



Contents lists available at ScienceDirect

Studies in History and Philosophy of Biological and Biomedical Sciences

journal homepage: www.elsevier.com/locate/shpsc

The Lenoir thesis revisited: Blumenbach and Kant

John H. Zammito

Department of History, MS-42, Rice University, P.O. Box 1892, Houston, TX 77251-1892, USA

ARTICLE INFO

Article history:

Available online 25 June 2011

Keywords:

Timothy Lenoir
 Johann Friedrich Blumenbach
 Immanuel Kant
 Teleomechanism
 Reflective judgment
 Intrinsic purposiveness

ABSTRACT

Timothy Lenoir launched the historical study of German life science at the end of the 18th century with the claim that J. F. Blumenbach's approach was shaped by his reception of the philosophy of Immanuel Kant: a 'teleomechanism' that adopted a strictly 'regulative' approach to the character of organisms. It now appears that Lenoir was wrong about Blumenbach's understanding of Kant, for Blumenbach's *Bildungstrieb* entailed an actual empirical claim. Moreover, he had worked out the decisive contours of his theory and he had exerted his maximal influence on the so-called 'Göttingen School' before 1795, when Lenoir posits the main influence of Kant's thought took hold. This has crucial significance for the historical reconstruction of the German life sciences in the period. The Lenoir thesis can no longer serve as the point of departure for that reconstruction.

© 2011 Elsevier Ltd. All rights reserved.

When citing this paper, please use the full journal title *Studies in History and Philosophy of Biological and Biomedical Sciences*

1. Introduction

Some thirty years ago, now, in pioneering work on the emergence of biology in Germany at the end of the 18th century, Timothy Lenoir formulated the thesis that the so-called 'Göttingen School' around Johann Friedrich Blumenbach took up methodological guidelines developed by Immanuel Kant and established a *strictly heuristic* (or in Kantian language, *regulative*) notion of 'teleo-mechanism,' whereby the imputation of natural teleology

(immanent purposiveness) to organisms was never an objective scientific knowledge claim.¹ Lenoir organized his reconstruction of German life science from 1790 to 1860 into three periods: those of 'vital materialism,' of 'developmental morphology,' and of 'functional morphology.' (Lenoir, 1981b, p. 298, 1989) My critique will concern his claims specifically concerning the 'vital materialism' of Blumenbach and the 'Göttingen School' in the 1790s.² While Lenoir has many interesting claims concerning 'teleo-mechanism' in the nineteenth century, these will not enter into consideration here.³

E-mail address: zammito@rice.edu

¹ 'My principal thesis is that the development of biology in Germany during the first half of the nineteenth century was guided by a core of ideas and a program for research set forth initially during the 1790s. The clearest formulation of those ideas is to be found in the writings of the philosopher Immanuel Kant. I do not claim that German biologists discovered a program of research in Kant's writings which they set out to realize in practice rather than in the latter part of the eighteenth century a number of biologists were seeking to establish a foundation for constructing a consistent body of unified theory for the life sciences which could adapt the methods and conceptual framework of Newtonian science to the special requirements of investigating biological organisms. Kant stepped into this ongoing dialogue and set forth a clear synthesis. It was through Blumenbach and his students that Kant's special brand of teleology entered biology.' (Lenoir, 1989, pp. 2–3) See also Lenoir (1978, 1980, 1981a, 1981b, 1988). For thoughtful critiques, see Caneva (1990), Richards (2002).

² I thank the peer reviewer on my piece for urging me to specify exactly what in Lenoir's thesis I am disputing and to cite sources. In that light, since my emphasis is on the Kant-Blumenbach relationship, I would point out that it is Lenoir's articles, not his book of 1982/1989, that spell out the details of his view, as he admits in the book: 'Elsewhere I have attempted to document in detail the relationship between these two men and the extent to which Blumenbach incorporated Kant's work into the mature formulation of his ideas.' (Lenoir, 1989, p. 22) He refers the reader specifically to Lenoir (1980). It is with that text (and the other articles) that I will be primarily engaging.

³ Of course, Kant was for nineteenth-century Germans an eminence fervently to be invoked as a model or warrant. (See Friedman & Nordmann, 2006). Yet whether the Kant they invoked was the historical Kant, and whether, more significantly, they really needed (or even used, rather than mentioned) Kant for their undertakings: these are matters that allow for more than one reading. That is, first: whatever they *thought* Kant meant (assuming we can establish *that*), there is a whole guild devoted to jousting over what Kant *really meant*, and jousting sometimes decide the best way to win the day is to proclaim what he *should have meant*. Usually that involves dismissing what others have thought Kant meant/should have meant. The nineteenth-century Kant reception falls fully within this conspectus, and Lenoir's book documents some striking instances of this. Second: the arguments of nineteenth-century biologists typically involved both theoretical and empirical elements that were simply not part of Kant's possible intellectual horizon, and these, rather than any direct appeal to Kant, appear far more plausibly central to their actual arguments, though Kant was always a rhetorical trump card, if he could be plausibly invoked. In any event, these are not questions here to be pursued.

In Lenoir's view, Kant's philosophy of science played a major role 'in helping to shape the theoretical foundations of the life sciences' led by Blumenbach after 1790. (Lenoir, 1980, p. 77) 'Initiated by Kant's probing insights, the goal of uniting the teleological and mechanical frameworks of explanation was a topic of central importance in discussion on the philosophy of nature in the 1790s.' (Lenoir, 1980, p. 83n) Concretely, Lenoir claimed: 'from the late 1780s to the late 1790s Blumenbach's ideas on natural history underwent a thorough revision in light of Kant's analysis of the conceptual foundations for the construction of a scientific theory of organic form.' (Lenoir, 1980, p. 77) Lenoir found evidence of 'a revolution in [Blumenbach's] whole manner of thinking about the phenomena of natural history' in the years 1795–1797. (Lenoir, 1980, p. 77) Thus, 'Blumenbach's most significant achievement, from our point of view, was to synthesize some of the best elements of Enlightenment thought on biology [...] in terms of a view of biological organization that he found in the writings of Kant.' (Lenoir, 1981a, p. 115) That thesis has remained a powerful influence on the field to this day, but it has serious problems both as a historical claim about the 'Göttingen School' and its founder, Blumenbach, as well as for the larger question of the place of natural teleology in the history of modern biology and even for its status as a special science today.

Lenoir notes: 'It cannot be argued that Blumenbach fashioned himself a follower of Kant.' Instead, 'Kant's main contribution to Blumenbach's work was in making explicit the quite extraordinary assumptions behind the model of the *Bildungstrieb*.' (Lenoir, 1989, pp. 22, 24) My claim is that these were *not* Blumenbach's assumptions, and that he could never assimilate them as assumptions, even after he became aware of Kant's 'contribution.'⁴ I dispute that any 'revolution in [Blumenbach's] whole manner of thinking' took place, or that the essential features of Blumenbach's life science derived from Kant. On the contrary, I propose to demonstrate here that Blumenbach and his school actually took natural teleology to be an objectively ascertainable feature of biological organisms. Lenoir himself equivocates: Kant's ideas 'only came to be embraced fully by Blumenbach in the period between 1795 and 1797.' (Lenoir, 1980, p. 90) Two points are clear: first, by then, Blumenbach had worked out almost all his important ideas, hence, Kant could not have been 'embraced fully' in their constitution; second, Blumenbach's influence upon the Göttingen School came primarily in the years before 1795. So what is left of the decisive continuity that Lenoir claims, and what of Kant's preeminent place? This systematically undercuts Lenoir's central contention that Kant's philosophy of biology formed the 'hard core' of the 'research programme' (in the Lakatosian sense) of the 'Göttingen School.' (Lenoir, 1981b, 1989, pp. 12–13)

The period between 1786 and 1797 brought the Göttingen physiologist and the Königsberg philosopher into direct communication, and there is clear evidence that Blumenbach assimilated many aspects of Kantianism into his scientific writings. The fullest incorporation of Kant's ideas, entailing abandonment of ideas Blumenbach had long held, came in his *theory of race* after 1797. Lenoir pointed to Blumenbach's completely reorganized third edition of the dissertation on human variety (1795) and the 1797 and 1799 editions of the *Handbuch der Naturgeschichte*. Robert Bernasconi similarly identifies dramatic revisions in Blumenbach's

theory of race after 1795 which he associates with Kant. (Bernasconi, 2001a, 2001b, 2001c; compare Lagier, 2004) Phillip Sloan sees a substantial influence of Kant on Blumenbach's ideas about species and organic form in these years, especially via the work of his student and associate, Christoph Girtanner, (Sloan, 1979)⁵ There is also evidence in the converse direction, i.e., Kant's assimilation of Blumenbach's scientific work into his own exposition of philosophy of science. Was this a real convergence or was it a mutual misunderstanding? (Richards, 2000; compare Jardine, 2000, pp. 11–55)

There is no question that Blumenbach increasingly *inflected* his theory of the *Bildungstrieb* in language taken from Kant. There is similarly no question that he *incorporated* a great deal of Kant's theory of race into his later writing. (See esp. Blumenbach, 1795) My question is whether Blumenbach actually *understood* and *accepted* the epistemological prescriptions of Kant for biological science. Robert Richards has suggested that Blumenbach's practice was in fact inconsistent with Kant's prescriptions, and that Kant improperly assimilated Blumenbach's practices to his prescriptions. (Richards, 2000, 2002, pp. 221–237) I agree with Richards. (Zammito, 2003) I believe that Lenoir misunderstands both Kant and Blumenbach at crucial points, enabling a false assimilation of their positions. Lenoir does detect a crucial metaphysical and methodological agreement between Kant and Blumenbach: 'it is not possible to reduce life to physics or explain biological organization in terms of physical principles. Rather, organization must be accepted as the primary given [...] At the limits of mechanical explanation in biology we must assume the presence of other types of forces following different types of laws than those of physics. These forces can never be constructed *a priori* from other natural forces, but they can be the object of research. Within the organic realm the various empirical regularities associated with functional organisms can be investigated.' (Lenoir, 1981b, p. 305) Lenoir goes further, however: 'the origin of these original forms themselves can never be the subject of theoretical treatment.' (Ibid., p. 306) But if, as Lenoir elsewhere argues, 'the task of biology is to uncover the laws in terms of which those forces in the organic realm operate' (Lenoir, 1989, p. 33), then, as Robert Richards rightly insists, 'Blumenbach wanted to explain the origin of organization in the first place.' (Richards, 2002, p. 235)⁶

I question Lenoir's conception of empirical science and especially of life science. Lenoir gets off on the wrong foot by suggesting that 'the solution to this problem lies in determining whether the notion of *Naturzweck* is capable of generating *a priori* deductive statements constitutive of experience.' Of course 'it is not possible to offer a deductive, *a priori* scientific treatment of organic forms.' (Lenoir, 1989, p. 28) The fallacy, here, is to believe that *any* substantial part of empirical science—including *physics*—can be deduced *a priori*. Lenoir writes: 'biology as a science must have a completely different character from physics. Biology must always be an empirical science. Its first principles must ultimately be found in experience [...] This contrasts sharply with physics.' (Lenoir, 1980, p. 306, 1989, p. 29) Kant certainly insisted that (some) physics could be deduced *a priori*, but instead of taking Kant's postures about a *a priori* science in the *Metaphysical Foundations of Natural Science* (1786) as having any long-term staying power, we must recognize that the turn to

⁴ I concur entirely with Robert Richards on this score: 'Blumenbach's *Bildungstrieb* [...] directed the formation of anatomical structures and the operations of physiological processes of the organism [...] Kant would have rejected any such force pretending to be constitutive of nature [...] For Kant, [...] the *Bildungstrieb* could only be a regulative concept [...] But for Blumenbach, [...] [it] was a teleological cause fully resident in nature.' (Richards, 2002, pp. 220–221) While Richards agrees that Blumenbach 'continued gradually to alter and refine the core of the concept,' he denies that this 'turn[ed] the *Bildungstrieb* into what Lenoir has called a teleomechanistic principle.' (Ibid., pp. 226–227) Even in the later editions of his work, 'the *Bildungstrieb* was thus not a Kantian 'as if' cause but a real teleological cause [...] known only through the ends it achieved.' (Ibid., p. 229)

⁵ On the other hand, Sloan has been taken to have affirmed a substantial disparity on the question of species between Kant and Blumenbach. (Richards, 2002, p. 235n)

⁶ And so does modern biology; see the enormous literature on the problem of the origin of life.

empirical laws as *discovered*, not *deduced*, as contingent, not *a priori*, was the essential advance of the sciences in the modern era. The contrast of biology with physics in *a priori* terms is a function of Kant's *metaphysical* agenda, not a legacy we should embrace.⁷ Nor was it one that Blumenbach or his school could embrace. To be sure, they distinguished their science from physics, but not because they believed physics was a deductive *a priori* science and not because they believed that biology was an inherently defective empirical science. They, as Lenoir himself noted, wanted biology to be a legitimate, if special empirical science in a broadly Newtonian unity of science. (Lenoir, 1989, pp. 2–3) Kant preached that biology could *never* be a science at all.⁸

Lenoir's claim boils down to this: 'Kant's formulation of the notion of generic preformationism was an exact, if unhappy, expression of the fundamental idea behind Blumenbach's *Bildungstrieb*,' and Blumenbach acknowledged this. (Lenoir, 1980, p. 91) No, it wasn't, and no, he didn't. To dispute Lenoir's thesis, what is required is a finer-grained consideration of how Blumenbach changed his positions and of the degree to which these can be seen as *accurate* and *informed* adoptions of Kant's views. My strategy will be, first, to lay out Kant's position in a brief sketch (Section 2), and then explore the changes in Blumenbach's thought in the era Lenoir proposes as crucial to his assimilation of Kant's principles (Section 3). Following this, I will turn my attention to the 'Göttingen School' of Blumenbach's students and associates, focusing primarily on Christoph Girtanner, and to the actual course of biological research in the era after 1790 (Section 4).

