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Naturalising purpose: From comparative anatomy to the 'adventure of reason'

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Abstract

Kant's analysis of the concept of natural purpose in the *Critique of judgment* captured several features of organisms that he argued warranted making them the objects of a special field of study, in need of a special regulative teleological principle. By showing that organisms have to be conceived as self-organizing wholes, epigenetically built according to the idea of a whole that we must presuppose, Kant accounted for three features of organisms conflated in the biological sciences of the period: adaptation, functionality and conservation of forms. Kant's unitary concept of natural purpose was subsequently split in two directions: first by Cuvier's comparative anatomy, that would draw on the idea of adaptative functions as a regulative principle for understanding in reconstituting and classifying organisms; and then by Goethe's and Geoffroy's morphology, a science of the general transformations of living forms. However, such general transformations in nature, objects of an alleged 'archaeology of nature', were thought impossible by Kant in §80 of the *Critique of judgment*. Goethe made this 'adventure of reason' possible by changing the sense of 'explanation': scientific explanation was shifted from the investigation of the mechanical processes of generation of individual organisms to the unveiling of some ideal transformations of types instantiated by those organisms.

Keywords: Georges Cuvier; Johann Wolfgang von Goethe; Morphology; Adaptation; Organism; Explanation

In his classic book *Form and function*, E. S. Russell conceived the history of biology as torn between two poles: the concept of form—anatomy-oriented biology—and the

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concept of function—physiology-oriented biology.[1] The famous Geoffroy–Cuvier debate over the possible unity of plans across the animal world, later analysed by Toby Appel, can be (and has been) interpreted in those terms.[2] Here I show the fruitfulness of considering how Kant's 'philosophy of biology' can be situated in this framework. This will lead to some interesting results concerning form and function in biology, and the fate of the main Kantian ideas in the nineteenth century.

I will argue that Georges Cuvier's zoology, as well as Goethe and Etienne Geoffroy Saint-Hilaire's morphology, the two sides of the form–function debate, inherited some of the features of the Kantian theory. The basic claim is that purposiveness, in a Kantian sense, can be elaborated either in a formal sense, or in a functional sense; and whereas the latter meaning was instantiated by Cuvier's comparative anatomy, the former meaning was developed in Goethe's morphological work. The poet intended such a filiation when he said retrospectively that he initiated the 'adventure of reason' that Kant explicitly prohibited in §80 of his *Critique of judgment*.

I will first briefly sketch some major points of the Kantian thesis regarding organisms, and then I will follow its influences on Cuvier's comparative anatomy. Secondly, I will address the notion of type involved in the Kantian concept of 'archaeology of nature', and trace its development in the idea of morphology, as it was conceived and realised first by Goethe and then by Geoffroy. This will show how, by turning the word 'archaeology' from a 'mechanical–real' to a 'process–ideal' meaning, the Kantian 'adventure of reason' was eventually undertaken.[3]

1. Kant's theory of the organism

First, I will sketch Kant's ideas of natural purpose and organisms, and how they were related to the state of biological sciences at the end of the eighteenth century, by showing how they were connected to his theories of races and heredity. This will allow me to understand how in the third *Critique* purposiveness became a transcendentally legitimate concept able to capture three features of organisms, namely adaptation, function and inheritable form.

The very concept of an 'organized being' [*organisierte Wesen*] should be located in the metaphysical context of Kant's concept of purpose. Kant's speculation on organized beings was continuously concerned with this problem of purposiveness, for which he finally found a solution in the third *Critique*. Since his precritical texts, Kant had emphasized the need for a non-mechanistic understanding of the phenomena manifested by organized beings, not satisfied with the extant theories vindicating the mechanistic stance, such as formulated by Albrecht Haller or Herman Boerhaave. In the *Only proof of the existence of God* (1763), he rejected accounts of generation which rested on Newtonian laws of nature applied to preformed germs, arguing that no really scientific theory of epigenesis existed (the ones proposed by Pierre-Louis Maupertuis or Georges-Louis Le Clerc Buffon were not intelligible).[4] In the *Dreams of a ghost seer* (1766) he found mechanical

[1] Russell (1916).
[2] Appel (1987).
[3] Reill (2005), Ch. 5, suggests a genealogy of the 'adventure of reason' that parallels the one here sketched, but also emphasizes other arguments, mostly pertaining *Naturphilosophie*.
[4] Kant (1910–), Vol. 2, p. 114.

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physiology correct from a methodological point of view, but asserted that it missed the point that was settled by Georg Ernest Stahl's *Theoria medica vera* (1708),[5] namely, the uniqueness of the organic realm, while pointing out that Stahl's theory as such was not rational enough.[6]

Kant tried to fill this gap between what was offered as scientific explanations and what is required for a proper understanding of organisms, with some works in the field of 'physical geography'. Here he needed to work through the concept of 'human species', which was a natural-historical one at the time. As is well known, Kant elaborated his own theory of generation in his essays on race (from 1775 onwards), alongside contemporary works by Caspar Wolff and Friedrich Blumenbach.[7] Kant's theory had both a Buffonian character—focusing on the definition of races, and suggesting a mechanism in order to explain their appearance—and a Blumenbachian character—since it asserted an epigenesis disposed to reach a type.[8] It characterized germs and dispositions (*Keime und Anlagen*) as 'reproductive powers' inherited by the offspring of an individual.

Germs indicate the future features of organisms, and sound a little more 'preformationist' than the dispositions, which indicate the ability to respond to a potential milieu. Phillip Sloan (2002) distinguishes between a strong preformationism, defended by Nicolas Malebranche and Gottfried Wilhelm Leibniz, which made use of the concept of germs, germs being like individual shapes pre-existing in the zygote, and a weaker form of preformationism, the one of Charles Bonnet and Haller, which made use of predispositions rather than germs.[9] But in any case, both concepts were used by Kant to provide an epigenetic answer to the problems of the conservation and the variation of form through the generations. Both the process of *generation* and the *criterion* for races are concerned with such concepts. A race has to be something robust across the generations, so, when it is mixed with another race, the result has to consist of something from each of them. That is why the outcome of any racial interbreeding has always to be a half-breed: this indicates that something from the reproductive power of each race is conserved through the generations. Reciprocally, the criterion for races, such as skin colour, must be a hereditary trait which is constantly mixed when we cross two races. Kant emphasized the difference between skin colour, which is a race criterion, and hair colour, which can persist or disappear when an individual of a given hair colour mixes with an individual of another hair colour and hence is contingent regarding the race.[10] This means that the germs and dispositions, from which a determinate race stems, are preserved despite external influences. In contrast with Buffon and Blumenbach, who thought that the diversity of races could be derived from a single one by the action of environment (and, above all, climate), Kant thought that the races

[5] For example in the preliminary essays, such as 'On the difference between organism and mechanism'.

[6] Kant (1910–), Vol. 2, p. 331.

[7] Among several papers on Kant's theory of generation, see Lenoir (1980), Richards (2000), Zammito (2007, Forthcoming), and Huneman (2007, Forthcoming).

[8] Briefly stated, while Wolff in his *Theorie generationis* (1758—German edition, *Theorie der Generation*, 1763) insisted on a generalized *vis essentialis* that would underpin the whole developmental process in the living world, Blumenbach conceived of an epigenesis directed by a *Bildungstrieb*, for example a *Trieb* directed towards the formation, *Bildung*, of an individual of a special type. He explains those differences in his 1789 essay *Uber das Bildungstrieb*, published together with an essay of Wolff and one of Born in *Zwei Abhandlungen*. See Blumenbach (1792), pp. 26–29.

[9] On germs and dispositions, see Sloan (2002).

[10] 'Determination of the concept of human race', Kant (1910–), Vol. 8, p. 100.

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are produced by the activation of some germs inherent in their reproductive power, and according to the situation.[11] 'What shall propagate, must already have been posited in the reproductive force, as an antecedent determination for an occasional development, adequate to the circumstances in which the creature could be engaged and in which it has constantly to maintain itself'.[12] Circumstances and climate are only occasions of the manifestation of hidden dispositions.

Therefore, Kant's conception of races, and hence of the *preservation of form* through *reproduction*, is at the same time a logic of *adaptation*. Different races of a species, placed in different lands and circumstances, manifest different features, each fitting those different circumstances. This is *adaptation*, and can be explained by the activation of the proper disposition, in each race stem, by the milieu. The set of germs and dispositions is an 'original organization [*originar Organization*]',[13] transmitted to every generation, and able to adapt the beings to new circumstances, given that this stem includes the requisite dispositions.[14]

The third *Critique* formulates the concept of 'natural purpose', in order to elucidate the possibility of such a theory. Briefly, a natural purpose is a peculiar kind of relationship between a whole and its parts, in which we judge (in a reflective manner) the whole to condition the form and relations of the parts, and does it in a kind of epigenetic manner, meaning that those parts build themselves from themselves according to this whole. Certainly, the dependence of the parts on the whole obtains also in the case of a watch. But in natural entities the parts *produce* themselves and the other parts according to the whole (§65).[15] This product of nature, 'being organized [like a watch—*purposiveness*] and organizing itself [contrary to a watch—*naturally*]', is called a 'natural purpose'. The 'original organization' of the essays on race becomes, here, the 'idea of a whole', which has to be posited by us, as a principle of cognition [*Erkenntnisgrund*], at the origin of the living thing.[16] We can not understand the functioning of an organism unless we presuppose an idea of the whole that constrains the forms and relationships of the parts; and we can not understand the emergence of an organism unless we presuppose this idea, as an original organization that governs how the parts produce the whole and the other parts. But this presupposition of a whole is required by our cognition, and, hence, is internal to our faculty of judgment. Notice that if it were a real causal principle, it would be a technical production, not a *natural* purpose.[17] A real causal principle would be the plan of a designer, and we describe the entire process as proceeding from this plan to the actual product. Yet in the case of natural purposes, it is necessary and sufficient that the idea

[11] On this issue see Huneman (2005), pp. 107–120.

