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Hein van den Berg

Kant on Proper Science

Biology in the Critical Philosophy and the *Opus postumum*

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Biology in the Critical Philosophy and the *Opus postumum*

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Note on Citation and Translation

Citations from *Kritik der reinen Vernunft* are located in the usual fashion by their pagination in the first (A) and/or second (B) edition. Citations from other works of Kant are located by volume and page number of the Akademie edition (AA): *Kants gesammelte Schriften*. Translations from the work of Kant are from *The Cambridge Edition of the Works of Immanuel Kant*, unless indicated otherwise. Translations that are my own are accompanied by a footnote with the original German text.

Contents

Chapter 1
Introduction: Kant on Science and Biology

The status of biology in Kant's philosophy of science is often deemed to be problematic. In the *Metaphysische Anfangsgründe der Naturwissenschaft* (1786), Kant specifies several conditions that a proper natural science must satisfy. *Prima facie*, only Newtonian physics satisfies these conditions. Hence, it is not uncommon to think that Kant dismisses all other doctrines of nature as unscientific. This also holds for biology, which is taken to be unscientific because it does not satisfy the conditions of proper (Newtonian) science. In line with this view, organisms have been described as capital anomalies that do not fit into Kant's system of science.[1] There is apparently no way of "reconciling biology *at all* with Kant's prescriptions for science".[2] There thus seems to be a discrepancy between Kant's views on biology and his views on proper natural science. This raises the question of how these two sets of views are related.

The main aim of this work is to analyze Kant's philosophy of biology on the basis of his conception of proper natural science. I show how Kant's views on proper natural science and method, as articulated most explicitly in his *Metaphysische Anfangsgründe* (1786), shaped his conception of biological science and methodology as articulated in the *Kritik der Urteilskraft* (1790) and in the *Opus postumum* (1796–1803). As such, I relate two strands of Kant's philosophy of science that have separately received a lot of attention but are not often treated in conjunction. My main thesis is that Kant's conception of biological science and methodology is continuous with and profoundly influenced by his views on proper natural science. Kant adopts a classical model of scientific rationality and we can only understand his views on biology on the basis of this model.

In the present study I develop an interpretation of Kant's views on natural science and biology that comprises three core parts. These are the following:

(i) First, I explicate Kant's conception of proper natural science. A proper science is a *systematic* whole, in which more fundamental judgments *objectively ground*

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[1] Zammito 2006, 763. See also Guyer 2001.

[2] Zammito 2003, 102.

H. van den Berg, *Kant on Proper Science: Biology in the Critical Philosophy and the* Opus postumum, Studies in German Idealism 15, DOI 10.1007/978-94-007-7140-6_1,

judgments that are derivable from them and in which all judgments are *apodictically certain*. Kant adopts a traditional ideal of scientific explanation. Scientific explanations are explanative demonstrations, i.e., demonstrations showing *why* things are such and such. This ideal of explanation leads Kant to privilege mechanical explanations. Insofar as biology contains proper scientific explanations, they are mechanical explanations. Teleology is not explanatory. However, teleology is a necessary presupposition of biology because it allows us to delimit the object or domain of biology. The proper method of biology consists in the subordination of mechanism to teleology. That is, given the assumption that organisms and their parts are purposive objects, the biologists must specify mechanisms or physical causes that govern organic processes.

(ii) Second, Kant thought that physics, understood as natural science as a whole, should constitute a systematic unity. Biology is a part of physics. In particular, it is part of what was traditionally called *physica specialis*, which was taken to be grounded in the universal doctrine of nature (*physica generalis*). According to Kant, physics does not reduce to mathematical physics. As a part of *physica specialis*, biology must be grounded in *physica generalis*. As such, organic phenomena and processes must be explicable in terms of more fundamental physical laws or forces, although the purposive unity and adaptedness of organisms does not allow of such mechanical explanation. Kant did not and could not specify how biology is grounded in more fundamental physical sciences. However, the idea that biology should be based on such sciences is a persistent methodological ideal.

(iii) Third, in his critical period and in the *Opus postumum* Kant was concerned to strictly distinguish the scientific study of organisms from metaphysical theories on the nature of organisms. He construed the claim that one should comprehend organisms in teleological terms and the claim that one should explain organisms mechanically as regulative *methodological* maxims. These maxims should not be conflated with ontological theses. Kant criticized several biological theories of his contemporaries insofar as he takes them to involve metaphysical claims that cannot be justified. Hence, the relationship between Kant's philosophy and eighteenth-century biological theory is often problematic.

On the basis of this interpretation we can determine Kant's views on the scientific status of biology. I argue that, according to Kant, biology is not a proper natural science. For Kant, only natural sciences that employ mathematics are proper sciences. In the eighteenth century, however, biology was fundamentally a non-mathematical science. In addition, Kant never fully articulated how we should understand the relationship between biology and other natural sciences. He thought that biology should somehow be based on more fundamental natural sciences, such as, for example, physics or chemistry. However, he never fully specified *how* biology is grounded in other natural sciences. Finally, Kant argued that the purposiveness or adaptedness of organisms cannot be explained. In short, Kant did not secure the apodictic certainty of judgments of biology, the position of biology in the sciences was unclear, and he denied that we can explain fundamental characteristics of organisms.

Nevertheless, Kant articulated a method for biology that in many other ways was consistent with his views on proper natural science. By emphasizing that teleology determines the object of biology, he specified the conditions under which biology can be taken to have a determinate *domain*. In addition, Kant argued that it is possible to provide explanations in biology. He construed mechanical explanations as ideal forms of explanation and allowed for mechanical explanations in biology, even if the purposiveness of organisms is mechanically inexplicable. He was committed to the ideal of a systematic natural science and argued that biological sciences should be integrated with other natural sciences. Finally, Kant consistently endeavored to distinguish between the life sciences and metaphysical accounts of organic form. His philosophy of biology was intended to solve a demarcation problem and to differentiate between life science and metaphysical belief.

Kant thus provided a mixed evaluation of biological science. In the present work, I show that by taking into account Kant's views on proper natural science we can explain why he provided this evaluation. Kant's stance towards the life sciences was not uncommon in the eighteenth century. Many thinkers grappled with the problem of how to understand the relationship between biology and other natural sciences. Kant never solved this problem. For a more detailed analysis of the position of biology in the sciences we may turn to Kant's philosophical successors such as Schelling.

1.1 Biology, Teleology, and Explanation

Kant's philosophy of natural science has received enormous scholarly attention. The literature on the topic is vast and sometimes hard to survey. Roughly, we may say that a dominant strand of interpretation has focused on Kant's philosophy of the physical sciences. Within this strand, in which the *Metaphysische Anfangsgründe* is one of the main texts of interest, Kant's philosophical foundation of dynamics, mechanics, his theory of matter, his views on the methodology and epistemology of physics, and his views on chemistry have received much attention.[3] A different strand of interpretation has focused on Kant's inquiries in the life and human sciences. In the last decades, interest in Kant's views on sciences such as psychology, anthropology, and history has steadily increased.[4] This is also true of Kant's philosophy of biology, a

[3] Erich Adickes provided one of the first comprehensive analyses of Kant's philosophy of science. Adickes 1924–1925. Influential systematic treatments of Kant's philosophy of natural science have been given by Plaaβ 1965; Buchdahl 1969; Gloy 1976; Hoppe 1969; Brittan 1978; Cramer 1985; Butts 1984; Friedman 1992a; Falkenburg 2000. Carrier 1990, 2001a, and Friedman 1992a discuss Kant's views on chemistry. Konstantin Pollok has written a formidable critical commentary of Kant's *Metaphysische Anfangsgründe*. See Pollok 2001.

[4] Kitcher 1990 provides an influential account of Kant's views on psychology. Eric Watkins (ed.) 2001, contains essays on psychology, anthropology, history, and biology. Sturm 2001 treats Kant's views on psychology, and Makkreel 2001 treats psychology, anthropology and history. On history, see also Kleingeld 1999.

topic that has been intensively investigated in recent times.[5] The present study aims to relate these two lines of interpretation by showing how Kant's conception of proper natural science determines his conception of biological methodology.

The usefulness of this approach can be shown by relating the present work to two influential strands of interpretation concerning Kant's philosophy of biology. One strand of interpretation, which can be traced to Clark Zumbach's *The Transcendent Science* (1984), stresses that Kant argues for the *autonomy* of biology. Biology is presented as an autonomous science, which has its own particular standards and methodology and is irreducible to physics. Zumbach argues that biology has its own particular 'mode of explanation', which cannot be introduced by the mechanical (physical) point of view.[6] This mode of explanation is made possible by adopting a teleological point of view. According to Zumbach, teleology is a permanent and irreducible conceptual feature of biology, which implies that biology is irreducible to physics. Kant is thus shown to be a methodological or explanatory anti-reductionist, although he is *not* taken to be an ontological anti-reductionist.[7]

According to Zumbach, Kant distinguishes between two types of explanation. On the one hand, to "explain the occurrence of a phenomenon is to give a causal account of it".[8] On the other hand, he notes that "we recognize a sense of 'explanation' where 'to explain' is 'to bring understanding' ".[9] This latter type of explanation is brought about by teleology, which allows us to *unify* certain phenomena. To cite an example of Kant, if we view the construction of a bird as having the *purpose* of enabling flight, we comprehend the particular unity of this construction, e.g., of the hollowing in its bones, the position of its wings, the position of the tail, etc.[10] In this manner, Zumbach introduces a notion of scientific explanation strongly related to unification. Recently, Hannah Ginsborg and Marcel Quarfood have adopted a similar position, arguing that teleology enables us "to regard biological regularities as lawlike or necessary",[11] and that teleology "serves as a substitute" for mechanical laws of nature in cases where "we find no other way to unify the regularities that cry out for explanation".[12] Quarfood further argues that, according to Kant, teleology enables the identification of the subject matter of biology.[13]

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[5] The historian of science Timothy Lenoir has extensively analyzed Kant's philosophy of biology in light of eighteenth and nineteenth-century biology. Lenoir 1980, 1981, 1989. Lenoir's work has been very influential and has given rise to much debate. Influential discussions of Kant's philosophy of biology further include: Löw 1980; McLaughlin 1990; Zammito 1992, 2003, 2006, 2012; Larson 1994; Richards 2000, 2002; Ginsborg 2001, 2004; Guyer 2001, 2005; Sloan 2002, 2006; Breitenbach 2009; Zuckert 2007.

[6] Zumbach 1984, 92.

[7] Zumbach 1984, 87–92.

[8] Zumbach 1984, 110n.

[9] Zumbach 1984, 123.

[10] AA 5: 360.

[11] Ginsborg 2001, 248.

[12] Quarfood 2006, 738.

[13] Quarfood 2006. This position is also developed in Toepfer 2004 and Breitenbach 2009.

A second line of interpretation, developed by Robert Richards and John Zammito,[14] provides a different and more negative evaluation of Kant's philosophy of biology. Zammito argues that Kant denies that biology can ever be reconciled with his prescriptions for science. Organisms are anomalies that threaten the ideal of a systematic and unified science. The mechanical inexplicability of organisms implies that organisms cannot be properly explained. Finally, there is a discrepancy between Kant's views on biology and those of his contemporary life scientists. According to Richards, the reception of Kant's third *Critique* by late-eighteenth-century biologist is a case of a 'historical misunderstanding'.[15] As Zammito puts it: only "by misunderstanding Kant did biology as a special science emerge at the close of the eighteenth century".[16]

Not surprisingly, these interpretations reflect some of the main interests of twentieth-century philosophers of biology. In 1985 Alex Rosenberg stated that the question of whether and how biology differs from other natural sciences is the most controversial issue the philosophy of biology faces.[17] Ernst Mayr took this question to be central to the philosophy of biology. In various publications he argued for the *autonomy* of biology, i.e., for the claim that "biology differs fundamentally in its subject matter, conceptual framework, and methodology from the physical sciences".[18] One of the questions dealt with in this context was the question of whether biology can be reduced to the physical sciences, where reduction was often understood in the sense introduced by Ernest Nagel.[19] This type of reductionism was rejected by the likes of Mayr and many others.[20] Arguing for anti-reductionism, Zumbach positively evaluates Kant's philosophy of biology,[21] whereas Ginsborg argues that Kant takes teleology to express certain normative laws to which organisms are subject.[22] Both authors stress the *differences* between biology and the physical sciences, and Ginsborg's interpretation suggests that Kant's conception of science is more pluralistic than often thought.

The interpretation developed by Richards and Zammito also relates to modern debates in the philosophy of biology. These authors claim that since Kant took

[14] Richards 2000, 2002. Zammito 1992, 2003, 2006, 2012.

[15] Richards 2002, 229.

[16] Zammito 2006, 765.

[17] Rosenberg 1985, 13.

[18] Mayr 1988, 8. See also Mayr 1982, 36–82.

[19] According to Nagel, a theory T_2 is reducible to a theory T_1 if (i) every term occurring in statements of T_2 can be defined or captured by means of the vocabulary specific to T_1 and (ii) every statement of T_2 is derivable from statements of T_1. Nagel 1951, 330.

[20] A contemporary history of the debate, from the 1950s up to the present, is provided by Grene and Depew 2004, 306–313. On reductionism, see also Rosenberg 2006, 25–5 and Rosenberg and McShea 2008, 96–126.

[21] See also Zumbach 1981.

[22] Ginsborg 2001. That biological laws exist in often denied within contemporary philosophy of biology. See Mayr 1982, 37–43 and Rosenberg and McShea 2008, 32–64. Ginsborg's interpretation is partly based on this view.

organisms to be mechanically inexplicable he denied that we can have genuine *explanations* in biology.[23] The question, of course, is how we should construe Kant's views on mechanical and biological explanation.[24] In discussing the topic of biological explanation, Ernst Mayr has stressed that explanations in biology can refer to proximate and ultimate causes.[25] To give a simple example: we may explain how the mammalian eye focuses by illustrating how the lens bends light rays.[26] In providing this explanation, we refer to a proximate cause. However, we can also ask the (historical) question of how this proximate mechanism arose. In answering this question, we refer to an ultimate cause or an evolutionary etiology that shows how this mechanism was "acquired through natural selection during thousands and millions of years of evolution".[27] According to Mayr, any kind of biological phenomenon is due to these *two* independent kinds of causation.[28] Kant denied that the purposiveness of organisms can be mechanically explained and limited the scope of historical explanations in biology. Hence, he denied the possibility of ultimate explanations in biology. The question is whether he denied the existence of explanations in biology altogether.

How does the present work relate to these existing accounts of Kant's philosophy of biology? The first line of interpretation has greatly increased our understanding of Kant's views on biology. It correctly stresses that, according to Kant, we necessarily conceptualize organisms, constituting the object of biology, in teleological terms. In the present study, I will further develop this interpretation from a historical perspective, arguing that teleology determines the *domain* of biology. It is only *because* we conceptualize certain objects of nature teleologically that biology has a distinct domain. Several of Kant's contemporary biologists, such as Johann Friedrich Blumenbach, adopted teleological notions to determine the domain of biology. However, whereas these biologists assumed that the organic and inorganic are ontologically distinct, Kant thought that it is our use of teleological concepts that allows us to demarcate the domain of biology. This position is not only developed in the third *Critique* but also in the *Opus postumum*.

In contrast to the first line of interpretation, however, I argue that Kant denies teleology an explanatory or even quasi-explanatory function. The reason is that he adopts a strict conception of proper explanation in natural science. This becomes clear if we relate Kant's views on biology to his views on proper natural science. I argue that according to Kant the more fundamental judgments of a proper science must *objectively ground* the less fundamental judgments. The idea of objective grounding is related to Kant's views on proper explanation. In providing a proof of a

[23] See, for example, Zammito 2006¸ 758. Richards 2002, 237.

[24] On this topic, see also McLaughlin 1990 and Ginsborg 2001, 2004.

[25] Mayr 1961. See also Mayr 1982, 67–71.

[26] Rosenberg and McShea 2008, 116.

[27] Mayr 1982, 67.

[28] Mayr 1982, 68.

non-fundamental judgment, we must provide an explanative demonstration of this judgment, i.e., a demonstration specifying the objective ground(s) for *why* something is the case. This conception of scientific explanation informs Kant's views on mechanical explanation. Proper explanations in biology are mechanical explanations, i.e., demonstrations proceeding from propositions of physical disciplines. Teleology is denied any explanatory function.[29] Kant's views on proper natural science and scientific explanation thus shape his conception of biological methodology. Importantly, the ideal of mechanical explanation is a methodological ideal that does not have any ontological implications. That we should explain organisms mechanically does not imply, for example, the metaphysical doctrine of materialism. Hence, contrary to what Zumbach suggests, Kant opposes ontological reductionism.

The second line of interpretation has also greatly increased our understanding of Kant's philosophy of biology. It has highlighted the problematic relationship between Kant's philosophy and eighteenth-century biology. However, when Richards and Zammito take Kant to deny the possibility of biological explanations in general they are wrong. To be sure, Kant, like his rationalist predecessors such as Wolff, took the purposiveness of organisms and their parts to be mechanically inexplicable (for Wolff, the cause of purposive organic form is God). Using Mayr's terms, we can say that Kant denied that we can specify the ultimate causes of the purposiveness of organisms. However, Kant does allow for the possibility of providing mechanical and genuine explanations in biology. According to Kant, biologists must take the purposiveness of organisms as a given, and consequently specify the mechanism and mechanical causes that give rise to certain organic phenomena or processes. Thus, we may say that Kant allowed for the possibility of biological explanation in terms of (mechanical) proximate causes.

Of course, Kant had little to no knowledge of such proximate causes and their grounds. On the basis of the idea that natural science as a whole should constitute a unity, he construed biology as a part of natural science that is grounded in more fundamental physical sciences. Biological phenomena, though viewed from a teleological perspective, must be explained in terms of more fundamental physical regularities and forces. Kant did not know how this should be done. Nevertheless, he insisted that biologists should always strive to provide mechanical explanations and he took this to entail that we must find some kind of physical principles on the basis of which we can explain, at least in part, organic processes. This line of thinking is most evident in his late works and the *Opus postumum*.

The present study adds to existing interpretations by analyzing Kant's conception of biological method on the basis of his views on proper natural science. In addition, it relates Kant's philosophy of biology to the relatively unknown views on

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[29] Zumbach writes that "purposiveness arises where there is a causal relation in which the idea of the effect may *prima facie* be cited as an explanation for why the cause of that relation occurred" Zumbach 1984, 9. Here, the 'idea of the effect' is a *purpose*. More recently, Kreines has argued that according to Kant a teleological judgment "M is for E" implies that M's benefit to E explains why M exists or occurs (namely for the sake of E). Kreines 2005, 272–273. In my view, Kant never takes teleology to explain *why* something is the case.

science, explanation, and teleology of his rationalist predecessors, most importantly Wolff and Baumgarten. Finally, the present work provides an extensive analysis of Kant's views on biology in the *Opus postumum*. I will discuss the importance of Wolff and Baumgarten for Kant's views on biology in the following sections. Here, I wish to briefly emphasize the importance of studying the *Opus postumum*.

In discussions of Kant's views on biology, the *Opus postumum* is hardly ever taken into account. In studies of this work, Kant's reflections on organic nature are often treated only marginally and not in relation to his views on biology or eighteenth-century biological theories.[30] This is a pity. In my view, our understanding of Kant's views on biology can be increased by taking this work into account. There, we find clear expression of the idea that teleology determines the domain of biology, that proper explanations in biology are mechanical explanations, and that biology is a part of physics grounded in more fundamental physical sciences. In addition, the *Opus postumum* shows that Kant provided a philosophical interpretation of late-eighteenth-century biological theories and reinterpreted these theories on the basis of his regulative doctrine of teleology. Hence, the relationship between Kant's views on biology and eighteenth-century biology becomes clearer by taking this work into account.

1.2 Methodology

The methods employed in this study are historical reconstruction and history of ideas. The main focus of inquiry is Kant's conception of proper natural science and biology as articulated in the critical corpus and the *Opus postumum*. With respect to the critical period, the *Metaphysische Anfangsgründe* (1786) and the *Kritik der Urteilskraft* (1790) are key texts of analysis.

In analyzing Kant's views on proper natural science and biology in the critical period, I employ pre-critical works, various early and late essays of Kant relating to the topic of biology, the *Jäsche Logik*, and notes from Kant's lectures on logic, metaphysics, and physics. The inclusion of works predating the first *Critique* is motivated by the fact that Kant was concerned with analyzing natural science and biological topics throughout the whole of his philosophical career.[31] A study of

[30] Erich Adickes 1920, providing the first comprehensive analysis of the *Opus postumum*, discusses Kant's reflections on organic nature but not in relation to his views on biology and eighteenth-century biological theories. The same is true for Tuschling 1971, Mathieu 1989, and Hoppe 1969. Eckart Förster 2000, typically treats of the reflections on organic nature contained in Kant's last projected work as preliminaries to the *Selbstsetzungslehre*. Michael Friedman 1992a, abstracts from any discussion relating to biology, as do Edwards 2000a and Emundts 2004. Noteworthy exceptions to this trend include Heimsoeth 1940, Löw 1980, and Guyer 2001.

[31] For an analysis of Kant's pre-critical views on natural science, see Friedman 1992a, 1–52. See also Falkenburg 2000. The importance of biological topics in Kant's early writings has been stressed by Zammito 1992. See also Sloan 2002, 2006, and Ferrini 2000.

Kant's early views on natural science and biology increases our understanding of his later views on these topics. It is for this purpose that I employ the pre-critical writings and early essays relating to biology. The inclusion of the *Jäsche Logik* and lecture notes is motivated by the fact that these sources provide invaluable insight into Kant's views on scientific methodology. In dealing with these sources, I am mainly focused on continuities in Kant's thought. A detailed historical analysis of changes in Kant's philosophy of science and biology lies beyond the scope of this work.

The focus on continuity is also apparent in the strong *ideengeschichtlich* character of the present study. Kant's views on proper natural science, scientific method, and biological method are quite similar to traditional ideals of scientific rationality that were widespread in the modern period. We can increase our understanding of Kant's views on natural science and biology by taking into account the views of his philosophical and scientific predecessors.

I will analyze Kant's views on objective grounding and on the role of mathematics in natural science in relation to the works of Christian Wolff and Isaac Newton (Chap. 2). Kant's views on mechanical explanation are analyzed in relation to Christian Wolff's views on scientific explanation (Chap. 3), whereas Kant's views on teleology are interpreted on the basis of Alexander Gottlieb Baumgarten's conception of teleology (Chap. 4). In discussing Kant's views on the method and domain of biology, I take into account the writings of the biologist Blumenbach (Chap. 5). Kant's conception of physics is studied on the basis of eighteenth-century textbooks on physics (Chap. 6). Kant's reflections on biology in the *Opus postumum* are interpreted on the basis of his published writings, late-eighteenth-century biological theories (developed by Blumenbach, Brandis, Reil, and Sömmering), and metaphysical interpretations thereof (Chaps. 7 and 8).

The *ideengeschichtlich* method provides a fruitful perspective on Kant's philosophy of natural science and biology. It sheds new light on Kant's views on grounding in natural science, which in turn allows us to better understand his views on the role of mathematics and metaphysics in natural science. Whereas the notion of grounding is typically understood in epistemic terms,[32] I relate this notion to the idea of objective scientific explanation. In addition, Kant's philosophy of biology has to my knowledge never been related to Christian Wolff's views on explanation and biological methodology. There are noteworthy similarities and differences between the views of Wolff and Kant on the methodology of natural science and biology. An investigation of these continuities and differences will increase our understanding of Kant's views on biology. The same is true of Kant's views on teleology, which can be profitably understood by taking into account the views on teleology of Baumgarten. Finally, Kant's views on biology espoused in the *Opus postumum* have rarely been investigated in relation to eighteenth-century biological theories. The present study aims to do just that.

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[32] Friedman 1992b.

1.3 An Overview of the Work

The scope of the present work is rather large. In the present section, I will therefore provide a detailed account of its structure and contents. Before presenting this overview, however, two methodological remarks are in order.

First, it must be emphasized that the present study is concerned with providing an analysis of Kant's conception of proper *natural* science. In analyzing this conception, I also treat conditions that according to Kant any science must satisfy. However, these conditions are always analyzed in relation to Kant's views on natural science. The present study does not aim to investigate Kant's views on how, e.g., mathematics or transcendental philosophy can constitute proper sciences.

Second, it must be noted that the use of the term 'biology' is slightly anachronistic. It is common to locate the origin of the term 'biology', designating a special science of life, in 1802 when Gottfried Reinhold Treviranus published the first volumes of his *Biologie*, *oder Philosophie der lebenden Natur*. In the same year, Jean-Baptiste de Lamarck employed the term biology in a similar fashion.[33] Thus, the term biology became accepted right before Kant's death in 1804. To my knowledge Kant never employed the term 'biology'. However, in contemporary discussions of Kant it is quite common to take this term to refer to various disciplines dealing with organic nature, e.g., zoology and botany (two realms of natural history), physiology, embryology, and (comparative) anatomy.[34] In the present study I follow this usage of the term biology.

In Chap. 2, I analyze Kant's conception of proper natural science. I identify three core conditions that Kant thinks a proper natural science must satisfy: (i) systematicity, (ii) objective grounding, and (iii) apodictic certainty. These conditions are analyzed in relation to the Classical Model of Science of de Jong & Betti, which is an interpretative framework that aims to capture the basics of how many thinkers in history construed the concept of science.[35]

Kant's notion of systematicity (i) is treated in relation to his views on the ordering of concepts. Kant's idea of (objective) grounding (ii) is discussed in relation to his views on the ordering of concepts *and* his views on the ordering of judgments. I argue that both concepts and judgments of a science satisfy different kinds of grounding-relations. With respect to judgments, I take Kant to hold that the judgments of a proper science must be grounded in more fundamental judgments. This relation of grounding is stronger than that of logical derivability: more fundamental judgments in science must *objectively ground* less fundamental judgments. This entails that in providing a scientific proof of a judgment α, we must provide an *explanative demonstration* of α. Kant thus adopts the Aristotelian idea that in science we should provide a demonstrative or scientific syllogism (a *demonstratio*

[33] Hodge 1971, 323–352; Theunissen and Visser 1996; Richards 2000, 12. Earlier uses of the term have been noted by McLaughlin 2002.

[34] See Zumbach 1984; Richards 2000.

[35] De Jong and Betti 2010.

propter quid). This is a demonstration providing the reason *why* things are such and such. Finally (iii), the notion of apodictic certainty captures an epistemic requirement that the judgments of a science must satisfy. According to Kant, the judgments of a proper science must be apodictically certain, i.e., we must be justified in asserting their necessary truth. This implies that the judgments of a science must allow of proof from *a priori* principles.

Conditions (ii)–(iii) allow us to understand why Kant argues that any proper natural science must contain mathematics and be based on metaphysics. I argue that Kant takes mathematics to be necessary for natural science because it ensures the apodictic certainty of judgments of natural science *and* because it aids us in providing proper scientific explanations (demonstrations *propter quid*). For similar reasons, Kant takes metaphysics to be necessary for natural science. Hence, proper natural science does not merely require mathematics and metaphysics in virtue of the epistemic function the latter fulfill. Mathematics and metaphysics are also necessary because they allow us to provide genuine explanations.

In Chap. 3, Kant's views on proper natural science are compared to his views on the possibility of scientific cognition of organisms. In the *Kritik der Urteilskraft*, Kant famously argues that organisms defy mechanical explanation. The main aims of this chapter are to specify how Kant understands the notion of mechanical explanation and why mechanical explanation is construed as an *ideal* of scientific explanation. I argue that mechanical explanations are construed as proper explanations because they are understood as providing *objective* scientific explanations (demonstrations *propter quid*).

Kant construes mechanical explanations as explaining wholes in terms of their parts. In order to understand what this entails, I analyze Christian Wolff's views on explanation. I argue that part-whole conceptualizations figuring in Wolff's logic and metaphysics influence his view on the nature of scientific explanation. In logic, definitions are construed as explanations of wholes in terms of their parts. In his metaphysics, Wolff argues that cognition of the parts of a thing and their mode of composition provides cognition of the *essence* of a thing, which contains the ground (reason *why*) of its attributes. Hence, by knowing the parts of a thing and their mode of composition we can explain *why* a thing has certain attributes. This idea of explanation is also applied by Wolff to natural science. In natural science, we explain features of corporeal bodies in terms of: (a) their parts, (b) the mode of composition of these parts and (c) forces acting upon the parts. Explanations in terms of (a)–(c) are *mechanical explanations*. Wolff attempts to provide such explanations in biology, arguing that we can specify the true *ground* of the growth, nutrition, and propagation of organisms on the basis of cognition of their parts and mode of composition.

Kant is shown to adopt a similar view on mechanical explanation. As in the case of Wolff, this view is based on part-whole conceptualizations employed within logic. According to Kant, mechanical explanations are explanatory demonstrations proceeding from general principles ('parts') to more specific consequences ('wholes') and are therefore construed as ideal scientific explanations of nature. Finally, I argue that Kant's claim that organisms defy mechanical explanation concerns specific features of organisms: the purposive order and unity of the parts of organisms and the adaptation of organisms to their surroundings.

Chapter 4 contains an analysis of Kant's views on teleology. The main thesis of this chapter is that Kant cannot assign any explanatory role to teleology. I relate Kant's views on teleology to the treatment of teleological concepts given in the works of Christian Wolff and Alexander Gottlieb Baumgarten. These rationalists adopted an intentional conception of 'purpose': purposes are the objects of intentions of some agent with a will and an intellect. For Baumgarten, an object is a purpose only relative to some subject or intellect that *represents* this object as good and tries to obtain this good by *employing* certain means. Wolff and Baumgarten typically identify this subject with God. We can construe natural objects and organisms as purposes only relative to the intentions of God.

Like his rationalist predecessors, Kant adopted an intentional concept of 'purpose'. However, Kant denied that we can have theoretical knowledge of God and his intentions. This partly explains why Kant did not assign any explanatory role to teleology in natural science. Proper explanations in natural science are objective and explanative demonstrations representing the order of nature. However, the appeal to the *nexus finalis* in natural science leads us *beyond* the order of nature. The *nexus finalis* is a connection of *ideal* causes. For these reasons, Kant takes purposes to be subjectively ascribed to objects of nature. They are not objective grounds in terms of which we can explain *why* something is the case. In biology, proper explanations are therefore mechanical explanations, which Kant associates with explanations in accordance with the *nexus effectivus*.

In Chap. 5, I discuss how Kant construes the domain and method of biology. I argue that, according to Kant, teleology is fundamental in determining the domain of biology. I will discuss Kant's views on the basis of an analysis of the manner in which Johann Friedrich Blumenbach distinguishes organic from inorganic bodies. Organic bodies (plants and animals) are distinguished from inorganic bodies by characterizing the former in terms of (i) reproduction, (ii) nutrition and growth, and (iii) a particular structure. (i)–(iii) provide criteria for distinguishing organic from inorganic bodies and are understood in teleological terms. Most importantly, organisms must have a *purposive structure* (iii) that is adapted to performing the functions (i) and (ii). In this manner, Blumenbach assigned a crucial role to teleology in distinguishing organic from inorganic bodies. However, whereas Blumenbach took organic and inorganic bodies to be ontologically distinct, Kant was agnostic on this issue. According to Kant, it is by *conceptualizing* certain objects as purposive that we make this distinction.

The proper method of biology is taken to consist in the *subordination* of mechanism to teleology. Through teleology, we delimit the object of biological investigation and take them to be *purposive* wholes. In particular, we comprehend organisms as having a structure adapted to performing organic functions such as growth and nutrition. Given this teleological characterization of the object of biological investigation, we must try to provide mechanical explanations of such processes as growth and nutrition. To give such mechanical explanations amounts to specifying the proximate (mechanical) causes of organic phenomena and processes. To substantiate this reading, I analyze Kant's views on the reproduction, growth and nutrition, and regeneration of organisms.

In Chap. 6, I analyze Kant's views on physics or natural science and discuss the so-called transition project (*Transition*) that Kant undertakes in the *Opus postumum*. I show that Kant adopts a broad Aristotelian conception of physics as a science of nature incorporating any doctrine of nature, including biology and psychology. He also adopts a more restricted conception of physics as a doctrine of *corporeal nature*. The latter doctrine includes mathematical physics, chemistry, and biology, while it excludes psychology. Hence, it is problematic to equate Kant's notion of physics with mathematical (Newtonian) physics. Biology and other non-mathematical natural sciences are parts of physics. Kant further distinguishes between a rational (a priori) and empirical part of physics. The a priori part of physics, in turn, is divided into a mathematical and metaphysical part.

Natural science or physics as a whole thus consists of many parts. If physics as a whole is to constitute a *system*, which Kant claims, these parts must be systematically related to one another. Through an analysis of some eighteenth-century textbooks on physics, I show that various thinkers grappled with the problem of how to establish physics as a systematic unity. In some textbooks a distinction was made between *physica generalis* (a priori physics) and *physica specialis* (empirical physics). *Physica generalis* contained, among others, discussion of the laws of motion and Newton's theory of universal gravitation. In contrast, *physica specialis* contained, among others, discussion of fluid and solid bodies, chemical topics, electricity, magnetism, and biological topics. Physics as a whole is established as a systematic science by grounding *physica specialis* in *physica generalis*. How this grounding project was to be effected, remained, however, a conundrum.

In the *Opus postumum*, in a project that provides the transition from the metaphysical foundations of natural science to physics, Kant aimed to solve this problem. I show that the project of effecting a transition from the metaphysical foundations of natural science to physics is similar to the project of exhibiting the systematicity of physics by grounding *physica specialis* in *physica generalis*. Importantly, Kant includes biological topics, which were traditionally taken to belong to *physica specialis*, within his *Transition*. In the *Opus postumum*, Kant aimed to provide a foundation or grounding of biology.

Chapter 7 contains an analysis of Kant's reflections on biology in the *Opus postumum*. In particular, I analyze his construal of the notion of 'vital force'. Kant's reflections must be read in the context of late-eighteenth-century biological theories. I interpret his views on vital force on the basis of his published writings and on the basis of the physiological and biological writings of Johann Friedrich Blumenbach, Joachim Dietrich Brandis, and Johann Christian Reil. I argue that Kant treats vital forces as regulative posits. Kant accepts Blumenbach's doctrine of vital force insofar as it stresses the idea that we must understand organisms as self-maintaining and purposive wholes. However, he does not argue for the existence of vital forces in nature. This is to transgress the realms of proper science and to adopt a dogmatic metaphysical position. Vital forces are thus reinterpreted as regulative posits, ascribed to organisms by analogy with human purposive action.

In Chap. 8, I discuss Kant's views on materialism, hylozoism, and natural history in the *Opus postumum*. As in the third *Critique*, Kant rejects materialism and hylozoism. He discussed these metaphysical positions, first of all, because he developed strongly mechanistic explanations of organisms. He argued, for example, that the ether could be construed as a ground of certain physiological phenomena. That Kant adopted such a view shows that he attempted to somehow ground the life sciences in more general physical disciplines. The attempt to articulate strongly mechanistic explanations of organic phenomena necessitated Kant to show that giving such explanations does not imply the truth of materialism or hylozoism.

Kant's critique of hylozoism is further shown to be related to his encounter with late-eighteenth-century biological theories and metaphysical interpretations of these theories. Kant's rejection of materialism in the *Opus postumum* is related to his encounter with Samuel Thomas Sömmering's *Über das Organ der Seele* (1796). In this work, Sömmering provides a physiological investigation into the organ or seat of the soul. Kant criticized Sömmering for confusing metaphysical and physiological questions. Kant's critique of hylozoism in the *Opus postumum* is related to his encounter with Salomom Maimon's *Ueber die Weltseele* (1790), in which Maimon employed Blumenbach's theory of vital force to argue for the existence of a world-soul, i.e., to argue for the truth of hylozoism.

I further discuss Kant's reflections on natural history in his published writings and the *Opus postumum*. Kant has a moderately positive view of natural history. Natural history aims to provide causal explanations of present effects (e.g., traits of organisms) in terms of historical causes (objective grounds). Hence, Kant's views on proper scientific explanation led him to positively characterize natural history. However, he argued that certainty cannot be obtained in natural history. He also denied that natural history can ever support the idea that organisms are generated from unorganized matter and he was skeptical of ideas affirming the transformation of species. Finally, Kant thought that the results of natural history should be consistent with viewing man as the final end of nature. Kant thus placed severe restrictions on natural history. These restrictions can also be located in the *Opus postumum*.

Finally, in Chap. 9, I review the main results of our analysis. It is clear that, according to Kant, biology is not a proper science. The reason is that he adopted a rigid conception of proper science. To be sure: Kant endeavored to elucidate the special characteristics of organisms, to delimit the domain of biology, and to demarcate biology and metaphysics. He further articulated a biological method that prescribed us to integrate biology with the physical sciences. As such, he applied his model of proper science, as far as possible, to biology. Nevertheless, because he applied this model to biology he took the explanatory potential of biology to be limited and argued that the purposiveness of organisms cannot be explained. From our modern Darwinian perspective, it is precisely the explanation of purposiveness with which biology is concerned.

Chapter 2
Kant's Conception of Proper Science

Kant is well known for his restrictive conception of proper science. In this chapter I will explain why he adopted this conception. I will identify three core conditions which Kant thinks a proper science must satisfy: systematicity, objective grounding, and apodictic certainty. Kant's infamous claim that any proper natural science must be mathematical should be understood in light of these conditions. The same holds for Kant's claim that any proper natural science must be based on metaphysical principles.

The Preface to the *Metaphysische Anfangsgründe der Naturwissenschaft* (1786) contains one of Kant's few systematic attempts to specify the notion of a proper science. Kant defines a proper science as a body of cognition that (i) is a system, (ii) constitutes a rational interconnection of grounds and consequences, and (iii) provides apodictically certain cognition. In addition, Kant states that any proper natural science must contain mathematics and be based on a metaphysics of corporeal nature.[1] The Preface does not contain a detailed explication of these conditions, yet the implications of these conditions are rich. They enable Kant to argue that natural description (the classification of natural kinds), natural history (the historical study of changes within nature), chemistry, and empirical psychology are not proper sciences.

This does not mean that Kant took no active interest in natural description, natural history, chemistry, and empirical psychology. Recent research has shown that Kant, throughout his life, undertook significant philosophical analyses of all of these sciences.[2] This raises the question of why he adopted his restrictive conception of proper science. In the present chapter I will answer this question by describing the conceptual background of Kant's idea of proper science. I will analyze Kant's conditions for proper science one by one and indicate how they are related to each other. I will also argue that several of these conditions correspond to conditions of the Classical Model of Science as set out by de Jong and Betti (2010).

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[1] AA 4: 467–471.

[2] See, for example, the collection of essays in Watkins 2001.

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The Classical Model of Science (hereafter: the Model) is an *ideengeschichtlich* interpretive framework that aims to describe an influential traditional ideal of scientific rationality. This model describes seven conditions. Any science that satisfies these conditions can be called a *proper* science. These conditions, for any system *S* of propositions and concepts (or terms), are:

(1) All propositions and all concepts (or terms) of *S* concern a *specific set of objects* or are about a *certain domain of being*(*s*).
(2a) There are in *S* a number of so-called *fundamental concepts* (or terms).
(2b) All other concepts (or terms) occurring in *S* are *composed of* (or are *definable from*) these fundamental concepts (or terms).
(3a) There are in *S* a number of so-called *fundamental propositions*.
(3b) All other propositions of *S follow from* or *are grounded in* (or *are provable* or *demonstrable from*) these fundamental propositions.
(4) All propositions of *S* are *true*.
(5) All propositions of *S* are *universal* and *necessary* in some sense or another.
(6) All propositions of *S* are *known to be true*. A non-fundamental proposition is known to be true through its *proof* in *S*.
(7) All concepts or terms of *S* are *adequately known*. A non-fundamental concept is adequately known through its composition (or definition).[3]

These conditions are meant to capture the core of a conception of science that was held by various thinkers in history. The Model is meant to *describe* what various philosophers and scientists throughout history took the ideal characteristics of a science to be (de Jong and Betti do not claim that sciences actually resemble this model or that sciences should do so). In addition, it is important to note that the Model is an abstraction. If we use the Model, we may for example conjecture that both Wolff and Kant thought that all non-fundamental concepts of a science are definable on the basis of fundamental concepts (2b). If this turns out to be true, (2b) may be taken to describe a view that is shared by Wolf and Kant. However, Wolff and Kant may differ on what it means to define a concept. In that case, the historian must *specify* or *determine* condition (2b) in order to describe the differences between Wolff and Kant. If we use the Model in this way, it allows us to describe both continuities and discontinuities in the history of thought.

In the present chapter, I relate Kant's conception of proper science to conditions (2a) and (2b), concerning the order of concepts by means of definitions, and to conditions (3a) and (3b), concerning the order of judgments by means of relations of grounding. In addition, I will focus on condition (6) in considering Kant's account of proper scientific knowledge. Most discussions of Kant's theory of science focus on his views on the a priori justification of scientific cognition (conforming to condition (6) of the Model). In my presentation, Kant's views on grounding (condition

[3] De Jong and Betti 2010, 186. The historiographical background of the Classical Model of Science, as presented by de Jong and Betti, is provided by the systematizations of Aristotle's theory of science by Heinrich Scholz 1930 and Evert W. Beth 1965. On the difference between the systematizations of Scholz, Beth and that given by De Jong and Betti, see De Jong and Betti 2010, 197–201.

(3b)) take center stage. I will argue that Kant adopted an idea of scientific explanation which conforms to the traditional Aristotelian idea of a demonstration of the reasoned fact. This conception of scientific explanation must be distinguished from his ideas concerning the adequate justification of scientific cognition.

In the first section I discuss Kant's views on systematicity in relation to his views on the ordering of concepts (Sect. 2.1). Kant's conception of the systematic order of concepts can be understood in terms of conditions (2a) and (2b) of the Model. In the second section I discuss Kant's claim that any proper science must provide a rational ordering of grounds and consequences (Sect. 2.2). This claim is sometimes interpreted as stating that any proper science must have a priori principles.[4] In my opinion, it is better understood as stating that any proper science must satisfy a grounding-relation, i.e., provide explanative demonstrations. The claim that a science must provide a rational ordering of grounds and consequences can thus be understood in terms of (3b) of the Model. It is Kant's third condition, discussed in section three, that *implies* that proper sciences must have a priori principles (Sect. 2.3). Kant's third condition states that scientific cognition must be apodictically certain and corresponds to condition (6) of the Model. Section four will provide an interpretation of the claim that any proper natural science must contain mathematics (Sect. 2.4). Finally, in section five I will discuss Kant's claim that any proper natural science must be based on metaphysical principles (Sect. 2.5). This section relates Kant's views on providing metaphysical foundations of natural science to conditions (3a), (3b), and (6) of the Model.

2.1 Systematicity

The first condition that any proper science must satisfy is that of systematicity.[5] According to Kant, sciences should be systems. How should we understand the notion of a system? In the first *Critique*, Kant specifies three characteristics of a 'system of cognition'.[6] First, (i) he notes that the systematic unity of cognition is brought about by the *faculty of reason*. This follows from Kant's construal of reason as a faculty that logically orders and unifies cognition.[7] The term 'cognition' refers to both *concepts* and *judgments*.[8] In this section, I restrict my discussion to concepts. Second, (ii) Kant claims that systems of cognition are interpreted as *complete wholes*. Third, (iii) Kant claims that the place of the parts (cognitions)

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[4] Watkins 2007, 5; Pollok 2001, 56–62.

[5] This notion has received considerable attention. For recent discussion, see Falkenburg 2000, 376–385; Fulda and Stolzenberg 2001; Guyer 2005, 11–73. My account is indebted to Falkenburg, from whose analysis of Kant's theory of science I have benefited greatly.

[6] *KrV*, A 645/B 673.

[7] *KrV*, A 298–302/B 355–359. Falkenburg 2000, 376–385.

[8] See *KrV*, A 68–69/B 93–94, in which Kant construes judgments as providing a "mediate cognition of an object".

within a system and the relations of these parts to each other are *determined* a priori in accordance with certain conditions.

These characteristics are highly abstract. They become intelligible when we consider how Kant takes systems of cognition to be constructed. I will argue that Kant takes a system of cognition to be constructed by following certain *logical rules* that establish necessary relations among cognitions. These rules are logical in a broad sense. Applied to concepts they comprise prescriptions for establishing order among concepts through definitions and through the specification of the extension of concepts. Kant is referring to such rules when he speaks of the conditions in accordance with which we determine the place of cognitions in a system (iii). A system of cognition can thus be construed as a complete whole composed of parts that are necessarily related to each other in accordance with logical rules. As such, it is distinguished from a contingent aggregate. In the following, I first discuss the rules in accordance with which we establish a system of cognition. I then explain how we should understand the claim that a system is complete.

In the Doctrine of Method of the *Jäsche Logik*,[9] systematicity is described as a *logical perfection*, i.e., as an *ideal* of scientific cognition.[10] The notion of systematicity is explained by showing how systems of *concepts* are constructed. According to Kant, the combination of concepts in a systematic whole depends on the "distinctness of concepts both in regard to what is contained *in* them and in respect of what is contained *under* them".[11] Here, the notion of systematicity is explicated in terms of traditional logical terminology.[12] Concepts *contained in* a concept are partial concepts (marks) comprising the concept's intension (*Inhalt*).[13] For example, the partial concepts 'animal' and 'rational' are *contained in* the concept 'man'. Conversely, concepts *contained under* a concept are concepts comprising its extension (*Umfang*). For example, the concepts 'gold' and 'silver' are contained under the concept 'metal'.[14] A concept is *distinct* if we possess a clear representation of its marks, i.e., if we know the partial concepts *contained in* this concept.

The claim that the combination of concepts into a systematic whole requires the distinctness of concepts with regard to what is *contained in* and *under* them can now be understood as follows: systematicity is brought about both by the determination

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[9] The *Jäsche Logik* (1800) is a textbook treating Kant's logic, edited by Gottlob Benjamin Jäsche (1762–1842). The publication of the *Jäsche Logik* was authorized by Kant. Nevertheless, it cannot be considered Kant's own text. See Boswell 1988, 192–203. Despite problems involving the authenticity of the text, the *Jäsche Logik* provides an important resource for analyzing Kant's logical concepts. I will frequently employ this work, as well as various student transcripts of Kant's lectures on logic, when analyzing Kant.

[10] AA 9: 139–140.

[11] Ibid.

[12] See, for example, Meier 1752b, 70–80. Meier's *Auszug*, a shortened version of his *Vernunftlehre* (1752), was employed by Kant as a compendium for his lectures on logic. It provides an important reference for understanding Kant's views on logic. On Meier's logics, see Pozzo 2005.

[13] AA 9: 95.

[14] AA 9: 96.

of the intension of concepts and by the specification of their extension.[15] The *intension* of concepts is determined by providing *definitions* of these concepts.[16] The extension of concepts is specified by means of *logical division*. Thus, through definitions and logical division we establish a systematic order among concepts. Let us first consider Kant's views on definitions.

2.1.1 Definitions

In the first *Critique*, Kant remarks that we define a concept if we specify clear and sufficient marks, thus rendering the concept complete. In giving a definition, it is further required that the specification of marks be precise.[17] This view on definitions is traditional and can be traced to the writings of Christian Wolff.[18] Wolff construes a definition as a concept that is clear, distinct, and complete.[19] A concept is *clear* if we can recognize the things to which it applies. A clear concept is *distinct* if we cognize its marks. A clear and distinct concept is *complete* if the marks we have cognition of are sufficient for cognizing the things represented by the concept and distinguishing them from other things. Kant similarly requires that a definition specify clear marks. These marks must be sufficient, i.e., they must allow us to distinguish the things represented by the defined concept from other things. The requirement of precision adds that we must not specify more marks than are necessary for completeness.[20] In short: a definition of a concept specifies marks of a concept that are sufficient for distinguishing the things to which it applies from other things, while not specifying more marks than necessary for completeness.

Definitions can be synthetic or analytic.[21] *Synthetic definitions* are definitions of concepts that are *made*. Mathematical definitions constitute a prime example. A *nominal* mathematical definition is given by the arbitrary combination of concepts. For example, the concept 'square' is defined through the combination of 'four-sided', 'equilateral', and 'rectangle'.[22] This definition provides a precise specification of clear and sufficient marks of the concept 'square'. Through such definitions, we define a concept in terms of more fundamental concepts. In the *Critique*, Kant construes mathematical definitions as constructive definitions.[23] Constructive definitions of mathemat-

[15] Longuenesse 1998, 150–151.

[16] AA 9: 141–142.

[17] *KrV*, A 727/B 755. Cf. AA 9: 140.

[18] A quite similar account of definitions can be found in Meier 1752b, 74–79. I am grateful to Job Zinkstok for helpful discussion on the topic of definitions.

[19] Wolff [1754] 1978, 141.

[20] *KrV*, A 727n/B 755n.

[21] AA 9: 141.

[22] AA 9: 141; AA 24: 757.

[23] *KrV*, A 729/B 757. Wolff ([1750] 1999, 11–13) and Meier (in his 1752b, 73–74) take construction to prove the *possibility* of the thing falling under the concept defined through the arbitrary

ical concepts are *real* mathematical definitions. For example, we may define a circle by giving the construction procedure of letting a straight line revolve around a fixed point.[24] In this case we define 'circle' in terms of more fundamental notions, namely 'fixed point' and 'line' and their combination through motion. Both real and nominal mathematical definitions are instances of synthetic definitions. Kant's conception of mathematical definitions thus gives clear expression to the idea that in a science concepts are composed of (more) fundamental concepts (condition (2b) of the Model).

Kant is not always clear on what he takes to be the fundamental concepts of mathematical doctrines, although he does state that they contain primitive concepts.[25] In Kant's time, constructive mathematical definitions were often taken to proceed from a limited number of primitive concepts. For example, in his *Anfangs-Gründe aller Mathematischen Wissenschaften* (1750), Christian Wolff argues that in geometry real definitions are easily obtained, for the motion of points gives lines, the motion of lines gives planes, and the motion of planes gives solids. If we combine points, lines, and planes in a sensible manner, and ascribe to all of them possible types of motion, we obtain different geometrical definitions.[26] This procedure is worked out in detail in Wolff's discussion of the foundations of geometry, in which non-fundamental concepts are defined in terms of fundamental concepts.[27] In this manner, the method of providing constructive definitions captures condition (2a) of the Model.

Analytic definitions are definitions of *given* concepts (they are not made, as in the case of synthetic definitions). Through analysis we cognize marks of given concepts, i.e., make them distinct, and try to render them complete. In this manner, we may define concepts in terms of more fundamental concepts (contained *in* the former) by means of the traditional method of *definitio per genus proximum et differentiam specificam* (condition (2b) of the Model). The relation of genera to species is a relation of higher to lower concepts. For Kant, concepts are called higher if they contain other concepts under themselves, which are called lower relative to the former.[28] Following de Jong, we may clarify Kant's conception on the containment relations of concepts by means of conceptual hierarchies called *porphyrian trees*.[29] Consider the following tree printed in John Wallis's *Institutio logicae* (1763) (Fig. 2.1).[30]

combination of concepts. As Meier puts it: definitions obtained through the arbitrary combination of concepts need to be proven. In mathematics this can be done through construction. Mathematical constructive definitions provide real definitions insofar as they show that a thing is possible.

[24] The example is taken from Wolff [1750] 1999, 12–13.

[25] AA 2: 279–280.

[26] Wolff [1750] 1999, 16.

[27] See Shabel 2003, 49–57, for an account of this procedure.

[28] AA 9: 96.

[29] De Jong 1995. De Jong explicates Kant's theory of concepts and analyticity in terms of porphyrian trees. Building on De Jong, Anderson 2005, 22–74, has discussed different types of analytic hierarchies of trees while emphasizing their representational limits. My account is indebted to both authors.

[30] Wallis 1763, 16.

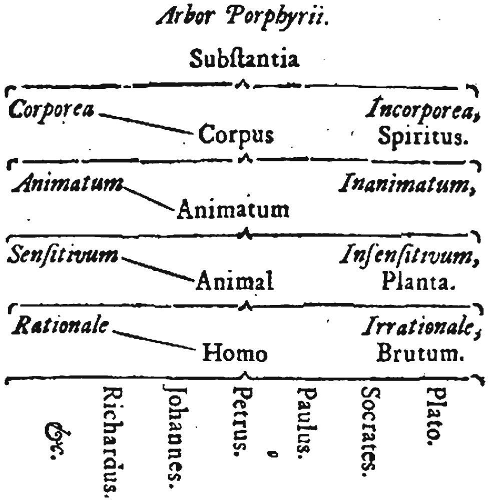

Fig. 2.1 Porphyrian tree from Wallis's *Institutio logicae* (1763)

Porphyrian trees provide a clear example of a system of concepts.[31] In porphyrian trees, species are specified in terms of a common genus and mutually exclusive *differentiae*. In this particular tree we specify, e.g., the species 'body' in terms of the genus 'substance' and *differentia* 'corporeal' as opposed to the mutually exclusive *differentia* 'incorporeal'. Both *differentia* and genus are partial concepts of the species, i.e., they are *contained in* the species. Species are represented in terms of the conjunction of proximate genus and specific difference. The *differentiae* can, in turn, be represented as species of a distinct genus and *differentia* in a different porphyrian tree. Porphyrian trees have a highest genus, in this case the concept substance.[32] In the above tree, individual concepts, such as 'Plato' and 'Socrates', are taken as the lowest species. However, Kant denies the existence of an *infima species*, arguing that they are specified by convention.[33]

For our present purpose, it is important to note that according to Kant analysis provides us with the marks of a species in terms of which the latter can be defined. Analysis is a procedure through which we successively render the marks of a concept clear.[34] In this manner, analysis allows us to provide *analytic definitions*. Insofar as we can in principle successively define lower concepts (species) in terms of

[31] Anderson 2005, 47–52, stresses the representational limits of porphyrian trees. Whereas the predicables (i) 'species', (ii) 'genus', (iii) 'differentia', and (iv) 'analytic propria' can be represented in such trees, i.e., the relationship between (ii)–(iv) and (i) can be understood as a containment relationship, neither synthetic propria nor accidents are contained in a species. This shows that the truth of *judgments* predicating synthetic propria or accidents of a species cannot be proven on the basis of concept hierarchies, confirming Kant's assessment that such judgments are synthetic.

[32] De Jong 1995, 625.

[33] *KrV*, A 655/B 683; AA 9: 97.

[34] AA 9: 142.

higher concepts up to a highest genus, Kant's views on analytic definitions capture condition (2a) of the Model, which states that a science has fundamental concepts in terms of which non-fundamental concepts are defined (condition (2b)).

Let us relate the results we have obtained to Kant's conception of systematicity. Kant argues that definitions bring about a systematic order of concepts. In the foregoing, we have seen *in concreto* how definitions function in establishing a system of concepts. In the case of synthetic (mathematical and constructive) definitions, we proceed from fundamental concepts. Through their arbitrary combination we define complex, non-fundamental concepts. As such, we systematically relate concepts by means of definitions (proceeding from fundamental concepts to more complex concepts). In the case of analytic definitions, we explicate the intension of a concept through analysis and define this concept in terms of its proximate genus and specific difference. Through this procedure, we specify the relations between lower concepts (species) and higher concepts (genera) and obtain a systematic ordering among concepts (proceeding from more complex concepts to more fundamental concepts).

2.1.2 Logical Division

Systematicity also requires that the extension of concepts be specified. Through analysis of a lower concept (species) we obtain cognition of the marks (higher concepts) contained in the former. However, the construction of a system of concepts also requires the specification of concepts contained under the species concept, comprising its extension. In the *Logik*, it is explained that we *specify* the extension of concepts through logical division.[35] In a division of higher concepts (genera) into lower concepts (species), we must follow the following rules: (a) the species must exclude each other, (b) the species must belong under one higher concept and, taken together, (c) the species must constitute the total extension of the divided concept.[36] These rules of specification govern the manner in which we establish a systematic order among concepts. They are logico-methodological rules that guarantee a determinate order among genera, *differentiae*, and species. As such, they provide rules for determining the place of a cognition and its relation to other cognitions.[37]

Note that the example of the porphyrian tree given above satisfies (a)–(c), though not all species of genera are specified. This results from the specification of genera by means of mutually exclusive *differentiae*. However, in constructing different trees, e.g., trees in natural history in which we aim to specify the multiple species of a genus, we cannot be certain that (c) is satisfied. In the *Jäsche Logik*, a distinction is

[35] AA 9: 146–147.

[36] Ibid. See Anderson 2005, 29.

[37] *KrV*, A 645/B 673. Here, the term 'logical rule' is again used broadly. It encompasses what we would call methodological rules in science. Kant discusses (a)–(c) in the so-called *Allgemeine Methodenlehre* of the *Logik*.

made between a subdivision, which is a (vertical) division of species into sub-species and so forth, and a co-division, which is a (horizontal) division of different species of a genus.[38] Both subdivisions and co-divisions are said to proceed *ad infinitum*.

That subdivisions proceed ad infinitum makes sense in light of Kant's denial of the existence of an *infima species*. Co-divisions also proceed ad infinitum. In the *Logik* it is claimed, with special reference to *empirical concepts*, that one cannot exhaustively describe all the relations among concepts.[39] This last point probably expresses the epistemic difficulty that confronts us in giving divisions in natural history, which are described as *polytomies*.[40] In constructing polytomies within natural history, Kant seems to argue, we cannot be certain that we have specified the total extension of a higher concept, because these constructions can be modified in light of ongoing empirical research.[41] The specification of concepts is therefore presented as a continuously ongoing process.

2.1.3 Completeness

If the specification of concepts can be indefinitely continued, how should we understand Kant's claim that a system of cognition should be complete? A partial answer to this question is given in the *Metaphysik Volckmann*. There, it is argued that the completeness of any system requires (y) the specification of upper and lower bounds, and (z) principles by means of which all the parts of a system can be related. A closed genealogical tree ordered by the relation 'generated by' is given as an example of a system.[42] Similarly, in constructing a system of concepts we can specify a highest genus and *infima species* and relate them in terms of their extension or intension by means of the logical rules governing definitions and the specification of concepts. Recall, however, that Kant takes *infima species* to be specified by convention. He further claims that the assumption of the existence of a highest genus is an assumption of *reason*. Hence, although in constructing a system we do specify upper and lower bounds, we cannot establish their objective reality.

Let us return to the description of the concept 'system' given in the beginning of this section. There, a system of cognition was construed as a *complete* whole whose parts are necessarily related to each other in accordance with certain rules. It is now clear that these rules comprise (i) logical rules by means of which we establish specific relations among cognitions, and (ii) the specification of upper and lower limits of a system. These conditions secure that a system is a complete and ordered whole.

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[38] AA 9: 147.

[39] Ibid.

[40] In a *Polytomie* we specify a concept into more than two members. If we specify two members, we obtain a dichotomy. Polytomies provided in the classification of nature are based on empirical intuition. AA 9: 147–148.

[41] AA 9: 147.

[42] AA 28: 355–356.

Hence, to say that a system is complete does not mean that we have exhaustive knowledge of all of its parts (e.g., concepts). Rather, a system is a homogeneous ordering with specified bounds, in which the relations of the parts are determined in accordance with a priori logical rules.

Finally, we may relate Kant's views on systems of concept to his views on biological classification. In his 1788 essay on teleological principles, Kant treats the classifications of Carl Linneaus as *systems*. He states that Linnaeus's systematic description of the vegetable kingdom was based on the principle of the "persistence of the characteristics of the parts for fructification in vegetables."[43] This refers to Linnaeus's method of employing the structure of the sexual organs of plants, i.e., the number of pistils and stamens, as a principle for classifying plants.[44]

Linnaeus's method of classification can be interpreted in line with Kant's prescriptions on how to construct systems of concepts. As Müller-Wille explains, Linnaeus's classification of plants, as given in his sexual system of plants, proceeds *per genus et differentiam specificam*.[45] It is based on the principle that all plants possess male and female sexual organs, i.e., the stamens and pistils contained in the flowers. The plant realm is *logically divided* into 'classes', according to the number of stamens, and into 'orders', according to the number of pistils. Definitions of classes are given by stating the genus 'plants' and a specific difference ('with one stamen', 'with two stamens', etc.). Definitions of orders are given by taking as a genus the respective class and by specifying a specific difference ('with one pistil', 'with two pistils', etc.). Importantly, since all plants have a determinate number of reproductive organs, they cannot fall into more than one class or order. In other words, Linnaeus's logical divisions satisfy rule (a) for logical division, according to which the species or lower concepts of a genus or higher concept *exclude* each other. Moreover, since all plants have a determinate number of reproductive organs, they must fall into one of the classes or orders. In other words, Linnaeus's divisions are interpreted as satisfying rule (c) for logical division, according to which species or lower concepts must constitute the total extension of the divided concept. Linnaeus's classifications can thus be taken to be constructed on the basis of the rules of logical division (a)–(c). As such, they provide us with a determinate ordering of concepts. It is therefore no surprise that Kant took Linneaus's classifications as prototypical examples of constructing systems of concepts.

2.2 Objective Grounding

In the Preface to the *Metaphysische Anfangsgründe* (1786), Kant takes natural description, natural history, and chemistry to be systematic doctrines. However, these doctrines are not *proper* sciences.[46] Hence, systematicity is not sufficient for distin-

[43] AA 8: 161.

[44] On Linnaeus's method, see Cain 1958 and Müller-Wille 2007. On Kant's reading of Linnaeus, see Oittinen 2009, 51–77. See also Anderson 2005, 63–69.

[45] Müller-Wille 2007, 546–547. In the following, I follow Müller-Wille.

[46] AA 4: 467–468, 471.

guishing science from science proper. To make this distinction, Kant adds a second condition that proper sciences must satisfy: a proper science must constitute a systematic interconnection of *grounds* and *consequences*.[47] If this condition is satisfied, a science can be called a *rational science*, where being a *rational* science must be understood as a necessary but not sufficient condition for being a proper science.

In short, a rational science is a system of cognition containing some kind grounding-relation.[48] This condition can be understood in terms of the proof postulate of the Classical Model of Science (3b), which states that all non-fundamental propositions of a science *S* are ultimately grounded in fundamental propositions.[49] In the Model, the proof postulate is related to the order of propositions or judgments. As we will see, Kant takes a grounding-relation to obtain *both* between concepts and between judgments. The grounding-relation obtaining between concepts may be related to the composition postulate of the Classical Model of Science (2b), according to which the non-fundamental concepts of a science are composed of (or definable from) fundamental concepts (Sect. 2.1).[50]

In the following, I identify some core elements of Kant's conception of grounding by analyzing passages from his pre-critical and critical writings. I argue that Kant entertains a conception of grounding which captures the idea that scientific explanations are *explanatory demonstrations*, i.e., demonstrations showing *why* something is the case. Demonstrations are explanatory if they represent the objective order of grounds and consequences. This conception of scientific explanation goes back to Aristotle, who distinguished between, as the medievals called it, a *demonstratio propter quid*, i.e., a demonstration showing *why* something is the case, and a *demonstratio quia*, i.e., a demonstration showing *that* something is the case.[51] Consider the following syllogisms:

The planets do not twinkle	The planets are near
What does not twinkle is near	What is near does not twinkle
Ergo: The planets are near	*Ergo*: The planets do not twinkle
(A1)	(A2)

A1 and A2 are both valid syllogisms.[52] However, in A1 we reason from effect to cause and merely explain *that* planets are near (it is a *demonstratio quia*). In A2 we

[47] AA 4: 469.

[48] As noted, Pollok and Watkins interpret this condition as claiming that proper sciences must have a priori principles. Pollok argues that Kant denies that natural description and natural history are proper sciences because they lack a priori principles. However, Kant does not criticize these doctrines in these terms and seems to allow that chemistry, based on *empirical* principles, provides a rational interconnection of grounds and consequences (AA 4: 468). I take Pollok and Watkins to conflate an *epistemic* condition that proper sciences must satisfy with the condition of grounding, which I interpret as the condition that proper sciences must provide explanative demonstrations reflecting the *order of nature*.

[49] De Jong and Betti 2010, 186.

[50] Ibid.

[51] Ibid, 190; Dear 1998.

[52] These two syllogisms are formulated by Aristotle in his *Posterior Analytics*. My account of them follows Beany 2012.

reason from a cause to an effect and thus objectively explain *why* planets do not twinkle. A2 is an explanative demonstration (*demonstratio propter quid*). I argue that Kant conceives of scientific explanations as explanative demonstrations.

This interpretation of Kant's view on grounding or scientific explanation differs from the influential interpretation of Michael Friedman, who takes grounding to be a relation between the a priori principles of a science and (empirical) laws proven on the basis of these principles.[53] That Kant thinks that scientific cognition must allow of proof from a priori principles is certainly true (Sect. 2.3). However, I take Kant's views on grounding to capture the different claim that proper scientific explanations are explanatory demonstrations reflecting the order of nature. The consequence of my argument is that Kant's views on scientific explanation are more Aristotelian than is often thought.

Kant provides an extensive discussion of the concept 'ground' (*ratio*) in his *Nova dilucidatio* (1755).[54] He construes a ground as a reason for predicating some concept *P* of a subject-concept *S*, while excluding predication of *not-P*.[55] Knowledge of grounds is a condition for asserting the truth of judgments, since it provides a reason for asserting a judgment 'S is P' while excluding the contradictory judgment 'S is not P'. In the absence of such knowledge there would be no knowledge of truths, since we would have no reason to assert the truth of a judgment while taking its contradiction to be false.[56] This discussion highlights the epistemic function of grounds but does not fully capture the notion of objective grounding. To see this, note that *any* demonstration or syllogism in which the premises are true provides us with grounds for asserting the truth of its conclusion. What we are looking for, however, is a characterization of grounding that allows us to distinguish *explanatory* demonstrations from other demonstrations.

Kant further interprets the concepts 'ground' and 'consequence' as referring to objects. Hence, strictly speaking the relation of ground to consequence obtains between objects. This relation can be represented conceptually: a grounding-relation can be represented by relations holding between *concepts* and by relations holding between *judgments*.[57] Any structure of concepts or judgments can thus

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[53] Friedman 1992b. Friedman does not provide a detailed conceptual analysis of the notion of 'grounding'. However, in reconstructing Kant's views on Newton's deduction of the law of gravitation, he brilliantly shows how Kant takes inferences in natural sciences to be based on a priori *principles*. In my view, this conception of grounding relates to Kant's views on *epistemic justification* in natural science. It does not fully capture Kant's views on scientific explanation. Falkenburg 2000, 367–373, provides an analysis of Kant's views on what she calls 'the logical proposition of sufficient ground', in which she construes the relation between ground and consequence in terms of derivability. This is correct, but, as I argue below, Kant's ideas on 'grounding' cannot be understood fully in terms of derivability.

[54] Longuenesse has provided detailed accounts of the concept 'ground' in Kant's pre-critical and critical writings. Longuenesse 1998, 345–358, 2001.

[55] AA 1: 391–392.

[56] AA 1: 393–394.

[57] Many commentators, in discussions of Kant's views on the foundation of scientific cognition, focus exclusively on relations between *judgments*. See Guyer 2005, 11–55; Friedman 1992b. This

express a grounding-relation. The view that structures of concepts can express a grounding-relation is retained in the critical period. In the *Jäsche Logik*, concepts are said to function as *grounds of cognition* with respect to representations comprising their extension.[58] For example, the genus 'metal' functions as a ground of cognition with respect to the species 'gold', 'silver', etc. The idea is that the relation of genus to species provides a ground for cognizing (say) *that* gold is a metal. Given that species are composed of concepts contained *in* them, we can take the composition postulate of the Classical Model of Science (2b) to capture a grounding-relation holding between concepts.

In the *Nova dilucidatio*, Kant provides an example of a grounding-relation expressed by *judgments* when he distinguishes between an 'antecedently determining ground' and a 'consequentially determining ground'. The former is a ground of being or becoming, the reason *why*, while the latter is a ground of cognition, the reason *that*.[59] For example: the eclipses of the satellites of Jupiter are a ground for cognizing that light is propagated with a finite velocity, whereas (following Descartes) the elasticity of the globules of the atmosphere in which light is propagated is a ground of becoming, i.e., a cause for the finite velocity of light (the reason why).[60] The eclipses of Jupiter's satellites are a consequence of the finite velocity of light and allow us to demonstrate this fact.[61] These eclipses are not an objective ground of the finite velocity of light. Accordingly, they provide us with a ground of cognition, not a ground of being or becoming, for the truth that light has a finite velocity. By contrast, Descartes' hypothesis that the propagation of light must be understood as a series of impacts of elastic globules identifies a ground of becoming (*reason why*) for the finite velocity of light.