2. Kant's stipulative methodology for life science⁹

Kant first mentioned Blumenbach in a footnote to his 1788 rejoinder to Georg Forster, *On the Use of Teleological Principles in Philosophy*. (Kant, 1788, p. 180n) He invoked Blumenbach's authority to dismiss the transformation of the great chain of being from a taxonomy to a phylogeny—that is, what later, in the *Critique of Judgment*, he would call a 'daring adventure of reason.' (Kant, 1790, 419n)¹⁰ Forster had questioned this 'widely cherished notion preeminently advanced by Bonnet' and Kant was happy to report that, under the critical scrutiny of Blumenbach's *Handbuch der Naturgeschichte*, all the weaknesses of that position had been exposed. (Kant, 1788, p. 180n)¹¹ Then he added the observation: 'this insightful man also ascribes the *Bildungstrieb*, through which he has shed so much light on the doctrine of generation, not to inorganic matter but solely to the members of organic being.' (Kant, 1788, p. 180n)¹² In 1790, in the *Critique of Judgment*, Kant elaborated:

He makes organic substance the starting point for physical explanation of these formations. For to suppose that crude matter, obeying mechanical laws, was originally its own architect, that life could have sprung up from the nature of what is void of life, and matter have spontaneously adopted the form of a self-maintaining finality, he justly declares to be contrary to reason. (Kant, 1790, pp. 378–379)

There were few ideas Kant struggled to keep divided more than life and matter. It is the idea of *hylozoism*—of any radical spontaneity in matter itself—that Kant could not abide.¹³ Kant denied that we could even think of nature as alive: 'the possibility of living matter cannot even be thought; its concept involves a contradiction, because lifelessness, *inertia*, constitutes the essential character of matter.' (Kant, 1790, p. 394) He elaborated: 'life means the capacity of a substance to determine itself to act from an internal principle, of a finite substance to determine itself to change, and of a material substance to determine itself to motion or rest as change of its state.' (Kant, 1786, p. 544)¹⁴ Consequently, he wished to secure the distinction of organic life from the inorganic, affirming the uniqueness and mystery of organisms as phenomena of empirical nature, and upholding the utter inexplicability of the origins of life.¹⁵

Marcel Quarfood sets the discussion of Kant's conceptualizations of organism as *Naturzweck* in the proper frame by asserting: 'The distinctive feature of Kant's view is [...] an *epistemic presupposition* constitutive for the study of life, rather than a definite *ontological* commitment.' (Quarfood, 2004, p. 145) Joan Steigerwald agrees Kant was concerned with the 'epistemic conditions of our estimation of living beings, the conditions of the possibility of our cognition of them, not with the nature of living beings.' (Steigerwald, 2006, pp. 2–3; now, more extensively: Zuckert, 2007) That might be a possible posture for a *philosopher* of science, but it is *not* a stance that can have any appeal to practicing life-scientists, for their inquiry *must* be into the 'nature of living beings' and to be denied cognitive access to it is to be stipulatively stripped of a scientific domain.¹⁶ Quarfood has gone so far as to suggest that what Kant really meant was that *transcendental philosophers* should consider the conceptualization of organisms as merely 'regulative' but that he recognized that for practicing biologists it had to be 'constitutive.' (Quarfood, 2006) Unfortunately, that is not true, but it would certainly have made Kant more amenable to practitioners of life science.

The 'marvelous properties of organized creatures,' which Kant adumbrates with confidence in the 'Analytic' of his 'Critique of Teleological Judgment,' are part of the empirical-experiential data available to human investigators trying to comprehend the order

⁷ On Kant's philosophy of science and its 'looseness of fit' with the critical philosophy, see especially Buchdahl (1965, 1967, 1969a, 1971, 1981, 1986, 1991); see also Friedman (1986, 1990, 1991, 1992a, 1992b); Allison (1991, 1994), Guyer (2001, 2003, 2005), Kitcher (1983, 1986, 1994), Morrison (1989), Okruhlik (1983), Butts (1990).

⁸ Thus, Richards writes: 'Most biologists of the period [...] thought their disciplines could be developed into sciences and could, in that respect, come to stand as certainly on that pinnacle of human accomplishment as Newton's physics. They believed [...] that teleological processes could be found governing natural phenomena and that valid laws could be formulated to capture such relationships.' (Richards, 2002, p. 231) He adds, in a note: 'That Kant excluded biology from the realm of real science (*Wissenschaft*) is, I think, indisputable.' (Ibid., p. 231n) That point needs to be hammered heavily: it pierces not only Lenoir's thesis but the whole effort to retrieve Kant as the basis for a more sophisticated philosophy of biology today. See Zammito (2006c).

⁹ For an overview of the field today, see Heidemann, ed. (2009), Huneman, ed. (2007), Steigerwald, ed. (2006).

¹⁰ On this historicization of the 'great chain of being,' see the classic Lovejoy (1936)

¹¹ He cited the first edition of the *Handbuch der Naturgeschichte* (1779), which he owned.

¹² It is not entirely clear when or how Kant came to know about Blumenbach's *Bildungstrieb*. It was not mentioned in the 1779 edition, but there were numerous other formulations—the original article version in the *Göttingisches Magazin* (1780), the first book version on the *Bildungstrieb* of 1781, the second edition of the *Handbuch der Naturgeschichte*—any of which Kant might well have perused, for he read voraciously and from all quarters—or the Latin versions (Blumenbach, 1785, 1787) explaining his discovery, which appeared before Kant's 1788 essay.

¹³ This constituted a decisive influence on Kant's receptivity towards the theory of epigenesis. See Zammito (2006a, 2007).

¹⁴ Hence Kant situated himself squarely in the tradition of the new scientific rationalism. For an old but still trenchant assessment of this view, see Burt (1954). For a more recent, penetrating analysis, see Buchdahl (1969b).

¹⁵ For a recent study of Kant's theory of organic form, see Löw (1980), esp. 138ff. For the older literature, see Menzer (1911), Roretz (1922), pp. 112–150; Ungerer (1922), 64–132; Bommersheim (1919, 1927), Lieber (1950), Baumanns (1965).

¹⁶ Biology is a special science concerned with actual entities in the physical world; it is not reasonable to pursue such an enterprise if it is *in principle* not possible to explain those entities. It may well be that such explanations are contingent and fallible, but biologists *must* resist any imposition by philosophy that would stipulate the impossibility of the venture. See Zammito (2003, 2006b); for an alternative view, see Breitenbach (2009).

of nature. (Kant, 1790, p. 371)¹⁷ That is, Kant appears to consider their *phenomenal description* unproblematic. But how these ‘marvelous properties’ can be explained as actual entities—and how they can be *integrated* into a unified system of empirical laws as the ‘order of nature’—remains, for Kant, a philosophical conundrum. (Zammito, 2003) As Quarfood explains, ‘organisms like all objects of experience are subject to the causal principle,’ but ‘there are features of organisms that appear to be intractable for the kind of explanations in terms of causal laws appropriate for ordinary physical objects’ and thus ‘there is no explanation (or ‘law’) for how matter comes together in the ways characteristic for organisms.’ (Quarfood, 2004, p. 146) Kant characterizes what presents itself as an organism ‘provisionally, [as] a thing [that] is both cause and effect of itself.’ (Kant, 1790, p. 370) While we can ‘think this causality without contradiction, we cannot grasp [*begreifen*] it.’ (Kant, 1790, p. 371) That is, we cannot bring it under concepts of the understanding.

That an entity can be cause and effect of itself, Kant argued, is beyond discursive rationality. To take teleology as explanatory would ‘introduce a new causality into natural science, even though in fact we only borrow this causality from ourselves’ (Kant, 1790, p. 361) This would be a quite ‘special kind of causality, or at least a quite distinct lawfulness [*Gesetzmäßigkeit*] of nature’ and ‘even experience cannot prove that there actually are such purposes [*die Wirklichkeit derselben [...] beweisen*].’ (Kant, 1790, p. 359) Kant insists ‘natural purpose’ is *our construction*, not an empirical given. What is empirically given is a problem, an anomaly, not a fact. Steigerwald stresses that Kant claimed we could only grasp ‘living beings by reference to our own purposive activity,’ i.e. he maintained only the *analogy to human purpose* gave us conceptual access to organic form. (Steigerwald, 2006, pp. 1–3) Technically, Kant had to deny that teleology can explain anything in phenomenal nature. (cf. Flasch, 1997; Fricke, 1990; Ginsborg, 1987; Warnke, 1992) What teleology is alone permitted to do is offer an *analogy* of some *heuristic* utility. It is even less than an empirical *conjecture*.

We perhaps approach nearer to this inscrutable property if we describe it as an *analogon of life*, but then we must either endow matter, as mere matter, with a property which contradicts its very being (hylozoism) or associate therewith an alien principle *standing in communion* with it (a soul). But in the latter case we must, if such a product is to be a natural product, either presuppose organized matter as the instrument of that soul, which does not make the soul a whit more comprehensible, or regard the soul as artificer of this structure, and so remove the product from (corporeal) nature. (Kant, 1790, pp. 374–375)

In short, ‘strictly speaking, [...] the organization of nature has nothing analogous to any causality known to us,’ that is, ‘*intrinsic natural perfection*, as possessed by those things that are possible only as *natural purposes* and that are hence called organized beings, is not conceivable or explicable on any analogy to any known physical ability, i.e., ability of nature, not even—since we belong to nature in the broadest sense—on a precisely fitting analogy to human art.’ (Kant, 1790, p. 375)

Consequently, Kant’s notion of *organism* is broader than that of *life*, and the failure of these two terms to have the same extension

expresses the insufficiency Kant acknowledged in his ‘analogy of life’ for natural purpose. (Dörflinger, 2000; Ingensiep, 2004) How do we construe the residual *disanalogy* for biology? Plants epitomize Kant’s conceptual discrimination of life from organism. They are very hard to reconcile with Kant’s stipulative formulation of ‘life’ and yet they are unquestionably ‘natural purposes’ in Kant’s technical sense. In the opening exposition of the ‘Critique of Teleological Judgment’ in the third *Critique*, he illustrated the features of organism precisely by a plant—a tree. Even plants have a *Bildungstrieb*, not just *Bildungskraft*, in the discrimination Kant adopted from Blumenbach. (Kant, 1790, p. 424) That is, they have some ‘internal, quasi-spontaneous principle of motion.’ (Ingensiep, 2004, p. 128) The question of *Trieb* in Kant’s notion of organism denotes the element unaccounted for even by Kant’s analogy of life. Organisms were clearly identified with *Trieb*. But what was a *Trieb* for Kant, and how did he distinguish it from a *Kraft*? How could an ‘inner’ force be actual for scientific inquiry? Lenoir is comfortable with a regulative, heuristic formulation of the matter, but that oversimplified Kant’s actual endeavors, especially if we consider his entire career as a *Naturforscher*.¹⁸

Kant did explicitly develop a scientific theory about such inner organismic forces in his essays on race. Lenoir is misleading (or misled) in suggesting that for Kant this was all simply ‘subjective’ or ‘heuristic’ in a manner that disowned empirical assertion. He writes: ‘Kant’s *Stamm* [...] is an Ideal Type, a transcendental idea whose only significance is regulative.’ (Lenoir, 1978, p. 68) The *Stamm* ‘is not to be conceived as an ancestral form.’ (Lenoir, 1988, p. 107) ‘The *Stamm* was a hypothetical construct of reason [...] it contained schematically all possible morphological structures within a given order’ (Lenoir, 1978, p. 69) ‘Rather than seeing these organic unities reconstructed by comparative anatomy as potential historical ancestors, it is more appropriate to view them as *plans of organization*, as the particular ways in which the forces constituting the organic world can be assembled into functional organs and systems capable of surviving.’ (Lenoir, 1981b, pp. 308–309) In a late article, published after the original edition of his book, Lenoir writes: ‘Kant advocated the construction of morphotypes or organizational plans to be arrived at through comparative anatomy and physiology.’ (Lenoir, 1988, p. 107) That, I submit, is ‘rational reconstruction’ (or in blunter German, *hineinlesen*) with a vengeance. Lenoir may wish to *interpret* Kant as holding this, but there is no such explicit advocacy in Kant’s texts. Kant, in contrast, developed an explicit *empirical* hypothesis, alleging actual causal relations in the physical world.¹⁹ Lenoir in one article does recognize that ‘Kant had gone on to provide a mechanical model [...] in a set of *Keime* and *Anlagen* present in the generative fluid.’ (Lenoir 1981b, p. 307), but for the most part he wants to claim that Kant restricted himself to a heuristic, a regulative ‘as if.’ On the contrary, Kant’s theory of *Keime* and *Anlagen* was, like *all* empirical hypotheses, a matter of construction (‘a model’), involving theoretical terms to account for observable macrophenomena, and hence dependent upon empirical confirmation, if only holistically. Bluntly, *Stammgattung* is not *simply* an ‘ideal’ in Kant’s technical sense; it is a theoretical concept to which is imputed a determinate historical actuality.²⁰

¹⁷ But to claim, as Lenoir does, ‘that such ‘natural purposes’ exist is an objective fact of experience according to Kant.’ (Lenoir, 1989, p. 25) is in flat contradiction to what Kant wrote in the *Critique of Judgment*: ‘even experience cannot prove that there actually are such purposes [*die Wirklichkeit derselben ... beweisen*].’ (1790, p. 359) For Kant, the whole problem is about the *recognition* of an anomaly in the empirical order of nature and its *conception* as a ‘natural purpose.’ The anomaly violates the categorial framework of the understanding, and the conception is a *subjective recourse* to deal with it.