[12] 'On the differences between human races', Kant (1910–), Vol. 2, p. 435; my translation.

[13] On this issue, see Zammito (2007, Forthcoming).

[14] For example, some of those dispositions that define race, pre-adapt people to distinct climates. See Alix Cohen (in this issue): she characterizes this part of the doctrine as 'epigenesis of multiple predispositions'.

[15] Put in modern terms, Kant's concept means that cells produce themselves—which is a natural productivity—but that the cells they produce are subordinated to the whole—for example. a cell in a muscle will give a muscle cell rather than a brain cell. 'Subordination to the whole' *alone* is not enough to understand this production, since it obtains also for machines, but without the subordination to the whole the productivity of cells is not understandable, and is not even describable.

[16] See Kant (1910–), Vol. 2, p. 418; my translation.

[17] The whole does not determine the part 'as a cause—because then it would be a product of art—but as a principle of cognition of the systematic unity of the form and the binding of all the plurality [*nicht als Ursache—denn da wäre es ein Kunstprodukt—sondern als Erkenntnisgrund der systematischen Einheit der Form und Verbindung alles Mannigfaltigen*]' (Ibid., Vol. 5, p. 365).

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of a whole is thought as a cause by us. We judge how the organized being organizes itself under this 'idea of the whole' as a principle of cognition, which means that parts cause each other according to a kind of production for which we have no analogue either in nature or in our technical productions (see the end of §65). Indeed, according to the familiar Kantian distinction, we can conceive of this causation but we cannot really know it. Kant used the term 'formative force' rather than the usual 'motive forces' of physics to account for this production.[18] He attempted here a sort of 'deduction', from the transcendental differences between organism and mechanism to those forces overwhelmingly used by contemporary scientists when they addressed living entities—forces such as Wolff's *vis essentialis* or Blumenbach's *Bildungstrieb*, or the vital forces of the physiologists from the end of the nineteenth century such as Johann Glauber, Thomas Unzer, Jiri Prochaska or even Haller.[19] I thus support Reill's (2005) contention that Kant's *Critique of judgment* belongs to the 'program' of those who have come to be called 'Enlightenment vitalists' (even if 'program' has to be taken in a very loose way).[20] However, Kant was the first to see the need of a philosophical justification of those concepts (and the subsequent need for sorting 'good' and 'bad' uses of them). He maintained that what matters is the form of the argument—which goes from the elucidating concept of natural purpose to the recognition that organisms are those entities in the world to which it applies, and, finally, to the distinction between formative and motive forces—rather than using the concept of formative forces actually to identify organisms. Hence, the epigenetic character of organized beings is derived from the necessities of our cognition of organisms.[21]

It is important to note that the vocabulary of dispositions and germs, albeit relevant for Kant's theory of generation and heredity in the essays on race, is absent from the third *Critique*.[22] This fact is significant because the project in the *Critique* is different from the biological theory stated in the precritical essays on race. In his critical work Kant theorized about the justification and the limits of such a biological theory. It could even be argued that his rethinking of those theories was one incentive for writing the third *Critique*, since the kind of science presented in the earlier essays contrasted with the physical sciences, the transcendental analysis of which he gave in the first *Critique* and the *Metaphysical foundations of natural science* (1786). Rather than a theory of generation of the kind put forward in the essays on race, the third *Critique* considers the possibility of any theory of this kind—whence the difference of lexicon.

Kant's thinking on epigenesis warrants particular attention. In §81 of the *Critique of judgment* he advocated 'generic preformationism', as opposed to either individual preformationism (which is classical preformationism) or epigeneticism.[23] 'Generic' means here that the dispositions and germs proper to a species are basically already present at the

[18] For this distinction see McLaughlin (1990) Ch. 2.

[19] Deduction here is not to be taken in Kant's technical sense, however it retains the idea that this argumentation is supposed to entail both the legitimacy of some uses of the concept, and a demarcation between legitimate and illegitimate uses of it.

[20] Reill (2005).

[21] This is the central point of §77 of the *Critique of judgment*. For commentary see Huneman (2007b, Forthcoming), Ch. 9.

[22] One might find some occurrences, such as Kant (1910–), Vol. 5, p. 420, but it's not as pervasive as in the 'Essays on races'.

[23] For an interpretation of 'generic preformationism' dismissive of any account of Kant as an epigeneticist on the same lines as Blumenbach, see Zammito (2007, Forthcoming).

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beginning of embryogenesis, and their relationship with the environment provides the guidelines for the embryogenetic process, even if the mechanisms at stake in this process are to be explained in natural physical terms. Compared to classical preformationism, according to which God created the individuals as miniatures that are later unfolded through the mechanical laws of nature, Kant was closer to epigeneticism, according to which individuals are clearly a result of a process of development and display a kind of relationship between their parts which is precisely not the development governed by mechanical laws. But compared to radical epigeneticism, Kant held a unique position since he contended that embryo-environment interactions alone are not likely to explain embryogenesis: he supported a *moderate* epigeneticism rather than the *radical* epigeneticism that we find by Herder or even by Caspar Wolff. It is important to recall that at the time epigeneticism was bound to spontaneous generation; radical epigeneticism implied spontaneous generation.[24] Kant absolutely rejected spontaneous generation, however, because it implied that the dispositions and germs within organisms are *mechanically caused*, and that the fundamental distinction between occasional and efficient causes of varieties (which lies at the basis of the concept of species), and hence the difference between species and varieties and thus the boundaries of species, would vanish. This means that he excluded every version of epigeneticism that would lead to spontaneous generation—as has been made clear by John Zammito.[25] Herder's idea of a 'plastic force' was the prime example of such a speculation. This kind of radical epigeneticism implied the denial of two epistemological boundaries: the boundary *between organized and unorganized beings*; and the *boundary between species*.

Kant held that the boundary between species is a requisite of reason, as is indicated in the 'Appendix' of the 'Transcendental dialectic' of the first *Critique*, since without the conservation of species there would be no order of nature, no possibility of ascribing natural kinds, and in the end no possibility of comparing empirical things and hence no empirical knowledge at all.[26] The review of the first part of Herder's *Ideas* is explicit about this second issue:

> As regards the issue of the hierarchy of organisms, its use with reference to the realm of nature here on earth leads nowhere . . . The minuteness of differences when one compares species according to their similarity is, in view of such a great multiplicity of species, a consequence of this multiplicity. But a parenthood [*Verwandschaft*] according to which either one species springs from another and all of them out of one original species or as it were they originate from one single generative mother womb, would lead to ideas that are so monstrous that reason shrinks back.[27]

In effect, reason cannot endorse the perspective of an all pervasive creative force with no limits, and creating freely any kind of species and varieties, since any systematic order of nature would thereby be lost.

[24] The consequence of spontaneous generation was a crucial point of controversy between Haller (who rejected epigeneticism for this reason) and Wolff (who implicitly acknowledged that epigeneticism might entail spontaneous generation but did not discuss it explicitly), see Roe (1980).
[25] See Zammito (2002), pp. 232 passim.
[26] Kant (1910–), Vol. 5, A651/B679.
[27] 'Review of Herder's *Ideen*: I', ibid., Vol. 8, p. 52; my translation.

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With regard to the boundary between organized and unorganized bodies, its denial would be as likely to undermine the whole order of nature. In a *Lecture on metaphysics*, Kant wrote about Leibniz's *scala naturae*: 'This is the so-called continuum of forms [*continuum formarum*], according to the analogy of the physical continuum [*continui physici*], where the minerals commence the order, which goes through the mosses, lichens, plants, zoophytes through the animal kingdom up to human being. *This is nothing more than a dream whose groundlessness Blumenbach has shown*'.[28] Therefore, for Kant the name of Blumenbach represented the discontinuity between organized and unorganized bodies. Since Blumenbach postulated the *Bildungstrieb* as inherent in living matter, and conceived the aim of the *Bildungstrieb*—the type realised at the end of the embryogenetic process—as immanent to this *Trieb*, Kant could see in his embryology the perfect example of an 'epigeneticism within the limits of simple reason'.[29] 'Generic preformationism' meant moderate epigeneticism, in contrast to both preformationism (Leibniz, Malebranche or Haller[30]) and radical epigeneticism (Herder). Kant's doctrine of organisms implied 'generic preformism', which is a kind of *epigeneticism subordinated to the conservation of forms*.

