno/interno in biologia*, ed. Continenza Barbara, Elena Gagliasso, and Sterpetti Fabio. Milano: Franco Angeli.

Callebaut, Werner. 2009. Multi-scale Phenomena in Biology and Scientific Perspectivism. In *Multi-scale Phenomena in Biology. Melville: American Institute of Physics Conference Proceedings*, ed. R. M. Sinclair and K. M. Stiefel, 57–69.

Callebaut, Werner. 2012. Scientific Perspectivism: A Philosopher of Science Response to the Challenge of Big Data Biology. *Studies in History and Philosophy of Biological and Biomedical Sciences* 43 (1): 69–80.

Callebaut, Werner, and Rik Pinxten. 1987. *Evolutionary Epistemology: A Multi-paradigmatic Program.* Dordrecht: Reider.

Callebaut, Werner, and Karola Stotz. 1998. Lines Evolutionary Epistemology. *Evolution & Cognition* 4–1: 1–36.

Callebaut, Werner, and Diego Rasskin-Gutman. 2005. *Modularity: Understanding the Development and Evolution of Complex Natural Systems.* Cambridge: MIT Press.

Callebaut, W., Müller Gerd, and Newman Stuart. 2007. The Organismic Systems Approach: Evodevo and the Streamlining of the Naturalistic Agenda. In *Integrating Evolution and Development: From Theory to Practice*, ed. Sansom Roger and Brandon Robert, 25–92. Cambridge: MIT Press.

Campbell, Donald T. 1974. Evolutionary Epistemology. In *The Philosophy of Karl Popper*, vol. I, ed. Paul A. Schilpp, 413–463. La Salle: Open Court.

Celentano, Marco. 2000. *Etologia della conoscenza.* Napoli: Città del Sole.

Celentano, Marco. 2011. *Konrad Lorenz e l'etologia contemporanea.* Milano: Franco Angeli.

Celentano, Marco. 2013. Etologia e antropologia. Utilità e limiti del principio di continuità. In *Una prospettiva evolutiva sulle emozioni. Da Charles Darwin alle neuroscienze*, ed. Bernardino Fantini, Giovann Destro Bisol, Fabrizio Rufo (a cura di), 47–66. Pisa: Edizioni ETS.

Celentano, Marco. 2018. Prospettivismo genealogico. Proposte integrative per un programma di ricerca sull'etologia del conoscere. In *Pluriversi cognitivi. Questioni di filosofia ed etologia*, ed. Marco Celentano and Roberto Marchesini. Milano-Undine: Mimesis.

Champagne, Frances and Rissman, Emilie. 2011. Behavioral Epigenetics: A New Frontier in the Study of Hormones and Behavior. *Hormones and Behavior* 59 (3): 277–278.

Craig, Wallace. 1918. Appetites and Aversions as Constituents of Instincts. *Biological Bulletin* 34 (2): 91–107.

de Waal, Frans. 1996. *Good Natured: The Origins of Right and Wrong in Humans and Other Animals.* Cambridge, MA: Harvard University.

de Waal, Frans. 2006. *Primates and philosophers.* Princeton, NJ: Princeton University Press.

Evans, Richard J. 1975. *Konrad Lorenz: The Man and His Ideas.* New York: Harcourt Brace Jovanovich.

Fancello, Omiti. 1985. *Dalle molecole all'uomo* [From molecules to man]. Roma: Editori Riuniti.

Giere, Ronald. 2006. *Scientific Perspectivism.* Chicago: University of Chicago Press.

Hauser, Mark. 2006. *Moral Minds.* New York: Ecco/Harper Collins Publisher.

Heimer, Armin. 1977. *Ethologishes Wörterbuch.* Berlin: Paul Parey.

Jablonka, Eva. 2006. Genes as Followers in Evolution—A Post-synthesis Synthesis. *Biologyand Philosophy* 21: 143–154.