The distinction between an antecedently determining ground and a consequentially determining ground can be related to the traditional distinction between *demonstratio propter quid* and *demonstratio quia*. Since Descartes' hypothesis identifies the cause of the finite velocity of light, his explanation of this phenomenon reflects the objective order of ground and consequence and allows us to give a *demonstratio propter quid*. By contrast, cognition of the eclipses of the satellites of Jupiter merely provides *subjective justification* for the truth that light has a finite velocity. In Kant's terms, an antecedently determining ground is the *source* of the truth of judgments, whereas a consequentially determining ground (ground of cognition) "does not bring the truth into being; it only displays it".[62] Of course, antecedently determining grounds also function as grounds of cognition. If we demonstrate that light has a finite velocity on the basis of Descartes' hypothesis, then this

is not incorrect but does not do justice to the fact that conceptual orderings can also satisfy grounding relations.

[58] AA 9: 96.

[59] AA 1: 391–392.

[60] AA 1: 392–393.

[61] Ibid. Longuenesse 2001, 69.

[62] AA 1: 394.

hypothesis (if true) allows us to *know* the truth of the proposition that light has a finite velocity. It is this type of demonstration, i.e., demonstrations that allow us to *know* a truth and that explain *why* something is true, that Kant interprets as proper scientific explanations.

The *Nova dilucidatio* provides evidence for the interpretation that Kant employs a notion of grounding to construe scientific explanations as explanative demonstrations. To further support this interpretation, we need to consider in detail how, in cases where grounding is a relation between judgments, Kant understands this relation. I will argue that Kant construes this relation as follows: α provides an explanative demonstration of β (α objectively grounds β), if (i) α specifies the objective ground for what is asserted by β, and (ii) β is derivable from α, where 'β is derivable from α' implies that both α and β are true. Condition (i) indicates that the relation of grounding is *not* identical to the relation of derivability. The notion of grounding is stronger than that of derivability. Condition (ii) indicates that grounding is a special case of derivability. In the following, I treat both conditions in turn. Then, I discuss how the notion of an 'objective ground' is interpreted in natural science, and how Kant applies the notion of grounding to natural description and natural history.

2.2.1 Grounding is not Identical to Derivability

It is not always clear that Kant distinguishes between grounding and derivability. In the first *Critique*, he describes every inference as proceeding from *ground* to *consequence*:

> In every inference there is a proposition that serves as a ground, and another, namely the conclusion, that is drawn from the former, and finally the inference (consequence) according to which the truth of the conclusion is connected unfailingly with the truth of the first proposition. (*KrV*, A 303/B 360)

Kant takes inferences to show that that the *truth* of the conclusion follows from one or multiple *true* premises. If we employ modern terminology and distinguish between logical inference and logical derivability (which Kant does not), we may think that Kant takes a valid logical inference to express a relation of logical derivability holding between (the content of) true judgments, and therefore that the grounding-relation can be fully understood in terms of derivability. This is problematic, however, as the notion of grounding is stronger than that of derivability. Grounding p means providing an explanative demonstration of p,[63] yet this is not necessarily the case for a derivation of p. In addition, grounding is a relation obtaining between truths, whereas from a modern point of view derivability can obtain between falsities (Kant, however, treats derivability as a relation between *truths*).

These two difficulties can be partially resolved by employing Kant's distinction between grounds of cognition, which merely *display* truths, and objective grounds,

[63] De Jong and Betti 2010, 190–191.

which are the source of truths. In Kant's view, the logical derivation of a true judgment β from α establishes that what is asserted by α is a *ground of cognition* for the truth of β (G_1). However, derivability does not establish that α grounds β in the sense of providing an explanative demonstration for the truth of β. This type of grounding requires that α specify an objective ground for what is asserted by β (as in the case of the Cartesian explanation of the finite velocity of light). It is the latter type of grounding, call it (G_2), that must obtain between scientific cognitions, since science must provide objective explanations representing the order of nature. We may thus distinguish between two types of grounding: (G_1) and (G_2). (G_2) captures the idea that science must provide demonstrations *propter quid*.[64]

That (G_1) and (G_2) must be distinguished from one another is supported by Kant's lectures on metaphysics, the *Metaphysik Volckmann*. Here, a distinction is drawn between the relation holding between a logical ground and logical consequence, and the relation holding between a real ground and real consequence.[65] The first relation obtains within analytic judgments such as the hypothetical judgment "if a being is an animal, it is mortal".[66] In such cases, the relation between ground and consequence can be established by means of analysis and the principle of identity.[67] The truth of this hypothetical can thus be proven logically. Such a proof can be interpreted as establishing a relation between a judgment (the consequent) and a *ground of cognition* for its truth (expressed in the antecedent), i.e., a ground for cognizing *that* animal beings are mortal. The objective ground of the mortality of animals, e.g., the specific *physical cause* of mortality, is *not* specified by this proof. In the *Metaphysik Volckmann* this is explicated by stating that the concept of ground, as pertaining to *logic*, is "treated in so far as it is a ground of cognition".[68] This suggests that the derivability of β from α is not sufficient to establish that α specifies the objective ground of β.[69]

The above discussion can be taken to support the more general interpretation that Kant accepted the following: the logical derivation of a true judgment β from true judgment(s) α establishes that α specifies a *ground of cognition* for the truth of β (G1). If we understand Kant's notion of logical inference as derivability, then even this is saying too much. For establishing a relation between a judgment and its ground of cognition via logical proof is tantamount to providing a ground for the

[64] Note that the difference between (G_1) and (G_2) corresponds to the difference between A1 and A2.

[65] AA 28: 401–402. For a thorough analysis of the notion of ground in the *Metaphysik Volckmann*, see again Longuenesse 1998, 354–356.

[66] AA 28: 397.

[67] AA 28: 402.

[68] AA 28: 399. I have argued that objective grounds can also function as a ground of cognition. The cited example is a case in which a ground of cognition is not an objective ground.

[69] To give another example: in the *Metaphysische Anfangsgründe*, Kant notes that the concept of impenetrability is contained *in* the concept of matter. Thus, 'matter is impenetrable' is an analytic judgment, provable logically by means of the principle of identity. However, Kant argues that the *objective ground* of matter's impenetrability is given by a repulsive force constitutive of matter. The truth of this claim cannot be established analytically. AA 4: 508–509.

truth of the latter, whereas the relation of derivability can hold between false judgments. However, in contrast to our modern view on derivability, Kant typically construes valid inferences as inferences for which the premises are *true*.[70] For this reason, he thinks that logical inference allows us to show that what is asserted in true judgment α provides a *ground of cognition* for the truth of what is asserted in β.

2.2.2 Grounding is a Special Case of Derivability

Let us turn to the second condition, according to which objective grounding (G_2) is a special case of derivability. Is it the case that if α objectively grounds β, β is derivable from α? If so, (G_2) is a stronger rendering of (G_1), as it adds the condition that the premises of a scientific demonstration must specify the objective grounds of what is asserted in the consequence. The *Jäsche Logik* suggests that the answer to this question must be affirmative. Moreover, Kant was rooted in a philosophical tradition in which syllogistic scientific demonstrations were taken to be paradigmatic examples of proper scientific explanations.

In the *Jäsche Logik*, the so-called 'principle of sufficient reason' is presented as providing a positive criterion for establishing truths.[71] This principle requires that cognitions are *logically grounded*, i.e., that true cognitions must have (a) grounds from which they can be derived and (b) no false consequences. This passage suggests that Kant thought that in order to have a reason for taking scientific judgments to be true, these judgments must be derivable from (or allow for the derivation of) other judgments. This view is not inconsistent with the fact that Kant takes scientific judgments to be synthetic. In the second edition of the *Critique*, Kant argues that although the synthetic *principles* of mathematics (geometry) cannot be cognized *from* the principle of contradiction, synthetic proposition can be comprehended *in accordance with* the principle of contradiction if "another synthetic proposition is presupposed from which it is deduced (*gefolgert*)."[72] Thus, Kant allows for the possibility that synthetic judgments can be logically inferred from each other.[73] These passages

[70] *KrV*, A 303/B 360. See also AA 9: 121.

[71] AA 9: 51–52. It is this passage on which Falkenburg 2000, 368–370 bases her reading of grounding as derivability between truths. Note that the construal of grounds in this passage is similar to the construal of grounds given in the *Nova dilucidatio*.

[72] *KrV*, B 14. This passage has given rise to multiple discussions concerning the nature of mathematical inference in Kant and the associated question of whether Kant's position is consistent with the invention of non-Euclidian geometries. See Beck 1965, 89–90; Friedman 1992a, 80–83. I will refrain from entering into these complexities.

[73] Note, however, that this passage also suggests that Kant allowed for propositions that are *grounded* by other propositions yet not *derivable* from other propositions. This is the case for the axioms of mathematics. Axioms do not require proof. Nevertheless, Kant takes mathematics to be grounded in transcendental philosophy, which shows how mathematical propositions (including axioms) can be *applied* to empirical objects (*KrV*, A 733–734/B 761–762). For Kant, the application of mathematical propositions to empirical objects is a condition for their *truth*. Here we see that the notion of grounding, which up to this point has been treated as a relation between

suggest that Kant took the non-fundamental propositions of a science to be derivable from more fundamental propositions. If so, propositions objectively ground other propositions only if the latter are derivable from the former.

How should we understand the idea that propositions in natural science are derivable from other propositions? A nice illustration of this idea is given by Christian Wolff.[74] We can significantly increase our understanding of Kant's conception of grounding through a discussion of Wolff. In the *Deutsche Logik* (1754), Wolff explains that syllogistic inferences enable us to provide proofs in natural science in accordance with the mathematical method. He provides a proof of the proposition that air has an expansive force. This proposition is cognized from experience, i.e., by placing a balloon filled with air under a glass jar and by extracting the air surrounding the balloon through an air pump, resulting in the expansion of the balloon. Wolff claims that this experiment suggests the following inference:

What begins to expand when resistance is removed has an expansive force. [5*]
The air begins to expand when resistance is removed. [6*]
Hence, the air has an expansive force. [7*]

Both the major and minor premises here are proven through new inferences. The major premise is proven by means of an inference where the middle term provides the *definiens* of expansive force:

What continuously endeavours to expand (*in steter Bemühung ist, sich auszudehnen*) has an expansive force. [1*]
What begins to expand when resistance is removed continuously endeavours to expand [2*]
Hence, what begins to expand when resistance is removed has an expansive force. [5*]

The major premise is a definition. The minor premise can be proved on the basis of another inference, but Wolff claims that it is sufficiently clear from experience. Hence, we can treat it as a fundamental principle (*Grundsatz*). The minor premise of our initial syllogism [6*] is proven as follows:

What expands a balloon when resistance is removed must also expand itself. [3*]
The air expands the balloon when resistance is removed [4*]
Hence, the air must expand itself, when resistance is removed [6*].

Like proposition [2*], proposition [3*] is treated as a fundamental principle (*Grundsatz*). Proposition [4*] is taken to be true on the basis of experience.

Wolff presents [7*] as following from [1*] to [4*].[75] [1*] can be taken to provide a nominal definition of expansive force. As such, it provides a true ground on the

propositions pertaining to a single science, shifts meaning when we consider the fundamental propositions of a science and the relations between different sciences.

[74] Wolff [1754] 1978, 176–178. For discussion of the first step of Wolff's argument, see Anderson 2005, 39–40.

[75] I have slightly simplified matters, since in the penultimate 'mathematical proof' Wolff additionally specifies two remarks and a corollary (*Zusatz*). The corollary provides Wolff's interpretation of the experiment, which supports [4*].

basis of which we can give proofs.[76] [2*] and [3*] are treated as certain, i.e., true *fundamental* propositions, while [4*] is taken to be true on the basis of experiment. The proof of [7*] from [1*] to [4*] is a proof from certain, true grounds, providing an instance of what Wolff takes to be the true method of demonstration in science, i.e., the "habit of inferring conclusions by legitimate sequence from certain and immutable principles."[77]

There are various lessons to be learned from Wolff's example. First, in proving the proposition 'air has an expansive force', *hypothetical syllogisms* seem to play a major role. All three syllogisms treated above can be taken (or reconstructed) as hypothetical. Wolff's construes hypothetical inferences as 'inferences under conditions'. He typically takes these to have the form: when A is the case B is the case, A is the case, hence B is the case.[78] Note that this conception of a hypothetical syllogism does not adequately capture the syllogisms treated above. These syllogisms typically move from a hypothetical major premise to a minor premise in which the *antecedens* is said to be true of some particular.[79] Despite these shortcomings, hypothetical syllogisms seem to play a privileged role in the logical reconstruction of scientific proofs.

Second, Wolff's example leads us to distinguish between what we may call *partial grounds* and *complete grounds*. Propositions [1*]–[4*] provide a sufficient ground for establishing the truth of [7*]. Given that [7*] is a consequence of [1*]–[4*], we can treat [1*]–[4*] collectively as a complete ground for the truth of [7*], whereas taken individually [1*]–[4*] constitute partial grounds for the truth of [7*].[80] In his *Discursus praeliminaris* (1728), Wolff distinguishes between partial and complete grounds, noting that phenomena are often explained in terms of a *complex* of partial reasons, grounds, or causes.[81] Kant also distinguishes between partial and complete grounds. In the Transcendental Doctrine of Method of the first *Critique*, he argues that in science direct or ostensive proofs (proofs via *modus ponens* or hypothetical syllogisms) are preferable to apagogic proofs (proofs by contradiction).[82] The reason is that apagogic proofs merely show *that* something is true but do not explain *why* it is true. In ostensive proofs, by contrast, we derive a consequence on the basis of a *manifold* of (partial) grounds, providing us with a

[76] Wolff [1754] 1978, 145–146.

[77] Wolff [1728] 1963, 17.

[78] Wolff [1754] 1978, 169–170.

[79] From our modern perspective, we would construe the hypothetical major premise to be a universal quantification over an implication. Our inference can then be construed as follows: $(x)\ (Px \rightarrow Qx)$, $Pa \rightarrow Qa$, Pa/Qa.

[80] The notions of complete and partial grounds do not derive from Kant or Wolff. They are, to the best of my knowledge, first made fully explicit by Bernard Bolzano (1781–1848), in his theory of grounding (*Abfolge*). Sebestik 2008, defines these notions as follows: "if a truth is a consequence of several truths, they constitute its total ground while each true premise is a partial ground".

[81] Wolff [1728] 1963, 5.

[82] *KrV*, A 789–794/B 817–822.

"complete insight into its possibility".[83] In scientific proofs, we should thus try to specify the *totality of grounds* of some truth, i.e., specify its complete ground.

I do not wish to argue that Kant fully endorsed Wolff's *mathematical* method of providing demonstrations in natural science. In the Doctrine of Method of the first *Critique*, Kant denies that the mathematical method, based on definitions, axioms, and mathematical demonstrations, can be imitated in philosophy.[84] Some of his reasons for denying that the method of mathematics is applicable in philosophy also apply to Wolff's method of demonstrating the propositions of natural science. First, note that Wolff takes proposition [1*] to provide an analytic definition of the concept of expansive force. For this reason, [1*] is a certain and immutable principle. Kant, however, denies that we can analytically define empirical concepts. The reason is that through analysis we cannot be sure to have *completely* specified the marks of an empirical concept. Through new observations, we can take away and add marks of an empirical concept, and therefore "the concept never remains within secure boundaries."[85] Hence, Kant would deny that [1*] is a definition and therefore a *certain* and *immutable* principle. Second, Kant would take issue with Wolff's construal of [2*] and [3*] as fundamental propositions. Wolff treats [2*] and [3*] as fundamental propositions (axioms) because he entertains them without proof. He recognizes that, in contrast to axioms in mathematics, they both allow of proof and are taken to be *certain* on the basis of experience.[86] Kant defines axioms as synthetic a priori principles that are immediately certain.[87] Hence, he would not count [2*] and [3*] as axioms and would question their certainty, given that they are justified empirically. Thirdly, and finally, Kant would criticize Wolff's demonstration because it is not *explanatory*. The reasoning from [1*]–[4*] to [7*] proceeds from cognition of the consequence (effect), specified in [4*], to cognition of the objective ground (cause), specified in [7*]. Wolff's demonstration is thus an instance of (G_1), i.e., it is a *demonstratio quia*. A demonstration *propter quid*, by contrast, proceeds from cognition of an objective ground to cognition of its consequences.[88]

It is clear that Kant would have objected to Wolff's demonstration. Nevertheless, Wolff's treatment of proofs in natural science nicely shows how judgments in natural science were taken to be derivable from each other. As we have seen, Kant also

[83] *KrV*, A 791/B 819.

[84] *KrV*, A 712–738/B 740–766. This argument was first developed by Kant in his *Untersuchung über die Deutlichkeit der Grundsätze der natürlichen Theologie und der Moral* of 1764.

[85] *KrV*, A 728/B 756. In the *Logik*, this difficulty is expressed by stating that the synthesis of empirical concepts can never be *vollständig*, since we can always discover more marks of an (empirical) concept through experience. AA 9: 141–142.

[86] Wolff [1754] 1978, 177.

[87] *KrV*, A 732–733/B 760–761.

[88] In the dynamics of the *Metaphysische Anfangsgründe*, Kant provides a causal-mechanical account of the elasticity of air (Wolff's [7*]), arguing that the expansive force of air rests on the matter of heat, which compels the parts of air to flee from one another through its vibrations. It is only through judgments that try to identify the objective grounds or causes (e.g., heat) of effects (e.g., the elasticity of air) that we can provide demonstrations *propter quid*. AA: 4: 522. Cf. 4: 530.

seems to accept that non-fundamental propositions of sciences are derivable from (more) fundamental propositions. This supports the reading that objective grounding (scientific explanation) is a special case of derivability.

2.2.3 Grounding in Natural Science, Natural Description, and Natural History

In the remainder of this section, we will consider how we should interpret the notion of an 'objective ground' in natural science. In the preceding, we have typically construed objective grounds as *causes* and consequences as *effects*. This also seems to be Kant's position in his critical period. He takes the judgments of natural science to satisfy a grounding-relation because they can be related in such a manner that they express a relation between *cause* and *effect*. This is clear in the *Metaphysik Volckmann*, where two methods of proof for the truth of cognitions are distinguished: (i) an *a posteriori* method in which one proceeds from cognition of the consequence to cognition of its ground, e.g., the observation of the world allows us to prove that God exists. In this case, we specify a *ground of cognition* for the truth that God exists. (ii) An a priori method, in which we proceed from cognition of the ground to cognition of its consequence. This is said to be the true method of natural science which consists in *specifying causes of effects*.[89] In light of the foregoing, we can thus conclude the following: in *natural science* α provides a proper explanation of β, if β is derivable from α and if α specifies the cause of β, where 'β is derivable from α' is taken to imply that α and β are true.

Let us finally return to the *Metaphysische Anfangsgründe* and consider how Kant invokes the notion of objective grounding in his discussions of natural description and natural history. In the Preface to this work, natural description is denied the status of a proper science on the basis of Kant's grounding condition.[90] This doctrine does not provide "cognition through reason of the interconnection of natural things".[91] I take this to mean that natural description does not provide dem-

[89] AA 28: 355. The same conception of scientific demonstration is articulated in the *Danziger Physik* of 1783. AA 29: 103–104. In the *Metaphysische Anfangsgründe* (1786), Kant also often adopts a view of proper scientific explanation as proceeding from causes to effects (see the example of the explanation of elasticity in the *Metaphysische Anfangsgründe* mentioned above). However, it must be emphasized that in his pre-critical work Kant does not always clearly endorse this position. In his *Untersuchung über die Deutlichkeit* (1764) Kant describes the proper (Newtonian) method of natural science as seeking out "the rules in accordance with which certain phenomena of nature occur". Kant states that even "if one does not discover the fundamental principle of these occurrences in the bodies themselves", complex natural events are "explained once it has been clearly shown how they are governed by these well-established rules" (AA 2: 286). In this passage, it is not clear whether proper explanations in natural science proceed from cause to effect (the well-established rules may or may not refer to causes).

[90] It must be noted that Kant's views on the scientific merit of natural description and natural history varied throughout his philosophical career. Cf. Sloan 2006, 627–648.

[91] AA 4: 467–468.

onstrations *propter quid*. Natural description is defined as a "system of classification for natural things in accordance with their similarity".[92] Kant employs this notion to characterize classifications given in disciplines such as zoology or botany. According to Kant, cognitions making up such classificatory systems are not properly grounded. Take for example the taxonomy of organisms based on morphological criteria as given by Linnaeus in his *Systema Naturae*. If we take this taxonomy to be correct, we are provided with a ground for cognizing the truth *that*, say, a lion is a feline. For recall that the genera provide us with grounds for the cognition of species. However, this taxonomy does not provide us with an objective ground for *why* lions are felines. Linnaeus' taxonomy tells us nothing of the relationships holding between real grounds (causes) and consequences (effects). Hence, this taxonomy does not allow us to explain why certain organisms have specific morphological characteristics. For this reason, Kant takes natural description to lack explanatory power.

Kant's views on natural history are more difficult to determine. I will return to this topic in Sect. 8.5. Here, we may note the following: in his 1788 essay on teleological principles Kant construes natural history as a discipline investigating the relations between present properties of natural objects and their historical causes.[93] Causal regularities relating present effects to earlier causes are derived from the observation of forces presently operative in nature and inferences by analogy, supporting the claim that these forces have been operative in the past and have produced effects similar to those presently observed. Since causal relations constitute relations between objective grounds and consequences, natural history may be interpreted as providing objective explanations, e.g., of the origin of human races.[94] However, Kant emphasized that inferences by analogy merely provide empirically (non-apodictically) certain cognition[95] and stressed that natural history is a novel science in need of further development.[96] This may explain why natural history is classified as a *doctrine* rather than a *science* of nature.

2.3 Apodictic Certainty

The third and final condition that a proper science must satisfy is that its cognitions are apodictically certain, i.e., we must be justified in asserting their necessary truth. In the *Metaphysische Anfangsgründe*, this point is expressed by noting that

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92 Ibid.

93 AA 8: 161–162.

94 Hence, I cannot subscribe to Sloan's thesis that Kant, from the 1780s onwards, gave theoretical preference to natural description over natural history. Kant has systematic reasons for preferring natural history over natural description, insofar as the former (at least in principle) allows us to provide objective explanations. Sloan 2006, 629.

95 AA 9: 133.

96 AA 8: 162.

"empirical certainty is only *knowledge* improperly so-called".[97] We have *knowledge* only if our cognitions are apodictically certain.

In the *Logik*, Kant defines knowledge, opinion, and belief as modes of holding-to-be-true (*Fürwahrhalten*). They are modes through which subjects represent something as being true[98] The terms 'opinion', 'belief', and 'knowledge' thus indicate different modes of *epistemic justification*. Kant's final condition of scientificity corresponds to what is called the *Knowledge Postulate* in the Classical Model of Science (condition (6)), which states that any proposition of a science is known to be true.[99] In Kant's work, the *Knowledge Postulate* is related to the *Necessity Postulate* of the Classical Model of Science (condition (5)), according to which the propositions of a science are necessary, since he thinks that we only have knowledge of a proposition if we are justified in asserting its necessary truth.

Kant describes the three modes of epistemic justification as follows. We have an *opinion* if we judge without having sufficient subjective or objective grounds for the truth of this judgment. In this context, the concept 'ground' refers to a *ground of cognition*, a ground on the basis of which we take a judgment to be true. A ground is *subjectively* sufficient for taking a judgment to be true if it is sufficient for myself, and a ground is *objectively* sufficient for taking a judgment to be true if it is sufficient or valid for everyone.[100] We opine if in the act of judging we take the judgment to be problematic, i.e., take the judgment to be merely possibly true. *Believing* is taking something to be true based on a ground of cognition that is objectively insufficient but subjectively sufficient, e.g., one can rationally believe that God exists since this belief "depends on subjective grounds (of moral disposition)".[101] We believe something if in the act of judging we assert the truth of the judgment. *Knowing* is taking something to be true based on grounds that are both objectively and subjectively sufficient. We have knowledge if we have a judgment that is *apodictically certain*, i.e., if we take the judgment to be necessarily true.[102]

In the *Logik*, Kant distinguishes between rational cognition (based on reason) and empirical cognition (based on experience). Rational knowledge is apodictically certain and comprises knowledge that is mathematically certain or philosophically certain.[103] The epistemic status of mathematical and philosophical cognition is related to the manner of demonstration employed in mathematics and philosophy.

[97] AA 4: 468.

[98] AA 9: 65–66.

[99] De Jong and Betti 2010, 186–187. The fact that Kant's third condition, stating that the cognitions of a science must be apodictically certain, relates to the *ordo cognoscendi*, indicates that this condition should be distinguished from Kant's grounding condition, which relates to the *ordo essendi*.

[100] *KrV*, A 820–822/B 848–850.

[101] *KrV*, A 829/B 857.

[102] Falkenburg 2000, 364–365. Chignell 2007, argues that objective grounds for knowing propositions indicate that propositions have an objective *probability* of being true. This cannot be true if, as I will argue, objective grounds of cognition must typically be understood as a priori principles on the basis of which we take propositions to be *necessarily* true.

[103] AA 9: 70–71.

Mathematical theorems are mediately certain propositions demonstrated from immediately certain or *intuitive* synthetic a priori axioms. Philosophical propositions are mediately certain propositions derived from *discursive* synthetic a priori principles. According to Kant, both mathematical theorems and philosophical propositions are apodictically certain *because* they are proven on the basis of a priori principles. Cognition that is justified merely empirically is empirically certain or contingent. However, empirical cognition is apodictically certain "insofar as we cognize an empirically certain proposition from principles a priori".[104] Thus, if empirical cognition can be cognized from a priori principles, this cognition is apodictically certain and we obtain knowledge. Something can therefore be cognized with apodictic certainty even if this cognition is based partially on empirical evidence.

The foregoing shows that the epistemic justification we have for judgments in a particular science is determined by the relation of these judgments to the *principles* (fundamental judgments) of this science. A judgment is apodictically certain if it can be proven by means of a priori principles. These principles are necessary and strictly universal truths, providing subjectively and objectively sufficient grounds of cognition for the truth of judgments somehow derivable from them. It follows that scientific judgments provide us with *knowledge* only if they can be proven by means of a priori principles. In the *Metaphysische Anfangsgründe*, Kant expresses this point by stating that the principles of a proper science must be a priori.

In the next two sections, we provide concrete examples of what Kant takes to be the a priori principles of natural science. We will also provide examples elucidating how Kant conceives of cognition from (or proof from) a priori principles in natural science. Importantly, the idea of a proof from a priori principles does *not* entail that empirical judgments play no role in this proof. In fact: in proofs from a priori principles in natural science, empirical judgments play a crucial role. The idea of a proof from a priori principles in natural science can be best described as follows: a judgment A is cognized on the basis of (proven from) a priori principles if A is derivable from a collection of judgments which contains both a priori principles and empirical judgments. Proofs of propositions or judgments in natural science through the application of mathematical (a priori) principles to empirical generalizations provide us with examples of proofs from a priori principles.

2.4 Mathematics, A Priori Justification, and Grounding

Kant's conception of proper science can be summarized as follows: any body of cognition must (1) be systematically organized, (2) express relations between objective grounds and consequences, and (3) have a priori principles on the basis of which the non-fundamental judgments of a science can be proven. On the basis of these conditions Kant argues that proper natural sciences must be based on mathematics and metaphysics.

[104] AA 9: 71.

Kant's claim that any proper natural science must contain mathematics is infamous. On the basis of this claim, he denies that chemistry and psychology are proper natural sciences. What is the precise meaning of this claim and why does Kant entertain it? The requirement that proper natural sciences must contain mathematics is sometimes read as stating that the concepts of a science must be quantifiable. On this reading, only doctrines dealing with *measurable* magnitudes qualify as proper natural sciences.[105] This reading certainly captures part of Kant's intention. In the modern period, mathematics was often thought of as providing a quantitative description of (empirical) objects.[106] However, considerations concerning measurability play no role in Kant's argument for the claim that natural sciences must contain mathematics. This argument is based on the premise that proper natural sciences require a "pure part lying at the basis of the empirical part" and that they are based on "a priori cognition of natural things".[107] Mathematics is interpreted as a science that, through providing mathematical constructions, provides a priori cognition of the possibility of determinate natural things. It is because mathematics fulfills this role that proper natural sciences must contain mathematics.

The above argument suggests that Kant assigns mathematics a foundational role with respect to natural science. I will argue that Kant takes mathematics to provide a priori principles on the basis of which propositions in natural science are demonstrated. As such, mathematics secures the apodictic certainty of the judgments of natural science. If this reading is correct, the view that natural sciences must contain mathematics is related to condition (3) specified above. To substantiate this reading, we need to consider how Kant construes the role of mathematics in natural science.[108]

Kant takes mathematical constructions to provide a priori cognition of determinate natural things. What does this mean? In the Discipline of Pure Reason of the first *Critique*, Kant states that we *construct* a concept if we exhibit a priori the intuition corresponding to this concept.[109] In contrast to concepts, which are general representations that represent their object mediately, intuitions are individual representations that represent their object immediately.[110] Hence, mathematical constructions provide (a priori) singular and immediate representations of individual

[105] This perspective has been endorsed by several commentators. See Okruhlik 1986, 313; Nayak and Sotnak 1995, 133–151. These latter authors assume that the purpose of the application of mathematics within natural sciences is to allow for the *measurability* of the objects of these sciences.

[106] Christian Wolff defines mathematics in his *Mathematisches Lexicon* as "a science that aims to measure everything that can be measured". Wolff [1716] 1965, 863.

[107] AA 4: 470. In the interpretation developed below, we will see how mathematics provides a priori cognition *lying at the basis* of the empirical part.

[108] Falkenburg 2000, 289, and Pollok 2001, 86–87, take Kant to assert that natural science must contain mathematics because the mathematical construction of concepts of natural science secures their objective reality, i.e., their application to objects of nature. It is true that for Kant the construction of concepts guarantees their objective reality. However, I do not think this reading captures Kant's full intentions. In the following I stress that Kant assigns an a priori foundational function to mathematics.

[109] *KrV*, A 713/B 741.

[110] AA 9: 91; *KrV*, A 68/B 93.

objects. Indeed, mathematics provides singular representations of *natural objects*. Kant takes mathematical concepts to relate to "data for experience" by means of the a priori construction of figures or images (i.e., intuitions).[111] In the *Prolegomena*, he states that (geometrically) constructed images agree with empirical phenomena.[112] As an example, we can think of line segments as geometric images of the velocity (speed plus direction) of corporeal bodies. Kant thus construes mathematics as providing a priori cognition of mathematical constructs, *images* or *models*, that represent quantitative features of natural objects. The conception of mathematics as being descriptive of nature was common in the eighteenth century. In his *Mathematisches Lexicon*, Christian Wolff defines geometry as "a science of the space taken up by corporeal things in their length, breadth, and width".[113] Since all things occupy space, geometry is applicable to all objects and provides cognition of the latter. This position is similar to that of Kant, who took mathematics to provide a priori cognition of the formal (spatio-temporal) features of natural objects.[114]

Kant's view on the role of mathematics in natural science can be profitably understood by considering Newton's use of mathematics in his *Philosophiae Naturalis Principia Mathematica* (1687[1]).[115] In the Preface to the *Principia*, Newton explains that in Book I and Book II he will set forth *mathematical principles* of natural philosophy. In Book III, these propositions are employed in order to derive from phenomena the gravitational forces by which bodies tend toward the sun and toward the individual planets.[116] The relation of mathematics to natural science is described by Newton as follows:

> Mathematics requires an investigation of those quantities of forces and their proportions that follow from any conditions that may be supposed. Then, coming down to physics, these proportions must be compared with the phenomena, so that it may be found out which conditions [or laws] of forces apply to each kind of attracting bodies. And then, finally, it will be possible to argue more securely concerning the physical species, physical causes, and physical proportions of these forces. (Newton [1726] 1999, 589)[117]

For example, in Proposition 2 of Book I, Newton mathematically demonstrates that if a body, moving in some curved line in a plane with respect to a fixed point,

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[111] *KrV*, A 240/B 299.

[112] AA 4: 287.

[113] Wolff [1716] 1965, 665. On Wolff's views on mathematics in relation to Kant, see Shabel 2003.

[114] As many commentators have noted, for Kant mathematical propositions are true only insofar as they are applicable to empirical objects. See Thompson 1992, 97–101; Parsons 1992a, 69–75; Friedman 1992a, 98–104.

[115] Cohen 1980, 52–154, has provided one of the most detailed accounts of Newton's use of mathematical principles in natural science. Cf. Cohen 1999, 148–155. I will focus here only on general aspects of Newton's conception of mathematics relevant to understanding Kant.

[116] Newton [1726] 1999, 382. See the introductory remarks to Book III, in which Newton claims that he will exhibit the system of the world from the mathematical principles of natural philosophy. Newton [1726] 1999, 793.

[117] Cohen 1980, 85–96, explicates this quote in relation to the structure of Book III of the *Principia* in order to explain Newton's method (termed the 'Newtonian style'). In the following I give a somewhat simpler account.

describes areas around that point proportional to the times (i.e., satisfies the law of areas), the body is subject to a centripetal force tending toward that point.[118] In Proposition 1 of Book III (in which 'we are coming down to physics'), we compare this mathematical principle to the phenomena. In particular: we compare it to what is called Phenomenon 1, which tells us that the satellites of Jupiter describe areas proportional to the times, i.e., their motion satisfies the law of areas.[119] This allows us to infer, in Proposition 1 of Book III, that the forces by which the satellites of Jupiter are continually drawn away from rectilinear motions and so are maintained in their orbits are centripetal forces, i.e., forces directed toward the center of Jupiter.[120] Finally (having arrived at the level of physics) we pose arguments concerning the physical species and causes of these forces (accelerations). This use of mathematics, through which we specify specific *relations* between propositions ($\alpha \rightarrow \beta$), enabling demonstrations *from* mathematical principles (from ($\alpha \rightarrow \beta$) to the conclusion that β holds of the satellites of Jupiter), conforms to Kant's conception of the use of mathematics in physics. In a phrase: mathematics enables deductive demonstrations from a priori principles in natural science.[121]

That Kant adopts Newton's views on the role of mathematics in natural science has been shown by Michael Friedman. In a brilliant analysis of §38 of the *Prolegomena*, Friedman shows that Kant refers to Newton's *mathematical* demonstration of the inverse square law in order to argue that the fact that gravity is an inverse-square force ($1/r^2$) is an a priori law prescribed to nature.[122] Kant thus interpreted mathematics as providing a priori cognition of quantitative features of physical objects. Here, I will not analyze Kant's complex argument in §38 nor Newton's equally complex derivation of the inverse-square law. In order to understand the role of mathematics in natural science, it is important to stress Newton's method of applying mathematical propositions in natural science (employed constantly in Book III of the *Principia*). This method can roughly be reconstructed in terms of a three step procedure. Returning to Newton's demonstration of Proposition 1 of Book III: first (i) we demonstrate *mathematically* (a priori) that if a body satisfies the law of areas it is subject to a centripetal force or acceleration ($\alpha \rightarrow \beta$); second (ii) we know, on the basis of *observation* (a posteriori), that the satellites of Jupiter describe areas proportional to the times (α holds of Jupiter's satellites); third (iii) we conclude that the satellites of Jupiter are subject to a centripetal force or acceleration (β holds of Jupiter's satellites).

[118] Newton [1726] 1999, 446.

[119] Newton [1726] 1999, 797.

[120] Newton [1726] 1999, 802.

[121] I use the term 'mathematics' in a broad sense. Newton is not dealing with pure mathematical concepts. He describes his mathematical style by noting that he is considering forces such as attraction and impulse "not from a physical but from a mathematical point of view". He is not defining "a species or mode of action or a physical cause or reason", or "attributing forces in a true and physical sense to centers", which are treated as mathematical points. Newton's mathematical principles can be best described as kinematic principles. Newton [1726] 1999, 408. See Cohen 1980, 68–78; Friedman 1992a, 227–234.

[122] Friedman 1992a, Chap. 4.

If we relate the above demonstration to Kant's views on proper science, we can note that the progression from (i) to (iii) is a perfect example of using a priori propositions (i) to derive propositions in natural science (iii). On the basis of these kinds of inference, we can thus take (iii) to be *apodictically certain* (Sect. 2.3). Kant would interpret (i) as providing us with an a priori mathematical construct that can be applied to nature: this proposition mathematically analyzes a condition (motion according to the law of areas) that can hold of objects in nature. Through applying (i) to individual objects in nature, we can derive specific properties of individual objects. Hence, mathematics allows us, employing Kant's terminology, to obtain a priori grounded cognition of *determinate natural things*. Kant also takes philosophy or metaphysics to provide a priori (discursive) principles that are valid of natural objects. These principles play a crucial role in providing a philosophical foundation of natural science. Nevertheless, only mathematics can, through the a priori construction of concepts, provide us with apodictically certain cognition of specific relations obtaining between the *quantities* of individual objects. It is for this reason that proper natural sciences must be based on mathematics. In terms of the Classical Model of Science, only if natural sciences contain mathematics can they satisfy condition (6), i.e., can we actually *know* propositions concerning the quantities of determinate individual objects.

The upshot of our discussion is that mathematics fulfills a crucial epistemic function with respect to physics. However, this is not the end of the story. For mathematics can also be taken to allow us to provide explanatory demonstrations in natural science. To see this, I will relate Kant's views on the role of mathematics in natural science to his conception of grounding.

2.4.1 Mathematics and Grounding

We have construed Kant's conception of objective grounding (explanation) as follows: α provides an explanative demonstration of β, if α specifies the objective ground for what is asserted by β, β is derivable from α, and α is true. Up to this point, we treated grounding as a relation between propositions pertaining to a *single* science. However, demonstrations in natural science can be based on premises taken from different sciences. The Newtonian demonstrations considered above take mathematical propositions and propositions based on observation as premises. As we will see, these demonstrations can again be divided into two kinds: demonstrations *propter quid* and demonstrations *quia*.

According to Kant, mathematical propositions themselves never specify the objective grounds or causes of phenomena. The reason is simply that in mathematics or kinematics we do not consider causes. In the Phoronomy of the *Metaphysische Anfangsgründe*, Kant argues that in phoronomy (kinematics) we provide a merely mathematical analysis of motion. We abstract from concepts of force, mass, and physical body and do not treat of causal relations.[123] In order to infer to the existence

[123] AA 4: 480.

of a physical force in natural science, we require, apart from mathematical propositions, propositions recording observations and the application of the laws of motion, which for Kant are *metaphysical* principles. For these reasons, Kant typically construes mathematics as a mere organon (heuristic) for bringing about *certain* cognition in natural science.[124] Nevertheless, mathematical propositions can be taken to play an important instrumental role in giving explanatory demonstrations in natural science.

To see this, we may again look at Newton's use of mathematical principles in Book III of the *Principia*, where he famously deduces the law of gravitation from phenomena. The method employed in this deduction is described by Newton as follows: we employ mathematically demonstrated propositions (of Book I and II) in order to derive, *from* celestial phenomena, the gravitational forces by which bodies tend toward the sun and toward individual planets.[125] Hence, Newton employs the *analytic method*: we reason from effects (celestial phenomena) to their causes (gravitational forces).[126] In the analytic steps of Newton's argument, we employ mathematical principles in order to discover the true causes (forces) of motions. Since the discovery of true causes is based partly on the application of mathematical propositions, Kant's description of mathematics as an *organon* is apt: mathematics provides a priori principles on the basis of which we can reason (with *certainty*) from effects to causes.

Let's return to our example to illustrate (part of) Newton's analytic method: the demonstration of Proposition 1 of Book III of the *Principia*. As a whole, this demonstration shows that the satellites of Jupiter are subject to a centripetal inverse-square force.[127] In Propositions 1 and 2 of Book I, Newton demonstrated mathematically that a force acting on a body with uniform linear motion is centrally directed towards a given point if and only if this motion satisfies the law of areas. In corollary 6 to Proposition 4 of Book I, he demonstrated that if a body in circular motion satisfies the harmonic law, it is subject to an inverse-square force.[128] On this basis, Newton can demonstrate that the satellites of Jupiter are subject to a centripetal inverse-square force by appealing to Phenomenon 1, which tells us that the motion of the satellites of Jupiter satisfies the law of areas and the harmonic law.[129] Call this demonstration [A*].[130]

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[124] AA 9: 13. Here, it is further argued that an *organon*, such as mathematics, *anticipates the matter* of the sciences. This claim is nicely illustrated by the interpretation of mathematics as providing (a priori) constructs of physical objects, providing grounds of cognition for propositions of physics.

[125] Newton [1726] 1999, 382.

[126] In the *Editor's Preface to the Second Edition*, Cotes describes Newton's method as follows: "[…] they proceed by a twofold method, analytic and synthetic. From certain selected phenomena they deduce by analysis the forces of nature and the simpler laws of those forces, from which they then give the constitution of the rest of the phenomena by synthesis." Newton [1726] 1999, 386.

[127] Newton [1726] 1999, 802.

[128] Newton [1726] 1999, 451.

[129] Newton [1726] 1999, 797. I follow Harper 2002, 175–177.

[130] This, of course, is merely the first step in Newton's deduction of the law of gravitation. I will not treat the argument in full. For a full account, see Harper 2002.

After deducing the causes by analysis, Newton applies the *synthetic method*.[131] As he puts it: after deriving the laws of gravitational forces, the "motions of the planets, the comets, the moon and the sea are deduced from these forces by propositions that are also mathematical."[132] For example, in Proposition 13 of Book III Newton states that the planets move in ellipses that have a focus in the center of the sun and that this motion satisfies the law of areas. That the motion of the planets satisfies the law of areas was accepted from phenomena. However, Newton states that "now that the principles of motion have been found, we deduce the celestial motions from these principles a priori."[133] In providing this a priori deduction, he refers to the result that the "weights of the planets toward the sun are inversely as the squares of the distance from the center of the sun".[134] Hence, planets gravitate toward the sun in accordance with a central, inverse-square force. Newton then refers to several mathematically demonstrated propositions of Book 1, including Proposition 1, according to which moving bodies subject to a centripetal force describe areas proportional to the times, in order to demonstrate that the orbital motion of the planets satisfies the law of areas.[135] Call this demonstration [B*].

Note that both [A*] and [B*] are based on mathematically demonstrated propositions. For this reason, Kant would take both demonstrations to establish the apodictic certainty of their conclusions. In addition, both may be reconstructed as logically valid inferences. However, in [A*] we infer from effect to cause. In contrast, in [B*] we infer from cause (forces) to effect (planetary motions). For Kant, only the latter type of demonstration can constitute a proper scientific explanation since it specifies the relation between objective ground(s) and consequence(s). [A*] is a demonstratio *quia*; [B*] is a *demonstratio propter quid*. For our present purposes, it is important to stress that [B*] can only be given by employing a mathematical proposition. Only by means of knowledge of the quantitative features of gravity, e.g., knowledge of the fact that it is a centripetal, inverse-square force, can we objectively demonstrate that the motion of planets satisfies the laws of areas. Hence, mathematics can be taken to be necessary (though not sufficient) for providing explanatory demonstrations in natural science.

In the modern period, it was common to conceive of mathematics as providing insight into the quantitative features of objective grounds, which, in turn, allows us

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[131] Note that in his *Untersuchung über die Deutlichkeit* (1764), Kant himself describes the proper method of natural science as the combined analytic-synthetic method and ascribes this method to Newton (AA 2: 286).

[132] Newton [1726] 1999, 382.

[133] Newton [1726] 1999, 817.

[134] Ibid.

[135] This is a highly simplified rendering of Newton's argument, who bases his argument on the conditions that the sun is at rest and that the remaining planets do not act upon one another, while also referring to proposition 11 and corollary 1 of proposition 13 of Book I. These propositions relate orbital motion subject to an inverse-square force to motion along an elliptical (conic) orbit, and are thus important for establishing that the orbits of the planets "would be elliptical, having the sun in their common focus". Newton [1726] 1999, 818. See Cohen 1999, 231–233.

to provide explanative demonstrations in natural science. For example, Christian Wolff takes mathematics both (i) to ensure the certainty of physical knowledge and (ii) to perfect our insight into the *grounds* of phenomena (as in the case of [B*]).[136]

In order to fully understand (ii), I will point to an example recently described by Paulo Mancosu in order to elucidate the explanatory role of mathematics in natural science. Mancosu notes that in order to explain why hive-bee honeycombs have a hexagonal structure, we refer to evolutionary facts, i.e., that bees that use less wax and spend less energy have a better chance at being selected, while completing the explanation by noting the mathematical fact that "any partition of the plane into regions of equal area has perimeter at least that of the regular hexagonal honeycomb tiling." The proof of this so-called honeycomb conjecture shows that the "hexagonal grid represents the best way to divide a surface into regions of equal area with the least total perimeter".[137] Thus, the hexagonal grid is optimal.[138] Exactly the same example is given by Wolff[139]:

> […] there are things in nature whose reason is seen only from what is demonstrated mathematically because they depend on some determinate figure or quantity. They would be otherwise if in the given case another figure or a greater or smaller quantity would be admitted. For example, the philosopher should give a reason why bees construct their honeycombs with hexangular cells rather than with cells of some other figure. And if one ought to be fully responsible, one needs mathematical as well as historical and philosophical knowledge where one wishes to prove that of all the possible figures in a given case, that is chosen which is the most convenient of all. (Wolff [1728] 1963, 20)

Hence, an objective demonstration of why bees construct their honeycombs with hexangular cells requires a combination of historical knowledge (knowledge of the fact), philosophical knowledge (knowledge of the reason or ground why, which we now seek in evolutionary facts), and mathematical knowledge (knowledge of quantity). It is only through mathematics that we gain full insight into the reason or ground of some phenomenon: mathematics shows that the hexagonal structure is, in Wolff's terms, most convenient.

I have not found passages in Kant's works in which he explicitly states that mathematics is necessary for providing explanatory demonstrations in natural science. His official argument, as we have seen, stresses the foundational epistemic function of mathematics. Nevertheless, one can hardly think of (Newtonian) explanative demonstrations in natural science that do not employ mathematics. We can thus conclude that Kant's adherence to the idea that scientific cognition must be apodictically certain (condition (6) of the Model) explains why he thought that proper

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[136] Wolff [1728] 1963, 15, 18–21.

[137] Lyon and Colyvan 2008, 228–229.

[138] Mancosu 2008.

[139] Mancosu bases his account on the work of Lyon and Colyvan 2008 and Hales 2001. Hales was the first to provide the actual proof of the (above cited) honeycomb conjecture. Hales also describes the history of the honeycomb conjecture, locating it in the works of Pappus of Alexandria and remarking that it was often discussed in the eighteenth century up until Darwin in the nineteenth century. I have found no mention of Wolff, however.

natural sciences must contain mathematics, while the latter belief may be also be informed by the idea that in science we must provide explanative demonstrations (condition (3b) of the Model).

2.5 Metaphysics, A Priori Justification, and Objective Grounding

In the final section of this chapter, we treat Kant's views on the relation between *metaphysics* and natural science. The aim of the *Metaphysische Anfangsgründe* is to provide the metaphysical principles of natural science. These principles are part of a *special* (*besondere*) metaphysics of corporeal nature, which is contrasted to *general* metaphysics.[140] A *proper* natural science must be based on a priori principles of special metaphysics. This requirement is related to the condition that scientific cognition must be apodictically certain (Sect. 2.3), which demands that scientific cognition is demonstrated on the basis of a priori principles. In terms of the Model, the claim that natural science requires metaphysical principles is related to condition (6). However, I argue that this claim can also be related to the idea that the propositions of a science must be objectively grounded, i.e., to conditions (3a) and (3b) of the Model.

In the Preface to the *Metaphysische Anfangsgründe*, Kant states that proper natural sciences must be based on a *pure cognition of nature*.[141] This secures the apodictic certainty of scientific cognition. Mathematics and metaphysics provide (different forms of) pure a priori cognition of nature.[142] Hence, proper natural science must be based on both metaphysical and mathematical principles. Natural science must be based on metaphysical principles because these latter secure the possibility of laws of nature, i.e., principles "of the necessity of that which belongs to the *existence* of a thing".[143] Since laws of nature concern *existing* objects, they cannot be justified (solely) by mathematical principles. For mathematics is not concerned with "existence as such at all".[144] By itself, mathematics does not allow us to infer to the existence of an object, and in a purely mathematical treatment of nature we abstract from physical and causal concepts. For this reason, laws of nature concerning relations among existent objects must (also) be grounded by a priori metaphysical principles.

Kant's conception of the role of metaphysics in natural science is too complex to be dealt with in full in this section. It has given rise to various debates that lie beyond the scope of our present investigation. I treat some of the debates in passing,

[140] AA 4: 469–470.

[141] AA 4: 469.

[142] AA 4: 468.

[143] AA 4: 469.

[144] *KrV*, A 719/B 747.

but will focus on providing a general discussion of topics that allow me to relate Kant's views to the Classical Model of Science. First, I highlight how metaphysical principles function in securing the apodictic certainty of scientific cognition. This allows us to relate Kant's views on metaphysics to condition (6) of the Model. Second, I relate Kant's views on metaphysics in natural science to conditions (3a) and (3b) of the Model. This elucidates how metaphysics helps natural science to provide explanative demonstrations.

2.5.1 Metaphysics and Apodictic Certainty

The claim that natural science must be based on metaphysical principles is intended, at least in part, to highlight that certain fundamental principles of physics must be proven a priori. In the Preface to the *Metaphysische Anfangsgründe*, Kant criticizes mathematical physicists for making use of *metaphysical* principles, while not investigating the a priori *sources* of these principles.[145] Newton is the likely target of this criticism.[146] While discussing his proof of the third law of mechanics, Kant criticizes Newton for not proving it a priori.[147] In the Scholium to the laws of motion, Newton indeed appeals to empirical evidence for these laws, citing (e.g.) experiments with colliding pendulums and machines as evidence for the third law of motion.[148] For Kant, this procedure establishes only the empirical certainty of the laws of motion. It does not demonstrate their *apodictic certainty*. Newton further treated the laws of motion as axioms. Kant thinks that only pure mathematics can have axioms: in (natural) philosophy, axioms have no place.[149] These remarks show that Kant took the laws of motion, which function as fundamental principles of (Newtonian) mathematical physics, to be insufficiently justified by his predecessors. They must be proven a priori in a special metaphysics of nature in order to show that they are apodictically certain. This holds for various principles of natural science, including principles concerning the kinematic analysis of velocity and concerning the fundamental forces of matter.

The above is relatively uncontroversial. However, the question of *how* Kant proves the metaphysical principles of natural science has given rise to various debates. On what is sometimes called the 'standard view', Kant derives the a priori (metaphysical) principles of natural science from the a priori principles of transcendental philosophy presented in the first *Critique*.[150] To illustrate this procedure, we may point to Kant's demonstrations of the laws of mechanics, which are based on

[145] AA 4: 472.

[146] See Pollok 2001.

[147] AA 4: 549.

[148] Newton [1726] 1999, 424–430.

[149] *KrV*, A 732–733/B 760–761. See Falkenburg 2000, 290.

[150] For criticism of 'the standard view', see Watkins 1998.

the analogies of experience.[151] In these proofs, we specify (instantiate) the principles of transcendental philosophy with respect to corporeal nature, thus providing a transition from general metaphysics to a special metaphysics of corporeal nature.[152] For example, Kant proves the law of inertia, according to which every change in matter has an *external* cause,[153] on the basis of the *transcendental* proposition that every change has a cause. He bases his argument on the claim that all changes in matter occur by means of *motion*.[154] The causal principle of general metaphysics tells us that all changes have a cause. Hence all changes in matter (occurring through motion) must have a cause. These changes cannot be due to an internal cause (e.g., desires, intentions, etc.). Hence, changes in matter are due to external causes. Here, the *apodictic certainty* of the law of inertia seems to be guaranteed by the fact that it is proven on the basis of the transcendental (a priori) principle of causality.

On the above reading, the procedure of deriving the metaphysical principles of natural science (e.g., the laws of mechanics) from transcendental principles provides a priori justification of the former. Hence, the metaphysical principles of natural science are apodictically certain. Moreover, if we grant that the metaphysical principles of natural are a priori, we may also take propositions proven on the basis of these principles to be apodictically certain. In Sect. 2.3, we have seen that Kant even allowed empirical knowledge to be apodictically certain "insofar as we cognize an empirically certain proposition from principles a priori".[155] Michael Friedman provides an example of an empirical proposition that is apodictically certain by pointing to the law of gravitation. On Friedman's reading, Kant takes the law of gravitation to be an empirical law, derived from phenomena, that is proven by means of the application of a priori laws of mechanics and dynamics, as well as a priori mathematical propositions.[156]

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[151] The three analogies (following the formulation of the *Metaphysische Anfangsgründe*) are: (1) in all changes of nature no substance either arises or perishes; (2) every change has a cause; (3) all external action in the world is *interaction*. On the basis of (1)–(3), i.e., by applying them to the empirical concept of matter, Kant supposedly proves his three laws of mechanics: (1a) in all changes of corporeal nature the total quantity of matter remains the same, neither increased nor diminished; (2a) every change of matter has an external cause (every body persists in its state of rest or motion, in the same direction, and with the same speed, if it is not compelled by an external cause to leave this state); (3a) In all communication of motion, action and reaction are always equal to one another. AA 4: 541–548. The most detailed discussion available of Kant's mechanics is given by Pollok 2001, 384–472.

[152] On the relation between general and special metaphysics, see Cramer 1985; Friedman 2001.

[153] Kant also explicates this law in Newtonian terms as: "every body persists in its state of rest or motion, in the same direction, and with the same speed, if it is not compelled by an external cause to leave this state". AA 4: 543.

[154] AA 4: 482, 543.

[155] AA 9: 71.

[156] Friedman 1992a, 174–177, 1992b. Mechanical laws and mathematics provide, in Friedman's terms, a priori grounds of the law of gravitation. This law is taken to be 'materially necessary'. Kant's logic supports this view, although there the term 'apodictic certainty' is used (not 'material necessity'). This is not to say, however, that Friedman endorses what is here called the standard view of the proof of the metaphysical principles of natural science. See Friedman 2001.

The so-called standard view on Kant's proof of the metaphysical principles has been criticized on the grounds that throughout the *Metaphysische Anfangsgründe* the relation between transcendental principles and (special) metaphysical principles is problematic.[157] For this reason, Eric Watkins has suggested that Kant proves the metaphysical principles of natural science via *transcendental arguments* that aim to show how experience of objects of outer sense is possible.[158] On this reading, the relationship between Kant's special metaphysics of nature and transcendental philosophy is looser than on the traditional reading. Here, we will not pursue this interpretation further. It is clear that even if the traditional reading is incorrect, Kant still intends to provide a priori demonstrations of the metaphysical principles of natural science in order to secure the apodictic certainty of both the *principles* and the *non-fundamental propositions* of natural science. On the traditional reading, we provide an a priori demonstration of the metaphysical principles of science by deriving them from transcendental principles. On the transcendental argument interpretation, we provide an a priori demonstration of the metaphysical principles of science by giving a transcendental argument. Whatever may be the correct reading: Kant argues that the metaphysical principles of natural science must be a priori in order to secure the possibility of *knowledge* in natural science (condition (6) of the Model).

2.5.2 Metaphysics and Grounding

We have related Kant's views on the foundational role of metaphysics to condition (6) of the Model, i.e., the requirement that we must have knowledge of the propositions of natural science. We can also relate Kant's views on metaphysics to conditions (3a) and (3b) of the Model. For Kant, metaphysics provides fundamental principles of natural science that *objectively ground* non-fundamental propositions.

Kant's special metaphysics of corporeal nature specifies apodictically certain principles of physics. In particular, it specifies principles of (a) phoronomy (kinematics), (b) dynamics, and (c) mechanics. (a)–(c) provide fundamental principles of physics, corresponding to condition (3a) of the Model. They are principles on the basis of which non-fundamental propositions or judgments are demonstrated.

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[157] Watkins 1998. On the difficult relation between transcendental and (special) metaphysical principles and possible defects in Kant's proof of the laws of motion, see further Westphal 1995a, 413–421. Westphal 2004, 137–172, 206–214. On the difficult relation of the third analogy to the third law of mechanics, cf. Watkins 1997, 406–441. On difficulties in relating Kant's laws of mechanics to Newton's laws of motion, see Watkins 2001a, 136–159.

[158] Watkins 1998. The inspiration of this reading comes in part from Friedman, who argues that for Kant the laws of mechanics and the immediacy and universality of gravitational attraction are necessarily presupposed (and are in this sense a priori) in determining a privileged frame of reference that allows the physicist to distinguish between the true and apparent motion of bodies. As such, they are necessary conditions for the possibility of the experience of matter. Friedman 1992a, 157–158.

Recall that we can distinguish different kinds of demonstrations in natural science: demonstrations *propter quid* and demonstrations *quia*. Kant takes metaphysical principles to be employed in both types of demonstrations. Consider Friedman's reconstruction of Kant's account of the derivation of the law of gravitation. On this reading, Kant takes the derivation of the law of gravitation to involve the application of *mathematical* propositions and *metaphysical* principles (the a priori laws of motion and principles of mechanics) to phenomena (empirical regularities).[159] Insofar as the law of gravitation is proven on the basis of a priori principles, it is apodictically certain. Nevertheless, the deduction of the law of universal gravitation remains an analytic deduction *from* phenomena (from effects to causes). Hence, on my account of grounding, it is a *demonstratio quia*. Kant takes proper scientific explanations to be explanative demonstrations proceeding from cause to effect.[160] Can we somehow relate Kant's views on the role of metaphysics in natural science to his views on explanative demonstrations?

The answer to this question is yes. In the *Dynamics* of the *Metaphysische Anfangsgründe*, Kant aims to specify objective grounds that explain *why* matter has certain characteristics. In this chapter, he introduces the causal concept of force. In Proposition 1, he argues that matter fills a space through a particular *moving force*, i.e., a force that is the *cause of motion*.[161] In particular, matter fills a space by virtue of the repulsive forces of all of its parts.[162] This fundamental repulsive force is taken to contain the *ground* of the (relative) impenetrability of matter.[163] The fundamental force of repulsion is counteracted by a fundamental force of attraction which is the *cause* of weight (*Schwere*).[164] If there is a balance between attraction and repulsion, matter of a determinate extension is generated.[165]

Note that Kant takes attraction and repulsion to belong to the *essence* of matter.[166] In the writings of Wolff and Baumgarten, the essence of a thing is construed as that which contains the *ground* (the reason why) of its necessary characteristics. This view nicely fits Kant's characterization of attraction and repulsion as pertaining to the essence of matter. For Kant, attraction and repulsion are constitutive of matter. Moreover, attraction provides the objective ground for the weight of bodies whereas repulsion provides the objective ground for the relative impenetrability of bodies, both weight and impenetrability being *necessary* and *universal* characteristics of matter.[167] The fundamental forces of attraction and repulsion can

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[159] Friedman 1992a, Chaps. 3 and 4.

[160] In this sense, the notion of grounding developed in this chapter is stronger than that held by Friedman.

[161] AA 4: 497.

[162] AA 4: 499.

[163] AA 4: 508.

[164] AA 4: 534.

[165] For a detailed account of Kant's dynamical theory of matter, see Carrier 2001a, 206–212, 1990, 170–210.

[166] AA 4: 511.

[167] AA 4: 518.

thus be interpreted as providing the reason *why* the universal characteristics of matter are such as they are.

Kant's forces of attraction and repulsion provide the fundamental posits of dynamics (condition (3a) of the Model). They provide objective grounds from which we can objectively explain the possibility of matter and its necessary characteristics (condition (3b) of the Model). In the General Remark to Dynamics, Kant extends his dynamical theory, providing an account of the *specific variety* of matter, e.g., an account of density differences among material bodies in terms of attraction and repulsion, the aggregate states of matter, etc.[168] In this manner, non-fundamental propositions are explained in terms of fundamental grounds (conditions (3a) and (3b) of the Model).[169] Kant's treatment of the fundamental forces of attraction and repulsion in the Dynamics thus nicely fits his views on explanative demonstrations expounded in this chapter.

Kathleen Okruhlik has described Kant's *Metaphysische Anfangsgründe* as an attempt to 'ground' physics in an 'ontology of forces'.[170] More recently, Eric Watkins has emphasized Kant's indebtedness to the Leibnizian-Wolffian tradition, which sought to develop an adequate ontology to provide a foundation for physics.[171] The above account of Kant's dynamics stresses, in a way similar to Okruhlik's and Watkins' accounts, that Kant intended to specify objective grounds (forces) that allow us to explain various characteristics of matter. We have an account of grounding that allows us to understand why Kant intended to base physics on a limited number of fundamental forces. Physics should aim to provide demonstrations *propter quid*, and this requires the specification of fundamental, objective grounds on the basis of which propositions in physics can be objectively explained.

2.6 Conclusion

In the present chapter we have analyzed Kant's conception of proper science in terms of the conditions of (i) systematicity, (ii) objective grounding, and (iii) apodictic certainty, while relating these conditions to the Classical Model of Science. Kant's claims that a proper natural science must allow for mathematization and that it must be based on metaphysical principles of corporeal nature were shown to follow from conditions (ii) and (iii).

In particular, Kant argues for the necessity of applying mathematics within the study of nature because mathematics provides a priori cognition (models) of

168 AA 4: 523–535. For details, see once again Carrier 2001a, 212–215.

169 As Friedman has emphasized, Kant also seems to argue, in Observation 2 to Proposition 7 of Dynamics, that it is necessary to take attraction as an essential, universal property of matter in order to ground the proposition that gravitational attraction is proportional to the mass of the attracting body. Friedman 1992a, 153–159. See Carrier 2001b for a partial critique of Friedman.

170 Okrhulik 1983, 251–268, esp. 256–261.

171 Watkins 2001a, 138–139. See also Watkins 2001b.

individual corporeal objects. As such, mathematics provides a priori principles for doctrines that aim to explain specific quantitative features of corporeal objects. These principles can be applied to corporeal objects and enable deductive demonstrations of specific quantitative features of corporeal objects from a priori principles. The cognition of these mathematically demonstrated quantitative features is thus apodictically certain (iii). In addition, mathematics can be taken to increase our insight into how specific grounds bring about particular consequences, and can thus make possible the provision of explanative scientific demonstrations (ii).

In a similar manner, the apodictic certainty of natural science requires that scientific cognition be based on *metaphysical* principles. These principles allow us to formulate *laws* concerning existing objects (iii). In addition, Kant takes metaphysical principles to explicate the *essence* of matter. As such, these principles specify objective grounds (the reason *why*) of fundamental properties of matter (ii).

Kant's views on the scientific status of particular disciplines can all be understood on the basis of conditions (i)–(iii) and their implications. For example, whereas natural description satisfies condition (i), it does not satisfy condition (ii). Alternatively, 'natural history' and 'chemistry' may be taken to satisfy both conditions (i) and (ii), but fail to satisfy condition (iii). Mathematics and (mathematical) physics provide clear instances of sciences that, according to Kant, satisfy conditions (i)–(iii). As such, they are paradigmatic examples of a proper science.

The condition of systematicity (i) ensures that the sciences possess a logical order and coherence. Condition (ii), corresponding to condition (3) of the Classical Model of Science, secures that scientific demonstrations are properly explanatory. This condition takes explanative demonstrations to represent the relation between objective grounds and consequences. Finally, condition (iii), corresponding to condition (6) of the Classical Model of Science, shows that knowledge requires justification in terms of a priori principles.

In our discussion of Kant's conception of biology, condition (ii) will take center stage. In particular, we will see that Kant construes 'mechanical explanation' as an ideal of scientific explanation of nature because these explanations capture condition (ii). This will be the focus of the next chapter.

Chapter 3
Mechanical Explanation and Grounding

In the first chapter we analyzed Kant's conception of proper science. The present chapter relates some of Kant's views on proper science to his views on the life sciences. A proper science satisfies the conditions of systematicity, objective grounding, and apodictic certainty. In the third *Critique*, Kant does not explicitly discuss the life sciences in light of these conditions. He does claim, however, that organisms defy mechanical explanation. This is problematic for the biologist, for Kant takes mechanical explanations to be ideal explanations of nature.

The notion of mechanical explanation has been thoroughly analyzed in recent literature on Kant.[1] It is not clear, however, how precisely we should understand this notion. It is also not clear why Kant construed mechanical explanations as *ideal* explanations of nature. In the present chapter, I argue that Kant took mechanical explanations to be *explanatory demonstrations*, i.e., deductively valid demonstrations that show *why* something is the case. This interpretation allows us to explain why he assigns such explanations a privileged status. I further determine the scope of the claim that organisms are mechanically inexplicable, showing that Kant took the complex unity of organisms and the fact that traits of organisms are adaptive to be inexplicable.

I reconstruct Kant's conception of 'mechanical explanation' by placing this notion in its historical context. Kant understands mechanical explanations as explanations of *wholes* in terms of their *parts*. In order to understand this characterization, it is helpful to consider the philosophical and scientific writings of Christian Wolff. The study of Wolff shows that the notions 'part' and 'whole' figure in two closely related scientific contexts: in logico-methodological and metaphysical discussions concerning the nature of demonstration and explanation (*ordo cognoscendi*), and in scientific discussions concerning the nature of bodies (*ordo essendi*). In his logic and metaphysics, Wolff construes scientific explanations as explanatory demonstrations proceeding from the part (the more universal) to the whole (the more particular). In this context, he applies the notions 'part' and 'whole' to concepts and demonstrations. In his writings on natural science, Wolff applies the notions 'part' and 'whole' to material objects

[1] See the authors discussed in Sect. 3.1.

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and invokes these notions to characterize the mechanical explanation of these objects. We mechanically explain the properties of a material object by showing how these properties are grounded in its parts, the structure of these parts, and the forces acting on these parts.[2]

Like Wolff, Kant adopts the idea that scientific explanations are explanatory demonstrations proceeding from part (the more universal) to whole (the more particular). Mechanical explanations are understood as explanatory demonstrations from general laws and are therefore construed as ideal scientific explanations of nature. This is not to say that Kant shared Wolff's views on nature and physics. There are substantial differences between them, which I highlight throughout this chapter. Yet despite these differences, both Wolff's and Kant's views on mechanical explanation are informed by a general ideal of demonstrative science. The present chapter will further elucidate how Wolff thinks that mechanical explanations can be given in biology. This background is important to understand Kant's views on the possibility of providing mechanical explanations in biology. I argue that Kant did not think that mechanical explanations are impossible in biology. However, like his predecessor Wolff, he thought they were very restricted in *scope*.

The chapter is structured as follows. In Sect. 3.1, I discuss some influential interpretations of Kant's views on mechanical explanation. Section 3.2 offers an analysis of some traditional part-whole conceptualizations in logic, philosophy, and natural science. I then turn to Wolff's use of the part-whole scheme in his writings on logic (Sect. 3.3), metaphysics (Sect. 3.4), and natural science (Sect. 3.5). In Sect. 3.6, I show that Kant construes mechanical explanations as explanatory demonstrations proceeding from the part (the more universal) to the whole (the more particular). Section 3.7 provides an analysis of Kant's mechanical account of crystallization. This shows that Kant's notion of mechanical explanation is tailored to his dynamical natural philosophy and encompasses explanations in physics and chemistry. In Sect. 3.8, I show that Kant took the complex (purposive) unity and the adaptive traits of organisms (and their parts) to be mechanically inexplicable. Section 3.9 discusses Kant's construal of the principle of mechanism as a regulative principle in the Dialectic of Teleological Judgment.

3.1 Understanding Mechanical Explanation

In the Dialectic of Teleological Judgment, Kant claims that organisms cannot be explained mechanically. He states that it is absurd to hope for a "Newton who could make comprehensible even the generation of a blade of grass according to natural laws that no intention has ordered".[3] In addition, mechanical explanation is treated

[2] I also analyze Kant's views on mechanical explanation in relation to Wolff's views on scientific demonstration in my van den Berg (2013). There, I mainly discuss the logical and metaphysical theories that informed Wolff's and Kant's views on explanation. These topics are treated more extensively in the present chapter and are related to explanation in natural science and biology. The paper, however, discusses the relation between mechanism and mathematics.

[3] AA 5: 400.

as an *ideal* of scientific explanation. If naturalists do not aim to explain everything in nature mechanically, there can be no *proper cognition of nature*.[4] This raises the following questions: (a) what is mechanical explanation? (b) Why does mechanical explanation constitute an ideal of scientific explanation of nature? Question (a) has been much debated in recent scholarship. In contrast, question (b) has received less attention.[5] In the following, both questions will concern us.

The most influential account of Kant's notion of mechanical explanation has been given by Peter McLaughlin.[6] According to McLaughlin, giving a mechanical explanation consists in explaining (properties of) a whole in terms of properties of its parts. In particular: "a mechanical explanation means the reduction of a whole to the properties (faculties and forces) which the parts have 'on their own', that is, independently of the whole".[7] McLaughlin thinks that if the parts of an object have properties *in* the whole and *due* to their presence in the whole – properties, that is, that they do not have independently of their existence in the whole – then the object cannot be mechanically explained.