Finally, the concept of natural purpose, as presented in the *Critique of judgment*, concerns three capacities of organisms: functions and the physiological activities of organisms; heredity and the power of conserving forms as 'original organizations'; and adaptation (established by the geographical investigation of the distribution of organisms, as it is indicated by the opportunistic appearance of varieties).

The key feature of this tripartite concept, in contrast to traditional notions of teleology applied to physiology and natural history, is its critique of utility. Kant emphasized 'internal purposiveness' as the only legitimate sense of purposiveness, as is made clear in §63 of the *Critique of judgment*. One might object that utility, in the sense of external purposiveness, is not wholly rejected in the book since from §67 on Kant authorized the use of this concept in the consideration of the nature as a whole. However, those passages have to be read in their context, that is, in the course of Kant's argument. His point is not to reject relative purposiveness or utility as such, but to argue that it is not the original meaning and hence the proper use of the concept. Once we have legitimized the concept of purposiveness as internal purposiveness, and stated that some entities do realize it (organisms as self-organizing entities) we can use external purposiveness and see nature as a system of ends, but only as a secondary step of our reasoning, as we see, for example, in §§67, 68, 75, 83 and 84. To quote but one passage: 'Once we have discovered in nature a power to produce products that can be conceived by us only in accordance with the concept of purposes, we are entitled to go further and judge even those things (or their relations, although purposive), which do not render it necessary to look for another principle of their possibility beyond the mechanism of blind efficient causes, as belonging to a system of purposes'.[31] External purposiveness is only a subordinated sense of purposiveness, which

[28] Ibid., Kant (1910), Vol. 18, p. 762; my emphasis; translation modified from Kant (1997).
[29] See Blumenbach (1781).
[30] Haller's idea of preformation, like Bonnet's, was weaker in the sense that he held that dispositions rather than forms were preformed. However, the point is that in Kant's theory dispositions are not only developed by interactions with environment, they are also selected amongst all the dispositions proper to a species, whereas for preformationists the dispositions characterise the individuals and thus must be developed. This is precisely the epigeneticist character that distinguishes Kant's generic preformationism from Haller's weak preformationism
[31] Kant (1910–), Vol. 5, p. 380.

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depends upon the legitimacy of the concept of internal purposiveness. External or relative purposiveness do depend on the fact that some beings in this world fulfil the concept of natural purpose, for example organisms; if there were no organisms, there would be no external purposiveness, but we can not say the reverse. So the course of the argument of the *Critique of judgment* exhibits stages of decreasing degrees of necessity: internal purposiveness is necessary to do any biological science (or investigations of nature in a world where there are organisms); external purposiveness is necessary when we want to consider nature as a whole on the basis of this biological discourse, and so on. But my only concern here is that the very meaning of purposiveness has changed: its primary feature is not utility (which is relative purposiveness). That is why §§64–65, which are the crucial sections concerning organisms since they present the purposive character of organized beings, do not use the lexicon of means and ends, but the lexicon of parts and wholes.[32]

Traditionally, adaptation meant, firstly, that animals are useful to one another—such an idea leading to the concept of natural economy as expressed by Linnaeus's school; and, secondly, that the parts of an animal are always useful to it.[33] This notion of adaptation provided a double-faced concept of design: organisms are designed, and their design is such because they take part in a general design of nature which prescribes to them the role they have to fulfil. In contrast to this *immediate* equation of purposiveness and utility, in §66 of the third *Critique*, means and ends (hence utility) are not independent and primitive concepts in physiology, but their use is subordinated to the fact that entities have *previously* been judged to be natural purposes, which contains a reference to their epigenetic character.[34] That is why in §68 Kant formulated the teleological principle *in a strict connexion with heredity*: one cannot say immediately that nothing is gratuitous in an organism (as the *Critique of pure reason* mentioned with regard to physiologists[35]), but, 'nothing in an organized being is non-purposive if *it is preserved in the being's propagation* [*Fortpflänzung*]'.[36] Generally, these utility assertions are not testable—this was emphasised by Kant ever since the *Only ground for a proof*.[37] The question then arises what the criterion of a genuine utility could be, given that most of the presumed accounts of apparent utility can be ruled out as explicable by the effects of natural laws. Here, with the epigenetic ability of each part to produce other parts according to a pattern which is epistemologically necessarily presupposed, we have a robust criterion of finality that avoids utility. Biological teleology is no longer the craft-like or technical conception of a whole like a machine, but is similar to the concept of art: in a living creature, as in a work of art, parts are not useful for anything external to the organism, but their form and relations are necessary, with respect to the whole and also to the other parts. Both are purposive, but with a work of art, we cannot say what it is for, hence its relationship with a putative design is not the same as in craftwork. The design of organisms does not objectively result from intentions, and thus it cannot be reconstructed as designed by an intelligent entity in order to fulfil

[32] On this point see Huneman (2006, Forthcoming).
[33] See the texts presented in Limoges (1979).
[34] Kant (1910–), Vol. 5, p. 376.
[35] Kant (ibid., Vol. 3, A688/B716), mentioned that physiologists presuppose that 'all in an organism has its utility and its intention'. This presupposition is precisely what Cunningham has reconstructed as the working hypothesis pervasive in all of classical physiology. See Cunningham (2003).
[36] Kant (1910–), Vol. 5, p. 420; my translation.
[37] Ibid., Vol. 2, p. 98.

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some useful role. Even if we are required to conceive of a designer, since the idea of design logically entails the idea of a conceptualizing entity, this idea remains a requisite proper to our cognition, a reflective requisite, we do not have to posit an objective designer in reality.[38]

Since purposiveness is conceived in terms of a relationship between parts and wholes, rather than (as it was earlier) in terms of a relationship between means and ends as in technological purposiveness,[39] the *conservation of form in organisms* can be conceived as a major instance of purposiveness, on a par with adaptation and function.

Neutralising utility implies that finality is no longer committed to a demiurgic view of creation—a purpose is no longer some designer's purpose—and thus teleology is in some weak sense 'naturalised'. The 'idea of a whole' is a *necessary* principle of knowledge: this necessity makes the finality real for biologists, but, as a principle of *cognition*, this reality is posited by the biologist alone and is not an objective feature of nature like the physical laws (§65). And the so-called formative forces which form the original type of an individual are 'regulative forces', as Larson (1979) has argued, because they are correlated with this epistemological position of an 'idea of a whole'. This idea of a whole could be captured by the concept of norm, which Ginsborg (2001) puts to the fore. I interpret norm as the kind of intelligibility that is not entailed by a mechanical description of the whole process of production. When we consider an embryological process, for instance, we have to make sense of the distinction between a normal process—when the chick's embryo develops into a chick—and a teratological process—when the same embryo develops into a legless chicken. But since the same laws and the *same causes* are at stake in the two processes, the laws of the understanding and the mechanical explanation that is based on them cannot make sense of this distinction. Since simply stating that the majority of chickens give rise to chickens is not satisfactory, we have to recognize that norms are immanent to development and pertain to another kind of intelligibility than the mechanical one.[40] This second kind will be the teleological stance since we wish to say that the norm is satisfied when the type 'chicken' is *reached* by the process. Hence the 'idea of a whole' through which we consider the part is represented in embryology as the type of an embryological process; and this type is a norm.

The only visible historical consequence of the Kantian notion of 'regulative concepts'—given that the subtleties of Kant's position were lost in the development of the German philosophy and science, allowing scientists to refer indifferently to Kant and to Schelling, ignoring the huge differences between their positions—is that the 'original organization' is accepted as an epistemological absolute, upon which the mechanical explanations of development have to be built. According to Ginsborg, this organization has the epistemological status of a norm; this proposition makes it difficult to understand how a norm could fail to be realized, because it seems that the original organization is always there. However, we could consider some partial failures to enact the potentialities within the original organization; those failures would result from mechanical process that, due to external interactions, could not unfold what was in the original germs and dispositions. If the original organization is normative, so that its intelligibility is distinct from one in which the parts are moments of a mechanical process, then it can be argued that there is no contradiction

[38] Mc Laughlin (1990) states a similar argument by forging a difference between 'final cause' and 'formal cause'.
[39] On this idea of teleology, see Mc Laughlin (1990), Ch. 1.
[40] Lewens (Forthcoming) makes this point in comparing two models of the concept of function.

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between those two 'legislations,' but rather that in any biological judgment they must be articulated together. Yet if the Kantian emphasis on the 'regulative' status of this norm is undermined, as occurred with the scientists considered in the following and even with Blumenbach,[41] then the norm becomes an absolute, something that absolutely prescribes the course of processes in nature, so that mechanical processes are, so to speak, deriving from it, rather than merely occurring in accordance with it.