Jablonka, Eva. 2013. Behavioral Epigenetics in Ecological Context. *Behavioral Ecology* 24 (2): 325–326. http://scholar.google.com/scholar_lookup?publication_year=2013&pages=325-326&issue=2&author=E.+Jablonka&title=%E2%80%98Behavioral+epigenetics+in+ecological+context%E2%80%99&http://scholar.google.com/scholar_lookup?publication_year=2014&issue=2&author=E.+Jablonka&author=Z.+Z.+Bronfmanauthor=J.+Losos&title=Oxford+Bibliographies+in+Evolutionary+Biology&.

Jablonka, Eva. 2017. Cultural Epigenetics. *Sage Journal* 64 (1): 42–60.

Jablonka, Eva, and Marion Lamb. 2005 (revisited edition 2014). *Evolution in Four Dimensions.* Cambridge, MA: MIT Press.

Jablonka, Eva, and Zohar Bronfman. 2014. Epigenetics and Behavior. In *Oxford Bibliographies in Evolutionary Biology*, ed. Losos Jonathan. New York: Oxford University Press.

Jablonka, Eva, and Marion Lamb. 1995. *Epigenetic Inheritance and Evolution.* Oxford and New York: Oxford University Press.

Jenkin, Fleeming. 1867. [Review of] The Origin of Species. *The North British Review* 46 (June): 277–318.

Kant, Immanuel. 1783. *Prolegomenazu einer jeden künftigen Metaphysik.* Engl. transl. 1994. *Prolegomena to any future metaphysics.* Indianapolis: Pearson.

Kant, Immanuel. 1781 (1787). *Kritikderreinen Vernunft.* Engl. transl. 1999. *Critique of Pure Reason.* Cambridge: Cambridge University Press.

Lorenz, Konrad. 1937. Über die Bildung des Instinktbegriffes. *Die Naturwissenschaften* 25 (19): 289–300.

Lorenz, Konrad. 1941. *Kant's Lehrevom Apriorischen im Lichte gegenwärtiger Biologie.* Engl. transl. 1975. *Kant's Doctrine of the a Priori in Light of Contemporary Biology.* In R. I. Evans 1975: 181–217.

Lorenz, Konrad. 1973. *Die Rückseite des Spiegels.* Engl. transl. 1977. *Behind the Mirror: A Search for a Natural History of Human Knowledge.* London: Meuthen & Co.

Lorenz, Konrad. 1983. *Der Abbau des Menschlichen.* Engl. transl. 1987. *The Waning of Humaneness.* Boston: Little, Brown.

Lorenz, Konrad. Posthumous 1992. *Die Naturwissenschaft vom Menschen.* Engl. transl. 1995. *The Natural Science of the Human Species.* Cambridge, MA and London: MIT Press.

Mancuso, Stefano. 2018. *The Revolutionary Genius of Plants: A New Understanding of Plant Intelligence and Behavior.* New York: Atria Books.

Masullo, Aldo. 1986. *Fichte. L'intersoggettività e l'originario.* Guida: Napoli.

McGowan, Patrick and Szyf Moshe. 2010. The Epigenetics of Social Adversity in Early Life. *Neurobiology of Disease* 39 (1): 66–72.

Monod, Jacques. 1970. *Le Hasard et la Necessité.* Paris: Editions du Seuil.

Mivart, St. George Jackson. 1876. *Lessons from Nature.* London: John Murray.

Müller, Gerd. 1990. Developmental Mechanisms at the Origin of Morphological Novelty: A Side-Effect Hypothesis. In *Evolutionary Innovations*, ed. Nitecki Matthew, 99–130. Chicago: University of Chicago Press.

Müller, Gerd. 2015. Liberté, Egalité, Modularité: In Memory of Werner Callebaut (1952–2014). *Biological Theory* 10 (March 1): 1–4.

Müller, Gerd. 2017. Why an Extended Evolutionary Synthesis is Necessary. *Interface Focus* 7: 1–11.

Müller, Gerd, and Stuart Newman. 1999. Generation, Integration, Autonomy: Three Steps in the Evolution of Homology. *Novartis Found Symposium* 222: 65–73; discussion: 73–9.

Müller, Gerd, and Stuart Newman. 2003. Origination of Organismal form: The Forgotten Cause in Evolutionary Theory. In *Origination of Organismal Form: Beyond the Gene in Developmental and Evolutionary Biology*, ed. G. B. Müller. Cambridge, MA and London: MIT Press.