For McLaughlin, explanations of machines are paradigmatic instances of mechanical explanation.[8] We may explain the functioning of a watch, for example, in terms of the functioning of its gears, levers, etc. These parts have their properties, such as rigidity, *independently* of their existence in the whole. Organisms *defy* mechanical explanation because the existence and properties of each of their parts are *dependent* on the existence and properties of all of their other parts. If the heart stops beating, rigor mortis sets in.

Plenty of textual evidence supports McLaughlin's interpretation. In §77 of the third *Critique*, Kant notes that if we consider the form of material wholes to be a product of "the parts and of their forces and their capacity to combine themselves", we "represent a mechanical kind of generation".[9] In the First Introduction to the third *Critique*, he notes that in considering physico-mechanical causation we comprehend the possibility of the whole on the basis of its parts.[10] This suggests that Kant understands mechanical explanation as a kind of explanation of a whole in terms of its parts, though the nature of mechanical explanation remains unclear.

Hannah Ginsborg has rejected McLaughlin's interpretation.[11] According to Ginsborg, part-whole relations are not central to the notion of mechanical explanation. Rather, we explain an object mechanically if "we explain its production as a result

[4] AA 5: 387.

[5] This point has been stressed by Watkins 2009, 204.

[6] This account has been developed most fully in McLaughlin 1990. See also McLaughlin 2013. McLaughlin's analysis has been adopted by Allison 1991 and Guyer 2001. See Ginsborg 2004, 33–39, for a discussion of these interpretations.

[7] McLaughlin 1990, 153.

[8] Ginsborg 2004, 34–36.

[9] AA 5: 408.

[10] AA 20: 236.

[11] Ginsborg 2001, 2004. See also Ginsborg 2006. McLaughlin's interpretation is now generally taken to be problematic. See, for example, Renate Wahsner 2009, 165–168 and Teufel 2011.

of the unaided powers of matter as such."[12] Mechanical explanations are explanations in terms of laws concerning the physical or chemical forces of matter. Ginsborg distinguishes two conceptions of mechanical explanation. According to the first conception, we explain the structure and regularities of objects mechanically if we account for the latter *solely* in terms of forces of matter, without supposing any arrangement of matter.[13] Kant takes organisms to be mechanically inexplicable because the existence and functioning of organisms is inexplicable in terms of the forces of matter alone. Ginsborg notes, however, that most (natural) objects do not allow of mechanical explanation in this sense: neither artifacts, nor heaps of sand, nor organisms can be explained in terms of the forces of matter alone. Hence, she introduces a second, more liberal conception of mechanical conception. On this new conception, we explain properties of (natural) objects mechanically if we explain these properties both in terms of physical forces *and* in terms of some particular arrangement or configuration of matter. According to Ginsborg, Kant allows for the possibility that organisms can be explained mechanically in this second sense. Thus, for example, while we cannot account for the generation of a bird in terms of physical and chemical forces alone, we can, presupposing some *original organization*, explain the origin of a bird mechanically as a consequence of an arrangement of matter found in an intact egg.[14]

More recent interpretations of Kant's conception of mechanical explanation attempt to reconcile the positions of McLaughlin and Ginsborg. Thus, Angela Breitenbach, partly following Ginsborg, construes mechanical explanations as explanations in terms of laws concerning the (fundamental) forces of matter. However, Breitenbach also stresses, in line with the position of McLaughlin, that in explaining the formation of natural objects Kant appeals to laws concerning the interaction of the forces of the *parts* of material objects. In other words, to explain a material whole in terms of its parts *is* to explain how the forces of the parts form this material whole.[15] Rachel Zuckert similarly claims that mechanical explanations are explanations in terms of physical laws, while also arguing that such explanations are explanations of wholes in terms of their parts.[16]

In the present chapter, I develop an interpretation of Kant's concept of mechanical explanation that supports the readings of Breitenbach and Zuckert. I argue that in order to understand Kant's conception of mechanical explanation we must closely consider his use of the part-whole scheme. Kant takes a mechanical explanation to explain a whole in terms of its parts. As I will show, this characterization captures, on the one hand, the procedure of explaining phenomena in terms of (general) laws. Like his predecessor Wolff, Kant took (explanatory) demonstrations in natural science to proceed from more general principles or laws to more specific consequences.

[12] Ginsborg 2004, 42.

[13] Ginsborg 2004, 40–41.

[14] Ginsborg 2001, 242–243.

[15] Breitenbach 2009, 51–56. See also Breitenbach 2006.

[16] Zuckert 2007, 101–111.

These demonstrations were taken to proceed from the *part* to the *whole*. Hence, when Kant argues that the discursive understanding, which proceeds from part to whole, leads humans to explain natural objects mechanically, he is thinking of the procedure of providing scientific demonstrations on the basis of general principles. Kant also interprets mechanical explanations, in line with McLaughlin's interpretation, as explanations of (the properties of) natural objects in terms of their material parts and the forces acting on these parts. These explanations can, however, be understood as explanations in terms of laws concerning the forces of the parts of material objects.

The present analysis adds to existing accounts by placing Kant's views on mechanical explanation in the context of Wolff's views on scientific and mechanical explanation. In addition to increasing our knowledge of the historical background of Kant's views, this procedure will allow us to show that Kant's conception of mechanical explanation is based on traditional logico-methodological ideals of scientific (explanatory) demonstration. Kant's claim that mechanical explanations are proper scientific explanations, and his view that one must always try to provide mechanical explanations in natural science, can be understood against this background.[17] Through an analysis of Wolff's explanations of organic processes, as given in his writings on physics, we can further gain insight into how Wolff thought that mechanical explanations can be given in the life sciences. This background is again important to understand the views of Kant. For although Wolff, like Kant, did not attempt to explain the purposive character of organisms mechanically, he did think that the explanation of (goal-directed) organic processes necessarily involves the application of mechanical laws. As I will argue, Kant adopts a similar view.

3.2 A Tradition of Part-Whole Conceptualizations

In the writings of Wolff and Kant, the notion of mechanical explanation is understood in terms of the part-whole scheme. Mechanical explanations are a certain kind of explanation of wholes in terms of their parts. What does this mean? Wolff and Kant employ the notions 'part' and 'whole' differently in different philosophical and scientific contexts. These notions are for example applied to concepts, figure in characterizations of (syllogistic) demonstrations, and are used to characterize the parts of material objects and explanations in natural science. In order to come to grips with

[17] Of course, although Wolff and Kant both construed scientific and mechanical explanations as explanatory demonstrations of phenomena in terms of the laws of nature, they had different views on what the laws of nature *are*. In contrast to Wolff, Kant adopted a *dynamic* natural philosophy, which attempts to explain nature in terms of (fundamental) forces of attraction and repulsion. Tonelli 1974, 245 has argued that the notion of mechanical explanation, which traditionally referred to Cartesian impulsionistic explanation, underwent some basic changes following the acceptance of Newton's dynamic natural philosophy. On this point, with which I am in total agreement, see also Ferrini 2000. I highlight the influence of Kant's dynamical conception of natural science on his views on mechanism in Sect. 3.7.

these diverse uses of the notions ‘part’ and ‘whole’, the present section provides a brief overview of how these notions were employed prior to Wolff and Kant.

In the history of philosophy, the notions ‘part’ and ‘whole’ have been frequently applied within the domain of *logic*. This is the case, for example, in Boethius’ tract *De divisione* (written between 505 and 509). In this tract, Boethius distinguishes (i) the (quantitative) division of a whole into its parts from (ii) the (qualitative) division of a genus into its species.[18] A whole is divided into its parts (i) if we resolve it into the things of which it is composed. For example, Boethius construes the genus *man* as a whole and treats the individuals comprising what we would call its extension (Cato, Vergil, etc.) as parts of this whole. What Boethius’ calls a qualitative division of a genus into its species (ii) is illustrated though the procedure of defining a concept. In definitions, parts are put together to make a whole. These parts comprise the genus (e.g., ‘animal’) and various *differentiae* (‘rational’, ‘mortal’) in terms of which we define a species (‘man’). In definitions, then, the genus and *differentiae* are taken to be *parts* of the species *man*.[19]

In the (early) modern period, we find similar applications of the part-whole scheme. For example, in his *De Corpore* (first published 1655), Thomas Hobbes writes:

> […] as when we see a man, the conception or whole idea of that man is first or more known, than the particular ideas of his being *figurate*, *animate*, and *rational*; that is, we first see the whole man, and take notice of his being, before we observe in him those other particulars. (Hobbes [1839] 1962, 66–67)

The view expressed in this passage is similar to Boethius’ treatment of *genera* and *differentiae* as parts: ‘animate’ and ‘rational’ constitute particulars or parts of the whole idea of man.

Hobbes employs the notions ‘part’ and ‘whole’ to characterize the distinction between the analytic (resolutive) and synthetic (compositive) scientific method. This is common in the modern period. The analytic method was often conceived of as a method proceeding from the *effect* to the *cause*, from the *more particular* to the *more general*, and from the *whole* to the *part*. Conversely, the synthetic method was taken to proceed from the *cause* to the *effect*, from the *more general* to the *more particular*, and from the *part* to the *whole*.[20] Isaac Newton, for example, construes the analytic method as follows:

> By this way of Analysis we may proceed from Compounds to Ingredients, and from Motions to the Forces producing them; and in general, from Effects to their Causes, till the Argument end in the most general. (Newton [1730] 1952, 404)

Through analysis we resolve compounds (wholes) into ingredients (parts), and, moreover, proceed from *motions* (effects) to the *forces* producing them. The method of synthesis proceeds in the opposite direction.[21]

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[18] Boethius [505–509] 1988, 13–14.

[19] Boethius [505–509] 1988, 31.

[20] De Jong 2010, 239. For one of the most thorough historical accounts of the notions ‘analytic’ and ‘synthetic’, see Engfer 1982.

[21] For a clear account of Newton’s conceptions of analysis and synthesis, see Falkenburg 2012, 83–85.

Proper scientific explanations were often taken to proceed from the universal (or part) to the more particular (whole). Thus, Thomas Hobbes thinks that in science the parts should be known earlier than the whole.[22] A similar view is suggested by the following methodological rule formulated by Arnauld and Nicole in the Logic of Port-Royal:

> Treat things as much as possible in their natural order, beginning with the most general and the simplest, and explaining everything belonging to the nature of the genus before proceeding to particular species. (Arnauld and Nicole [1683] 1996, 259)

The natural order is the order of nature. This rule thus tells us that if explanations of nature are to mirror the order of nature, we should proceed from the more universal to the more particular, or, if we construe the 'part' as the more universal, from the part to the whole. These explanations mirror the *ordo essendi* and constitute what we have called demonstrations *propter quid*.

In conclusion, the notions 'part' and 'whole' have been used in the history of philosophy to characterize the distinction between the analytic and synthetic method and are applied in diverse disciplines such as logic, where they refer to concepts and their parts, and natural science, where they are used to characterize physical objects. In the next sections, we will see that these diverse applications of the part-whole scheme can all be found in the writings of Wolff and Kant.

3.3 Parts, Wholes, and Definitions

To understand Wolff's views on scientific demonstration and mechanical explanation, we must come to terms with the general and rather indeterminate idea of explaining wholes in terms of their parts. In the present section, we will discuss how Wolff applies the part-whole scheme in his philosophy by focusing on his views on *definitions* as expounded in his logic. I show that, by applying the part-whole scheme to concepts, Wolff comes to understand definitions as explanations of wholes in terms of their parts. The application of the part-whole scheme to concepts provides the basis for understanding (syllogistic) demonstrations as proceeding from part to whole, as I show in the following sections.

In the first chapter of the *Deutsche Logik*, Wolff distinguishes nominal from real definitions. Nominal definitions specify the properties of a thing by means of which we can distinguish it from other things. Real definitions show how a thing is possible and thus provide cognition of its essence.[23] The concept of essence is explained by means of the example of a clock.[24] We comprehend the essence of a clock if (a) we have cognition of its parts, and (b) we have cognition of the manner in which these parts are necessarily combined to form the clock. By comprehending a thing (whole)

[22] Hobbes [1839] 1962, 66–68.

[23] Wolff [1754] 1978, 143–147.

[24] Wolff [1754] 1978, 147.

in terms of its *parts* (a) and their necessary *mode of composition* (b), we comprehend its essence. Since a real definition provides cognition of the essence of a thing, real definitions can be taken to explicate wholes in terms of their parts. In fact, both real and nominal definitions explicate wholes in terms of their parts.

According to Wolff, we define a concept if we specify *marks* of this concept that allow us to identify and distinguish the things comprising its extension. In the eighteenth century, marks (higher concepts) were generally construed as *parts* of composite concepts (lower concepts).[25] If we define a species by specifying its *genus proximum* and *differentia specifica*, we explicate a whole in terms of its parts. For example, if we define a 'human' (species) as an 'animal' (genus) with 'reason' (difference), we represent a composite concept (species) in terms of parts (genus and difference) *contained in* the former. In giving a definition, we also specify a relation between genus and specific difference and thus specify a relation *between* the parts of a whole. In Wolff's terminology, we specify the *mode of composition* of these parts. Definitions thus explicate a whole in terms of its parts and their mode of composition.

Different types of definitions proceed in different directions. Analytic definitions are obtained through analysis of given composite concepts, through which we cognize the partial concepts contained in these concepts. For example, through analysis of the concept 'human' we may obtain the genus 'animal' and the difference 'reason'. Here, we proceed from *whole* to *part*. Synthetic definitions are obtained through the arbitrary combination of partial concepts. For example, given the concepts *rectangle*, *equilateral*, and *four-sided*, we may synthetically compose the concept *square*. Here, we proceed from *part* to *whole*.[26]

The above definition of a square is, for Wolff, a *nominal* definition.[27] Nominal definitions do not show *how* this thing is possible.[28] The possibility of a thing is shown by its *real definition*. In mathematics, real definitions are given by constructing the object of a concept. Here, again, we proceed from part to whole. For example, Wolff states that we can provide a real definition of a circle if we let a straight line AB move around a point A.[29] In providing this definition, the straight line AB and point A can be conceptualized as *parts*, which, if combined in a certain manner (moving AB around A), result in a *whole* (the circle). We constructively define a circle by picking out parts and specifying a manner of combining these parts (mode of composition).

[25] For Wolff's account of his conceptions of marks and containment, provided in his discussion of abstraction, see Wolff [1754] 1978, 136–138. Kant, in his lectures on logic, often takes concepts that are *contained in* another concept (comprising its intension) to be parts of the latter. See AA 16: 345–346; AA 24: 342–343, 568, 753, 910. This point is stressed by De Jong, who notes that Leibniz, Reimarus, and Crusius apply the part-whole scheme to relations of concepts. De Jong 1995, 627. See also Anderson 2005.

[26] Wolff's account of the different ways to obtain concepts and definitions is given in Wolff [1754] 1978, 132–139.

[27] Wolff [1750] 1999, 6.

[28] Wolff [1754] 1978, 147.

[29] Wolff [1754] 1978, 148; [1750] 1999, 12–13.

Let us summarize the results of our analysis. For Wolff, definitions explicate wholes in terms of their parts. We define a concept if we (i) explicate this concept in terms of its parts and (ii) specify the mode of composition of these parts. Analytic definitions proceed from whole to part, whereas synthetic definitions proceed from part to whole. In the next section, we will see how Wolff's applies the part-whole scheme both in metaphysics and in natural science. In this way, his conception of scientific explanation will come into sharp focus.

3.4 Parts, Wholes, and Explanation

In Wolff's logic, the part-whole scheme is applied to *concepts*. In his metaphysical writings, this scheme is applied to *objects*. In these writings, Wolff construes what we may call explanations of wholes in terms of their parts as proper scientific explanations, because he takes such explanations to explain *why* something is the case. Wolff's reasons for adopting this view become clear if we consider how he relates the notions 'ground', 'essence', 'part', and 'whole'.

Wolff describes a ground as that from which one can know *why* something is.[30] The essence of a thing provides the ground for its attributes, i.e., the necessary and non-relational determinations of a thing. If we know the essence of a thing, we know *why* it has certain attributes.[31] For example, the essence of God explains why God is supremely wise, and the essence of an equilateral triangle explains why equilateral triangles are equiangular.[32] For Wolff, the essence of a *composite* thing consists in the mode of composition of its parts. If we know the mode of composition of the parts of a composite thing (its essence), we thus know the ground of its attributes. We may, for example, come to know the essence of the human eye through analyzing the mode of composition of its parts (cornea, iris, lens, etc.). On the basis of this analysis, we can explain *why* the eye enables sight.

An explanation of a whole in terms of its parts and their mode of composition thus constitutes a proper explanation because it yields cognition of the ground (reason why) of its *attributes*. In the first chapter, we have seen that explanations that show why something is the case are construed as explanatory *demonstrations* or *syllogisms*. In the following, I show how demonstrations of the attributes of a thing can be taken to explain these attributes in terms of its parts.

We have seen that in logic the part-whole scheme is applied to concepts: marks such as *genus* and *differentia* are taken to be parts of composite concepts (species). A concept can, however, have different kinds of parts. In the eighteenth century, *genus* and *differentia* are typically treated as *essential* marks or parts.[33] The genus

[30] Wolff [1751] 2003, 15–16.

[31] Wolff [1751] 2003, 18–19; 23.

[32] On Wolff's conceptions of essence, attributes, and accidents, see Wolff [1736] 2001, 120–126.

[33] The notion of essential parts can be found in rationalists such as Meier. See Meier 1752a, 178–180; b, 31. Thanks to Job Zinkstok for these references and discussion.

'animal', for example, is taken to be *part of the essence* of 'man'. From Wolff's metaphysical writings, we know that the attributes of a thing are grounded in its essence. In logic, this idea is expressed by construing attributes as marks *derivable* from essential marks by syllogistic inference.[34] The following syllogism (A) provides an example of the derivation of an attribute:

(Minor) Bodies have extension	
(Major) Whatever has extension is divisible	
(Conclusion) Bodies are divisible.[35]	(A)

In (A), the fact that divisibility is an attribute of bodies is proven by referring to the essence of bodies. The minor premise is a judgment in which 'extension', the specific difference of 'body', is predicated of 'bodies'. 'Extension' is an *essential mark or part* of the concept of 'body'. The major premise is a judgment in which the concept 'divisibility', which is an *attribute* of 'body', is predicated of extended objects. The middle term and essential mark 'extension' provides us with the *ground* (reason why) for predicating 'divisibility' of 'bodies'. The ground for predicating 'divisibility' of 'bodies' is thus a part of (is contained in) the concept of a body. Syllogism (A) is an explanative demonstration that explains *why* bodies are divisible. It can be interpreted as a demonstration in which we explain an attribute ('divisibility') of some whole ('body') in terms of one or more of its essential parts (such as the partial concept 'extension').

The premises of syllogism (A) explicate the essence of the concept of 'body'. It is *by virtue of* the essence of 'body' that bodies are divisible. For this reason, divisibility is an attribute of bodies. Wolff defines attributes as properties of an object that are *solely* grounded in their essence and *always* pertain to this object.[36] The essence of a thing is, moreover, a *sufficient ground* for demonstrating its attributes.

The case is different for demonstrations of so-called *modes* (accidents) or *relations*. In contrast to attributes, modes and relations are not properties that always pertain to a thing. Rather, they pertain to objects at certain times and in specific circumstances.[37] Cognition of the essence of a thing is also not sufficient to explain why an object has certain modes (e.g., for explaining why 'some humans are *pale*') or why an object stands in certain relations to other objects. It does not follow from the essence of 'human', for example, that some humans are pale. How, then, do we demonstrate propositions in which we assign modes or relations to some subject?

In his *Philosophia rationalis sive logica*, Wolff argues that the demonstration of judgments in which we ascribe modes or relations to some concept requires the *determination* of a concept.[38] Determination can be viewed as a process of forming

[34] Meier 1752a, 178–180.

[35] This example is taken from Kant. AA 8: 229.

[36] Wolff [1751] 2003, 23.

[37] Wolff [1754] 1978, 158.

[38] Wolff [1728] 1963, 63–64. For more discussion on these and the following topics, see van den Berg (2013).

complex concepts (wholes). For example, we determine the concept of 'animal' by adding the concept (determination) 'rational'. As such, we form the complex concept 'animals that are rational'. Through determining (or specifying) a concept we can demonstrate and explain propositions predicating modes or relations of a thing. Take the following example (B):

(Major) What is warm makes warm
(Minor) Stones which are warm are warm
(Conclusion) Stones which are warm make warm (B)

In the minor premise, the concept of 'stone' is *determined* by the mode of being warm. We thus have the complex concept 'stones which are warm'. The mode of being warm is the *ground* for the truth of the conclusion. It is only if stones are warm that the *relation* 'making warm' can be predicated of stones. Importantly, Wolff takes concepts of modes and relations to be *parts* of complex (determined) subject concepts.[39] The concept of 'being warm' (specifying a mode) is *part* of the complex concept 'stones which are warm'. In the above syllogism, we thus highlight a part ('being warm') of some whole (the complex concept 'stones which are warm') in order to explain why the relation 'making warm' pertains to this whole. As such, we again explain features of some whole in terms of their parts.

The above discussion illustrates how Wolff applies the part-whole scheme to various syllogistic demonstrations. It is likely that Wolff took such syllogisms to *proceed* from part to whole. This is suggested, first of all, by the fact that he construes inductive arguments (and not deductive arguments) as proceeding from the (more) particular to the (more) general or universal.[40] If we adopt Wolff's use of the part-whole scheme, this is to say we proceed from the whole to the part. Consider the following inductive argument:

(1) Socrates is wise
(2) Plato is wise
Etc.
(Conclusion) All philosophers are wise (C)

Here, we reason from premises concerning particulars (Socrates, Plato, etc.) to a conclusion in which the subject term denotes all philosophers. In other words, we reason from the particular (whole) to the (more) universal (part). Contrast this with syllogism (B), for example, which can be read as proceeding from a major premise in which the subject term denotes warm things in general, to a minor premise and conclusion in which the subject term denotes warm stones. Thus we may say that in the case of syllogism (B) we proceed from the more universal (part) to the more particular (whole).

[39] See Wolff [1754] 1978, 157–159.

[40] Wolff [1740] 1983, vol. II, 369.

3.5 Parts, Wholes, and Forces: Mechanical Explanation

Having seen how the part-whole scheme is applied to syllogistic demonstrations, we can turn to Wolff's use of this scheme in natural science. In his writings on natural science, Wolff treats the idea of explaining a whole in terms of its parts and their mode of composition as an ideal of scientific explanation of *nature*. In his *Deutsche Physik* (1723), he notes that corporeal objects are composite objects consisting of parts. One comprehends the *essence* of corporeal objects if one understands how their parts have a determinate order and constitute a whole.[41] Here, we see how Wolff's metaphysical views on the essence of objects determine his construal of the objects of natural science. In the following, I will first treat Wolff's views on mechanical explanation in natural science. Then I consider his views on the mechanical explanation of organic phenomena.

3.5.1 Mechanical Explanation in Natural Science

In order to understand Wolff's conception of mechanical explanation, we must understand his conception of physical bodies. For Wolff, natural science studies physical bodies (*Cörper*).[42] Bodies are composite things characterized by *attributes* such as figure, quantity, and divisibility. In addition, physical bodies have *material parts*. It is in virtue of these material parts that bodies resist (changes in) motion, i.e., that they are *inert*.[43] Finally, Wolff argues that physical bodies are characterized by a *force*.

How should we understand the notion 'force' in this context? Wolff introduces this notion to explain the possibility of motion. For Wolff, physical bodies are characterized by inertia and cannot move themselves. The motion of physical bodies (or change in their state of motion) must have an *external cause*. What is this external cause? To answer this question, Wolff provides the following argument. If a moving body A collides with a body at rest B, the resulting motion of B is caused by A. A contains the ground (reason why) for the motion of B.[44] However, since matter is inert or passive, the matter of A cannot be the ground for the motion of B. Neither can the essence of A be the ground for the motion of B. This is the case because, according to Wolff, essences cannot explain why things have certain modes (accidents) or relations. The motion of a body is a change of *relation*. As such, it cannot be explained in terms of the essence of bodies. Wolff concludes that in order to explain the resulting motion of B, we must attribute a *motive force* to A, which is

[41] Wolff [1723] 2003, 1–2.

[42] Wolff [1723] 2003, 1–3.

[43] Wolff [1751] 2003, 374–377.

[44] Wolff [1751] 2003, 381.

the ground of this motion.[45] It is in terms of the motive force of bodies that we objectively explain the (changes in) motion of other bodies.

According to Wolff, it is by virtue of having a motive force that bodies have a *nature*, as opposed to merely an *essence*. That which has its ground in the *essence* and *force* of a body is called *natural* and constitutes the object of natural science.[46] In explaining properties of corporeal bodies, Wolff argues, one must take into account their essence, i.e., their parts and the mode of composition of these parts, and forces acting on bodies and their parts. In other words, explanations in natural science take into account (i) the parts of bodies, (ii) the mode of composition of bodies, and (iii) forces acting on bodies and their parts. Let us consider an example of such an explanation.

Wolff takes the vaporization of water in hot air to be grounded in both the *essence* and *force* of water and hot air.[47] In the *Deutsche Physik*, he provides an account of the vaporization of water.[48] This account is based on the fact that water contains a large amount of air (i.e., oxygen). If the air contained in the water is heated, it will expand and form globules (*Blaselein*) which rise in the water.[49] If these globules expand enough, their density will be lesser than that of both the water and the surrounding air. Consequently, they will separate from the water and rise into the air, i.e., will become vapours (*Dünste*). This rise will continue as long as the density of the vapours is less than that of the surrounding air. Following Wolff's cue, we can indeed argue that in this account both the essence and the forces of corporeal bodies are employed to explain the vaporization of water. In explaining the formation of globules, we use cognition of the *parts* of water (air or oxygen) and of the action of heat, which, as the *cause* of expansion, can be said to have an expansive *force*. It is in this manner, I propose, that the notions 'essence' and 'force' are integrated within Wolff's conception of scientific explanation: (i) we explain objects in terms of their parts; (ii) the mode of composition of these parts; and (iii) the forces acting upon these parts.

Scientific explanations in terms of (i)–(iii) can be called *mechanical explanations*. Wolff defines a machine as a composite thing or product, the motions of which are partly grounded in (explained by) the mode of composition of its parts.[50] A clock provides a perfect example. In explaining the functioning of a clock, we take into account (i) its parts, (ii) their mode of composition, and (iii) the motive forces acting on these parts. According to Wolff, all composite things are machines.[51]

[45] Wolff [1751] 2003, 382–383.

[46] Wolff [1751] 2003, 384–385.

[47] Wolff [1751] 2003, 386.

[48] Wolff [1723] 2003, 333–348.

[49] Wolff [1723] 2003, 337–338.

[50] Wolff [1751] 2003, 336–337. The term 'partly' is introduced by me. Wolff simply states that the motion of a machine is grounded in the mode of composition of its parts, even though, as we have seen, the explanation of *motion* requires the introduction of the notion of 'force' (the mode of composition of parts provides only a partial ground of the motion of machines).

[51] Wolff [1751] 2003, 337–338.

It follows that explanations of physical bodies are explanations of machines. Here, we are confronted with one way in which an explanation of a whole in terms of (i)–(iii) can be termed a mechanical explanation: it is an *explanation of machines*.

The fact that every corporeal body is a machine also provides a reason for construing mechanical explanations as proper explanations of nature. For it can be argued that if all corporeal bodies are machines, then all corporeal bodies should be explained mechanically. This line of reasoning appears to be quite common in the eighteenth century. For example, in his *Grösses vollständiges Universallexicon*, Johann Heinrich Zedler notes that if all bodies are machines, then proper knowledge of these bodies must be obtained by the so-called mechanical natural philosophy. Machines, after all, must be explained mechanically.[52]

3.5.2 Mechanical Method in Biology

To conclude our discussion of Wolff, we will consider his views on method and explanation in what we may call biology. These views are, as we shall see, heavily informed by his views on mechanical explanation. Wolff takes *growth*, *nutrition*, and *propagation* to be the principal phenomena of study of biological investigation.[53] These topics are discussed thoroughly in the so-called *Deutsche Physik*.[54]

To understand Wolff's views on biological method, it is useful to consider his discussion of plants. When discussing of the growth of plants, he presents the following methodological considerations:

> We find that all plants are composed from certain parts and every part consists again of other smaller parts. Since the essence of a body consists in the mode of its composition (§606 Met.), one knows the essence of plants if one knows the parts from which they and further their parts are composed, and understands how they are composed from their parts and how these again are composed from other small parts. If one wants to indicate the true ground of that which belongs to plants, and as well of why they feed themselves and grow, live for a certain length of time, die afterwards, and generate their like (§384.), one must worry about their essence (§ 33 Met). (Wolff [1723] 2003, 600–601)[55]

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[52] Zedler (1731–1754), vol. 20, 20–21.

[53] On the prominence of these topics as subjects of biological investigation in the seventeenth and eighteenth centuries, see McLaughlin 2001, 173–179.

[54] The discussion is contained in the fourth part of the *Deutsche Physik*, entitled "On Plants, Animals and Man". Wolff also devotes chapters to the senses and to the motion of animals and man.

[55] Original: "Wir finden, daß alle Pflantzen aus gewissen Theilen zusammen gesetzet sind, und jeder Theil wieder aus andern kleinern Theilen bestehet. Da nun das Wesen eines Cörpers in der Art und Weise seiner Zusammensetzung bestehet (§606 Met.); so erkennet man das Wesen der Pflantzen, wenn man die Theile erkennet, daraus sie und ferner ihre Theile zusammengesetzet sind, und verstehet, wie sie aus ihren Theilen und diese wiederum aus den andern kleineren zusammen gesetzet worden. Wenn man von demjenigen, was den Pflantzen zukommet, und also auch davon, warum sie sich nähren und wachsen, eine Zeitlang leben, darnach sterben und ihres gleichen zeigen [sic!] (§384.) richtigen Grund anzeigen will; so muß man sich um ihr Wesen bekümmern (§ 33 Met)."

Thus, we know the essence of plants if (i) we have cognition of their parts, of the parts of these parts (etc.), and (ii) we have cognition of the mode of composition of their parts, the mode of composition of the parts of these parts (etc.). If we have cognition of (i) and (ii), at least up to a certain level,[56] we can specify the proper *grounds* of the nutrition, growth, and propagation of plants. We can thus explain *why* nutrition, growth, and propagation are characteristic features of plants. On the basis of these views, Wolff determines what he takes to be the correct methodology for the investigation of plants. Scientific cognition of plants is obtained by primarily *anatomical* research into the parts of which plants and their parts are composed, and the *mode of composition* of these parts.[57]

In discussing the growth of plants, Wolff carefully follows these methodological prescriptions. He first specifies the parts that can be discerned in plants, namely: (i) root, (ii) stem, (iii) eyes or buds, (iv) leaves, (v) blossoms and seeds, and their mode of composition. He then specifies the parts of the root, stem, and leaves and their mode of composition.[58] This analysis provides the basis for understanding the growth of plants.

For example, after distinguishing the main parts of plants, Wolff notes that the root of a plant consists of three main parts: (a) the bark (*Rinde*), (b) the wood (*Holtze*), and (c) the pith (*Marcke*).[59] Here, Wolff provides a description from the outermost to the innermost layers of the root. This analysis is then extended to more fundamental levels. After specifying the parts of the roots of plants ((a)–(c)), Wolff specifies the parts of these parts. For example, the bark (*Rinde*) of a root is taken to consist of: (α) a membrane (*Hautlein*), and (β) a spongy substance (called, after Grev, *parenchyma*).[60] The membrane is said to be porous and the spongy substance is taken to absorb water.

Through this analysis of the parts and sub-parts of plants, Wolff establishes a framework for understanding nutrition and growth. For example, after identifying water as the primary source of nutrition of plants, he aims to explain how water is taken up by roots. He argues that the membrane (α) and spongy substance (β) of the bark (a) of the roots of plants enable the absorption of water: the membrane attracts and enables the passage of water and the spongy matter absorbs water like a sponge.[61] To explain the absorption of water by the roots, we further require cognition of physical laws governing the movement of water. Wolff explains the process of absorption as follows: the root is that part of a plant which lies under the surface of the soil or earth.[62] If the earth is wet, it contains droplets of water. The bark of

[56] At some level of analysis, we take certain parts to be basic.

[57] Wolff [1723] 2003, 600–602. Wolff praises the anatomical and experimental research on plants of Malphighi, Grev, van Leeuwenhoek and Thümmig, and dismisses the ‘ancients’ who did not care for anatomical research.

[58] Wolff [1723] 2003, 603–613.

[59] Wolff [1723] 2003, 603–604.

[60] Ibid.

[61] Wolff [1723] 2003, 603–605, 626–627.

[62] Wolff [1723] 2003, 603.

the root of a plant contains a large quantity of air. If the earth is wet the droplets of water will move downward, due to the fact that the weight of water is greater than that of air, while the air contained in the bark will move upward.[63] Hence, from cognition of (i) the parts of the root of a plant, (ii) their interconnection, and (iii) laws concerning the motion of fluids, we gain cognition of the absorption of water by roots. This account fits Wolff's views on mechanical explanation treated in the previous paragraphs.

After explaining the absorption of water by roots, Wolff continues his investigation by inquiring how the leaves of a plant obtain water, how water is transformed into a 'nutritious fluid', how this nutritious fluid is transported through the plant, and so forth.[64] All of these accounts proceed on the basis of the analysis of the parts and sub-parts of plants, which yield insight into their essence. Through these inquiries, we can deepen our knowledge of how plants obtain and transport nutrition and, as such, come to know the *grounds* (reasons why) of the complex process of growth. Wolff's proposed methodology for the study of the growth of plants nicely illustrates his mechanical method in (what we may call) biology.

Two characteristics of Wolff's study of organisms must be highlighted. First, note that Wolff takes the study of organic processes (such as growth, nutrition, and propagation) to be a task of *physics*. He does not think that the study of organisms constitutes a special science. In his account of organic processes, Wolff refers to the regularities (or laws) of physics. Thus, as we have seen, when explaining the absorption of water by the roots of plants, he refers to the fact that the weight of water is greater than that of air. The latter is a regularity that Wolff establishes, following Boyle, in his *experimental physics*.[65] Throughout his discussion of organic processes, Wolff refers to many such regularities. His procedure is as follows. In explaining a complex process such as nutrition (call this α), we need to account for many sub-processes, such as, among others, how roots obtain water, how leaves obtain water, and so forth (call these α_1, α_2, etc.). In explaining α_1 and α_2, etc., in turn, Wolff refers to the structure of plants and their parts as well as to multiple regularities of physics (call these β_1, β_2, etc.). Explaining process α, he finds, requires an appeal to an immense multitude of regularities. In his writings on physics, Wolff is *not* concerned with the question of how it is possible that, in organisms, these regularities seem to be coordinated in a way that makes it possible for organisms to achieve certain purposes. More generally, he does not discuss the purposive characteristics of organisms and their parts. According to Wolff, these characteristics do not allow of explanation in terms of the regularities of physics. The purposes of organisms and their parts are discussed in the discipline of *teleology*, where they are explained in terms of the intentions of God.[66]

[63] Wolff [1723] 2003, 626–627.

[64] Cf. Wolff [1723] 2003, 628–636.

[65] Wolff [1727] 1982, 153–159.

[66] Wolff [1725] 1980, [1726] 1980.

Second, Wolff's study of organisms and organic processes *proceeds* from descriptive claims concerning the complex structure of organisms. This is because knowledge of organisms must be based on knowledge of their essence or structure. In his writings on physics, Wolff is rarely concerned with the question of how the complex structure of organisms originally came to be. This is not to say that he is silent on this subject, for he does discuss the generation and embryological development of organisms. However, he provides a (spermist) preformationist account of generation and embryological development, according to which the complex structure of organisms is (to a certain extent) *preformed*. That this is his view becomes clear in chapter 16 of the *Deutsche Physik*. There, Wolff discusses the generation of man and animals and notes that conception occurs through the fertilization of the egg through sperm. He argues against the theory of epigenesis, according to which embryos are generated through a gradual development from unorganized material, stating that a foetus cannot be formed from merely unformed matter.[67] In the egg there must be something "composed from members", and, according to Wolff, this composite is introduced in the egg through the male semen.[68] All parts of a body are thus contained in miniature in the sperm (*Saamen-Thierlein*), although not in exactly the same proportion as in a grown body.[69] In short, Wolff insists that the complex structure of organisms must be preformed and rejects naturalist or materialist explanations of this structure. In his physics, then, Wolff does not explain the purposive nature and complex structure of organisms by appeal to the regularities in physics.

Let us summarize the results of our discussion of Wolff. In Sects. 3.3 and 3.4, we have seen how Wolff applied the part-whole scheme to concepts and demonstrations. Explanatory demonstrations can be viewed as valid syllogisms proceeding from the part (the more universal) to the whole (more particular). In Sect. 3.5, we have seen how Wolff applies the part-whole scheme in natural science. In order to explain the properties of natural objects, we must take into account (i) the parts of these objects, (ii) the mode of composition of these parts, and (iii) the regularities or laws concerning the forces acting on bodies and their parts. Explanations in terms of (i)–(iii) are mechanical explanations that explain *why* something is the case. In short, mechanical explanations are explanatory demonstrations.

3.6 Parts, Wholes, and Mechanical Explanation in Kant

Having discussed Wolff's notion of mechanical explanation, we now turn to Kant. What is Kant's conception of mechanical explanation? Why *must* we explain nature mechanically according to Kant? To answer these questions, we should consider the notion of mechanism discussed in §77 of the Dialectic of Teleological Judgment.

[67] Wolff [1723] 2003, 718.

[68] Wolff [1723] 2003, 719.

[69] Wolff [1723] 2003, 722.

There, Kant suggests that we explain the formation of an object mechanically if we show how its parts and the forces of these parts give rise to the object.[70] It is further argued that it is due to the discursive nature of our understanding that humans must necessarily explain nature mechanically. Kant characterizes the discursive understanding as proceeding from the part to the whole:

> Our understanding, namely, has the property that in its cognition, e.g., of the cause of a product, it must go from the **analytic universal** (of concepts) to the particular (of the given empirical intuition), in which it determines nothing with regard to the manifoldness of the latter, but must expect this determination for the power of judgment from the subsumption of the empirical intuition (when the object is a product of nature) under the concept. Now, however, we can also conceive of an understanding which, since it is not discursive like ours but intuitive, goes from the **synthetically universal** (of the intuition of a whole as such) to the particular, i.e., from the whole to the parts, in which, therefore, and in whose representation of the whole, there is no **contingency** in the combination of the parts, in order to make possible a determinate form of the whole, which is needed by our understanding, which must progress from the parts, as universally conceived grounds, to the different possible forms, as consequences, that can be subsumed under it. In accordance with the constitution of our understanding, by contrast, a real whole of nature is to be regarded only as the effect of the concurrent moving forces of its parts. (AA 5: 407)

How should we interpret this complex passage? What is the relation between Kant's notion of discursive understanding and his notion of mechanical explanation? In what follows, I show that Kant's position can be fruitfully understood on the basis of Wolff's use of the part-whole scheme. First, as above in the case of Wolff, I will consider Kant's application of the part-whole scheme to concepts and to demonstrations. This will allow us, second, to determine Kant's conception of mechanical explanation.

3.6.1 Parts, Wholes, and Demonstrations in Kant

We have seen in the previous sections that Wolff applied the part-whole scheme to concepts. The marks contained in a complex concept are parts of that concept. Kant adopts a similar position. In the *Wiener Logik*, for example, it is said that universal concepts contained in the concepts from which they are abstracted are *parts* of those concepts from which they are abstracted.[71]

This view on the order of concepts informs Kant's characterization of the discursive understanding given in §77 of the Dialectic of Teleological Judgment. Kant characterizes the discursive understanding as proceeding from the analytic universal (the part) to the particular (whole). In contrast, an intuitive understanding proceeds from the whole (synthetic universal) to the part. The notions 'analytic universal' and 'synthetic universal' are logical notions.[72] In the *Jäsche Logik*, they are applied to

[70] AA 5: 408.

[71] AA 24: 910.

[72] This is stressed by Düsing 1968, 90–92. See also Friedman 1992a, 307–308.

rules, i.e., to concepts or judgments.[73] A rule is an 'analytic universal' if it "abstracts from differences" and is a 'synthetic universal' if it does not.[74] The notions 'analytic universal' and 'synthetic universal' are thus related to a notion of 'abstractness'. For Kant, concepts and judgments can be more or less abstract.[75] More universal concepts are more abstract than less universal concepts. Partial concepts (parts) contained in the complex concepts falling under them (wholes) are more abstract than these latter concepts. For example, the partial concept 'animal' is more abstract than the complex concept of 'human'.

The foregoing suggests that when Kant characterizes the human understanding as proceeding from the analytic universal to the particular, he is thinking of a process of *determination* in which we proceed from more universal (abstract) concepts to more specific concepts. Logical determination is, as we have seen, a process of forming lower or more specific concepts.[76] By determining a concept, we restrict its extension. For example, we determine the concept 'animal' by adding the concept 'rational', thus obtaining the complex concept 'rational animal'. This process of determination proceeds from the *part* (the more universal) to the *whole* (the less universal). As Kant indicates in the passage quoted above, determination can also be effected by subsuming an *empirical intuition* under a concept. For example, we can determine the concept 'body' by subsuming under it the intuition or individual representation of 'Jupiter'. Here, again, we proceed from the more universal or the part to the particular or whole. To conclude: Kant's description of the nature of the discursive understanding captures the idea that if we determine concepts we proceed from part to whole.

Like Wolff, Kant appears to apply the part-whole scheme to syllogisms or demonstrations. He states that our discursive understanding proceeds from "the parts, as universally conceived grounds, to the different possible forms, as consequences, that can be subsumed under it".[77] This claim becomes clear if we recall that Kant takes higher concepts (genera) to function as *grounds of cognition* with respect to representations that are contained under them.[78] For example, Kant would take the concept 'animal' to function as a ground for knowing that humans are bodies. Consider the following syllogism:

(Major) All animals are bodies.	
(Minor) All humans are animals.	
(Conclusion) All humans are bodies.	(D)

In this syllogism, the concept 'animal', which is part of the intension of the concept 'human', functions as a middle term. The concept 'body', in turn, is part of the

[73] AA 9: 102–103.

[74] Ibid.

[75] For a discussion of the notion of abstraction in relation to concepts, see AA 9: 94–95, 99–100.

[76] AA 9: 99.

[77] AA 5: 407.

[78] AA 9: 96.

intension of the concept ‘animal’. The middle term ‘animal’ functions as the *ground* for predicating ‘bodies’ of ‘humans’ (it allows us to connect these concepts). It is in this sense that concepts function as grounds of cognition with respect to representations contained under them: they can function as a middle term in a syllogism, allowing us to ascribe various predicates to the minor term (a representation subsumed *under* the middle term).

Recall that Wolff adopted a similar view. According to Wolff, concepts that are parts of the essence of a thing provide a ground for explaining why that thing has certain attributes. Above, we illustrated this idea by means of the following syllogism:

(Minor) Bodies have extension.	
(Major) Whatever has extension is divisible	
(Conclusion) Bodies are divisible.	(A)

Syllogisms (A) and (D) are highly similar. In both, the premises make explicit what is *contained in* the subject concepts of the conclusion. In traditional terms: the premises explicate *essential parts* of these subject concepts. In applying the part-whole scheme to demonstrations, Kant is following a line of thought we encountered in Wolff. Yet there are also important differences between Wolff’s and Kant’s views on (syllogistic) demonstration and explanation. These differences will be discussed in the following subsection. By examining these differences, we can pinpoint Kant’s views on mechanical explanation and explain why such explanations are construed as ideal explanations of nature.

3.6.2 Mechanical Explanations as Explanatory Demonstrations proceeding from Synthetic Principles

In order to identify the differences between Wolff’s and Kant’s views on demonstration and explanation, we can start by considering syllogism (A) specified above. Recall that Wolff took (A) to explain *why* something is the case. Does Kant also adopt this view?

The answer to this question is *no*. Kant treats the major premise, minor premise, and conclusion of (A) as *analytic* a priori judgments. In his *Ueber eine Entdeckung* (1790), Kant discusses (A). There, he notes that the predicate ‘divisible’ is an attribute of bodies because it can be derived from an essential part of ‘body’, namely, the concept ‘extension’. However, for Kant ‘divisible’ is an *analytic attribute*.[79] The conclusion of (A) can be proven merely by analysis of the concept ‘body’. Kant does not assign analytic judgments any explanatory role in science. Hence, he would not construe (A) as an explanatory demonstration.

[79] AA 8: 229–231.

Wolff takes syllogism (A) to explain why bodies are divisible because it specifies the ground for the divisibility of bodies. (A) explains why divisibility is an attribute of bodies by referring to their *essence* (*ratio essendi*), i.e., by referring to the fact that bodies are *extended*. Since Kant denies that (A) is explanatory, he does not take what Wolff calls 'essence' to be a ground that explains why something is the case. In short, Wolff and Kant have different views on what constitutes an *objective ground*. Let us consider another example to illustrate this difference.

Wolff took the concept of *filling a space* to be an attribute of composite things.[80] Hence, we can derive this attribute from the essential parts of the concept of composite things. These essential parts can be identified through the analysis of the concept of a composite thing. Given that all bodies are composite things, it seems to follow purely *analytically* that bodies fill a space. In short: Wolff seems to think that the proposition or judgment that 'bodies fill a space' can be analytically proven merely by attending to the intensions of the concept of a composite thing and the concept of a body.

Kant would argue that in such a derivation we do not specify the objective ground for the fact that bodies fill a space. The essence of the concept of a composite thing at issue here is called by Kant its 'logical essence', i.e., the complex of essential marks contained in a certain concept.[81] The logical essence provides a logical ground, i.e. a *reason that*, for the truth of judgments. In order to objectively demonstrate that bodies fill a space, however, we need to specify the *objective ground* of bodies filling a space. In the *Metaphysische Anfangsgründe*, Kant provides this objective ground, arguing that matter fills a space through a particular repulsive force.[82] In contrast to Wolff, then, Kant does not assign what he calls the 'logical essence' of a composite thing any explanatory role in natural science. Instead, he holds that explaining why material bodies fill a space requires an appeal to forces or causes.

The above example also suggests that, unlike Wolff, Kant did not take the filling of space to be an (analytic) attribute of bodies. In the Dynamics of the *Metaphysische Anfangsgründe*, while discussing how matter fills a space, he remarks (arguing against Lambert) that:

> […] the principle of noncontradiction does not repel a matter advancing to penetrate into a space where another is found. Only when I ascribe to that which occupies a space a force to repel every external movable that approaches, do I understand how it contains a contradiction for yet another thing of the same kind to penetrate into the space occupied by a thing. (AA 4: 498)

If 'filling a space' were an analytic attribute of the concept of matter, it could be analytically derived from the logical essence of the concept of 'matter'. Kant denies that this is possible. It is only through a *synthetic judgment* that specifies that

[80] Wolff [1751] 2003, 26–27.

[81] AA 24: 839.

[82] AA 4: 497.

material bodies are constituted by repulsive forces that we can explain objectively *why* material bodies fill a space.[83]

How does the above discussion relate to the idea of mechanical explanation? We have seen that in characterizing the discursive understanding as proceeding from part to whole, Kant is thinking of a process of determining concepts. In addition, he seems to allow for an application of the part-whole scheme to demonstrations or syllogisms. In these two respects, Kant's position is similar to Wolff's. However, Kant's conception of what constitutes an explanatory demonstration differs from that of Wolff. For Kant, explanatory demonstrations in natural science must be based on synthetic a priori or synthetic a posteriori judgments. Despite this difference, however, Kant still adopted the idea that scientific demonstrations proceed from part to whole.

The reason for this is that demonstrations proceeding from synthetic judgments can be construed as proceeding from the more universal (part) to the more specific (whole). Consider, for example, a simplified reconstruction of Newton's demonstration given in the first proposition of Book III of the Principia (our stock example from Chap. 1).

1. If a body that moves in some curved line described in a plane and, by a radius drawn to a point, describes areas around that point proportional to the times (call this [A]), it is urged by a centripetal force tending toward that same point (call this [B]).
2. The satellites of Jupiter, by radii drawn to the center of Jupiter, describe areas proportional to the times.
3. Hence, the satellites of Jupiter are maintained in their respective orbits by forces directed toward the center of Jupiter.[84]

Premise (1) is demonstrated mathematically by Newton in Book I of the *Principia*.[85] Proposition (2) captures part of Newton's so called Phenomenon 1. This proposition is an empirical generalization. Proposition (1) provides us, according to Kant, with a synthetic a priori rule that is *determined* in proposition (2). In (2) we determine rule [A] by saying that this rule, which holds for a certain class of bodies, holds for the satellites of Jupiter. This allows us to conclude in (3) that [B] holds for the satellites of Jupiter ([A] provides the ground for predicating [B] of the satellites of Jupiter). In this demonstration, we thus move from the more universal to the more particular and from the part to the whole.

The above demonstration nicely illustrates what Kant has in mind when he characterizes the discursive understanding as proceeding from part to whole. It also illustrates the activity of what Kant calls the faculty of *determining judgment*. According to Kant, the faculty of determining judgment subsumes a particular under a given universal rule.[86] In natural science, this will often mean that we

[83] On Kant's dynamics, see: Warren 2001.

[84] Newton [1726] 1999, 802.

[85] Newton [1726] 1999, 446.

[86] AA 5: 180.

subsume particulars (e.g., intuitions of particular objects) under synthetic judgments (e.g., judgments of mathematical physics). This is roughly what Newton does in the demonstration given above.

In the First Introduction to the third *Critique*, Kant relates the activity of determining judgment to the procedure of giving mechanical explanations. Like our discursive understanding, the faculty of determining judgment directs us to explain objects mechanically.[87] This suggests that mechanical explanations can be understood as *demonstrations* that proceed from (more) general synthetic propositions to conclusions that concern the more specific or particular. These kinds of demonstrations, as I have argued, can be understood as proceeding from the *part* to the *whole*.

The above analysis supports the following conclusion. For Kant, mechanical explanations are *scientific demonstrations*. In the first chapter, we argued that for Kant scientific explanations are explanatory demonstrations, proceeding from objective ground to consequence. Hence, it is likely that he construes mechanical explanations as *explanatory demonstrations*. The notion of a mechanical explanation is similar to what Kant calls a *physical-mechanical* explanation: explanations based on judgments found in the *rational* science of nature and in sciences containing *empirical* laws of motion.[88] In other words, mechanical explanations are demonstrations in natural science based on synthetic a priori judgments (such as (Newtonian) *mathematical* or *kinematic* judgments and Kant's *metaphysical* principles of natural science) and/or synthetic and empirical judgments. Newtonian explanatory demonstrations provide good examples.

The construal of mechanical explanations as explanatory demonstrations elucidates why Kant treats mechanical explanations as *ideal* explanations of nature. Mechanical explanations, if understood as explanatory demonstrations, are the best scientific explanations we have. They are deductively valid arguments, proceeding from true premises that explain why something is the case. Moreover, if mechanical explanations are understood as proceeding from (more) universal judgments to (more) particular judgments, mechanical explanations in natural science must, according to Kant, ultimately be based on the mathematical and metaphysical principles of natural science. In the previous chapter, we have seen that these principles secure the apodictic certainty of judgments of natural science and provide objective grounds for explaining natural phenomena. Hence, Kant's conception of mechanical explanation is intimately linked to the conception of proper science developed in the *Metaphysisiche Anfangsgründe*. Natural science is a system of judgments based (ultimately) on universal a priori (metaphysical and mathematical) principles. The discursive understanding, proceeding from part to whole, derives more and more specific regularities from these principles and, as such, directs us to explain nature *mechanically*. Kant's claim that we *must* explain nature mechanically is thus a consequence of his understanding of proper science and reflects his adherence to methodological ideals of scientific practice widely accepted in the eighteenth century (among others, by Wolff).

[87] AA 20: 218.

[88] AA 20: 237.

3.7 Crystallization

In the previous section, we interpreted mechanical explanations as explanatory demonstrations. I have illustrated Kant's conception of scientific demonstration by referring to demonstrations in mathematical physics. This section analyzes his views on crystallization or solidification as presented in the third *Critique* and the *Opus postumum*. This analysis will show that mechanical explanations are given not only in mathematical physics, but also in experimental disciplines such as chemistry. It will further show that scientific explanations given in the framework of Kant's dynamical natural philosophy are construed as mechanical explanations.

In §58 of the Critique of Aesthetic Judgment, Kant cites the "free formations" of nature as natural objects that are mechanically generated.[89] The term 'free formations' is applied, among other things, to crystals. Kant notes that it might seem to be the case that these *beautiful* objects (like flowers, blossoms, etc.) are designed "for our own taste".[90] In other words, Kant discusses an inference from the appearance of beauty of natural objects to the design of these objects. He describes the mechanical formation of crystals in order to reject this inference. The formation of crystals shows that nature has a "faculty for forming itself aesthetically and purposively in its freedom".[91]

The notion 'free formation' is described as follows:

> By a **free formation** of nature, however, I understand that by which, from a **fluid at rest**, as a result of the evaporation or separation of a part of it (sometimes merely of the caloric (*Wärmematerie*)), the rest assumes upon solidification a determinate shape or fabric (figure or texture) […]. (AA 5: 348)

This description is similar to other descriptions of crystals in Kant's time.[92] For example, J.S.T. Gehler, in his *Physikalisches Wörterbuch* (1787–1796), defines crystals as substances, the parts of which are ordered in such a manner that they constitute regularly structured solid masses.[93] Crystals are the result of crystallization, i.e., of a *phase transition* from the fluid to the solid state resulting in the formation of regular structures.[94] A similar description of crystals and crystallization can

[89] AA 5: 348–350.

[90] AA 5: 347–348.

[91] AA 5: 349.

[92] Fritscher 2009, 243–248. Fritscher has provided an extensive account of Kant's views on crystals in light of eighteenth-century crystallography. He notes the importance of René-Just Haüy (1743–1822), Johan Gottschalk Wallerius (1709–1785) and Johann Samuel Traugott Gehler (1751–1795). Here I focus merely on the remarks on crystals and crystallization in Gehler's dictionary in order to elucidate Kant's views.

[93] Gehler 1787–1796, Bd. 2, 819.

[94] Gehler 1787–1796, Bd.2, 825.

be found in Macquer's *Chymisches Wörterbuch* (1781).[95] Kant himself describes crystallization as follows:

> The formation in such a case takes place through **precipitation** (*Anschießen*), i.e., through a sudden solidification, not through a gradual transition from the fluid to the solid state, but as it were through a leap, which transition is also called **crystallization**. The most common example of this sort of formation is freezing water, in which straight raylets of ice form first, which then join together at angles of 60 degrees, while others attach themselves at every point in exactly the same way, until everything has turned to ice, so that during this time, the water between the raylets of ice does not gradually become more viscous, but remains as completely fluid as it would be if it were at a much higher temperature, and yet is fully as cold as ice. The matter that separates itself, which suddenly escapes at the moment of solidification, is a considerable quantum of caloric (*Wärmestoff*), the departure of which, because it was required only for maintaining a fluid state, leaves what is now all ice not the least bit colder than was the water that shortly before was still fluid. (AA 5: 348)

Michael Friedman has shown that Kant was aware of developments in the theory of heat in the second half of the eighteenth century.[96] The passage above is therefore best interpreted in light of these developments. Kant construes the matter of heat (*Wärmestoff*)[97] as the cause of a body's maintaining a fluid state. He further appears to invoke the notion of latent heat, i.e., heat that is, (a) bound to a particular substance, that (b) has no perceivable effect on the temperature of a substance, and that is, (c) the cause of the state (solid, liquid, gaseous) of the substance to which it is bound.[98] According to the doctrine of latent heat, the states of aggregation of a substance depend on the quantity of latent heat combined with it. Phase transitions are explained in terms of the combination of heat with a substance (vaporization or liquefaction) or separation of heat from a substance (solidification). The matter of heat is held to combine with particular substances in accordance with the chemical affinity that material substances possess for the matter of heat. In short, the chemical combination of the matter of heat with a substance is the cause of liquefaction, whereas the release of heat results in a solidification of this substance, a transition which Kant calls crystallization.

The theory of latent and specific heat provides us with cognition of (some of) the physico-chemical regularities that govern crystallization. It is important to note that

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[95] Macquer 1781, 255–258.

[96] Friedman 1992a, 264–290.

[97] One should be careful in translating the terms *Wärmestoff* and *Wärmematerie* with 'caloric'. In Kant's time, the term caloric (*Calorique*) was a term of art which, though referring to the matter of heat, was employed within Lavoisier's anti-phlogistic chemistry. It is not clear whether Kant adopted the chemistry of Lavoisier when writing the *Kritik der Urteilskraft*. Friedman cites the passage above as evidence that Kant adopted the doctrine of *latent heat*. However, Kant's full conversion to Lavoisier's chemistry might have occurred later. Friedman 1992a, 281–290.

[98] For this notion, as construed in Kant's time, see Gehler's article on *Wärme* in his *Physikalisches Wörterbuch*. Gehler 1787–1796, bd. 4, 533–568. Friedman discusses the article. Friedman 1992a, 269–280.

scientists like Gehler and Macquer argued that accounts of crystallization that only take into account the action of heat are inadequate. For example, Gehler takes the matter of heat to be the cause of fluidity and takes phase transitions to involve the combination or release of heat. However, he criticizes chemists who apply the term 'crystallization' to any transition from the fluid to the solid state, i.e., who conflate *crystallization* with *solidification*. Crystallization, he holds, must be understood as a *particular type* of phase transition.[99] According to Gehler, crystallization involves both the release of a fluid (e.g., heat) from a body, which separates the parts of the body, *and* the ensuing tendency of the parts to form specific regular structures.[100] This latter tendency is dependent on the shape of the parts.[101]

In contrast to Gehler, Kant did *not* distinguish between crystallization and solidification.[102] This becomes clear in the *Opus postumum*. There, as Martin Carrier has noted, Kant provides his most developed account of solidification. This account takes fluids to be substances dissolved in the matter of heat. In addition, fluids are taken to be substances consisting of heterogeneous components of distinct density.[103] If heat is released from a fluid, these heterogeneous components are segregated and, in accordance with their chemical affinities,[104] form aggregates or solids with an inner texture resistant to the displacement of its parts. This process of *solidification* is described as a process of *crystallization*. For our present purposes, it is not necessary to analyze Kant's views on crystallization or solidification in more detail. We must ask simply how Kant's account of crystallization (solidification) sheds light on his views on mechanical explanation.

First, note that Kant's account of crystallization fits the description of mechanical explanation given in the third *Critique*. We explain the formation of a whole mechanically if we explain the formation of this whole in terms of its parts and their forces. Kant's account of crystallization is based on (a) the characterization of fluids as substances consisting of heterogeneous ingredients dissolved in the matter of heat; (b) a (caloric) conception of heat as a substance that is the cause of fluidity; (c) an account of the causal process underlying crystallization. The process involves the release of heat and the formation of rigid textures from heterogeneous ingredients in accordance with their chemical affinities. Hence, we can explain the formation of wholes (crystals) in terms of certain material parts (e.g., the heterogeneous ingredients of a fluid and the matter of heat) and their forces or chemical affinities.

Second, the example of crystallization shows that Kant adjusted the notion of 'mechanism' to better fit both the scientific theories of his time and the principles of his own dynamical natural philosophy. Bernhard Fritscher has interpreted Kant as providing a "chemical-dynamical explanation" and not merely a

[99] Gehler 1787–1796, Bd.2, 825–826.

[100] Ibid.

[101] Ibid.

[102] AA 22: 232. Fritscher 2009, 250.

[103] AA 21: 452–453. Carrier 2001a, 214.

[104] Fritscher 2009, 253.

"mechanical-mathematical one".[105] This is true. Kant's account of crystallization is, for example, based on a conception of heat foreign to anyone who accepts a mechanical theory of heat in the sense of a *kinetic* theory of heat. According to the kinetic theory of heat, heat consists of the motions of the parts of matter.[106] Kant, however, construes heat as a particular substance that can chemically combine with other substances. He takes this conception of heat, and his account of crystallization, to accord with his *dynamical* approach to natural philosophy.[107] Nonetheless, the account of crystallization is still a *mechanical* account. The fact that Kant construes explanations given within the framework of his *dynamical* natural philosophy as *mechanical* shows that it is problematic to construe the notion of mechanical explanation in terms of what Kant himself calls the (Cartesian) mechanical or *corpuscular* natural philosophy. The notion 'mechanical explanation' is assigned a much broader scope.

Third, and finally, the example of crystallization shows that Kant thought that mechanical explanations can be given in experimental disciplines such as chemistry. His explanation of crystallization is, after all, based on *chemical* regularities. Ginsborg has pointed out that already in his *Der einzig mögliche Beweisgrund*, Kant construed laws concerning chemical, magnetic, and electrical phenomena as mechanical.[108] Hence, explanations in chemistry, magnetism, and the theory of electricity can all be mechanical. Recall also, however, that Ginsborg construed mechanical explanations as explanations in which we explain (the formation of) material objects *without* "appeal to any particular arrangement" of material objects.[109] This is problematic. For Kant's account of crystallization is based on a particular conception of the composition of fluids (see (a)–(c) above). In general, Kant's conception of mechanical explanation appears to be weaker than Ginsborg's (strong) conception of mechanical explanation suggests.

3.8 The Mechanical Inexplicability of Organisms

Having discussed Kant's views on mechanical explanation, we must ask what features of organisms Kant took to be mechanically inexplicable. Which properties of organisms resist proper scientific explanation? Commentators have provided a variety of (partially overlapping) answers to this question.

[105] Fritscher 2009, 241.

[106] Friedman 1992a, 271.

[107] Whether this is justified is another matter. Carrier has shown that Kant's contemporaries did not regard the assumption of a matter of heat to be compatible with the prescriptions of a truly dynamic natural philosophy. Carrier 2001a, 215.

[108] AA 2: 113. Ginsborg 2001, 241–243.

[109] Ginsborg 2001, 242.

It is common among interpreters to provide a strong interpretation of Kant's claim that organisms resist mechanical explanations. For example, John Zammito claims that Kant took organisms and organic processes such as growth, reproduction, and regeneration to be "inexplicable by all the resources of science".[110] This reading is informed by McLaughlin's account of mechanical explanation. Recall that McLaughlin took mechanical explanation to consist in the *reduction* of a whole to the properties its parts have independently of the whole. In the third *Critique*, Kant argues that the properties and behaviour of the parts of organisms *are* dependent on the whole.[111] In particular, he takes processes such as the growth and reproduction of organisms and the regeneration of organic parts to show that the properties and behaviour of parts of organisms depend on the properties and behaviour of other parts. It follows, if one accepts McLaughlin's account of mechanical explanation, that organisms and organic processes such as growth, reproduction, and regeneration cannot be mechanically explained.

Other interpretations of the mechanical inexplicability of organisms have been proposed by Hannah Ginsborg, Rachel Zuckert, and Angela Breitenbach. According to Ginsborg, Kant takes what she calls the *composite character* of organisms to defy mechanical explanations.[112] Ginsborg also claims that, according to Kant, biological regularities concerning the growth, reproduction, and maintenance of organisms are mechanically inexplicable insofar as they cannot be explained in terms of the laws of inorganic nature. In line with Ginsborg, Zuckert interprets Kant as holding that the (fundamental) laws of nature cannot explain 'organic unity', i.e., the unity obtaining among particular and contingent properties of the parts of organisms.[113] Breitenbach, finally, maintains that the *purposive* character of organisms and their parts resists mechanical explanation.[114]

In the following, I develop an interpretation of Kant's claim that organisms defy mechanical explanation that supports the readings of Ginsborg, Zuckert, and Breitenbach. I discuss several of Kant's arguments for the claim that organisms are mechanically inexplicable. These arguments show that Kant took two elements in particular to defy mechanical explanation: (i) the complex (purposive) unity of the parts of organisms, and (ii) the adaptation of organisms to their environment and the adaptation of the parts of organisms to one another. In other words, *organic and purposive complexity* and *adaptation* do not allow of proper scientific explanation.

3.8.1 The Contingent Unity of Organisms

In the third *Critique*, Kant notes that the unity of the structure of a bird, exemplified by the hollowness of its bones, the placement of its wings for steering, and so forth, is

[110] Zammito 2006, 758.

[111] See, for example, AA 5: 372.

[112] Ginsborg 2004, 44.

[113] Zuckert 2007, 108.

[114] Breitenbach 2009, 61–66.

contingent with respect to the *nexus effectivus*.[115] This unity is therefore mechanically inexplicable. How should we understand these claims?

The view that the unity of (properties of) organisms is mechanically inexplicable is, as Ginsborg stresses,[116] most fully developed in Kant's pre-critical *Der einzig mögliche Beweisgrund*. There, Kant explicitly argues that the unity of (the properties of) organisms is contingent. This is to say, as will become clear in the following, that the unity of organisms cannot be explained by appealing to the principles or laws of natural science. Kant distinguishes the unity of (the properties of) objects studied in natural science from the unity of (the properties of) organisms. Whereas the unity of the properties of objects studied in natural science can be explained by appealing to fundamental principles or laws, such an explanation is not possible in the case of organisms. Hence, the unity of organisms is contingent *with respect to* the principles or laws of natural science. Let us consider Kant's argument more closely.

In the second section of *Der einzig mögliche Beweisgrund*, Kant aims to show that various phenomena that may appear to be designed by God can be explained simply in terms of the universal laws of natural science. In nature, Kant notes, we often encounter "extensive adaptedness and natural harmony".[117] However, the harmony encountered in nature can often be explained by mere appeal to natural laws and does not necessitate an inference to divine design. For example, Kant notes that the various consequences of the atmosphere (consequences all useful to human beings) constitute a harmonious unity:

> […] the possibilities of the pump, respiration, the conversion of liquids, when present, into vapours, the winds, and so on, are inseparable from each other, for they all depend on a single ground, namely, the elasticity and pressure of the atmosphere. This harmony of the manifold in one is thus in no way contingent, and it is, therefore, not to be attributed to a moral ground. (AA 2: 101)

Kant argues that the multiplicity of wonderful consequences of the atmosphere (the possibility of respiration, pumps, etc.) can be explained in terms of a *single ground*. They are, that is, consequences of a single ground and thus constitute what Kant calls a *necessary unity*. Since the harmonious unity of these consequences is necessary and can be explained in terms of natural laws, Kant argues that we should not take this unity to be the product of divine design. In a similar fashion, Kant argues that gravity is the *single ground* of the spherical form of the earth, of the orbit of the moon, and of a host of other consequences.[118] All of these consequences thus constitute a *necessary unity* that can be explained *mechanically* in terms of the laws of physics.

The case is different for organisms. Organisms are characterized by laws or regularities that constitute a *contingent unity*. Kant applies the term 'contingent unity' to laws or regularities concerning consequences that (i) inhere in an individual being and (ii) do not have a common ground.[119] If some set of consequences satisfies both

[115] AA 5: 360.

[116] Ginsborg 2001.

[117] AA 2: 96–97.

[118] AA 2: 106–107.

[119] AA 2:106.

(i) and (ii), the unity of laws concerning these consequences is contingent. Kant takes (i) and (ii) to be satisfied with respect to the parts of organisms (and the parts of these parts, etc.):

> Human beings see, hear, smell, taste, and so on. But the properties which are the grounds of seeing are not the grounds of tasting as well. Man has to have other organs in order to hear, and likewise in order to taste. The union of such different faculties is contingent, and, because their union aims at perfection, their union is artificial in character. And then again, in the case of each organ individually, there is a unity which is artificial. In the eye, the part which permits light to enter is different from the part which refracts it, and the part which receives the image is, in turn, different from the other parts. (AA 2:106)

Thus, because the grounds that enable seeing are not identical to the grounds that enable tasting (and so forth), the faculties of seeing, tasting, etc., constitute a *contingent unity*. Likewise, different parts of the human eye have different grounds and thus constitute a contingent unity. Hence, we cannot give a unified mechanical explanation of the unity of organisms and organs. Moreover, in spite of the fact that, say, the parts of the eye are all distinct and have different grounds, these parts are harmoniously coordinated and constitute a purposive whole. This *purposive* unity resists mechanical explanation, Kant argues. In short, there is no single ground or law (or at least we do not know of any) that can explain the unity of the parts of organisms, or explain the unity of the laws or regularities that govern the functioning of the parts of organisms, while organisms are also characterized by an (inner) purposiveness that is mechanically inexplicable.

We can illustrate Kant's views on the contingent unity of (the properties of) organisms by reference to our discussion of Wolff's method of mechanical explanation in biology. Recall that Wolff also did not mechanically explain the purposiveness of organisms. In addition, when explaining some organic process α (such as growth), Wolff proceeded by analytically distinguishing a host of sub-processes α_1, α_2, etc. In an attempt to explain these sub-processes, he then appealed to a large number of physical regularities β_1, β_2, etc. In claiming that organisms constitute a contingent unity, and are hence mechanically inexplicable, Kant is highlighting both the fact that the parts of organisms are contingently related and the fact that we have no unified explanation of the fact that, in organisms, β_1, β_2 constitute a (purposive) unity.