The indifference of Kant's followers in physiology to the subtleties of his philosophical position explains why the contrast between a so-called teleo-mechanist or Kantian school and the *Naturphilosopher* is not as clear-cut as Lenoir (1980) wanted it to be.[42] But I argue that Kant's conception grasped some important features of the developing biological sciences, especially comparative anatomy; many of the dimensions of Kantian teleology were realized there. My claim is that Russell's function biology and form biology are two ways of accentuating the Kantian concept of natural purpose, two ways pervasive in nineteenth century comparative anatomy.

2. Cuvier's comparative anatomy and teleology

I will now show how Cuvier's comparative anatomy, that is historically explicitly related to Kant's idea of organisms, instantiated the Kantian idea of 'regulative principles of teleological judgement', proper to the science of living things, in the form of the main principles that zoologists and paleontologists should use.

In his *Lectures on comparative anatomy* (1802) Cuvier invoked Kant's definition of an organism, when he stated that 'the reason of the way of being of each part lies in the whole'.[43] This quotation is not a chance occurrence. Cuvier's biological thinking had been partly formed in a German context: he had studied at the Stuttgart's Caroline academy from 1787 to 1788, and throughout his life maintained a correspondence with Christian Heinrich Pfaff, the German professor of medicine and chemistry. In these letters it can be seen that between 1788 and 1790 he speculated in a Blumenbachian manner about the derivation of the races. Cuvier met Carl Friedrich Kielmayer in 1785 and studied dissection with him, and in 1792 he asked Pfaff for transcriptions of Kielmayer's lectures on physiology. Kielmayer was an important figure in the naturalisation of teleology with his acknowledgement of and classification of forces in the animal reign.[44] To establish his allegiance to Kant's principles, which he knew very well, however, is difficult solely on the basis of manuscripts of his lectures, yet we can suppose that he taught some Kantian ideas.

For Cuvier, comparative anatomy aims at knowledge of the functioning animal. He held that 'the machines which are the object of our investigations cannot be disassembled without being destroyed'.[45] Therefore, the comparisons between two species performing the same function differently enable us to understand *what* an organ's function is and

[41] On this point see Richards (2000).

[42] However, Reill (2005) defends the difference between Kant and *Naturphilosophie*, arguing that Kant is in a moderate sceptical tradition proper to the Enlightenment that he called 'Enlightenment vitalism', which reacted to the absolutism of mechanical explanation in natural sciences, and that *Naturphilosophie*, with its absolute ambition and its totalistic view of nature, broke with this tradition.

[43] Cuvier (1805), p. 6; my translation.

[44] On Kielmayer and his influential unpublished discourse of 1794, see Richards (2002), Ch. 3, Reill (2005), pp. 191–195, and Coleman (1973).

[45] Cuvier (1805), Vol. I, p. v; my translation.

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how this organ functions. In this manner we also see what would follow from the presence and the lack of an organ, and from its union with another organ. For example, animals which have relatively small lungs have a big liver, while insects whose bodies are like 'a big lung' have no liver; Cuvier concluded that the liver removes from the blood its 'combustible principle'.[46] So, we can explain functions, and we do that because there is no longer a one to one correspondence between a function and an organ, but two series of correspondences, that between one function (such as locomotion) and several organs in several groups, and that between one organ (such as the anterior member of vertebrates) and several functions. Thereby the gap between structure and function becomes epistemologically productive in establishing the anatomical comparison into a physiological instrument of knowledge.[47]

But not any combination of organs is possible. All combinations, possible or realised in the animal kingdom, are submitted to the 'principle of the conditions of existence', which Cuvier added is 'vulgarly called principle of the final causes'. According to this principle, 'all the organs concur to a common purpose; hence, the alterations of one of them produce an influence over all the others'.[48] This common purpose is the existence of the animal in its milieu. Having to survive, the animal must be able to exert its vital functions in a manner and following an order which are not constrained by the milieu. For example, a carnivorous animal must be able to chew its prey, so it will have teeth, but it must also be able to catch its prey, so it must have prehensile organs and claws, and must move quickly, and see things at a distance. The existence of one physiology function (namely here carnivorous digestive system) entails the corresponding adaptations. But contrary to Ospovat,[49] it is not that adaptation is perfect, rather it is that the emphasis on physiological function makes *ipso facto* its realization perfect: if an animal is to be carnivorous, its organization has to be such and such to fulfil digestive and ingestive functions, and since it will be able to eat meat, its organization must be well fitted to catch prey, and hence will be adapted to its milieu. It is not that the animal is held to fulfil a role that is predefined, rather it means that its functional coherence is able to cope with its milieu in an adapted manner.

The 'principle of the conditions of existence' leads to another principle, the 'principle of the correlation of parts'. The principle is a regulative one, providing a rule for knowledge, be it anatomical or paleontological. Famously, Cuvier showed how he could infer the complete animal from one singular fossil bone in the prologue of the *Investigations on the fossil bones of quadrupeds*, entitled 'Discourse on the revolutions of the earth' (1805). Of course, his claim was quite exaggerated, but it is clear that, like Kant's 'idea of a whole' as *Erkenntnisgrund*, the principle of the correlation of parts, applied to a part of an animal, makes intelligible the *form* of the part and its connections to other parts. Cuvier did not claim that the animals are built to reach a goal, but rather that we must presuppose a principle according to which the parts are linked and the functions to which they contribute co-ordinate themselves.

[46] Ibid., p. 5.

[47] It is still disputed whether Cuvier's concept of function means the fulfilment of an adaptive role (an interpretation widely defended by Ospovat (1978), and subscribed to by Amundson (2005), pp. 41–44, or whether this notion has to be primarily understood in a physiological sense, independently of environmental demands, as claimed by Caponi (2004). See our position below.

[48] Cuvier (1817), p. 46; my translation.

[49] Ospovat (1978).

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The use of the principle of correlations by Cuvier in reconstructing extinct vertebrates clearly illustrates Kant's idea of a regulative principle. The parts—here, for example, the bones of the legs and claws or jaw—are conditioned by the total form of the animal (more precisely, the viable, functioning form). And the necessity that links those parts to the whole is not the same as the *causal necessity* of mechanisms—since there might have been some dysfunctional and abnormal vertebrates in which parts are misconstrued—but is a kind of conceptual necessity. If X is a specific kind of animal, and if a part is so and so and if it is the part of a carnivorous animal in general, then the other parts must be so and so; but nothing in the physical laws of nature guaranteed that this animal had to be viable and live. It is not because it lived that it had its parts correlated in such a way, but it is because its parts were correlated in such a way that it could live. The correlations assumed by the principle of the conditions of existence are necessary correlations that pertain to another kind of necessity than that of the mechanisms of nature. Paleontology as well as comparative anatomy are rational investigations of those specific necessities, neither of which would be possible without such regulative principles.

Cuvier thus reassessed the Kantian dismissal of the equivalence of utility and finality in natural history: while Kant threw away 'relative finality' in §63 of the *Critique of judgment*, Cuvier's principle focused on the animal itself as existing, thereby discrediting relative purposiveness in favour of internal purposiveness. The totality of relationships instantiated by an organism is a condition of possible existence in a given milieu: so it is an adaptive structure, articulating adaptive functions oriented towards the proper functioning of a given physiological structure. Here, we meet again the Kantian idea that the regulative principles in biology should ascribe an adaptive dimension to the structures set at the origin of life—Kant's idea of an 'original organization', with its adaptive dispositions.

Cuvier did not, of course, create comparative anatomy. He made extensive use of Vicq d'Azyr's studies in his *Discourse on comparative anatomy* (1764), particularly the idea that there is a constant conjunction between superficial organs and hidden vital organs, which implied that any classification based on visual criteria had to state actual functional correlations, and, most of all, of Vicq's suggestion that comparative anatomy should not be devoted to the study of external organs, but must takes viscera into account. But Cuvier settled it into the natural teleological framework he inherited through his German formation.

Cuvier might be regarded as a follower of Kant. His emphasis on function and adaptation renders his discourse faithful to Kant's position. Concerning spontaneous generation, for example, he argued that organic matter is organized from the beginning. This organization is to be conceived not so much as a structure as a kind of motion, what he called 'tourbillon vital', since he had no real way to describe it with satisfactory concepts. But what is important here is the boundary drawn between organic and inorganic matter, and the fact that the laws of inorganic matter do not allow us to explain or predict the characteristics of organisms, since pure chemistry applied to the 'tourbillon' always tends to its destruction. Cuvier's presentation of vital organization is the synthesis of Kant's insistence on the boundary between organized and unorganized beings, and Stahl's idea of a generalized fight between organic matter and chemistry, which involves a dynamic relation between the organized and the unorganized.[50] Regarding generation,

[50] One can see a parallel here to his contemporary Bichat, who argued that 'life is the set of forces which resist death' at the beginning of his *Physiological investigations on life and death* (Bichat, 1800).

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Cuvier would advocate a kind of epigeneticism close to that of Blumenbach: firstly, because in epigenesis the sets of conditions of existence are articulated in their general features, exactly in the same way that germs and dispositions are articulated in Kant's conception, so that external causes can not modify them arbitrarily; and, secondly, because they are given from the beginning, rather than constructed through the effect of the environment according to mechanical laws. Although those questions are not central to comparative anatomy, they would be answered by Cuvier in a quasi Blumenbachian or Kantian manner.