¹⁸ Long ago, Erich Adickes wrote extensively about Kant’s sense of himself as a ‘Naturforscher.’ Adickes judged Kant’s expertise in natural history and physical anthropology far more harshly than more recent commentators, and it turns out he was more apt than they. (Adickes, 1924, pp. 406–459)

¹⁹ Over the 1780s, as Kant worked up the critical philosophy, Rafael Lagier has argued quite persuasively that this *empirical* component waned in the face of increasing epistemological scruples. See Lagier (2004, p. 140).

²⁰ A better way to make sense of this whole problem of idealizations in scientific model building and its relation to scientific ‘objectivity’ is developed especially in the treatment of eighteenth-century science in Daston & Galison (2007).

Kant conceived of *Keime* [germs] and *natürliche Anlagen* [natural potentialities] as real forces in human variation. (Kant, 1775–77)²¹ Clark Zumbach observes, for example: ‘*Keime*, as part of the generative force [*Zeugungskraft*], are postulated [...] as the inner mechanisms for development in future circumstances [T]hey control the permanence of phenotypic traits and are ‘kept back or unfolded’ depending on the situation at hand.’ (Zumbach, 1984, p. 102) Through them Kant sought to characterize the mysterious ‘inner possibility’ of organic form in its objective reality or real possibility. What kind of ‘theoretical terms’ did they constitute, and what sorts of observational evidence could substantiate them? The cognitive status of these concepts is all the more pressing since Kant postulated an *original* or *ancestral* form [*Stammgattung*] which, at least in the case of humans and in all likelihood for any other life forms, no longer persisted in the present.²² Without some *empirically determinate* principle of the derivation of current species from these ancestors, the whole approach would be less than an art, it would be arrant speculation.²³ In Kantian terms, what made these ‘real possibilities’ and not just wild hypotheses irreconcilable with ‘proper Newtonian science’?²⁴

To grasp that, we must consider Kant’s advocacy of a newly emergent empirical science in the late eighteenth century, for which he proposed to appropriate the going concept, *Naturgeschichte*. The term ‘natural history’ in German science before Kant had really only signified natural *description*. It was heuristic and classificatory, as exemplified above all by Linnaeus. Kant, taking up impulses from Buffon, suggested in 1777 this could be displaced by a real and genetic conception of the order of living forms (*Naturgattungen* in place of *Schulgattungen*), making *history* central to the project of the life sciences. (Kant, 1775–77; Zammito, 2010) But Kant came increasingly to doubt the efficacy of this new empirical science. Above all, ‘how this stock [of *Keime*] arose, is an assignment which lies entirely beyond the borders of humanly possible *natural philosophy*, within which I believe I must contain myself,’ Kant proclaimed. (Kant, 1788, p. 179)²⁵ ‘Chance or general mechanical laws can never bring about such adaptation. Therefore we must see such developments which appear accidental according to them, as *predetermined* [*vorgebildet*].’ External factors could be occasions, but not direct causes of changes that could be inherited through generation. ‘As little as chance or physical-mechanical causes can generate [*hervorbringen*] an organic body, so little will they be able to effect in them a modification of their reproductive powers which can be inherited.’ (Kant, 1790, p. 435) This was the essential postulate to which Kant had committed himself in his second essay on race (1785), and the stakes were not small: without some fixity in the power of generation [*Zeugungskraft*], the prospect of the scientific reconstruction of the connection between current and originating species—*Naturgeschichte*, as Kant formulated it in his first essay on race (1775–77), or the ‘archaeology of nature’ as he would call it in the third *Critique* (Kant, 1790, p. 424)—would be altogether dim.

Yet it was not simply a *methodological* issue, however dire. There was also an essential *metaphysical* component. Kant was adamant that the *ultimate* origin of ‘organization’ or of the formative drive [*Bildungstrieb*] required a *metaphysical*, not a physical, account. (see Zammito 2003, 2006c, 2007, 2009, forthcoming; cf. Rang, 1998; Quarfood, 2004; Steigerwald, 2006; Zuckert, 2007; Breitenbach, 2009; Beihart, 2009) All organic form had to be fundamentally distinguished from mere matter. ‘Organization’ demanded separate creation. ‘This inscrutable *principle* of an original *organization*’ lay beyond natural science. (Kant, 1790, p. 424) That put *life science* beyond the pale of empirical science. Organisms, as empirically given—indeed, *pervasive*—occurrences in nature, became literally indecipherable once the concept *life* was removed, leaving us to grope after them by analogies. In the third *Critique* Kant would twice insist that there would never be a Newton of even a ‘blade of grass.’ (Kant, 1790, pp. 400, 429) Robert Richards says what needs to be said: ‘the *Kritik der Urteilskraft* delivered up a profound indictment of any biological discipline attempting to become a science.’ (Richards, 2002, p. 229) Eternal inscrutability was preferable to any ‘monstrous’ conjectures of hylozoism and transformationism that made reason flinch. (Kant, 1785a, p. 54)²⁶ Kant invoked Blumenbach for support in these *metaphysical* reservations. (Kant, 1788, p. 180n; 1790, p. 424) The leading life scientist of the day seemed to be affirming just the same *metaphysical* and *methodological* discriminations that Kant himself demanded. But could Blumenbach, whose whole career exemplified a ‘biological discipline attempting to become a science,’ really have embraced such a philosophy of science? That disconnect puts Kant’s appropriation of Blumenbach—and *a fortiori* Lenoir’s assimilation of the two of them—starkly in question.

3. Blumenbach’s life science and Kant’s influence

Blumenbach began serious consideration of the philosophy of Kant in 1786 as a direct consequence of the dispute surrounding Kant’s reviews of Herder’s *Ideen zur Philosophie der Geschichte der Menschheit*, especially Kant’s controversy with Georg Forster. (Forster, 1786; see Riedel, 1980; Lüsebrink, 1994; Schmied-Kowarzik, 1994; Strack, 2001; Weingarten, 1982; and above all, van Hoorn, 2004) But already five years before, in 1781, Blumenbach proposed the most important revision in the 18th-century fields of embryology and physiology with his idea of the *Bildungstrieb* and his implied endorsement of epigenesis. (Blumenbach, 1781) How did Blumenbach respond to Kant’s appropriation of his ideas? Blumenbach’s first major publication after Kant’s essay appeared, the third edition of the *Handbuch der Naturgeschichte*, was dated March 1788, and it unsurprisingly gives no evidence of Blumenbach’s attention to Kantian ideas. (Blumenbach, 1788) But less than a year later, in January 1789, he published his revised version of *Über den Bildungstrieb* and sent Kant a copy of this work in acknowledgment

²¹ This theory was reasserted without revision in Kant’s reviews of Herder in 1784/5 and in the 1785 reprise of Kant’s treatment of race, then defended against Georg Forster in 1788. It remains (vestigially) in the *Critique of Judgment*. See Zammito (2006b).

²² ‘Indeed, if we depart from this principle, we cannot know with certainty whether several parts of the form which is now apparent in a species have not a contingent and unpurposive origin; and the principle of teleology: to judge nothing in an organized being as unpurposive which maintains it in its propagation, would be very unreliable in its application and would be reliable solely for the original stock (of which we have no further knowledge).’ (Kant, 1790, p. 420)

²³ Here I am invoking the language from the Preface to Kant (1786, pp. 467–469).

²⁴ Here I am invoking the framework proposed by Buchdahl (1965) etc. See Zammito (2003, 2006c).

²⁵ ‘[I]f some magical power of imagination [...] were capable of modifying [...] the reproductive faculty itself, of transforming Nature’s original model or of making additions to it, [...] we should no longer know from what original Nature had begun, nor how far the alteration of that original may proceed, nor [...] into what grotesqueries of form species might eventually be transmogrified [...] I for my part adopt it as a fundamental principle to recognize no power [...] to meddle with the reproductive work of Nature [...] [to] effect changes in the ancient original of a species in any such way as to implant those changes in the reproductive process and make them hereditary.’ (Kant, 1785, p. 97; tr. in Lovejoy 1959, p. 184)

²⁶ The connection between this reaction to Herder, Kant’s equivocations in the debate with Forster, and his eventual discussion of the ‘daring adventure of reason’ is crucial to an understanding of this whole configuration. In my view, Lenoir (1981a, pp. 150–514), gets Kant’s argument in §§ 80–81 of the *Critique of Judgment* altogether wrong. He thinks Kant was *affirming* what he was in fact problematizing. Ironically, Lenoir’s misreading tallies with that of most creative life scientists in the 1790s. But that means it was not Kant but their misinterpretation of Kant that was the driving force here. See Sloan (2006).

of Kant's references to him in the 1788 essay. (Blumenbach, 1789)²⁷ The Preface to this second edition of his essay on the *Bildungstrieb* advised readers that his earlier version was 'immature.' (Blumenbach, 1789, p. A4)

What did Blumenbach intend by his Preface of January 1789, and by routine appeals in later versions of his *Handbuch* and of his dissertation on human variety, 'not to confuse [this second edition] with the immature treatise that appeared under a similar title in 1781?' (Blumenbach, 1789, p. A4)²⁸ Can we take it for granted that this was 'immaturity' by Kantian standards? Lenoir explicitly claims Blumenbach's 'mature formulation resulted from his encounter with Kant's work.' (Lenoir, 1980, p. 84n)²⁹ That is not historically defensible for the Preface of January 1789, and it is quite problematic for later incorporations of Kantian language. I suggest that we must regard Blumenbach's judgment of his earlier work in a more complex light. He was already making changes in his 1788 *Handbuch*, before we have any reason to suspect Kantian influence. He had encountered significant resistance to his ideas—and from two fronts: the die-hard preformationists (Bonnet, Spallanzani, Caldani), but also the more aggressively naturalistic epigenesists—Thomas Sömmerring and Georg Forster and, of far greater importance, Caspar Friedrich Wolff.³⁰ If we consider the texts of 1781 and 1789 in juxtaposition, what is foremost is the clarity with which Blumenbach characterizes his central innovation. The structure of the argument is considerably clearer: after the historical background leading up to his own discovery, Blumenbach presents a thorough drubbing of the arguments for preformation, followed by a clear account of the advantages of his *Bildungstrieb* theory. He is far more comfortable that he has made a major breakthrough and that he has defeated his rivals on that front. That is, Blumenbach believed he had dramatically improved the exposition of his scientific position by 1789, not—or not just—his sophistication about philosophy of science.

One of the most important aspects of his argument in 1781 was that the *Bildungstrieb* encompassed and explained three vital functions—generation, nutrition, and regeneration. In the 1789 version, nutrition gets scant attention. It is generation and regeneration that Blumenbach believes offer the best support for his theory in comparison with others. But it may also be that he had addressed the nutrition issue separately, in a prize-winning essay submitted to a competition sponsored by the Academy of Sciences in St. Petersburg, and presided over by his rival epigenesist, Caspar Friedrich Wolff. (Blumenbach, 1789b) While Wolff awarded Blumenbach the prize, he published a far lengthier work of his own on the topic, taking a sharply critical posture towards Blumenbach's views. (Wolff, 1789) There are thus grounds to think that there is another presence besides Kant whose appraisal of his work loomed large for Blumenbach in 1789, namely Wolff.

And this might well explain the most important methodological clarification in the 1789 version, which did bring Blumenbach happily into alignment with Kant: the radical separation of organic from inorganic form and the repudiation of any hylozoism. Blumenbach embraced a fundamental ontological distinction between the general order of nature and the specific order of the organic. In the 1789 version of his *Bildungstrieb* book, Blumenbach made this very clear: 'No one could be more totally convinced by something than I am of the mighty abyss which nature has entrenched

[befestigt] between the living and the lifeless creation, between the organized and the unorganized creatures.' (Blumenbach, 1789, p. 79) Indeed, Blumenbach shared Kant's skepticism about a bridge from the inorganic to the organic and about the phylogenetic continuity of life forms. What bound them most together was their commitment to the fixity of species and their rejection of the reality of the *scala naturae*. Yet Blumenbach drew neither of these commitments from Kant. They were already expressed with clarity in his dissertation of 1775 and especially the first edition of his *Handbuch* of 1779. These were basic issues for anyone taking up natural history or life science in the 18th century. It is far more likely that Blumenbach adopted them from Albrecht von Haller than from Kant.³¹ What remains is to consider whether the reasons for Blumenbach's commitments were the same as the reasons for Kant's commitments to these same positions.