3.8.2 Adaptation and Mechanical Explanation

In his *Beweisgrund*, Kant construes organisms and organs as purposive wholes that resist mechanical explanation. To say that organisms are purposive is to say, among other things, that the traits of organisms are adapted to some end. In his 1775 essay on race, Kant stresses that the traits of organisms are adaptive, i.e., that these traits are well adapted to the environment in which organisms live. According to Kant, the adaptedness of organisms' traits to their environment, i.e., their good *fit* with their environment, cannot be mechanically explained.

Kant's discussion of what we call adaptation occurs, as shown nicely by McLaughlin, in the course of his discussions of heredity and race.[120] In his essay Kant argues, adopting Buffon's rule that animals belong to the same species if they can produce fertile offspring, that all the different human races belong to one and the same natural species.[121] Races are characterized by invariable hereditary traits, such as skin color, which are taken to be adaptive, i.e., to be "suited to the difference of the climate and the soil."[122] Kant's aim in his essay on race is to give a (historical) account of how these traits have arisen. Throughout history, he thinks, different humans came to occupy different regions of the earth and became adapted to different environments. This process of becoming adapted to different environments resulted in the formation of different human races.

How did humans become adapted to different environments? Kant argues that so-called *germs* and *natural predispositions* constitute the ground for the coming to be of the adaptive traits of organisms. To illustrate the first notion, he notes that in birds of the same kind "there lie germs for the unfolding of a new layer of feathers if they live in a cold climate, which, however, are held back if they should reside in a temperate one".[123] If, for example, some of the (original stock) of these birds were transplanted from a hot climate to a cold one, the germs of these birds would be activated and cause the development of a new (thick) layer of feathers. If such an adaptive trait has arisen, it becomes a permanent and hereditable feature of organisms.[124] According to Kant, purposive provisions such as germs and natural predispositions explain the coming to be of the hereditary traits that characterize the different human races.

For our present purposes, it is important to note that Kant argues that the coming to be of adaptive traits, which he also calls *unfoldings*, cannot be explained in a purely mechanical way:

> Chance or the universal mechanical laws could not produce such agreements [*Zussamenpassungen*]. Therefore, we must consider such occasional unfoldings as *preformed*. […]. For outer things can well be occasioning causes but not producing ones of what is inherited necessarily and regenerates. As little as chance or physical-mechanical causes can produce an organic body, just as little will they add something to its generative power, i.e., bring about something that propagates itself. (AA 2: 435)

Physico-mechanical laws alone cannot explain the production of adaptive traits, such as the thick layer of feathers of some birds living in cold climates, because, as Kant argues, physico-mechanical causes (e.g., environmental causes such as heat) cannot have produced traits that are hereditary.[125] Kant takes the (invariable) hereditary and adaptive traits of organisms to be *good for* these organisms: they allow

[120] McLaughlin 2007.

[121] AA 2: 429.

[122] AA 2: 434.

[123] Ibid.

[124] AA 2: 441–442.

[125] AA 2: 435.

organisms to reproduce and maintain their species. Mechanical causes, he thinks, cannot be the primary cause of such traits, since it is in no way necessary that such blind causes should have effects that benefit the organism.

For Kant, therefore, the adaptedness of traits of organisms to their environment defies mechanical explanation. We can say that Kant thought that adaptation in general cannot be explained mechanically. Kant also defends this view in the third *Critique* of 1790. In this work, he does not extensively discuss the fit of organisms to their environment. Rather, he stresses that the parts of organisms are adapted to one another. In line with his earlier views he maintains that the fact that the parts of organisms are adapted to one another cannot be mechanically explained. We can thus conclude that Kant took two features of organisms to be mechanically inexplicable: the complex unity of organisms and the purposive nature of organisms and their parts.

3.9 Mechanism as Method

In this final section, we summarize the results we have obtained and relate these to Kant's discussion of mechanism in the Dialectic of Teleological Judgment of the third *Critique*. In the Dialectic, Kant argues that the principle of mechanism, according to which one should explain natural objects mechanically, is a *regulative maxim* (of reflective judgment) that guides scientific investigation. This maxim states that: "All generation of material things and their forms must be judged as possible in accordance with merely mechanical laws".[126] This maxim is necessary in the sense that, without following it, we cannot obtain proper scientific cognition of nature. Hence, we should also follow this maxim in the study of organisms. On the other hand, Kant construes the maxim as a (merely) regulative or subjective principle that does not determine the nature of organisms. On the basis of our preceding analysis, we can explain why Kant takes the principle of mechanism to be both *necessary* and *regulative*.

In our discussion of Wolff, we have shown that Wolff took (explanatory) demonstrations to proceed from the part (the more universal) to the whole (the more particular). The application of the part-whole scheme to demonstrations informs, as we have seen, Kant's construal of mechanical explanations. Mechanical explanations are explanatory demonstrations in which we proceed from the more universal principles of science to certain more particular consequences. The discursive understanding, Kant argues, directs us to *determine* the universal principles of natural science. As such, it directs us to explain nature mechanically.

This construal of mechanical explanation allows us to understand why Kant treats the principle of mechanism as specifying a *necessary maxim* of scientific explanation. The principle of mechanism directs us to ground the judgments of natural

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[126] AA 5: 387.

science in more fundamental (and ultimately a priori) judgments and thus to establish a *systematic unity* among the judgments of natural science. As such, the principle of mechanism is strongly related to the methodological ideal that proper sciences constitute a system based on a priori (metaphysical and mathematical) principles enabling us to provide explanatory demonstrations. In other words, by following the mechanistic maxim, i.e., by consistently determining or specifying the principles of natural science, we aim to reach the ideal of a systematic and unified science. Insofar as the principle of mechanism directs us to achieve these ideals of cognition, Kant takes this maxim to be necessary for scientific enquiry in general.

The above account of the principle of mechanism also allows us to understand why Kant takes it to be a *regulative maxim*. In the first *Critique*, the regulative maxims of reason are described as subjective principles drawn not from the object but rather from the interest of reason in the *perfection* of cognition.[127] One of the highest perfections of cognition is the systematicity of concepts and judgments.[128] The principle of mechanism is precisely such a regulative maxim: it is a methodological principle that directs us to obtain the perfection of systematic unity among our cognitions.

The principle of mechanism is also regulative, as Breitenbach has stressed, because it does not imply that *all* objects of nature *can* be mechanically explained.[129] Indeed, as we have seen, Kant argues that the contingent unity and the purposive nature of organisms *cannot* be mechanically explained. Rather, the principle of mechanism is a maxim that directs us to achieve a systematic and unified science. The ideal of a systematic and unified science is, however, a regulative ideal that according to Kant can never be actually reached. For this reason, Kant construes the principle of mechanism as regulative: it is a maxim that directs us to explain the whole of nature mechanically, although there may be objects that cannot be so explained.

To assign the principle of mechanism a regulative status is therefore not, as has sometimes been held, to deny that the principle of causality of the first *Critique* is constitutive. As many modern commentators have stressed, the principle of mechanism should be distinguished both from the principle of causality of the first *Critique* and from Kant's metaphysical principles of natural science.[130] Rather, the principle of mechanism is treated as a regulative maxim because it points towards an ideal systematic science in which the whole of nature is mechanically explained.

In conclusion, it is important to stress that Kant assigns the principle of mechanism a regulative status because he wants to strip the idea of mechanical explanation of ontological implications. In doing so, he rejects the position of his rationalist predecessors. Recall that Wolff took mechanical explanations to be an ideal of explanation partly because he took all objects of nature to be mechanisms. Here we

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[127] *KrV*, B 694.

[128] AA 9: 140.

[129] Breitenbach 2009, 109–131.

[130] This common view goes back to McLaughlin 1990.

have a traditional *ontological* justification for the idea that mechanical explanations are proper explanations in natural science: natural objects must be explained mechanically *because* they are machines.

In stark contrast to Wolff, Kant strips the idea of mechanical explanation of any ontological implications:

> […] if I say that I must **judge** the possibility of all events in material nature and hence all forms, as their products, in accordance with merely mechanical laws, I do not thereby say that they **are possible only in accordance with such laws** (to the exclusion of any other kind of causality); rather, that only indicates that I **should** always **reflect** on them **in accordance with the principle** of the mere mechanism of nature, and hence research the latter, so far as I can, because if it is not made the basis of research then there can be no proper cognition of nature. (AA 5: 387)

In other words, that we should explain natural objects mechanically does not imply that these objects are *mechanisms*, e.g., that they ontologically reduce to parts and forces. According to Kant, rather, it is *in accordance with the constitution of our understanding* that "a real whole of nature is to be regarded only as the effect of the concurrent moving forces of the parts".[131] This fact, concerning the nature of our understanding and not the apparently mechanical character of natural objects, is cited by Kant to explain why mechanical explanation is an ideal of explanation in natural science. However, the fact that mechanical explanations constitute ideal explanations of nature does not imply that natural objects ontologically reduce to mechanisms.

3.10 Conclusion

In the present chapter we have analyzed Kant's conception of mechanical explanation in light of the views on scientific and mechanical explanation articulated in the works of Christian Wolff. Mechanical explanations explain wholes in terms of their parts. We have analyzed the notion of mechanical explanation by investigating how Wolff and Kant applied the part-whole scheme in philosophy, logic, and natural science. This has allowed us to explain why Kant construed mechanical explanations as ideal explanations of nature, and why he takes the principle of mechanism to be a necessary maxim of scientific research.

In our discussion of Wolff, we have seen that, in logic, definitions are treated as explanations of wholes in terms of their parts and the mode of composition of these parts. The idea of explaining wholes in terms of their parts and mode of composition is linked to the idea of scientific explanation via the metaphysical concept 'essence'. If we have cognition of the parts of a thing and of their mode of composition, we comprehend its essence, which contains the ground of its attributes. In syllogistic demonstrations, we can derive a judgment predicating an attribute of some concept

[131] AA 5: 408.

and thus, according to Wolff, objectively *ground* this judgment on the basis of our cognition of the essential parts (*genus*, *differentia*) of a concept. In general, explanatory demonstrations (syllogisms), in which we proceed from (more general) premises to (more particular) consequences, can be treated as proceeding from part to whole. In natural science, we explain determinations of corporeal bodies by taking into account (i) their parts, (ii) the mode of composition of these parts, and (iii) (laws concerning) forces acting upon bodies and their parts. Explanations in terms of (i)–(iii) are *mechanical explanations*. In the parts of physics dealing with organisms, we can also develop a mechanical explanation of the features of organisms in terms of (i)–(iii). If we aim to specify the objective ground of features such as growth, nutrition, and propagation, we must try to explain these features in terms of (i)–(iii). Wolff denies, however, that the complex unity and purposive character of organisms can be explained mechanically.

Like Wolff, Kant applies the part-whole scheme to concepts and demonstrations. Mechanical explanations are explanatory demonstrations proceeding from (more general) principles to (more particular) consequences, i.e., from part to whole. When Kant claims that the *discursive understanding* proceeds from the part to the whole, and thus directs the understanding to explain nature mechanically, he has in mind the process of determining or specifying the synthetic principles of natural science. The principle of mechanisms directs us to continuously determine (specify) the (fundamental) principles of natural science and thus directs us to the ideal of a systematic and unified science, in which (more particular) regularities are subsumed under a priori principles.

This conception of mechanical explanation explains why Kant construes mechanical explanations as ideal explanations of nature, which must be provided in every science (including biology). Mechanical explanations are deductively valid demonstrations, proceeding from true premises, which explain why something is the case. Moreover, the attempt to provide mechanical explanations in natural science is an attempt to construct natural science as a *system* based on a priori principles. Kant's construal of mechanical explanations as ideal explanations of nature is thus a consequence of his conception of proper science discussed in the previous chapter. Like his predecessor Wolff, however, Kant argues that both the complex unity of organisms and their purposive nature (the adaptation of organisms and organs) resist mechanical explanation. Although it is a necessary methodological maxim to attempt to explain natural objects mechanically, we cannot be certain that every object of nature allows of mechanical explanation. Hence, the principle of mechanism is a *regulative maxim*.

Chapter 4
Kant on Teleology

As we have seen in the previous chapter, Kant treats mechanical explanations as explanatory demonstrations. Mechanical explanations demonstrate why something is the case on the basis of principles of natural science. A regulative maxim of mechanism continuously directs us to determine principles of natural science and thus, in turn, to establish a systematic and unified science. However, the purposive unity of organisms and the adaptedness of organisms and organs resist mechanical explanation. In line with these views, Kant also argues that questions concerning the ultimate origin of organisms defy scientific treatment.[1]

What, then, is the status of biology? As stated in the Introduction, some commentators take Kant's discussion of organic nature in the third *Critique* to imply that biology cannot be a science. If organisms cannot be explained mechanically, and if in natural science we must provide mechanical explanations, biology can never constitute a science.[2]

Other commentators, stressing the function that Kant assigns to teleology in biology, evaluate Kant's views on biology more positively. Zumbach argues, as we have noted, that according to Kant biology is an autonomous science having its own particular mode of teleological explanation.[3] Ginsborg and Quarfood have argued along similar lines, maintaining that teleology enables us to regard biological regularities as lawlike and that it allows for the unification of these regularities.[4] Teleology thus seems to have some kind of explanatory function, or at least a quasi-explanatory function.

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[1] On this last point, see Steigerwald 2006, 713–716.

[2] Zammito 2006, 2012; Richards 2000, 2002. It is important to emphasize that both Richards and Zammito criticize the interpretation of Kant's influence on the development of biology developed by Lenoir, the historian of science. See Lenoir 1989. There are thus two main points of criticism. First, Zammito and Richards challenge the coherence of Kant's philosophy. Second, in contrast to Lenoir, they deny that Kant had a substantial influence on the development of biology. I return to Lenoir's interpretation in the next chapter.

[3] Zumbach 1984, 92.

[4] Ginsborg 2001; Quarfood 2004, 2006.

H. van den Berg, *Kant on Proper Science: Biology in the Critical Philosophy and the* Opus postumum, Studies in German Idealism 15, DOI 10.1007/978-94-007-7140-6_4,

In the present chapter, I argue that Kant did not assign any genuine explanatory function to teleology.[5] For Kant, proper explanations in natural science are always mechanical explanations. In the previous chapter, we related the notion of mechanical explanation to the notion of grounding. Mechanical explanations specify *objective grounds* that allow us to demonstrate why something is the case. Natural scientists cannot, however, construe purposes as objective grounds. Accordingly, scientists cannot cite purposes to explain why something is the case.

Why did Kant adopt this view? He was led to do so because he modelled the concept of 'purpose' on intentional agency. In other words, Kant adopted an intentional concept of purpose.[6] That Kant adopts such a position is clear. He claims that to construe organisms as purposes is to conceive of them *as if* designed (or as if they are the product of reason).[7] The 'as if' clause indicates that we merely reflect on organisms as purposes. We do not claim that they actually are purposes. To make the latter claim, i.e., to treat the concept of a natural purpose as a constitutive concept of determinative judgment, is to introduce intentional causality in nature illegitimately.[8]

That Kant adopted this conception of purpose is generally recognized.[9] Commentators have argued, however, that Kant's appeal to intentionality in discussing organic purposiveness is unfortunate.[10] Moreover, Zammito and Richards have stressed that Kant's regulative conception of purposiveness is not easy to reconcile with the biological practice of his time, given the fact that many eighteenth-century biologists had no problem with affirming the objective reality of natural purposiveness.[11] Why, then, did Kant think of purposiveness in terms of intentionality and assign the concept of purpose a regulative role in scientific investigation?

In the present chapter, I will once again tackle this question from a historical perspective. I relate Kant's views on the concept of purpose to the views of his rationalist predecessors Wolff and Baumgarten (my focus will be on Baumgarten).[12] As we will see, these rationalists adopted an intentional concept of purpose. In particular, purposes are construed as *objects of intentions*. For Wolff and Baumgarten, natural objects are purposes insofar as they are objects of the intentions of God. Kant's views on the concept of purpose are, I argue, highly similar to the views of Wolff and Baumgarten. However, Kant could not, of course, construe natural objects as objects of the intentions of God. Accordingly, he assigned the concept of 'purpose' a merely regulative and thoroughly non-explanatory status.

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[5] In this respect, I am thus in full agreement with Zammito 2006.

[6] Toepfer 2004, 46–75.

[7] AA 5: 370. See also AA 5: 397–398.

[8] AA 5: 361.

[9] See, for example, Nagel 1977, 288–290; Guyer 2001, 264–266; Beiser 2006, 12–13; Zuckert 2007, 141–142; Breitenbach 2009, 66–70.

[10] See Toepfer 2004, 49–50, who thinks that Kant's introduction of intentionality in his account of (biological) purposiveness is an unfortunate illustration.

[11] Richards 2000, 19–20; Richards 2002; Zammito 2003.

[12] On Wolff's teleology, see my van den Berg (in press).

The chapter is structured as follows. In Sect. 4.1, I discuss some recent interpretations of Kant's concept of (natural) purpose. Section 4.2 provides an analysis of the use of teleological notions in the works of Baumgarten and Wolff. In Sect. 4.3, I relate the views on teleology expounded in Kant's lectures on metaphysics to the views of Baumgarten and Wolff. Section 4.4 analyzes Kant's views on teleology expounded in his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788) and the *Kritik der Urteilskraft* (1790). Section 4.5 summarizes Kant's reasons for maintaining that purposes cannot be genuinely explanatory in natural science. Finally, in Sect. 4.6 I briefly discuss Kant's critique of his rationalist predecessors.

4.1 Recent Interpretations of Kant's Biological Teleology

According to Kant, organisms must be understood in teleological terms. Organisms are *natural purposes*. The precise content of the concept 'natural purpose' will be discussed in the next chapter. In the present section, I discuss some contemporary interpretations of the role that Kant assigns to teleology in the scientific investigation of organism.

Why did Kant think that organisms must be understood in teleological terms? The most common explanation given by commentators is the following. Kant took organisms to be objects in which (i) the whole is determined by the parts, (ii) the parts are reciprocally dependent on each other, and (iii) the parts seem to be dependent on the whole. Thus, organisms exhibit various forms of reciprocal dependence. Kant takes these features of organisms to necessitate the introduction of teleology.[13] If we adopt a model of physical-mechanical causality to understand organisms, we can make sense of the idea that the parts of organisms determine the whole (i), but not of the idea that the whole determines the parts (iii). However, if we adopt a model of final causality, we can take the whole to be the purpose of the parts, and make sense of case (iii), i.e., of the idea that the whole determines the parts. I will further elaborate these ideas in the next chapter.

What role does teleology play in the investigation of organisms? Peter McLaughlin has argued that teleology serves a merely *descriptive* role. He emphasizes that "Kant replaces the apparent causal influence of the whole organism on the properties of its own parts with the (merely regulative) assumption of the causal influence of a representation of the whole on the production of the parts".[14] In short: Kant rejects holism. The whole is not an actual cause of the parts; this is impossible. Rather, we understand organisms as determined by a *representation* of the whole, which is to say that we construe organisms as being (as if) designed. The implication, according to McLaughlin, is that teleology is not explanatory but only "*phenomenally* or *descriptively satisfying*

[13] For this reading, see for example Guyer 2001; McLaughlin 1990, 2001; Steigerwald 2006.

[14] McLaughlin 2001, 178–179.

in the case of organisms".[15] We can adequately describe organisms in teleological terms, but nothing more. That teleology serves a descriptive function is accepted by all commentators on Kant. I see no reason whatsoever to deny that this is the case. The question is whether Kant assigns a more substantive role to teleology.

In contrast to McLaughlin, some commentators have assigned a more substantial role to teleology in Kant's philosophy of organic nature. As noted, Clark Zumbach takes Kant to assign to biology a particular mode of teleological explanation.[16] Hannah Ginsborg has stressed that Kant's concept of 'purpose' expresses *normative constraints*: if we assign a purpose to a natural object (e.g., an organism), we claim that there is something that it *ought* to be. According to Ginsborg, this enables Kant to explain that regularities displayed by organisms are *lawlike*. These regularities exhibit normative lawlikeness. Although biological regularities are mechanically inexplicable, i.e., contingent with respect to the laws of physics and chemistry, Kant can still argue that biological regularities are necessary by virtue of their having *teleological grounds*.[17] In Ginsborg's reading of Kant, then, teleology assumes a kind of explanatory role in biological science, although (as is the case for Zumbach) this notion of explanation must be distinguished from Kant's notion of explanation proper to physico-mechanical sciences.

Finally, recent commentators such as Quarfood and Breitenbach have argued that, for Kant, teleology serves a kind of *identificatory* function. Teleology enables the demarcation of the subject-matter of biology.[18] I will return to this reading, which goes back to the writings of Flach and Toepfer,[19] in the next chapter. In the present chapter, I am concerned with the question of whether, for Kant, it makes sense to assign any kind of explanatory role to teleology. I will argue that it does not. Kant's intentional construal of the concept of purpose makes it impossible to take teleology to be explanatory. Moreover, the fact that Kant takes the concept of 'purpose' to express normative constraints, as Ginsborg stresses, is precisely one of the reasons to *deny* teleology any explanatory function in natural science. To see this, it is helpful to reconstruct the historical context of Kant's teleological views.

4.2 Baumgarten and Wolff on Efficient Causes, Utility, and Final Causes

In §10 of the third *Critique*, Kant defines a purpose as the "object of a concept insofar as the latter is regarded as the cause of the former (the real ground of its possibility)".[20] He notes, however, that one can also call objects purposive if their

[15] McLaughlin 2001, 18–19.

[16] Zumbach 1984.

[17] Ginsborg 2001, 248–254.

[18] Quarfood 2006, 736; Breitenbach 2009, 119–123.

[19] Flach 1994; Toepfer 2004.

[20] AA 5:220.

"possibility can only be explained and conceived by us insofar as we assume as its ground a causality in accordance with ends, i.e., a will that has arranged it so in accordance with the representation of a certain rule."[21] This is the case for organisms. According to Kant, we conceive of organisms as purposes by analogy with human purposive action. This analogy is limited, however, and the idea of organisms as purposes serves a merely regulative function.[22]

The above definition of the concept of purpose shows that Kant adopts an intentional notion of purpose. We can trace this notion to the works of Wolff and Baumgarten. In the following, I will focus mainly on Baumgarten's construal of the notion of 'purpose'. According to Baumgarten, this notion can be predicated of an object only relative to some subject that conceptualizes the object as being *good* and employs some means to realize this good. In other words, purposes exist relative to (some) subject that has an intellect, will, and intentions.

In Baumgarten's *Metaphysica*, which Kant used as a textbook in his lectures on metaphysics,[23] the concept 'purpose' (*finis*) is discussed in section seven, chapter three of part I (*Ontologia*). This chapter deals with relative predicates of beings, i.e., with *relations*,[24] among which are included causal relations. Baumgarten takes a purpose to be a cause, and more specifically a final cause (*causa finalis*).[25] The concept of purpose is explicated in terms of the concepts of (i) 'cause', (ii) 'efficient cause', and (iii) 'utility'. In the following, I discuss how Baumgarten construes (i)–(iii). This allows us to understand his discussion of 'purpose' (iv). Since Baumgarten's discussion of (i)–(iv) is often quite similar to that of Wolff, I will refer to Wolff's writings in order to elucidate the views of Baumgarten.

(i) Baumgarten defines the concept 'cause' by means of the concepts 'ground' (*ratio*) and 'source' (*principium*).[26] A ground is construed as that on the basis of which it is possible to know *why* something is.[27] A source is that which contains the ground of something else, while that which is grounded in that source is called a *principiatum*.[28] Hence, if α is the source of β, α contains the ground on the basis of which it is possible to know why β is the case. Baumgarten

[21] Ibid.

[22] On this argument, see Guyer 2001, 264–267; Beiser 2002, 519–520; Steigerwald 2006, 716–727. Breitenbach 2009 contains a very detailed account of Kant's views on analogy.

[23] Kant lectured on the basis of the fourth edition of Baumgarten's *Metaphysica* (1757), printed in AA 15: 5–54 and AA 17: 5–226. I have consulted both the German translation by Meier of 1783 and the Latin fourth edition of the *Metaphysica*. In the references, when possible, I refer to both works.

[24] AA 17: 82.

[25] Baumgarten 1783, 99. AA 17: 100.

[26] I here follow Meier's German translation of *principium* as *Quelle*. In his notes to Baumgarten's *Metaphysica*, Kant also employs this translation. AA 17: 94. This translation may strike one as odd. However, it is probably meant to reflect the idea that in ontology the notion of a principle must be applied to *substances*.

[27] Baumgarten 1783, 6. AA 17: 27–28.

[28] Baumgarten 1783, 88. AA 17: 94.

further distinguishes between the source of the possibility of a thing (*principium essendi*), the source of the existence of a thing (*principium existentiae*), and the source of the coming to be of a thing (*principium fiendi*).[29] A *cause* is that which is the source of the existence (*principium existentiae*) or coming to be (*principium fiendi*) of a thing.

In his *Deutsche Metaphysik* (1751), Wolff provides the following example in order to elucidate the distinction between ground and cause: if we find that the increased speed of the growth of plants is due to the heat of the air, then we call the heat the *ground* of the increased speed of growth, whereas the air is the *cause* of the latter.[30] In Baumgarten's terminology: the air is the source of the reality, or of the coming to be, of the increased speed of the growth of plants.

The concept of 'cause' (*causa*) is juxtaposed to the concept of "that which is caused" (*causatum*). The connection between *causa* and *causatum* is called the *nexus causalis*.[31] The term 'connection' (*nexus*) denotes a relation between *things*.[32] The notion of a 'thing' refers to possible objects.[33] Hence, a connection can obtain between possible objects (whether actual or not),[34] though a *nexus causalis* obtains only between actual objects. This follows from Baumgarten's construal of *causa* as the source of reality or existence and *causatum* as that whose reality is grounded in a cause. Hence, to affirm the existence of a connection between *causa* and *causatum* (a *nexus causalis*) is to affirm the existence of a causal relation between actual objects.

(ii) Baumgarten's concept of 'efficient cause' builds on his account of 'cause'. An efficient cause (*causa efficiens*) is the cause of some reality by means of an act.[35] The term 'act' is technical. It denotes a change of state of a substance by means of a force.[36] A force, in turn, is defined as the ground of the actuality of accidents of substances.[37] Baumgarten notes that, properly speaking, efficient causes are substances. Hence, when a substance contains a force that is the ground of the actuality of accidents (whether accidents of the substance itself or of another substance), this substance is itself the efficient cause of these accidents. As in his discussion of *causa* and *causatum*, Baumgarten affirms the existence of a connection between efficient causes and effects, i.e., a *nexus effectivus*.[38] This *nexus* can be interpreted as a relation between substances and accidents.

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[29] AA 17: 94–95.

[30] Wolff [1751] 2003, 15–16.

[31] Baumgarten 1783, 90. AA 17: 95.

[32] Baumgarten 1783, 6. AA 17:27. Wolff [1751] 2003, 332.

[33] Baumgarten 1783, 3–4. AA 17: 24. Wolff [1751] 2003, 9.

[34] For Wolff, every actual object is possible but not every possible object is actual. Wolff [1751] 2003, 7–9.

[35] Baumgarten 1783, 92. AA 17: 96–97.

[36] Baumgarten 1783, 58. AA 17: 70.

[37] Baumgarten 1783, 55. AA 17: 68.

[38] Baumgarten 1783, 92. AA 17: 99.

Baumgarten's concept of efficient cause is rather abstract. We can illustrate it by considering Wolff's concept of an efficient cause, which is similar to Baumgarten's. Wolff defines an efficient cause as that which, by its act, generates the actual or real from the possible, and defines 'effect' as that which "arrives at its actuality" (comes to be) by means of an act.[39] For example: if the sun melts wax, this occurs by means of the sun's heat. In this example, the sun's heat is the sun's *act*, the melting of the wax is the *effect*, and the sun itself is the *efficient cause*.[40]

(iii) After discussing the notion 'efficient cause', Baumgarten turns to a discussion of "usefulness". He construes that which is useful (*utile*) as "that which is good for something else", that which is not useful (*inutile*) as "that which is not good for something else", and that which is harmful (*noxium*) as "that which is bad for something else".[41] He further takes 'usefulness' (*utilitatis*) to be a determination of a thing insofar as this thing is considered in relation to other things. This is simply to say that usefulness is a relation: x is *useful* for y. To say that x is useful for y is to say that x is *good for* y. The connection between an object x that is useful for y can be termed the *nexus utilitatis*.[42]

Remember that Baumgarten discusses the notion of 'usefulness' (*utilitatis*) in a chapter that deals with different types of causes and causal relations. However, it seems that the relation of usefulness is not a causal relation. Some object x may be useful for y without being the cause of y. Nevertheless, Baumgarten argues that when some subject recognizes the usefulness of x for y and puts it to use, x is causally efficacious in bringing about y. As Baumgarten puts this: The usefulness of something is made actual when we *employ* the thing for some use: employment is the actualisation of usefulness (*Usus est utilitatis actuatio*).[43] Through this employment, that which is useful functions as a cause.

Baumgarten thus seems committed to the following two claims: (a) that usefulness is a relation between objects, and (b) that the employment of that which is useful renders that which is useful a cause. Hence, it is proper to relate the notion of 'usefulness' to the idea of causation only relative to some subject that can *recognize* and *employ* the usefulness of an object. The usefulness

[39] Wolff [1751] 2003, 62–63.

[40] I have slightly simplified matters in my presentation of Baumgarten. Baumgarten adopts two concepts of action or act: (i) influx or influence (*actio transiens*), i.e., the action of one substance on another; (ii) all other types of action called *actio immanens*. The notion of action figuring in Wolff's example of the sun melting wax is *actio transiens*. Baumgarten places heavy emphasis on the notion *actio immanens*. He defines the notion of 'act' as a change of state of a substance by means of its own force. Here we can think of a substance that, by its own force, makes one of its own possible accidents actual, i.e., activates one of its dispositions. In this context, Wolff provides the example of someone who is seated and who exerts a force in order to stand up. Wolff [1751] 2003, 61–62.

[41] Baumgarten 1783, 97–98. AA 17: 99–100.

[42] Ibid.

[43] Baumgarten 1783, 98–99. AA 17: 100.

of x for y plays a causal role in bringing about y only if some subject recognizes the usefulness of x for y and employs x to bring about y. Consider, for example, a baseball bat. Baseball bats are (by their nature) useful for many things. They can be used in order to hit balls, for protection, for robbing banks or for starting a campfire (if wooden). However, it is only when some subject recognizes, for example, that a baseball bat can be used to hit a ball and then *uses* the bat to hit a ball that the bat is made to be causally efficacious in bringing about this effect.

(iv) The above considerations lead Baumgarten to a discussion of 'purpose'. Recall that to employ something is to actualize its usefulness. A branch of a tree is useful (good) for walking. We employ a branch if we actually use it as a walking stick. The concept 'purpose' is defined in terms of the notion of employment: if we employ something in order to realize something that *appears* to us as good, that which appears as good and which we try to realize is a *purpose*.[44] The *representation* of this purpose is called an intention (*intentio*).[45] In other words, *purposes are the objects of intentions*. Finally, those things by means of which we realize a purpose are called means.

The upshot of the above discussion is that, according to Baumgarten, an object is a purpose only relative to some subject that represents this object as good and tries to obtain this good by employing some means. Purposes (and means) exist only relative to subjects that have *intentions* and are able to act on them. If subjects that can act in accordance with their intentions do not exist, means and purposes do not exist. Returning to our example: a branch is useful for walking. It is also useful for a host of other things (building something, hitting something, etc.). However, we can take one of the things for which the branch is useful, such as walking, to be good for us and employ the branch to achieve this good, i.e., try to achieve our intention of walking. If this is the case, walking is the purpose (*Zweck*) of the branch and the branch itself is a means to realize this purpose.

Baumgarten calls the connection between means and purposes the *nexus finalis*.[46] He also takes a purpose (something that appears as good) to be a cause (*causa finalis*) *if* the purpose is a source of the employment of means.[47] This idea can be illustrated by referring to Wolff's construal of the concept of purpose or final cause in his *Philosophia prima sive ontologia*. Wolff defines a cause as something upon which the existence of another being depends.[48] For example, if an architect conceives of the form of a building, provides an outline of its form, and performs other

[44] Baumgarten 1783, 99. AA 17: 100.

[45] This definition of *intention* is somewhat different from the definition given by Christian Wolff. Wolff takes an intention to be something that we try to obtain by our will. Wolff [1751] 2003, 563. In the first paragraph of the *Vernüfftige Gedancken von den Absichten der natürlichen Dinge*, he defines an intention as that which a *rational and free being* tries to obtain by means of its will or desire. As such, he is able to interpret natural objects as divine intentions. Wolff [1726] 1980, 1–2.

[46] Baumgarten 1783, 100. AA 17: 101.

[47] Baumgarten 1783, 99. AA 17: 100.

[48] Wolff [1736] 2001, 652–653.

acts leading to the construction of a building, the existence of the building depends on the architect and the architect is an efficient cause of the building. A final cause or purpose is that for the sake of which an efficient cause acts.[49] If the architect acts for the sake of money, for example, money is the final cause of her actions and thus can be taken to explain why the architect acts as she does. Using Baumgarten's terminology, money is a source for the employment of (certain) means.

Note, finally, that purposes are *objects*, i.e., final *causes*, and that purposes or final causes are the *effects* of efficient causes.[50] Insofar as a cause (in general) is something on which the existence of a being depends, we can say that the existence of an efficient cause depends upon its final cause. Conversely, insofar as a final cause is an effect of its efficient cause, the existence of the final causes depends upon its efficient cause. Efficient cause and final cause are *causes of each other*, and the idea of reciprocal causation is thus central to the conception of final causation that we find in Wolff and Baumgarten. Thus, for example, if a fertilized ovum (A) is the final cause of a sperm cell (B), (B) exists because of (A) and vice versa. This manner of speaking is legitimate, however, only insofar as we construe (A) as a final cause or purpose relative to the intentions of an intellect (God of course). In other words, we can say that (B) exists because of (A) because God intended for the ovum to be fertilized and created sperm cells for this purpose. In this manner, i.e., by appeal to God's intentions, we can reduce apparent backwards causation to simple efficient causation.

It is clear that for both Wolff and Baumgarten the concept of 'purpose' is modeled on the idea of intentional agency. In his *Metaphysica*, Baumgarten sometimes models the idea of 'purpose' on *human* intentional agency. Wolff, however, always happily refers to God's intentions when construing objects as purposes. For Wolff, natural objects are purposes because they are objects of the intentions of God. As he maintains in his metaphysics, every effect of the essence or nature of things is intended by God.[51] Since Wolff takes the latter claim to be a demonstrable truth of metaphysics, he also allows for teleological explanations in natural science. Since we *know* that every effect of an efficient cause was intended by God and that God created the efficient cause in order to achieve the object of his intention, we can refer to the effect in order to explain why the efficient cause exists.

This sketch of Baumgarten's and Wolff's concepts of 'purpose' provides a background on the basis of which we can try to comprehend Kant's concepts of purpose and of natural purposes. It allows us to understand why, according to Kant, the concept of purpose can only be problematically (regulatively) ascribed to nature and why teleological explanations are impossible in natural science. For Wolff and Baumgarten, purposes are *objects of intentions*. Thus, money may be the purpose (object of intention) of an architect who designs a house. If this is the case, we can refer to this purpose to explain why the architect designs the house. What we are doing in such a case, of course, is to explain the actions of the architect in terms of

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[49] Wolff [1736] 2001, 678–679.

[50] Wolff [1736] 2001, 679.

[51] Wolff [1751] 2003, 633–634.

her *intentions*. However, if a purpose is the object of an intention, a *natural object* is a purpose only if it is the object of the intention of some subject. This idea leads, as we have seen, to the idea that natural objects are objects of the intentions of God.

Kant allows for explanations of artifacts in terms of intentions. In the third *Critique*, he explains the notion of a *nexus finalis* (in a manner similar to Wolff) by means of the example of the building of a house.[52] The *representation* of the money that can be obtained by letting a house, he notes, can be the cause of the construction of the house. Hence, our representation of a certain effect (a purpose) guides our actions in constructing a house, and the purpose may partly explain *why* we build a house. However, according to Kant, this type of reasoning can be applied to nature only problematically. For example, we have no sufficient grounds to think that plants have representations that guide their action, i.e., that they have purposes. Neither do we have sufficient theoretical grounds to argue that a divine intellect constructed plants so as to enable them to realize certain purposes (i.e., we cannot assert that certain organic traits, e.g. self-maintenance, are purposes relative to a divine intellect). One of the core arguments of the first *Critique*, after all, is that we cannot know God's existence or his intentions. Hence, according to Kant, an ascription of purposes to plants is a problematic (regulative) ascription based on an *analogy* between certain organic processes or phenomena and *human* purposive actions.

This interpretation is only correct, of course, if Kant, like his rationalist predecessors, models the notion of 'purpose' on intentional agency. In the following sections, I show that this is indeed the case. According to Kant, the notion of 'purpose' must be related to the idea of a subject endowed with an intellect, will, and intentions. It is for this reason that the notion of 'purpose', when applied to nature, is not a constitutive concept of determining judgment, i.e., a concept that expresses an objective property of the objects of nature, and thus cannot properly play a role in natural scientific explanations.

4.3 Kant on Purpose, *Nexus Effectivus*, and *Nexus Finalis*: The Lectures on Metaphysics

In order to determine the affinity between Kant's views on purpose and those of Baumgarten and Wolff, we may first consider Kant's lectures on metaphysics. These are based on Baumgarten's *Metaphysica*. Most of the student transcripts of these lectures contain a section on ontology with subsections devoted to the concepts 'cause' and 'effect'.[53] In these subsections the distinction between the *nexus effectivus* and the *nexus finalis* is also discussed. The lectures on metaphysics suggest that Kant, like his rationalist predecessors, holds that purposes exist only relative to some intellect. In addition, purposes are denied any explanatory role in natural science.

[52] AA 5: 372–373.

[53] AA 28: 522–524.

In the *Metaphysik von Schön* (1785–1790) it is claimed that the *nexus finalis* is not properly a subject of ontology. The reason given is that the *nexus finalis* involves a relation obtaining between a representation of a thing and the thing itself, insofar as the former is the cause of the latter.[54] This claim is presented as a criticism of Baumgarten, who discusses the *nexus finalis* within ontology. However, Kant's claims regarding the *nexus finalis* explicate a line of argument contained in Baumgarten's *Metaphysica*. Baumgarten construed a purpose as something we *represent* as good and try to obtain by employing some means. In the account of the *nexus finalis* in the *Metaphysik von Schön*, it is similarly emphasized that our *representation* of an object plays a causal role in the coming to be of this object. The relation between pack animals (*Lastthiere*) and the nutrition and clothing of humans is presented as an instance of the *nexus finalis*.[55] This example makes perfect sense on Baumgarten's reading of the *nexus finalis*. The relationship between animals and our nutrition and clothing is a means-end relationship, because we represent nutrition and clothing as a good and employ live stock to achieve this good. Hence Kant, like Baumgarten, seems committed to the view that the *nexus finalis* is a relation attributed to objects relative to our conceptualization and employment of them.

The lectures on metaphysics also contain passages in which the idea that purposes are explanatory is rejected. In the *Metaphysik L2* (1790–1791), it is argued that the proper method of philosophy consists in the specification of the *nexus effectivus*.[56] In science, we aim to explain how something comes about, which requires cognition of the relation between efficient causes and effects. In contrast, a mere appeal to the *nexus finalis* provides no objective explanations of how something comes about.

The *nexus effectivus* is described as a connection of causes and effects through which one can know *how* some event occurs.[57] For example, confronted with the question 'why does a wound heal in the body?', the specification of efficient causes will provide cognition that explains how wounds heal. By specifying efficient causes, we can explain how the process of healing in animal bodies *works*. This is not the case if we specify a final cause. For example, we might answer the above question by stating that wounds heal because this is so "arranged by providence (*Vorsicht*)".[58] This answer appeals to the *nexus finalis*, and provides no insight into how natural processes (such as regeneration or healing) work. True philosophy, for this reason, consists in understanding the *nexus effectivus*.[59] In philosophical research the appeal to the *nexus finalis*, if one thereby presumes to bypass the search for true (efficient) causes, is characterized as a *cushion of lazy philosophy*.[60] The treatment of the notions of '*nexus effectivus*' and '*nexus finalis*'

[54] AA 28: 524.

[55] Ibid.

[56] AA 28: 573–575.

[57] AA 28: 574.

[58] Ibid.

[59] Ibid.

[60] Ibid.

in the lectures on metaphysics thus strongly suggests that Kant conceives of proper scientific method as consisting of the search for and specification of efficient causes for natural phenomena.[61]

The accounts of the notion of 'purpose' contained in the student transcripts of Kant's metaphysics lectures are also contained in various of his published writings. In his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant associates proper scientific method with the specification of efficient causes, while also maintaining that purposes exist relative to cognitive subjects. In the *Kritik der Urteilskraft*, we find a similar construal of the notion of 'purpose'. Let us now turn to these writings.

4.4 Kant on Purpose, *Nexus Effectivus*, and *Nexus Finalis*: *Über den Gebrauch teleologischer Principien in der Philosophie* and the *Kritik der Urteilskraft*

Kant's essay on teleological principles was published in 1788 in *Der Teutsche Merkur*[62] as a response to criticism from Georg Forster. In the same magazine, Forster had published a critique of Kant's theory of race, objecting that Kant allows for metaphysical speculations in natural science.[63] Kant replied by defending himself against the charge that he introduces foreign elements in natural science.

In his essay, Kant stresses that he adheres to the principle that everything in natural science must be explained naturally.[64] In the opening passages, he juxtaposes the 'theoretical' and the 'teleological' methods for the investigation of nature.[65] Kant claims that one should follow the theoretical method when investigating nature, but that an employment of the teleological method is justified in cases where the theoretical method does not suffice. Nevertheless, the teleological method cannot be taken to solve any of the deficiencies of the theoretical method and provides us with no insight into efficient causes.[66] Kant associates the search for efficient causes with what he calls the theoretical method, which provides natural *explanations*. Hence, although Kant stresses that natural science does involve the study of natural purposes and incorporates teleological principles, he understands natural science (in line with the lectures on metaphysics) as an enterprise primarily concerned with gaining insight into the efficient causes of natural phenomena.

[61] Note that the example of the healing of a wound is an example of organic *regeneration*. The lectures on metaphysics suggest that we must explain this organic process mechanically.

[62] It is reprinted in the *Akadamie-Ausgabe*, AA 8: 157–84.

[63] Forster 1786a, b. On the historical context of this debate, see Zammito 1992, 199–213.

[64] AA 8: 178.

[65] AA 8: 159.

[66] Ibid.

In the final sections of his essay, Kant rejects attempts to invoke fundamental forces of matter independently of experience to explain the possibility of organized beings (organisms). He presents an argument against *hylozoism*, the view that unorganized matter can organize *itself*.[67] This argument is preceded by noting that the possibility of organized beings cannot be understood physico-mechanically and requires teleology.[68] Here, then, we have a case where the theoretical method does not suffice and where we can legitimately appeal to the teleological method. By examining this argument, we can elucidate Kant's concept of 'purpose'.

Against hylozoism, Kant argues that the necessity of understanding organisms teleologically implies that if one assumes a fundamental force as a cause of organization, the efficacy of this force must be understood in relation to some purpose, i.e., a purpose "must be assumed as the basis for the very possibility of its efficacy".[69] Thus, a force construed as a cause of organization must have this particular organization as its goal (e.g., a force causing embryological development must have a mature organism as its goal). However, Kant argues that we only know these types of forces *from ourselves*, e.g., by virtue of our familiarity with our own faculties of *will* and *understanding*. The 'will' is a force or capacity that, if determined by an *idea* of the understanding, produces "something in accordance with an idea, which is called purpose."[70] We experience such forces in ourselves when we are aware of our own *goal-directed action*, e.g., when we produce artifacts. Kant criticizes hylozoism since it posits the existence of forces effecting organization *without* these forces being guided by some idea. We have absolutely no empirical support for assuming the existence of such forces, and hylozoism is thus to be rejected.[71]

Kant thus construes a purpose as an object brought about by a will that is determined by an idea of that object. This view is highly similar to the account of 'purpose' we have encountered in Baumgarten. In the *Kritik der Urteilskraft*, Kant defines a purpose as "the object of a concept insofar as the latter is regarded as the cause of the former.[72] Given this view, it is no surprise that Kant concludes his argument against hylozoism by noting that "purposes have a direct relation to reason.[73] As noted in our discussion of Baumgarten and Wolff, *purposes exist only relative to some intellect*.

Kant's argument against hylozoism also shows that it is *human* purposive activity, i.e., our own activity in accordance with our ideas, which provides the model of

[67] For a thorough discussion of Kant's critique of hylozoism (with Johann Herder as its main proponent), see once again Zammito 1992, 178–213; Zammito 2003, 80–98.

[68] AA 8: 179.

[69] AA 8: 181.

[70] Ibid.

[71] See in particular AA 8: 179, where Kant speaks of "*selbst erdachten Kräften der Materie*" and AA 8: 181, where the concept of a force of beings to organize themselves without any determining purpose or intention is described as "*völlig erdichtet und leer*". Cf. Zammito 1992, 210–213.

[72] AA 5: 220.

[73] AA 8: 182.

purposiveness attributed to natural objects such as organisms.[74] In the third *Critique*, he explains that this model allows us to conceive of a series of causes and effects in accordance with the *nexus finalis*, so that a thing that is called the effect of some other thing can also be called the cause of that other thing.[75] Here, Kant introduces the idea of reciprocal (and backwards) causation between objects, a topic that, as we have seen, was also discussed by Wolff in his treatment of final causes. A causes a future effect B, while conversely that future effect B causes A. Thus, to cite Kant's example, the house (A) is the cause of the sums taken in as rent (B), while conversely the sums (B) are the (final) cause of the house (A). How can we make sense of this troublesome idea of backward causation, i.e., causation in which a future effect determines its cause?

We can say, as Wolff did, that in construing B as the (final) cause of A we are simply appealing, if perhaps implicitly, to the intentions and desires of some agent that guide his or her actions.[76] In this way, we can neutralize the danger of backwards causality. Kant adopts the same perspective.[77] B is not the *real* cause of A. Rather, we construe B as a final cause of A because, say, an architect has the *intention* and *desire* to build and rent out a house. These *representations* determine the architect's decision to build the house, or in Kant's terms, these representations determine the will and are thus (partially) the cause of the building of the house. In short: the sums (B) are, as Baumgarten would put it, represented as good, and it is this representation (not the actual sums) that is the real ground for bringing about (A). There is no backwards causality, then, but only one-directional (efficient) causality. In line with this view, Kant construes the *nexus effectivus* as a connection of *real causes* while construing the *nexus finalis* as a connection of *ideal causes*.

To apply this mode of reasoning to nature, we can take refuge in the intentions of God. This is what Wolff did. For Wolff, as we saw, every effect of the essence or nature of things is a purpose (final cause) because it is an object of God's intentions. God intended that these effects should come about and created natural objects in such a manner as to ensure they would. Wolff, therefore, could argue that, for example, the purpose (final cause) of the wings of (certain) birds is flight because God intended these birds to fly (and consequently endowed them with wings). Kant cannot accept this line of thought. Nevertheless, as we have seen, he does model the notion of 'purpose' on intentional agency. He thus argues that we construe organisms as natural purposes and assign functions to nature by a mere analogy with *human* purposive action, i.e., action in accordance with representations.[78] It follows, however, that purposes cannot be in any sense genuinely explanatory.

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[74] This is stressed by Beiser 2006, 12–13.

[75] AA 5: 372–373.

[76] See, for example, Rosenberg and McShea 2008, 12–16.

[77] AA 5: 372–373. This is also stressed by Zuckert 2007, 141–142. See also McFarland 1970, 102–106.

[78] AA 5: 360. See also AA 5: 366.

In conclusion: Kant, like his rationalist predecessors, took purposes and connections between means and purpose to exist relative to some subject with intellect and intentions. This circumstance allows us to understand why Kant construed the concept of 'natural purpose' as a regulative concept of reflective judgment. Because objects are purposes only relative to some intellect, we construe organisms as natural purposes by *analogy* with human purposive action. Kant forcefully articulates this position throughout the whole of the third *Critique*, arguing that we judge nature as purposive only "in a subjective relation to our faculty of knowledge and not in an objective relation to the objects."[79] It is this view that crucially undergirds Kant's claim that the concepts of 'purpose' or 'purposiveness' are *regulative* as opposed to *constitutive*, and thus have no explanatory function. It follows that teleological explanations cannot be explanatory. Proper explanations are always mechanical.

4.5 Purposes and Explanation

I have argued that Kant does not assign an explanatory role to teleology in natural science. This follows simply from the fact that Kant has a rather strict conception of scientific (or *mechanical*) explanation. In both his lectures on metaphysics and his published writings, Kant associates proper scientific method with the search for efficient causes. This is because proper explanations in natural science consist in the specification of objective grounds of certain effects. Since teleological notions do not specify the objective properties or relations of natural objects (or, since we cannot know whether they do), they can serve no explanatory function in natural science. In addition, teleology does not provide insight into how organic processes *work*. For these reasons, the concept of a purpose has no explanatory function (purposes are not real grounds, but only ideal grounds).

As I have indicated, a different interpretation has been proposed by Hannah Ginsborg.[80] In the First Introduction to the *Kritik der Urteilskraft*, Kant describes the concept of 'purpose' as a concept expressing a normative claim (see below). Ginsborg argues that Kant takes the concept of purpose to express normative constraints *in order to* explain that regularities displayed by organisms are lawlike, i.e., that these regularities exhibit normative lawlikeness. The fact that the concept of 'purpose' expresses an 'ought' allows us to regard contingent biological regularities, i.e., regularities that hold independently of the laws of physics or chemistry, as necessary.

In contrast to Ginsborg, I take the claim that purposes express normative constraints to show that Kant thinks that purposes exist relative to subjects endowed with intellect and are thus fully *non-explanatory* in natural science. Let us consider some relevant passages that support this claim. Kant claims that in a teleological

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[79] AA 20: 200–201.

[80] Ginsborg 2001. For a partial endorsement of Ginsborg's position, see Quarfood 2006.

judgment, i.e., a judgment concerning the purposiveness of things in *nature* (natural purposes or organisms),[81] one makes the following comparison:

> A teleological judgment compares the concept of a product of nature as it is with one of what it **ought to be.** Here the judging of its possibility is grounded in a concept (of the end) that precedes it *a priori*. There is no difficulty in representing the possibility of products of art in such a way. But to think of a product of nature that there is something that it **ought to be** and then to judge whether it really is so already presupposes a principle that could not be drawn from experience (which teaches only what things are). (AA 20: 240)

Hence, to construe a natural object as purposive is to make the normative claim, as Ginsborg correctly notes, that there is some way the object ought to be.[82] Kant elucidates the claim that teleological judgments compare a natural object 'as it is' with 'what it ought to be' by noting that, in construing an eye as purposive, for example, we judge that it *ought* to be suitable for seeing. If we encounter an eye that is not suitable for seeing, we take it to be defective. According to Kant the claim that the eye ought to be suitable for seeing is (at least partly) based on an *a priori* principle. This is the case because a judgment that specifies what a natural object *ought to be* is not derived from our experience of nature. Nature tells us only what things are.

However, it is precisely because purposes express normative constraints that Kant takes such concepts to be employed regulatively. Thus, following the above remark, he claims that all judgments concerning the purposiveness of nature are "merely reflecting and not determining judgments",[83] i.e., are *subjective* judgments for our reflection on an object and do not determine anything with regard to the constitution of the object. That the concept of a purpose expresses an 'ought' allows us to understand why this is the case. The normative standards that we assign to natural objects in construing them as purposes are not intrinsic to these objects. Rather, these standards are entertained by subjects with intellect (e.g., anatomists, artisans, etc.) who ascribe these standards to natural objects.[84] This is one reason for denying that the concept of purpose is a constitutive concept.

We can fruitfully compare this position to the views of Baumgarten. According to Baumgarten, a 'purpose' is something that appears as good. Hence, what is good is specified relative to some cognitive subject. An object is a purpose relative to a subject that assigns a value to this object. For someone like Wolff, this concept of 'purpose' is wholly unproblematic. We can objectively treat organisms (and indeed all natural objects) as purposes (and as good) simply because God created them. Indeed, in his writings on physiology, Wolff analyzes propositions expressing purposes or functions as normative claims.[85] To say, for example, that the purpose of the roots of plants is to absorb water is to say that roots ought to absorb water, as God

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[81] Cf. AA 20: 232.

[82] Ginsborg 2001, 248–54.

[83] AA 20: 241.

[84] For a similar account of the ontological status of functions, see Searle 1995, 13–23.

[85] Wolff [1725] 1980.

created them for that purpose. For Kant, however, the implication of the view that purposes express norms is that they are regulative concepts of reflective judgment.

The foregoing shows why it is problematic to interpret Kant as assigning any explanatory role to purposes in the biological sciences. In the previous chapters, we have interpreted Kant's views on proper scientific explanation in terms of the notion of grounding: a proper explanation must specify the objective grounds of consequences. It is clear that purposes do not constitute objective grounds or causes. Rather they are ascribed to natural objects subjectively and thus function as merely subjective *grounds of cognition*.[86] Kant sometimes expresses this by claiming that the concept of purpose leads us outside of the concept of *nature*. Thus, the purposive unitary structure of a bird is comprehensible, Kant claims, only by appealing to a ground (a purpose) lying outside the concept of nature.[87] The conception of purpose as expressing an 'ought' allows us to understand why this is the case and shows that Kant simply could not ascribe a genuine explanatory function to purposes.

It is important to note, in concluding this section, that a similar criticism applies to those interpreters that take teleology to have a (quasi-)explanatory function because they allow for the *unification* of organisms and biological regularities.[88] It is true that Kant thought that we can comprehend, e.g., the contingent unity of the construction of a bird, i.e., the hollowness of its bones, the position of its wings, and the position of its tail,[89] if we understand the manifold parts of the bird as serving the purpose of flight. Such a unification amounts to an explanation, however, only if we specify objective grounds that explain why certain parts constitute a unity. In Chap. 3, we saw that Kant took gravity to explain the necessary unity of manifold consequences (the orbits of the heavenly bodies, the form of the earth, etc.). In this example, we actually *explain* the unity of a manifold by citing an *objective ground*. This is not the case, however, if we cite purposes, which are subjective grounds that allow us only to describe and comprehend the manifold parts of organisms as a unity.

4.6 Kant's Critique of the Rationalists

Up to this point, I have stressed the similarities between Kant's treatment of 'purpose' and the manner in which his rationalist predecessors employed this term. Here in the final section of this chapter, I wish to consider Kant's critique of those same predecessors. This will provide further insight into Kant's views on teleology. In the following, I show that Kant's denial that the concept of a (natural) purpose is a constitutive concept of determining judgment can be understood as a critique of Wolff's use of teleological notions in science. I will further

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[86] AA 5: 373.

[87] AA 5: 360.

[88] Zumbach 1984; Quarfood 2006; Zuckert 2007, 108–119.

[89] AA 5: 360.

show how Kant's distinction between usefulness and purposiveness implies a critique of traditional rationalist teleology.

In the third chapter, we discussed Wolff's analytic and mechanical method for explaining organic phenomena as presented in his writings on physics. Wolff also allowed for the teleological investigation of nature. His *Deutsche Teleologie* is relatively well known (though often subject to ridicule). Wolff takes teleology to be a sort of experimental theology, which uses the propositions of *physics* to gain insight into the nature and intentions of God.[90] Wolff has also written on *physiology*, however. The goal of his physiology is to determine the purpose of organisms and their parts.[91] In modern terminology, Wolff investigates how we can specify the function of organisms and their organs. According to Wolff, we can *deductively* demonstrate the purposes of organisms and organs on the basis of observational claims established in physics and on the basis of propositions of metaphysics (ontology) and rational theology. Here is a rough example of what such a demonstration looks like (the example is mine).

(1) The essence of composite objects consists in the mode of composition of their parts (definition of ontology).
(2) The essence of bodies is created by God as a means for achieving his intentions (proposition of theology).
(3) The essence (mode of composition) of the wings of (certain) birds enables flight (empirical proposition of physics)
(4) Hence, God created the wings of these birds in order to enable flight.

The above demonstration is, of course, highly problematic. The important point, however, is that we infer the function of wings (which boils down to inferring the intentions of God) on the basis of propositions drawn from metaphysics and theology. This is what Wolff constantly does in his physiology.[92] The upshot of this way of thinking is that we can only attribute purposes (functions) to organisms if we accept the existence of God and accept that metaphysics (i.e., ontology) and (rational) theology are sciences that provide us with true propositions. The above demonstration provides a nice example of the *subordination* of physics to theology and ontology. Only if we accept this view of the hierarchy of science, Wolff thinks, can we infer the function of organisms and organs by investigating their structure.

In the third *Critique*, Kant rejects just this type of inference. In §68, he argues that teleology should provide principles that are internal to natural science. Teleological propositions should not be *external*, i.e., should not belong to another science.[93] Yet in the case of the demonstration cited above, they do: it is by appealing to propositions (1)–(2), propositions external to physics, that we

[90] Wolff [1726] 1980. On Wolff's teleology, see Euler 2008; McLaughlin 2001, 22. On the hierarchy of sciences, see: Blackwell 1961 and Hettche 2008. See also van den Berg (in press).

[91] Wolff [1725] 1980. For details on Wolff's physiology, see van den Berg (in press).

[92] See, for example, Wolff [1725] 1980, 1–2.

[93] AA 5: 381.

can know the purposes of organisms and organs. Yet to do this, Kant argues, is to confuse theology with physics.

Note that the demonstration above illustrates what it means to take the concept of a 'natural purpose' as a constitutive concept of *determining* judgment. The process of determination, as we saw in the previous chapter, involves the derivation of more specific consequences from (more) general principles. In the demonstration above, we take general propositions of metaphysics and theology to ensure that certain of the objects of nature are purposes (objects of intentions), and we apply these principles to particular organisms in order to infer their proper functions. Kant denies that the concept of a natural purpose is a constitutive concept of determinative judgment. To accept this, Kant thinks, is to introduce (as Wolff does) a new type of (intentional) causality in natural science.[94] In contrast to Wolff, Kant claims that the ultimate ground of construing organisms as natural purposes is not (a priori) theology but experience (observation and experiment). The experience of organisms necessitates that we conceptualize organisms in terms of purposes. It does not imply the ontological claim, however, that objects *objectively are purposes*, i.e., the objects of intentions. In the next chapter, we consider in more detail why Kant thinks that experience leads us to construe organisms as natural purposes.

One motive for construing the concept of a natural purpose as regulative is thus the attempt to demarcate physics and theology. In this respect, Kant distances himself from the Wolffian tradition. He also distances himself from this tradition by strictly distinguishing the notion of usefulness from that of purposiveness. For Wolff, every consequence (use) of a cause is intended by God. Hence, from the perspective of God, there is no distinction between usefulness and purpose.[95] Throughout most of his writings, Kant vehemently rejects this identification. Let us consider his arguments.[96]

We may focus first on Kant's discussion of physico-theology in the second section of *Der einzig mögliche Beweisgrund* of 1763.[97] In the First Reflection of this section, Kant notes that the appearance of *usefulness* among causes and effects often leads us to judge that these causes are "instituted to produce these effects" and are (thus) the product of choice.[98] If we discover that x is useful for y, we infer that x has the purpose of bringing about y and take x to exist *because* it brings about y. Kant illustrates this inference in the following manner:

> Suppose that one positively insisted that there must first be some underlying purpose to explain the occurrence of a provision of nature. The necessity for an atmosphere might then be explained in terms of one of the thousand uses (*Nutzen*) it might have. For the sake of argument, I shall concede the point. I propose that the ultimate purpose of this provision of nature is, for example, to render possible the respiration of man and animals. (AA 2: 97)

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[94] AA 5: 383. Cf. AA 20: 234–236; AA 5: 360–361.

[95] Wolff [1751] 2003, 633–634.

[96] For an excellent discussion of Kant's distinction between internal and external purposiveness, which I briefly touch upon in the following, see Breitenbach 2009, 134–140.

[97] On these sections, see also Ginsborg 2001.

[98] AA 2: 96.

Kant identifies the usefulness of an object x (its 'thousand uses') with its natural effects. Thus, he argues that the elasticity and pressure of the atmosphere make possible the respiration of man and animals, of suction, of pumps, of the dawn, of the alternating winds in tropical countries, etc.[99] These effects are *uses* of the atmosphere. It is by identifying one of these uses as a *purpose*, that we can give a teleological account of the existence of the atmosphere relative to this purpose. Thus, taking the respiration of man and animals to be the purpose of the atmosphere, we may argue that the atmosphere exists *because* it renders possible the respiration of man and animals. Here, we witness a transition from the *nexus utilitatis* to the *nexus finalis*.

Kant denies the legitimacy of inferring that the atmosphere has a particular purpose on the basis of the appearance of usefulness. For the "atmosphere, operating in accordance with general laws of motion, accomplishes on its own what an arrangement, instituted in accordance with reflective choice, would itself achieve."[100] The variety of uses of the atmosphere follows from the nature of the atmosphere and can be explained in terms of its elasticity and pressure. The usefulness of natural objects can thus be explained without any appeal to a purposive arrangement of nature. In accordance with this view, Kant rejects any attempt to explain, on the basis of the usefulness of a natural object, the existence of a natural object in terms of its purported purpose:

> Nature offers countless examples of a single thing being extremely useful in a wide variety of employments. It is a great mistake to suppose, without further ado, that these advantages are purposive or the sort of effect which involves motives, for the sake of which the divine choice ordered their causes in the world. (AA 2: 131)

The fact that a natural object is *useful* for something else is not a proper ground for understanding this object in terms of its (supposed) *purpose*.[101] For this fact can be explained in terms of mechanical laws. Employing Baumgarten's terminology: the *nexus utilitatis* can be explained perfectly well in terms of the *nexus effectivus*.

A similar argument can be found in §63 of the Critique of Teleological Judgment. In this paragraph, where the notion of relative purposiveness is discussed, Kant inquires whether relations of usefulness or advantageousness justify teleological explanations.[102] In other words: Kant asks whether cognition of the fact that x is useful or advantageous for y allows us to explain the existence of x in terms of y. He argues that this kind of explanation requires that y be specified as a goal of nature, which implies that y must exist. Under this condition, one can take x, insofar as it is advantageous or useful for y, as a means that exists for the sake of y.[103] Thus, Kant

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[99] AA 2:97–98.

[100] AA 2: 98.

[101] If one does argue in this fashion, Kant argues that one commits the mistake of attributing something "to an artificially devised order of nature before one has properly established that nature is capable of producing that phenomenon in accordance with her universal laws." AA 2: 135.

[102] On this point, see also McLaughlin 1990, 42–44; Kreines 2005, 275–277.

[103] "Only **if** one assumes that human beings have to live on earth would there also have to be at least no lack of the means without which they could not subsist as animals […]." AA 5: 368.

envisions the following type of account: (i) sandy soils are advantageous for pine trees; (ii) pine trees are a goal of nature; (iii) hence, sandy soils are a means that exists because of their advantageousness for pine trees.

Kant takes the above type of explanation to be highly *problematic*. He holds that *if* y is a goal of nature, we can account for the existence of its (necessary)[104] means x in terms of y. However, we have no grounds for assuming that pine trees are a goal of nature and that sandy soils are a (necessary) means for this goal. The justification for construing the relation between sandy soils and pine trees as a means-end relationship is, according to Kant, often taken to lie in the fact that sandy soils are advantageous for pine trees. However, the advantageousness of sandy soil for pine trees can be understood in terms of natural causes and the existence of sandy soil can be explained without construing the existence of pine trees as a goal of nature. Hence, advantageousness or usefulness does not justify teleological explanation.

In conclusion, then, Kant's concept of purpose is highly similar to the concept of purpose developed in the works of Wolff and Baumgarten. In particular, all three philosophers model the idea of purpose on intentional agency. Since Kant cannot accept the idea of intentional causation in nature (whether human or divine), he assigns the concept 'purpose' a regulative status when applied to nature. In contrast to Wolff, Kant thinks we have no objective guarantee that organisms *are* objects of intentions.[105] In this way, Kant distanced himself from the rationalist tradition. He denied that theological and metaphysical (ontological) propositions can be used to derive the purposes or functions of organs and organs, and denied any identification of usefulness with purposiveness. Still, the differences between Kant's concept of 'purpose' and those of his rationalist predecessors are not as immense as is sometimes claimed.[106] Kant took the traditional view that purposes exist only relative to cognitive subjects to imply that we ascribe the concept of purpose to natural objects regulatively. This is ultimately a shift of focus from the divine intellect to the human intellect, a hallmark of Kant's transcendental philosophy.

4.7 Conclusion

In the present chapter we have analyzed Kant's conception of 'purpose'. I have argued that Kant's intentional construal of the concept of purpose is highly similar to Wolff's and Baumgarten's construals of this concept. For Wolff and Baumgarten, purposes are objects of intention, and natural objects are objects of God's intentions. Although Kant also adopted an intentional definition of 'purpose', he could not construe organisms as objects of intentions. For matter has no intentions, we do

[104] The inference from the premise that y necessarily exists to the conclusion that the means for y exist is valid *if* these means are taken to be necessary for the existence of y. Kant does not always make this point explicit.

[105] AA 20: 234.

[106] See, for example, Cassirer 1981, 338.

not know whether animals and plants have intentions, and we have no sufficient theoretical grounds to affirm the existence of divine intentional causation in nature. Accordingly, the concept of purpose can be ascribed to nature only problematically and has no explanatory function. In natural science, the only proper explanations are mechanical explanations. The above conclusion raises questions concerning the status of biology as a science. For, as we saw in the previous chapter, the purposive unity of organisms and adaptedness of organs and organisms are inexplicable mechanically. It may seem, therefore, that we should subscribe to the thesis of Richards and Zammito that the third *Critique* provided ‘a profound indictment of any biological discipline attempting to become a science’.

Yet this conclusion is too strong. In the next chapter, I will argue that, although teleology has no explanatory function, it is also not merely descriptive or heuristic. Rather, as has been stressed by Flach and Toepfer, Kant takes teleology to enable the demarcation of the subject-matter of the biological disciplines. Or, to employ a terminology I prefer, teleology determines the *domain* of the biological disciplines. In arguing that the realm of the organic constitutes a special domain of scientific investigation, Kant thus at least contributed to the view that biology is a science distinct from, say, physics. In other words, he subscribed, at least in part, to the idea that biology is a special science with a special object. In addition, he argued that the proper method of biology consists in the subordination of mechanism to teleology. In arguing in this manner, Kant claimed that mechanical explanations can still, under certain conditions, be given in biology. Hence, it is not the case that organisms are placed totally beyond the pale of normal scientific investigation and explanation.

Chapter 5
Kant on the Domain and Method of Biology

In the previous chapter, we saw that Kant did not assign any genuine explanatory function to teleology. This is a consequence of his intentional construal of the concept of purpose. To treat purposes as objective grounds that allow us to explain why something is the case is to introduce intentional causation in nature illegitimately. In natural science, proper explanations are always mechanical explanations. However, Kant also claims that the purposiveness of organisms is mechanically inexplicable. The conjunction of these claims has led commentators such as Richards and Zammito to deny that biology is a science for Kant.[1] Zammito formulates the point with great clarity, stating that Kant put "life science beyond the pale of empirical science".[2]

This interpretation is based (at least in part) on two assumptions. First, Richards and Zammito take Kant to assign teleology a *mere* heuristic or descriptive function.[3] Second, they take the explanation of the purposiveness of organisms to be a main objective of (eighteenth-century) biological science.

In the present chapter, I argue that Kant does *not* think of teleology as merely heuristic or descriptive, as Richards and Zammito claim. Rather, as Flach, Toepfer and Quarfood have stressed, for Kant teleology has an *identificatory* function. Teleology plays a methodological role in identifying organisms as special objects of scientific and biological investigation.[4] As Toepfer explains, teleology plays a role in specifying biology as a particular science with a specific subject-matter.[5] In the present chapter, I analyze Kant's views on the role of teleology in determining the subject-matter of biological science. I adopt a historical perspective and compare Kant's views on the domain of biology to the views of Johann Friedrich Blumenbach on the domain of natural history.

[1] Richards 2000, 2002; Zammito 2006, 2012.

[2] Zammito 2012, 124.

[3] Zammito 2006, 123. See also McLaughlin 2001, 19.

[4] Flach 1994; Toepfer 2004; Quarfood 2006.

[5] Toepfer 2012, 115.