More generally Cuvier's emphasis on adaptive functions as a regulative principle settled his position on the fixity of species. As Ospovat (1978) has argued, Cuvier's idea that animals are adapted to their milieu makes unconceivable any transformation of species, as he would argue against Lamarck and later Geoffroy. Only catastrophes—and not a process inherent to living species—can account for the extinction of prehistoric species. This result fits Kant's considerations in the review of Herder. Cuvier's argument, relying on the 'principle of the conditions of existence' (that justifies ascribing adaptive functions to organisms), and hence on a regulative principle proper to biological knowledge, would not have been disavowed by Kant. However, I will now argue that another interpretation of the regulative judgment would allow figures like Goethe or Schelling and later Geoffroy Saint-Hilaire to overcome this Kantian caveat.

3. Kant's archaeology of nature

I will now consider Kant's idea of an 'archaeology of nature', which he incidently mentions in §80 of the third *Critique*. This discussion marks a shift from his position in the review of Herder and the doctrine of generation and heredity that Kant presented there, because it is implicitly based on a concept of type. This discussion will allow us to understand the reading of Kant undertaken by those, like Goethe, who will be concerned by a science of biological form.

In §80 of the *Critique of judgment*, Kant considered comparative anatomy and the possibility of an 'archaeology of nature'. His point was that the possibility of a real common parenthood between the species is attested by the extensive analogies of form that comparative anatomy unveils, a parenthood that would mean a mechanistic derivation of the entire living realm. The quest for parenthood is justified by the rational requirement for systematicity: according to the 'Appendix' of the 'Dialectic of teleological judgment', this requirement entails that one has to presuppose and seek *Verwandshäfte* amongst the natural entities. Since there are genuine causal relationships between instances of biological varieties—unlike the genera of minerals, for example—the idea occurs of a system of genera of organisms with causally real (e.g. generational) links. Animal diversity could then be produced by mechanical transformations acting upon a unique pattern or type. The visible morphological homeomorphisms between species are clues to the real processes of transformation:

> So many genera of animals share a certain common schema on which not only their bone structure but also the arrangement of the other parts seems to be based; the basic outline is admirably simple but yet was able to produce this great diversity of species, by shortening some parts and lengthening others, by the involution of some and the evolution of others. Despite all the variety among those forms, they

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> seem to have been produced according to a common archetype, and this analogy among them reinforces our suspicion that they are actually akin; produced by a common original mother.[51]

This is an 'archaeology of nature', and seems to reject the transcendental bipartition between teleology and mechanism: apparently, we could reduce teleology to a mechanical production of the multiple species.

> When the archaeologist of nature considers these points, he is free to have that large family of creatures (for that is how we must conceive of them if that thoroughly coherent kinship among them is to have a basis) arise from the traces that remain of nature's most ancient revolutions, and to have it do so *according to all the natural mechanisms he knows or suspects*. He can make mother earth (like a large animal, as it were) emerge from her state of chaos, and make her lap promptly give birth initially to creatures of a less purposive form, with these then giving birth to others that became better adapted to their place of origin and to their relations to one another, until in the end this womb rigidified, ossified, and confined itself to bearing definite species that would no longer degenerate, so that the diversity remained as it had turned out when that fertile formative force ceased to operate.[52]

But this archaeology, according to Kant, cannot go further than the first, simplest, species, so it is still necessary to presuppose an original organization, and thus teleology remains uncorrupted:

> And yet in giving this account, the archaeologist of nature will have to attribute to this universal mother an organization that purposively aimed at all those creatures, since otherwise it is quite unconceivable how the purposive form is possible that we find in the products of the animal and plant kingdoms. But if he attributes such an organization to her, then he has only put off the basis for his explanation and cannot pretend to have made the production of those two kingdoms independent of the condition of requiring final causes.[53]

Kant's target here was spontaneous generation, as a form of radical epigeneticism. In considerations of the history of life, radical epigeneticism is a consequence of theories that conceived races and varieties as created by contingent circumstances: under such a view, there would be no limit to the creation of races or species. Herder was still Kant's principal target here, and reading these passages in the *Critique of judgment* we cannot but remember Herder's argument in *Ideas for a philosophy of the history of humanity* (1784):

> It is undeniable that given all the differences of living creatures on the earth, generally a certain similarity of structure or a principal form seem more or less to govern, a form that mutates into multiple varieties. The similar bone structure of land animals is obvious: head, rear, hands and feet are generally the chief parts; indeed the principal limbs themselves are formed according to one prototype and vary in almost infinite ways.[54]

[51] Kant (1910–), Vol. 5, p. 418; translation modified from Kant (1987), p. 305.
[52] Ibid., p. 419; my emphasis; translation modified from Kant (1987), p. 305.
[53] Ibid.; translation modified from Kant (1987), p. 305.
[54] Herder (1985), Vol. 6, p. 63; my translation.

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It seems that Herder represented for Kant the consequences of theories which regarded varieties as deriving solely from the action of the environment. The paradigm for such theories is Buffon; indeed, Kant's account of one main argument supporting this Herderian project in §80 is reminiscent of Buffon's famous paragraph on the natural history of the ass.[55]

But such a hypothesis has some supporting evidence, so that even the most perspicuous scientists get attracted by it, which becomes for them a 'daring adventure of reason': 'a hypothesis like this may be called a daring adventure of reason, and one that has probably entered, on occasion, even the minds of virtually all the most acute natural scientists'.[56] Kant's reconstruction of such a program was twofold. Firstly, he pointed out that it is based on evidence from comparative anatomy: the forms of animals seem to be generated from one another through homeomorphisms. Recall that under the name 'history of nature' [*Geschichte der Natur*] Kant advocated a consideration of nature viewed through the laws of reproduction and heredity, which establishes real genera (e.g. genera defined by the reproductive criterion), opposing such a theory to a description of nature [*Naturbeschreibung*] (e.g. Linnaean natural history).[57] Incorporating the evidence from comparative anatomy would be an argument for extending the *history* of nature towards an *archaeology*, which means a generation of the *whole* organic nature (and not only races and species) from brute matter. Secondly, Kant considers a kind of Buffonian theory of races, which states that the environment causes the transformation of stocks—hence, races and even species could be generated from one another. It could be argued along these lines that, in the end, the correspondence between environment and races is reached through the purely causal action of environment—to this extent §80 speaks about the emergence of fitter varieties ('giving birth to others that became better adapted to their place of origin and to their relations to one another'[58]), which suggests some progress. Thus the transformations of forms through homeomorphisms would introduce the idea of a generalized archaeology of nature according to mechanistic laws, with a sort of Buffonian theory providing the mechanisms for these developments. But Kant insisted that even such a theory presupposes an original organization and teleology, since it is based upon some initial organisms.

Nevertheless, *conceptually speaking*, the adventure of reason is grounded in the Kantian schema itself: if a species is defined by germs and dispositions, potentially adaptive, found in an 'original organization', and if the several varieties are different subsets variously activated in this organization, we could say the same thing for species compared to a genus, and so on. So it could be expected that the third *Critique* would examine this hypothesis.

Kant's argument here, however, is more complex than his previous attack on Herder. A *restricted archaeology of nature* concerning the species of living beings is *transcendentally* possible according to his own principles of germs and dispositions, and that a variety might be included in a set of dispositions is ultimately a matter of *empirical testing*. 'This

[55] Buffon (1753), Ch. VII.

[56] Kant (1910–), Vol. 5, p. 421; translation modified from Kant (1987), p. 307.

[57] For example, see *Ueber den Gebrauch teleologischer Principien in der Philosophie* (ibid., Vol. 8, p. 163), translated in Kant, 2001).

[58] Ibid., Vol. 5, p. 419; translation modified from Kant (1987), p. 305.

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is not a priori inconsistent in the judgment of mere reason'. So here reason does not 'shrink back' (as he wrote about Herder's *Ideas*). Organized beings generate organized beings: it is 'generatio *univoca*', not 'generation *equivoca*', which mixes organized and unorganized beings. The question is whether this generation is *homonymous* or *heterogeneous*, meaning whether an organization of a given type generates only organization of this type or not. This is strictly an empirical issue; one can empirically assess whether some new features of an organism manifest a set of previously non-manifested dispositions or not. 'Experience however does not show an example of it. The only generation we know from experience is a generation that is not only univocal—as opposed to aequivoca, from unorganized material—but also homonyma, where the product shares even the organization of what produced it. As far as our empirical knowledge of nature goes, we do not find anywhere a *generatio heteronyma*'.[59] We have no evidence for such a transformation since empirically we only know generation within a species: no one has witnessed individuals of a species giving birth to individuals of another species. Therefore a more radical archaeology, one advocating the transformation of species, is not *empirically* plausible. Transformationism is transcendentally possible but deprived of any empirical evidence.