Müller, Gerd, and Stuart Newman (eds.). 2005. The Innovation Triad: An Evo-Devo Agenda. *Journal of Experimental Zoology* 304: 487–503.

Newman, Stuart. 2014. Form and Function Remixed: Developmental Physiology in the Evolution of Vertebrate Body Plans. *Journal of Physiology* 592 (11): 2403–2412.

Newman, Stuart, and Gerd Müller. 2010. *Morphological Evolution: Epigenetic Mechanisms*. New York: Wiley.

Nietzsche, Friedrich. 1882. *Die fröhliche Wissenschaft*. Engl. transl. 2001. *The Gay Science*. Cambridge: Cambridge University Press.

Oeser, Erhard. 1987. *Psichzoikum. Evolutions und Mechanismus der menschlichchen Erkenntnisfähigkeit*. Berlin und Hamburg: P. Parey.

Oeser, Erhard. 2000. Anatomia della coscienza: il metodo trascendentale kantiano come neuroepistemologia. In *Natura e cultura*, ed. Giuseppe Cantillo and Rossella Bonito Oliva (a cura di), 325–341. Napoli: Guida.

Pigliucci, Massimo, and Gerd Müller. 2010. *Evolution—The Extended Synthesis*. Cambridge: MIT Press.

Pinker, Steven. 2008. *The Moral Instinct*. lumerinnovato. blogspot.com/…/listinto-morale-di-steven-pinker.html.

Popper, Karl. 1972. *Objective Knowledge an Evolutionary Approach*. London: Oxford University Press.

Popper, Karl. 1984. *Evolutionary Epistemology*. In *Open Questions in Quantum Physics*, ed. Gino Tarozzi and Alwyn van de Merwe. Dordrecht, Boston, Lancaster: D. Reidel Publishing Company.

Popper, Karl. 1990. *A World of Propensities*. Bristol: Thoemmes.

Popper, Karl, and John Condry. 1994. *Cattiva maestra televisione*. Venezia: Marsilio.

Riedl, Rupert. 1975. *Die Ordung des Lebendigen*. Hamburg and Berlin: Paul Parey.

Riedl, Rupert. 1980. *Biologie der Erkenntnis*. Berlin: P. Parey.

Riedl, Rupert. 1995. Deficiences of Adaptation in Human Reason: A Constructivistic Extension of Evolutionary Epistemology. *Evolution and Cognition* 1 (1): 27–37.

Schank, Wallace, and William Wimsatt. 1986. Generative Entrenchment and Evolution. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2: 33–60.

Somenzi, Vittorio. 1996. *L'epistemologia evoluzionistica*, in *Un'introduzione all'epistemologia contemporanea*, ed. Antiseri Dario, Gava Giacomo, Petroni Angelo, Somenzi Vittorio, Stanzione Massimo. Padova: Cleup.

Stanzione, Massimo. 1984. *Epistemologia evoluzionistica: confronti e critiche*. In *Evoluzione e modelli*, ed. Continenza Barbara, Cordeschi Roberto, Gagliasso Elena, Ludovico Anna, and Stanzione Massimo. Roma: Editori Riuniti.

Vollmer, Gerhard. 1975. *Evolutionäre Erkenntnistheorie*. Stuttgart: Hirzel.

Vollmer, Gerard. 1983. *Mesokosmos und objektive Erkenntnis*. In *Die Evolution des Denkens*, ed. Konrad Lorenz and Frans Wuketits. München: Piper.

Waddington, Conrad Hal. 1975. *The Evolution of an Evolutionist*. Edinburgh: Edinburgh University Press.

Wagner, Gunt P. 1996. Die Größte Herausforderung der EE. In *Die Evolutionäre Erkenntnistheorie im Spiegel der Wisssenschaften*, ed. Riedl Rupert, Delpos Manuela. Wien: WUV Universitätverlag.

Wuketits, Franz M. 1990. *K. Lorenz. Leben und Werk eines großen Naturforschers*. Italian translation. 1991. *Konrad Lorenz. Una vita*. Milano: Mondadori.