When he first presented his notion of the *Bildungstrieb*, Blumenbach concentrated on how it answered certain physiological problems in organisms better than the alternative theories of preformation and of epigenesis. He did not dwell yet on the methodological or epistemological status of his concept. In the 1782 edition of his *Handbuch der Naturgeschichte*, his treatment of the idea of the *Bildungstrieb* once again gave no attention to this epistemological issue. He simply carried forward with his empirical exposition. Perhaps he came to regard this as one of the 'immature' features of his work. He changed already in the 1788 edition of the *Handbuch*—presumably before he could have absorbed very much of Kant's methodological thinking. He introduced a new section, immediately after defining his *Bildungstrieb*, with the following language:

The cause of this formative drive can admittedly be so little adduced as that of attraction or gravity and other such generally recognized natural forces. It is enough that it is a distinctive force whose undeniable existence and broad influence throughout all of nature is revealed by experience, and whose constant phenomena offer a far more ready and clear insight into generation and many other of the most important topics of natural history than other theories offered for their explanation. (Blumenbach, 1788, p. 14)

There is, here, a tacit Newtonian analogy, without the mention of Newton by name. Moreover, the argument is presented in terms of the general order of nature: no strong distinction is made between the organic and the inorganic realms in terms of the nature of such forces, though, clearly, this particular force operates in generation and organic forms.

In the second edition of his *Bildungstrieb* book, Blumenbach became far more explicit about the Newtonian connection: 'The term formative drive, just like the terms attraction and gravity, etc. serve no more and no less than to denote a force whose constant effect is recognized but whose cause just as little as the causes of the other, nonetheless so generally recognized natural forces, remains for us a *qualitas occulta*. That does not hinder us in any way whatsoever, however, from attempting to investigate the effects of this force through empirical observations and to bring them under general laws.' (Blumenbach, 1789, pp. 32–33) In the attached footnotes, Blumenbach referred directly to Newton, and then, in the context of the phrase *qualitas occulta*, to Voltaire's exposition of Newton,

²⁷ Blumenbach's transmission to Kant in 1789 is acknowledged by Kant in his letter to Blumenbach, August 5, 1790, in Kant, B, AA:11, pp. 176–177.

²⁸ For later avowals along the same lines see, for instance, Blumenbach (1791, p. 13; 1797, p. 17n).

²⁹ Lenoir argues that Blumenbach's 'mature theory' was composed only 'after he had begun to wrestle with Kant's philosophy of organic form,' and ostensibly upon that basis. (Lenoir, 1980, p. 83)

³⁰ For one seminal discussion of the epigenesis controversy in Germany, see Shirley Roe (1981). See also: Duchesneau (1979, 1985), Roger (1963, 1968, 1980), Gaisinnovich (1968), Müller-Sievers (1993, 1997); and with specific reference to Kant, Ginsborg (1987, 2001, 2004), Genova (1974), McLaughlin (1990), Hunemann (2002), Huneman, ed. (2007), Wubnig (1968/69).

³¹ Blumenbach commented: 'I think it says a lot—but, as I see it, not too much—when I maintain that Haller was the greatest among all recently deceased scholars who have been working in Europe since Leibniz's death. He was the greatest scholar as concerns variety as well as quantity and depth of his knowledge.' (Blumenbach, *Medicinische Bibliothek* 2 (Göttingen, 1785, p. 177)

in particular to the passage where Voltaire argued that from a mere ‘blade of grass’ to the order of the stars, *all* causes (physical as well as biological) were simply occult qualities. (Blumenbach, 1789, pp. 32n, 33n)³² This was standard epistemology of science in the wake of John Locke’s discrimination of ‘nominal’ from ‘real’ essences, of empirical (external) observation from ‘inner’ or ultimate reality of nature. (Locke, 1698) It is important to stress that Kant was hardly a necessary influence for Blumenbach in making this Newtonian appeal. It was common practice among all innovative life scientists. Haller and Buffon had done it, and so had Caspar Friedrich Wolff. (Wolff, 1764; see, e.g., Gaissinovich, 1968; Roe, 1979) As Peter McLaughlin has argued, making the Newtonian appeal was constitutive for the emergent life sciences in the late 18th century. (McLaughlin, 1982) While it was epistemologically expedient, this may well have been disingenuous in many cases, for the forces were taken quite straightforwardly as real, even if the *ultimate* causes remained mysterious. That anything like Kant’s critical epistemology was in play must be open to considerable doubt.

Ultimately, then, what major break was there between Blumenbach’s 1781 formulation and the new ‘mature’ formulation of 1789? McLaughlin has set this inquiry on the proper path by a very close reading of Blumenbach’s various formulations of the notion of the *Bildungstrieb* in successive publications. As McLaughlin is quite right to maintain, Blumenbach did not do a very good job in explicating his *Bildungstrieb*: ‘what that is supposed to mean exactly is nowhere systematically elaborated.’ (McLaughlin, 1982, p. 364)³³ But McLaughlin offers three avenues to clarify the concept: first, how Blumenbach contrasted it with other theories and other forces; second, how he specified its typical laws of operation; and, finally, how he used it to explain other phenomena in natural history. (McLaughlin, 1982, p. 364) For McLaughlin, the contrast with C. F. Wolff is most illuminating, and the issue of the relation of the formative drive to organic matter is central. I think that is exactly the right line of attack, though I deviate somewhat from McLaughlin in the interpretation of these matters.

In his *Handbuch* of 1782, Blumenbach wrote that ‘a particular, innate *drive*, active throughout its life, lies in every organized body.’ (Blumenbach, 1782, p. 15) In the *Handbuch* of 1788, he wrote that one could find ‘throughout all nature the most unmistakable traces of a virtually general drive to give matter a determinate form, which already in the inorganic realm is of striking effectiveness.’ (Blumenbach, 1788, pp. 12–13) As McLaughlin properly observes: ‘In fact, the *only clear substantive difference* in the key formulations of the theory of the *Bildungstrieb* between the ‘more mature’ and the ‘immature’ phase is the replacement of an ‘innate’ drive by a ‘general’ drive.’ (McLaughlin, 1982, p. 371) As the editor of the reprint of Blumenbach’s classic comments, though Blumenbach called the earlier version immature, ‘nevertheless even stylistically the essential statements are hardly changed’ in the later ones. (Karolyi, 1971, p. vi) What Karolyi discerns is a clearer self-assertion versus Haller and Wolff, but ‘argumentation, examples, and the core of the statement remain unchanged.’ (Karolyi, 1971, p. xii) There were, to be sure, ‘in part more refined, more

differentiated formulations and some additions to the exposition of the first edition,’ but for Karolyi these hardly amounted to the ‘completely new construction of the theme’ alleged by Robert Herrlinger in his preface to the reprint of the work of C. F. Wolff. (Karolyi, 1971, p. xi) Herrlinger had implied Blumenbach *needed* such a new formulation in light of Wolff’s criticisms. (Herrlinger, 1966, p. 19n) In short, there is more to the tension between Blumenbach and C. F. Wolff than to the affinity of Blumenbach to Kant that needs to be considered in Blumenbach’s discomfort with the ‘immaturity’ of his work of 1781.

This would make no sense if Blumenbach really believed that C. F. Wolff was a ‘mystical’ vitalist, as Lenoir strangely conceives him.³⁴ Rather, it is the notion of a continuity from the inorganic (in Wolff, the chemical) to the organic—i.e., a materialist naturalism or ‘hylozoism’—in Wolff that Blumenbach wishes to distance himself from. Blumenbach found Wolff’s notion of epigenesis problematic as much—or more—for the metaphysical quandaries as for the methodological ones. There is a high level of ambivalence and ambiguity in his critique of Wolff and in his assimilation of Kantian principles over the 1780s and early 1790s, such that his own position has occasioned widely divergent reconstructions.³⁵ There is good reason to question whether his ultimate version of epigenesis diverged that substantially from Wolff’s, despite all his efforts to uphold a difference.³⁶ That professed difference, nonetheless, proved central for his affiliation with Kant.

McLaughlin identifies crucial changes that Blumenbach introduced in 1791, after he had absorbed Kant’s ideas not only from the 1788 essay but from the *Critique of Judgment* which Kant had sent him. As we have noted, in 1788 Blumenbach found ‘throughout all nature the most unmistakable traces of a virtually general drive to give matter a determinate form, which already in the inorganic realm is of striking effectiveness.’ (Blumenbach, 1788, pp. 12–13) In 1791, Blumenbach pruned the line as follows: one finds ‘in the entirety of organic nature the most unmistakable traces of a generally distributed drive to give matter a determinate form.’ (Blumenbach, 1791, p. 14) The appended clause from 1788 was eliminated altogether. In 1789, as we have noted, Blumenbach compared the *Bildungstrieb* to ‘the *terms* attraction and gravity [...] generally recognized natural forces’ But in 1797, he changed this to: ‘The term *Bildungstrieb* just like all other life forces’ (Blumenbach, 1797, p. 18) The point, here, is that Blumenbach wished his formative drive to be considered only in comparison with other *life-forces*. The thrust, as McLaughlin notes, was to make a radical distinction between the organic and the inorganic realms and to assign the drive exclusively to the former.

The point that McLaughlin wishes to derive from this shift in position in Blumenbach by 1791 is that the *Bildungstrieb* is not the *cause* of life but rather its *consequence*. (McLaughlin, 1982, p. 359) That is, what all the earlier (materialist/naturalist) proponents of epigenesis sought to explain (life as an emergent property arising out of matter itself) in Blumenbach becomes an inexplicable presupposition. For La Mettrie, Buffon and Holbach,

³² One wonders whether it was not this passage from Voltaire that provoked in Kant the famous passage that there would never be a Newton of the blade of grass.

³³ Jardine moves too quickly from the correct observation that Blumenbach ‘offers no positive account of the nature of the formative drive’ to the inference that ‘it is proposed as a heuristic in the search for empirical laws . . .’ (Jardine, 2000, p. 26) The Newtonian analogy did not minimize at all the actuality of the formative drive, but only denied access to its *ultimate* cause. This is a vital discrimination if we are to understand the relation between Blumenbach and Kant.

³⁴ I think in several of his publications Lenoir misunderstands Wolff in a manner than sets up his misconstrual of the whole epoch of life science from the late 18th to the mid-19th centuries, because he identifies vitalism with ‘idealism’—i.e., animism. We must rescue ‘vital materialism’ from Lenoir’s residual positivism. See Reill (2005). Further, Lenoir imputes to the imaginative construction of hypotheses in life science a ‘mystical’ propensity—or a (privately) ‘aesthetic’ one—that deeply misprizes (as irrational) the *interpretive* idea of science that was being developed by its most brilliant eighteenth-century expositors—Buffon, Daubenton, Diderot, Camper, Goethe, and Herder. See Daston & Galison (2007).

³⁵ Thus different interpreters see Blumenbach moving towards vitalism or away from it, as achieving the clear distinctions between constitutive and regulative that Kant required and as dissolving these, e.g., McLaughlin vs Lenoir on the first, Larson vs. Lenoir on the second. See Larson (1979).

³⁶ Most commentators are hard-pressed to uphold, though they clearly try to articulate, what Blumenbach thought distinguished himself from Wolff. For a good discussion, see McLaughlin (1982, pp. 365–367).

according to McLaughlin, ‘life was a mechanical result of organization’—that is, of the general order of nature grounded in physics and chemistry. Blumenbach, by contrast, aimed ‘to explain organic form through organic matter.’ That is, an *organic* force is ‘a force that only has effect within organic matter, not a force that somehow causes the transition from inorganic to organic matter.’ The *Bildungstrieb* did not explain life but rather presumed it. (McLaughlin, 1982, p. 357)³⁷ While there was organization already in inorganic matter, there was something extra about organic matter, which John Hunter called a ‘supplementary force,’ something ‘applied in addition.’ (McLaughlin, 1982, p. 359)³⁸

For McLaughlin, ‘Wolff’s essential force was a *chemical* attraction-repulsion force.’ (McLaughlin, 1982, p. 365) Thus, for Wolff, matter was heterogeneous, i.e., it achieved various *levels* of organization, and once it passed a certain threshold, there ensued something of a chemical chain-reaction that initiated life. The important inquiry was into the component constraints that directed the chain-reaction. (Wolff, 1764; see the divergent views on Wolff: Aulie, 1961; Gaissinovich, 1968, 1990; Herrlinger, 1959; Lukina, 1975; Mocek, 1995; Roe, 1979, 1981; Schuster, 1941; Uschmann, 1955) For Blumenbach, by contrast, McLaughlin believes the important question was the *inherent* relation between a distinctively organic matter and the forces unique to it. That did not mean one could not draw *analogies* from the inorganic to the organic, for, Blumenbach wrote,

even in the inorganic realm the traces of formative forces are so unmistakable and so general. Of formative forces—but not by far of the formative *drive* (*nisus formativus*) in the sense this term assumes in the current study, for it is a *life-force* [*Lebenskraft*] and accordingly as such inconceivable in inorganic creation—rather of other formative forces, which provide the clearest proof in this inorganic realm of nature of determinate and everywhere regular formations [*Gestaltungen*] shaped out of a previously formless matter. (Blumenbach, 1789, p. 80; my emphases)

This distinction between the formative *forces* [*Kräfte*] that structure the inorganic realm and the formative *drive* (*Trieb*; note that it is always singular in Blumenbach’s usage) which is unique to organic life, and indeed a *Lebenskraft* among others, proved crucial for Kant.