This paragraph of the *Critique of judgment* appears less radical than the review of Herder's *Ideas*, because it does not state that an archaeology of nature is impossible. In the third *Critique* the perceived danger is no longer the suppression of the principle of species as a maxim of order, which would be challenged by a restricted archaeology of nature (e.g. transformism). In effect, the order of nature has already been guaranteed by the demonstration of the autonomy of the reflecting power of judgment in the 'Introduction' of the text. The *same* reflecting power of judgment has as its principle the presupposition of the general purposiveness of nature (e.g. its systematicity) *and* the concept of natural purposes. As long as the concept of natural purpose is preserved, namely, as long as the boundary between organisms and brute matter is not attacked, then the presupposition of systematicity—relying on the same power of reflecting power of judgment—remains intact.[60] Hence, unlike what Kant said in the review of the *Ideas*, one can conceive of a restricted archaeology of nature according to mechanical laws, to the extent that this archaeology rests on the presupposition of an original organization. The truth or falsity of such a scientific hypothesis is just a matter of fact. This difference is a consequence of the shift Kant effected in the

[59] Ibid., p. 421; translation modified from Kant (1987), p. 307.

[60] More precisely, since the principle of the purposiveness of nature is given by the reflecting power of judgment, we will have a unity of empirical laws. The order of nature is then warranted, and whether or not all the original organizations pertain to one and the same organization, and hence all the species turn out to be races of a single original species, is an empirical question; however, in both cases the organic nature is ensured to be systematic (the question being to what degree). The same reflecting power of judgment transcendentally ensures this systematicity and the concept of natural purpose, so no restricted archaeology of nature, that is, no derivation of several kinds of original organization as realizations of natural purposes, can threaten this systematicity (in contrast to Kant's argument in the review of Herder). But if there is no natural purpose, if original organization is proved to result from inorganic nature, then we can not rely on this systematicity, and the order of nature is threatened. One might object that natural purposes (hence the discontinuity between organic and inorganic nature) challenge the systematicity of nature, and that this is precisely the problem of the 'Antinomy'. But the fact of natural purposes threatens here another kind of systematicity, the universal system of mechanical laws, which is more a priori, and is not this systematicity established by the power of judgment.

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Critique of judgment when he ascribed the concept of purposiveness to the power of judgment rather than to reason (as in the first *Critique*).[61]

But what is relevant for subsequent developments in the study of organized beings is that Kant grounded the archaeology of nature on *comparative anatomy*, with his aim being to dismiss any purely *mechanical generation* of species and whole nature.[62] His arguments are precisely the features noted by zoologists: in some species, two bones of a parent species become one by fusion. But, as I am about to show, Kant's argument *describing* the clues for an archaeology of nature that he rejected, will be used by Goethe to *initiate* this archaeology and then to dare the forbidden adventure of reason.

4. Science of form: reinventing the archaeology of nature

I will now show in which manner Goethe's project of a science of forms as science of transformations relies on the same premises as Kant's idea of archaeology of nature, but nevertheless reaches an opposite result regarding the legitimacy of an adventure of reason, and thereby opens new pathways for morphology, as is attested by Etienne Geoffroy Saint-Hilaire's main achievements.[63]

A major step in the constitution of a science of form is Goethe's botany and zoological morphology and its concept of primordial type or *Urtypus*. Although Goethe's influence as a scientist is difficult to establish since he was perceived primarily as an artist by his contemporaries,[64] he still had scientific disciples, such as Voigt, especially of his *Metamorphosis of plants*, and his general approach towards the organic world was diffused in the general culture of *Naturphilosophie*. Goethe acknowledged that his program was highly influenced by Kant: 'Then the *Critique of judgment* fell into my hands and with this book a wonderful period came into my life'.[65] Yet in a retrospective memoir, Goethe said that in the 1790s, together with Herder, he embarked on precisely the 'adventure of reason' that had been prohibited by Kant.[66]

First of all, it is important to recognize the proximity of Goethe and Kant concerning the *idea of organic purposiveness*. Goethe shared with Cuvier the rejection of final causes as considerations of utility. Whereas Cuvier, after Kant, rejected utility as an operative concept, Goethe went even further in this dismissal. He explicitly acknowledged that it was

[61] Phillip Sloan (in this issue) defends the view that §80 belongs to Kant's progressive distancing of himself from the ideal of a 'history of nature', and marked a return to his defence of the more traditional *Naturbeschreibung*. The critical turn, by casting doubt on any account of origins in the 'Dialectic of teleological judgment', rendered an investigation of the history of organic nature from its beginnings—hence the very notion of a history of nature—quite problematic. However, the case considered by Kant in §80 is very specific, because, with regard to organisms (as opposed to nature in general), the 'history of nature' and the 'description of nature' are not two epistemologically discrete programs: description might be a clue for history, since affinities (*Verwandschäfte*, in the 'Appendix' of the 'Dialectic of teleological judgment') cover some of the causal processes of descent. It is a reworking of the relationships between *Naturbeschreibung* and *Naturgeschichte* in the specific case of the organic realm, rather than a re-evaluation of those two programs in general.

[62] I use the definition of mechanism from §64, which states that mechanical explanation proceeds from the parts to the whole, notwithstanding the criticisms of Hannah Ginsborg (2004) addresses to McLaughlin's interpretation of mechanism along those lines in McLaughlin (1990).

[63] On Goethe's method, see Amrine, Zucker, & Wheeler (1987), and Richards (2002), pp. 413–491.

[64] On this issue, see Steigerwald (2002).

[65] 'The influence of modern philosophy', in Goethe (1995), p. 29.

[66] *Anschauende Urteilskraft*, in Goethe (1987), Vol. XII, pp. 98–99, and Goethe (1995), p. 32.

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thanks to the third *Critique* that 'the antipathy (he) felt toward ultimate causes was now put in order and justified'.[67] The contradiction between this relative or external purposiveness (which §63 of the *Critique* dismissed) and biology is explicitly stated: 'the progress of natural philosophy has been obstructed for many centuries by the conception that a living being is created for certain external purposes and that its form is so determined by an intentional primal force'.[68] The language of 'conditions' is substituted for the language of purposes:

> The statement 'the fish exists for the water' seems to me to say far less than 'the fish exists in the water and by means of the water'. The latter expresses more clearly what is obscured in the former; i.e. the existence of a creature we call 'fish' is only possible under the conditions of an element we call 'water', so that the creature not only exists in that element, but also develops there.[69]

This kind of deflationist account of purposiveness ties together Cuvier's program in comparative anatomy and Goethe's morphology, with both being closely concerned with Kant's formulation of natural purposiveness, or epistemological purposiveness without transcendent intentions.

Goethe's concern was to establish the *type* of living creatures, both in botany and in morphology, and this appears clearly connected to Kant's reference to a 'common archetype' mentioned above.[70] Goethe started with the desire to find the 'primordial plant', the *Urpflanze* he thought he had recognized in the botanical gardens of Palermo.[71] He then moved toward the definition of an original form from which all the stages of a plant could be constructed. In fact, the *Metamorphose of Plants* shows that a leaf can become all of these stages, through some regular transformations; and all the plants as cycles of transforming leaves appear to be deducible from a general pattern of transformation in a non-genealogical but ideal or morphological manner. Hence there are two levels of morphological processes, the first one (cycles of the leaf) allowing us to understand the second one (the system of plants). Metamorphosis is thus an ideal process of generation of the principal vegetal forms. Such a transforming leaf, of course, becomes 'transcendental' because it is less a real thing than a concept of a non-physically attested entity used to describe the real processes. That is why Goethe's type is a dynamical one, as Brady (1987) shows, a dynamical scheme through which two plants can be related because they can both be situated in the same transformation process, a process that happens ideally, not physically It is exactly like homeomorphisms allowing us topologically to relate two figures, this homeomorphing having not yet been used actually to produce a figure.

Goethe writes: 'The organ which expanded on the stem as a leaf, assuming a variety of forms, is the same organ which now contracts in the calyx, expands again in the petal, contracts in the reproductive apparatus, only to expand finally as the fruit'.[72] (Such a description of the various features of plants belongs to the same lexicon of homeomorphisms that §80 of the *Critique of judgment* used about skeletons at about the same time, as discussed

[67] 'The influence of modern philosophy', in Goethe (1995), p. 29.
[68] 'Toward a general comparative theory', in ibid., pp. 54–55.
[69] 'Ibid., p. 53.
[70] Kant (1910–), Vol. 5, p. 418.
[71] April, 1789, *Italienische Reise*, Goethe (1978), Vol. 15, p. 237.
[72] *Metamorphosis of plants*, §115, in Goethe (1995), p. 98.

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above.) This sentence provides a good way to spell out the contrast between a genealogical or archaeological explanation and an ideal explanation: the actual sequence of events does not matter in the ideal one. What is regarded as temporally earlier forms can be described as modifications of later forms, so long as one is speaking ideally. They are different manifestations of 'the same' organ.