H. van den Berg, *Kant on Proper Science: Biology in the Critical Philosophy and the* Opus postumum, Studies in German Idealism 15, DOI 10.1007/978-94-007-7140-6_5,

Richards and Zammito correctly stress that Kant denied that natural purposiveness can be explained. The question is whether Kant denied the possibility of providing explanations in biology altogether. This is not the case. If this were true, Kant's claim that in natural science we must always search for mechanical explanations is vacuous. As Lenoir already noted, Kant thought that in biology we combine a teleological and mechanical perspective.[6] Kant himself thinks that in biology mechanism must be *subordinated* to teleology. In the present chapter, I reconstruct what it means to subordinate mechanism to teleology by analyzing Kant's views on reproduction, nutrition, growth, and self-maintenance. These organic processes are often analyzed as resisting mechanical explanation altogether. In contrast, I argue that Kant assigns mechanism a fundamental role in explaining these processes.

The chapter is structured as follows. In Sect. 5.1, I give an overview of recent interpretations that take Kant to assign teleology a role in identifying the subject-matter of biology. In addition, I describe Lenoir's interpretation of Kant's biological teleology. Section 5.2 offers an analysis of Kant's critique of Leibniz's conception of organisms. I show that this critique provides textual evidence for Flach's and Toepfer's view that the *method* by means of which we investigate organisms determines how we construe their nature. In Sect. 5.3, I discuss how Kant's influential contemporary biologist Johan Friedrich Blumenbach conceived of the domain of natural history. In determining this domain, Blumenbach referred to teleological presuppositions of natural historians and to characteristic empirical features of organisms, such as reproduction, growth, and nutrition. In Sect. 5.4, I show that Kant also took reproduction, nutrition, growth, and self-maintenance to be empirical features in terms of which we distinguish organic from inorganic bodies. In addition, these features prompt a *teleological description*. Nevertheless, these features must be explained *mechanically*. Through an analysis of Kant's views on these features, we can determine his views on proper method in biology, consisting in the subordination of mechanism to teleology. In Sect. 5.5, I summarize Kant's conception of biological method and compare my position to that of Lenoir. Finally, in Sect. 5.6 I show how Kant's conception of biological method determines his conception of the object of investigation of biology.

5.1 Constitutive Teleology and Teleomechanism

Throughout the third *Critique*, Kant stresses that teleology has a mere regulative function. This fact has led many commentators to argue that for Kant teleology has a mere descriptive and heuristic function. We can describe organisms as purposes, we can interpret organs as means to an end, and we can take teleological notions to be heuristic devices for analyzing organisms. That Kant ascribes such functions to

[6] Lenoir 1989, 23–35.

teleological notions is clear. However, why is teleology *indispensable* to our understanding of organisms if teleology has a mere heuristic function? Quarfood articulates this problem as follows:

> The difficulty lies in balancing the claimed indispensability of teleology with its regulative status. Too heavy stress on the necessity of teleological considerations for the understanding of organisms would seem to lead to the conclusion that teleology is a constitutive condition for the possibility of biology, and thus not regulative. On the other hand, if one stresses the mere regulativity of the teleological principle, one might come to a rather trivial interpretation of the indispensability claim: it would be a heuristic principle at best, indispensable only in the sense that without it we would find it more cumbersome to reach the non-teleological, mechanistic explanations of which biology as a science presumably should consist. (Quarfood 2006, 736)

Quarfood provides a solution to this problem by arguing that for Kant teleology is not merely descriptive. Rather, teleology has an *identificatory* function. More specifically, he introduces a distinction between two levels: "on the object-level of biological science, teleology is an enabling condition for experiencing organisms".[7] On this level teleology has a *constitutive* function: it demarcates the subject-matter of biological science. In contrast, on a meta-level of philosophical reflection concerning the ultimate ground of the existence and organization of organisms (a topic on which we must remain agnostic), teleology has a mere *regulative* function.[8] A similar interpretation has also been developed by Flach and Toepfer.[9] According to these authors, teleology enables the identification and demarcation of the subject-matter of biological disciplines. The teleological *method* by means of which we investigate organisms enables us to take organisms as a special object of biological investigation.

This interpretation is attractive. However, it must be noted that Kant simply cannot assign teleology a constitutive function.[10] In addition, it is not fully clear what specific role teleology fulfills in identifying organisms as a special object of biological investigation. What does it mean to say that the method by means of which we investigate organisms allows us to identify and demarcate the subject-matter of biology? Is it the case that Kant strictly delimited the domain of the life sciences? If so, how did he do this? Quarfood admits that his interpretation is 'somewhat reconstructive'. In other words, his interpretation is in need of textual evidence.

In the present chapter, I will further develop the interpretation developed by the above mentioned authors. I argue that in many of his works, Kant argues that the method by means of which we investigate objects leads us to attribute certain properties to these objects rather than others. In Sect. 5.2, I show that Kant believes that the *mechanical* investigation of organisms leads us to construe organisms as wholes

[7] Quarfood 2006, 736.

[8] Ibid. See also Quarfood 2004.

[9] Flach 1994; Toepfer 2004, 2012.

[10] Zammito 2012, 122. Note that Toepfer 2012 provides a systematic argument for the claim that teleology is *constitutive* for biology. In his historical reconstruction of Kant's position (Toepfer 2004) he stresses that for Kant teleology is regulative.

consisting of (relatively) simple parts. In Sect. 5.5, I show that Kant takes the teleological conceptualization of certain objects of nature to lead us to construe the composition of these objects in teleological terms. This teleological mode of description is not available to the physicist because she does not construe the objects of her investigation as purposes. Hence, by conceptualizing organisms as natural purposes we take organisms to be characterized by a variety of properties and relations that we do not ascribe to inorganic bodies. I further show how Kant identifies the domain of biological sciences by discussing his views on (i) organic reproduction, (ii) nutrition and growth, and (iii) the self-maintenance of organisms. I compare Kant's views to Blumenbach's views on (i)–(iii). This comparison will show that both Kant and Blumenbach took (i)–(iii) to be empirical properties that cannot properly be ascribed to inorganic bodies and that elicit a teleological description. Hence, the identification of the domain of the biological sciences is based on *empirical criteria* and *teleological conceptualization*. Blumenbach also provided an ontological basis for distinguishing organisms from inorganic bodies, arguing that only the former are subject to vital forces. This ontological point of view is foreign to Kant's philosophy.

Finally, I show that Kant took the combination of teleology and mechanism to be distinctive of biological method. The proper method of biology consists in the *subordination* of mechanism to teleology. This is to say that in biology the *explanandum* is comprehended in teleological terms. However, proper scientific and biological explanations are always mechanical explanations. Hence, the *explanans* in biology must be some kind of mechanism. It is in this manner that in biology we combine teleology and mechanism.

The interpretation I develop is similar to Lenoir's interpretation of Kant.[11] Richards and Zammito have forcefully rejected Lenoir's claim that Kant's views on biological method shaped the 'teleomechanistic' research program of the so-called Göttingen School, which included late-eighteenth-century biologists such as Blumenbach, Reil, Kielmeyer and von Humboldt. This criticism is correct. As we shall see, there are important differences between the actual method of these biologists and Kant's philosophy of biology (although we should also not overlook the similarities). Moreover, Lenoir is not clear on the meaning of the notion 'teleomechanism', employing it interchangeably with terms such as 'vital materialism' or 'emergent vitalism'.[12] With respect to Kant the latter terminology is unfortunate, for he would regard materialism and vitalism to be dogmatic metaphysical theories. Nevertheless, Lenoir's claim that Kant conceived of biological method as combining the teleological and mechanical perspective is correct.

The question remains, however, whether Kant could coherently claim that biologists should subordinate mechanism to teleology. Kant is often interpreted as arguing that organisms resists mechanical explanations altogether. This is for example the case when commentators discuss Kant's views on propagation (reproduction), growth and nutrition, and regeneration. Zammito claims that the question of how

[11] Lenoir 1989.

[12] Lenoir 1980, 1981.

these processes "can be explained – and how they can be *integrated* into a system of empirical laws as the 'order of nature' – remains, for Kant, a philosophical conundrum".[13] Although she thinks that according to Kant mechanical explanations can be provided in biology, and stresses that in biology we should subordinate mechanism to teleology, Ginsborg also argues that processes such as reproduction, growth, and nutrition, do not hold "in virtue of the kinds of regularities studied within physics and chemistry". Rather, only teleology provides a *ground* of "biological regularity".[14]

I will argue that Kant thinks that processes such as reproduction, growth, and nutrition must be explained mechanically. To be sure, these processes must be comprehended in teleological terms. They are conceptualized as processes that serve the maintenance and preservation of organisms. However, these processes must be *explained* in terms of mechanisms. Kant construed mechanical explanations as ideal explanations in natural science. In his writings on biological topics he stayed true to this ideal. To give an example: we can plausibly reconstruct Kant's discussion of nutrition and growth as involving the thought that these processes must be explained (at least in part) in terms of *chemical* processes or mechanisms. Chemistry can be taken to provide *partial grounds* for explaining processes such as nutrition and growth. Hence, Ginsborg's dissociation of physical and chemical regularities on the one hand and biological regularities on the other seems to me to be unjustified. Kant did not think that the purposive unity of mechanisms in organisms allows of explanation. Nevertheless, explanations in biology necessarily involve appeal to mechanical regularities. To put the point differently: explanations in biology invoke propositions established in higher physical sciences (such as chemistry).

5.2 Kant's Critique of Leibniz: Parts, Wholes, and Organisms

How does the method by means of which we investigate organisms determine our understanding of the nature of organisms? A preliminary answer to this question emerges if we analyze Kant's critique of Leibniz's conception of organisms. This critique is contained in the resolution of the second antinomy of the *Kritik der reinen Vernunft*. There, Kant rejects Leibniz's view that organisms are infinitely complex natural machines. This criticism shows that he took to manner in which we *conceptualize* organisms to determine how we view the composition of organisms. More specifically, the mechanical method of explaining wholes in terms of their parts leads us to construe organisms as wholes consisting of (relatively) simple

[13] Zammito 2006, 758.

[14] Ginsborg 2001, 246.

parts. Here, we have a clear example of how the method by means of which we investigate objects determines our view of the nature of these objects.

Kant's critique of Leibniz has been discussed by McLaughlin and Ginsborg.[15] McLaughlin argues that this critique shows that Kant did not take the particular character of organisms to lie in the *kind* of matter of which it is composed, for organisms are composed of *inorganic parts*. In contrast, Ginsborg argues that Kant held that fundamental parts of organisms are *organic* and irreducible to inorganic matter. I will argue that Kant's critique of Leibniz makes the *epistemic* point that by conceptualizing objects as organized, we take them to consist of simple parts (relative simples). This construal of the composition of organisms is a result of the attempt to (mechanically) explain wholes in terms of their parts. Kant's argument can be taken to support a mild form of reductionism, insofar as he is committed to the idea that wholes must be explained in terms of their parts. However, this does not imply anything concerning the nature of these parts. In order to understand Kant's argument, we must first reconstruct Leibniz's conception of organisms. This topic will concern us in the present section.

Leibniz construed organic bodies as true substantial unities. As such, organisms are distinguished from aggregates. An aggregate can be considered as a collection of parts having *accidental unity*.[16] The unity of the parts of an aggregate is mind-dependent. If we understand a collection of things as having a common feature, we can construe this collection as an aggregate. For example: we can identify an infantry battalion as an aggregate because we perceive the members of this battalion to wear the same uniform.

According to Leibniz, the unity of aggregates exists by *opinion* or *convention*.[17] Their parts possess a mere conventional unity and lack true order. Organic bodies are not aggregates. They are taken to have a true, substantial unity. It is important to note that organic bodies are not true unities merely because of the purposeful arrangement of their parts. Leibniz takes artifacts to be aggregates even though their parts are purposefully arranged.[18] Rather, organic bodies are complex bodies that possess unity in virtue of their soul or substantial form.[19]

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[15] McLaughlin 1990, 107–110; Ginsborg 2004, 46–50, especially note 26.

[16] GP II, 58. 'GP' designates: Leibniz, G.W. (1875–1890). *Leibniz: Die philosophischen Schriften* (7 vols.). Edited by Gerhardt, C.I. Berlin: Weidman. My account of Leibniz's notion of an aggregate and his views on organisms largely follows Lodge 2001, 467–486 and Garber 2009.

[17] GP II, 76, 101.

[18] Writing to Arnauld, Leibniz argues that a body, considered by itself, i.e., abstracting from the soul, is similar to an artifact (machine) or heap of stones. Garber 2009, 67.

[19] In a letter to Arnauld, Leibniz writes: "One will never arrive at a thing of which it may be said: 'Here really is an entity', except when one finds animate machines whose soul or substantial form creates substantial unity independent of the external union of contiguity." GP II 77. Garber 2009, 77–81 (I have followed Garber's translation). In §63 of the *Monadology*, Leibniz defines an organism as a composite of a body and a monad. An organism is an *animal* if its central monad is a *soul*. Hence, animals are distinguished as a species of organisms by virtue of the fact that they have a soul. Plants do not have a soul.

Hence, Leibniz provides a metaphysical explanation of the unity of organic bodies (a view that is foreign to Kant).

Apart from understanding organic bodies as substantial unities, Leibniz describes organisms as 'divine machines' or 'natural automata'. The terms 'divine' and 'natural' indicate the difference between organic bodies (plants and animals) and artifacts (man-made automata). Nevertheless, insofar as organic bodies are construed as machines they are similar to artifacts. How do we distinguish organisms from artifacts?

As we have seen, organisms, as opposed to artifacts, are substantial unities and not aggregates. In the *Monadology*, Leibniz further argues that though organic bodies are machines, they differ from artifacts because they are *infinitely complex* machines:

> Thus each organic body of a living being is a kind of divine machine or natural automaton which infinitely surpasses all artificial automata. For a machine made by human artifice is not a machine in each of its parts. For example, the tooth of a brass wheel has parts or pieces which to us are no longer artificial things, and no longer have something recognizably machine-like about them, reflecting the use for which the wheel is intended. But the machines of nature, namely living things, are still machines even in their smallest parts, *ad infinitum*. It is this that constitutes the difference between nature and artifice, that is, between divine artifice and ours. (Leibniz [1720] 1991, 25)

In contrast to artifacts, organic bodies are machines in each of their parts. Leibniz takes all the parts of organic bodies to be purposefully arranged. These parts contain further parts that are all purposefully arranged, and so forth (*ad infinitum*). In contrast, not all the parts of artifacts are purposefully arranged. The reason is that we do not perceive all these parts, e.g., the parts of the tooth on a brass wheel, to have a specific role in enabling the wheel to fulfill its intended use (e.g., setting another wheel in motion). In short: organic bodies are complexes of machines nested within each other to infinity.

As Duchesneau and Garber have argued, Leibniz's views on organic bodies are consistent with the idea that organisms should be explained mechanically.[20] Leibniz was convinced that the whole of nature should be mechanically explained. In the case of organic bodies (complexes of minute machines), we aim to analyze the properties of observable macro-level organisms in terms of the organization of micro-mechanisms. For Leibniz, the proper scientific method for analyzing organic bodies consists in framing hypothetical and mechanical models, representing the micro-level mechanism constituting the inner economy of organic bodies, that allow us to explain macro-level organic structures.[21] By following this method, Leibniz thought that one could discover true mechanical reasons for organic processes.

In conclusion, we may note that Leibniz's conception of organic bodies fits a preformationist account of organic generation.[22] On the preformationist view, embryogenesis can be understood as a mechanical unfolding (evolution) of a preformed miniature organism contained in either the ovaries or the spermatozoa. This

[20] Duchesneau 2003; Garber 2009.

[21] Here I follow Duchesneau 2003, 378–409.

[22] See Grene and Depew 2004, 95–96.

organism, in turn, contains or encases all of its descendants. The preformationist account of embryogenesis, in particular the encasement theory developed by Malebranche,[23] was influential in the late seventeenth and early eighteenth century. Hence, Leibniz could cite scientific support for his conception of organic bodies.[24]

5.2.1 *Organisms and their Relative Simple Parts*

Kant rejected Leibniz's view that organic bodies are complex machines organized to infinity. This rejection may have been motivated by scientific developments.[25] From the middle of the eighteenth-century preformationist accounts of organic generation gradually fell into disrepute and were replaced in favor of epigenetic theories. However, Kant also formulated a philosophical objection:

> To assume that in every whole that is articulated into members (organized), every part is once again articulated, and that in such a way, by dismantling the parts to infinity, one can always encounter new complex parts – in a word, to assume that the whole is arranged to infinity – this is something that cannot be thought at all, even though the parts of matter, reached by its decomposition to infinity, could be articulated. (*KrV*, A 526/B 554)

The justification for these claims runs as follows:

> In the case of an organic body articulated to infinity […] the whole is represented through this very concept as already divided up, and a multiplicity of parts, determinate in itself but infinite, is encountered prior to every regress in the division – through which one contradicts oneself, since this infinite development is regarded as a series that is never to be completed (as infinite) and yet as one that is completed when it is taken together. The infinite division indicates only the appearance as *quantum continuum*, and is inseparable from the filling of space […]. But as soon as something is assumed as a *quantum discretum*, the multiplicity of units in it is determined; hence it is always equal to a number. (*KrV*, A 527/B 555)

Kant seems to argue that it is contradictory to think of an organism as a machine composed of an infinity of articulated (organized) parts, since the representation of a body as organized implies that we take this body to be composed of a determinate or *finite* multiplicity of parts. He treats the representation of a body as organized, through which a whole is represented as being divided into members, to be analogous to the representation of an object as a discrete quantity (*quantum discretum*), through which we take the multiplicity of units contained in this object to be

[23] It is this theory, sometimes called 'strong preformationism', to which my brief description of preformationism corresponds. One should note, however, that several preformationist theories of organic generation existed. See Sloan 2002, 232–236.

[24] In the *Monadology*, Leibniz remarks "that the organic bodies of nature are never products of chaos or decay [*putrefaction*], but always grow from seeds in which there was undoubtedly some *pre-formation*". Leibniz [1720] 1991, 26–27. Thus, Leibniz accepts the basic tenets of preformationism. However, Leibniz often refrained from defending either ovist or animalculist (spermist) pre-existence. Duchesneau 2003, 401–402.

[25] Grene and Depew 2004, 96–97.

determined or finite. Hence, an analysis of the notion *quantum discretum* may shed further light on Kant's argument. Kant's concept of quantity has been thoroughly analyzed by Parsons, Longuenesse, and Shabel.[26] Building on these authors, I will now identify aspects of Kant's concept of quantity that will enable us to make sense of his critique of Leibniz.

First a terminological remark on the concept 'quantity' is in order. For Kant the term 'quantity' can refer to both a quantifiable object or to the quantity that this object is determined to have.[27] In Kant's lectures on metaphysics, a distinction is made between the concepts '*quantum*' and '*quantitas*'. A *quantum* is a single entity containing a multiplicity (*Menge*) of parts that can be quantitatively determined.[28] By determining the multiplicity of parts of a *quantum* we determine its *quantitas*. Thus, a *quantum* is an *object* that has a quantity.

In addition, a quantity is construed as a collection of *homogeneous* parts. This distinguishes a quantity from a *compositum*, which is simply a collection of parts (heterogeneous or homogeneous). A *quantum continuum* is an entity whose magnitude leaves the multiplicity of parts undetermined.[29] To say that the multiplicity of parts of a quantum is undetermined is to say that it has infinitely (or indefinitely) many parts. Hence, every *quantum* that has an infinite multiplicity of parts is a *quantum continuum*.[30]

According to Kant, a *quantum continuum* can be taken as a *quantum discretum*, i.e., can be *represented* as a discrete quantity. We represent a continuous quantity as discrete by assigning a number to it. In particular: we represent a *quantum continuum* as discrete by means of the choice of a unit of measurement, in terms of which we determine the quantity (*quantitas*) of the *quantum*.[31] The following passage from the *Metaphysik Volckmann* elucidates Kant's position:

> *Quantum discretum* is that whose parts are considered as units; that whose parts are considered as multiplicities is called a continuum. We can also consider a continuum as discrete; for example, I can consider the minute as unit of the hour, but also as a multiplicity [*Menge*] which itself contains units, namely 60 seconds. (AA 28: 423)[32]

If we are dealing with continuous quantities such as temporal segments, we can pick out a unit that we treat as simple, i.e., as a part that does not contain a multiplicity of parts. This allows us to determine the *quantum* by assigning a number to it that represents the multiplicity of its parts.

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[26] Parsons 1992b; Longuenesse 1998, 263–271; Shabel 2005.

[27] Shabel 2005, 29–32.

[28] *Metaphysik Herder*, AA 28: 21; *Metaphysik Volckman*, AA 28: 422–23. On Kant's use of the concept 'quantity' in the lectures on metaphysics, see Parsons 1992b, 135–158 and Longuenesse 1998, 263–271. Longuenesse highlights the difference between *quantum* and *quantitatis*.

[29] *Metaphysik Pölitz*, AA 28: 560. Longuenesse 1998, 264.

[30] Parsons thinks that Kant does not hold that every quantum with infinitely parts is a continuous quantity. Parsons 1992b, 144. However, I am in agreement with Longuenesse who takes *continuum* to mean 'infinitely divisible'. Longuenesse 1998, 264. See also Friedman 1992a, 60–62.

[31] Longuenesse 1998, 264–265.

[32] I adopt the translation of Parsons 1992b, 144.

As Parsons has stressed, the fact that we can represent continuous quantities as discrete is important since this allows the measurement of continuous quantities.[33] Kant takes physical bodies to be continuous because they are given in space.[34] The assignment of numbers to physical bodies requires that we have a procedure for representing these bodies as discrete. It is our description of a continuous quantity that allows us to represent it as discrete. To employ Kant's example: by *describing* an hour as composed of minutes, and by taking the minute as opposed to some other *quantum* as a unit of measurement, an hour is represented as discrete. Hence, by means of our conceptualization of a continuous quantity we take it to have simple parts, even though a continuous quantity does not actually have simple parts.

We are now in a position to understand Kant's critique of Leibniz. For Kant, any physical body is given in space and is thus continuous, i.e., consists of an infinite (indefinite) multiplicity of parts. However, by describing this body in a certain manner we can represent is as a discrete quantity and thus represent it as having a determinate or finite multiplicity of parts. This is the case if we describe an object as an organized body. As Kant puts it: in "the case of an organic body articulated to infinity […] the whole is represented *through this very concept* as already divided up".[35] By describing an object as organized, we represent it as composed of a finite number of discrete parts that we take to be simple and that make up its organization. According to Kant, this proves that Leibniz's view that organisms are infinitely organized machines is contradictory. Leibniz takes organisms to be organized, which implies that we conceive of them as consisting of a finite number of parts, but he also takes organisms to have an infinite multiplicity of complex parts.

Kant's argument shows that our description of an object as organized determines how we conceive of the constitution of this object. This follows from the claim that by describing an object as an organized body we represent it as having a finite multiplicity of parts, whereas if we consider an object as spatially extended we take it to consist of an infinite multiplicity of parts. Note that Kant does not claim that organized bodies actually have simple parts. He merely claims that by conceptualizing objects in a certain manner we *treat* them as having simple parts, i.e., we construe their parts as relative simples. In short: by describing an object as an organized body we attribute certain properties of it (being composed of simple parts) rather than others (having indefinitely many parts).

It is not yet clear why organized bodies must be taken to have simple parts. A possible answer to this question emerges if we recognize, following Duchesneau, that Leibniz's view of organisms as infinitely complex machines is difficult to square with allowing for the possibility of determinate knowledge of organisms.[36] It

[33] Parsons 1992b, 144–46.

[34] *KrV*, A 525/B 553.

[35] *KrV*, A 527/B 555, emphasis mine.

[36] Duchesneau 2003.

seems impossible that finite human minds can cognize the *ratio essendi* of organic bodies if (i) these are understood as complexes of machines nested within each other to infinity and (ii) one adopts the position that higher level mechanisms (such as organisms) should be scientifically explained in terms of micro-level mechanisms.[37]

It is also not entirely clear how Leibniz's conception of organic bodies can be squared with scientific practice. When investigating natural objects, we can explain wholes in terms of their parts while *abstracting* from the fact that these parts are composite. Kant's conception of organic bodies seems to capture this aspect of scientific practice, for he recognizes that we consider an organized body as having simple parts even if this is not in fact the case. A similar point of view is adopted by Christian Wolff. In his *Deutsche Metaphysik*, Wolff notes that we can explain a whole in terms of its parts while we abstract from the complex nature of these parts themselves:

> […] with respect to natural things we proceed just as in art. When we wish to know a clock, we pay attention to the parts of which it is composed, while abstracting from the matter of which the wheels and other parts are made. Not as if the matter, e.g. metals, do not also have their own particular mode of composition, but because the latter does not contribute anything to knowledge of the clock, and it is immaterial in regard to the clock however its matter may be constituted. (Wolff [1751] 2003, 378)[38]

When investigating bodies, we identify a collection of basic parts in terms of which the structure and properties of bodies should be explained. These parts are treated as (relatively) simple. Wolff argues that the identification of a collection of parts depends on what we want to explain. If one wants to explain the functioning of a clock, we take its wheels or other parts relevant to understanding the functioning of a clock to be simple parts. The complete material constitution of these wheels is left out of account, because this type of knowledge is not needed in order to understand the functioning of the clock.

If we investigate an organism or organ, our identification of its (relatively) simple parts will also depend on what we wish to explain. For example, if we aim to explain the organization and functioning of the eye, we can take the cornea, aqueous humor, lens, etc., as its simple parts. However, if we want to explain the structure of the cornea, we will take another collection of parts to be simple and take these to be the basis of our explanation. Kant's conception of organic bodies, i.e., of objects that are conceptualized as wholes having simple parts, nicely captures these facets of the

[37] Duchesneau 2003, 405.

[38] Original: "[…], wir in dem Wesen der Cörper bey zusammengesetzten, das ist, cörperlichen Theilen stehen bleiben. Nehmlich wir machen es in natürlichen Dingen eben so wie in der Kunst. Wenn wir eine Uhr erkennen wollen; so geben wir acht auf ihre Theile, daraus sie zusammen gesetzet worden, setzen aber bey Seite die Materie, daraus die Räder und andere Theile verfertiget sind, nicht als wenn die Materie, z. E. die Metalle, nicht auch ihre besondere Art der Zusammensetzung hätten, sondern weil dieses zur Erkäntniss der Uhr nichts beyträget, und es in Ansehung der Uhr gleichviel ist, was es auch für eine Beschaffenheit mit der Materie hat […]."

scientific explanation of bodies. In this manner, the mechanical method of investigating natural objects (e.g., organisms) determines how we construe these objects.

5.3 Blumenbach on the Domain of Natural History

In the previous section, I argued that for Kant our understanding of the constitution of objects that pertain to the domain of biology is shaped by our conceptualization of these objects. This line of thought will be developed in the following sections. I argue that, according to Kant, we construe the domain of biology by conceptualizing organisms as natural purposes.

In dealing with the question of how Kant construes the domain of biology, it is useful to describe how his contemporary biologists specified their object of investigation. An illustrative example is provided by Blumenbach in his *Handbuch der Naturgeschichte* (1779–1780; and 11 subsequent editions). In the following, I will focus on the manner in which Blumenbach distinguishes organic from inorganic bodies. The manner in which Blumenbach introduces this distinction can be found in several versions of his *Handbuch*. I have consulted the second edition of 1782 and the English translation by R.T. Gore of the tenth edition (1825). In the following, I will mainly discuss the latter edition. Many of Blumenbach's views articulated in the tenth edition are contained in the second edition (I refer to passages of the second edition in footnotes).[39] Kant did not have knowledge of the tenth edition of the *Handbuch*. Nevertheless, this late edition is of interest because Blumenbach articulates, partly under the influence of Kant, a clear account of his views on proper biological method.[40] By focusing on this late edition we can also easily specify some of the *differences* between Kant's views and those of Blumenbach.[41] In the tenth edition, Blumenbach distinguishes organic from inorganic bodies by appealing to vital forces that exist within the realm of organic nature. This ontological appeal to vital forces is largely absent in the writings of Kant.

In the first section of his *Handbuch*, entitled "Of natural bodies in general, and of their division into three kingdoms", Blumenbach aims to specify the domain of *natural history*. The term 'natural history' is taken to refer to the study of the three

[39] On the distinction between inorganic bodies and organic bodies in the second edition, see Blumenbach 1782, 1–27.

[40] Lenoir 1980 argues that Kant's philosophy influenced Blumenbach's biological theories. The tenth edition of the *Handbuch* substantiates this view. My aim in the following is merely to employ Blumenbach's views on biological method to elucidate Kant's views on this subject.

[41] The question of whether the views of Blumenbach and Kant on biology are similar or not is much debated. Lenoir 1980, 1989 argues that Kant provided a philosophical underpinning for the so-called *teleomechanistic* research program of the Göttingen School of biology (which includes Blumenbach). In contrast, Richards, 1998, 2000; Caneva 1990; Beiser 2006, 9; Zammito 2003, 2006, all argue that the views of Kant and Blumenbach are fundamentally different. In the following, I will highlight both similarities and differences.

kingdoms of nature, i.e., the study of animals, plants, and minerals.[42] Natural history thus comprises zoology, botany, and mineralogy. Animals, plants, and minerals are construed as the three classes of *natural* bodies that constitute the "object of Natural History".[43] Natural bodies are bodies in which man has not effected any essential alteration. In contrast, artificial bodies are bodies in which "changes have been *designedly* produced by the hand of man".[44] The latter bodies are excluded from the domain of natural history. Blumenbach distinguishes between the three classes of natural bodies by noting differences among bodies with respect to (i) their origin, (ii) their growth, and (iii) their structure.[45]

In particular: (i) plants and animals are the product of reproduction or propagation, i.e., they are "invariably produced by other bodies of the same form and kind". Their existence in an unbroken series "presupposes other similar bodies, to which they owe their being."[46] Furthermore (ii), the growth of plants and animals occurs by means of nutrition, which is understood as the assimilation or transformation of external materials. As Blumenbach puts it, plants and animals "introduce various extraneous substances into their bodies as nutriment, assimilate them to their own composition, separate the superfluous parts, and by this constant change and renewal grow *from within* – by *intussusceptio*."[47] Finally (iii), Blumenbach argues that the propagation, nutrition, and growth of plants and animals presuppose a specific purposive *organization or structure* of these natural bodies:

> For, in order to introduce and to assimilate nutriment, and at a future period to produce other creatures of their own kind, it is necessary that their bodies should be provided with vessels and other organs, suitably connected, endowed with (so called) *vital powers*, and adapted to the reception of certain fluids, the assimilation of aliments, and the procreation of progeny. (Blumenbach 1825, 2)[48]

The growth and reproduction of plants and animals presuppose that their parts are *suitably connected* and *adapted* to the reception of fluids, the assimilation of nutriments, and the production of offspring. If we wish to understand how organisms are capable of reproduction, nourishment, and growth, we must presuppose that they have a structure adapted to performing these functions. This is a presupposition

[42] This use of the term 'natural history' is quite common in eighteenth-century Germany. At the turn of the century this conception of natural history seems to be abandoned, partly under the influence of Kant. In his *Physik-Vorlesung*, for example, Lichtenberg follows Kant in distinguishing between 'natural description' (a descriptive discipline concerned with the external characteristics of natural bodies) and 'natural history' (a discipline concerned with the natural changes and genesis of natural bodies). Lichtenberg 1808, 5–6.

[43] Blumenbach 1825, 1–2.

[44] Blumenbach 1825, 1. Blumenbach notes that the terms 'essential alteration' and 'designed' are relative. A mule or carib can be construed as an artificial body but can also be taken to be a natural body. He further notes that it is often quite difficult to distinguish between natural bodies and products of art because of their close resemblance.

[45] The same line of reasoning can be found in Blumenbach 1782, 1–5.

[46] Blumenbach 1825, 2; Cf. 1782, 2.

[47] Blumenbach 1825, 2 (emphasis mine); Cf. 1782, 2.

[48] Cf. Blumenbach 1782, 2–3. Note that here, Blumenbach does not refer to vital forces.

fundamental to biological inquiry. In the *Kritik der Urteilskraft*, Kant expresses the same point: the "investigator of nature" must base her judgments on organized beings "on some original organization".[49]

The attribution of vital forces to organisms is necessary because Blumenbach takes characteristic functions and properties of plants and animals, such as propagation, nutrition, and growth, to be inexplicable in terms of physical or mechanical laws *alone*. In several of his writings, Blumenbach distinguished between *vital forces*, construed as causes of vital properties of organism, and *physical* and *mechanical* forces, construed as causes of properties possessed by both inorganic and organic bodies.[50] In contrast to physical or mechanical forces, vital forces are taken to be efficacious only within the domain of organic nature. In his manual on natural history, Blumenbach notes with respect to the nutrition and growth of organisms:

> They are rendered capable of performing these important *functions*, by the *organization* of their *structure*, and by the *vital powers* connected with it. For it is by means of the latter that the *organs* receive as well their *sensibility* to impressions, (*stimuli*), as their *powers* of *motion*, without both of which it would be impossible to conceive either *nutrition* or *growth*, or the mutual influences of the parts for the support of the whole, and the contrary. (Blumenbach 1825, 8)

The capacity of organisms to propagate, grow, and nourish themselves presupposes a structure that is adapted to the performance of these functions. In addition, however, vital forces are attributed to parts of plants and animals. These forces account for the sensibility and the powers of motion of these parts, without which nutrition and growth are impossible. As an example of a vital force we may think of 'irritability' (*vis muscularis*), i.e., the force pertaining to the muscular tissue responsible for the capacity of the muscles to respond to stimuli by means of contraction.[51]

Apart from assigning vital forces to parts of organized beings, such as contractility, irritability, and sensibility, Blumenbach posited the existence of a vital force in order to account for the organization of organized beings as a whole. This was the infamous *Bildungstrieb*[52]: the cause of the form of organisms, their preservation and their regenerative capacities.[53] In his manual, Blumenbach argues that the *Bildungstrieb* allows for an explanation of the origin of organized bodies by the "*progressive formation* (epigenesis) of the seminal matter".[54] In short: the *Bildungstrieb*

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[49] AA 5: 418.

[50] Cf. Blumenbach's account of vital force in his *Institutiones physiologicae* 1817, 16–17. See also *Über den Bildungstrieb und das Zeugungsgeschäfte* 1781, 11–13. I return to this topic in Sect. 7.2.

[51] Cf. Blumenbach 1817, 18.

[52] A discussion of the *Bildungstrieb* is also contained in Blumenbach 1782, 14–18. Note, however, that in this earlier edition the concept of 'vital force' does not play such a dominant role as in the later editions. The concept of vital force also does not play a significant role in Kant's reflections on biological method in the third *Critique*.

[53] On Blumenbach's *Bildungstrieb* and his conception of vital forces, see Larson 1979; Lenoir 1980, 1981; Richards 2000. Cf. Sect. 7.2.

[54] Blumenbach 1825, 10. On Blumenbach's rejection of preformationism (evolution) and his endorsement of the *Bildungstrieb*, see also the earlier Blumenbach 1782, 14–16.

allows for an epigenetic account of embryological development. The process of epigenesis is explained as follows:

> This may be done by admitting, that the mature and previously *unorganized*, but *organizable,* seminal matter of the progenitors, when transmitted at the proper time, and under certain necessary circumstances, to the place of its destination, comes under the influence of a *vital power*, the so called *Formative Impulse* (*Nisus Formativus*, *Bildungstrieb*) which gives origin to suitable actions. This *impulse* is distinguished from all purely mechanical *formative powers* (such as that which produce crystallizations, &c. in the mineral kingdom), by its capability of molding the varied kinds of organizable seminal matter by an infinite number of modifications into forms corresponding to, and equally numerous with the endless differences in the purposes which organized bodies and their parts are destined to fulfill. (Blumenbach 1825, 11)

The *Bildungstrieb* is construed in teleological terms. It guides the process of embryogenesis in accordance with the endless variety of purposes that organisms and their parts have. Mechanical formative forces are not capable of producing the *variety* of purposive forms characteristic of organisms. Blumenbach notes that forces responsible for crystallization produce bodies characterized by the "geometrical regularity of their almost invariable rectilinear outlines", outlines that are "reducible to a few primary forms".[55] In contrast, bodies of animals and plants must, in order to "render them suitable to their destined offices", be molded into an "incalculable number of forms with endless varied outlines".[56] In this manner, Blumenbach distanced himself from *mechanical* theories of epigenesis.[57] The variety of purposive forms of organisms cannot be accounted for purely in terms of mechanical forces, e.g., merely in terms of chemical affinities or crystallization. According to Blumenbach, only the *Bildungstrieb* is able to account for the *plasticity* of organism.

The foregoing does not imply that mechanical forces do not play any role in the formation of embryos. It also does not imply that Blumenbach denies mechanism a role in biology. As said, Blumenbach takes mechanical forces to be efficacious in organic bodies. Following Kant he hails his methodology as combining the 'mechanical' and the 'teleological' principle of biological inquiry.[58] How this combination is effectuated *in concreto* remains a mystery, since Blumenbach does not specify any clear mechanism operative in, for example, the generation of embryos. I will return to this topic in Chap. 7. Here we may note that Blumenbach's general idea seems to be that in organisms mechanical forces are subjected to vital forces. Vital forces somehow govern mechanical forces. As such, mechanical forces can be taken to operate in accordance with purposes.

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[55] Blumenbach 1825, 11.

[56] Ibid.

[57] Blumenbach 1825, 10, explicitly distances himself from epigenetic theories in which it is "supposed that the progeny was formed at its conception by a kind of crystallization."

[58] Blumenbach 1825, 10–12. Here, Blumenbach follows Kant. In a letter to Blumenbach of August 1790, Kant praised Blumenbach for uniting the physical-mechanical and teleological mode of explanation. AA 9: 184–185.

Let us return to Blumenbach's delineation of the classes constituting the domain of natural history. Recall that organized bodies are characterized by (i) reproduction, and (ii) nutrition and growth. In addition, (i) and (ii) presuppose (iii) an organization or structure that is *adapted* to performing these functions and lead (iv) to the posit of vital forces. (i)–(iv) allow Blumenbach to differentiate between organized bodies and minerals (inorganic bodies):

> All this is wanting in natural bodies of the other class, viz. in minerals. Both origin and growth in them (if they can be said to grow), are not the effects of nutrition, but simply of so-called physical (chemical and mechanical) laws of aggregation, the addition of homogeneous particles *from without*; consequently, neither organization nor vital forces are to be expected. (Blumenbach 1825, 2)[59]

Plants and animals nourish themselves through the reintegration of external substances and *grow* from *within*. In contrast, the growth of minerals is not the result of such organic assimilation. Mineral growth is the effect of mechanical laws of aggregation, i.e., the addition of particles from *without*. The *origin* of minerals can also be explained through the aggregation of inorganic materials. In contrast to organic bodies, minerals are *not* invariably produced through bodies of the same form and kind. Consequently, we do not need to presuppose any specific *purposive organization* of minerals in order to account for their origin or growth. The case is wholly different for organized beings. For example, the propagation of humans presupposes some kind of *adaptedness* of the human reproductive organs. Moreover, the fact that the origin and growth of minerals can be understood purely in mechanical terms shows that they are "without vital powers, and governed merely by the physical (mechanical and chemical) principles of attraction, affinity, plastic force, etc."[60] These are the reasons for distinguishing organized bodies from inorganic bodies.

Finally, within the class of organized bodies Blumenbach distinguishes plants from animals by noting differences with respect to the manner in which they introduce nutriments. Plants absorb nutritious fluids by means of their roots without the aid of voluntary motion, whereas animals introduce their food via their mouth into their stomach by means of voluntary motion.[61]

In conclusion: Blumenbach delineates the three kingdoms of nature by distinguishing natural bodies from artificial bodies, by distinguishing organic from inorganic bodies, and by distinguishing plants from animals. He distinguishes between organic and inorganic bodies by specifying various observable traits and functions of organisms: propagation, nutrition, and growth.[62] Teleology also

[59] Cf. Blumenbach 1782, 3.

[60] Blumenbach 1825, 3.

[61] Ibid, 2–3. Cf. Blumenbach 1782, 3–4.

[62] The role of these empirical criteria in delineating the domain of biological sciences is not always recognized. In the next paragraph, we will see that Kant also appeals to these criteria. Quarfood does not consider these criteria in detail. Hence, he has difficulties in accounting for how we delineate the domain of biology from those of other sciences (Quarfood 2006, 739–740). Ginsborg (2001, 2004), argues that it is merely the mechanical inexplicability of organisms that leads us to think of them as natural purposes. However, not only organisms are mechanically inexplicable.

figures heavily in Blumenbach's distinction between organized and inorganic bodies. The explanation of the growth and propagation of organisms requires reference to their purposive organization. This is not the case if we wish to explain the growth and origin of minerals. In addition, the traits peculiar to organisms are not explicable in terms of mechanical forces alone, which leads us assume the existence of vital forces peculiar to the domain of organic nature (this may be construed as an ontological conviction).

How do Blumenbach's views relate to Kant? Like Blumenbach and many other eighteenth-century biologists,[63] Kant took propagation, nutrition, and growth to be distinguishing features of organisms (see below). Regeneration, i.e., the capacity to regenerate injured or lost parts, was also frequently cited as a distinguishing trait of organisms.[64] In addition, Blumenbach gave clear expression to the idea that in biology we presuppose that organisms have a purposive structure adapted to performing functions such as propagation, nutrition, and growth. Kant adopts a similar idea. In the third *Critique*, he praises Blumenbach for *beginning* all physical explanations of organic formations with *organized matter*, i.e., in biology we presuppose some original purposive organization.[65] In these respects, Kant's views are quite similar to those of Blumenbach.

However, Kant's views *differ* from those of Blumenbach insofar as the concept of a vital force does not have a significant function in the third *Critique*. Kant refers to Blumenbach's *Bildungstrieb* and accepts its existence, but vital forces hardly play any significant role in his discussion of organisms. Although Kant assigns *teleology* a crucial role in determining the object or domain of biology, he does not do so in terms of the notion of a vital force (at least in the third *Critique*). Rather, we delimit the domain of biology by conceptualizing organisms as natural purposes. In a nutshell: whereas Blumenbach interprets the distinction between organic and inorganic bodies *ontologically*, i.e., in terms of the distinction between vital and physical-mechanical forces of nature, Kant argues that this distinction is made on methodological grounds, i.e., by conceptualizing some objects of nature (in contrast to others) in teleological terms.

Hence, this criterion is not sufficient for determining the domain of biology. Finally, Kreines (2005) argues that these empirical features are not related to Kant's analysis of 'natural purpose'. I take the opposite view. Zammito 2006, 757–759, provides a brief but useful account of these empirical criteria. I will discuss his position in the following.

[63] McLaughlin 2001, 173–179.

[64] Blumenbach 1782, 20–22.

[65] AA 5: 424. Here, Kant may be referring to Blumenbach's *Über den Bildungstrieb* (1781[1], 1789[2]) or to earlier editions of the *Handbuch der Naturgeschichte*. In the *Handbuch* of 1782, the idea that organisms must have a purposive structure adapted to performing functions such as reproduction and nutrition and growth (discussed above) is also clearly expressed. Cf. Blumenbach 1782, 2–3.

5.4 Kant on Propagation, Growth and Nutrition, and Self-Maintenance: Subordinating Mechanism to Teleology

In the Analytic of Teleological Judgment, Kant takes plants and animals to be organized beings. Organized beings must be thought of as natural purposes and therefore "provide natural science with the basis for a teleology".[66] Kant's most detailed account of the concept of natural purpose is given in §§64–65 of the Analytic of Teleological Judgment. In §64, he provisionally characterizes natural purposes as follows:

> I would provisionally say that a thing exists as a natural end **if it is cause and effect of itself** (although in a twofold sense); for in this there lies a causality the likes of which cannot be connected with the mere concept of a nature without ascribing an end to it, but which in that case also can be conceived without contradiction but cannot be comprehended. (AA 5: 370–371)

Kant acknowledges that the phrase 'cause and effect of itself' is a somewhat improper expression.[67] The discussion of the concept of natural purpose in §65 suggests that this phrase is meant to capture the idea of a reciprocal causality between a whole and its parts.[68] If (a) a whole is taken as the cause of its parts, and (b) the parts are the cause of the whole, the whole can be said to be cause and effect of itself. In thinking of the reciprocal causality between a whole and its parts, we think of a causal nexus that carries with it "descending as well as ascending dependency",[69] i.e., we take α (the parts) to be the cause of effect β (the whole) while also taking β to be the cause of α.

Note, however, that Kant denies that a whole can be the real cause of its parts. For it is "entirely contrary to the nature of physical-mechanical causes that the whole should be the cause of the possibility of the causality of its parts […]."[70] Hence, organisms, which seem to exhibit a reciprocal causation between whole and parts, necessitate the appeal to the connection of *ideal* causes, i.e., the *nexus finalis*.[71] This allows us to treat the *representation* of a whole as the cause of its parts, which conversely are the efficient causes of the whole.

In the previous chapter, we saw that in the rationalist tradition the idea of backwards causation was neutralized by reducing backwards causation to intentional causation. Kant adopts a similar perspective. We can say that an organism or whole (B) is the *final cause* of its parts (A), and thus say that the existence of parts (A) depends on (B), because we take (B) to be the object of a *representation* that determines the form

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[66] AA 5: 375–376.

[67] AA 5: 372.

[68] McLaughlin has stressed the importance of understanding organisms in terms of this idea. McLaughlin 1990, 18, 46–51. Cf. Guyer 2001, 264–267; Quarfood 2006, 737–738.

[69] AA 5: 373.

[70] AA 20: 236.

[71] AA 5:376–373. Kant's construal of the *nexus finalis* as a connection of ideal causes makes perfect sense against the background of Baumgarten's ontological conception of the *nexus finalis*. See discussion in the previous chapter.

and connection of the parts (A).[72] Of course, for Kant this representation is not the actual cause of the organisms. This would be to introduce intentional causality in nature and to affirm that organisms are objects are design. Hence, we only treat organisms as being *as if* designed. It is by *analogy* with human purposive action, i.e., action in accordance with representations, that we construe organisms as natural purposes.

In order to elucidate the claim that organisms are conceived as 'cause and effect of itself', Kant cites several features of organisms. These features include *propagation*, *growth*, the capacity for *nourishment* and *self-preservation*. Recall that Blumenbach specified these traits in order to delineate the domain of natural history. Kant treats these features as various modes of generation (*Zeugung*).[73] Here, Kant might have followed Blumenbach. In his first published article on the *Bildungstrieb*, Blumenbach treated generation (propagation), nutrition, and reproduction (regeneration) as similar capacities:

> Generation, nutrition and regeneration are at bottom mere modifications of one and the same force, which in the first case builds, in the other case maintains, and in the third case repairs! In other words: nutrition is a universal, yet imperceptible, continued generation, whereas reproduction is a repeated, yet merely partial generation. A light spread on one of these three would with certainty also illuminate the other two at the same time. (Blumenbach 1780, 252)[74]

Kant's claim is that these traits *lead us* to think of organisms as cause and effect of themselves. In order to understand this claim, I will treat these traits in turn.

In discussing these traits, I will also return to the topic of mechanical explanation. As we have noted, several commentators interpret these organic traits to be mechanically inexplicable. Thus, John Zammito argues that organisms are mechanically inexplicable *tout court*.[75] Hannah Ginsborg argues that the functioning of organisms resists mechanical explanation. She further states that biological regularities do not hold in virtue of regularities of physics and chemistry and strongly dissociates the domain of physics and chemistry on the one hand and biology on the other.[76] I argue that Kant's discussion of the distinguishing traits of organisms does not support these views. The functioning of organisms can partly be explained mechanically and these explanations can invoke chemical regularities, which may be taken to provide *partial grounds* for explanations in biology. Kant's discussion of the traits of organisms is consistent with his conception of proper method in biology, which consists in the subordination of mechanism to teleology.

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[72] AA 5: 373.

[73] Kant states that growth is to be "regarded as equivalent, although under another name, with generation." AA 5: 371.

[74] Original: "[…] Zeugung, Ernährung und Wiederersetzung im Grunde bloße Modificationen einer und eben derselben Kraft sind, die im ersten Fall baut, im andern unterhält, im dritten repariert! Mit andern Worten: Nutrition ist eine allgemeine, aber unmerklich continuirte-, Reproduction hingegen, eine wiederholte aber nur partielle Generation. Ein licht über eine von diesen dreyen verbreitet, würde zuverlässig auch die andern beiden zugleich erhellen."

[75] Zammito 2006, 758–759.

[76] Ginsborg 2001, 246.

5.4.1 Reproduction and Species

To elucidate the idea of a natural purpose, Kant cites the capacity of organisms to reproduce or propagate themselves and thus to preserve the species to which they belong. Taking the example of a tree, he states:

> First, a tree generates another tree in accordance with a known natural law. However, the tree that it generates is of the same species and so it generates itself as far as the **species** is concerned, in which it, on the one side as effect, on the other as cause, unceasingly produces itself, and likewise, often producing itself, continuously preserves itself, as species. (AA 5: 371)

Kant's remarks are far from clear. How is this example supposed to elucidate the idea that a natural purpose is cause and effect of itself? Paul Guyer describes Kant's example as most opaque.[77] John Zammito objects that in this example Kant slides between the type or species tree and its individual tokens.[78] I think both criticisms are justified. In the following, I will try to provide an account of Kant's example that sheds light on his position.

Kant's views become a little bit clearer if we take into account a possible source of his species concept. In his 1775 *Von den verschiedenen Racen der Menschen*, Kant adopts Buffon's species concept according to which animals that can produce fertile young with one another "belong to the same physical species", irrespective of any difference in form between these animals.[79] According to Kant, the division into species in the animal kingdom is based on a law of *common propagation*, i.e., we divide animals into species by taking reproduction as our criterion of species division. Note that Kant only applies Buffon's rule to animals. However, this rule can of course also be applied to the vegetable kingdom. Buffon himself applied his species definition to the vegetable kingdom (see below). Moreover, as Mayr has noted, already toward the end of the seventeenth century John Ray argued that variants of plants are members of a species if they sprung "from the seed of one and the same plant".[80]

The foregoing suggests that Kant accepted the genealogical species concept of Buffon. This would imply that he does not take species to be universals (e.g., types, classes or sets). According to Buffon's views, species are sequences of reproducing

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[77] Guyer 2001, 264.

[78] Zammito 2006, 757. Possible historical sources of Kant's remarks have been discussed by Ingensiep and Cheung. Ingensiep has argued that Kant stress on the capacity of the species tree to preserve itself via reproduction is reminiscent of the teleological function traditionally assigned to the Aristotelian *vis generativa* (a partial function of the *anima vegetativa*), which was taken to enable the preservation of the form of a species. Ingensiep 2009, 95–96. Cheung has argued that Kant's position can be traced to Bonnet's views on palingenesis. Cheung 2009, 32–34. In the following, I will reconstruct Kant's position in light of Buffon's species concept.

[79] AA 2: 429.

[80] Mayr 1987, 150–151. Mayr emphasizes the similarities between Ray's species concept and that of Buffon.

organisms connected by genealogy.[81] As Philip Sloan has often stressed,[82] Buffon defines a species as follows:

> […] It is neither the number nor the collection of similar individuals, which form the species, but the constant succession and renewing of these individuals which constitute them; for, a being which existed for ever would not be a species. Species then is an abstract and general term, the meaning of which can only be determined on by considering nature in the succession of time, and in the constant destruction and renewal of beings. It is by comparing the present state of nature with that of the past, and actual individuals with former, that has given us a clear idea of what is called species. (Buffon [1753] 1792, 187)

Hence, a species may be described as an *individual* historical entity rather than as a class, type, or set.[83] The above account of species leads Buffon to apply the term 'species' only to vegetables and animals, and not to minerals:

> Species, then, being nothing more than a constant succession of individuals alike, and which reproduce, ought only to extend to animals and vegetables, and that it is only an abuse of the term, and confounding ideas when used to point out the different kinds of minerals. (Buffon [1753] 1792, 189)

Animals and vegetables reproduce. Minerals do not. Hence, the term 'species' applies to animals and vegetables, but does not apply to minerals. Recall that when distinguishing minerals and organisms, Blumenbach also referred to the fact that minerals do not reproduce (in the strict sense of the term).

In discussing the generation of a tree, Kant associates the idea of a species with the idea of the continual propagation of organisms. Kant may thus be taken to argue at the level of species understood in Buffon's sense, i.e., an individual lineage of reproducing organisms. He emphasizes that a tree, by reproducing itself, helps to preserve the species, which, if we adopt Buffon's species concept, must be understood as a sequence of organisms related through genealogy. Hence, the generation of a single organism helps to preserve the species, which, understood as a reproductive sequence of organisms, in turn makes the generation of individual organisms possible. Kant further construes the continual preservation of the species as the *purpose* of reproduction. As such, reproduction is understood in *teleological* terms.

Recall that for Kant a thing exists as a natural purpose if it is 'cause and effect of itself'. For Kant the phrase 'cause and effect of itself' is often employed to capture the idea of a reciprocal dependency between a whole and its parts. This idea can be related to Buffon's species concept. Buffon defined species as wholes.[84] Hence, it seems reasonable to construe organisms as parts of the species (whole). This allows

[81] On Buffon's species concept, see Sloan 1976, 2008; Gayon 1996, 220–227; Grene and Depew 2004, 79–82.

[82] Sloan 1976.

[83] Grene and Depew 2004, 80.

[84] Gayon 1996, 221–222, 224. In modern debates on the (ontological) status of species, the view that species are individuals is often taken to imply that the relation between an organism and its species is a part-whole relation, as opposed to member-class relation. Cf. Ereshefsky 2010 for an overview of this debate.

us to understand why Kant seems to understand the preservation of species through reproduction as exhibiting a reciprocal dependency between whole and parts. One the one hand, a species (whole) is constituted by its parts, i.e., organisms related through genealogy. Hence, the parts determine the whole. On the other hand, the species, understood as an individual lineage, makes possible the coming to be of new organisms (parts) that preserve the species. Hence, the whole determines the parts. Insofar as Kant conceives of the parts (organisms) to be determined by the whole (species), he attributes to the parts the *purpose* of preserving the whole (species). In this manner, a teleological description of reproduction is introduced: reproduction *serves* the preservation of the species.

Kant does not claim that the reproduction of organisms is mechanically inexplicable. However, his account of reproduction *is* based on the idea that we can only make sense of reproduction if we already presuppose the existence of species (lineages of reproducing organisms). This is implied by the idea that the species (whole) *makes possible* the coming to be of new organisms (parts). In the terms of Blumenbach, the reproduction of organisms "presupposes other similar bodies, to which they owe their being."[85] As we have seen, it is this feature of the reproduction of organisms that distinguishes organisms from inorganic bodies (e.g., minerals). Hence, Kant's account of reproduction excludes the possibility that mere matter gives rise to organisms. In investigating the reproduction of organisms, we must presuppose some *original organization*. In the present context, this is to say that we presuppose that only organized bodies can produce organized bodies. However, this does not imply that mechanical explanations are of no use whatsoever in the investigation of organic reproduction.

Kant himself stresses this point in §81 of the Methodology of Teleological Judgment, in which he praises Blumenbach's epigenetic theory of generation framed on the basis of his notion of the *Bildungstrieb*. This theory is praised because it adopts the proper method of biological inquiry, namely: the subordination of mechanism to teleology. Kant claims that Blumenbach rightly rejects the idea that "life should have arisen from the nature of the lifeless", while also correctly stressing the importance of providing mechanical explanations in biology.[86] Hence, Kant attributes mechanism and mechanical explanation an important role in coming to terms with phenomena of organic generation.

Kant makes the same point in §80 of the Methodology of Teleological Judgment, in which he discusses a possible mechanical account of similarities among members of a species. According to Kant, the production of a manifold of species may allow of mechanical explanation. However, he argues that this production of species (and ultimately the origin of species) cannot be understood *materialistically*, i.e., we cannot see how raw matter could have formed organized beings.[87] We must always subordinate mechanism to teleology or presuppose an inscrutable principle of original organization. In making these claims, Kant rejects a materialistic interpretation of mechanism, while also consistently emphasizing that in biology we must always

[85] Blumenbach 1825, 2; Cf. 1782, 2.

[86] AA 5: 424.

[87] AA 5: 418–419.

strive to give mechanical explanations of phenomena. This position is fully consistent with his remarks on the reproduction and preservation of species analyzed above.

5.4.2 Growth and Nutrition

After discussing generation and the preservation of species, Kant discusses the capacity of organisms to grow via nutrition. The growth of a tree is construed as a form of self-generation of the individual:

> Second, a tree also generates itself as an **individual**. This sort of effect we call, of course, growth; but this is to be taken in such a way that it is entirely distinct from any other increase in magnitude in accordance with mechanical laws, and is to be regarded as equivalent, although under another name, with generation. (AA 5: 371)

Recall that Blumenbach cited growth and nutrition in order to differentiate between organisms and inorganic bodies. In particular: plants and animals nourish themselves and grow through the assimilation of external substances, i.e., they grow from within (by *intussusceptio*), whereas minerals grow through the aggregation of particles from without. Kant reasons in a similar way. He stresses that the growth of a tree occurs through a specific capacity for nourishment. With respect to a tree Kant notes:

> This plant first prepares the matter that it adds to itself with a quality peculiar to its species, which could not be provided by the mechanism of nature outside of it, and develops itself further by means of material which, as far as its composition is concerned, is its own product. For although as far as the components that it receives from nature outside of itself are concerned, it must be regarded only as an educt, nevertheless in the separation and new composition of this raw material there is to be found an originality of the capacity for separation and formation in this sort of natural being that remains infinitely remote from all art […]. (AA 5: 371)

Kant's remark that organic growth is distinct from any other increase in magnitude in accordance with mechanical laws, and the remark that the matter that a tree adds to itself in order to grow cannot be provided by the mechanism of nature outside of it, have led some interpreters to think that the nutrition and growth of organisms resists mechanical explanation.[88] This is the position taken by Zammito.[89] Marcel Quarfood seems to adopt a similar position, arguing that Kant remarks concerning nutrition and growth highlight a vitalist strand in his thought.[90]

I think these interpretations point to the wrong direction. First, they seem to be inconsistent with Kant's insistence that in biology we must always strive to provide mechanical explanations of organic phenomena. Second, Kant can simply be taken to distinguish between organic growth (growth from within) and the growth of minerals (growth from without through aggregation). As we shall see, the former type

[88] Cf. the authors mentioned in the Introduction to this chapter.

[89] Zammito 2006, 758.

[90] Quarfood 2006, 743.

of growth can be understood (at least in part) in terms of chemical processes. Kant can thus allow for the possibility that nutrition and growth can (and should) be explained *mechanically* (at least in part).[91]

In order to understand Kant's position on growth and nutrition, we may recall the position of Blumenbach. According to Blumenbach, plants and animals grow from within (by *intussusceptio*), i.e., through the assimilation of external substances. In contrast, minerals grow from without through the aggregation of particles. This manner of characterizing the nourishment and growth of organisms is common in the eighteenth century[92] and also adopted by Kant. In the first *Critique*, Kant states that an animal body grows "internally (*per intus susceptionem*) but not externally (*per appositionem*)".[93]

How should we understand the notion of *Intussusception*? Kant introduces the term *Intussusception* (*intus*, inside; *suscipio*, to take up) in the context of a discussion of *chemistry*. In the General Remark to Dynamics of the *Metaphysische Anfangsgründe*, this term is applied to what Kant calls chemical penetration, a form of chemical dissolution:

> A dissolution of specifically different matters by one another, in which no part of the one is found that would not be united with a specifically different part of the other, in the same proportion as the whole, is *absolute dissolution*, which can also be called *chemical penetration*. (AA 4: 530)

The notion of chemical penetration applies to chemical compounds construed as completely homogeneous and uniform mixtures of ingredients. As Kant explains, chemical penetration does not obtain when parts of a dissolved matter remain separate small clots (moleculae).[94] Rather, it obtains when dissolution proceeds "until there is no longer any part that is not made up of the solvent and the solute, in the same proportion in which the two are found in the whole".[95] Hence, both the solvent and the solute fill the whole space constituting the volume of a mixture as a continuum. In this manner, chemical compounds are construed as homogeneous and uniform mixtures that occupy a space through *intussusception*.[96]

As Martin Carrier has explained, Kant's conception of chemical compounds must be read as a rejection of corpuscularian accounts of chemical compounds, according to which the ingredients of a compound are contained separately in the compound and the latter is conceived of a particle aggregate kept together by geometrical fit.[97] Hence, on the corpuscularian account chemical compounds are conceived of as mechanical *aggregates* of corpuscles. These compounds are (we may say) aggregated

[91] Although it must of course be emphasized that Kant and his contemporaries had very little knowledge of the mechanisms involved in processes such as nourishment and growth.

[92] Cf. Gehler 1798–1801, Bd. 3, 388–389.

[93] *KrV*, A 833/B 861.

[94] AA 4: 530. In the passage under consideration, Kant argues for the possibility and intelligibility of chemical penetration.

[95] Ibid.

[96] AA 4: 531.

[97] Carrier 2001a, 223.

per appositionem. However, this is not the conception of chemical compounds that Kant adopts, who treats the latter as homogeneous and uniform mixtures filling a space through *intussusception*.

Let us now return to Kant's remarks on the growth and nutrition of organisms. Kant takes organisms to nourish themselves and grow internally through *intussusception*. Given the chemical context in which Kant introduces this term, it is possible that he allows for the possibility that chemical processes (partly) explain processes such as growth and nutrition. When Kant argues that the growth of organisms is distinct from the increase in *magnitude* in accordance with mechanical laws, I think he simply aims (similar to Blumenbach) to distinguish between the growth of organisms and the growth through the aggregation of separate parts (as, e.g., minerals can be said to grow). This does not entail, however, that we cannot provide a (partial) mechanical explanation of processes such as organic growth.

We can increase our understanding of Kant's position by taking into account some of the experimental and chemical research on the physiology of plants in Kant's time. If we consider J.S.T. Gehler's *Physikalisches Wörterbuch*, it becomes clear that from the 1780s onwards considerable scientific discussion existed concerning the phenomena of organic nutrition and growth. In his article on plants,[98] Gehler discusses the research of the physicist Senebier as reported in his *Recherches sur l'influence de la lumière solaire pour metamorphoser l'air fixe en air pur par la vegetation* (1783). According to Gehler, Senebier developed the theory that the growth of plants involves the decomposition of carbon dioxide gas (fixed air, *l' air fixe*) into carbon, which is retained in the plant and is used for the generation of parts of plants (such as oils, resins, etc.) and oxygen, which is exuded as oxygen gas (oxygen base plus caloric) under the influence of light. Gehler states that this theory has sound experimental support.[99] This does not mean that it was accepted in its details. For example, Gehler also describes the theory developed by C. Girtanner in his *Anfangsgründe der antiphlogistischen Chemie* (1792). In contrast to Senebier, Girtanner argued that the largest part of oxygen gas produced by plants in sunlight is due to the decomposition of *water*, and that the generation of the parts of plants (oils, resins, and other components of the plant) is the result of the combination of hydrogen and carbon.[100]

The above theories elucidate Kant's claim that plants develop itself (*ausbilden*) by means of material which as far as its *composition* (*Mischung*) is concerned is its own product. Scientists like Senebier and Girtanner recognized that the materials providing nutrients for plants, e.g., carbon, hydrogen, water, are drawn from the

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[98] J.S.T. Gehler 1798–1801, Bd 5, 683–695. I have adopted a late edition of Gehler's dictionary because it contains extensive discussion of nutrition in plants. Kant was not aware of this edition when writing the third *Critique*, nor of the research of Girtanner discussed in this edition. Gehler also employs the anti-phlogistic chemical nomenclature, which Kant adopted in the course of the 1790s. However, Gehler's discussion summarizes developments in the 1780s and 1790s. Moreover, Kant was likely aware of some of the research of Senebier, which is discussed in Karsten's *Anleitung zur gemeinnützlichen Kenntniß der Natur* 1787. AA 29: 573–576.

[99] Gehler 1798–1801, Bd 5, 683–684.

[100] Gehler 1798–1801, Bd 5, 686.

realm of inorganic nature, i.e., from inorganic compounds such as carbon dioxide gas. Kant also emphasizes this point, stating with respect to a tree that “as far as the components that it receives from nature outside of itself are concerned, it must be regarded only as an educt”.[101] In other words, these components are preexisting materials given *from without*. However, plants decompose inorganic compound materials, retain certain material elements that chemically combine with other elements, which in turn leads to the generation of parts of plants, e.g., oils as compounds of carbon and hydrogen. The chemical composition of these parts is not given, but newly produced, i.e., produced *from within*. Similarly, Kant claims that the composition of the material by which plants develop themselves is produced by the plant itself. In this sense, a plant (tree) is not an educt but (its own) product.

As John Zammito has emphasized, the distinction between *educt* and *product* is crucial to Kant’s understanding of organisms.[102] In Kant’s lectures on metaphysics, a distinction is made between matter *tanquam eductum* and matter *tanquam productum*.[103] In matter insofar as it is an educt, matter has only taken on new form. In matter insofar as it is a product, new parts are produced. Kant seems to treat (the parts of) plants and organisms as matter *tanquam productum*. For our present concerns, it is important to stress that the distinction between matter as educt and matter as product is treated as a distinction made *within* chemistry. This distinction is not meant to distinguish chemical processes from non-chemical processes. Kant seems to take the *chemical composition* of the material by which plants develop to be their own *product*. This supports our suggestion that Kant took chemical processes to be crucial to our understanding of organic growth and nutrition and that these phenomena must be explained (at least in part) in terms of such processes. Like Blumenbach, Kant distinguishes growth via nutrition of organisms (growth from within by the production of new organic parts) from growth of inorganic bodies such as minerals (growth via aggregation). But this does not imply that mechanical explanations are useless in discussing organic growth and nutrition. Chemistry provides partial grounds for giving explanations of such processes as nutrition and growth.

How does the growth of organisms elicit a teleological description? Kant’s treatment of the capacity of plants to grow highlights that we conceptualize organisms as objects in which a reciprocal dependency obtains between parts and whole. What is at issue is the assimilation and transformation of inorganic compounds by organisms (wholes), which results in the generation of organic *parts* (oils, resins, sugars), which in turn contribute to the growth of the whole organism. The apparent influence of the whole plant on its parts can be understood teleologically by taking the growth of the whole to be a purpose of the plant. In this sense, teleology allows us to provide an adequate description of the phenomena of nutrition and growth.

Moreover, if we construe nourishment and growth as purposes, the mechanisms enabling the obtainment of nutrition and growth are also viewed from a teleological perspective: they are construed as means serving a purpose. In turn, nourishment

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[101] AA 5: 371.

[102] Zammito 2003, 90–92, 2006, 757–758.

[103] AA 28, 684; AA 29: 760–761. Cf. Zammito 2003, 90–91.

and growth may be construed as means that enable the preservation of individual organisms, just as reproduction is a means for the preservation of the *species*. This is precisely what Blumenbach does in discussing the nutrition and growth of organisms. He introduces the *Bildungstrieb* while emphasizing that nutrition and growth enable the *preservation* of individual organisms.

In the first edition of his *Über den Bildungstrieb und das Zeugungsgeschäfte* (1781), Blumenbach notes that organic bodies are characterized by continuous change and renewal.[104] The fluid parts of organic bodies evaporate and the solid parts wear away. However, the continual loss of organic parts is balanced by the continuous renewal of these parts aided through the process of nutrition. There is a delicate equilibrium between the continual loss and renewal of organic parts, and for this reason Blumenbach posits the existence of the *Bildunsgtrieb*: a formative drive that bestows upon organisms their form, guides processes such as nutrition and growth, and thus helps to *preserve* organic form. Teleology allows us to describe how various processes enable (are adapted to) the preservation of individual organisms. Kant would not object to this use of teleology (abstracting from the question of whether he allowed for the existence of vital forces). For Kant, teleology is a *presupposition* of biological inquiry: mechanisms are construed as means for a certain purpose. However, Kant always stresses that we must also specify mechanisms (e.g., chemical processes) involved in organic processes such as nutrition and growth. The specification of these mechanisms constitutes the explanatory work of biologists.

5.4.3 Self-Preservation and Regeneration

The final phenomena described by Kant in §64 of the Analytic of Teleological Judgment highlight that the *parts* of organisms are also reciprocally dependent on each other. Kant mentions (a) agricultural grafting and shield budding, (b) self-preservation through the reciprocal dependency of parts, (c) regeneration, and (d) what he calls the "self-help of nature". All of these phenomena elicit a teleological description.[105]

Kant's discussion of (b) self-preservation shows that organisms are taken to exhibit a reciprocal dependency between whole and parts *and* between the parts themselves. Describing a tree, Kant remarks: "one part of this creature also generates itself in such a way that the preservation of the one is reciprocally dependent on the preservation of the others."[106] For example: "the leaves are certainly products of the tree, yet they preserve it in turn, for repeated defoliation would kill it, and its

[104] Blumenbach 1781, 69–73.