This was what Kant found most gratifying in the new book, as he reported in his letter of acknowledgment to Blumenbach, August 5, 1790. (Kant, B, AA: 11, pp. 176–177) In the *Critique of Judgment* he elaborated:

Blumenbach [...] rightly declares it to be contrary to reason that raw matter should originally have formed itself in accordance with mechanical laws, that life should have arisen from the nature of the lifeless, and that matter should have been able to assemble itself into the form of a self-preserving purposiveness by itself; at the same time, however, he leaves natural mechanism an indeterminable but at the same time also unmistakable role under this inscrutable *principle* of an original *organization*, on account of which he calls the faculty in the matter in an organized body (in distinction from the merely mechanical *formative power* [*Bildungskraft*] that is present in all matter) a *formative drive* [*Bildungstrieb*] (standing, as it were, under the guidance and direction of that former principle). (Kant, 1790, p. 424)

This passage in the *Critique of Judgment* makes the distinction between formative force and formative drive prominent.³⁹ Yet it remains problematic within Kant’s own philosophical system on two counts. First, how Kant relates the orders of the two suggests that the formative *forces* (of general, physical nature) constrain the formative *drive*. This is a plausible scientific claim, but it goes against the metaphysical thrust of his whole argument, which is to suggest that organisms as natural purposes urge us toward the notion that there is a larger purpose in nature as a whole which constrains the physical order (a ‘supersensible substrate’). (Kant, 1790, pp. 377–378, 398–399) Some translators of this key passage have been so motivated by this larger concern that they have mistranslated Kant’s text. Second, it is not clear how Kant conceives of the notion of drive (*Trieb*) in his philosophy: in what measure is it really different conceptually from force (*Kraft*)? Are they not all equally ‘inscrutable,’ or is there a supplementary inscrutability about *life-forces*? More importantly for my argument, Kant is simply appropriating Blumenbach for philosophical purposes alien to Blumenbach’s own scientific practice. Blumenbach never considered his formative drive anything but an actual force in nature. To be sure, he found Kant’s suggestion that he brought teleological and mechanical explanations together in his scientific practice quite pleasing, but it is not clear that he understood Kant’s painstaking argument for their radically different roles in scientific explanation. In short, notwithstanding Lenoir (and Jardine), Blumenbach’s affiliation with Kant is best understood as a *misunderstanding*. But it was a *creative* misunderstanding, because it enabled Blumenbach and his followers to continue with even greater energy the development of that new science of *Naturgeschichte*, that ‘daring adventure of reason,’ that Kant by 1790 found deeply problematic. To illustrate this, we must turn briefly to the wider ‘Göttingen School.’

4. The ‘Göttingen School’ and Kant’s ‘Daring Adventure of Reason’

Christoph Girtanner’s *Über das Kantische Prinzip für die Naturgeschichte* (1796) offers insight into how Kant was being understood by Blumenbach and the Göttingen school at the decisive moment. He began learning about Kant around the same time Blumenbach did, and, like Blumenbach himself, he was stimulated by Kant’s controversy with Herder and Forster, which drew the attention of most of the leading life scientists in Germany. (See documentation in *Fam-bach*, 1959, III, pp. 357–397) In 1787 Girtanner corresponded regarding Kant’s philosophy of science with Karl Reinhold, who in 1786 had converted from a defender of Herder into the decisive popularizer of Kant. (Sloan, 1979, p. 138; Lenoir, 1980, p. 99) In 1788, Girtanner formed a personal acquaintance in Edinburgh with one of Kant’s disciples, Johann Jachmann, who would serve as an intermediary between Blumenbach and Kant in the 1790s. (Sloan, 1979, p. 138; see Jachmann to Kant, October 14, 1790, in Kant, B, AA 11, pp. 201–213) Once back in Göttingen from 1790 onward, Girtanner participated in the Blumenbach circle during the years of the composition and reception of his work, which he dedicated to Blumenbach as a contribution to the assimilation of Kantianism by Blumenbach and his school.

Girtanner presented Kant’s thought as the paradigm for a new research program in the life sciences under the rubric of *Naturgeschichte*. Girtanner’s extension of Kant’s work followed just the

³⁷ ‘The formative drive is not the *cause* of this leap [from inorganic to organic], but rather its *expression*.’ (McLaughlin, 1982, p. 364) I share the view of Robert Richards (2002, p. 221f) that the relation in Blumenbach in fact tended to flow in the other direction, even if Blumenbach’s metaphysical preferences inclined him to want to see it as McLaughlin reconstructs.

³⁸ See Duchesneau (1985). This, of course, becomes the Achilles heel of ‘vitalism’ in historical retrospect.

³⁹ Christoph Girtanner would pick this up explicitly. See Girtanner (1796). On Girtanner, see Wegelin (1957), Querner (1990).

vein that Kant himself had indicated his theory of race would require were it to become a serious scientific research program.⁴⁰ This new research program would ask, in Girtanner's words, 'what the primal form of each ancestral species of animals and plants originally consisted of, and how the species gradually devolved from their ancestral species.' (Girtanner, 1796, p. 2) This was a new and specific science that would explore and explain how environmental changes on the earth—indeed 'violent revolutions in nature'—occasioned dramatic changes in life forms. Yet however dramatic, the point was that these were not *chaotic* changes; rather, the variation in observed traits in current species emerged always under the guidance of a 'natural law' requiring that 'in all of organic creation, species remain unaltered.' (Girtanner, 1796, p. 6) Kant's great achievement, in Girtanner's eyes, was his connection of this law to a more determinate 'natural law' (proposed by Buffon) to explain this process, namely that 'all animals or plants that produce fertile offspring belong to the same physical [i.e., real] species,' notwithstanding considerable observed variation in traits. (Girtanner, 1796, p. 4) That is, these organisms *must* have 'derived from one and the same stem [*Stamm*].' (Girtanner, 1796, p. 4) While there could be hereditary variations [*Abartungen*] within the confines of the governing stem, there could not be 'degenerations' [*Ausartungen*], that is, permanently heritable departures from the fundamental traits of the ancestral stem. Races constituted decisive evidence for this theory, because their crosses always showed perfect proportion in the offspring: *Halbschlachtigkeit* (half-breeding). To account for these internal variations within species, Kant had offered the view that 'the ancestral stem of each species of organic life contained a quantity of different germs [*Keime*] and natural potentialities [*natürliche Anlagen*].' (Girtanner, 1796, p. 11) Girtanner followed Kant literally in identifying *Keime* with the source of changes in the parts (organs) of an organic life form, while *natürliche Anlagen* occasioned changes only in the size or proportion of such parts. Kant used winter feathers in birds to exemplify the first, and thickness in the husk of grain to exemplify the second. Girtanner replicated these examples.⁴¹

To help explicate the *process* of variation, Girtanner turned to his teacher Blumenbach. It was 'through different directions of the *Bildungstrieb*, [that] now these and now those [germs or natural potentialities] developed, while the others remained inert.' (Girtanner, 1796, p. 11) Only climate acting on organisms over extended time could educe such variation, such shifts in the 'direction of the *Bildungstrieb*,' and thus permanently alter 'the primal forces of organic development and movement.' (Girtanner, 1796, p. 12) Moreover, once such shifts in direction took place, once certain germs or natural potentialities triggered into actualization, the rest atrophied and the process proved irreversible. (Girtanner, 1796, p. 27) This claim represented one of Kant's decisive interventions in the theory of race, separating him sharply from Buffon, for example. (Bernasconi, 2001a)

Girtanner was acutely aware of the way in which Kant's 'natural history' interpenetrated with his theory of organic form. Not only did Kant require a specific theory of generic transmission, but he needed a theory of organic life in which to cast it. The only form of generation that had been empirically observed, Girtanner noted, was *generatio homonyma*, the persistence of species, though *generatio heteronyma* [*Ausartung*] was not impossible (against reason), but only unheard of (against experience). The essential point was that these both contrasted with *generatio aequivoca* (spontaneous

generation). 'That by mechanism organized beings should emerge from unorganized matter [...] contradicts reason as well as experience.' (Girtanner, 1796, p. 15)⁴² That is, 'it contradicts all known laws of experience that matter which is not organized should have by itself, without the intervention of other, organized matter, organized itself.' (Girtanner, 1796, pp. 14–15) *Anti-hylozoism*, then, was the essential posit of Kant's theory of organic form. Girtanner stressed this about the idea of organism. Not only was it 'not a machine' in consequence of the mutuality of cause and effect, of parts and whole, but neither was it the 'analogue of art,' for 'organized Nature organizes itself.' (Girtanner, 1796, pp. 17–18) If Girtanner replicated Kant's presentation of the perplexity, he did nothing to advance its resolution. Certainly he did not find the regulative/constitutive distinction of any use in the science he proposed to elaborate.

Girtanner was clear that Blumenbach's *Bildungstrieb* was a *Lebenskraft*, namely 'that force by virtue of which the chemical and physical laws are subordinated under the laws of organization.' (Girtanner, 1796, p. 17) Because life forms showed characteristics—reproduction, growth through nourishment and assimilation, regeneration of lost organs and self-healing generally—which could not be assimilated to the mechanistic model of natural science, they represented anomalies requiring recourse to teleological judgment, the analogy of 'purposiveness.'

Girtanner, whom Lenoir is happy to identify as authentically Kantian in some places, clearly does not serve in that capacity for Lenoir here: 'Girtanner defended a view concerning Kant's *Stammgattung* which seems to run directly counter to the regulative function attributed to it in Kant's own works [...] Girtanner argued that the task of natural history was to delineate the original form (*Urbild*) of each *Stammgattung* and show how the present species were degenerated from these originals.' (Lenoir, 1978, p. 74) That was exactly what Girtanner endeavored, but—Lenoir notwithstanding—because of, not despite Kant's own statements regarding the *Stammgattungen* as actual ancestors. Though Lenoir seeks to exonerate Girtanner of 'sinn[ing] against a [...] sacred Kantian principle' and rescue him for authentic Kantian 'regulative' thinking and the 'ideal type' notion, he has to admit that Kiehmeyer and Link—indeed the entire new generation of the 1790s—did go constitutive: 'For them the *Stamm* was not a regulative Ideal Type; it had a historical existence.' More, they believed 'a naturalistic explanation of organic form can be given.' (Lenoir, 1978, p. 92) Lenoir concludes for this generation of 1790: 'The *Urtyp*, transcendental ideal, or *Stamm* of the previous generation is no longer merely a regulative, necessary methodological tool of reason; it has become an actual historical entity shaped by the physical forces of nature.' (Lenoir, 1978, p. 98). I have established that this was always true for Blumenbach, even after his assimilation of Kant. Now Girtanner, Kiehmeyer, Link—core members of the 'Göttingen School'—appear lost as well for any authentically Kantian 'transcendental philosophy of nature.' Lenoir's historical train of connections gets unhitched right at his locomotive!

Blumenbach and his school took the *Bildungstrieb* for actual, not regulative. Their project was to specify its *effects* through the mechanisms (*Bildungskräfte*) it set in motion. Kant's regulative/constitutive distinction proved useless for them in that pursuit. There is no doubt that the life scientists of Blumenbach's school did reach out to Kantian philosophy for legitimation of their methodology, as Lenoir contended. Kant's philosophical endorsement gave them some

⁴⁰ In a letter responding to the publisher Breitkopf's invitation to submit a more extended work on race in 1778, Kant, declining the invitation, explained: 'my frame of reference would need to be widely expanded and I would need to take fully into consideration the place of race among animal and plant species, which would occupy me too much and carry me into extensive new reading which in a measure lies outside my field, because natural history is not my study but only my game ...' (Kant to Breitkopf, April 1, 1778, in Kant, B, AA 10, pp. 227–230) The project of extending consideration of race to animals and plants took up the bulk of Girtanner's study.

⁴¹ It is not surprising, then, that Kant should have endorsed Girtanner's exposition of his theory of race. See Kant, 1798, p. 320.