This concern for a type then impinged on Goethe's anatomical work, taking him even closer to §80 of the *Critique of judgment*. In 1795, he began to publish similar views about comparative anatomy of the vertebrates, arguing that the bone will be for them what the leaf was for the plants.[73] Goethe wished to suggest 'an anatomical archetype', for example 'a general picture containing all the forms of animals as potential, one which will guide us to an orderly description of each animal'.[74] Hence, we conceive an invariant, the animal type, through recognition of constancies between species. This type allows us to 'describe individual species in terms of the archetype', and to 'trace descriptively a particular part of the archetype through all the major genera'.[75]

Those transformations of the archetype highlight *hidden continuities* in the series of animal forms. There is 'a gulf between the *os intermaxillare* of the turtle and the elephant, and yet an intermediate series of forms can be found to connect the two! What none would deny of the entire body could here be shown in a small part of it'.[76] Following this reasoning Goethe discovered the intermaxillary bone in humans in 1784.[77] The lines of juncture, in the vertebrae, are analogous in several species, including human beings and the monkey. Therefore, if the monkey has this bone, it should exist within human beings in a masked manner. So the type, as a construct, allows us to discover *non-immediately manifest entities*. Albeit ideal, types are a way to uncover empirical regularities, so the contrast between physical processes and morphological-ideal connections should not be too sharp, since the novel intelligibility established by Goethe resides precisely in their articulation.

Goethe's vertebral theory of the skull—later to be refuted by Huxley—is analogous to the botanical theory of the *Urpflanze*. The form of the entire animal is conceived through the regular transformation of one abstract or 'transcendental' element. The form, as type, is understood through being reinserted in the process of the logical transformation of an archetype. That is why for Goethe the science of form is *ipso facto* a science of transformations. In this context, Goethe could claim that he achieved this critically forbidden program of archaeology of nature. Notice that unlike Kant, the types are accessible through empirical phenomena; and on the other hand they are more metaphysical than Kant's regulative ideas, since Goethe would infer their objective existence from their necessity for our cognition of organic morphologies, since they are somehow visible.[78]

[73] 'As I had earlier sought out the archetypal plant I now aspired to find the archetypal animal', 'Preface' to *On morphology*, in ibid., p. 68.

[74] 'Outline for a general introduction to comparative anatomy commencing with osteology', in ibid., p. 118.

[75] 'Ibid., p. 119.

[76] 'An intermediary bone is present in the maxillar jaws of man as well as in the animals', in ibid., p. 116.

[77] Whereas his essay was written and began to be circulated in 1784, it was only published with his morphological works in 1820. On this episode, see Richards (2002), pp. 371–377. Herder—it is worth noting—was enthusiastic about this idea, which of course gave support to the kind of archaeology of nature he vindicated and that Kant rejected.

[78] Given their cognitive function, and the fact that they are not immediately given in phenomenal data, I call them 'transcendental' to emphasize that they work in our knowledge of the living work in a similar manner than Kant's regulative ideas, notwithstanding that Goethe would account for them in a different manner.

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But in these developments of his theory of type Goethe departed radically from Kant: Kant's point was to restrain mechanism as an exploration of types; while Goethe's point was an ideal reconstruction of *Urtypus* with analogies, without regard for the mechanical laws according to which the different empirical instances of types derive from one another. In Goethe's account, the first part of Kant's argument about the archaeology of nature, namely the connection of the idea of types and inclusion of types in broader forms, or the morphological part, became disconnected from its second part, namely issues about the processes of mechanical generation. Empirical production of tokens or real processes were *bracketed by Goethe*, allowing him to propose a science of forms, e.g. a science guided by and directed towards the construction of the zoological type. The explanation of the empirical forms and of their relations is not the numerous real mechanical processes that underlie the production of organisms. Goethe's neutralization of the Kantian veto of a generalized archaeology of nature was *a shift in the idea of explanation*, which separated 'explaining' from 'identifying some processes'. As Goethe stated in the *Metamorphosis*, knowledge of plants means 'establishing the rules of transformation through which nature can produce the most varied forms through modifying one unique organ'.[79] Even if in the end the ideal connections of types and their derivation from archetypes might refer to real processes, they do not involve the same explanatory strategy as physical mechanical causal processes underlying the generation of individual organisms; and unlike in Kant the discovery of the geometrical connections of types is linked only to this ideal-morphological explanatory strategy. In this viewpoint, the restricted archaeology of nature, which was for Kant logically possible but empirically false, becomes true because the same set of empirical evidence is no longer needed. Even if no one has experienced heteronymous generation—a wolf generating a dog, for example—it is no longer important since production of types as deriving from a transcendental archetype is not understood to be an actual physical process. The type of an animal is still a product, but a product of ideal transformations (whereas the instantiation of a type is a product of a mechanical transformation: generation); exactly as the form of the petal is the product of the ideal transformations of a transcendental leaf, but not in the same sense as a concrete petal is the product of generation.[80]

This schema of explanation makes Goethe's position on epigenesis understandable. On the one hand, he totally agreed with epigeneticism, and approved of the theories of Wolff and Blumenbach.[81] He argued that the kind of generation of plants through the continued and repeated action of the same force on elementary parts, which accounts for the epigenesis of plants, was seen by Wolff but better understood in his own *Metamorphosis of plants*.[82] But

[79] *Metamorphosis of plants*, §3, in Goethe (1995), p. 76.

[80] Obviously, Goethe was not indifferent to the physical processes of generation, and he shared with Herder the concern for physical origins of life. He says, for instance: 'our daily conversation was concerned with the primal origins of the water-covered earth and the living creatures which have evolved on it from time immemorial. Again and again we discussed the primal origin and its ceaseless development' ('Preface' to *On morphology*, in ibid., p. 69). However, even if this formulation would not resist the objections to such a project stressed by Kant in §80 of the *Critique of judgment*, I am arguing here that Goethe's conception and achievement of morphology itself, with its idea of type, is logically independent from those concerns and avoids Kant's critique.

[81] 'The formative impulse', in Goethe (1995), p. 35.

[82] 'During the development of the plant, he saw that the same organ contracts and narrows constantly, but did not see that this reduction alternates with an expansion. He saw that the volume diminished, and did not recognize that in the same time the organ gets refined; hence he wrongly ascribed to an atrophy this way to perfection'.

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closer examination, as emphasized by Joan Steigerwald (2002) reveals that this agreement hides a difference of explanatory interest. While Wolff and Blumenbach are interested in the controlled perturbations of development that unveils the specific stages and antagonisms of embryogenesis, Goethe is concerned with the construction of a type of plant that underlies the whole process.[83] Where Wolff emphasized the *vis essentialis*, which is a kind of transcendental force guaranteeing the continuity of the embryological process, Goethe highlighted the transcendental leaf, the form which is acted upon by the forces. That was the meaning of his critique of Blumenbach.[84] Here there is a common ground between Kant (emphasizing self-organization as definitive of organisms, as found in §65 of the *Critique of judgment*) and the early embryologists that is alien to Goethe, who was pursuing another line of thought.

But the interesting point, is that Goethe's reference to Kant when he wrote of the 'adventure of reason'[85] situates the problematic of type within the Kantian problem of determining the boundaries of an original organization, that Kant addressed in §80. The crucial point here is the shifting context of the archaeology of nature—from Kant's question about the limits of mechanism to Goethe's attempt to draw a logic of form, which was later to be reinforced by Schelling's *Naturphilosophie*.

If indeed Goethe can be seen as a non-professional scientist (since he was above all a poet), a strong connection can be made between *Naturphilosophie* and comparative anatomy and the later transcendental morphology. For example, the connection between Oken and Owen is now well known—Phillip Sloan's as well as Philip Rehbock's work on this period of biology have been essential to reincorporate this kind of science into the main history of science.[86] The figure most faithful to Goethe's program was the French naturalist who inherited the tradition of *Naturphilosophische* morphology, the one who has been accused of being speculative (especially by Cuvier in their famous debate at the Museum in 1830[87]) namely Etienne Geoffroy Saint-Hilaire. Goethe's famous words to Eckermann in 1830, about forgetting the political French revolutions in favour of the debate at the museum, acknowledge the proximity between his program and Geoffroy's.

Aiming to state the most general type in the animal kingdom, Geoffroy departed from Goethe in creating his own concept of form. In his *Anatomical philosophy* he did not consider the shape of each bone, but rather the relationships and the positions of the bones connected to one another. He was thus able to determine the invariants, despite the changing shapes of bones by fusion, widening, sharpening, etc. His rule was named 'principle of connections'. Commenting upon it, he indicated that he 'prohibited any consideration of

[83] 'The laws of *Lebenskraft* were purely functional; Goethe's law, in contrast, addressed strictly formal constraints' (Steigerwald, 2002, p. 299).

[84] 'Admittedly, the theory of encasement quickly becomes unacceptable to the well-educated. Nonetheless, any theory of accommodation will have to presuppose something which adapts and something to which it adapts; if we want to avoid the concept of preformation we will arrive at a concept of predelineation, predetermination, prestabilization or whatever we wish to call the process which would have to occur before we perceive a thing' ('The formative impulse', in Goethe, 1995, p. 36). These words are similar to Kant's theory of 'generic preformationism', of course. However, in the context of Goethe's morphology and botany, the general idea of Kant, who linked his original organization with adaptive dispositions, is accentuated rather towards a structuralist interpretation, stressing the form rather than the forces of development.