[105] In the following, I will abstract from a discussion of (a). For a helpful discussion of (a)–(d), see Ingensiep 2009, 97–98.

[106] AA 5: 371.

growth depends on their effect on the stem."[107] The preservation of the tree (a whole) is dependent on the (proper) functioning of its parts (the leaves), while conversely the parts of the tree are taken to be the product of the whole tree. In addition, the production of the leaves of a tree depends on the proper functioning of the roots, which in turn is dependent on the effect of the leaves on the roots. These various types of reciprocal dependency elicit a teleological description in which the whole or a part is construed as a purpose (final cause).

Kant further cites the capacity of (c) organic regeneration and (d) the "self-help of nature". If an organism is injured, for example, the "lack of a part that is necessary for the preservation of the neighboring parts can be made good by the others". These features of organisms show that the individual parts of organisms can be understood as being reciprocally dependent on each other.[108] Once again, these phenomena are adequately described in teleological terms. The regeneration and self-help of organisms suggest that the parts of organisms are supposed to *preserve* other parts and the whole.

The regenerative powers of organisms were extensively analyzed throughout the eighteenth century. Regeneration played a significant role in debates on preformationism and epigenesis.[109] Blumenbach's theory of the *Bildungstrieb* aimed to provide a proper account of organic regeneration. The *Bildungstrieb* was taken as a cause of the self-maintaining capacity of organisms.[110] Blumenbach contrasted his theory to existing preformationist accounts of organic regeneration. The latter explained the regeneration of organic parts by postulating the existence of a variety of encased germs distributed throughout the parts of organisms. These germs lie dormant in organisms until external causes trigger them to develop themselves (a rather *ad hoc* account of regeneration according to Blumenbach).

It is clear that Kant interprets organic regeneration in teleological terms. Can we explain organic regeneration mechanically? Kant is silent on the issue. Recall, however, that according to Kant only a mechanical account of such processes allows us to explain how they work. In the previous chapter, we have discussed Kant's lectures on metaphysics. There, it was claimed that a proper scientific answer to the question 'why does a wound in a body heal?' must appeal to efficient, mechanical causes.[111] Of course, Kant had no knowledge of these causes. However, his views on biological method imply that we must always aim to specify mechanisms.

In conclusion, the study of Kant's views on reproduction, nutrition, growth, and regeneration provides the following results. Like most eighteenth-century philosophers and biologists, Kant takes these traits to be characteristic of organisms. These traits allow Kant to distinguish between organic and inorganic bodies. The traits are described teleologically, i.e., when analyzing these traits we represent the whole as determining the parts. Teleology is a fundamental presupposition of biological

[107] Ibid.

[108] AA 5: 372.

[109] Lenoir 1981; Richards 2000, 16–20; Zammito 2006, 758.

[110] Cf. Blumenbach 1781, 73–85.

[111] AA 28: 574.

inquiry. The structure of organisms is construed as being adapted to the performance of functions such as reproduction, nutrition, growth, etc. In addition, mechanisms involved in such organic processes are understood teleologically (as means to an end). However, teleology is not explanatory. Explanations in biology are mechanical explanations. The explanatory work of biologists consists in specifying the mechanisms involved in organic processes and showing how these mechanisms work. Here, we can also invoke physical or chemical laws or regularities (e.g., in explaining nutrition and growth in plants), which provide partial grounds for explanations in biology. The proper method of biology thus consists in subordinating mechanism to teleology.

5.5 Kant on Purpose and Natural Purpose: Determining the Proper Method of Biology

After discussing the reproduction, growth, nutrition, and self-preservation of organisms, Kant proceeds to give a general account of the concept 'natural purpose' in §65 of the third *Critique*. In this well-known section,[112] Kant specifies two conditions that must be satisfied in order for a thing to be a natural purpose. The first condition (i) states that "its parts (as far as their existence and their form are concerned) are possible only through their relation to the whole".[113] The second condition (ii) states that the parts of a natural purpose must produce a whole out of their own causality.

We have encountered the relevance of condition (i) in our discussion of organic traits and processes above. The possibility of the *reproduction* of organisms (*parts*) presupposes the species as a *whole*. The assimilation and transformation of inorganic compounds by organisms, resulting in the generation of new organic *parts*, presupposes an organic structure (*whole*) that is adapted to assimilating nutriments. In both examples, parts are taken to be possible by virtue of their relation to the whole. Hence, Kant's general discussion of the concept 'natural purpose' and the preceding discussion of observable organic phenomena are intimately related.[114]

Kant notes that not only organisms but also artifacts satisfy condition (i). An artifact is the product of a rational cause (the artificer) who produces this artifact on the basis of an idea. For example, the watchmaker produces and combines springs, gears, and so forth on the basis of some blueprint. Hence, we can say that the existence and form of the parts of the watch are possible through their relation to the whole.

[112] For clear accounts, see for example McLaughlin 1990, 49–51; Ginsborg 2001; Grene and Depew 2004, 98–103.

[113] AA 5: 373.

[114] Hence, I cannot follow Kreines 2005, 280, who strongly dissociates Kant's analysis of 'natural purpose' in §65 from Kant's discussion of the characteristic features of trees in §64 of the third *Critique*.

Although both organisms and artifacts satisfy condition (i), organisms are not artifacts. Kant's condition (ii) stresses that organisms are *natural* purposes and thus distinct from artifacts.[115] If a thing is a *natural* purpose, it is required that its parts determine the form of each other and that the parts bring about the whole. Kant expresses condition (ii) by stating that the parts of a natural purpose reciprocally produce each other and thus produce a whole out of their *own causality*.[116] Natural purposes (organisms) are *self-generating* natural objects.

All of the organic phenomena that Kant discusses, i.e., generation, nutrition, growth, etc., are meant to capture the idea that organisms are *self-generating* natural objects. As such, these phenomena elucidate condition (ii). The reciprocal dependency among the parts of organisms (natural purposes) leads us to consider these parts as being determined by the idea of the whole. However, this idea is not the *cause* of the form and combination of the parts of a natural purpose, for that would imply that a natural purpose *is* an artifact. Rather, the idea of a whole is a ground for cognizing (*Erkenntnißgrund*) the systematic unity of the parts of natural purposes.

Zammito aptly summarizes Kant's views on the reciprocal dependency of the parts of organisms, noting that "what Kant highlights in organic systems is *persistence* and *plasticity* in securing system-maintenance".[117] These features are manifest, for example, in the capacity of organisms to regenerate lost parts or in what Kant calls the self-help of nature (see Sect. 5.4.3). Insofar as these features show that the properties and maintenance of the parts of an organism are dependent on (all of) its other parts, they lead us to construe the parts of organisms as being dependent on the whole. As we have noted in the third chapter, the fact that Kant takes the existence and properties of the parts of organisms to be dependent on the other parts (the whole) is sometimes taken to imply that organisms are mechanically inexplicable. This interpretation is also the basis for Zammito's claim that organic phenomena lie beyond the scope of scientific explanation. However, while it is true that Kant takes the properties of the parts of an organism to depend on the properties of the other parts (the whole), Kant himself does not infer from this that organisms lie "beyond the pale of empirical science".[118] Rather, Kant argued that organic phenomena cannot be explained in terms of mechanical or physical laws *alone*. In §65 of the third *Critique*, Kant notes:

> An organized being is thus not a mere machine, for that has only **motive** power, while the organized being possesses in itself a **formative power**, and indeed one that it communicates to the matter, which does not have it (it organizes the latter): thus it has a self-propagating formative power, which cannot be explained through the capacity for movement alone (that is, mechanism). (AA 5: 374)

The self-generating or self-formative nature of organisms cannot be explained through mechanism *alone*. Although mechanism is not sufficient for explaining the

[115] AA 5: 373.

[116] AA 5: 373.

[117] Zammito 2006, 758.

[118] Zammito 2012, 125.

self-organizing nature of organisms, it nevertheless plays a crucial role in our understanding of the nature of organisms, as I have argued in the previous section.

Recall that Kant illustrates the self-organizing nature of organisms by discussing the reproduction, nutrition, growth, and regeneration of organisms. The proper scientific method of investigating these phenomena consists in the subordination of mechanism to teleology. Thus, in investigating how plants nourish themselves and grow, we presuppose that plants have a structure adapted to performing the functions required for obtaining nutrition and growth. This presupposition makes sense in light of Kant's view that the particular purposive structure of organisms is mechanically inexplicable. Nevertheless, if we base our inquiry on the (teleological) presupposition that plants have a structure adapted to obtaining nutrition and growing, we can (and should) consequently investigate the mechanical processes involved in obtaining nutrition and growing. This type of reasoning can for example have the following form:

(i) We assert that a tree ought to have the capacity for obtaining nutrition via the transformation of inorganic into organic compounds, i.e., we construe the obtainment of nutrition as a *purpose* of the whole. This leads us to conclude that a tree *must* have parts enabling the obtainment of nutrition and to subsequently identify those parts on the basis of observation.
(ii) This type of reasoning allows us to conclude *that* trees must have parts enabling the transformation of inorganic compounds (e.g., carbon dioxide) into organic compounds (e.g., oils, resins, sugars, etc.). In this manner, the purpose attributed to organisms functions as a *ground of cognition*. However, purposes provide no insight in the *objective grounds* (causes) that govern the obtainment of nutrition and growth. In order to cognize these objective grounds, the physiologist must specify the relevant parts and specify the mechanical processes involved in nutrition and growth, e.g., the chemical processes involved in the transformation of inorganic compounds into organic compounds. Purposes ascribed to organisms direct the search for such mechanical processes and in this sense have a heuristic function.[119] However, only cognition of the relevant mechanical processes allows us to provide proper explanations in biology.[120]

The procedure above illustrates how we subordinate mechanism to teleology in biology. Note that if we adopt this method we follow the analytic/synthetic method. We ascribe purposes or effects to wholes and try to discover the causes of these effects. Hence, we reason analytically from effects to causes. We subsequently try to find a mechanical explanation of these effects, i.e., we reason synthetically from objective grounds or causes to effects. In this respect, the methodological structure of biology is not different from that of other doctrines or sciences.

[119] "No one has doubted the correctness of the fundamental principle that certain things in nature (organized beings) and their possibility must be judged in accordance with the concept of final causes, even if one requires only a **guideline** for coming to know their constitution through observation […]". AA 5: 389.

[120] Hence, I cannot follow Kreines 2005, 277–281, who argues that through the concept 'natural purpose' Kant introduces an "objective notion of explanation into the analysis of teleology". There are no teleological explanations.

In conclusion, I will relate the interpretation developed to the one developed by Lenoir, who takes Kant to provide a philosophical account of teleomechanism. In construing the method of biology as consisting in the subordination of mechanism to teleology, I agree with the interpretation of Lenoir. When investigating organisms, we presuppose that organisms have a structure adapted to performing organic functions and consequently investigate the mechanisms enabling the performance of these functions. Hence, what is crucial to Kant's views on biological methodology is the combination of mechanism and teleology, as Lenoir has also stressed.[121]

Nevertheless, Lenoir's interpretation also suffers from shortcomings that have been identified by Richards and Zammito. In our description of Blumenbach, we have seen that Blumenbach invoked *vital forces* such as the *Bildungstrieb* in order to determine the domain of natural history. That teleology figures in constructing the domain of the biological sciences is an idea that Kant endorses. However, in the third *Critique* Kant is mostly silent on the topic of vital forces. We are presented with a philosophical analysis of the role of teleology in biology. Kant does not take into account any *ontological* ideas that guide biological inquiry. Moreover, for Blumenbach vital forces have an *explanatory* function in biology: they function as causes of organic phenomena (e.g., the epigenetic development of embryos) and we can frame biological regularities in terms of the actions of vital forces.[122] Whether Kant would have accepted this use of vital forces is unlikely, given his regulative doctrine of teleology and his conviction that explanations in biology must be mechanical.[123] For Kant, teleology provides a *methodological* presupposition that provides a foundation for biological inquiry. Hence, it is no surprise that teleology is construed as a topic of *philosophical critique*, preceding biological scientific investigation.[124]

Lenoir explicates the idea of teleomechanism as follows:

> In order to conduct biological research it is necessary to assume the notion of *zweckmässig* or purposive agents as a regulative concept. […] At the limits of mechanical explanation in biology we must assume the presence of other forces following different types of laws from those of physics. These forces can never be constructed *a priori* from other natural forces, but they can be the object of research. (Lenoir 1989, 29)

The forces Lenoir speaks of are exemplified by Blumenbach's *Bildungstrieb*. Here, we find a complete identification of Kant's analysis in the third *Critique* with the actual biological method of Blumenbach. However, this is to confuse Kant's philosophical analysis of the methodological presuppositions of biological inquiry with specific ontological assumptions made within biological research. Hence, although the term 'teleomechanism' can be applied to Kant, it should be analyzed as above: teleology determines the object of biological investigation, whereas explanations in biology are always mechanical explanations.

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[121] Lenoir 1980, 1981.

[122] Richards 2000; Zammito 2012.

[123] I return to this topic in Chap. 7.

[124] AA 5: 417.

5.6 Construing the Domain of Biology

In the previous sections, we have discussed Kant's views on method in biology. We may now return to the question of how Kant demarcates the domain of biology. For Kant, the method of a doctrine or science determines how we construe its domain. In particular, Kant takes the method of a science to determine how we construe its objects of investigation. A method thus does not have a mere instrumental, but an objective function.[125]

We have encountered this objective function of method in Sect. 5.2. There we have seen that the (mechanical) method of explaining wholes in terms of their parts lead Kant to conceptualize organic bodies as wholes having (relatively) simple parts. Nevertheless, Kant does not make the ontological claim that bodies are actually constituted of simple parts: it is our method that determines how we construe the object of scientific investigation. We will now consider how Kant takes the method of biology, which leads us to subordinate mechanism to teleology, to determine the object of biology.

Similar to Blumenbach, Kant cited reproduction, growth, nutrition, and self-preservation or self-maintenance as features characterizing organized beings. These features function as *empirical criteria* for differentiating between organisms and inorganic bodies. In addition, Kant argues that these features lead us to consider organisms as wholes that are reciprocally dependent on their parts and thus lead us to consider organisms teleologically. It is on the basis of both these empirical criteria *and* our teleological conceptualization of organisms that we specify the object of biological investigation.

In §66 of the Critique of Teleological Judgment, Kant formulates what he calls the principle for judging the internal purposiveness in organized beings. This principle states that an "organized product of nature is that in which everything is an end and reciprocally a means as well",[126] i.e., in organisms we take nothing to be in vain or purposeless. This principle is *occasioned* by scientific observation and experiment. In addition, it functions as an *a priori* maxim because it is taken to apply universally to (the parts of) organisms. This maxim is presupposed, for example, by the anatomists of plants and animals in order to investigate their structure and in order to understand for what reason plants and animals have a particular combination of parts.[127] Hence, the teleological maxim provides a principle underlying the method of the scientific investigation of organisms.

These remarks lead Marcel Quarfood to claim that teleology has an *identificatory* function insofar it demarcates the subject-matter of biological science. This is correct. It must be emphasized, however, that empirical criteria such as reproduction, nutrition, and so forth, fulfill a crucial role in Kant's attempt to demarcate the domain of

[125] I am grateful to Christian Krijnen for emphasizing the importance of this Kantian conception of method. Krijnen 2007a, b.

[126] AA 5: 376.

[127] Ibid.

biology. We do not identify organisms merely on the basis of teleology, but on the basis of empirical features and teleological principles. What, then, is the specific role of teleology in determining the domain of biology?

Kant answers these questions in §66 of the third *Critique*. There, he notes that if we construe organisms as natural purposes, we are led "into an order of things entirely different from that of a mere mechanism of nature".[128] Traditionally, the notion 'order' is employed when discussing the *order of nature*. For example, Wolff construes the notion 'order of nature' as referring to the "rules, in accordance with which changes in nature occur and corporeal things are composed."[129] Hence, we may interpret Kant as affirming that conceptualizing objects as natural purposes implies a distinctive conception of the manner of their composition. This conception differs from the conception we adopt if we conceive of objects in *purely* mechanical terms.

This interpretation is confirmed by an argument in §65 of the Critique of Teleological Judgment. Here, Kant argues that to conceive of a body as a natural purpose implies the following:

> In such a product of nature each part, in so far as it exists through all the others (*durch all übrigen da ist*), is also thought of as existing for the sake of the others and the whole (*um der anderen und des Ganzen willen existierend*), i.e., as an instrument (organ) […] (AA 5: 372, amended)

If we think of an object as a natural purpose, we conceive of two different relations holding between its parts. (i) A (teleological) relation of 'existing for the sake of others', which applies to the parts of both artifacts and organisms. (ii) A relation of 'existing through others', which is particular to the parts of organisms.

Relation (ii) ('existing through others') is understood in terms of efficient causality. Some part y exists through x if x is the efficient cause of y and if x produces y. This characterization allows us to distinguish organisms from artifacts. The parts of, say, a watch do not produce one another and hence they do not *exist* through one another. For this reason we take the efficient cause of a watch to be contained outside of nature.

The relation 'existing for the sake of others' applies to the parts of artifacts and organisms. It is the attribution of this relation to the parts of organisms that leads us to think of "an order of things entirely different from that of a mere mechanism of nature".[130]

To judge that a part x is there for the sake of another part y is a paradigmatic case of a teleological judgment. It is to say that x is a *means* for the *end* y. Kant illustrates this relation by noting that the parts of a watch exist for the sake of (i.e., are instruments for) the motion of other parts.

The parts of an organism can be analyzed in a similar fashion. If we construe a product of nature as a purpose, we make the claim that there is "something that it

[128] AA 5: 376. This passage is also emphasized by Quarfood 2006, 743.

[129] Wolff [1751] 2003, 448–449.

[130] AA 5: 376.

ought to be."[131] For example, if we construe the human eye as a purpose, we judge that it "ought to have been suitable for seeing."[132] This is the purpose that is attributed to the eye as a whole. It is because of the attribution of this particular purpose to the eye, that we can consequently apply the relationship 'exists for the sake of' to the parts of the eye. The attribution of instrumental relations to the parts of an organism (or organs) is relative to the purpose attributed to the whole. In modern terms, we might say that things have a function relative to the goal of a system of which these things are a part.[133]

In this manner, construing natural objects as natural purposes leads to a different order of things from that of a mechanism of nature. If we assign a purpose to a whole, we take the parts to be instruments for obtaining the purpose of the whole. In contrast, if we consider a whole in purely mechanical terms, we do not construe the whole as a purpose nor take the parts to exist for the sake of this purpose. The moon does not orbit in a conic section for the sake of the earth-moon system.

On the present interpretation, Kant takes the teleological maxim, according to which natural objects are judged in accordance with purposes, and the mechanical maxim, according to which natural objects are judged merely in accordance with mechanical laws, as complementary, *regulative* principles governing *method* in natural science.[134] Such an interpretation has also been developed by Breitenbach.[135] If we adopt one of these principles rather than the other, we will ascribe certain properties to our object of investigation rather than others (e.g., teleological relations among the parts of objects construed as natural purposes).

Why is the foregoing relevant to our understanding of the domain of biology? The answer consists in the fact that for Kant the method of a science is one of its fundamental distinguishing features. Consider the following example. If we attempt to differentiate biology from chemistry in terms of different sets of objects studied within these sciences, we would not get very far by virtue of the fact that both sciences are often concerned with the same objects. What distinguishes biology and chemistry are their respective methods. Different sciences can be concerned with the same objects. At the same time, they will be concerned with different *topics* by virtue of the fact that they have different methods. For Kant, the unifying feature of what we now call biological sciences, e.g., (comparative) anatomy, physiology, etc., lies in their method based on the teleological principle, which distinguishes biology from what we may call mechanical sciences in which the teleological maxim does not play any role.

Although teleology fulfils a special role in determining the subject-matter of the biological sciences, it is essential that the teleological maxim is construed as a

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[131] AA 20:240.

[132] Ibid.

[133] This aspect of a theory of function can be found in the works of Hempel 1965 and Nagel 1961. It has recently been revived in the work of McLaughlin 2001.

[134] Cf. Kant's description of both maxims in the Dialectic of Teleological Judgment: AA 5: 386–388.

[135] Breitenbach 2008; Cf. Zumbach 1984.

regulative maxim.[136] Hence, I cannot follow Quarfood when he claims that teleology has a *constitutive function* on the object-level of biological science.[137] Kant argues that if the teleological and mechanical principles are treated as constitutive, they would "contradict one another" and hence one of them would "necessarily be false".[138] To treat these methodological principles as constitutive is to take a stance on ontological issues without proper warrant. The advantage of treating the mechanical and teleological principles as regulative principles is that Kant is not committed to any ontological commitments.[139] The metaphysical questions whether man is merely a chemical laboratory or an object of design is placed beyond the limits of reason.

From Kant's perspective, Quarfood's interpretation boils down to allowing the biologist to make unacceptable metaphysical (ontological) claims. Kant's intention in treating the mechanical and teleological principle as regulative is to *distinguish* between the domains of metaphysics and biology. A different way of putting the point is that although teleology determines biological method, the discussion of the correct interpretation and use of teleology (preceding the use of teleology by the biologist) is a philosophical enterprise. Kant makes this point in §79 of the Methodology of Teleological Judgment, claiming that teleology as a science belongs to the *critique* of the power of judgment.[140] A critique of judgment provides a proper account of teleology. It shows that teleology has a necessary regulative function and as such provides a *philosophical* foundation for the use of teleology within natural science (biology).

Finally we may note that, according to Kant, assigning teleology a constitutive function boils down to conflating teleology with theology or to ascribe intentionality to plants and animals. This is the price of understanding the notion of 'purpose' in terms of intentional agency. To argue that teleology is constitutive at the object level of biology, as Quarfood does, is ultimately to introduce a new causality, and a special ground for this causality, in physics (natural science). Hence, teleology determines the subject-matter of the biological sciences, but is not in any way constitutive of nature.

5.7 Conclusion

In the present chapter I have argued that Kant does not merely assign a descriptive or heuristic role to teleology. Rather, teleology also fulfills a crucial role in identifying and delimiting the domain of biology. Kant's reflections on teleology in the third *Critique* provide a philosophical basis for conceiving biology as a science

[136] Cf. AA 5: 387–388.

[137] Quarfood 2006.

[138] AA 5: 387.

[139] As has been stressed by Allison 1991.

[140] AA 5: 417.

with a specific domain of its own. Biology concerns organisms, i.e., self-maintaining natural objects that reproduce, nourish themselves, and grow. Like his biological contemporaries, Kant took these empirical characteristics to be inapplicable to inorganic objects, while he further construed them as necessitating a teleological description. Through conceptualizing organisms as natural purposes, we assign teleological properties and relations to organisms that we do not assign to inorganic objects. Hence, biological investigation is always conducted from a teleological perspective. As such, the method of biology is also distinct from that of other (non-teleological) disciplines.

In addition, Kant construes proper biological method as consisting in the subordination of mechanism to teleology. Although biological inquiry is always conducted from a teleological point of view, proper explanations in biology are always mechanical explanations. By construing mechanical explanations as ideal forms of explanation, and allowing for mechanical explanations in biology, he allows for the possibility of objective and explanative demonstrations in biology, even though the scope of mechanical explanations in biology is severely limited.

In the terms of the criteria of proper science expounded in Chap. 2, we can say that Kant allows for the possibility of biology as a science with a particular domain. In addition, he allows for the possibility of objective scientific explanations in biology. We must always presuppose that organisms are purposefully organized (the principle of original organization). However, given this presupposition, we can specify mechanisms that are involved in organic processes. These explanations must show how organic processes are based on regularities found in other ('higher') physical disciplines, such as chemistry.

Biology does not, however, satisfy the other criteria of proper science specified in Chap. 2. Kant does not specify how biology is related to the *a priori* principles of natural science as specified in the *Metaphysische Anfangsgründe* (although, as argued for above, this should somehow be possible). In addition, biology is a non-mathematical science. Hence, ultimately biology remains an improper science for Kant. In the next chapter, we will see that this conception of biology was quite common in Kant's time.

Chapter 6
Kant on the Systematicity of Physics and the *Opus postumum*

According to Kant, organisms constitute a special object of scientific investigation. Organisms are characterized by characteristics and capacities that inorganic objects lack, such as reproduction, growth, self-preservation, and regeneration. These characteristics necessitate a teleological description. Hence, the life sciences can be said to have a specific domain of investigation and the conceptual framework of these sciences necessarily incorporates teleological concepts. At the same time, biologists must strive to find mechanical explanations of organic phenomena. Although we cannot explain the purposiveness of organisms, we must, taking the purposiveness of organisms as a given, specify the mechanisms that account for how organisms function. In doing this, the biologist can use propositions established in other natural sciences.

If we ask how the life sciences are related to other natural sciences according to Kant, the following answer seem appropriate. Insofar as biologists necessarily employ teleological concepts, biology cannot be reduced to other physical sciences. The method by means of which we study organisms also differs from the method that we employ in other physical sciences (e.g., Newtonian physics). In this manner, biology is *distinguished* from these other natural sciences. Nevertheless, insofar as biologists need to provide mechanical explanations biology is also subordinated to other natural sciences such as physics and chemistry.

In short: biology is (a) characterized by concepts and principles that are peculiar to this science, while also being (b) subordinated to other physical sciences. In the present chapter, I will further develop point (b). I will be concerned with the question of how Kant conceptualized the relation between biology and other natural sciences. I will try to answer this question by reconstructing Kant's views on the systematicity of natural science ('physics as a whole') and by considering the place of biology within such a unified science. The chapter contains three main parts.

On the basis of a study of Kant's published writings, I will first (i) argue that Kant adopted a broad conception of physics and took biology to be a part of physics. For Kant, the term 'physics' does not only denote mathematical physics. Rather, Kant often uses the term 'physics' to refer to natural science as a whole. Biology is

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included within such a science. I further show that Kant adopted an ideal of a systematic and unified natural science, according to which (a priori) rational physics grounds other (empirical) parts of physics. The life sciences are included among the empirical parts of physics.

I will then (ii) show how the term 'physics' is construed in a number of eighteenth-century handbooks on physics that Kant was familiar with. I discuss the views on physics articulated by Johann Peter Eberhard (1727–1779), Wenceslaus Johann Gustav Karsten (1732–1787), and Johann Samuel Traugot Gehler (1751–1795). The importance of these works for understanding Kant's philosophy of science has been marvelously established by Konstantin Pollok.[1] I show that all three authors conceived of physics in general terms as a science that contained mathematical physics, empirical sciences such as chemistry, and various other disciplines. In addition, biological topics were often discussed within physics. All three men were furthermore concerned with the question of how physics or natural science as a whole could constitute a unity. They adopted the ideal of a unified natural science, even though the differentiation and specialization of natural sciences led Gehler to doubt whether it was possible to treat physics as a unity.

Finally (iii), I will give an account of the main aims and objectives of Kant's so-called *Opus postumum*. In this projected work, Kant undertook the grand project of establishing the whole of natural science as a systematic unity. This project was provisionally called "*Übergang von den Metaphysische Anfangsgründen der Naturwissenschaft zur Physik*". Because the *Opus postumum* is a highly problematic work, I will give an overview of some of its main (scientific) contents. This will help the reader to understand how we should understand Kant's attempts to ground the systematicity of physics. I will then argue that one of the aims of Kant's project undertaken in the *Opus postumum* is to provide a foundation of the scientific study of organisms so as to establish physics as a systematic unity. In the next two chapters, I will provide a more detailed account of topics relevant to Kant's philosophy of biology in the *Opus postumum*.

The chapter is structured as follows. In Sect. 6.1, I discuss the *differentiae* in terms of which Kant understands a science and delimits it from other sciences. Section 6.2 offers an analysis of how Kant distinguishes between different parts of physics or natural science on the basis of these *differentiae*. In Sect. 6.3, I analyze the views on physics articulated in the works of Eberhard, Karsten, and Gehler. In Sect. 6.4, I interpret Kant's transition project (*Übergang*) undertaken in the *Opus postumum* on the basis of views on physics expounded in the earlier sections.

6.1 Three Distinguishing Features of a Science

In order to determine Kant's views on physics, it is necessary to consider how he *demarcates* sciences. In the *Prolegomena*, Kant argues that in order to present a body of cognition as a science one must specify its distinguishing feature:

[1] Pollok 2001.

> If one wishes to present a body of cognition as *science*, then one must first be able to determine precisely the differentia it has in common with no other science, and which is therefore its *distinguishing feature*; otherwise the boundaries of all the sciences run together, and none of them can be dealt with thoroughly according to its own nature.
>
> Whether this distinguishing feature consists in a difference of the *object* or the *source of cognition*, or even of the *type of cognition*, or several if not all of these together, the idea of the possible science and its territory depends first of all upon it. (AA 4: 265)

We can delimit sciences in terms of (i) the objects with which a science is concerned. In addition (ii), we can delimit sciences by focusing on differences regarding the sources of cognition, i.e., on whether a science provides us with cognition having its source in reason (*a priori*) or with cognition having an empirical source (*a posteriori*). Finally (iii), we can focus on differences regarding the type of cognition (*Erkenntnissart*). Differences regarding the type of cognition are differences concerning the *method* through which cognition is obtained.

According to Kant, we have to employ several of these *differentiae* in order to distinguish sciences from one another. This view is motivated by the idea that sciences cannot be adequately delimited merely in terms of their object. For example, in the Transcendental Doctrine of Method of the first *Critique*, Kant argues that one cannot strictly distinguish philosophy from mathematics by defining the former as a science of quality and the latter as a science of quantity.[2] The reason is that philosophy and mathematics can have a common object of investigation. Like mathematics, philosophy deals with magnitudes (e.g., with totality or infinity), whereas mathematics is partly concerned with qualitative differences between mathematical objects. In addition, we cannot distinguish philosophy from mathematics in terms of their sources of cognition, since both provide us with a priori cognition. Hence, philosophy and mathematics are distinguished in terms of their different *methods* of acquiring cognition.[3] Philosophical cognition provides 'rational cognition from concepts', whereas mathematical cognition provides 'rational cognition from the construction of concepts'.[4]

The *differentiae* described above determine the *territory* of a science. Kant employs the term 'territory' to capture the notion of the *domain* of a science. According to the Domain Postulate of *Classical Model of Science*, introduced in Chap. 2, all propositions and all concepts of a science are about a *certain domain of being(s)*.[5] Kant accepts something like the Domain Postulate. However, he does not take the set of objects with which the propositions and concepts of a science are concerned to be a sufficient criterion for delimiting sciences from one another. The use of the term territory reflects that we do not merely understand a science in terms of its object (i), but also in terms of (ii) the source of cognitions of a science, and (iii) the method of cognizing its object. If we understand a science in terms of (i)–(iii), it can be said to have a determinate territory.

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[2] *KrV*, A 714–715/B 742–743.

[3] cf. *KrV*, A 844/B 872.

[4] *KrV*, A 713/B 741. Cf. AA 4: 266; AA 9: 23.

[5] De Jong and Betti 2010, 1, 5.

The territory of a science is subject to specific conditions. In the third *Critique*, Kant construes the territory of a concept as the set of objects to which it can be applied and that we can have cognition of.[6] He notes that the territory of philosophy is given by the "set of objects of all possible experience."[7] Any theoretical science is concerned with objects of experience, for we can only have *knowledge* of objects of experience. Insofar as the territory of any theoretical science consists of objects of possible experience, these objects are subject to the transcendental conditions of experience established in the first *Critique* (they are spatio-temporal objects, subject to causal laws, etc.).[8]

The territory of a science depends on its distinguishing features. Hence, the territory of a science depends on (ii) its mode of justification (a priori or empirical) and (iii) its method. We can illustrate this point with an example. In The Discipline of Pure Reason of the first *Critique*, Kant distinguishes two procedures for proving geometric theorems, such as Euclid's theorem (*Elements* I.32) stating that "in any triangle, if one of the sides be produced, the exterior angle is equal to the two interior and opposite angles, and the three interior angles of the triangle are equal to two right angles."[9] The first procedure is empirical. As Shabel has shown, this procedure consists in proving this theorem by measuring the angles of a constructed triangle by means of a compass.[10] Kant claims that this empirical procedure fails to yield proper (necessary and universal) mathematical cognition.[11] The second procedure amounts to proving this theorem via construction in *pure* intuition. This *Euclidean* proof is a priori and yields universal and necessary truth.

Both the empirical and the a priori or Euclidean demonstration have a common object. Nevertheless, only the Euclidean demonstration yields proper mathematical cognition. This is because the Euclidean demonstration differs from the empirical demonstration with respect to: (ii) its mode of justification (a priori or a posteriori), and (iii) its method of proof. Hence, although both demonstrations have a common object, Kant would argue that only the constructed triangle figuring in the Euclidean demonstration belongs to the *territory* of geometry. This object is constructed a priori in pure intuition and is dealt with in a manner that secures universal and necessary mathematical cognition. As such, the empirical features of the constructed triangle, the investigation of which does not belong to the province of mathematics,

[6] AA 5: 174.

[7] Ibid.

[8] In line with this view, Kant also argues that a condition for the legitimacy of scientific hypotheses is that they assume the existence of really possible objects, i.e., objects conforming to the conditions of experience. *KrV*, B 798; AA 9: 85. See Butts 1961, 1962, 1984, 223–244.

[9] Euclid 1956, 316–317.

[10] Shabel 2004, 195–215. See also Shabel 2003, 96–101. This empirical procedure, as Shabel shows, is called providing a 'mechanical demonstration' by Christian Wolff. Wolff [1716] 1965, 506–507.

[11] *KrV*, A 718/B 746. Wolff would agree. He assigned mechanical demonstrations a didactic purpose. They function as a guide to proper geometric demonstrations and serve "to properly grasp that which is to be proved, and to understand mathematical reports." Wolff [1716] 1965, 507.

are not taken into account. The mode of justification and the method characteristic of a science thus determine *which* features of the object under consideration are taken into account: they determine how we understand the object of a science.

In conclusion: Kant's use of the term territory shows that theoretical sciences are concerned with objects that conform to the transcendental conditions of experience. In addition, this term reflects that how we understand a science depends on (i) the object of a science, (ii) the source of cognitions belonging to a science, and (iii) the method of a science. In the following sections, we will see how these ideas figure in Kant's conception of physics.

6.2 Kant's Varieties of Physics

In the previous section we considered the *differentiae* that allow us to delimit sciences from one another. The present paragraph will be concerned with Kant's conception of physics (*Physik*). Kant has a differentiated conception of physics. Several elements of his view on physics follow from his conception of proper science (Chap. 2). The view that natural science must be based on a priori principles leads Kant to distinguish between an a priori and empirical part of physics. Within the a priori part of physics we can distinguish between mathematical and metaphysical principles. The first can be taken to be expounded in Newton's *Mathematical Principles of Natural Philosophy*, the second in Kant's *Metaphysische Anfangsgründe*. In addition, physics must be a system. If we are to provide a philosophical foundation of physics, we must show how a systematic physics is possible. In a system we determine *a priori* "the extension of the manifold as well as the position of the parts with respect to each other".[12] In other words: if physics is to constitute a system, we must determine the domain of physics, its parts (sub-disciplines), and the relation of these parts to one another.

In the present section, I will employ the three distinguishing features of a science discussed in the previous section to illustrate Kant's understanding of physics and its parts. First, I discuss Kant's views on the *object* of (universal) physics. Second, I consider his distinction between the a priori (rational) and empirical part of physics. Finally, I consider his distinction between *physica generalis* and *physica rationalis*.

6.2.1 The Object of Universal Physics

We will first focus on Kant's use of the term 'physics' in its most generic sense. In the *Prolegomena*, Kant introduces the phrase 'universal natural science' or 'universal physics' in the *strict sense* to denote a science concerned with nature as a *whole*.

[12] *KrV*, A 832/B 860.

Universal physics in the strict sense is a science that concerns objects of the outer senses (objects of physics) and objects of inner sense (objects of psychology).[13] The term 'universal physics' provides us with an Aristotelian conception of physics: a science of nature that incorporates *any* doctrine of nature, including the study of organized beings (biology) and of the mind (psychology).[14] Kant also allows for the use of the term 'universal physics' in a *non-strict sense*. In this discipline, we *exclude* the study of objects of inner sense (psychology) from physics. In the following, I show how Kant distinguishes between different doctrines pertaining to universal physics in terms of: (a) the object of these doctrines, (b) the method (*Erkenntnissart*) of these doctrines, and (c) the source of cognition (a priori or a posteriori) of the principles of these doctrines.

In the *Prolegomena*, Kant cites the principle of the permanence of substance (First Analogy of the first *Critique*) and the principle of causality (Second Analogy of the first *Critique*) as principles grounding universal physics in the strict sense. These principles constitute a priori laws of nature.[15] They are *transcendental* principles that provide a priori conditions for the possibility of experience of any empirical object. Hence, transcendental principles ground universal physics in both the strict and non-strict sense.

Transcendental principles are contrasted to a priori principles found in the so-called "propaedeutic to the theory of nature", which is said to precede *physics*.[16] The latter principles comprise *mathematical* principles and *philosophical* principles. The philosophical principles are those developed in the *Metaphysische Anfangsgründe* (providing a special metaphysics of *corporeal* nature). These are distinguished from mathematical principles of natural science by virtue of the fact that they are *discursive*, i.e. they provide a priori cognition from concepts, whereas mathematical principles provide a priori cognition from the *construction* of concepts (a distinction qua method or *Erkenntnissart*). The philosophical principles of natural science of the *Metaphysische Anfangsgründe* are distinguished from the transcendental principles of the first *Critique* by noting that the former, in contrast to the latter (which concern *nature in general*), are developed on the basis of an empirical concept of matter and *merely* concern objects of outer sense or corporeal nature (a distinction qua object). Finally, *physics* is construed as a doctrine concerning objects of outer sense (corporeal nature) based on *empirical principles*, i.e., physics is construed in terms of its object and its a posteriori source of cognition.[17] In this manner, (a)–(c) allow Kant to distinguish different parts of physics.

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[13] AA 4: 295.

[14] Cf. the explanatory notes to the Cambridge Translation of the *Prolegomena* by Hatfield 2002, 479. Hatfield notes that in the eighteenth century the term 'physics' gradually came to be restricted to the study of bodies, excluding psychology but not biology.

[15] AA 4: 295.

[16] Ibid.

[17] AA 4: 295. Cf. AA 4: 470; *KrV*, A 847–848/B 875–876.

According to Kant, universal physics is concerned with nature. 'Nature' is a technical term that can have both a formal and material meaning.[18] If we take 'nature' in its formal meaning it signifies the "*conformity to law* of the determinations of the existence of things in general".[19] In this sense, we speak of the nature of types or classes of objects (nature taken adjectively). In its material meaning, 'nature' signifies the "*sum total of all objects of experience*".[20]

In §36 of the *Prolegomena*, Kant argues that nature in the material sense is possible "by means of the constitution of our sensibility",[21] i.e., by means of the pure forms of intuition (space and time). Nature in its formal sense is possible by means of "the constitution of our understanding".[22] Hence, to construe universal physics as a science of *nature* is to say that it is concerned with objects that conform to the transcendental conditions of experience of the *Kritik der reinen Vernunft*. What counts as an object of experience is determined by the pure forms of intuition (space and time) and the principles of the understanding. These provide transcendental and a priori *sources* of cognition. Hence, the pure forms of intuition and the principles of the understanding determine the *territory* of *universal physics*, i.e., they determine the objects of which scientific knowledge is possible.

Let us now ask how biology is related to physics. Kant's notion of physics is sometimes equated with mathematical (Newtonian) physics. The above analysis suggests that this conception of physics is too narrow. Kant also employs a more liberal conception of universal physics. If 'universal physics' is taken in its strict sense we are dealing with a science of nature as a *whole*. Biology is certainly part of this science. It is also a part of universal physics taken in the non-strict sense. The territory of universal physics in the non-strict sense consists of objects of experience given in outer sense, i.e., we are dealing with a doctrine of *corporeal nature*. It is difficult to see why organic *bodies* should be excluded from this territory.

The conception of physics as a general science of nature including biology is present in Kant's lectures on physics. In the *Danziger Physik* of 1785, the term 'physics' is used to describe a 'universal doctrine of nature' containing mathematical physics, chemistry, and natural description. This universal doctrine of nature is taken to provide *grounds* for chemical and organic phenomena.[23] Hence, propositions of the universal doctrine of nature can be used to provide explanations in biology, as I have also argued in the previous chapter.

In the second chapter, we have emphasized that for Kant a *proper* natural science is a mathematical natural science. The above reconstruction is not meant to detract from this interpretation. Mathematics provides a priori principles grounding judgments in natural science and thus secures their apodictic certainty. Insofar as

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[18] Cf. AA 4: 294–296; 4: 467; A 418/B 446$_n$. See also Pollok 2001, 45–56.

[19] AA 4: 295.

[20] Ibid.

[21] AA 4: 318.

[22] Ibid.

[23] AA 29: 97–99.

chemistry and biology are non-mathematical sciences they are not *proper* natural sciences. Kant also takes *systematicity* to be a necessary condition for any proper (natural) science. A system is constructed on the basis of a priori principles. Hence, if physics (as a whole) is to be a system, we must specify a priori principles on the basis of which physics can constitute a system. This means that if physics is to incorporate mathematical physics, chemistry, and biology, we must specify a priori how these disciplines are related to each other. This is one of the tasks Kant sets himself in the *Opus postumum*.

6.2.2 Rational and Empirical Physics

Having treated Kant's conception of universal physics, we will turn to the distinction between *rational* and *empirical* physics. The distinction between rational and empirical physics is made in terms of the mode of justification characteristic of a science (a priori or a posteriori). It is a distinction in terms of the *sources of cognition*.[24]

In the *Prolegomena*, Kant distinguishes 'pure natural science', which is grounded on a priori principles, and physics, which is grounded on empirical principles.[25] Kant's lecture notes on physics provide a more extensive discussion of the distinction between rational and empirical cognition of nature. There, empirical cognition of nature is said to employ grounds for explaining nature that are taken from experience (a posteriori). In contrast, in the rational cognition of nature the grounds for explaining natural phenomena are *merely* a priori. These grounds can be *metaphysical* or *mathematical*.[26] Finally, cognition of nature is said to be *applied* when we apply a priori principles to empirical propositions.

We can thus distinguish between (i) an a priori part of physics (rational physics), (ii) an empirical part of physics (empirical physics), and (iii) cognition of nature obtained through the application of a priori principles to empirical propositions. Kant's *Metaphysische Anfangsgründe* provides us with a rational physics (i).[27] Given that in the latter work Kant takes the grounds of chemistry to be empirical, chemistry is there construed as a discipline pertaining to empirical physics (ii).[28] Newton's mathematical physics as presented in his *Principia*, in which on Kant's view we apply both metaphysical and mathematical principles to empirical

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[24] My analysis of rational physics will be brief. For a detailed exposition of the place of rational physics in Kant's system of philosophy and metaphysics, see Falkenburg 2000, 263–305. See also Pollok 2001, 122–128.

[25] AA 4: 295.

[26] AA 29: 99.

[27] Cf. *KrV*, A 846/B 874; AA: 4: 470.

[28] AA 4: 468.

propositions, provides an instance of (iii). Note that the possibility of applying a priori principles to empirical propositions (iii) is important to Kant. As we have seen in Chap. 2, it is this fact that secures the apodictic certainty of propositions in natural science. Explanations in natural science can be based on a composite of a priori and empirical principles (recall Newton's application of mathematical propositions to phenomena in book III of the *Principia*).

The distinction between (i)–(iii) is made in terms of the sources of cognition. This is not surprising, for (i)–(iii) can be interpreted as having a common object of investigation. In The Architectonic of Pure Reason of the first *Critique*, Kant construes rational physics as a part of physics that is concerned with corporeal nature (objects of outer sense) and not with thinking nature (objects of inner sense).[29] The same is true of empirical physics and cognition of nature obtained through the application of a priori principles. However, (i)–(iii) can be said to have a different *territory*, given that they can be distinguished in terms of the different modes of justification peculiar to these doctrines (purely a priori, a priori and a posteriori, and purely empirical).

6.2.3 Physica Rationalis *and* Physica Generalis

In conclusion of this section, we may consider how Kant distinguishes between different parts of physics in terms of the different methods by means of which cognition is obtained. In the Architectonic of Pure Reason of the first *Critique*, Kant distinguishes *physica rationalis* from *physica generalis*, noting that the latter "is more mathematics than philosophy of nature."[30] *Physica rationalis* provides a priori *metaphysical* principles of natural science. As a purely metaphysical science, it is distinguished from *physica generalis*. In the *Metaphysische Anfangsgründe*, Kant notes that in *physica generalis* metaphysical and mathematical principles are not strictly distinguished. He argues that it is necessary to *separately* present the metaphysical and non-mathematical principles of natural science in a system.[31] This is the task of the *Metaphysische Anfangsgründe*. Insofar as the distinction between *physica rationalis* and *physica generalis* mirrors the distinction between metaphysical and mathematical principles of natural science, the distinction between these types of physics is a distinction qua *Erkenntnissart* (method).

It is not clear how we should understand the locution *physica generalis*. Apart from a brief mention in the first *Critique* and the *Danziger Physik*, Kant does not provide a precise description of how he understands the term. Following Konstantin Pollok, we can increase our understanding of the notion of *physica generalis*

[29] *Krv*, A 846/B 874.

[30] *KrV*, A 847/B 875n.

[31] AA 4: 472–473.

if we consider a popular textbook on physics in the eighteenth century.[32] In this textbook the notion of a *universal part of the doctrine of nature* (a *physica generalis*) fulfils a very important role.

In his *Erste Gründe der Naturlehre* (1774), Johann Peter Eberhard distinguishes between a universal and particular part of the doctrine of nature. The universal part discusses universal properties of bodies. It contains metaphysical expositions, experiments, mathematical descriptions, and discussions of kinematics, mechanics, and the theory of gravitation.[33] The particular part of the doctrine of nature contains discussion of particular properties pertaining to particular classes of objects. In this latter part, Eberhard discusses topics such as the distinction between fluid and solid bodies, the various types of fluids and solids, etc. Kant's notion of *physica generalis* corresponds to Eberhard's universal part of the doctrine of nature: it is a doctrine concerning the universal properties of bodies or a universal doctrine of nature.[34]

The topics that Eberhard treats within his so-called particular part of the doctrine of nature (*physica specialis*) correspond to the topics Kant treats in the General Remark to Dynamics of the *Metaphysische Anfangsgründe*. In contrast, Kant's metaphysical foundations of phoronomy, dynamics, and mechanics, provide a *metaphysical* analysis of the *universal* properties of matter. Kant prides himself in strictly distinguishing between the metaphysical, mathematical, and empirical principles of natural science. His presentation is stricter than that of Eberhard, in which *physica generalis* is an amalgam of metaphysics, mathematics, and specific experiments. Kant can strictly distinguish between the metaphysical and mathematical principles of natural science because he focuses on the *method* characteristic of different disciplines. This is clear if we consider Kant's lecture notes of physics, the so-called *Danziger Physik*. There, *physica generalis* is construed as a 'mathematics of nature' which provides "cognition of nature from mathematical grounds or the construction of concepts".[35] The term *physica generalis* primarily signifies a body of cognition that is obtained by the *method* of mathematics.

[32] Pollok 2001, 122–126, provides an analysis of the notion *physica generalis*. My account is indebted to that of Pollok.

[33] Here I base myself on Pollok 2001, 516–518, which contains an appendix presenting the overall structure of the second edition of Eberhard's *Erste Gründe der Naturlehre* (1759). I have consulted the fourth edition of 1774. This edition is ordered in two parts. The first part discusses universal properties of bodies, whereas the second part contains discussion of specific properties of bodies. The list of universal and particular properties corresponds closely to that of the second edition.

[34] In his *Anfangsgründe der Naturlehre* (1772), Johann Christian Polykarp Erxleben defines the universal doctrine of nature (*physica generalis*) as a doctrine concerning the properties of bodies in general. It is distinguished from the natural description of the earth or physical geography (*geographia physica*), natural history (*historia naturalis*, *physica specialis*), and physical astronomy (*astronomia physica*). Erxleben 1772, 8–9. Note that Eberhard does not employ the Latin terms *physica generalis* and *physica specialis*. He simply speaks of the universal doctrine of nature and the special doctrine of nature. In the following, I will nevertheless employ the Latin terms.

[35] AA 29: 101.

6.3 Physics as Presented in Eighteenth-Century Textbooks

In the previous sections, we have discussed Kant's conception of physics. Kant conceived of physics as a universal science of nature as a whole. He further distinguished various parts of this universal physics: rational physics (the *metaphysical* part of physics), general physics (the *mathematical* part of physics) and empirical physics (the *empirical* part of physics, containing, for example, chemistry and the life sciences).

In the present section, I want to contextualize Kant's views on physics by discussing the views on physics adopted by German scientists in the latter half of the eighteenth century. I will analyze two textbooks on physics and one dictionary, spanning the second half of the eighteenth century. I will discuss J.P. Eberhard's *Erste Gründe der Naturlehre* (first published in 1753), W.J.G. Karstens's *Anleitung zur gemeinnützlichen Kenntniß der Natur* (1783), and J.T.S Gehler's *Physikalisches Wörterbuch* (1787–1796). I have referred to some of these writings in the preceding discussion of Kant. However, a more detailed discussion of these works will be useful for understanding the manner in which the notion 'physics' was employed in the eighteenth century and how different parts of physics were classified. These textbooks and dictionaries are vital for understanding Kant's philosophy of physics, as has been shown by Pollok.[36] In the following, I will focus on how the authors of these works construed the nature and unity of physics.

Kant was familiar with all three cited works. He employed Eberhard's textbook in his lectures on physics in the 1750s and 1760s.[37] After adopting Erxleben's *Anfangsgründe der Naturlehre* from 1772 to 1783,[38] Kant lectured on physics using Karsten's *Anleitung* in 1785. Both Kant's lectures and Karsten's *Anleitung* are printed in the *Akademie-Ausgabe*. Finally, Gehler's dictionary constituted a very influential source on physics at the end of the eighteenth century.

Historians of science sometimes refer to the late eighteenth century as containing the origins of modern science.[39] It is argued that in this period the word 'science' became restricted to the investigation of *nature*. In addition, we witness radical developments within the experimental sciences. Here one may think of developments within chemistry associated with the so-called chemical revolution. One may also think of the creation of biology and geology as special sciences. In light of these developments, it is no surprise that the proper conception of physics was a point of controversy. The study of eighteenth-century textbooks on physics shows that physicists asked themselves how, in light of the *differentiation* of natural sciences, it is possible to still understand physics as a unified whole.

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[36] Pollok 2001.

[37] For an overview of Kant's activity as a lecturer and of the textbooks employed in his lectures, see Naragon 2010.

[38] I briefly mention Erxleben's *Anfangsgründe der Naturlehre*, but will not subject this work to a separate analysis since for my purposes it does not add much to what we can learn from the other works.

[39] Cunningham and Williams 2003, 218–246.

In the following, I describe some of the controversies concerning the nature of physics that come to the fore in the mentioned sources. These are controversies concerning: (i) the role of mathematics within physics; (ii) the status of chemistry; (iii) the importance of understanding physics as a systematic and unified science. In addition (iv), I will show that although the study of organic nature is not assigned a central place within physics, it is typically treated as a *part* of physics.

6.3.1 Eberhard's **Erste Gründe der Naturlehre**

Eberhard's *Naturlehre* contains a standard presentation of physics in the eighteenth century. One of the main purposes of this textbook is to present physics as a systematic and unified whole. This requires delimiting physics from other sciences, such as pure and applied mathematics. In specifying the content of physics, Eberhard employs a number of important conceptual distinctions that will constitute the focus of inquiry in what follows.

In the Introduction to the *Naturlehre*, the doctrine of nature (physics) is defined as the science of the properties and effects of actual bodies and of the *causes* derivable from these properties and effects.[40] As such, it is distinguished from pure and applied mathematics.[41] In contrast to physics, pure mathematics is concerned with abstract representations of bodies. It considers bodies merely in accordance with their extension and quantity and is not concerned with actual and empirically given bodies. Physics is also distinguished from applied mathematics. In contrast to pure mathematics, applied mathematics studies actual bodies (e.g., in optics or astronomy). However, applied mathematics merely provides a *mathematical treatment* of forces of material bodies: it does not investigate the *causes* of phenomena.

Eberhard distinguishes between a general and a special part of physics, which I will describe as *physica generalis* and *physica specialis*. This distinction informs the structure of the textbook. Eberhard introduces this distinction by noting that in physics, we consider either (a) the universal properties of bodies or (b) the particular phenomena or properties that are dependent on these universal properties. Some universal properties of bodies can be proven a priori, i.e., can be derived from *first grounds*. In contrast, the particular properties of bodies must be learned *a posteriori*, i.e., these properties are determined *solely* on the basis of *experience*.[42] Here, we find a distinction that is similar to Kant's distinction between rational and empirical physics.

In line with the distinction between universal and particular properties of natural bodies, we can divide physics in a universal and particular part. In the first part, we consider the universal properties and laws of bodies. In the second part, we *apply*

40 Eberhard 1774, 2.

41 Eberhard 1774, 2–4.

42 Eberhard 1774, 6.

the universal properties and laws of natural bodies to specific bodies in order to explain their appearance. This yields a special physics, in which we consider specific types of bodies (e.g., air, water). If we consider specific phenomena of specific types of bodies (e.g., rain, thunderstorms) we are operating within the domain of what is called *physica specialissima*.[43] Thus, moving from the universal to the more particular we can distinguish the following doctrines: *physica generalis*, *physica specialis*, *physica specialissima*.

Insofar as special properties must be learned a posteriori, *physica specialis* can be described as an *empirical physics*. Eberhard describes empirical physics as the part of the doctrine of nature in which we determine the properties, effects, and forces of bodies on the basis of experience. In contrast, he describes rational physics or *physica rationalis* as the part of the doctrine of nature in which the phenomena of corporeal nature are *derived* from the forces of bodies.[44] The distinction between empirical and rational physics is thus understood in terms of the traditional distinction between the analytic and synthetic method. *Physica rationalis* proceeds synthetically from cause to effect, whereas empirical physics proceeds analytically from effects given in experience to causes. Given that in *physica generalis* we consider universal properties of bodies that are partly cognizable from first grounds (a priori), *physica generalis* can be treated as *physica rationalis*. Eberhard aims to connect rational and empirical physics. Hence, the purpose of the textbook is to present physics as a systematic and unified whole, explicating the relationship between *physica generalis* (*physica rationalis*) and *physica specialis* (empirical physics). According to Eberhard, *physica generalis* grounds *physica specialis*.

In the first part of his *Naturlehre*, Eberhard presents what we have called *physica generalis*. He discusses the following topics: (i) ‘extension’, (ii) ‘impenetrability’, (iii) ‘divisibility’, (iv) ‘movability’, and (v) ‘force’. These are *universal properties* of matter. While treating (i)–(iii), Eberhard provides many metaphysical discussions on the nature of material bodies. When treating (iv), he discusses kinematics and (Newton’s) laws of motion.[45] In (v), he argues that attractive force is essential to matter. He further discusses the force of cohesion, Newtonian universal attraction or gravitation, weight, and the motion of pendulums.[46]

The second part of the *Naturlehre* provides us with what we have called *physica specialis*. There, Eberhard considers particular properties of specific classes of material objects. He provides discussion of (1) fluid bodies, (2) solid bodies, (3) the effect of fluids and solids on one another in dissolution and precipitation, and (4) specific phenomena concerning specific types of bodies. In (1), Eberhard discusses

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[43] Eberhard 1774, 11–12.

[44] Eberhard 1774, 11.

[45] Eberhard 1774, 47–112. Eberhard’s presentation of the laws of motion is rather different from Newton’s presentation in the *Principia*. For example, Newton’s first law of motion (the law of inertia) is not specified as a separate law, whereas Newton’s parallelogram rule for motions is presented as a separate law of motion. In general, Eberhard’s presentation of physics seems to differ quite substantially from that of Newton.

[46] Eberhard 1774, 133–161.

the properties of fluid bodies in general. He further discusses droplet-forming fluidity, the motion of fluids in capillary tubes, and specific fluid bodies such as: (1a) air, (1b) heat and light, (1c) cooling matter (*kaltmachende Materie*), (1d) electricity or electric matter, (1e) magnetism or magnetic matter, and (1f) water. In (2), Eberhard discusses specific solid bodies: *elastic* solid bodies and *brittle* solid bodies. In (3), he provides a discussion of various chemical topics. I will return to the content of (4) below.

In introducing the second part of his *Naturlehre*, Eberhard notes that in the special part of the doctrine of nature (*physica specialis*) we *derive* the special properties of bodies from the universal properties specified in *physica generalis*. In the universal doctrine of nature (*physica generalis*), Eberhard established that the nature of bodies consists in their force. In *physica specialis*, we must determine on which forces the particular properties of specific material bodies depend.[47]

In short: in *physica generalis* we explain universal properties of matter in terms of fundamental forces. In *physica specialis*, we attempt to show how particular properties of specific bodies can be explained in terms of these fundamental forces. In developing this programme, the notion of an attractive force (more specifically: cohesion) developed within *physica generalis* is of crucial importance. Eberhard claims that in *physica specialis*, we consider the effects of attractive force in relation to the particular properties of bodies. Fluidity, the brittleness of solid bodies, and the elasticity of solid bodies are all taken to be explicable in terms of attractive force.[48] Here we see how the programme of explaining the specific variety of matter in terms of fundamental forces, which Kant undertakes in the General Remark to Dynamics of the *Metaphysische Anfangsgründe*, is present in the presentation of physics in contemporary textbooks on physics (although there are differences in the manner in which this programme is executed).[49] The idea informing this program is that physics should constitute a *unified*, *systematic whole*.

In conclusion, it is important to note that part (4) of *physica specialis* provides us with what Eberhard called *physica specialissima*. In this part, Eberhard provides a discussion of topics pertaining to natural history, i.e., a discussion of mineralogy, botanics, and zoology.[50] Plants (lifeless bodies having a regular structure and organization) and animals (bodies having a regular structure, organization and endowed with life) are discussed in accordance with (a) their division, (b) their structure, (c) their origin, and (d) their growth. For example, Eberhard discusses

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[47] Eberhard 1774, 162–163.

[48] Ibid.

[49] One of Kant's central claims in the *Metaphysische Anfangsgründe* is that repulsive force is essential to matter. This view was not adopted by Eberhard. In addition, whereas Eberhard takes cohesion to be essential to matter, Kant treated cohesion as a derivative force. Finally, Eberhard first treats of cohesion, arguing that it is a universal property of matter, and then treats of universal Newtonian attraction. This presentation has the purpose of countering mechanist objections to Newtonian gravitation. Kant reverses this presentation. He first argues that universal Newtonian gravitation is essential to matter and subsequently discusses cohesion.

[50] Eberhard 1774, 4–5.

Linné's classification of plants according to the *methodus sexualis* in (a). In (b), he discusses the structure of plants. In (c), Eberhard argues that the structure of plants derives from God. To assume a formative force in nature that is responsible for the structure of plants is absurd. Finally, in (d) the process of nutrition is discussed. The discussion of animals follows the same structure.[51] Eberhard's textbook thus contains a discussion of most of the biological topics that we have surveyed in the previous chapters.

The presentation of physics found in Eberhard's textbook was common in the latter half of the eighteenth century. For example, in his *Grundriß der Naturlehre* (1793[3]) Friedrich Albrecht Carl Gren also structured his textbook in accordance with the distinction between a universal and a particular part of the doctrine of nature.[52] However, the relatively neat conceptual distinction between *physica generalis*, *physica specialis* and *physica specialissima* was not always followed. For example, in Johann Christian Polykarp Erxleben's *Anfangsgründe der Naturlehre* (1772), the universal doctrine of nature (*physica generalis*) is described as studying the properties of bodies in general. Erxleben's *physica generalis* encompasses both Eberhard's *physica generalis* and (!) *physica specialis*. In addition, Erxleben defines natural history as *physica specialis*.[53] Hence, there was some confusion concerning the proper definition of physics in the eighteenth century.

6.3.2 *Karstens's* Anleitung zur gemeinnützlichen Kenntniß der Natur

In the present section, we will turn our attention to Karstens's *Anleitung zur gemeinnützlichen Kenntniß der Natur* (1783). As we will see, one of the main concerns of this work is again the question of how we can understand physics as a unified and systematic whole.

The *Preface* to Karsten's *Anleitung* provides a critique of traditional presentations of physics. According to Karsten, the traditional presentation of physics given in textbooks is based on a wrong conception of the nature of physics. The target of Karsten's criticism is not entirely clear. As we shall see in the following, there is quite some agreement between Karsten's views and the views of Eberhard for example. What is typical of Karsten's work, however, is his great stress on the importance of chemistry.[54] Karsten criticizes: (i) the reduction of physics to applied mathematics (ii) the exclusion of chemistry from physics, and (iii) the artificial classification of the universal doctrine of nature into physics, chemistry,

[51] Eberhard 1774, 762–781.

[52] Gren 1793.

[53] Erxleben 1772, 8–9.

[54] See Friedman 1992a, 282–286.

and natural history. These points are intimately related. In the following I will briefly describe them.

(i) Karsten emphasizes in his preface that physics has often been reduced to applied mathematics. This reduction is rejected, since according to Karsten applied mathematics is a *mere doctrine of magnitude*. Applied mathematics does not provide any insight into the nature or properties of material bodies.[55] It should however be the goal of physics to provide us with this insight. Karsten's point seems to be that applied mathematics, which is usually taken to comprise the mechanical, optical, and astronomical sciences,[56] does not provide any insight into the actual *causes* of the properties of bodies. This critique of applied mathematics is probably directed against the Newtonian tradition of natural philosophy. Newton can be interpreted as believing that phenomena can be explained by determining how they follow from a law of nature. Thus, for example, we might say that the theory of gravitation allows us to explain celestial phenomena, though we do not know the cause of gravity and we cannot specify any physical mechanism governing the motions of celestial bodies. Karsten would criticize these kinds of explanations for not taking into account the physical nature of bodies and the actual causes of phenomena.[57]

(ii) In contrast to the view that physics is reducible to applied mathematics, Karsten argues that physics is a science that should primarily study the physical properties and inner constitution of material bodies. Explanations of phenomena should be framed in terms of the nature of material bodies. This implies that chemistry, construed as the science of the nature of physical bodies, is an integral part of physics.

Karsten's criticism of the traditional conception of physics is largely motivated by his recognition of the fundamental importance of chemistry for physics. Throughout his textbook, he stresses the importance of interpreting chemistry as a part of physics. He argues, for example, that physics should be developed into a mathematico-chemical physics. These claims must be understood against the background of the developments taking place within the theory of heat and chemistry in the eighteenth century. Michael Friedman has given a detailed exposition of the development of chemistry in the late eighteenth century and of its reception in Germany. In this context, he has also discussed Karsten's work.[58] For us, it is merely important to note that these scientific developments led Karsten to argue that a 'true physics' must include chemical doctrines.

[55] AA 29: 173–174.

[56] Gehler 1787–1796, Bd. 3, 157–158.

[57] Whether this interpretation is correct is another issue, Friedman 1992a, 226–231, would certainly object to such a characterization.

[58] Friedman 1992a, 264–290.

(iii) Finally, Karsten criticizes the classification of the doctrine of nature into three *distinct* parts, i.e., into physics, chemistry, and natural description. This classification is artificial and does not do justice to the fact that these disciplines are interrelated. As Karsten puts it, these three disciplines are principally indivisible and must be taken together as constituting one unitary science.[59] A proper presentation of natural history, in particular of mineralogy, requires chemical knowledge. Alternatively, a chemist cannot analyze the basic materials found in nature without basing himself on the classifications of materials provided by natural history. Thus, chemistry and natural history are intimately related.[60] Similarly, physics and chemistry cannot be interpreted as two distinct doctrines.

The conception of a unified doctrine of nature provides Karsten with a scheme on the basis of which he presents his introduction to physics. The goal of his *Anleitung* is to present a truly universal doctrine of nature. This doctrine will specify the general grounds and principles of (mathematical) physics, chemistry, and natural history, explain some of their fundamental theories, and explicate the relationships between these disciplines. As such, the *Anleitung* is meant to provide a presentation of the doctrine of nature which allows us to understand this doctrine as a single whole consisting of various interrelated disciplines. According to Karsten, such a conception of the doctrine of nature is in harmony with the contemporary practice of the natural sciences and anticipates future developments of these sciences.[61] Like Kant, Karsten thus adopted a conception of physics as a system.

It is important to note that Karsten's unified doctrine of nature contains natural history, defined as the study of the kingdoms of animals, plants, and minerals. Natural history consists of zoology, botanics, and mineralogy.[62] A unified doctrine of nature should thus also include the study of organic nature. To be sure, Karsten does not conceptualize plants and animals as purposeful organisms. This conceptualization was essential for the emergence of biology in the late eighteenth and beginning of the nineteenth century. Moreover, Karsten's treatment of plants and animals is often limited to the chemical analysis of the materials found in plants and animals. Nevertheless, as was the case for Eberhard, the study of plants and animals is taken to be an integral part of physics.

6.3.3 Gehler's Physikalisches Wörterbuch

In order to understand how the notion of 'physics' was understood at the end of the eighteenth century, we turn our attention to Gehler's *Physikalisches Wörterbuch* (1787–1796). Gehler's conception of physics is both similar to and distinct from

[59] AA 29: 175.

[60] Ibid.

[61] AA 29: 174–175.

[62] AA 29: 187–188.

that of Karsten. Like Karsten, Gehler takes chemistry to constitute a part of physics. Unlike Karsten, Gehler defends the value of applied mathematics. Gehler further notes the difficulties in conceiving of physics as a unified science of nature. The ideal of a unified physics is not abandoned by Gehler. However, he is sensitive to the fact that many doctrines of nature are simply not related to each other. He describes these doctrines of nature as loosely connected *fragments*. Hence, Gehler recognizes that a unified natural science is extremely difficult to realize.

In the lemma on *Physik*, Gehler attempts to provide an adequate definition of physics. He proposes various definitions but ultimately concedes that he is unable to give one. He first defines physics, in the most general sense of the term, as the doctrine of corporeal nature.[63] Understood in this sense, physics is understood as the sum of all empirical cognition of nature. This definition is not strictly speaking wrong. However, Gehler rejects it because it is unfit for didactical purposes: we cannot teach physics understood as the sum of empirical cognition of nature.[64] Hence, he proposes to differentiate between different particular *sciences* of nature in order to arrive at a definition of physics proper.

Gehler describes a common classification of the doctrines of nature that is based on a distinction between different types of knowledge. Analogous to the distinction between historical, philosophical, and mathematical knowledge, we may distinguish between natural history, physics, and applied mathematics. Natural history is then taken to be a mere descriptive or historical discipline concerned with the classification of natural kinds, whereas applied mathematics is defined as a quantitative study of nature in which we apply pure mathematics to nature. If we accept this division of natural science, 'physics' is what remains if we treat natural history and applied mathematics as separate sciences. As Gehler puts it:

> In this manner there remained for physics proper nothing more than the doctrines of the universal properties of bodies, of simple materials […], of electricity, magnetism and the phenomena of air. One felt forced to fill the gaps between these few and poorly connected fragments with something. (Gehler 1787–1796, Bd. 3, 490)[65]

Physics is a thus described as a fragmentary aggregate of different doctrines.

Is the strict distinction between natural history, applied mathematics, and physics justified? Gehler argues that it is not. The isolation of physics, applied mathematics, and natural history is motivated by the thought that the latter two disciplines are not genuinely explanatory. In this context, scientific explanation is understood as a type of *causal* explanation. Natural history and applied mathematics are denied the status of explanatory sciences because they do not provide insight into the *causes* of properties of natural bodies.[66] Gehler rejects this argument and criticizes the strict

[63] Gehler 1787–1796, Bd. 3, 489.

[64] Ibid.

[65] Original: "So blieb für die eigentliche Physik nichts übrig, als die Lehren von den allgemeinen Eigenschaften der Körper, von den einfachen Stoffen […], von der Elektrizität, dem Magnetismus, und den Luftbegebenheiten. Man sah sich genötigt, die Lücken zwischen diesen wenigen und übel verbundenen Fragmenten mit etwas auszufüllen".