⁴² This is unquestionably a recapitulation of the argument in Kant, 1790, §§ 80–81.

epistemological and metaphysical comfort, especially given the thinness of their analogy to the Newtonian mysteriousness of gravity. (See Barnaby, 1988; Gregory, 1989; Huneman, 2006a, 2006b; Ingensiep, 1996; Larson, 1979; Lieber, 1950; Sloan, 2006; Williams, 1973) Yet the ultimate irony is that this affiliation went awry. There is perhaps no more widely accepted idea about the life sciences in the German 1790s, even—or especially—when they invoked Kantian critical terms, than that they slid one and all from a strictly regulative into an unmistakably constitutive use of natural teleology. (See, esp. Larson, 1979, 1994) This was a natural, indeed inevitable consequence of their commitment to the *empirical practice* of a life science, which Kant's philosophy of science in fact proscribed.⁴³ William Coleman demonstrates, for example, the way in which the crucial figure of Kiehmeyer has to be read as having transgressed Kant's divide of constitutive and regulative. (Coleman, 1973, pp. 342–347) Leeann Hansen demonstrates, similarly, how J. C. Reil's *Von der Lebenskraft* (1795) 'included reason itself as an organic force; the highest force, it is true, but rooted in the chemical properties of matter like all the others.' (Hansen, 1993, p. 63) Indeed, as both Robert Richards and Frederick Beiser recognize, they are closer to Kant's disparaged former student, Johann Gottfried Herder, than they are to Kant. (Beiser, 2002; Richards, 2002; Zammito, 1998)

Daniel Kolb sums up the argument and then charges that the source of the 'border crossing' is in Kant's own ambiguity:

Is the use of teleological explanations nothing more than a declaration of ignorance? [...] [Kant's] argument against reduction leaves open the question of the exact specification of organic teleology. His idea of teleology consequently proves to be frustratingly difficult to pin down. (Kolb, 1992, p. 13)

It is this irony that Clark Zumbach captures in his provocative title, *The Transcendent Science*. (Zumbach, 1984) Goethe even found Kant himself equivocating between constitutive and regulative uses of teleology in the *Critique of Judgment*. (Cited in Jardine, 1988, pp. 330–331) As Michael Friedman acutely notes, in his philosophy of science Kant was faced with a very uncomfortable question: 'how was [the] brilliantly successful Newtonian paradigm to be extended beyond astronomy and celestial mechanics?' (Friedman, 1992b, p. 240) Friedman elaborates: 'Kant's developing awareness (in 1785) of the new chemical developments and of the general importance of chemistry' made this problem of a unified 'order of nature' for natural science acute for Kant. (Friedman, 1992b, p. 285) Friedman establishes that Kant from this point onward saw himself caught in the toils of a 'gap in the critical system' which became the obsessive theme of the *Opus postumum*. (Friedman, 1992b, pp. 214–215)⁴⁴ Friedman's conclusion is grave:

After the execution of the *Metaphysical Foundations* and the articulation of reflective judgment as an autonomous faculty, it becomes clear—from the point of view of the critical philosophy itself—that the absolute dichotomy between regulative and constitutive principles cannot be maintained. (Friedman, 1992b, p. 305)

Yet it was precisely in upholding that distinction that Kant sought to prescribe methodology to the emerging life sciences in Germany. (Zammito, 1998)

5. Conclusion

The failure of the regulative-constitutive barrier casts severe doubt on the adequacy of Kant's program, Lenoir notwithstanding. Lenoir recognizes the collapse of the constitutive-regulative distinction after 1790, although his commitment to a Kantian interpretation of the life sciences in this epoch simply presumes that 'teleomechanism' is unaffected by that collapse. (Lenoir, 1978)⁴⁵ My argument suggests that Lenoir's effort to construe a Kantian 'transcendental *Naturphilosophie*' as a coherent teleomechanist 'research programme' for the life sciences in the first half of the nineteenth century simply blurs too many categories on the one hand and introduces too many arbitrary distinctions on the other.⁴⁶

The issue is what to make of vitalism in emergent life science at the end of the eighteenth century (which cannot set out from Kant's position that precisely vitalism *excluded* life from any valid science). Kant has a role in that historical constellation, but not as a coherent master model; rather, as a source of conflicting impulses that needed to be sorted out. I submit that Kant's language of *Keime* and *natürliche Anlagen* and his acceptance of the idea of a *Lebenskraft* as exemplified by Blumenbach's *Bildungstrieb* entangled him in a conception of science entailing the *objective reality* of forces which could not be reduced to those he admitted in the Newtonian order of physics. (Zammito, 2009) That was certainly where he ended up in the *Opus Postumum*. (Tuschling, 1991) If Kant himself could not hold this line, it can hardly be surprising when the leading biologists of his day, even in invoking his theory, found it impossible in practice to observe it.

Perhaps this helps explain why Kant's view came so swiftly to be overshadowed by Schelling. Frederick Gregory, no enthusiast for that development, identified three factors: that in Kant nature seemed somehow less real than mind, that Kant's scientific description of nature had to be restricted to mechanistic interaction alone, and the confusion that reigned about the status of scientific theory and the relation of science to religion (Gregory, 1989, p. 60)

Above all, what Kant refused to warrant was the overweening intuition of the epoch, that, in Gregory's formulation, 'Nature was not a timeless and immutable machine, but a temporal and developing organism.' (Gregory, 1989, p. 57) Goethe gave expression to this when he tried to explain how he reacted to Linnaeus: 'what he wanted to hold apart by force I had, according to the innermost need of my nature, to strive to bring together.' (Cited in Oppenheimer, 1967, p. 136) Robert Richards put it succinctly: 'The impact of Kant's *Kritik der Urteilskraft* on the disciplines of biology has, I believe, been radically misunderstood by many contemporary historians. [...] Those biologists who found something congenial in Kant's third *Critique* either misunderstood his project (Blumenbach and Goethe) or reconstructed certain ideas to have very different consequences from those Kant originally intended (Kiehmeyer and Schelling).' (Richards, 2002, p. 229)

Lenoir was most concerned to establish that 'there were fundamental differences between Kant's teleology and that of the *Naturphilosophen*.' (Lenoir, 1989, p. 6) His aim was to rescue teleology from vitalism, but simultaneously to rescue biology from reductive mechanism. Kant's program for life science seemed to Lenoir to have been historically a viable path for one phase in the emergence

⁴³ Therefore, Frederick Beiser has it right: 'Kant's regulative doctrine was *not* the foundation of empirical science in the late eighteenth and early nineteenth century; rather it was completely at odds with it. It is striking that virtually all the notable German physiologists and biologists of the late eighteenth and early nineteenth centuries conceived of their vital powers as causal agents rather than regulative principles ...' (Beiser, 2002, p. 508).

⁴⁴ On this idea of the 'gap,' see Förster, 1987; and Tuschling (1971), Tuschling (1989, 1991).

⁴⁵ That one could still take oneself for a Kantian teleomechanist in the nineteenth century without subscribing to the regulative/constitutive distinction has been suggested in a private communication to me by Lenny Moss.

⁴⁶ Lenoir deserves the harsh judgment of Kenneth Caneva that he is guilty of 'errors, misrepresentations, inconsistencies, unsupported claims, and plain unclear writing,' above all that 'he seems to lose [sic] sight of the fact that his categories are *his* categories, and not in any explicit sense also those of the scientists he studied.' (Caneva, 1990, p. 300)

of modern biology as a special science and a resource for its continued conceptualization in the present. There is much to appreciate in these ambitions. But if the notion of 'vital materialism' as it was developed by the Göttingen School is not quite the Kantian 'transcendental philosophy of nature' that Lenoir wants it to have been, then we in fact find the Göttingen School far closer to the *Naturphilosophen* than Lenoir would like.⁴⁷ Lenoir's 'third way' collapses back towards what has garnered historical opprobrium as 'vitalism,' and the only alternative seems the reductive mechanism Lenoir welcomes neither as a historical development nor as a current theory of life science.⁴⁸ My suggestion is that the historical question of 'vital materialism' needs to be reconsidered.⁴⁹ Instead of viewing the closeness of the Göttingen School to *Naturphilosophie* as a contamination, we might view it as historical evidence that something essential to the character of biology as a special science was at stake, and thus this episode in the history of biology might reopen issues in the contemporary philosophy of biology.⁵⁰ In such a scenario, however, I believe Kant's particular views on teleology constitute a hindrance, not an aid.

Acknowledgements

I would like to acknowledge the generosity of Mr. and Mrs. Bruce Dunlevie for their endowment of my John Antony Weir Professorship in History with a research account that made it possible to travel to the Brisbane conference where this paper was first delivered.

References

- Adickes, E. (1924). *Kant als Naturforscher*. Berlin: Walter de Gruyter.
- Allison, H. (1991). Kant's antinomy of teleological judgment. *Southern Journal of Philosophy*, 30 Supplement: System and teleology in Kant's *Critique of Judgment*, 25–42.
- Allison, H. (1994). Causality and causal laws in Kant: A critique of Michael Friedman. In P. Parrini (Ed.), *Kant and contemporary epistemology* (pp. 291–308). Dordrecht: Kluwer.
- Aulie, R. (1961). Caspar Friedrich Wolff and his 'Theoria Generationis', 1759. *Journal of the History of Medicine*, 16, 124–144.
- Bach, T., & Breidbach, O. (Eds.). (2005). *Naturphilosophie nach schelling*. Stuttgart/Bad Cannstatt: Frommann-Holzweg.
- Barnaby, D. (1988). The early reception of Kant's *Metaphysical Foundations of Natural Science*. In R. Woolhouse (Ed.), *Metaphysics and philosophy of science in the Seventeenth and Eighteenth Centuries* (pp. 281–306). Dordrecht: Kluwer.
- Baumanns, P. (1965). *Das problem der organischen Zweckmäßigkeit*. Bonn: Bouvier.
- Beihart, C. (2009). Kant's characterization of natural ends, in *Kant Yearbook 1:2009: Teleology*, 1–30.
- Beiser, F. (2002). *German idealism: The struggle against subjectivism, 1781–1801*. Cambridge, MA/London: Harvard University Press.
- Bernasconi, R. (2001a). Who invented the concept of race? Kant's role in the Enlightenment's construction of race. In R. Bernasconi (Ed.), *Race* (pp. 11–36). Oxford: Blackwell.
- Bernasconi, R. (2001b). Kant and Blumenbach on the *Bildungstrieb*. Paper presented at the conference of the American Society of eighteenth-century studies, New Orleans, April, 2001.
- Bernasconi, R. (Ed.). (2001c). *Introduction. Concepts of race in the eighteenth century. Volume IV: Blumenbach, De generis humani varietate native*. Bristol: Thoemmes.
- Blumenbach, J. F. (1776, 1781, 1795). *De generis humani varietate nativa*. Reprint: in *Concepts of race in the eighteenth century*. Vol. IV. Bristol: Thoemmes, 2001. Translated in Bendysche, T., (trans.), (2005; reprint of 1865). *The anthropological treatises of Johann Friedrich Blumenbach*. London: Elibron.
- Blumenbach, J. F. (1779). *Handbuch der Naturgeschichte*. Göttingen: Dieterich.
- Blumenbach, J. F. (1781). *Über den Bildungstrieb und das Zeugungsgeschäfte*. Reprint: Stuttgart: G. Fischer (1971).
- Blumenbach, J. F. (1782). *Handbuch der Naturgeschichte* (2nd ed.). Göttingen: Dieterich.
- Blumenbach, J. F. (1785). *De nisu formativo et generationis negotio nuperae observationes*. N.p.
- Blumenbach, J. F. (1787). *De nisu formativo et generationis negotio nuperae observationes*. Göttingen: Dieterich.
- Blumenbach, J. F. (1788). *Handbuch der Naturgeschichte* (3rd ed.). Göttingen: Dieterich.
- Blumenbach, J. F. (1789a). *Über den Bildungstrieb* (2nd ed.). Göttingen: Dieterich.
- Blumenbach, J. F. (1789b). 'Versuch einer Beantwortung der von der kaiserlichen Akademie der Wissenschaften zu St. Petersburg, zum drittenmal aufgegebenen Preisfrage, uti nutritio aequabilis, etc.,' in *Zwo Abhandlungen über die Nutritionskraft [...] nebst einer fernern Erläuterung eben derselben Materie von C. F. Wolff*. St. Petersburg: Royal Academy of Sciences.
- Blumenbach, J. F. (1791). *Handbuch der Naturgeschichte* (4th ed.). Göttingen: Dieterich.
- Blumenbach, J. F. (1797). *Handbuch der Naturgeschichte* (5th ed.). Göttingen: Dieterich.
- Bommersheim, P. (1919). Der Begriff der organischen Selbstregulation in Kants Kritik der Urteilskraft. *Kant-Studien*, 23, 209–220.
- Bommersheim, P. (1927). Der vierfache Sinn der inneren Zweckmäßigkeit in Kants Philosophie des Organischen. *Kant-Studien*, 32, 290–309.
- Breidbach, O. (1995). Die Geburt des Lebendigen—Embryogenese der Formen oder Embryologie der Natur?—Anmerkungen zum Bezug von Embryologie und Organismustheorien vor 1800. *Biologisches Zentralblatt*, 114, 191–199.
- Breitenbach, A. (2009). Teleology and biology: A Kantian perspective. In *Kant Yearbook 1:2009: Teleology*, 31–56.
- Buchdahl, G. (1965). Causality, causal laws and scientific theory in the philosophy of Kant. *British Journal for Philosophy of Science*, 16, 187–208.
- Buchdahl, G. (1967). The relation between 'understanding' and 'reason' in the architectonic of Kant's philosophy. *Proceedings of the Aristotelian Society*, 67, 209–226.
- Buchdahl, G. (1969a). The Kantian 'dynamic of reason', with special reference to the place of causality in Kant's system. In L. W. Beck (Ed.), *Kant studies today* (pp. 341–374). La Salle, IL: Open Court.
- Buchdahl, G. (1969b). *Metaphysics and the philosophy of science: The classical origins: Descartes to Kant*. Cambridge: MIT Press.
- Buchdahl, G. (1971). The conception of lawlikeness in Kant's philosophy of science. *Synthese*, 23, 24–46.
- Buchdahl, G. (1981). Zum Verhältnis von allgemeiner Metaphysik der Natur und besonderer metaphysischer Naturwissenschaft bei Kant. In B. Tuschling (Ed.), *Probleme der 'Kritik der reinen Vernunft'* (pp. 97–142). Berlin/NY: Walter de Gruyter.
- Buchdahl, G. (1986). Kant's 'special metaphysics' and the *Metaphysical Foundations of Natural Science*. In R. E. Butts (Ed.), *Kant's philosophy of physical science* (pp. 121–161). Dordrecht: Reidel.
- Buchdahl, G. (1991). Comments on Michael Friedman: 'Regulative and Constitutive.' *Southern Journal of Philosophy*, 30 Supplement: System and Teleology in Kant's *Critique of Judgment*, 103–108.
- Burr, E. A. (1954). *Metaphysical foundations of modern physical science*. Garden City: Doubleday.
- Butts, R. E. (1990). Teleology and scientific method in Kant's *Critique of Judgment*. *Nous*, 24, 1–16.
- Caneva, K. L. (1990). Teleology with regrets. *Annals of Science*, 47, 291–300.
- Coleman, W. (1973). Limits of recapitulation theory: Carl Friedrich Kielmeyer's critique of the presumed parallelism of earth history, ontogeny, and the present order of organisms. *Isis*, 64, 341–350.
- Daston, L., & Galison, P. (2007). *Objectivity*. NY: Zone.
- Dörflinger, B. (2000). *Das Leben theoretischer Vernunft*. Berlin/NY: de Gruyter.
- Duchesneau, F. (1979). Haller et les théories de Buffon et C. F. Wolff sur l'épigenèse. *History and Philosophy of the Life Sciences*, 1, 65–100.
- Duchesneau, F. (1985). Vitalism in late eighteenth-century physiology: the cases of Barthez, Blumenbach and John Hunter. In W. F. Bynum & R. Porter (Eds.), *William Hunter and the eighteenth-century medical world* (pp. 259–295). Cambridge: Cambridge University Press.
- Fambach, O. (Ed.). (1959). *Ein Jahrhundert deutscher Literaturkritik (1750–1850). Vol. III Der Aufstieg zur Klassik*. Berlin: Akademie (pp. 357–397).
- Flasch, W. (1997). Kants empiriologie: Naturteleologie als wissenschaftstheorie. In P. Schmid & S. Zurbuchen (Eds.), *Grenzen der kritischen Vernunft* (pp. 273–289). Berlin: Schwabe.
- Förster, E. (1987). Is there a 'gap' in Kant's critical system? *Journal of the History of Philosophy*, 25, 533–555.
- Forster, G. (1786). Noch etwas über die Menschenraßen. *Teutsche Merkur*, 57–86, 150–166.
- Fricke, C. (1990). Explaining the inexplicable: The hypotheses of the faculty of reflective judgment in Kant's third critique. *Nous*, 24, 45–62.
- Friedman, M. (1986). The metaphysical foundations of Newtonian science. In R. E. Butts (Ed.), *Kant's philosophy of physical science* (pp. 25–60). Dordrecht: Reidel.
- Friedman, M. (1990). Kant and Newton: Why gravity is essential to matter. In P. Bricker & R. I. G. Hughes (Eds.), *Philosophical perspectives on Newtonian science* (pp. 185–202). Cambridge, MA: MIT Press.
- Friedman, M. (1991). Regulative and constitutive. *Southern Journal of Philosophy*, 30 Supplement: System and Teleology in Kant's *Critique of Judgment*, 73–102.