[85] Goethe also quotes Kant's acknowledgment to Blumenbach in §81 of the *Critique of judgment*, (ibid., p. 35).

[86] See his 'Introduction' to Owen in Sloan (1992) or Sloan (2003), and Rehbock (1983).

[87] Regarding these accusations, and Geoffroy and *Naturphilosophie*, see Apel (1987).

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form and use', reinforcing Cuvier and Goethe's dismissal of final causes.[88] Thus he still stood in the Kantian territory of a naturalised teleology. The principle of connection led Geoffroy to acknowledge a unique plan across Cuvier's four embranchements. Whereas Cuvier distinguished the vertebrates and articulates (the insects and the crustaceans), through his principle of connections Geoffroy correlated the six segments of the insect's structure with the six vertebras of the vertebrate spine: while the first three segments stem from a decomposition of the vertebrate's skull, the following three correspond to thorax, abdomen and coccyx. He could then identify the articulated organisms with the vertebrates, because the connection plan of the segments stays the same—'an animal lives in or out of its spinal column'.[89] Finally, this unity was also applied to the internal organs: a lobster's structure can be connected with a mammal's structure by rotating the lobster's spinal cord 180 degrees. With this principle a rule is provided to design the most general forms transmitted by heredity, and to determine how the animals are build.

Two important consequences follow. Firstly, for Geoffroy *form* is no longer the visible shape but is now an invisible setting that is grasped only through the principle of connections, because it no longer concerns the organs but just the materials of the organs.[90] Only this invisible form can ground the genealogical connection between species, be this connection understood as ideal or as real.[91] Of course, neither the genuine production of individuals nor the production of types (this is only the case with Schelling) is not at stake here, but only their reconstruction.[92] In a way, Geoffroy's principles enable the biologist to grasp what Kant labelled an 'original organization'. Hence, the second point: the type, as thought by Geoffroy, is constructed in our judgment about the animals; this would allow his disciples to assert a large unity of plan. It is not a law of nature—such as the a priori laws of physics—but is a totality reconstructed a posteriori by us in order to describe the living creatures, and to put some order into the functional diversity of animals. Therefore, the guiding principle of connections is a regulative principle in a Kantian sense. For this reason, it is possible to trace it back to the 'original organization' without violating the strictures placed on reflecting power of judgments by Kant. The 'adventure of reason' is possible with no unfaithfulness to Kant, since the archaeology of nature has shifted from a mechanical strategy to a regulative reconstruction of the invisible forms underpinning the different compositional structures of organisms. As a *Naturphilosopher*, Geoffroy in fact achieved the archaeology of nature Kant formulated. He explicated the

[88] Geoffroy Sainte-Hilaire (1818), p. 445; my translation.
[89] Geoffroy Sainte-Hilaire (1820); my translation.
[90] Geoffroy Sainte-Hilaire (1990), p. 6.
[91] It is still unclear if in Geoffroy's school and his German transcendental disciples the ideal morphological derivation was really separated from the natural sense of production of species. In Richards (1992), Richards argues that they were actually evolutionists, conceiving real processes in nature, and that Darwin inherited some of their ideas about progress. However, the kind of processes they had in mind, if any, were not at all the same as the Darwinian ones. As to Geoffroy, he became more and more a Lamarckian. But concerning the issue addressed here, Geoffroy belonging to a tradition of form-biology and its relationship to Kantian purposiveness, this is not so relevant.
[92] Of course, generation is closely related to the establishment of types, since some derivations can only be seen at early embryonic stages. Hence embryology is relevant for Geoffroy's program, whereas it is not for Cuvier's program. This relevance will have important consequences in later morphology, both German and English. See Ospovat (1980), and Balan (1980).

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regulative principle that is involved in the idea of natural purpose when this purposiveness is understood in a formal sense. The types that can be reconstructed in this manner are not, of course, principles of production, but principles of cognition—exactly in the sense that Kant distinguished these two senses of teleology, the technical and the biological sense, in §65 of the *Critique of judgment*.

The only domain where types are productive in the third *Critique* is art. Yet for Goethe, types were more 'real' and objective than they were for Kant, and this surely encouraged his undertaking the 'adventure of reason'. Since he found in Kant the idea of a proximity between art and nature, allowing him to say that works of art are created through the same operations that the scientist uses to understand nature, he transferred the productivity of types in art to the productivity of nature, and then conceived the archetypes as producing the various species. He endowed archetypes with existence, hence for him forces were operating to give rise to types. However, those creative forces were not the usual physical forces involved in the generation of individual organisms; and for him only a kind of artistic intuition was able to give access to them.[93] His conception of the production of types, as well as Geoffroy's, was still demarcated from causal physical mechanisms.

Robert Richards (2002) has argued that some individuals elaborated on Kant's remark in §80 of the *Critique of judgment* to undertake an idealist-morphologist program. Phillip Sloan (in this volume) rightly emphasises that those, like the *Naturphilosophen* who thought they could rely on Kant's idea of organisms to grant their program in morphology, in fact misconstrued Kant's theory. This is clearly correct, but my purpose here was to understand how they misread it. My answer is that they switched the meaning of 'explanation' from the causal–mechanistic one to the ideal–formal. However, since Cuvier did not need this switch to elaborate his own program, I agree with Sloan that he was indeed the most faithful follower of Kant.

5. Conclusion

I have tried to show that Kant's concept of natural purpose ties together three forms of purposiveness in biology, on each of which it confers the same legitimacy based on transcendental considerations: function, adaptation and form (including its conservation). I focused primarily on the third point, as represented by Goethe and mostly clearly achieved by Geoffroy's principle of connections. In Geoffroy's *Anatomical philosophy* as well as in Cuvier's comparative anatomy and palaeontology can be found what Kant would have called 'regulative principles', which lead to specific reconstructions of organisms—two ways of apprehending what Kant called 'original organization' of organisms. The archaeology of nature that Kant famously forbade in the third *Critique* could be undertaken by Goethe and his followers precisely because they shifted its meaning, eliminating the mechanistic reading of 'archaeology of nature' that Kant held and replacing it by a formal reading. Archaeology of nature then became a field of reconstructing types, formal types rather

[93] This 'intuition of a continuously creative nature, of mental participation in its productivity' (Goethe, 1987, pp. 12, 98; 1995, p. 32) is one of the reasons Goethe suggested when he stated his undertaking of the 'adventure of reason'; however, I want to argue that this was accompanied by a shift in the idea of explanation that was essential in overcoming Kant's objection. That is why scientists like Geoffroy, disagreeing with Goethe about the role of art in science, still shared this 'adventure'.

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than functional types, and was finally achieved by Geoffroy's principle and his vindication of the unity of type.

The Geoffroy–Cuvier debate is thus not reduced to a misunderstanding, as Russell regarded it after Goethe, rather it concerned two heterogeneous conceptions of life. But the common language they spoke was the framework of naturalised teleology, in which two distinct principles—the Cuvierian and the Geoffroyan—were available as rules to construct an explanation of the proper features of living things, neither with commitments to a causal explanation by mechanical laws. In this context, the debate appears as a split between two axes in naturalised teleology. The first one is teleology as adaptation, and would be indicated, in the concept of 'original organization', by the concept of 'disposition'. The second axis is form-biology, best exemplified by Geoffroy, which followed the implications of the regulative presupposition of an invisible type hereditarily transmitted, a type which is not given a priori but must be a posteriori reconstructed.

Even if form-biology neutralised the functional and adaptational aspects because form is prior to adaptation to a milieu, as Geoffroy was led to emphasize, it is important to remember that the very concept of a form as transmissible and as invisible presupposes some of the teleological features stated by Kant with his 'original organization'. Naturalising teleology was therefore the very strategy of thinkers like Kant and Blumenbach, and has been conceptually formulated in Kant's work through the concept of natural purpose. Form-biology and adaptation-biology were two heterogeneous biological options that developed from this concept.

Hannah Ginsborg (2004) distinguishes two kinds of mechanical inexplicability in Kant: the first one, linked to the first criteria of natural purposes—irreducibility of wholes to the parts, which obtains also with machines; and the other one, linked to the second criteria, which is proper to *natural* purposes, and is the epigenetic character of the organism, since it self-organizes. A hypothesis would be that the first kind of inexplicability concerns the first reading of 'natural purposes', the functional-adaptive one (note that Cuvier's principle of conditions of existence could be renamed 'conditions of functionality' and applied to any machine. . .); and the second kind would concern the second reading of 'natural purposes', the one which deals with conservation of forms and was represented by Goethe and Geoffroy. This is very sketchy; one argument, however, could be found in Amundson (2005). The author claims that functional biology, represented by Cuvier and later by the Neo-Darwinists, for whom 'conditions of existence' prevail on 'unity of type', was not very interested in embryological processes. On the other hand, the 'structuralists' were inclined to study those processes. Hence the epigenetical character of organisms stated by Kant might be the proper focus of the 'form-oriented' reading of 'natural purposes'.

6. Uncited references

Cohen (2006), Kant (1998), Owen (1992), Sloan (2006).

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