[66] Gehler 1787–1796, Bd. 3, 494.

division between natural history, applied mathematics, and physics. His critique can be summarized as follows:

(a) Gehler criticizes the attempt to strictly distinguish applied mathematics from physics. Advocating the use of mathematics within physics, he argues that scientific experiments and the specification of physical laws are only possible by means of mathematics. The physico-mathematical sciences called applied mathematics (e.g., optics and astronomy) provide us with an ideal of scientific knowledge and form an integral part of physics.[67]
(b) Gehler criticizes the idea that scientific explanation should be understood as causal explanation. Understanding scientific explanation as a form of causal explanation does not harmonize with scientific practice. According to Gehler, scientific explanation is often understood not in causal but in deductive terms: a particular event is scientifically explained if it can be derived from natural laws. Gehler argues that the latter view of scientific explanation captures the scientific method that was introduced by Newton.[68]
(c) The inadequacy of the idea of causal explanation points to the inadequacy of conceiving of physics as a science that investigates the causes of phenomena. If we define physics in this manner we would deprive physics of any genuine content, since we hardly have any knowledge of the true causes of phenomena.[69] That is to say: physics would merely provide us with a collection of hypotheses and could not teach us any truths.[70]
(d) Gehler rejects the above mentioned division of natural sciences because it does no justice to the fact that natural history, applied mathematics, and physics are *interrelated disciplines* that cannot be treated in isolation. In addition, this division does not enable us to properly classify chemistry.[71] Gehler emphasizes the importance of including chemistry within physics. The reason is that chemistry has increased our cognition of the nature of the fluid bodies, air, and heat. These were topics that were traditionally treated within (special) *physics*. For these reasons, chemistry is indispensable for physics.[72]

In light of the numerous interrelationships between various doctrines of nature, Gehler adopts a pragmatic stance toward the definition of physics. He admits that he is unable to give a precise definition of ‘physics’.[73] It is up to teachers and practitioners of the physical sciences to determine what they take to be a correct definition and classification of physics. Whether or not a particular study pertains to physics is to be decided on the basis of didactical grounds or on the basis of specific scientific needs.[74]

[67] Gehler 1787–1796, Bd. 3, 492–493.
[68] Gehler 1787–1796, Bd. 3, 456–457.
[69] Gehler 1787–1796, Bd. 3, 496.
[70] Gehler 1787–1796, Bd. 3, 490.
[71] Ibid.
[72] Gehler 1787–1796, Bd. 3, 491, 493.
[73] Gehler 1787–1796, Bd. 3, 494.
[74] Gehler 1787–1796, Bd. 3, 489.

To conclude our discussion of Gehler, we will discuss his presentation of organic nature. Gehler's dictionary provides a common late-eighteenth-century characterization of organisms. He defines plants and animals as *organized bodies* and treats minerals as non-organized bodies. Organized bodies are those that have an *organic structure*, i.e., a structure that enables the obtainment of specific *purposes*.[75] This organic structure constitutes the basis for distinguishing between plants and animals one the one hand and minerals on the other. For it is in virtue of this organic structure that plants and animals can *assimilate* external materials in order to nourish and maintain themselves, thus growing from within (*per intus susceptionem*), whereas minerals originate through the aggregation of materials from without (*per iuxta positionem*).[76] In Gehler's dictionary we thus find a characterization of organisms in teleological terms and he distinguishes between organic and inorganic bodies in the same manner as Kant and Blumenbach did.

6.3.4 The Unity and Disunity of Natural Science

The study of the works of Eberhard, Karsten, and Gehler allows us to draw the following conclusions. All three authors adopt the ideal of establishing physics as a whole as a systematic and unified science. However, they also recognized that the goal of a unified natural science was difficult to achieve.

The works we have surveyed are all concerned with the difficult task of finding a proper definition of 'physics' and with delimiting physics from other sciences. This enterprise was conducted on the basis of a broad conception of physics. All three authors adopted a conception of physics as a science including (parts of) Newtonian physics and mechanics, chemistry, and the study of organic nature. Moreover, the importance of non-mathematical disciplines such as chemistry was increasingly stressed towards the end of the eighteenth century.

Starting with this broad notion of physics, attempts were often made to distinguish physics from mathematics and applied mathematics. However, these attempts were controversial. As we have seen, Gehler rejected any attempt to strictly distinguish physics from applied mathematics. Finally, we must note that although all three authors include the study of organic nature in physics, it is only in Gehler that we find a characterization of organisms in teleological terms that we have also located in the works of Kant.

In order to understand how these authors conceptualized the place of biology in natural science, it is important to keep the problematic status assigned by Gehler to the ideal of a systematic physics in mind. Physics is characterized as a collection of poorly connected fragments. Hence, although all natural sciences should constitute a unity and are interrelated, the question of how they are related is difficult to answer. These problems already affected Eberhard. Although he presented *physica*

[75] Gehler 1787–1796, Bd. 3, 388.

[76] Gehler 1787–1796, Bd. 3, 388–389.

generalis as grounding *physica specialis*, the specific relation between these two parts of physics is never specified. Moreover, although Eberhard discussed various biological topics within his textbook he does not systematically relate this discussion to theories discussed in, for example, *physica generalis* or chemistry. Although biological topics were taken to be a part of physics the relationship of biology to the other natural sciences was completely obscure.

It is against this background that Kant wrote his *Metaphysische Anfangsgründe* of 1786, the *Kritik der Urteilskraft* of 1790, and the reflections contained in the *Opus postumum* in the 1790s. If we give a highly simplified overview of the contents of Kant's works, we can say that the *Metaphysische Anfangsgründe* provides Kant's philosophical foundation of scientific topics traditionally discussed within *physica generalis* (phoronomy or kinematics, dynamics, and (rational) mechanics). In the General Remark to Dynamics, Kant also treated topics that were traditionally studied within *physica specialis*, such as the distinction between fluid and solid (rigid) bodies, elasticity, and chemical interaction.[77] However, Kant acknowledged that he could not provide a complete explanation of such phenomena.[78] Hence, he was not able to fully explain how physics as a whole constitutes a unity. Kant's discussion of organic nature in the third *Critique* reflects the problematic status assigned to biological topics in eighteenth-century textbooks on physics. In the previous chapters we have seen that Kant insisted that biologists should aim to provide mechanical accounts of organic phenomena. Hence, biology should somehow be based on other natural sciences. However, the integration of biology within a unified physics remained a mere ideal.

6.4 Kant's Transition (*Übergang*) to Physics

In the previous section, we have described how eighteenth-century physicists grappled with the ideal of a unified natural science. The problem of establishing physics as a systematic unity was a problem that already concerned Kant in the *Metaphysische Anfangsgründe*. He struggled with this problem right up to his death. His last projected work, with the terrible name "*Übergang von den Metaphysische Anfangsgründen der Naturwissenschaft zur Physik*", was an attempt to establish natural science as a systematic science. Kant never finished this transition project (*Transition*). His writings are contained in the so-called *Opus postumum*. In the following, I will provide a general overview of the purpose of Kant's transition project and briefly consider the status of biology within this project. In the next two chapters, we will give a detailed account of Kant's reflections on biological topics in the *Opus postumum*.

[77] AA 4: 523–535 The General Remark to Dynamics is crucial to Michael Friedman's and Dina Emundt's interpretation of Kant's transition project in the *Opus postumum*. Friedman 1992a, 215–216; Emundts 2004, 32–73. I discuss their interpretations below.

[78] AA 4: 525.

Since the *Opus postumum* is a highly contentious work, I will introduce the reader to the *Opus postumum* by describing some of the most influential interpretations of Kant's last (projected) work (Sect. 6.4.1). I then show how Kant's *Transition* is supposed to ground the systematicity of physics (Sect. 6.4.2). We will see, more specifically, that the project of providing a transition from the metaphysical foundations of natural science to physics is similar to the traditional project of grounding *physica specialis* in *physica generalis* (Sect. 6.4.3). Through discussing some of scientific topics reviewed in the *Opus postumtum*, we will understand how Kant attempts to ground physics as a unified science (Sect. 6.4.4). Finally, I show that Kant's transition project has ramifications for his views on the status of biology. Biology is a part of physics and should therefore be treated within the *Transition* (Sect. 6.4.5).

6.4.1 Interpretations of the **Opus postumum**

The so-called *Opus postumum* is a collection of reflections and drafts composed by Kant for a work originally to be entitled *Übergang von den Metaphysische Anfangsgründen der Naturwissenschaft zur Physik*.[79] The writings pertaining to Kant's transition project (*Transition*) are recorded in volumes 21 and 22 of the Academy edition. Erich Adickes has established the chronological order of Kant's manuscript. However, these volumes do not present Kant's writings chronologically. This circumstance provides a hindrance for interpreting the *Opus postumum*. There are many other problems. The work is unfinished and lacks the structure normally supplied by chapters, sections, paragraphs and chapter and section headings. Given these circumstances, it is no surprise that Kant's *Opus postumum* is a hotly debated work.

Eckart Förster has shown that Kant came to envisage his transition project around 1788–1790. In a letter to Kant on June 8, 1795, Johann Gottfried Carl Christian Kiesewetter wrote: "For some years now you have promised to present the public with a few sheets that are to contain the transition from your *Metaphysical Foundations of Natural Science* to physics itself, which I await eagerly".[80] Given that Kiesewetter studied with Kant in 1788–1789 and visited Kant in the fall of 1790, after which Kant broke off relations with Kiesewetter, Förster concludes that "Kant had formed the plan for a Transition by at least the fall of 1790, if not already in the previous year".[81] What, however, is the point of Kant's *Transition*?

[79] For a history of the manuscript, see Eckart Förster's introduction to his English translation of parts of the *Opus postumum* in the *Cambridge Edition of the Works of Immanuel Kant*.

[80] AA 12: 23.

[81] Förster 2000, 3.

We can distinguish three main lines of interpretation of Kant's transition project. The first line of interpretation has been developed by Burckhard Tuschling.[82] Tuschling argues that the idea of a *Transition* resulted from Kant's recognition that the project of the *Metaphsische Anfangsgründe* of 1786 was flawed and in need of revision. According to Tushling, the *Metaphysische Anfangsgründe* does not allow of an extension (transition) of metaphysics to physics, since the latter work grounded physics.[83] The mere fact that Kant envisioned a transition project already points to deficiencies in Kant's *Metaphysische Anfangsgründe*.[84]

Tuschling specifies two problems afflicting the *Metaphysische Anfangsgründe*. First, he argues that Kant's proof of Proposition 1 of the Dynamics of the *Metaphysische Anfangsgründe* is problematic. This proposition is essential to Kant's dynamic theory of matter. It aims to show that matter fills a space through a special moving force.[85] Tuschling argues that after publishing the *Metaphysisiche Anfangsgründe*, Kant recognized that the proof of this proposition is defective.[86] Hence, Kant came to believe that the only valid content of the *Metaphysische Anfangsgründe* is contained in phoronomy.[87]

Second, Tuschling argues that in 1792 Kant came to recognize that his explanation of differences in the density of matters, as presented in the Dynamics of the *Metaphysische Anfangsgründe*, is circular.[88] Kant himself describes this problem in a letter to Jacob Sigismund Beck of October 16, 1792.[89] According to Tuschling, this problem also necessitated Kant to revise his theory of matter presented in the *Metaphysische Anfangsgründe*.

[82] Tuschling 1971, 1991, 2001. Tuschling's views have been defended and developed by Edwards 2000a, b; Westphal 1995b, 2004. Förster 2000, also adopts certain lines of thought of Tuschling, although he rejects several main theses of Tuschling's interpretation.

[83] Tuschling 1991, 107.

[84] Westphal 2004, 224.

[85] AA 4: 497.

[86] There seems to be consensus among commentators that Kant's proof of proposition 1 of Dynamics is problematic. See Carrier 1990, 181; Pollok 2001, 234–235.

[87] Tuschling 1971, 93–98. Tuschling articulates these ideas in chapters 3 and 5 of his 1971 work. See also Westphal 2004, 185–190. Both Tuschling and Westphal point to a review of Kant's *Metaphysische Anfangsgründe* on December 2, 1786 of the *Göttingen Anzeigen von gelehrten Sachen* no. 191, which questions the validity of Kant's proof of the first proposition of Dynamics. Kant was aware of this review, paraphrasing it at AA 21: 415. Friedman 1992a, 222–237, provides a critique of Tuschling but does not discuss Kant's proof of Proposition 1 of Dynamics.

[88] Tuschling 1971, 46.

[89] AA 11: 376–377. The circularity in question concerns a reciprocal dependency between the intensity of the fundamental force of attraction and density. It was discussed by Adickes. AA 14: 337–339. Many commentators on the *Opus postumum* discuss the problem of circularity and take it to necessitate some kind of revision of the *Metaphysische Anfangsgründe*. Förster 2000, 33–37, 41–45; Westphal 2004, 191–197; Emundts 2004, 74–117. However, like Adickes 1924, Vuillemin 1989, 243 denies that Kant's theory of matter is afflicted by this problem of circularity. Friedman 1992a, 223 argues that Kant never explicitly refers to the problem of circularity in the *Opus postumum* and refrains from discussing it.

A different interpretation of Kant's transition project is provided by Friedman.[90] Friedman does not consider the *Transition* to be a fundamental revision of the *Metaphysische Anfangsgrunde*. Rather, he views the *Transition* as an extension of the latter work. According to Friedman, the *Metaphysische Anfangsgründe* grounded Newtonian rational mechanics and the theory of universal gravitation. The *Transition* extends this project in order to ground what Friedman calls 'experimental physics'.[91] According to Friedman, Kant became convinced of the possibility of providing a foundation of experimental physics due to developments within chemistry. He argues that in the course of the early 1790s Kant adopted the chemistry of Lavoisier and that the *Transition* provides "a priori foundations of this new science".[92]

Dina Emundts has provided an interpretation of Kant's *Transition* incorporating strands of both lines of interpretation mentioned above.[93] In line with Friedman, Emundts rejects the idea that the *Transition* constitutes a fundamental revision of the project of the *Metaphysische Anfangsgründe*. However, she argues that the project of providing a foundation of empirical physics is already contained in the latter work. According to Emundts, Kant attempted to ground empirical physics in the General Remark to Dynamics of the *Metaphysische Anfangsgründe*.[94] However, because Kant recognized that his theory of matter was circular he was forced to provide a new foundation of empirical physics. This foundation is provided by the *Transition*.

The third line of interpretation has been developed by Vittorio Mathieu.[95] In line with Gerhard Lehmann,[96] Mathieu interprets Kant's last work in relation to the *Kritik der Urteilskraft*. Mathieu takes the *Transition* to explain how physics can constitute a system. In the third *Critique*, Kant had specified a subjective principle of the purposiveness of nature that allows us to view nature as systematic. According to Mathieu, Kant came to believe that the unity of the laws and phenomena of nature cannot be merely grounded on *subjective* principles. The *Transition* is supposed to ground the systematicity of the laws of nature categorically.

These are the most influential interpretations of Kant's *Opus postumum* currently available. It is necessary to mention them, since it allows the reader to appreciate the problematic nature of Kant's final (projected) work. Within the scope of this book, it is not possible to fully evaluate the strengths and weaknesses of these various interpretations. However, it is quite clear that all of them are partially correct. As we shall see, Kant revised various aspects of his matter theory within the *Opus postumum*. Moreover, the *Transition* is also clearly an attempt to provide philosophical foundations of what we may call empirical or experimental physics, allowing us to establish physics as a whole as a unified science.

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[90] Friedman develops this interpretation in chapter 5 of his 1992a work. See also Friedman 2006.

[91] Friedman 1992a, 240.

[92] Friedman 2006, 60.

[93] Emundts 2004.

[94] AA 4: 523–535.

[95] Mathieu 1989, 42–45.

[96] Lehmann 1939.

In the following, I will interpret Kant's *Transition* by taking into account Kant's conception of physics articulated in his critical period, and the conception of physics articulated in eighteenth-century textbooks on physics. I show that the *Transition* is similar to the enterprise of establishing physics as a systematic science by grounding *physica specialis* in *physica generalis*. In the *Metaphysische Anfangsgründe*, Kant reflected on topics that were traditionally treated within *physica generalis*. However, these reflections were tentative and Kant did not ground what we may call *physica specialis*. Hence, after publishing the *Metaphysische Anfangsgründe* Kant was still confronted with the task of grounding physics as a systematic science. The interpretation that will be developed is thus in line with the interpretation of Kant's transition project developed by Friedman and Emundts.

6.4.2 Kant's Transition Project and the Systematicity of Physics

Kant begins to work on the *Transition* in the so-called *Oktaventwurf* (1796), a term introduced by Erich Adickes.[97] In one of the first drafts of a preface, Kant introduces his *Transition* by distinguishing between the metaphysical foundations of natural science and physics:

> The *science of nature* (*philosophia naturalis*) turns upon two hinges, the one being its *metaphysical* foundations (that is, bound *a priori* in a system), the other containing universal principles based on experience (that is, empirical principles) of its application to objects of outer sense, which is called *physics*. (AA 21: 407)

The notion '*philosophia naturalis*' denotes a science of corporeal nature as a whole. The metaphysical foundations are interpreted as providing *a priori* principles of natural science, whereas physics is taken to contain (comparatively) universal empirical principles. Hence, the metaphysical foundations constitute a rational physics (*physica rationalis*), physics is an empirical science, and both sciences are construed as parts of *philosophia naturalis*.

Kant's transition project is construed as providing a transition from the metaphysical foundations of natural science to physics. It explicates the relationship between a priori and empirical cognition of nature:

> The transition (*transitus*) from one form of knowledge to another must be a step (*passus*) only, not a leap (*saltus*); that is, the doctrine of method requires one to *pass* from the metaphysical foundations of natural science to physics – from concepts of nature given *a priori* to empirical ones which yield empirical knowledge. (AA 21: 387)

The necessity of a transition from the metaphysical foundations of natural science to physics is prescribed by the doctrine of method (*Methodenlehre*). According to Kant, the doctrine of method specifies how the conditions of scientific cognition in general, such as *distinctness* (*Deutlichkeit*), *thoroughness* (*Gründlichkeit*), and

[97] Adickes 1920, 54–86.

systematicity, are to be obtained.[98] This doctrine prescribes us to show *how* physics can constitute a *systematic* whole. The task is taken up by Kant's *Transition*, which *grounds* physics as a systematic science.[99] The *Transition* grounds physics as a systematic science in a twofold sense. It shows how physics, construed as an empirical doctrine of nature, can constitute a system. In addition, by providing a transition from rational physics to empirical physics it shows how natural science (physics) as a *whole* constitutes a system.

In the second chapter, we have discussed Kant's conception of systematicity. A system of cognition constitutes a complete and ordered whole of cognition, in which the parts are necessarily related to each other in accordance with a priori rules. Insofar as the structure of a system is based on a priori rules, the ordering of a system is necessary. A system of cognition can grow internally but not externally, analogous to an organized animal body whose "growth does not add a limb", but rather "makes each limb stronger and fitter for its end without any alteration of proportion".[100] In the *Opus postumum*, Kant stresses that the systematicity of physics cannot be established *empirically*:

> Merely empirical science of nature can never amount to a system, but, at best, a fragmentary, ever-increasing aggregate. For, however far we may be acquainted with the empirical laws of nature, we do not know to what extent that may suffice for the purpose [*Gebrauch*] of the philosophy of nature; and the gaps make us dubious of our supposed explanations of the laws of nature. (AA 21: 474)

If physics is based on *merely* empirical principles, it can never constitute a system and remains an aggregate. It would constitute a contingent complex of cognition lacking a definite order, in which no part has a determinate place and the relation of the parts is subject to continuous revision. An empirical system is impossible: a system requires a priori foundations.[101] As Kant indicates in the passage above, if physics is based on merely empirical principles, it constitutes a fragmentary aggregate in which we are confronted with various *gaps* between different parts of physics.

Recall that in his dictionary on physics, Gehler analyzed physics as a fragmentary doctrine composed of doctrines that are not systematically related (Sect. 6.3.3). When discussing Eberhard, we have noted that the relationship between *physica generalis*, treating the universal properties of bodies, and doctrines pertaining to *physica specialis*, such as chemistry, electricity, and magnetism, was unclear (Sect. 6.3.4). In the *Opus postumum*, Kant thus intended to solve a foundational problem of eighteenth-century physics.[102] What is original to Kant's thought is the idea that if physics is to be a systematic science, this systematicity is to be

98 AA 9: 139–140.

99 This aspect of Kant's thought in the *Opus postumum* is stressed by Gloy 1976, 175–218; and Hoppe 1969.

100 *KrV*, A 833/B 861.

101 On this topic, see for example AA 21: 402 (1796); AA 21: 161, 164, 360, 363, 367 (1798); AA 22: 279–280, 287–289 (1799–1800).

102 See also Friedman 1992a, 240.

grounded philosophically. The transition project is a *philosophical* and *a priori* project that grounds physics as a systematic science.

It is important to note that Kant conceives of his transition project as a transition between distinct *territories*. In a draft of an introduction, contained in fascicle 4 (September–October 1798), he introduces his transition project by distinguishing the metaphysical foundations of natural science and physics in terms of their distinct territories. The territory of the metaphysical foundations is determined on the basis of a priori principles, whereas physics, construed as the whole of *empirical* cognition pertaining to natural science, is assigned a different territory.[103] Although the metaphysical foundations of natural science and physics have distinct territories, both are concerned with the *same set of corporeal object*. The distinction between the metaphysical foundations and physics is merely a distinction in terms of the status of their principles (a priori versus empirical).[104]

Kant argues that since the metaphysical foundations and physics are concerned with the same object, the doctrine of method directs us to specify the specific relationship between these sciences.[105] The necessity of a transition project thus arises in part from the fact that the metaphysical foundations and physics have the same object of investigation. Because both sciences are concerned with a common object, it is necessary to show not only that these disciplines are consistent with each other, but also how they are related to each other. In addition, Kant argues that a transition from the metaphysical foundations of natural science to physics is necessary in order to secure that the propositions of physics are not mere opinions and hypotheses.[106] Scientific knowledge must constitute *certain* cognition and should thus have a priori foundations. By showing how physics as a whole can constitute a systematic unity, the *Transition* provides preliminary steps in grounding empirical physics as a *proper science*.

6.4.3 **Physica Generalis** ***and*** **Physica Specialis** ***in Kant's Transition Project***

In the previous section, we have described Kant's transition project as having the purpose of grounding physics as a systematic science. The question remains why Kant thought an intermediary a priori science such as the *Transition* is necessary. Did not the *Metaphysische Anfangsgründe* already ground physics as a systematic science? In order to answer this question, we must provide an account of how Kant construes the nature of physics in the *Opus postumum*.

[103] AA 21: 360. On the notion 'territory' in relation to the *Transition*, see also: AA 21: 163, 172–173, 175, 289 (1798); AA 22: 279, 465, 491 (1799–1800).

[104] AA 21: 178.

[105] Ibid.

[106] AA 21: 177.

In the *Opus postumum*, Kant often characterizes physics as an *empirical* science. Physics is described as a system of cognition based on experience or as a doctrine of the laws of moving forces insofar as they are *derived* from experience.[107] This characterization is significant. Recall that Eberhard described empirical physics as the part of the doctrine of nature in which we determine properties and effects of bodies from experience (a posteriori). Empirical physics is a science that proceeds *analytically* from effects to causes. In contrast, *physica rationalis* is a science in which effects are derived *synthetically* from the forces of bodies. Moreover, Eberhard associated *physica rationalis* with the universal part of the doctrine of nature (*physica generalis*), whereas empirical physics was associated with the special part of the doctrine of nature (*physica specialis*). In the following, I show that in the *Opus postumum* Kant often associates physics with what was traditionally called *physica specialis*.[108]

There are various passages in the *Opus postumum* that support this reading. Kant often conceptualizes the transition project as enabling the *application* of the metaphysical foundations of natural science (rational physics) to empirical physics:

> The doctrine of the laws of the moving forces of matter, insofar as they are known *a priori*, is called metaphysics; insofar as they can only be derived from experience, physics. That doctrine, however, which envisages only the *a priori* principles of application of the former, rational [doctrine] to [the latter] empirical one, can form the transition of the philosophy of nature from the metaphysics of corporeal nature to physics. (AA 21: 310)[109]

Kant elucidates this claim by noting that the doctrine of "attraction at a distance in general" pertains to the metaphysical foundations of natural science.[110] In the *Metaphysische Anfangsgründe*, Kant took the universality and immediacy of universal attraction to be established *a priori*. In the *Opus postumum*, Kant notes that the doctrine of gravity as "its laws are observed at different heights" pertains to physics.[111] Here, Kant is hinting at the fact that the acceleration of falling bodies through gravity decreases with altitude. Variations among the measure of this acceleration cannot be determined a priori but must be determined experimentally. For this reason, this topic pertains to *empirical* physics.

It is important to note that the idea of *applying* rational physics to empirical physics is contained in the work of Eberhard. As we have seen, Eberhard argued that in *physica specialis* we *derive* the special properties of bodies from the universal properties specified in *physica generalis*. This amounted to *applying* principles of *physica generalis* to *physica specialis*, in order to explain particular properties pertaining to specific types of bodies (e.g., fluidity, solidity, etc.). For example,

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107 Cf. for example, AA 21: 387, 402–403, 407, 310 (1796–1798); AA 22: 279, 281, 289, 448 (1799–1800).

108 I will make this claim more precise in the following. It is important to note that Kant's conception of physics and its divisions differs from that of Eberhard, a divergence resulting from Kant's project undertaken in the *Metaphysische Anfangsgründe*.

109 Cf. AA 21: 407, quoted above.

110 AA 21: 311.

111 AA 21: 311.

Eberhard applied the notion of an attractive, cohesive force (developed in *physica generalis*) in order to explain fluidity, the brittleness of solid bodies, elasticity, etc. Through his *Transition*, Kant similarly wants to show how the a priori principles of rational physics, as developed in the *Metaphysische Anfangsgründe*, can be applied within empirical physics in order to establish a systematic and unified natural science.

In some passages in the *Opus postumum*, Kant uses the terms *physica generalis* and *physica specialis*. For example, in the *Oktaventwurf* (1796) we read:

> […] physics, is, in turn divided into *general physics* (*physica generalis*), which expresses only the properties of *matter* in outer objects of experience, and that (*physica specialis*) which attends to bodies formed from this matter in a particular way, and which draws up a system for them – for example, regarding the difference between organic and inorganic bodies. (AA 21: 407)

This description of *physica specialis* is similar to Eberhard's conception of special physics as a doctrine concerned with properties peculiar to specific classes of corporeal bodies. In a passage of later date (September–October 1798), Kant defines *physica generalis*, again in line with Eberhard's terminology, as a 'universal doctrine of nature' (*allgemeine Naturlehre*) that is concerned with the moving forces of matter and the a priori specifiable *universal* properties of matter.[112] Finally, in a passage of the third fascicle (August–September 1798) Kant defines *physica specialis* as a doctrine concerned with a *specific class* of moving forces, while the study of organic nature is defined as *physica specialissima*.[113] Here, we have Eberhard's tripartite division between *physica generalis*, *physica specialis* and *physica specialissima*.

In short: there is plenty of evidence suggesting that in the *Opus postumum*, the term 'physics' (considered as an *empirical doctrine*) is often used to denote what was traditionally called *physica specialis*. Kant's *Transition* can thus be fruitfully interpreted in light of a traditional conception of physics, in which (a) it was believed that natural science (physics as a *whole*) should constitute a system, (b) a distinction was made between general and special physics, and (c) the propositions of special physics were taken to be subordinated to and grounded by the propositions of general physics.

There are of course significant differences between these two projects. These differences stem from the fact that Kant's *Metaphysische Anfangsgründe* of 1786 provides a critique of classifications and divisions of physics found in eighteenth-century textbooks on physics.[114] Eberhard's *physica generalis* incorporated metaphysical discussions, kinematics, discussions on cohesion, and parts of Newtonian physics as presented in the *Principia*. Kant did not discuss many of these topics in the *Metaphysische Anfangsgründe* or did not think they belonged to the a priori part of physics. The aim of this work was to provide a rational physics in the strict Kantian science, i.e., a *metaphysical and a priori* foundation of natural science. In this science, *mathematical* and *empirical* principles did not have any place.

112 AA 21: 366.

113 AA 21: 293.

114 See Pollok 2001, 122–128.

Let us summarize the results we have obtained. The task of the *Transition* is to provide an a priori foundation for physics as a systematic science. The *Transition* is meant to show how the a priori principles of the *Metaphysische Anfangsgründe* can be applied to empirical physics, so as to demonstrate (i) how empirical physics constitutes a system and (ii) how rational and empirical physics constitute a unified system. As such, Kant's transition project is similar to (though not identical with) the project that we have located in the work of Eberhard: the project of showing how *physica specialis* is grounded by *physica generalis*.

This type of project was not fully articulated in Kant's *Metaphysische Anfangsgründe* of 1786. In the General Remark to Dynamics of the *Metaphysische Anfangsgründe*, Kant treated many topics that pertained to empirical physics (e.g., cohesion, the distinction between fluid and solid bodies, etc.). However, he acknowledged that he could not provide a "sufficient explanation for the possibility of matter and its specific variety from these fundamental forces".[115] In other words, he acknowledged the existence of gaps between rational and empirical physics: that propositions of empirical physics are grounded by propositions of rational physics had not been fully shown. However, this must be shown if physics is to constitute a true system. For these reasons, Kant's *Transition* is essential to his philosophical project.

6.4.4 Scientific Topics in the Transition

Kant took gaps existing in the philosophy of nature to necessitate his transition project. These gaps must be bridged if physics is to constitute a system. Yet, why did Kant think that a *mediating* a priori science is necessary in order to ground physics as a system? In the textbooks we have studied, the idea of such a mediating science is absent. In Eberhard's *Naturlehre*, the transition between *physica generalis* and *physica specialis* occurs directly through the application of propositions of general physics to the domain of special (empirical) physics. Eberhard adopted a consequent dynamist position, according to which many specific properties of specific types of material bodies, treated in *physica specialis*, are to be explained in terms of microscopic forces (treated in *physica generalis*). Thus, for example, Eberhard argued that the action of a short-range attractive force of cohesion (discussed in *physica generalis*) can explain phenomena such as fluidity and elasticity (topics pertaining to *physica specialis*).

In the fourth sheet of the fifth fascicle (July 1797–July 1798), Kant explains why he thinks that a mediating science or a *Transition* is necessary:

> One might think that the transition from the metaphysical foundation of natural science to physics requires no bridge, for the former, as a system constituted by concepts *a priori*, exactly adjoins the ground [*Boden*] of experience onto which it could alone be applied. But this very application creates doubts and contains difficulties which should be embarrassing for physics, as a particular system, separate from the former. For the admixture or insertion

[115] AA 4: 525. See Friedman 1992a, 237–239.

> of the one into the other, as commonly occurs, is dangerous; not just to its elegance, but even to its thoroughness, because *a priori* and empirical principles might communicate with or make claims upon one another. (AA 21: 526)

The application of the metaphysical foundations (rational physics) to empirical physics is often problematic because it results in the conflation of a priori and empirical principles. Although Kant does not specify a target of his criticism, we may note that it applies to Eberhard (and presumably many others). As said, Eberhard discussed the attractive force of cohesion in *physica generalis* and took this attractive force to be essential to explain phenomena treated in *physica specialis*. By contrast, in the *Metaphysische Anfangsgründe* Kant assigned cohesion to *empirical physics*, treating it as a derivative force.[116] Hence, from Kant's perspective Eberhard (i) confounded a priori and empirical principles of physics, (ii) based his *physica specialis* solely on empirical principles, and (iii) did not give a precise account of the relation between rational and empirical physics.

Kant's claim that physics is often treated fragmentarily is not unjustified. Take, once again, the example of Eberhard. Although Eberhard argues that the propositions of *physica specialis* should be derivable from the propositions of *physica generalis*, he does not elaborate this programme in detail. In his discussion of *physica specialis*, Eberhard rarely explicates the relation between *physica generalis* and *physica specialis*. For example, he provides a phenomenological description of fluids in terms of cohesion (a universal property of matter discussed within *physica generalis*). Fluids are bodies whose parts are invisible, and which cohere so little that they assume a different surface with the least change in the position of their parts.[117] In addition, the transition from solids to fluids is understood in terms of a decrease in cohesion among its parts.[118] However, apart from such general descriptions Eberhard does not explain how the principles of *physica generalis* ground *physica specialis*. Moreover, within his discussion of *physica specialis* Eberhard introduces various empirical hypotheses that bear no relation to the topics discussed within *physica generalis*. For example, the elasticity of solid bodies is (partly) explained in terms of the action of an elastic and fluid ether that penetrates solid bodies.[119] However, the ether is not systematically discussed within *physica generalis*.

How does Kant's *Transition* provide a solution to these kinds of problems? In order to provide an answer to this question, we may describe some of the scientific topics Kant discusses in the *Opus postumum*. In the *Oktaventwurf*, we find discussions of the following topics: (i) density differences among material bodies; (ii) cohesion; (iii) dissolution, precipitation, and crystallization; (iv) theories of heat; (v) electricity and magnetism; (vi) the states of matter; (vii) the different types of air (*Luftarten*); (viii) light; (ix) droplet-shaped fluidity; (x) the behaviour of liquids in capillary tubes. I will not describe Kant's views on all of these themes in detail. For our

[116] AA 4: 526.

[117] Eberhard 1774, 164.

[118] Eberhard 1774, 165. Kant argued that the distinction between fluid and solid bodies cannot be accounted for in terms of different degrees of cohesion.

[119] Eberhard 1774, 616–619.

present purpose, it is important to note that almost all of these topics were traditionally studied within *physica specialis*. How can Kant provide a unified and systematic treatment of these topics?

In the earlier parts of the *Opus postumum*, Kant attempts to ground physics as a systematic science by discussing the concept of matter in accordance with the table of the categories.[120] This methodology mirrors that of the *Metaphysische Anfangsgründe*.[121] The aim of the *Transition* is to classify the moving forces of matter in accordance with the categories of *quantity*, *quality*, *relation*, and *modality*.[122] Through following this procedure Kant hopes to establish an *elementary system* of moving forces.

Kant never arrived at a definite description of an elementary system of moving forces of matter.[123] However, his discussions of matter under the heading of the categories do provide insight into how he attempted to ground physics as a systematic science. In the following, I briefly highlight some of the scientific topics Kant discusses in accordance with the categories of quantity, quality, and relation.[124]

(a) Under the rubric of the *quantity* of matter, Kant often discusses the means for determining the quantity of matter (mass). He claims that *weighing* is "the only general and dynamical means for the precise determination of the quantity of matter, of whatever type it be".[125] This claim results from the fact that Kant takes universal gravitation to provide a universal basis for determining the mass of bodies. As Martin Carrier has shown, Kant already adopted this view in the *Metaphysische Anfangsgründe*.[126] In the *Opus postumum*, he invokes the view that weighing provides a universal basis for determining mass in order to argue that the ether (caloric) constitutes a condition for the possibility of experience. In a nutshell, the argument is as follows. The quantity of matter (mass) must be determined experimentally by weighing. This requires an instrument, such as a balance, which is a *solid* or *rigid* physical body. Yet according to Kant the rigidity of physical bodies depends (as we shall see below) on the action of an ether (caloric). Hence, the ether functions as a condition for the possibility of experience insofar as it is a condition for determining the mass of bodies.[127]

[120] See Förster 2000, 1–23.

[121] AA 4: 474–477.

[122] See AA 21: 311.

[123] Förster 2000, 12–19.

[124] I abstract from 'modality' given that Kant's remarks on modality do not really add to the scientific content discussed within the transition project.

[125] AA 22: 208.

[126] Carrier 2001b.

[127] See AA 22: 138–139, 260, 587. This argument is often discussed. See Adickes 1920, 475–483; Mathieu 1989, 98–100; Friedman 1992a, 297–299; Förster 2000, 15–17. Friedman points out the problem of this supposedly *transcendental* argument: "Why *must* cohesion and rigidity be explained by the penetration of a universally distributed heat matter – and not, for example, by microscopic action-at-a-distance forces? […]. Until such alternative accounts of cohesion and rigidity are somehow ruled out […] the claim that Kant's caloric theory "is in no way based on experience and borrows nothing from physics" must appear hollow indeed."

(b) When discussing the *quality* of matter, Kant provides an analysis of the states of aggregation.[128] In particular: if we consider matter in accordance with its quality, matter can be construed as *fluid* or *solid* (*rigid*). Fluids are divided in attractive fluids (liquid state) and expansive or elastic fluids (gaseous state).[129] The cause or principle of all fluidity is taken to be the matter of heat or caloric (ether).[130] The ether can penetrate bodies and communicate its motion to the parts of these bodies. These parts are set in a state of motion and mixed, which brings about fluidity. The transition from the state of attractive fluidity to expansive fluidity occurs by the addition of heat, whose expansive (repulsive) forces bring matter into a greater state of expansion. Finally, the formation of solid bodies is explained through the release of caloric from fluids and the subsequent formation of a crystalline structure that resists internal displacement.[131] In the *Metaphysische Anfangsgründe*, Kant had proclaimed he could not yet explain how rigid or solid bodies are possible.[132] In the *Opus postumum*, this problem is solved and Kant provides a unified account of the states of aggregation in terms of the action of the ether or caloric.

Kant also accounts for more specific properties of fluids in terms of caloric such as the tendency of liquids to assume a spherical droplet shape and the rising of water in capillary tubes. I will not analyze Kant's explanation of these phenomena in terms of the action of the ether in detail.[133] His arguments are primarily based on the elimination of alternative explanations of these phenomena. For example, he argues that the tendency of liquids to assume a spherical droplet shape cannot be explained by microscopic attractive forces. Neither can this phenomenon be explained in terms of the pressure of an ether. These considerations lead Kant to postulate that it is through the impact of a penetrating and oscillating ether that liquids assume a spherical, droplet shape.[134] In a similar fashion, he argues that the rising of water in capillary tubes is a partial effect of the ether.

(c) Kant usually discusses cohesion under the heading of the category of *relation*.[135] In the *Opus postumum*, Kant emphasizes that cohesion cannot be explained in terms of microscopic attractive forces. In the early leaves predating 1796, Kant asks whether "cohesion be possible through inner forces of matter (like gravity)."[136] His answer is negative. Kant's arguments are anything but perspicuous. He often simply emphasizes the differences between cohesion and attraction or gravitation. Thus, for example, cohesion is said to be a contact

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[128] See, for example, AA 22: 213, 141–142. For a detailed account of this topic, see Adickes 1920, 483–489. Friedman 1992a, 291–294; Carrier 2001a, 214.

[129] Cf. AA 21: 317, 296; AA 22: 218.

[130] AA 22: 213.

[131] AA 21: 298. Cf. AA 21: 276–280.

[132] AA 4: 529.

[133] For a more detailed account, see Adickes 1920, 489–500.

[134] These argumentative steps can be found, for example, at AA 21: 521–522.

[135] Cf. AA 22: 146.

[136] AA 21: 417.

> force as opposed to a penetrating (long-range) force, cohesion is not proportional to mass or density and cohesion is not an inverse-square force. These considerations quickly lead to postulating the ether as the cause of the cohesion of physical bodies. In contrast to the *Metaphysische Anfangsgründe*, where it was tentatively suggested that the cohesion of bodies derives from the pressure of the ether, Kant now states that it is through the ether's communication of motion through impact that bodies cohere.[137]

In arguing that the cohesion of physical bodies is not possible through microscopic attractive forces, Kant rejects the views of Eberhard and Erxleben. Eberhard treated cohesion as a microscopic attractive force, whereas Erxleben argued that bodies cohere in virtue of an 'actual inner force' efficacious within microscopic bodily parts.[138] It is worth noting that Gehler also rejected such views. In his article on attraction, Gehler notes that although we conceive of cohesion as a form of attraction, only the law of universal attraction or gravitation has been precisely determined. Laws governing other types of attraction, e.g., attraction in contact (cohesion), have not been established.[139]

According to Gehler, it is clear that the law of universal gravitation does not hold for all types of attraction. This was established by Newton himself.[140] Proposition 85 of Book 1 of the *Principia* establishes the following implication:

> If the attraction of an attracted body is far stronger when it is contiguous to the attracting body than when the bodies are separated from each other by even a very small distance, then the forces of the particles of the attracting body decrease, as the attracted body recedes, in a more than squared ratio of the distances from the particles. (Newton [1726] 1999, 610)

Gehler notes that that the antecedent of this implication is true of attraction in contact (cohesion). Hence, cohesion is not an inverse-square force and the laws governing cohesion are quite different from those governing universal gravitation. The problems that Kant ascribes to the view that cohesion results from microscopic attractive forces are thus partly identified by Gehler. In contrast to Kant, Gehler did not however conclude that it is *impossible* that microscopic attractive forces cause cohesion. He simply acknowledged that we have no real knowledge of the causes of cohesion.

Let us return to the question of how Kant believed he could ground empirical physics as a system. The answer emerging from the above analysis is clear: Kant attempted to ground empirical physics as a system by treating the *ether* as the fundamental principle of empirical physics.[141] It is by appealing to the ether that most phenomena traditionally discussed within *physica specialis* are taken to be explicable.

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[137] AA 22: 146–147. Cf. Förster 2000, 43–45.

[138] Erxleben 1772, 33–34.

[139] Gehler 1787–1796, Bd. 1, 171–172.

[140] *Ibid*.

[141] Friedman 1992a, chapter 4.

According to Kant, the systematicity of empirical physics must be grounded on a priori principles. Hence, if the existence of the ether is a mere empirical hypothesis, empirical physics would not be properly grounded. In the early parts of the *Opus postumum*, Kant treats the existence of the ether as an empirical hypothesis.[142] However, guided by the idea that a systematic physics must be based on a priori principles, he comes to treat of the ether as an a priori principle. This leads to Kant's infamous a priori proofs for the existence of the ether, contained primarily in the sheets *Übergang 1-14* (May–August 1799). Here, Kant argues that the existence of matter that is distributed through the universe as a continuum, whether it is called ether, caloric or anything else, constitutes a "principle of the possibility of the unity of the whole of possible experience".[143] I will not discuss Kant's ether proofs.[144] On the basis of the foregoing, I will summarize why Kant believed that a transitional science is necessary in order to connect rational and empirical physics:

> (i) In the *Metaphysische Anfangsgründe*, Kant had difficulties in systematically relating rational and empirical physics. (ii) Kant distanced himself from the project of explaining phenomena studied within empirical physics in terms of microscopic attractive and repulsive forces. The direct application of the principles or fundamental forces studied within rational (general) physics to special physics, a project undertaken by Eberhard and Erxleben for example, is taken to be problematic because: (iia) the laws concerning microscopic forces are often unknown, and (iib) this involves the mixing up of rational and empirical physics. (iii) Kant became convinced that phenomena discussed within empirical physics can be explained in terms of the action of the ether. (iv) However, a systematic science must be based on a priori principles. (v) Therefore, Kant undertakes the project of providing an a priori proof for the existence of the ether. This is a *philosophical* task belonging to the province of the transition project.

6.4.5 The Transition and Biology

In spite of the numerous difficulties that confront Kant's transition project, the *Transition* shows how Kant developed his program of establishing physics as a whole as a systematic science. In this section, I will return to the question of how we should understand the place of biology within natural science. In the previous chapter, I have argued that according to Kant biology should be considered as part of natural science (physics as a whole), insofar as explanations in biology are partly based on propositions pertaining to other natural sciences (such as chemistry).

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[142] AA 21: 378.

[143] AA 21: 224.

[144] The ether proofs constitute the most discussed part of the *Opus postumum*. See Adickes 1920, 363–397; Mathieu 1989, 111–127; Förster 2000, 75–101; Edwards 2000a, 147–166; Emundts 2004, 156–201; Friedman 1992a, 290–316.

In the present chapter, we have seen that biological topics were discussed in eighteenth-century textbooks on physics. The position of biology within natural science was problematic. Nevertheless, biology was a part of physics. If one accepts the ideal of a systematic and unified physics, this means that biology should somehow be related to other doctrines pertaining to physics.

What status did Kant assign to biology in his transition project? This question is rarely asked by commentators of Kant's *Opus postumum*. In general, the *Transition* is not taken to have much significance for Kant's views on the status of biology as a science. This is understandable. Kant excluded the study of organic nature from his transition project in the early parts of the *Opus postumum*. In the *Oktaventwurf* (1796), he states:

> Physics itself does not contain a further transition from merely mechanical to organic nature (founded on the concept of purpose) <which [transition], and according to which causal laws these [purposes] could be explained, exceeds the insights of human reason>. (AA 21: 388)

A few pages later, Kant states: "Physics of mineral or organic nature. Only the former do we treat according to *a priori* principles."[145] Hence, in the early stages of the *Transition* the study of organic nature is excluded from the *Transition*. However, early 1799 Kant begins to argue that a systematic physics must be taken to include the study of organic nature. For example:

> One can, in fact, also draw on the concept of *organic* (as opposed to *inorganic*) nature, in the consideration of the moving forces of nature, without, [thereby], transgressing the limits, determined *a priori*, of the transition to physics, or mixing into it what belongs to the material part of physics […].
>
> The *final causes* belong equally to the moving forces of nature, whose *a priori* concept must precede physics, as a clue for the investigation of nature. One must see whether (and how) *they*, too, form a system of nature, and can be attached to metaphysics. (AA 21: 184)

The sudden introduction of these passages has given rise to diverse interpretations. Gerhard Lehmann and Vittorio Matthieu have argued that it was the task of preparing the third edition of the third *Critique* in 1799 that led to Kant to introduce considerations concerning organic nature in the *Transition*.[146] In contrast, Eckart Förster argues that the introduction of these topics can be explained without reference to a third edition of the third *Critique*.[147] He treats Kant's reflections on organic nature as preliminaries to the *Selbstsetzungslehre* developed in the *Opus postumum*.

The interpretation of Kant's *Transition* developed above allows for another interpretation of the introduction of organic nature within Kant's project. Recall first of all that Kant entertains a broad conception of physics. We have seen that Kant does not equate physics with mathematical physics. Rather, with the exception of empirical psychology, physics includes all doctrines of nature, including the study of organic nature. Recall further that in their textbooks and dictionaries on physics,

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[145] AA 21: 402.

[146] Lehmann 1968, 371; Mathieu 1989, 240.

[147] Förster 2000, 21–23; Cf. also Tuschling 1971, 164–168.

Eberhard, Karsten, and Gehler all took the study of plants and animals to be included in physics. Eberhard treated organic nature within *physica specialis* or what he sometimes calls *physica specialissima*. In the *Transition*, Kant himself describes the study of organic nature as *physica specialissima*.[148] Given that the *Transition* corresponds to the project of grounding *physica specialis*, it comes as no surprise that Kant included biological topics within his transition project. The project of grounding physics as a systematic science requires an account of how biology is related to physics. This project was fundamental to understanding the nature of both physics and biology at the end of the eighteenth century, in which philosophers and scientists were confronted with the problem of how natural science can be understood as a systematic unity.

If this interpretation is correct, one would expect that reflections concerning organic nature are included within Kant's transition project from the very beginning. How can we square this with the fact that up to early 1799 Kant excludes the study of organic nature from his *Transition*? I must confess that I cannot answer this question. However, it must be emphasized that reflections on organic nature are indeed already contained in the *Oktaventwurf* of 1796. There, Kant introduces the concept of a vital force and lists the paradigmatic organic processes of nutrition, growth, and generation.[149] Hence, reflections on organic nature were from the beginning contained within Kant's transition project. In the next chapters, we will investigate how Kant conceives of biology within the *Transition* in more detail.

6.5 Conclusion

Kant often uses the term 'physics' to denote natural science as a whole. He demarcates different natural sciences in terms of (i) their object, (ii) their a priori or a posteriori mode of justification, and (iii) their method. (i)–(iii) determine the *territory* of a science.

Kant adopts a rather broad conception of physics as a science including doctrines such as chemistry and biology. He also believes that natural science as a whole should constitute a systematic unity. In eighteenth-century textbooks and dictionaries on physics, the ideal of a unified natural science or physics was also often articulated, even if the feasibility of such a project was sometimes doubted. In some of these works, a distinction was made between a universal doctrine of nature (*physica generalis*), in which we consider universal properties of material objects, and a special doctrine of nature (*physica specialis*), in which we consider particular properties pertaining to particular classes of objects. Propositions pertaining to *physica specialis* are taken to be *grounded by* propositions pertaining to *physica generalis*. It is this fact that secures the systematic unity of natural

[148] AA 21: 510, 512.

[149] AA 21: 376.

science as a whole. Moreover, the study of organic nature is often taken to be a part of *physica specialis*.

Kant's transition project, recorded in the *Opus postumum*, aims to ground the systematicity of physics by providing a bridge between the metaphysical foundations of natural science (rational physics) and physics, construed as an empirical doctrine. This is a bridge between two sciences that concern the same object (corporeal nature) yet have distinct territories. This *Transition* is similar to (though not identical with) the traditional project of grounding *physica specialis* in *physica generalis*. In contrast to the views of his contemporary physicist, Kant argues that this requires philosophical (a priori) principles. In developing his foundation of empirical physics, he introduces the ether as a fundamental a priori principle grounding the unity of physics. It is on the basis of the ether that most or even all phenomena traditionally discussed within *physica specialis* can be explained, or so Kant thinks. Since biology is a part of physics or natural science, biology should also somehow be grounded in the universal (a priori) doctrine of nature. Hence, although Kant's position on this matter fluctuates, the study of organic phenomena is included within the transition project.

Chapter 7
Vital Forces and Organisms in the *Opus postumum*

In the previous chapter we have analyzed Kant's transition project. The *Transition* aims to provide a foundation of physics as a systematic science. The study of organic nature is a part of physics. Hence, considerations concerning what we call biology are pertinent to Kant's project. The *Transition* is supposed to ground biology in order to establish physics as a systematic science. However, Kant never fully succeeded in providing a foundation of biology. The reason is that the relationship between biology and other natural sciences remained unclear.

In the present chapter, I analyze Kant's reflections in the *Opus postumum* that concern the concept of 'vital force'. Kant's views on vital forces have been heavily debated in the recent literature. Timothy Lenoir has argued that Kant's so-called teleomechanism provided a conceptual model that explicated the assumptions lying behind Blumenbach's theory of the *Bildungstrieb*.[1] Blumenbach's theory of the *Bildungstrieb*, a *vital force* responsible for the generation, nutrition and growth, and regeneration of organisms, was praised by Kant because it supposedly united the physico-mechanical and teleological mode of explanation in biology.[2] Partly for this reason, Lenoir takes Kant's and Blumenbach's views on biological method to be very similar. Robert Richards and John Zammito have rejected Lenoir's interpretation. They argue that Blumenbach's theory of vital force, which assumed the actual *existence* of teleological agents in nature, was incompatible with Kant's *regulative* construal of teleology.[3] In the present chapter, I argue that although the relationship between Kant's views on biological method and the biological praxis of his contemporaries is complex, Richards and Zammito are ultimately correct. A study of Kant's use of the notion 'vital force' in the *Opus postumum* shows that he took vital forces to be merely regulative ideas.

Next to discussing Kant's views on vital forces, I will analyze how he construes the concept 'organism' in the *Opus postumum*. I show that Kant took the concept of

[1] Lenoir 1989, 22, 24. See also Zammito 2012.

[2] Lenoir 1980, 83. Kant himself praises Blumenbach's work in these terms. See AA 11: 184.

[3] Richards 2000; Zammito 2012.

H. van den Berg, *Kant on Proper Science: Biology in the Critical Philosophy and the* Opus postumum, Studies in German Idealism 15, DOI 10.1007/978-94-007-7140-6_7,

'organism' ('natural purpose') to be a priori presupposed within physics or natural science. It is a concept that *precedes* empirical investigation and that allows us to construct the domain of biological investigation. In the *Opus postumum*, Kant thus clearly articulates the idea, which we have developed in Chap. 5, that the concept of a natural purpose determines the *domain* of biology.

Kant reflected on the notions of 'vital force' and 'organism' throughout his life. In order to understand how these topics are treated in the *Opus postumum*, I will therefore first consider his published writings. In addition, the reflections on organic nature contained in the *Opus postumum* must be interpreted in light of eighteenth-century biological theories. By relating Kant's views on organic nature as articulated in this last projected work to eighteenth-century biology, we can increase our understanding of the *Opus postumum* and of Kant's position with respect to the biological science of his day.

My interpretation of Kant's reflections on organic nature in the *Opus postumum* is conservative. In this and the following chapter, I argue that Kant's late reflections build on the position developed in the *Kritik der Urteilskraft*. In the *Opus postumum*, Kant does not significantly revise his earlier views. Most importantly, he remains convinced that the concept of a natural purpose is a *regulative* concept. I argue that Kant's confrontation with particular biological concepts and theories in the 1780s and 1790s, as well as metaphysical interpretations thereof, led him to reassert his philosophy of organic nature articulated in the *Kritik der Urteilskraft*. Kant was confronted with biological theories that he took to have materialist and/or hylozoist implications, and with metaphysical interpretations of these theories that conflated science and metaphysics. According to Kant, the view that the concept of an organism is a regulative concept provided a natural antidote to these transgressions.

The chapter is structured as follows. In Sect. 7.1, I discuss some existing interpretations of Kant's philosophy of organic nature in the *Opus postumum* and position myself with respect to these interpretations. Section 7.2 provides an analysis of the notion of 'vital force' as it was employed by the eighteenth-century biologists Johann Friedrich Blumenbach, Joachim Dietrich Brandis, and Johann Christian Reil. In Sect. 7.3, Kant's views on vital forces are discussed. I describe Kant's critique of Herder's notions of 'organic force' and 'genetic force', contained in his 1785 reviews of Johann Gottfried Herder's *Ideen zur Philosophie der Geschichte der Menschheit*, his critique of hylozoism in the *Kritik der Urteilskraft* (1790), and his views on vital force as contained in the *Opus postumum* (1790s). Throughout all these writings Kant intended to strip the concept 'vital force' of its metaphysical (ontological) implications. According to Kant, we cannot affirm the objective reality of vital forces in nature. In adopting this position, Kant partly distanced himself from the views of Blumenbach. Finally, in Sect. 7.4 I show that in the *Opus postumum* Kant develops the view that it is by conceptualizing organisms as natural purposes that we determine the *domain* of the biological sciences.

7.1 The *Opus postumum* and Kant's Philosophy of Organic Nature

Kant's views on organic nature in the *Opus postumum* have been little discussed. Nevertheless, a number of influential interpretations do exist. According to these interpretations, Kant's philosophy of organic nature, as articulated in his last work, is at odds with the position of the third *Critique*. In the following, I will briefly review some of these interpretations.

In his influential commentary on the *Opus postumum*, Erich Adickes provided a brief discussion of Kant's ideas on organic nature. Adickes took Kant to develop a dogmatic metaphysical account of organic nature.[4] To substantiate this claim, Adickes identified various passages in which Kant states that organisms have an immaterial principle as their ground (e.g., a soul), that they are created, etc. These passages indeed occur frequently in the *Opus postumum*.

More recently, Vittorio Mathieu has also argued that Kant's views on the organic constitute a revision of his views in the *Kritik der Urteilskraft*. According to Mathieu, Kant assigns ideas of reason a new function in his *Transition*. This is also true for the idea of an organism, which is assigned a *constitutive* function.[5] Matthieu thus argues that Kant abandons the idea that the concept of a natural purpose is a regulative concept of reflective judgment.

In this chapter and the next, I develop a different interpretation and argue that Kant retains committed to his *regulative* conception of teleology. I show that many passages in the *Opus postumum* are fully in line with Kant's position articulated in the third *Critique*. Moreover, I argue that Kant's confrontation with biological theories developed in the 1780s and 1790s led him to *reaffirm* the regulative status of teleology. I show that the various problematic metaphysical implications of biological theories or metaphysical interpretations of these theories provide a number of reasons for why Kant continued to think of the idea of an organism as regulative.

That Kant remained committed to his regulative conception of teleology becomes clear if we analyze his views on vital forces in the *Opus postumum*. As we have noted, Timothy Lenoir has argued that Kant's philosophy of organic nature was in agreement with Blumenbach's theory of the *Bildungstrieb*. According to Lenoir, Kant's philosophy provided a theoretical foundation for the Göttingen School of Biology, including biologists as Johann Friedrich Blumenbach (1752–1840), Johann Christian Reil (1759–1813), and others.[6] In contrast, Robert Richards and John Zammito have argued that Kant's philosophy and Blumenbach's work on the *Bildungstrieb* and epigenesis are radically at odds with each other. According to the

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[4] Adickes 1920, 216–235.

[5] Mathieu 1989, 209–213.

[6] Lenoir 1989.

latter authors, the praise that Kant and Blumenbach exchanged to each other was based on a grand misunderstanding.[7]

If we take into account Kant's reflections in the *Opus postumum*, it becomes clear that the relationship between Kant's views on biological method and the views espoused by his contemporary biologists is highly complex. Kant's views on biological method cannot be identified with the views of for example Blumenbach or Reil. Rather, he entertained some views that are very akin to those of Blumenbach, whereas he entertained other views that are similar to those of Reil.

In particular: Kant was attracted to Blumenbach's theory of vital force because he took it to express a fundamental presupposition of biological inquiry. In biology, we presuppose that organisms are *purposive* objects. As I have argued in Chap. 5, we take organisms to have a structure that is *adapted* to performing functions such as propagation, nutrition, growth, regeneration, etc. Processes such as propagation, nutrition and growth, and regeneration, are in turn conceptualized teleologically, i.e., as *serving* the maintenance of organisms. Both Kant and Blumenbach adopted this view on biological method.

However, as we have also seen in Chap. 5, Kant emphasized that we should always strive to provide mechanical explanations in biology. In biology, we presuppose that organisms have a structure that is adapted to performing functions such as reproduction, growth, etc. Proceeding from this assumption, we must try to provide mechanical accounts of such processes, e.g., by specifying the chemical processes involved in the nutrition and growth of organisms. In this respect, Kant's conception of biological method is akin to that of for example Reil.

Kant *differed* from both Blumenbach and Reil (and various other biologists) by strictly distinguishing between *methodological* presuppositions grounding biological research and *ontological* presuppositions. According to Kant, we construe organisms as purposive. However, this is a methodological presupposition and we are not allowed to infer to the objective reality of teleological causation in nature. For this reason, we are, for example, not allowed to affirm the existence of teleological forces such as Blumenbach's *Bildungstrieb*. Similarly, the claim that we should always explain organic phenomena mechanically is a methodological maxim that does not imply that teleological causation in nature does not exist. In eighteenth-century biological theories various biologists proceeded from ontological assumptions, whereas many biologists and philosophers took biological theories to have ontological or metaphysical implications. Kant insisted on the demarcation of biology and metaphysics. He criticized anyone who attempted to derive metaphysical conclusions from biological theories.

The study of the *Opus postumum* shows that Kant interpreted developments within biology from his own philosophical perspective, being aware of differences existing between his philosophical views and the assumptions made by biologists of his time. These differences were often *metaphysical* differences. The lesson to draw

[7] Richards 2000 is titled: "Kant and Blumenbach on the *Bildungstrieb*: A Historical Misunderstanding". See also Zammito 2006, 2012.

from the *Opus postumum* is that Kant mainly distanced himself from metaphysical presuppositions of biologists. From Kant's perspective, biology often intruded in the domain of metaphysics and vice versa.

7.2 Theories of Vital Force

In reflections concerning organic nature in the *Opus postumum*, Kant introduces the term vital force (*Lebenskraft*) and employs similar terms such as organic formative force (Sect. 7.3.3). Moreover, Kant takes such forces to be fundamental to biological inquiry. The introduction of these terms is novel with respect to the third *Critique*. Apart from a brief reference to Blumenbach's *Bildungstrieb*,[8] notions such as vital or organic force do not play a significant role in the latter work.

The introduction of these terms must be understood in light of biological theories developed in the late eighteenth century. In several of these theories, the notion of a vital force was assigned a crucial role. In addition, biologists vehemently discussed how we should interpret the notion of vital force. In order to understand Kant's reflections on organic nature in the *Opus postumum*, we must present a brief overview of the manner in which the notion of vital force was employed by biologists in the late eighteenth century. In the present section, I will, building on the works of Timothy Lenoir and Robert Richards,[9] provide such an overview.

In Sect. 7.2.1, I discuss the theory of vital force developed by Johann Friedrich Blumenbach. I have treated some of Blumenbach's works and theories in Chap. 5. However, a full understanding of his theory of vital force requires further analysis. I will focus on Blumenbach's notion of *Bildungstrieb*, while also briefly discussing the project of establishing distinct orders of vital forces. The latter project consisted in the specification of distinct vital forces in order to account for different classes of vital properties (i.e., properties characteristic of organisms and their parts). I will also highlight Blumenbach's distinction between vital and physical forces of bodies. The former only exist within organic nature whereas the latter act universally on all corporeal bodies. Vital forces are taken to be *irreducible* to physical forces.

In Sect. 7.2.2, I discuss two theories of vital force that differ from that of Blumenbach. First, I describe the views of Joachim Dietrich Brandis. Similar to Blumenbach, Brandis posited vital forces as causes of the organization of organisms and of so-called organic motions of parts of organisms. However, in contrast to Blumenbach he allowed for the possibility that vital forces may be *reducible* to physical forces. Second, I treat the views of Johann Christian Reil, who adopts a strong reductionist position with respect to the notion of a vital force. Reil ultimately rejects the intelligibility of the notion of a vital force, arguing that we must explain properties of organic bodies in terms of the (chemical) mixture of their

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8 AA 5: 424.

9 Lenoir 1989; Richards 2002.

matter or parts. In addition, he questions the universal applicability of teleology in biological research, attacking Kant's claim that we must always reflect on organisms in teleological terms.

7.2.1 Blumenbach's Theory of Vital Force and the **Bildungstrieb**

Before treating Blumenbach's theory of vital force a terminological note of caution is required. It is impossible to identify a definitive theory of vital force in Kant's time. As indicated, the notion of vital force was the subject of considerable controversy and different biologists interpreted this notion in different ways. Biologists also employed various terms, e.g., 'vital force', 'organic force', or 'genetic force', to characterize these forces. The choice of which term to adopt seems to have been a matter of convention.[10] In all cases, we are dealing with a term denoting some cause of properties of organisms (the nature of such causes is again a matter of controversy). In the following I will for the most part adopt the terminology of Blumenbach and speak of vital force (*Lebenskraft*).

In the present section, I focus on the account of vital forces developed by Blumenbach. My reasons for focusing on Blumenbach are twofold: (i) Kant was familiar with the work of Blumenbach, which is therefore, an important point of reference for determining Kant's view on vital forces; (ii) Blumenbach's biological research significantly influenced his contemporaries, including his many students at Göttingen (as Lenoir has shown).[11] Hence, Blumenbach's conception of vital forces was dominant, although not universally accepted. I will first discuss Blumenbach's views on vital forces by analyzing his conception of the *Bildungstrieb*. Then, I discuss his distinction between physical and vital forces and the manner in which he distinguishes between different kinds of vital force.

In his treatise *Über den Bildungstrieb und das Zeugungsgeschäfte*, first published in 1781,[12] Blumenbach introduced the concept of *Bildungstrieb* while developing an epigenetic theory of organic generation. This theory was based on a rejection of preformationist theories, in particular that of von Haller, who understood embryological development as the unfolding of preformed embryonic parts contained in preexisting germs.[13] Blumenbach, by contrast, endorsed an epigenetic theory,

[10] This, at least, is what Reil 1795, 48, claims.

[11] Blumenbach's works influenced Alexander von Humboldt, Karl Friedrich Kielmeyer, Heinrich Friedrich Link, Georg Reinhold Treviranus and Christoph Girtanner. On the possible influence of Kant's philosophy of biology on these biologists, see Lenoir 1981, 111–205.

[12] Kant was probably familiar with the first and second edition of *Über den Bildungstrieb*, published in 1781 and 1789. I will refer to both editions in the following. Blumenbach first published his ideas on the *Bildungstrieb* in the *Göttingisches Magazin der Wissenschaften und Litteratur* 1780.

[13] Blumenbach 1789, 15–19. For discussion of Blumenbach's concept of *Bildungstrieb*, to which my account is indebted, see Lenoir 1980, 82–87 and Richards 2000, 16–21.

according to which the organization of the embryo developed from a not yet organized mass.[14] In order to explain the possibility of epigenesis, Blumenbach postulated the existence of a formative force, the *Bildungstrieb* (*nisus formativus*), which directed the formation of the embryo out of homogeneous material. In order to understand Blumenbach's arguments for the existence of the *Bildungstrieb*, it is important that we do not conceive of preformationism and epigenesis as merely embryological theories. The scope of these theories is broader, since both provide a framework for understanding what we might call various types of organic generation, including regeneration, nutrition, and growth.

How did Blumenbach come to the notion of a *Bildungstrieb*? In the first section of his treatise, Blumenbach stated that the observation of various instances of organic regeneration, such as the regeneration of the cut-off parts of a polyp, led him to conclude:

> That no preformed germs preexist. But that in the previously raw unformed generative material of organized bodies, after it has reached its maturity and place of destination, a particular life-long drive becomes active. This drive initially bestows on bodies their form, then preserves it, and, if they become injured, where possible restores their form. This is a drive which consequently belongs to the vital forces, but which is also clearly different from both the other kinds [*Arten*] of vital force of organized bodies (of contractility, irritability, sensibility etc.) and from the universal physical forces of bodies in general. It appears to be the first important force for all generation, nutrition and reproduction, and, in order to distinguish it from other vital forces, one can designate it with the name of *Bildungstrieb* (*nisus formativus*). (Blumenbach 1789, 24–25)[15]

This passage contains Blumenbach's most explicit description of the *Bildungstrieb*. The *Bildungstrieb* is a first cause of organic form, whose continuous efficacy helps to preserve the form and vitality of organisms. The assumption of such a first cause allows us to understand the possibility of epigenetic embryological development. In addition, Blumenbach distinguishes between vital and physical forces, and between different types of vital force (the *Bildungstrieb* being the most fundamental vital force). In the following, I will (i) describe how Blumenbach inferred the existence of the *Bildungstrieb*, (ii) consider the distinction between mechanical (physical) and vital forces, and (iii) consider the distinction between various types of vital forces. Points (i)–(iii) will allow us to give a general characterization of the manner in which Blumenbach conceptualized *Lebenskräfte*.

(i) In his treatise on the *Bildungstrieb*, Blumenbach provided several observations, such as instances of organic regeneration, confirming the existence of this particular force.[16] However, the hypothesis of the *Bildungstrieb* was mainly

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[14] Blumenbach 1789, 5–6.

[15] My translation, with help from Richards translation of the first edition. Richards 2000, 18.

[16] Blumenbach 1789, 66–68, 57–61, also cited many observations disconfirming the preformationist account of generation. For example, he argued that the generation of hybrids and the fact that in the early stages after fertilization one cannot observe any specific organic structure in the human embryo or in chicken eggs, provided empirical evidence against the theory of preformationism. See Richards 2000, 18–19.

taken to be justified because it accounted for empirical observations that could not be handled by alternative preformationist theories. A simple example can illustrate this point. Blumenbach argued that preformationism could not account for the regenerative capacities possessed by organisms.[17] On the preformationist account, the regeneration of the parts of, for instance, a polyp, is explained by postulating the existence of a variety of encased germs distributed throughout its parts. These germs lie dormant in the polyp until external causes trigger them to develop themselves, thus regenerating the lost or injured parts. Blumenbach rejected this hypothesis. He observed that when half a green polyp and half a brown polyp are put in a glass they come together, forming a 'chimera' of different animal kinds.[18] This case shows that, contrary to what the preformationist account implies, the regeneration of organisms does not always proceed by the formation of *new* organic material. Rather, organisms have a self-maintaining capacity enabling them to restore their initial organization.[19] Blumenbach argued that the regenerative processes characteristic of organisms could be best understood by postulating the existence of a *Bildungstrieb*.

Above we have described an example meant to show that the *Bildungstrieb* is responsible for the *regeneration* of organisms. Blumenbach also provides positive examples providing evidence for the fact that the *Bildungstrieb* is responsible for the *generation* of organisms. Finally, he also takes the *Bildunsgtrieb* to guide phenomena such as nutrition and growth.

In discussing generation, Blumenbach referred for example to the generation of what we would now call plant galls. More specifically: he referred to the generation of what he calls sleep apples on wild roses, occasioned by the prick of gall wasps.[20] According to Blumenbach, this is a particular mode of generation, a mode distinguished from the generation of like organisms by like organisms (the mode of generation typical of humans for example). The sleep apples are purposive structures, which, however, have little in common with the roses on which they grow.[21] The generation of sleep apples cannot be explained on the preformationist account. According to Blumenbach, the preformationist would have to absurdly assume the existence of encased germs for the production of sleep apples contained in all the branches and leaves of roses throughout the world, germs lying dormant and waiting for the very unlikely occurrence that they are somehow activated.[22] If this hypothesis were true, nature would do a lot in vain. In contrast, Blumenbach thought it was plausible that plants

[17] Blumenbach 1789, 85–87.

[18] Ibid.

[19] Blumenbach 1789, 89.

[20] Blumenbach 1789, 40–41; Cf. Blumenbach 1781, 23–24. In the following, I focus on the first edition, since it provides a more detailed account of the argument under consideration.

[21] Blumenbach 1781, 21–24.