⁴⁷ For a view that seeks to come to better terms with the situation, see Huneman, 2006a, 2006b.

⁴⁸ For the most eminent statements, see Mayr (1982), Ghiselin (1997).

⁴⁹ For the most extensive and persuasive treatment of this question, see Reill (1989, 1992, 1998, and esp 2005).

⁵⁰ On the Göttingen School and emergent Naturphilosophie, see: Hansen (1993), Gloy and Burger, eds. (1993), Bach and Breidbach, eds. (2005), Breidbach (1995), Coleman (1973), Jahn (1995), Jardine (1988), Rheinberger (1981, 1986), Stein (2004).

- Friedman, M. (1992a). Causal laws and the foundations of natural science. In P. Guyer (Ed.), *The Cambridge companion to Kant* (pp. 161–199). Cambridge: Cambridge University Press.
- Friedman, M. (1992b). *Kant and the exact sciences*. Cambridge, MA: Harvard University Press.
- Friedman, M., & Nordmann, A. (Eds.). (2006). *The Kantian legacy in nineteenth-century science*. Cambridge: MIT.
- Gaissinovich, A.E. (1968). Le rôle du Newtonianisme dans la renaissance des idées épigénétiques en embryologie du XVIIIe siècle. In *Actes du XIe Congrès International d'Histoire des Sciences* (Vol. 5, pp. 105–110).
- Gaissinovich, A. E. (1990). C. F. Wolff on variability and heredity. *History and Philosophy of the Life Sciences*, 12, 179–201.
- Genova, A. C. (1974). Kant's epigenesis of pure reason. *Kant-Studien*, 65, 259–273.
- Ghiselin, M. (1997). *Metaphysics and the origin of species*. Albany: SUNY.
- Ginsborg, H. (1987). Kant on aesthetic and biological purposiveness. In A. Reath, B. Herman, & C. Korsgaard (Eds.), *Reclaiming the history of ethics* (pp. 329–360). Cambridge: Cambridge University Press.
- Ginsborg, H. (2001). Kant on understanding organisms as natural purposes. In E. Watkins (Ed.), *Kant and the sciences* (pp. 231–258). Oxford & NY: Oxford University Press.
- Ginsborg, H. (2004). Two kinds of mechanical inexplicability in Kant and Aristotle. *Journal of the History of Philosophy*, 42, 33–65.
- Girtanner, C. (1796). *Über das Kantische Prinzip für die Naturgeschichte*. Göttingen: Vandenhoeck & Ruprecht.
- Gloy, K., & Burger, P. (Eds.). (1993). *Die Naturphilosophie im Deutschen Idealismus*. Stuttgart/Bad Cannstatt: Frommann-Holzweg.
- Gregory, F. (1989). Kant's influence on natural scientists in the German Romantic period. In R. P. W. Visser, H. J. M. Bos, L. C. Palm, & H. A. M. Snelders (Eds.), *New trends in the history of science* (pp. 53–66). Amsterdam/Atlanta: Rodopi.
- Guyer, P. (2001). Organism and the unity of science. In Eric Watkins (Ed.), *Kant and the sciences* (pp. 259–281). Oxford & NY: Oxford University Press.
- Guyer, P. (2003). Kant and the systematicity of nature: Two puzzles. *History of Philosophy Quarterly*, 20, 277–295.
- Guyer, P. (2005). *Kant's system of nature and freedom*. Oxford: Oxford University Press.
- Hansen, L. (1993). From Enlightenment to *Naturphilosophie*: Marcus Herz, Johann Christian Reil, and the Problem of Border Crossings. *Journal of the History of Biology*, 26(1), 39–64.
- Heidemann, D. (Ed.). (2009). *Kant Yearbook: I. Teleology*. Berlin: de Gruyter.
- Herrlinger, R. (1959). C. F. Wolff's 'Theoria generationis' (1759). *Zeitschrift für Anatomie und Entwicklungsgeschichte*, 121, 245–270.
- Herrlinger, R. (1966). 'Vorwort', to C. F. Wolff, *Theorie von der Generation in zwei Abhandlungen erklärt und bewiesen* (1764). *Theoria generationis* (1759). Reprint: Hildesheim, Olms. pp. 5–28.
- Huneman, P. (2002). *Métaphysique et biologie: Kant et la constitution du concept d'organisme*. Villeneuve: Presses Universitaires du Septentrion.
- Huneman, P. (2006a). From the *Critique of Judgment* to the hermeneutics of nature. *Continental Philosophy Review*, 39, 1–34.
- Huneman, P. (2006b). Naturalising purpose: From comparative anatomy to the 'adventure of reason'. *Studies in History and Philosophy of the Biological and Biomedical Sciences*, 37, 649–674.
- Huneman, P. (Ed.). (2007). *Understanding purpose: Collected essays on Kant and philosophy of biology*. University of Rochester Press/North American Kant Society Studies in Philosophy.
- Ingensiep, H.-W. (1996). 'Die Welt ist ein Thier: aber die Seele desselben ist nicht Gott': Kant, das Organische und die Weltseele. In Ingensiep & R. Hoppe-Sailer (Eds.), *Naturstücke: Zur Kulturgeschichte der Natur* (pp. 101–120). Ostfildern [Germany]: Edition Tertium.
- Ingensiep, H. W. (2004). Organismus und Leben bei Kant. In H. W. Ingensiep, H. Baranzke, & A. Eusterschulte (Eds.), *Kant-reader: Was kann ich wissen? Was soll ich tun? Was darf ich hoffen?* (pp. 107–136). Würzburg: Königshausen & Neumann.
- Jahn, I. (1995). Georg Forsters Lehrkonzeption für eine 'Allgemeine Naturgeschichte' (1786–1793) und seine Auseinandersetzung mit Caspar Friedrich Wolffs 'Epigenesis'-Theorie. *Biologisches Zentralblatt*, 114, 200–206.
- Jardine, N. (1988). The significance of Schelling's 'epoch of a wholly new natural history': An essay on the realization of questions. In R. S. Woodhouse (Ed.), *Metaphysics and philosophy of science in the seventeenth and eighteenth centuries* (pp. 327–350). Dordrecht: Kluwer.
- Jardine, N. (2000). *The scenes of inquiry: On the reality of questions in the sciences* (2nd ed.). Oxford: Clarendon.
- Kant, I. (1775–1777). *Gesammelte Schriften* Herausgegeben von der Preussischen Akademie der Wissenschaften (Vols., 1–29 (to date)). Berlin: de Gruyter (1901–Present) [hereafter noted as "Akademie-Ausgabe"], 2, 427–444.
- Kant, I. (1785a). Rezensionen von J. G. Herders *Ideen zur Philosophie der Geschichte der Menschheit*. Teil 1. 2. *Akademie Ausgabe*, 8, 43–66.
- Kant, I. (1785b). Bestimmung des Begriffs einer Menschenrace. *Akademie-Ausgabe*, 8, 89–106.
- Kant, I. (1786). Metaphysische Anfangsgründe der Naturwissenschaft. *Akademie-Ausgabe*, 4, 465–566.
- Kant, I. (1788). Über den Gebrauch teleologischer principien in der philosophie. *Akademie-Ausgabe*, 8, 157–184.
- Kant, I. (1790). Kritik der Urteilskraft. *Akademie-Ausgabe*, 5, 165–486.
- Kant, I. (1798). Anthropologie in pragmatischer Hinsicht. *Akademie-Ausgabe*, 7, 117–334.
- Kant, I. (B) Briefwechsel. *Akademie-Ausgabe*, 10–13.
- Karolyi, L. V. (1971). 'Vorwort' to Blumenbach. *Über den Bildungstrieb und das Zeugungsgeschäfte*, v–xx. Stuttgart: Fischer.
- Kitcher, P. (1983). Kant's philosophy of science. *Midwest Studies in Philosophy*, 8, 387–407.
- Kitcher, P. (1986). Projecting the order of nature. In R. E. Butts (Ed.), *Kant's philosophy of physical science* (pp. 201–235). Dordrecht: Reidel.
- Kitcher, P. (1994). The unity of science and the unity of nature. In P. Parrini (Ed.), *Kant and contemporary epistemology* (pp. 253–272). Dordrecht: Kluwer.
- Kolb, D. (1992). Kant, teleology, and evolution. *Synthese*, 91, 9–28.
- Lagier, R. (2004). *Les races humaines selon Kant*. Paris: PUF.
- Larson, J. (1979). Vital forces: Regulative principles or causal agents? *Isis*, 70, 235–249.
- Larson, J. (1994). *Interpreting nature: The science of living form from Linnaeus to Kant*. Baltimore: Johns Hopkins University Press.
- Lenoir, T. (1978). Generational Factors in the origin of *Romantische Naturphilosophie*. *Journal of the History of Biology*, 11, 57–100.
- Lenoir, T. (1980). Kant, Blumenbach, and vital materialism in German biology. *Isis*, 71, 77–108.
- Lenoir, T. (1981a). The Göttingen School and the development of transcendental *Naturphilosophie* in the Romantic Era. *Studies in History of Biology*, 5, 111–205.
- Lenoir, T. (1981b). Teleology without regrets. The transformation of physiology in Germany: 1790–1847. *Studies in History and Philosophy of Science*, 12, 293–354.
- Lenoir, T. (1988). Kant, Von Baer, and causal-historical thinking in biology. *Poetics Today*, 9, 103–115.
- Lenoir, T. (1989). *The strategy of life: Teleology and mechanism in nineteenth-century biology*. Chicago/London: University of Chicago Press.
- Lieber, H. J. (1950). Kants philosophie des organischen und die biologie seiner zeit. *Philosophia Naturalis*, 1, 553–570.
- Locke, J. (1689). *Essay concerning human understanding*. Oxford: Clarendon. Reprint, 1988.
- Löw, R. (1980). *Philosophie des lebendigen: Der begriff des organischen bei Kant, sein grund und seine aktualität*. Frankfurt: Suhrkamp.
- Lovejoy, A. (1959). Kant and evolution. In B. Glass (Ed.), *Forerunners of Darwin 1745–1859* (pp. 173–206). Baltimore: Johns Hopkins University Press.
- Lovejoy, A. (1936). *The great chain of being*. Cambridge: Harvard University Press.
- Lüsebrink, H.-J. (1994). Aufgeklärtes humanismus: Philosophisches engagement am Beispiel der Kontroverse über die 'Menschenrassen'. In R. Reichardt & G. Roche (Eds.), *Weltbürger–Europäer–Deutscher–Franke: Georg Forster zum 200. Todestag* (pp. 88–195). Mainz: Universitätsbibliothek Ausstellungskatalog.
- Lukina, T. (1975). Caspar Friedrich Wolff und die Petersburger Akademie der Wissenschaften. *Acta Historica Leopoldina*, 9, 411–425.
- Mayr, E. (1982). *The growth of biological thought*. Cambridge: Harvard.
- McLaughlin, P. (1982). Blumenbach und der Bildungstrieb: Zum Verhältnis von epigenetischer Embryologie und typologischem Artbegriff. *Medizinhistorisches Journal*, 17, 357–372.
- McLaughlin, P. (1990). *Kant's critique of teleology in biological explanation: Antinomy and teleology*. Lewiston: Mellen.
- Menzer, P. (1911). *Kants theorie von der Entwicklung*. Reimer: Berlin.
- Mocek, R. (1995). Caspar Friedrich Wolffs Epigenesis-Konzept—ein problem im Wandel der Zeit. *Biologisches Zentralblatt*, 114, 179–190.
- Morrison, M. (1989). Methodological rules in Kant's philosophy of science. *Kant-Studien*, 80, 155–172.
- Müller-Sievers, H. (1993). *Epigenesis: Naturphilosophie im Sprachdenken Wilhelm von Humboldts*. Paderborn: Schöningh.
- Müller-Sievers, H. (1997). *Self-generation: Biology, philosophy and literature around 1800*. Stanford: Stanford University Press.
- Okruhlik, K. (1983). Kant on the foundations of science. In W. Shea (Ed.), *Nature mathematicized* (pp. 251–268). Dordrecht: Reidel.
- Oppenheimer, J. (1967). *Essays in the history of embryology and biology*. Cambridge: MIT Press.
- Quarfood, M. (2004). *Transcendental idealism and the organism: Essays on Kant*. Almqvist & Wiksell: Stockholm.
- Quarfood, M. (2006). Kant on biological teleology: Towards a two-level interpretation. *Studies in History and Philosophy of the Biological and Biomedical Sciences*, 37, 735–747.
- Querner, H. (1990). Christoph Girtanner und die Anwendung des Kantischen Prinzips in der Bestimmung des Menschen. In G. Mann & F. Dumont (Eds.), *Die Natur des Menschen: Probleme der physischen anthropologie und rassenkunde (1750–1850)* (pp. 123–136). Stuttgart: G. Fischer.
- Rang, B. (1998). Zweckmäßigkeit, Zweckursächlichkeit und Ganzheitlichkeit in der organischen Natur: Zum Problem einer teleologischen Naturauffassung in Kants 'Kritik der Urteilskraft'. *Philosophisches Jahrbuch*, 100, 39–71.
- Reill, P. H. (1989). Anti-mechanism, vitalism and their political implications in late Enlightened scientific thought. *Francia*, 16, 195–212.
- Reill, P. H. (1992). Between mechanism and hermeticism: nature and science in the late Enlightenment. In R. Vierhaus (Ed.), *Frühe Neuzeit—Frühe Moderne?* (pp. 393–421). Göttingen: Vandenhoeck & Ruprecht.
- Reill, P. H. (1998). Analogy, comparison, and active living forces: Late Enlightenment responses to the skeptical critique of causal analysis. In J. van der Zande & R. Popkin (Eds.), *The skeptical tradition around 1800* (pp. 203–211). Dordrecht: Kluwer.
- Reill, P. H. (2005). *Vitalizing nature in the Enlightenment*. (Berkeley, etc.): University of California Press.
- Rheinberger, H.-J. (1981). Über Formen und Gründe der Historisierung biologischer Modelle von Ordnung und Organisation am Ausgang des 18. Jahrhunderts. In M.

- Hahn & H.-J. Sandkühler (Eds.), *Gesellschaftliche Bewegung und Naturprozeß* (pp. 71–81). Cologne: Paul-Rugenstein.
- Rheinberger, H.-J. (1986). Aspekte des Bedeutungswandels im Begriff organischer Ähnlichkeit vom 18. zum 19. Jahrhundert. *History and Philosophy of the Life Sciences*, 8, 237–250.
- Richards, R. (2000). Kant and Blumenbach on the *Bildungstrieb*: A historical misunderstanding. *Studies in the History and Philosophy of Biology and the Biomedical Sciences*, 31, 11–32.
- Richards, R. (2002). *The romantic conception of life*. Chicago/London: University of Chicago Press.
- Riedel, M. (1980). Historizismus und Kritizismus: Kants Streit mit G. Forster und J.G. Herder. In B. Fabian & W. Schmid-Biggemann (Eds.), *Deutschlands kulturelle Entfaltung* (pp. 31–48). Munich: Kraus.
- Roe, S. (1981). *Matter, life, and generation: 18th-Century embryology and the Haller-Wolff debate*. Cambridge: Cambridge University Press.
- Roe, S. (1979). Rationalism and embryology: Caspar Friedrich Wolff's theory of epigenesis. *Journal of the History of Biology*, 12, 1–43.
- Roger, J. (1963). *Les sciences de la vie dans la pensée française du XVIIIe siècle; la génération des animaux de Descartes à l'encyclopédie*. Paris: Colin.
- Roger, J. (1968). Leibniz et les sciences de la vie. *Studia Leibnitiana. Supplementa*, 2, 209–219.
- Roger, J. (1980). The living world. In G. Rousseau & R. Porter (Eds.), *The ferment of knowledge: Studies in the historiography of eighteenth-century science* (pp. 255–284). Cambridge: Cambridge University Press.
- Roretz, K. (1922). *Zur analyse von Kants philosophie des organischen*. Akademie der Wissenschaften: Vienna.
- Schmied-Kowarzik, W. (1994). Der Streit um die Einheit des Menschengeschlechts. Gedanken zu Forster, Herder und Kant. In C.-V. Klenke, J. Garber, & D. Heintze (Eds.), *Georg Forster in interdisziplinärer perspektive* (pp. 115–132). Berlin: Akademie.
- Schuster, J. (1941). Der Streit um die Erkenntnis des organischen Werdens im Lichte der Briefe C. F. Wolffs an A. von Haller. *Sudhoffs Archiv*, 34, 196–218.
- Sloan, P. (1979). Buffon, German biology, and the historical interpretation of biological species. *British Journal for the History of Science*, 12, 109–153.
- Sloan, P. (2006). Kant on the history of nature: The ambiguous heritage of the critical philosophy for natural history. *Studies in History and Philosophy of the Biological and Biomedical Sciences*, 37, 627–648.
- Steigerwald, J. (2006a). Kant's concept of natural purpose and the reflecting power of judgement. *Studies in History and Philosophy of Biological and Biomedical Sciences*, 37(4), 712–734.
- Steigerwald, J. (Ed.) (2006b). Special issue: Kant and biology. *Studies in History and Philosophy of Biological and Biomedical Sciences*, 37(4).
- Stein, K. (2004). *Naturphilosophie der Frühromantik*. Paderborn: Schöningh.
- Strack, T. (2001). Philosophical anthropology on the eve of biological determinism: Immanuel Kant and Georg Forster on the moral qualities and biological characteristics of the human race. *Central European History*, 29(3), 285–308.
- Tuschling, B. (1971). *Metaphysische und transzendente Dynamik in Kants Opus postumum*. Berlin: de Gruyter.
- Tuschling, B. (1989). Apperception and ether: On the idea of a transcendental deduction of matter in Kant's opus postumum. In E. Förster (Ed.), *Kant's transcendental deductions* (pp. 193–216). Stanford: Stanford University Press.
- Tuschling, B. (1991). The system of transcendental idealism: questions raised and left open in the *Kritik der Urteilskraft*. *Southern Journal of Philosophy*, 30 Supplement: System and Teleology in Kant's *Critique of Judgment*, 109–128.
- Ungerer, E. (1922). *Die teleologie Kants und ihre bedeutung für die logik der biologie*. Berlin: Borntraeger.
- Uschmann, G. (1955). *Caspar Friedrich Wolff: Ein Pionier der modernen embryologie*. Leipzig/Jena: Urania.
- van Hoorn, T. (2004). *Dem Leibe abgelesen. Georg Forster im Kontext der physischen Anthropologie des 18. Jahrhunderts*. Tübingen: Niemeyer.
- Warnke, C. (1992). 'Naturmechanismus' und 'Naturzweck': Bemerkungen zu Kants Organismus-Begriff. *Deutsche Zeitschrift für Philosophie*, 40, 42–52.
- Wegelin, C. (1957). Dr. Med. Christoph Girtanner (1760–1800). *Gesnerus*, 14, 141–163.
- Weingarten, M. (1982). Menschenarten und Menschenrassen: Die Kontroverse zwischen Georg Forster und Immanuel Kant. In G. Pickert (Ed.), *Georg Forster in seiner Epoche* (pp. 117–148). Berlin: Argument (Sonderband 87).
- Williams, L. P. (1973). Kant, Naturphilosophie and scientific method. In R. Giere & R. Westfall (Eds.), *Foundations of scientific method: The nineteenth century* (pp. 3–22). Bloomington: Indiana University Press.
- Wolff, C. F. (1764). *Theorie von der Generation in zwei Abhandlungen erklärt und bewiesen (1764). Theoria generationis (1759)*. Mit einer Einführung von Robert Herrlinger. Reprint: Stuttgart: G Fischer, 1966.
- Wolff, C. F. (1789). *Von der eigenthümlichen und wesentlichen Kraft der vegetabilischen sowohl als auch der animalischen Substanz, in Zwei Abhandlungen über die Nutritionskraft [...] nebst einer fernern Erläuterung eben derselben Materie von C. F. Wolff*. St. Petersburg: Royal Academy of Sciences.
- Wubnig, J. (1968/69). The epigenesis of pure reason. *Kant-Studien*, 60, 147–152.
- Zammuto, J. (1998). 'Method' vs 'Manner'?—Kant's critique of Herder's *Ideen* in light of the epoch of science, 1790–1820. *Herder Yearbook*, 1998, 1–25.
- Zammuto, J. (2003). 'This Inscrutable Principle of an Original Organization': Epigenesis and 'Looseness of Fit' in Kant's Philosophy of Science. *Studies in History and Philosophy of Science*, 34, 73–109.
- Zammuto, J. (2006a). Kant's early views on epigenesis: The role of maupertuis. In J. E. Smith (Ed.), *The problem of animal generation in modern philosophy* (pp. 317–354). Cambridge: Cambridge University Press.
- Zammuto, J. (2006b). 'Policing polygeneticism in Germany, 1775: (Kames,) Kant and Blumenbach'. In S. Eigen & M. Larrimore (Eds.), *The german invention of race* (pp. 35–54). Albany: State University Press of New York.
- Zammuto, J. (2006c). Teleology then and now: The question of Kant's relevance for contemporary controversies over function in biology. *Studies in History and Philosophy of Biological and Biomedical Sciences*, 37, 748–770.
- Zammuto, J. (2007). Kant's persistent ambivalence toward epigenesis, 1764–1790. In P. Hunemann (Ed.), *Understanding purpose: Collected essays on Kant and philosophy of biology* (pp. 51–74). University of Rochester Press/North American Kant Society Studies in Philosophy.
- Zammuto, J. (2009). 'Kant's Notion of Intrinsic Purposiveness in the *Critique of Judgment*: A Review Essay (and an Inversion) of Zuckert's *Kant on Beauty and Biology*'. *Kant Yearbook I* (2009): *Teleology* (Berlin/NY: de Gruyter), 223–247.
- Zammuto, J. (forthcoming). Kant and objective purposiveness: The problem of organisms. In W. Dudley, & K. Engelhard (Eds.), *Kant: Key Concepts*. London: Acumen.
- Zammuto, J. (2010). Kant, natural history, and the 'daring adventure of reason', Invited Lecture, North American Kant Society, Southern Section Inaugural Meeting, Texas A&M University, March 5–7, 2010 (unpublished).
- Zuckert, R. (2007). *Kant on beauty and biology: An interpretation of the critique of judgment*. Cambridge: Cambridge University Press.
- Zumbach, C. (1984). *The transcendent science: Kant's conception of biological methodology*. The Hague: Nijhoff.