[22] Blumenbach 1781, 25.

galls were formed by the *Bildunsgtrieb*, which becomes activated and forms fluids into plant galls when insects prick and lay their eggs into the plants.[23]

I will not discuss any further examples Blumenbach cites for taking the *Bildunstrieb* to be responsible for generation. It must, however, be emphasized that Blumenbach's positive evidence for one of the main claims of his treatise, i.e., that the *Bildungstrieb* guides epigenetic embryological development, is rather thin. In order to establish the claim that the *Bildungstrieb* is responsible for the generation of organisms, Blumenbach took recourse to the assumption that generation, nutrition and regeneration are modifications of a single force, i.e., they are processes of the same kind. As he puts it in his first essay on the *Bildungstrieb*:

> Generation, nutrition and regeneration are at bottom mere modifications of one and the same force, which in the first case builds, in the other case maintains, and in the third case repairs! In other words: nutrition is a universal, yet imperceptible, continued generation, whereas reproduction is a repeated, yet merely partial generation. A light spread on one of these three would with certainty also illuminate the other two at the same time. (Blumenbach 1780, 252)

Given this assumption, the possibility of explaining the regeneration of organisms in terms of the *Bildungstrieb* also provided evidence for the claim that this force was responsible for the generation of organisms (and thus, finally, for the truth of epigenesis).

The general argumentative strategy of Blumenbach can be described as follows. After citing numerous observations disconfirming preformationism, he highlighted empirical evidence concerning the *generation*, *nutrition* and *growth*, and *regeneration* of organisms, which was best explained by the efficacy of the *Bildungstrieb*. Given that these processes are of the same kind, one could not help to conclude that the *Bildungstrieb* existed. In other words, assuming that generation, nutrition and growth, and regeneration are similar processes, Blumenbach offered different arguments by *analogy* in order to conclude to the existence of the *Bildunsgtrieb*.

(ii) In his definition of the *Bildungstrieb*, Blumenbach distinguishes this force from the physical forces of bodies in general. The distinction between vital forces, conceived of as causes of vital properties of organisms, and physical or mechanical forces, conceived of as causes of properties possessed by both inorganic and organic bodies, constituted a central element of Blumenbach's thought. In his *Institutiones physiologicae* (1787), which has been thoroughly analyzed by Larson,[24] Blumenbach argued that all bodies are subject to physical or chemical forces. However, according to Blumenbach organic bodies also possess *vital* properties that are completely different from the properties of inorganic bodies, and which cannot be accounted for in terms of chemical and

[23] Blumenbach 1781, 25–26.

[24] Larson 1979, 236–241. I have consulted an English translation of Blumenbach's *Institutiones physiologicae* by John Elliotson of the third edition of 1810, published in 1817.

physical laws alone.[25] He illustrates this point by referring to the problem of Gian Alfonso Borrelli (1608–1679), according to which a dead muscle would be "broken asunder by the very same weight, which, if alive, it could easily raise".[26] A living muscle differs in its properties from a dead muscle, although both are subject to the same physical or chemical forces. In order to explain the specific properties of the living muscle vital forces are posited. In organic bodies, physical and chemical forces are subordinated to vital forces. Vital forces govern the mechanisms in organic bodies so that these bodies are adapted to performing organic functions (most importantly reproduction, growth, and regeneration).

Since the existence of vital forces is assumed to account for vital properties possessed solely by organisms, the former are taken to be efficacious only within the domain of organic bodies. Blumenbach emphasizes this point by stating that the *Bildungstrieb* cannot exist within the realm of non-living nature. As such, his conception of vital forces is based on the idea that there is a strict distinction between the domains of the organic and the inorganic. As Blumenbach puts it himself: "One cannot be more deeply convinced of something than I am of the mighty gap that nature has set up between animate and inanimate creation, between organic and inorganic creatures".[27]

(iii) Finally, we must consider Blumenbach's views on different kinds of vital forces. We have seen that Blumenbach distinguished the *Bildungstrieb* from other vital forces, such as contractility, irritability, and sensibility. The distinction between various types of vital forces allowed him to give a systematic account of a variety of organic phenomena. As Blumenbach explained in his *Institutiones physiologicae*, the variety of empirically discernible vital properties of organisms must be accounted for by establishing distinct orders of vital forces.[28] He specified three classes of vital properties: (i) organic *formation*, (ii) *motion* of the parts of organisms, and (iii) *sensation*.[29]

The possibility of organic formation is understood by postulating the existence of the *Bildungstrieb*, which directs the formation of organisms into a determinate structure. The vital forces invoked to explain the *motion* of the parts of organisms are divided into *common* and *proper* forces. Common vital forces belong to widely distributed yet similar parts of an organism, i.e., to tissues, while proper vital forces belong to individual organs. Blumenbach provides two examples of common vital forces: (a) contractility (*vis cellulosa*), which animates the mucous tissue and causes the distribution of fluids within the lymphatic system; (b) irritability (*vis muscularis*), the force pertaining to the muscular tissue responsible for the capacity of the muscles to respond to

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[25] Blumenbach 1817, 16–17.

[26] Ibid.

[27] Blumenbach 1817, 79–80.

[28] Blumenbach 1817, 18. See also Larson 1979, 237–238.

[29] Blumenbach 1817, 18.

stimuli by means of contraction.[30] Blumenbach also specified motions of individual organs of the living body, so-called *peculiar* motions, which could not be accounted for in terms of contractility or irritability. These peculiar motions were understood by positing the existence of proper forces possessed by individual organs and designated by the name of *vitae propriae*. Finally, Blumenbach posited sensibility (*vis nervea*) as a force pertaining to the nerves, which enabled the possibility of sensation upon stimulation of the nerves.[31]

The order in which these vital forces were enumerated was, according to Blumenbach, identical to the order in which these forces arise during embryogenesis.[32] Thus, before a new embryo comes into existence, the *Bildungstrieb*, as a cause of the formation of the embryo, must be efficacious. In the successive developmental stages of the embryo, contractility, irritability, and the *vitae propria* are added, until, after birth, the new born infant acquires sensibility and the capacity for perception.[33] Blumenbach also argued that the established order of vital forces corresponds to the order in which these forces are distributed to organisms within a biological kingdom or domain. For example, the *Bildungstrieb*, as the cause of organic form in general, is common to all organisms and is responsible for those characteristics which distinguish organic from inorganic bodies. Irritability and sensibility, by contrast, are peculiar to the domain of animals.

Blumenbach's attempt to establish distinct orders of vital forces illustrates the manner in which he attempted to establish a systematic physiology. Moreover, the fact that Blumenbach employed his table of vital forces to give a developmental account of embryogenesis, and specifies biological kingdoms according to this table, highlights the attempt to extend his theory of vital forces to different domains of biological inquiry. As such, Blumenbach's formulation of a system of vital forces constituted an attempt to construct a general model of biological explanation.

In conclusion: Blumenbach construed vital forces in teleological terms. Vital forces provide grounds for the fact that organic bodies have a purposive structure that is *adapted* to performing certain organic functions. This is especially clear in the case of the *Bildungstrieb*, which was construed as a first ground of the form of organic bodies and of the *maintenance* of organic form, i.e., the *Bildungstrieb* allows us to understand why organisms are adapted to maintaining themselves. Blumenbach did not, however, specify any clear physical basis for the operation of vital forces and insisted on a strict distinction between vital and physical forces. He conceived of the distinction between organic and inorganic nature in terms of an ontological distinction between vital forces (operative solely in the domain of organic nature) and physical forces (operating universally within nature).

[30] Blumenbach 1817, 18–19.

[31] Blumenbach 1817, 20.

[32] Richards has shown that this idea was also adopted by Kielmeyer. See Richards 2002.

[33] Blumenbach 1817, 20.

Kant should not have accepted this tenet of Blumenbach's thought. Although he took biology inquiry to be based on a teleological interpretation of organisms, he denied that we can affirm the objective reality of teleological causation in nature. Yet, to affirm the existence of vital forces in nature seems precisely to introduce teleological causation in nature. The insight that Kant shared with Blumenbach is that biology is based on the presupposition that organisms have a purposive structure adapted to performing functions such as propagation, nutrition, growth, etc. For Kant this is a methodological presupposition without ontological import. To posit vital forces as objective grounds of the nature of organisms and their purposive structure is a step too far. Hence, Richards and Zammito are entirely correct when they stress the differences between the views of Kant and Blumenbach. I will show that in the *Opus postumum*, Kant distances himself from the ontological implications of theories of vital force espoused for example by Blumenbach by reinterpreting vital forces as *regulative assumptions* ascribed to nature by analogy with human purposive action.

7.2.2 Brandis and Reil on Vital Force: Some Different Perspectives

In the previous section, I have discussed Blumenbach's conception of vital force. As said, the concept of vital force was the subject of considerable debate in the late eighteenth century. In the present section, I describe two different perspectives on vital forces. First (i), I describe the views of Joachim Dietrich Brandis, who published his *Versuch über die Lebenskraft* in 1795. Second (ii), I briefly discuss the views of Johann Christian Reil, who in has tract *Von der Lebenskraft* of 1796 provides a critique of the concept of a vital force as employed by Blumenbach. In contrast to Blumenbach, these authors allow for the possibility that vital forces can be *reduced* to physical or chemical forces.

(i) In the preface to his *Versuch*, Brandis describes the aim of his work as providing an account of the concept of vital force in light of new discoveries in chemistry, physics, and physiology.[34] His main concern is to explain how vital forces attributed to organic bodies relate to chemical processes that occur within organic bodies. In the following, I will refrain from discussing Brandis' views on chemistry and focus on his conception of vital force. As we shall see, Brandis ultimately allows for the reduction of vital forces to physical forces. Hence, the strict distinction between vital and physical forces argued for by Blumenbach is rejected.

In §1 of his *Versuch*, Brandis explains how to understand the concept 'organization'. He explicates this concept by specifying characteristics of our own human body.[35] The human body is an instrument of communication with the external world. It consists of parts (both fluid and solid) that have a determinate form.

[34] Brandis 1795, xi.

[35] Brandis 1795, 1–2.

These parts are formed in such a manner that they can fulfill a particular function with respect to the whole. In addition, these parts are purposively related to each other. The purposive form of the parts of the human body with respect to the whole (the body) and to each other is what Brandis calls ‘organization’.

According to Brandis, the human body can only function as an instrument of communication when it is alive. If human bodies cease to live, all reciprocal influence between them and the external world ceases to exist.[36] However, the structure of a dead body is not significantly different from the structure of a living body. Hence, apart from a regular and purposive composition of its parts, we require the posit of certain forces in order to explain that the body can communicate with the external world. Since the state in which our body can function as an instrument of communication with the external world is called ‘life’, these forces can be called vital forces.

In §7 of his *Versuch*, Brandis expounds on the above argument.[37] He argues that the specific chemical composition or mixture (*Mischung*) of organic bodies is maintained through their vital force. If a body ceases to live, the parts of organic bodies are subject to fermentation or putrefaction. These types of decomposition are taken to occur in accordance with the laws of chemical affinity operative in inorganic nature. The question is why such decomposition does not occur within organic bodies when alive. According to Brandis, this is because vital forces are efficacious within organic bodies, which are more powerful than the physical forces of chemical affinity. When the vital forces have left the organic body, these physical forces become fully operative and cause fermentation.

Organization is not only a property of the human body. Since other bodies also have parts that are purposive with respect to the whole and other parts, we can conceive of these bodies as organized and attribute vital forces to them.[38] The concept ‘organization’ is thus first analyzed with respect to our own body and consequently applied to bodies that are similar to the human body. Vital forces are employed to explain changes or motions in organic bodies that cannot be explained in terms of known physical forces. As Brandis puts it:

> (1) That the cause of these motions seems to be a force which does not permit of being reduced to any physical force known to us; consequently, that we are entitled provisionally to call it a distinct force: we call it vital force, because it belongs only to living organic bodies. (2) The force acts immediately in organic matter, not as the result of the formation of matter, or of its organization. (Brandis 1795, 15)[39]

Claim (2) is meant to show that a vital force is the cause of organization, i.e., the cause of a purposively structured whole, rather than the effect of organization.[40] Brandis explains (1) by arguing that a vital force is the proximate cause of organic

[36] Brandis 1795, 2–3.

[37] Brandis 1795, 15–17.

[38] Brandis 1795, 3–4.

[39] Here, I adopt the translation by Förster 1993, 258.

[40] Brandis 1795, 15–16.

motions in living bodies, i.e., motions that cannot be explained in accordance with the laws of physical forces *currently known to us*.[41] Take, for example, the capacity of organic matter to contract.[42] In line with recent chemical findings, one might want to explain this contraction by the penetration and subsequent release of the matter of heat (caloric). However, this process is governed by laws that are quite different from those concerning organic contractility. The speed of contraction of organic matter (e.g., the contraction of the muscles) is much higher than the speed of contraction observed in bodies that is due to the release of caloric. Hence, in order to explain organic contractility the existence of a vital force is posited.

In claiming (1), Brandis argues that we *provisionally* apply the title 'vital force' to the force responsible for organic motions and provisionally treat it as a distinct force. Organic motions are only mechanically inexplicable in terms of physical forces currently known to us. If our knowledge of physical forces operative in organisms increases, we might be able to give a fully mechanical account of organic motions. Brandis conjectures that it is probable that the vital force may be a force of electricity, claiming that physiology may expect wonderful results from Galvani's doctrine of animal electricity.[43] As such, Brandis ultimately allowed for the reduction of vital forces to physical forces, rejecting the strict distinction between vital and physical forces characteristic of Blumenbach's theory of vital force.

(ii) Johann Christian Reil provides a strong critique of the notion vital force as employed by Blumenbach.[44] In §1 of his *Von der Lebenskraft*, Reil argues that the phenomena of living bodies have their ground in their matter. More precisely, he argues that the ground of all phenomena of animal bodies (excluding representations) must be taken to lie in animal matter, in the original differences of its elementary materials (*Grundstoffe*) and in the mixture and form of these materials.[45]

According to Reil, the phenomena of organic bodies must be explained in terms of organic matter, i.e., the matter (parts) of organisms, just as in physical science the properties of bodies are explained in terms of inorganic matter. To adopt a different procedure is contrary to proper scientific methodology. The fact that organic bodies exhibit different phenomena than those observed in

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[41] Brandis 1795, 29.

[42] Brandis 1795, 30–31.

[43] Brandis 1795, 81.

[44] Reil's work is again instructively discussed by Lenoir 1989 and Richards 2002. Lenoir attributes to Reil the teleomechanistic method he also attributes to Kant and Blumenbach (Lenoir 1989, 35–27). Richards highlights the differences between the views of Blumenbach and Kant on the one hand and Reil on the other. I am in full agreement with Richards that the positions of Blumenbach and Reil are quite different. However, I will argue that in certain respects the views of Kant and Reil are quite similar.

[45] Reil 1795, 11.

inorganic bodies is simply a consequence of the different type and organization of matter of which the former are composed. There is no need to postulate a foreign principle, whether the *Nymphen* of the ancients, the *Archeus* of von Helmont, or the soul of Stahl.[46] Reil argues that one does not take the magnetic properties of iron to be grounded in anything other than its matter because one does not observe any magnetic properties in stones or wood. Why, then, should organic bodies be treated differently?[47]

In this manner, Reil stresses the continuity between the domains of organic and inorganic nature and argues that one should adopt the same methodology in investigating both domains. This methodology is described as follows[48]: first (1), through analysis of corporeal bodies and their parts we obtain cognition of the basic materials of which these bodies (and their parts) are composed and of their different mode of composition in different bodies. Second (2), we consider the form and structure of these bodies, which is a product of the aggregation of their composite parts. We investigate the different nature of the basic materials or elements found in step (1) and note that in virtue of their different nature their combination results in the generation of bodies of specifically different types. In particular, all elements combine with each other in accordance with their (chemical) elective affinities and thus produce, since these elements are of a different nature, different types of bodies. In this manner, the form of bodies is explained in terms of the elective affinity of the elements of which they are composed. The ground of phenomena of bodies (such as form, structure, organization), whether organic or inorganic, lies in the mixture of their matter, i.e., in the nature of their elements and in their mode of composition.[49] Reil points to the research of the new French chemists and of Grenn as promoting our cognition of the mixture of animal bodies.[50] As such, he promotes the explanation of organic bodies in terms of the chemical elements found in organic bodies and their mode of composition.

How did Reil conceive of the notion of a vital force? Reil construes the concept of a force as a *subjective* concept in accordance with which we think a relation between cause and effect. In particular, the concept 'force' specifies a relation between phenomena (effects) and the properties of matter (causes) through which these phenomena are generated.[51] According to Reil, one cannot think of forces as distinct from matter. In fact, if one were to have complete cognition of the basic materials of bodies, their composition, mixture, and form, one would not require the (subjective) concept of force. Thus, alkali salts combine with acids to form "middle salts". Apart from alkali salts and acids,

[46] Reil 1795, 12.

[47] Reil 1795, 13–14.

[48] Reil 1795, 15–19.

[49] Reil 1795, 19.

[50] Reil 1795, 24–25.

[51] Reil 1795, 45–46.

we do not require to posit a third element effecting this combination.[52] According to Reil, the concept of force is most precisely explained if one understands it as a *property of matter*.

In line with this account of the concept of force, Reil construes a physical force (a term which Blumenbach employed to denote forces studied within physics and chemistry) as the relation between what we take to be universal phenomena of bodies and general properties of matter.[53] The concept 'vital force' signifies the relation of particular phenomena (peculiar to organic bodies) to a particular type of matter (i.e., organic matter).[54] This is Reil's version of the distinction between physical and vital forces. Concepts of force denote relations between phenomena of bodies (effects) and properties of matter (causes). One can *subjectively think* of different types of forces depending on the manner in which one construes such relations, e.g., as obtaining between more general phenomena and more general properties of matter or between more particular phenomena and more particular types and properties of matter.[55] However, any phenomenon of any body is grounded in its basic materials and their elective affinities. Hence, Reil concludes that we will only understand what vital forces are if by chemical research we become acquainted with the particular type of mixture or chemical composition of organic matter.[56] In contrast to Blumenbach, Reil thus allowed for a complete reductionistic account of organic phenomena.

Reil also rejected more specific arguments for introducing vital forces invoked by his contemporaries. We have encountered such an argument in the work of Brandis, who pointed to the fact that the parts of a dead body are subject to putrefaction. Since putrefaction does not occur in living bodies, Brandis concluded that the mixture of organic bodies is maintained through the action of a vital force and that chemical or physical forces are subject to vital forces in organic bodies.

Reil rejects the view that physical forces are subordinated to vital forces.[57] This assumption is contrary to proper scientific methodology, which requires that we conceive of nature as governed by unchangeable laws. Proper methodology further requires that we explain different phenomena of a body, e.g., the weight, cohesion, chemical properties, and irritability of muscle fibers, in a unified manner, i.e., explain these phenomena in terms of its material parts and their mode of composition. Finally, Reil argues that the fact that dead matter is subject to putrefaction whereas living matter is not, can be explained in terms of the changing chemical composition of a body after it has ceased to live. Dead meat is normally subject to putrefaction, but not if one impregnates it in brandy.

[52] Reil 1795, 47.
[53] Reil 1795, 47–48.
[54] Reil 1795, 48–49.
[55] Reil 1795, 50.
[56] Ibid.
[57] Reil 1795, 52–53.

According to Reil this shows that differences in the composition of matter can explain variable susceptibility to putrefaction. If this is the case, why would one posit vital forces in order to explain that living bodies are not subject to putrefaction?

As Richards has stressed, Reil also criticized Kant's construal of organisms as natural purposes.[58] In the *Kritik der Urteilskraft*, Kant states that we must judge an organized product of nature as "that in which everything is an end and reciprocally a means as well".[59] In organisms, nothing is judged to be in vain or purposeless. Reil argues that Kant's construal of organisms as natural purposes is incorrect. The idea that in organisms everything is an end and reciprocally a means is not generally applicable to the parts of organisms, for many parts of organized beings (e.g., 'arbitrary' muscle groups, sense organs, the higher operations of the brain) can fail without hindering the maintenance of the whole.[60] As such, Reil rejected Kant's teleological understanding of organisms. Whereas Kant had insisted that it is necessary for biologists to reflect on organized beings in teleological terms, thus arguing that teleology is a necessary internal principle of natural science, Reil rejected this view.

Reil's reductionist conception of organic phenomena goes hand in hand with demoting the importance of teleology within natural science or biology. Indeed, Reil criticized Blumenbach's theory of vital force because of its overtly teleological character. While discussing the nutrition and growth of organisms, Reil notes that the capacity to assimilate and transform external substances is sometimes described by means of the term *Bildungstrieb*.[61] However, he argues that this term is inadequate, for the notion of a 'drive' signifies action in accordance with *representations* or *feelings*. This is totally inadequate to describe processes such as nutrition and growth, which are blind and necessary processes that can be explained purely in terms of chemical forces and regularities.

Reil's critical stance toward the concept of vital force was rather influential in the 1790s. For example, in the second edition of his *Lehrbuch der Physiologie* (1799), Friederich Hildebrandt, partially following Reil,[62] criticized the assumption of a vital force (*Lebenskraft*) existing *independently* of matter and effecting life.[63] To assume such a force does not explain anything. According to Hildebrandt, the term vital force merely refers to a *property of matter*. Moreover, within physiology it is unnecessary to assume anything other than chemical and mechanical forces. Organic phenomena are to be explained solely in terms of these forces, Hildebrandt argues.[64]

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[58] Reil 1795, 54–56; Cf. Richards 2002, 259–260.

[59] AA 5: 376.

[60] Reil 1795, 55.

[61] Reil 1795, 66–67.

[62] Hildebrandt 1799, 43.

[63] Hildebrandt 1799, 41. In the first edition of his *Lehrbuch* (1796), Hildebrandt still adopted a more neutral position, arguing that we know very little about the nature of the *Lebenskraft*. We may presume the work of Reil to have been influential with respect to Hildebrandt's change of position.

[64] Hildebrandt 1799, 41–44.

In conclusion: both Brandis and Reil adopted a reductionist stance towards vital forces. According to Brandis, vital forces ultimately allow of reduction to physical forces, even if he acknowledges that the nature of these physical forces is not sufficiently known. Reil takes forces to be properties of matter. We must explain phenomena of organic bodies in terms in terms of the (chemical) mixture or composition of their parts. The strict (ultimately ontological) distinction between vital and physical forces argued for by Blumenbach is thus rejected.

7.3 Kant, Vital Force, and Regulative Teleology

We have discussed different scientific theories concerning vital force in the late eighteenth century, as well as different views on proper biological method adopted by biologists of this period. How do these views relate to Kant's philosophy of organic nature as articulated in the *Kritik der Urteilskraft* and the *Opus postumum*?

According to Lenoir, as we have seen, Kant embraced Blumenbach's theory of vital force and both shared the same view on proper biological method, which is described as a form of *teleomechanism* (a conception of biological method also attributed to Johann Christian Reil).[65] In contrast, Richards has argued that assuming the existence of vital forces is inconsistent with Kant's regulative doctrine of teleology.[66] According to Kant, one is entitled to make a regulative use of teleological principles in order to understand the organization of organisms. However, one is not justified to assume that organisms are actually constituted by teleological causes. This conception seems to be in conflict with Blumenbach's conception of vital forces. For Blumenbach postulated the *Bildungstrieb* in order to explain the possibility of epigenesis, and construed the former as an existent teleological force (cause) directing the formation of organisms.

Thus, Kant's regulative conception of teleology seems to imply the rejection of any hypothesis affirming the existence of vital forces. I take this implication to hold: to affirm the objective reality of teleological causation in nature is *inconsistent* with Kant's regulative conception of teleology. Kant accepted the view of Blumenbach that in biology we presuppose that organisms and their parts are purposive wholes adapted to performing certain functions. However, he also argued that the teleological and mechanical maxim lying at the basis of biological research are regulative and methodological principles having no ontological import. Hence, Kant accepted some tenets of Blumenbach's thought. He could not, however, consistently adopt

[65] Lenoir 1980, 1981, 1989. Note that in the discussion of Reil in this chapter, we have already witnessed profound differences between the views of Reil on the one hand, and those of both Blumenbach and Kant on the other. Hence, Lenoir's stress on profound similarities between these scientists seems to be exaggerated.

[66] Richards 1998, 2000, 2002. Richard's thesis is generally accepted. Cf. Beiser 2006, 13–14; Zammito 2006, 765.

the ontological position of Blumenbach, who affirmed the objective reality of vital forces in nature.

The foregoing shows the complexities involved in specifying the relationship between Kant's philosophical views on biology and the views of Blumenbach. The same is true if we consider the relationship between Kant and for example Reil. In commenting on the works of Reil, Richards argues that Reil's mechanistic conception of organic phenomena is difficult to reconcile with Kant's teleological conception of organisms.[67] Richards is correct in emphasizing that Reil criticizes Kant's construal of organisms in teleological terms (Kant would no doubt resist such a criticism). Moreover, Kant insisted that the purposive character of organisms, e.g., the fact that parts of an organism are adapted to each other, *resists* mechanical explanation. However, Kant would have no problem in accepting the view that organic phenomena should as far as possible be explained mechanically, for he construed mechanical explanation as a form of proper scientific explanation. What Kant does object to is an ontological reduction of organisms to their material parts and forces.

Kant can be taken to adopt different levels of analysis when interpreting the works of his contemporary biologists. On the one hand, he analyzed the scientific research of his contemporary biologists and focused on the *method* employed within this research. On the other hand, Kant focused on *ontological* and *metaphysical* positions implicit in biological theories (positions which he often criticized).

When interpreting the relationship between Kant's philosophy of organic nature and the biological theories of his time, it is important to keep these different levels of analysis distinct. When, for example, Blumenbach emphasizes the necessity of conceptualizing organisms in teleological terms, Kant would have agreed. Conversely, when, for example, Reil emphasizes the necessity of explaining organic phenomena mechanically, Kant again would have agreed. These different biologists can be taken to emphasize the importance of either the teleological or the mechanist maxim. However, when, for example, Blumenbach affirms the objective reality of vital forces, Kant should criticize him for confusing regulative methodological principles with constitutive claims concerning the existence of teleological agents in nature. Conversely, if, for example, Reil would argue for the non-existence of final causation on the grounds that proper explanation in natural science is mechanical explanation, Kant would again argue that this is a conflation of methodological prescriptions with ontological claims.

In our analysis of the *Opus postumum*, we will see that Kant analyzes biological theories of his time by focusing on illegitimate ontological views contained in these theories (see Chap. 8). Kant treats vital forces as *regulative posits*, thus modifying Blumenbach's theory of vital force in terms of his regulative teleology. For Kant, the introduction of the term vital force merely points to the methodological claim that organisms must be interpreted teleologically. He denies that vital forces can be true causes in nature (note that this is a major departure from the views of Blumenbach). Conversely, in the *Opus postumum* Kant still argues that in

[67] Richards 1998, 709–711.

investigating organisms we should always search for mechanical explanations. However, he rejects metaphysical positions that dogmatically deny the existence of final causation. In this manner, Kant emphasizes that the regulative, methodological principles guiding biological research do not have ontological implications.

The views that Kant entertains in the *Opus postumum* are quite similar to his views on the concept 'vital force' articulated in his published writings. In the following, I will first discuss these latter writings. In Sect. 7.3.1, I discuss Kant's critique of Herder's notion of organic force, contained in the 1785 reviews of Herder's *Ideen zur Philosophie der Geschichte der Menschheit*. In Sect. 7.3.2, I discuss Kant's critique of hylozoism, contained in the Dialectic of Teleological Judgment of the third *Critique* (1790).[68] These texts show that notions such as vital force or organic force were employed in a variety of ways. Kant criticized particular scientific and most importantly *metaphysical interpretations* of such notions. His main objection to people such as Herder was that they invoke such notions to arrive at unsupportable metaphysical positions. For Kant, vital forces cannot be employed to support metaphysical theories. As I show in Sect. 7.3.3, this view is also expounded in the *Opus postumum*.

7.3.1 Kant's Critique of Herder

Kant's reviewed two volumes of Herder's *Ideen* in the *Allgemeine Literatur-Zeitung* on January and November 1785. The importance of these reviews has been established by Zammito.[69] In these reviews, Kant attacks Herder's conception of living or organic forces. According to Kant, Herder's hypothesis of organic forces boils down to an attempt to "explain that which is not understood in terms of what is understood even less".[70] In addition, Kant criticized Herder's notion of a genetic force (*genetische Kraft*), arguing that this notion does not belong to natural science but merely to speculative philosophy.[71] In this manner, Herder's conception of organic forces was dismissed as the fruit of dogmatic metaphysical speculation. But how did Herder employ notions such as 'organic force' and 'genetic force' in his *Ideen*?

Herder's use of the term *organic force* is quite similar to Blumenbach's use of the *Bildungstrieb*, although he was undoubtedly influenced by other biologists as well. For example, in the third book of the first part of the *Ideen*, Herder attributes an organic force to plants that is supposed to account for their generation or

[68] These texts are sometimes interpreted as expressing a positivistic stance wholly incompatible with biological theories invoking vital forces in Blumenbach's sense. Cf. Beiser 2006, 9. In the following, I adopt a slightly different perspective, arguing that Kant mainly criticizes people who misuse biological theories for dogmatic metaphysical positions.

[69] I have greatly benefited from Zammito's insightful analysis of the Kant-Herder controversy. Zammito 1992, 189–213. See also Zammito 2003.

[70] AA 8: 53.

[71] AA 8: 54.

reproduction and the processes of nutrition and growth.[72] In this context, he notes that the preformationist theory of preformed germs does not explain the formation and generation of plants. He then cites the famous regenerative capacities of polyps, stating that these capacities cannot be explained by postulating preformed germs distributed throughout the organism, but require the existence of mighty organic forces. Finally, Herder posits organic forces as being responsible for epigenetic embryological development. Herder's acceptance of epigenesis thus leads him to accept the notion of an organic force.

Herder's notion of a *genetic force* is more difficult to understand. Herder does not clearly define this notion, although it is clear that the genetic force belongs to the class of organic forces. He discusses the notion of genetic force in the seventh book of the second part of the *Ideen*.[73] In this book, Herder deals with the topic of human races. He first introduces the notion of an organic force as the cause of epigenetic embryological development, a force that produces organic parts out of the chaos of a homogeneous matter.[74] The notion of a genetic force is then introduced as a general formative principle. It is the mother of all formations on earth. The main purpose of introducing this notion is to show that it governs the adaptation of organisms to various climates, and can thus be construed as a partial cause of varying traits of individuals of a species (as witnessed in different *races*).[75]

One can identify two main lines of criticism in Kant's reviews. First, Kant rejects the metaphysical conclusions which Herder draws on the basis of his conception of organic forces. Second, Kant rejects the transformationist implications of Herder's conception of organic or genetic force. Let us start with the first line of criticism.

In his review of the first volume of Herder's *Ideen*, Kant describes the aim of Herder's work as follows:

> The spiritual nature of the human soul, its persistence and increasing perfection, are to be demonstrated by analogy with the natural forms of matter, particularly in their organization, without the help of any metaphysical investigations. (AA 8: 53)

Kant reconstructs Herder's argument for the persistence or immortality of the soul in the following manner: the observable similarities between different types of species led Herder to assume the existence of a vivifying force (*belebende Kraft*), which is the cause of all organization in nature. According to Kant, Herder ascribed the following functions to this vivifying force: (i) it guides the formation of all organisms in nature, including (presumably) the formation of organic bodies from inorganic material[76]; (ii) it is the cause of the transformation of species; and (iii) it is aimed at the realization of human nature.[77] As such, this force is conceived to be the cause of a continuous progression of species, a progression which cannot

[72] Herder 1785, 135–137.

[73] Herder 1786, 122–140.

[74] Herder 1786, 122–124.

[75] Herder 1786, 128–133. See Sloan 2002, 242–244.

[76] AA 8: 46–47.

[77] AA 8: 49.

end with the death of man and thus provides evidence for the *immortality of the human soul*.

Kant reject's Herder's analogy.[78] According to Kant, the hierarchy of species that we observe in nature might provide evidence for the existence of a species possessing a higher organization than mankind, but does not justify metaphysical claims concerning the immortality of the human soul. In general, as Zammito has stressed, Kant criticizes Herder's method of invoking presumed empirical facts in order to decide metaphysical questions.[79] Herder's use of the conception of a vivifying force constitutes a prime example.

This brings us to the second line of criticism, which must be understood in relation to the debate between preformationism and epigenesis. In his first review, Kant noted that Herder rejected the assumption of preformed germs (*Keime*),[80] i.e., the theoretical entities assumed within Haller's preformationism. Germs can be construed as species-specific entities that determine and limit ('preform') the range of possibilities within which organisms can develop their structure.[81] Herder rejected the existence of germs and fully endorsed epigenesis. Kant, however, did *not* advocate a full blown rejection of preformationism.

That Kant adopted such a position becomes clear in his review of the second volume of the *Ideen*, in which he discusses Herder's notion of a genetic force. In this review, Kant notes that Herder construes the genetic force as a cause of the existence of 'climatic differences', i.e., of different *races* among human beings.[82] Herder explained the existence of races or varieties in terms of the modified action of the genetic force caused by changing environmental conditions. Kant criticized Herder's position, as Zammito has shown, because he remained committed to the preformationist assumption of the existence of germs (*Keime*).[83] In reaction to Herder's account of variation within a species, Kant emphasized that the formative capacity of a genetic force should be *limited*. Kant wanted to place the ontogenetic development of organisms within specific limits in order to exclude the possibility of a transformation or evolution of species. It is precisely the hypothesis of germs that excludes this possibility. Since Herder did not think that the action of the genetic force is restricted in any way, the ability of organisms to adapt to environmental conditions is unlimited. Herder's account thus allowed for the possibility that varying environmental causes could lead to a transformation of species.[84] Kant could not accept this possibility.

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[78] AA 8: 53.

[79] Ibid. Zammito 1992, 185.

[80] AA 8: 50.

[81] On Kant's notions of *Keime* (germs) and *Anlagen* (predispositions) see Grene and Depew 2004, 96–97, and Sloan 2002. Kant developed these notions in his *Von den verschiedenen Racen*, AA 2: 429–443; and in his "Bestimmung des Begriffs einer Menschenrace", which appeared in the *Berlinische Monatsschrift*, November 1785, AA 8: 91–106.

[82] AA 8: 62–63.

[83] Zammito 2003, 86.

[84] AA 8: 54.

In conclusion, we can note that Kant criticized Herder's notion of a genetic force because (i) he rejected Herder's attempt to draw metaphysical conclusions from this notion, and (ii) Kant rejected the transformationist implications of the notion of a genetic force. The first rejection is related to Kant's conception of proper philosophical method, according to which one cannot decide metaphysical issues on empirical grounds. The second objection is based on Kant's commitment to the fixity of species. Note that Kant's critique of Herder's genetic force does not imply that he rejected any theory that invokes vital forces. Blumenbach's *Bildungstrieb*, for example, was not taken by Kant to have transformationist implications and was treated as unproblematic in the third *Critique*.

7.3.2 Kant's Critique of Hylozoism

Now that we have discussed Kant's critique of Herder's notion of a genetic force, we can turn our attention to Kant's argument against hylozoism presented in the Dialectic of Teleological Judgment of the third *Critique*.[85] As John Zammito has shown, Kant's critique of hylozoism must be understood in the context of his controversy with Herder.[86] According to Kant, Herder adopted the untenable hylozoist position that unorganized matter can form itself into a purposive whole. This position is unacceptable to Kant.

Kant presents his argument against hylozoism while discussing four metaphysical positions that are meant to explain the appearance of purposiveness in nature. These positions fall into two categories. First, we have what Kant calls (1) the "idealism of purposiveness".[87] According to this position, purposiveness in nature is "unintentional", i.e., the appearance of purposiveness in objects of nature (organisms) is considered to be the mere result of mechanical laws of nature. Hence, we cannot infer from the appearance of purposiveness to the *objective reality* of purposiveness. Second we have what Kant calls (2) the "realism of the purposiveness of nature".[88] According to this position the appearance of purposiveness is "intentional", i.e., it cannot be accounted for in terms of the mechanism of nature and proves the *objective reality* of final causation within nature.

Note that both (1) idealism and (2) realism are presented by Kant as *metaphysical* theories: whereas (1) denies the existence of final causation in nature, (2) affirms the existence of final causation in nature. Kant presents (1) and (2) as conflating regulative maxims for the reflecting power of judgment (i.e., the mechanical and teleological maxim) with constitutive principles for the determining power

[85] Frederick Beiser 2006, 9, 13–14, has, in an illuminating discussion, argued that this argument implies a rejection of 'vital materialism', a term introduced by Lenoir to designate the researches of Blumenbach and the Göttingen school. As I will argue, this reading is too strong.

[86] Zammito 1992, 189–213.

[87] AA 5: 391.

[88] AA 5: 392.

of judgment.[89] Hylozoism, which explains the appearance of purposiveness by hypothesizing the "life of matter", and theism, which derives ends of nature from an intentionally productive intelligent being (original ground), belong to the category of realism.

Kant distinguishes between two versions of hylozoism.[90] According to the first version *life* is an essential property of matter as such. This means that there is no (strict) distinction between the domains of the inorganic and organic. According to the second version, matter is *animated* by some (external) principle.

The first version of hylozoism is rejected by arguing that the assumption of living matter contradicts the law of inertia, according to which every change of matter has an *external cause*.[91] The inertia of matter implies that matter is *lifeless*, since 'life' is defined as the ability of a substance to *move itself* from an *inner* principle.[92] Hence, the assumption of the existence of living matter contradicts a fundamental principle of physics.

Against the second version of hylozoism, Kant argues that the hypothesis of an "animated matter" can only be employed insofar "as it is revealed to us […] in experience".[93] We can only assume the existence of, e.g., a world-soul or vital force governing matter, if we have empirical evidence that such a force exists. This implies that one cannot assume the existence of vital forces in order to explain the objective purposiveness of objects in nature (the reality of final causation). Such an explanation would be circular, since it is only by means of our experience of the purposiveness of certain natural objects that we can entertain such a hypothesis in the first place.[94]

Does Kant's critique of hylozoism imply that he denied the legitimacy of assuming vital forces within biology in general? Not necessarily. Assuming vital forces in order to account for biological phenomena does not imply that one takes life to be an essential property of matter. We have already seen that Blumenbach took vital forces to exist only within the domain of organic bodies. This is a position that harmonizes quite well with Kant's rejection of the first version of hylozoism. Indeed, according to Kant Blumenbach rightly rejected the idea that "life should have arisen from the lifeless".[95]

Kant's critique of the second version of hylozoism has little bearing on the question of whether we can legitimately postulate vital forces within biological inquiry. Kant's critique is directed against a *metaphysical position*, according to which we can explain the objective reality of purposiveness in nature by means of the hypothesis of an 'animated matter'. It is the explanation of the objective reality of purposiveness that is circular. To assume the existence of a teleological agent in

[89] AA 5: 398–391.

[90] AA 5: 394. This is also pointed out by Beiser 2006, 13–14.

[91] Ibid.

[92] This explication of the law of inertia is given in the *Metaphysische Anfangsgründe*, AA 4: 544.

[93] AA 5: 394.

[94] Ibid.

[95] AA 5: 424. Cf. Beiser 2006, 13–14.

order to explain the reality of final causation in nature is to assume what has to be explained. As such, Kant's argument is not directed against the legitimacy of postulating vital forces within the domain of science or biology (in which vital forces are used, e.g., to account for embryogenesis, irritability, etc.).

In conclusion, the analyses of Kant's critique of Herder and his critique of hylozoism show that he criticized the metaphysical conclusions drawn on the basis of the concept of vital (organic) force. Kant's critique is not primarily directed at the manner in which vital forces are employed in scientific or biological investigation. Nevertheless, it is clear that the notion of vital force is intimately related to metaphysical discussions.

In the *Opus postumum*, Kant assigns a positive function to the notion of a vital force, treating it as a notion that is essential to biological inquiry. However, this requires reinterpreting the notion of a vital force as a *regulative posit*. In this manner, Kant purged the idea of vital force from its metaphysical implications and he adopted a position that is ultimately quite different from that of Blumenbach. This topic will be the subject of the next section.

7.3.3 Vital Forces in the **Opus postumum**

In the *Opus postumum*, Kant discusses the concept 'vital force' (*Lebenskraft*) and several similar concepts in the context of his transition project (*Transition*), which aims to provide a transition from the metaphysical foundations of natural science to physics. As we know, it is the task of the *Transition* to specify the fundamental concepts of an empirical doctrine of nature, which enables us to ground physics as a *systematic* science.

The *Transition* aims to specify an elementary system of moving forces, which provides a scheme for the investigation of nature and allows us to systematically classify empirically given forces of nature. In the early stages of the *Opus postumum* (1796–1798), Kant is mainly concerned with explicating the concepts of forces invoked in the study of inorganic nature (although biological topics are already treated in the *Oktaventwurf*). However, early 1799, Kant begins to argue that a systematic physics must include the study of organic nature. In addition, he states that the completeness of an elementary system of moving forces of matter requires the inclusion of so-called "organically formative forces". For example:

> One can, in fact, also draw on the concept of *organic* (as opposed to *inorganic*) nature, in the consideration of the moving forces of nature, without, [thereby], transgressing the limits, determined *a priori*, of the transition to physics, or mixing into it what belongs to the material part of physics […].
>
> The *final causes* belong equally to the moving forces of nature, whose *a priori* concept must precede physics, as a clue for the investigation of nature. One must see whether (and how) *they*, too, form a system of nature, and can be attached to metaphysics. In this case, everything is, indeed, only established problematically, but the concept of a *system* of the moving forces of matter requires, nevertheless, the concept of an *animated* matter- which we at least think *a priori* and assign a possible classification (without demanding – or surreptitiously assuming – reality for it). (AA 21: 184)

Kant also writes:

> The inner formative forces (*vires interne formatrices*) can be either merely mechanical or organic formative. The latter are those which reciprocally combine the parts of bodies among one another as *end* and *mean* and as such constitute organic *bodies* (for self-organizing matter is a nonentity). (AA 21: 188–189)[96]

How are we to understand these difficult passages? Although Kant does not employ the term vital force (*Lebenskraft*) in this context, the notion of an organic formative force is similar to notions employed by biologists of Kant's time. As we have seen, Johann Christian Reil stated that one might also employ the term *organic force* instead of the term vital force and that the choice of either term is one of convention.[97] Moreover, in other passages of the *Opus postumum* Kant does employ the more common term vital force.[98]

To which theory of vital force can we relate the cited passages? In the last passage, Kant defines an organic formative force as a force that combines the parts of bodies according to means-ends relationships. As such, the force is taken as a ground of the purposeful organization of bodies. It is precisely because of this organization that we take bodies to be organic. This construal of organic formative forces is rather similar to Blumenbach's conception of vital forces. Recall that Blumenbach posited vital forces to account for the fact that organisms have a purposive structure adapted to performing certain functions. Thus, the *Bildunsgtrieb* was taken to guide processes such as generation, nutrition and growth, and regeneration, allowing for the self-maintenance of organisms. Similarly, the vital forces Blumenbach discusses within his physiological research are taken to govern physiological processes so that certain parts of (human) organisms are capable of performing specific functions. Both Kant and Blumenbach, therefore, emphasize the importance of introducing some kind of force in order to understand the purposeful organization of organisms.

In the *Opus postumum*, Kant thus seemingly adopted a conception of vital force that is akin to that developed by Blumenbach.[99] The most pertinent question confronting us, however, is whether Kant was committed to the objective existence of vital forces. That is, did Kant give up his regulative constraints and postulate the existence of teleological agents in nature? The reply to this question must be negative.

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[96] Original: "Die innerlich bildende Kräfte (*vires interne formatrices*) können nun entweder blos mechanisch oder organisch bildend seyn. Die letztere sind diejenige welche die Theile der Körper wechselseitig als Zwek (sic!) und Mittel unter einander verbinden und so organische Körper (denn sich selbst organisirende Materie ist ein Unding) ausmachen".

[97] Reil 1795, 48.

[98] For a passage invoking the term *Lebenskraft* written shortly after those cited above, see for example AA 21: 213 (May–Aug 1799). The term *Lebenskraft* occurs numerous times throughout the whole of the *Opus postumum*.

[99] I am not arguing for any concrete historical influence in this context. The concept of vital force was extremely widespread in Kant's time, and it would be incorrect to argue that Kant only based himself on the writings of Blumenbach in the *Opus postumum*. At the present, I am merely noting similarities between the manner in which Kant employed the concept vital force and the theory of vital force proposed by Blumenbach,

In the first quote given above, Kant remarks, with respect to the introduction of organic moving forces, that everything is established *problematically*, and that one cannot demand reality for the concept of an animated matter, i.e., for the concept of a matter (body) animated by some external principle (e.g., a vital force). The notion 'problematic' is a technical term that Kant employs to characterize concepts for which no theoretical grounds can be given to determine whether they correspond to an object.[100] Hence, even though Kant takes the concept of vital force to be a necessary theoretical assumption employed within biological inquiry, he denies that we can determine its objective reality. This shows that Kant is still committed to the idea that teleological agents cannot properly be conceived to be constitutive of natural objects. Further evidence for this interpretation is given by the following remark (Feb–May 1799), written on the same page as the previously cited remarks:

> Nevertheless, the organism [*Organism*] of corporeal beings is still an idea of a system of moving forces of matter, at least by means of the analogy with causes efficacious in accordance with purposes. This idea cannot be postulated yet also cannot be rejected, and therefore always maintains as problematic its place in reason as a principle of the possibility of such moving forces which the thinking being itself puts into practice in accordance with its ideas: in which it obviously does not operate as a material but as an immaterial being (as intelligence) or rather (to employ a more precise expression) acts.
>
> In the classification of moving forces of matter one is therefore justified to also display those of organized [breaks of]. (AA 21: 189)[101]

Given that this (admittedly extremely cryptic) remark occurs right after Kant's introduction of the idea of organic moving forces, I take these statements to justify the introduction of the concept of organically moving forces of matter into the classification of forces given in the transition project. An organism is defined as an idea of a system of moving forces of matter. This idea is a *problematic* idea of reason, functioning as a principle for the possibility of organic moving forces. These forces are conceived of in terms of forces exerted by a thinking being, i.e., a being endowed with intellect capable of acting in accordance with its own ideas.

Kant's remarks are difficult to follow. They become clearer if we consider the fact that he expressed a similar view in the third *Critique*. In the latter work, Kant argues that we conceptualize organisms as purposes *by analogy with human purposive action*, which provides instances of causality in accordance with purposes. Already in the essay *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant construed the human will as a *force* which, if determined

[100] Cf. *KrV*, B 310.

[101] Original: "Allein der Organism körperlicher Wesen ist doch eine Idee von einem System bewegender Kräfte der Materie, wenigstens nach der Analogie nach Zwecken wirkender Ursachen, welches wenn es gleich nicht postulirt doch auch nicht abgewiesen werden kann mithin als problematisch immer seinen Platz in der Vernunft behauptet als ein Princip der Möglichkeit solcher bewegenden Kräfte dergleichen das denkende Wesen selbst seinen Ideen gemäs in Ausübung bringt: wobey es aber freylich nicht als materielles sondern als immaterielles Wesen (als Intelligenz) wirkt oder vielmehr (nach einem angemessenern Ausdruck) handelt.

Man ist also berechtigt in die Classification der bewegenden Kräfte der Materie auch die der organisirten aufzustellen".

by an idea of the understanding or a *purpose*, produces something in accordance with a purpose (the will is a force acting in accordance with purposes).[102] Hence, we can attribute organic moving forces to organic bodies by analogy with forces that we, as beings capable of intentional action, are aware of exerting.

In the third *Critique*, the view that the purposiveness of organisms is thought of by analogy with human purposive action is a reason for taking the concept of a natural purpose to be a *regulative* concept of reflective judgment. Kant's insistence on the problematic status of the concept of organisation and of organic moving forces in the *Opus postumum* fits this view quite nicely. Objectively attributing vital forces to organisms is tantamount to ascribing intentionality to organisms. Hence, the concept of a vital force can only be a regulative concept. In the *Opus postumum*, Kant thus reinterprets one of the fundamental biological notions of his time on the basis of his regulative doctrine of teleology developed in the third *Critique*.

It is worth noting that in the second fascicle of the *Opus postumum*, Kant describes the *desires* of bodily substances as true vital forces.[103] For Kant, the faculty of desire is the capacity of a being to be the cause of the actuality of objects through ones *representations* of these objects.[104] Desire is the self-determination of the force of a subject through *representations*.[105] Thus, when Kant construes desires as true vital forces, he emphasizes that human purposive or intentional action (voluntary action in accordance with representations) provides a model for ascribing vital forces to organisms. The ascription of vital forces to organisms allows us to construe the latter as purposive and allows us to treat them *as if* they are capable of purposive action. However, we have knowledge of vital forces only through consciousness of ourselves as subjects capable of acting in accordance with representations (e.g., subjects endowed with desires), and vital forces can be ascribed to natural objects only by *analogy* with ourselves.

For example, we may treat of plants *as if* they are sensitive beings without claiming that this is objectively the case.[106] We treat plants as if they are sensitive beings, i.e., as if they are capable of acting in accordance with representations, by analogy with ourselves as cognitive beings that can act in accordance with representations. In short, Kant thinks that we can attribute vital forces to cognitive and volitional subjects, whereas vital forces are only problematically ascribed to other organisms. It is on the basis of this background that Kant interprets the notion of vital force.

[102] AA 8: 181.

[103] AA 21: 213.

[104] AA 5: 9.

[105] AA 7: 251.

[106] This example stems from Kant's *Physischen Geographie* (1802), where is spoken of *planta sensitiva*, which, when touched, drops its twigs and leaves *as if* it has sensations (*Empfindungen*). Cf. AA 9: 364. Thus we can treat of plants *as if* they have the vital force of sensibility, and may treat of them *as if* they are capable of action in accordance with representation (purposive action). Yet (following the line of argumentation of the *Opus postumum*) we treat of plants in this manner only by analogy with ourselves as agents capable of purposive action. I owe the reference to Ingensiep 2009, 103.

Kant’s reinterpretation of the notion of vital force as a regulative concept implies a profound critical distance towards the theory of vital force espoused (e.g.) by Blumenbach. The manner in which Kant construes this concept is akin to the manner in which Blumenbach construed this concept. However, for Blumenbach vital forces are not regulative posits. Vital forces are real forces of nature allowing for objective explanations in biology (e.g., of embryogenesis). Kant takes this use of the concept of vital force to be inadmissible. To affirm the objective reality of vital forces is to engage in dogmatic metaphysics. For Kant, vital forces are mere regulative posits expressing the methodological presupposition of biologists that organisms are purposive wholes in which everything is both end and means.

Kant does not, therefore, assign vital forces any properly explanatory role. This is no surprise, for he only takes mechanical explanations to be proper explanations in biology. This view is retained in the *Opus postumum*: “Organic bodies are natural machines and, like other moving forces of matter, must be assessed according to their mechanical relationships […]; their appearances must be explained in this way […]”.[107] As we have seen in Chap. 5, in mechanically explaining organic phenomena we must specify the physical forces and mechanisms underlying such phenomena. In this respect, Kant’s position does not profoundly differ from that of Reil for example. What is distinctive of biology, however, is that these mechanisms are treated as *serving a purpose*. It is this teleological *perspective* that Kant takes to be expressed by the concept of a vital force.

7.4 The Concept ‘Organism’ in Kant’s *Transition*

In the previous section, we have seen that Kant introduced the concept of ‘vital force’ within his transition project. What is the systematic significance of the concept of a vital force in Kant’s project? In addition: how is Kant’s general concept of an organism related to the concept of vital force?

In the *Opus postumum*, Kant defines organisms (also called natural machines) in a manner similar to the third *Critique*: organisms are wholes in which every part is an end and reciprocally a means.[108] This characterization is frequently explicated in terms of the notion vital force (or analogous terms).[109] Thus, organized bodies are assigned a vital force[110] or organic bodies are ascribed a productive force of life.[111] This shows that the concepts organism and vital force (as well as life) are intimately related.

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[107] AA 21: 186.

[108] AA 21: 189, 194. AA 5: 376.

[109] Cf. Kant’s multiple characterizations of organisms at AA 21: 184–189, 193, 197–199, 211–213.

[110] Cf. AA 21: 612. AA 22: 100.

[111] AA 21: 211.

The importance of introducing the concept of 'organism' (and the associated notion of a vital or organic force) within his transition project is explained by Kant in fascicle two. Here, Kant argues that the division (distinction) between organic and inorganic bodies is thought *a priori* within his transition project.[112] In the same fascicle, Kant writes:

> The division of the moving forces of matter, insofar as the latter has the tendency to form organic or inorganic bodies, thus also belongs to the form of the combination of these forces in a system. This is, however, only a principle for the *investigation of nature*, which, as an *idea*, precedes empirical [investigation], and may {not} be lacking in the complete division of the transition from the metaphysical foundations of natural science to physics – despite the fact that it is merely problematic and takes [no] notice of the existence or nonexistence of such bodies [and their] forces. (AA 21: 185)

Kant argues that in the *Transition* it is necessary to distinguish (*a priori*) between organic and inorganic bodies. Recall that the *Transition* aims to provide a systematic classification of moving forces of matter in order to establish the possibility of physics as a systematic science. The distinction between the organic and the inorganic is necessary in order to secure that this classification is complete,[113] even if the division between the organic and inorganic is *problematic*. We do not, therefore, affirm anything concerning the existence or nonexistence of organic bodies and their forces.[114]

Given that the *Transition* is supposed to provide a classification of moving forces of matter in order to ground physics as a systematic science, the claim that the distinction between inorganic and organic bodies (respectively forces) should be included in this classification shows that he took the study of organic nature (biology) to belong to physics. This supports our previous analysis of the notion of physics, as employed by Kant and several scientists of his time (Chap. 6). In the *Opus postumum*, Kant argues that if we are unable to justify the distinction between organic and inorganic bodies within the *Transition*, organic nature cannot properly be interpreted as a subject of physics and physics cannot be regarded as a systematic science. In short: the distinction between the organic and inorganic is *presupposed* within physics understood as a systematic science (for this reason this distinction is treated as a priori).

Insofar as the distinction between the organic and the inorganic is presupposed within physics, this distinction, Kant argues, functions as a principle for the investigation of nature. It is a principle that *precedes* empirical investigation. In the eleventh fascicle Kant states that through the a priori (yet problematic) division between organic and inorganic beings, physics obtains a second topic (*ein 2tes Fach bekommt*).[115] We have encountered a similar idea in Chap. 5. There, we saw that in the third *Critique* Kant argues that the object or domain of biology is determined by

112 Ibid.

113 Cf. also AA 21: 188.

114 The same idea is expressed, once again, at AA 21: 188.

115 AA 22: 466.

conceptualizing organisms as natural purposes. In the *Opus postumum*, this line of reasoning is made fully explicit.

It is worth emphasizing that in the *Opus postumum*, Kant often emphasizes that the object of physics is construed in terms of a priori presuppositions. This idea is developed primarily in fascicle 10 (August 1799–April 1800), in which Kant argues that the object of physics is made by the subject, i.e.: the object of physics is not empirically given but is (one might say) a theoretical construct. For example, with respect to the concept of organized bodies Kant remarks:

> Objects must all fit into the topic of the principles, without which they could not be objects of experience (e.g., *caput de finibus*). Thus we find in our own body and in nature characteristics by reason of which we must regard them as organized – that is, as formed for purposes – *since we would not otherwise understand them as such*. These concepts always precede the confirmation of their objects by experience; they are *a priori* principles by which experiences are made. (AA 22: 291, emphasis mine)

We do not empirically observe objects of nature to be organized, i.e., we do not observe them to be teleological wholes in which everything is both end and reciprocally means. Rather, we understand objects *as such* because we conceptualize them as organized bodies. Insofar as the concept of an organism is presupposed in identifying objects as organized bodies, i.e., insofar it *precedes* the confirmation of objects as organized beings through experience, this concept functions as an a priori concept by which experiences are made. In this sense, the concept of an organism (in the technical sense of a teleological entity) determines how we construe the subject matter of physics.

The idea that the subject construes the object of physics is primarily developed by Kant by introducing the technical notion of an *a priori* 'appearance of appearance', which is contrasted to a direct appearance (given *a posteriori*). In fascicle 10, Kant describes this notion as follows:

> The appearance of things in space (and time), however, is twofold: (I) that of objects which we ourselves insert in space (*a priori*), and which is metaphysical; (2) that which is empirically given to us (*a posteriori*), and which is physical. The latter is direct appearance, the former indirect – that is, appearance of appearance.
>
> The object of an indirect appearance is the thing [*Sache*] itself – that is, one which we only extract from intuition, insofar as we ourselves have inserted the appearance, that is, insofar as it is our own cognitive product.
>
> For we would have no consciousness of a hard or soft, warm or cold, etc. body, *as such*, had we not previously formed for ourselves the concept of these moving forces of matter (of attraction and repulsion, or of extension and cohesion, which we subordinate to them) and thus can say that one or the other of these [properties] falls under such a concept. Hence, there are given for empirical knowledge concepts which are not, for that reason empirical, but *a priori*; they are given for the sake of experience. (AA 22: 230)

This complex passage expresses the view that the object of physics is constructed by the subject. Let us give an example to illustrate Kant's point. In a passage from the third fascicle, Kant states that we cannot intuit a body *as such*, rather we form a body through composition (*Zusammensetzen*).[116] Hence, a body can be taken to be

[116] AA 21: 275. I owe the reference to Mathieu 1989, 139.

our own cognitive product (something we extract from intuition insofar as we have ourselves inserted it).

This idea is counterintuitive: surely physical bodies are empirically given? However, for Kant the term 'body' is technical. In the *Metaphysische Anfangsgründe*, Kant defined a body in the physical sense as "*a matter between determinate boundaries* (which therefore has a figure)".[117] In the lecture notes on physics, the *Berliner Physik*, the concept body is construed as a matter that *coheres* and that has a figure.[118] Hence, the concept of cohesion is presupposed in determining the concept of body. As we have seen in the previous chapter, in the *Opus postumum* Kant argues that the possibility of cohesion (and thus of a physical body) must be explicated in terms of the action of an ether, which Kant construes as an a priori presupposition of physics.[119] Finally, recall that in the first *Critique*, Kant defined matter (a genus of the concept body) in terms of the concepts "impenetrable", "lifelessness", and "extension",[120] while in the *Metaphysische Anfangsgründe* Kant specifies the grounds of these properties (the fundamental forces of attraction and repulsion and the law of inertia).

In short, according to Kant the concept 'body' occupies a determinate place within a hierarchy of concepts. In the *Opus postumum*, Kant argues that the form of this system is a priori and is presupposed within physics. It is for this reason that he argues that we cannot intuit a body as such and that bodies (in the technical sense of compounds of matter that cohere and have a figure) are not empirically given. Rather, when we identify an object as a body, we presuppose a specific hierarchy of concepts in terms of which we understand something as a body. The same is true for organized bodies. Organisms (in the technical sense of teleological wholes) are our own cognitive products or appearances of appearances. Once again: that the parts of plants and animals are related to each other as end and means is not empirical given but is a projection of the subject. We identify specific means-ends relationships among the parts of plants and animals *only because* we have conceptualized them in teleological terms. In the *Opus postumum*, Kant expresses this line of thought with a brief formula: *Forma dat esse rei*.[121]

To summarize: in the *Opus postumum* Kant takes the distinction between the organic and inorganic to be an a priori presupposition of physics. This implies that

117 AA 4: 525.

118 AA 29: 79.

119 Cf.: "To assume such a matter filling cosmic space is an inevitable necessary hypothesis, for, without it, no cohesion, which is necessary for the formation of a physical *body*, can be thought." AA 21: 378.

120 *KrV*, B 876.

121 See, for example, AA 22: 300, 318. Kant explains this formula as follows: "*Forma dat esse rei*: i.e., the a priori principle of composition precedes the empirical concept, which only thereby becomes a determinate thing [*Sache*]." (AA 21: 637) In the *Reflexionen zur Metaphysik* we find: "*Forma dat esse rei*. For that which is essential to a thing [*Sache*] can only be cognized by means of reason; now, all the matter of cognition must be given sensibly; hence the essence of things [*Sachen*], in so far as they are cognized by reason, is form." AA 17: 312

the concept of an organism is a necessary condition for knowledge of organic nature (biological knowledge). After all, without conceptualizing things as organisms biology lacks a determinate object of investigation. This claim might then also be taken to suggest that the concept of an organism is, in contrast to Kant's position in the third *Critique*, assigned a constitutive status. This is, as we have noted, the view of Vittorio Mathieu, who takes Kant to assign a constitutive status to the idea of an organism in the *Opus postumum*.

Such a reading is, however, incorrect. The idea that the concept of a natural purpose determines the object or domain of biology was already contained in the third *Critique*. There, Kant remained committed to the idea that the concept of a natural purpose, even though it determined the domain of biology, was a *regulative* concept of reflecting judgment. In the *Opus postumum*, Kant also remains committed to his regulative interpretation of teleology. As we have seen, Kant treats the concept of an organism as *problematic*, arguing that we cannot determine anything concerning the existence of nonexistence of organism and their specific forces. Hence, the idea of an organism remains regulative, even though this idea is necessarily presupposed within physics. The fact that principles are necessary conditions for scientific cognition (such as the ideas of 'natural purpose', 'system', and so forth) does not imply that they are constitutive.

7.5 Conclusion

At the end of the eighteenth century, the notion of a vital or organic force was construed in a variety of ways. For example, Blumenbach took his infamous *Bildungstrieb* to be a cause of organic form. It was a teleological force or agent, irreducible to physical or chemical forces, which explained the purposive, self-formative and self-maintaining character of organisms. In contrast, biologists like Brandis and Reil took vital forces to be reducible to some species of physical or material forces. These biologists stressed the necessity of providing thoroughly mechanical explanations of organisms and organic processes.

Kant could not have accepted the existence of teleological agents in nature such as the *Bildungstrieb*. He construed vital forces as regulative ideas. If we ascribe a vital force, e.g., a *Bildungstrieb*, to organisms, we are merely highlighting the purposive and self-maintaining character of organisms and their parts. According to Kant, biologists necessarily conceptualize or describe organisms as purposive structures. However, although we necessarily describe organisms in teleological terms, we cannot assume the existence of teleological forces or agents in order to *explain* the purposive character of organisms. For this is tantamount to ascribing intentionality (representations, desires, a will, and so forth) to organisms such as plants and animals. Hence, we can only ascribe vital forces to plants and animals on the basis of an *analogy* with human purposive action. In short: assuming the existence of teleological forces such as the *Bildungstrieb* is inconsistent with Kant's regulative conception of teleology. Proper explanations in biology are always mechanical explanations. In adopting the latter view, Kant's position is akin to that of Reil, although Kant insisted that the purposiveness of organisms does not allow of mechanical explanation.

In the *Opus postumum*, Kant remained committed to his regulative conception of teleology. He also developed the idea that the domain of the biological sciences is construed by conceptualizing organisms in teleological terms. The idea of an 'organism', understood as a purposive whole, is presupposed (*a priori*) within natural science. On the basis of this presupposition, we identify a certain class of objects as constituting the subject matter of biology and thus *construct* the domain of biology. According to Kant, biology is a part of natural science (physics). Nevertheless, it has its own fundamental (teleological) concepts and its own domain.

Chapter 8
Materialism, Hylozoism, and Natural History in the *Opus postumum*

In the *Kritik der Urteilskraft*, Kant strongly criticized the metaphysical theories of materialism and hylozoism. In the *Opus postumum*, Kant continued to criticize these doctrines. Kant's critique of materialism and hylozoism are related. Although materialist and hylozoists may differ in the properties they ascribe to matter, both take matter to be sufficient for explaining organic phenomena.[1] Many reflections on organic nature in the *Opus postumum* are concerned with a rejection of this view, i.e., with a rejection of the idea that matter can organize itself.

In the present chapter, I argue that in the 1790s Kant was confronted with biological theories that he took to have materialist and/or hylozoist implications and with metaphysical interpretations of these theories that conflated the domains of science and metaphysics. This led him to reassert his anti-materialism and anti-hylozoism in the *Opus postumum*. The chapter has three main parts.

First, I show that in 1795 Kant was confronted with the works of the physiologist and anatomist Samuel Thomas Sömmering, who provided a physiological theory of the so-called organ of the soul or *sensorium commune*. Kant took Sömmering's theory to conflate metaphysical and physiological questions. In his debate with Sömmering and in the *Opus postumum*, Kant attempted to provide strongly mechanist explanations of organic phenomena. He developed the idea that unorganized fluids can be *chemically organized* and treated the ether as an explanatory principle in physiology. I argue that Kant's encounter with Sömmering and his own attempts to provide thoroughly mechanistic explanations in the life sciences led him to reaffirm his anti-materialism. Kant was forced to show that striving for mechanical explanations in natural science does not commit one to materialism.

Second, I show that around 1790 Kant was confronted with Salomon Maimon's theory of the world-soul. Maimon took Blumenbach's theory of the *Bildungstrieb* to provide evidence for the existence of a world-soul that is the cause of the organization and life of matter. In other words, Maimon used Blumenbach's theory to argue for the truth of hylozoism. In addition, Kant was confronted with biologists who

[1] Zammito 1992, 216.

H. van den Berg, *Kant on Proper Science: Biology in the Critical Philosophy and the* Opus postumum, Studies in German Idealism 15, DOI 10.1007/978-94-007-7140-6_8,

assigned the concept 'life' a very wide scope in the 1790s. These circumstances led Kant to reassert his anti-hylozoism in the *Opus postumum*, or so I shall argue.

Third, I discuss Kant's views on the doctrine of 'natural history' in his published writings and the *Opus postumum*. I will show that Kant construed natural history as a possibly *explanatory* discipline that specifies the historical causes of present properties of objects and organisms. However, natural history is not a proper science since it involves analogical inferences and is based on uncertain hypotheses. Moreover, according to Kant natural history cannot transgress certain explanatory limits: it is impossible that unorganized matter gave rise to organisms and there is no evidence for the view that species transformed themselves or evolved. In the *Opus postumum*, Kant essentially retained the conception of natural history developed in his published writings.

The chapter is structured as follows. In Sect. 8.1, I discuss Sömmering's *Über das Organ der Seele* (1796), Kant's reception of this work, and Kant's anti-materialism in the *Opus postumum*. Section 8.2 provides an analysis of anti-materialist arguments in the *Opus postumum* that have been interpreted as showing that Kant adopted a metaphysical account of the nature of organisms. I reject this interpretation and argue that Kant's position in the *Opus postumum* is consistent with his views articulated in the third *Critique*. In Sect. 8.3, I discuss Maimon's theory of the world-soul and the manner in which the concept of life was used by biologists at the end of the eighteenth century. This will allow us to explain Kant's anti-hylozoism in the *Opus postumum*. In Sect. 8.4, I show that in his last work Kant introduced the ether as an explanatory principle in the life sciences. This supports the idea that Kant adopted the ideal of grounding biology as a science. Finally, in Sect. 8.5 I analyze Kant's views on natural history in his published works and in the *Opus postumum*.

8.1 Kant on Sömmering's *Über das Organ der Seele*

How do we properly demarcate metaphysics and physiology? This question is core to the encounter between Kant and the biologist Samuel Thomas Sömmering. In his *Über das Organ der Seele* (1796), Sömmering formulated a theory concerning the so-called organ of the soul or *sensorium commune*.[2] Sömmering argued that the organ of the soul, i.e., the organ through which perceptions obtained by different organs are combined, could be identified with the fluid contained in the ventricles of the brain. He argued that the nerves of smell, hearing, sight and various others could all be traced to the ventricles of the brain. The fluid contained in these ventricles (*acqua venticulorum cerebri*) could be interpreted as the common element uniting

[2] Sömmering's work is instructively discussed by Peter Hans Reil 2005, 152–153. Reil relates Sömmering's work to late-eighteenth-century theories on sensibility, nervous force, and Schiller's and Herz's theories on the relation between mind and body.

all nerve endings. Moreover, this fluid could be interpreted as being animated. According to Sömmering, this fluid constituted the *sensorium commune*.[3]

Before publishing his work, Sömmering sent the manuscript to Kant. He wanted to dedicate the work to Kant and asked for his opinion. On August 10, 1795 Kant replied and wrote a short piece on Sömmering's work. This piece was annexed at the end of Sömmering's book, which was published in 1796.

In this piece, Kant praised Sömmering for his anatomical and physiological research. However, he was also critical of Sömmering's undertakings. His main criticism is that Sömmering did not sufficiently distinguish between metaphysical and physiological questions.[4] The question concerning the organ of the soul is related to the metaphysical question concerning the seat or local presence of the soul. In his drafts to his article, Kant represented Sömmering as arguing that the soul itself is *located* in the fluid filling the ventricles of the brain.[5] This leads to an untenable materialistic conception of the soul, which must be understood as a substance *distinct* from matter. In his published essay, Kant writes that the soul can only perceive itself through inner sense and hence cannot be assigned any location. Any solution to the problem of the seat of the soul leads to the affirmation of an "impossible quantity ($\sqrt{-2}$)".[6] According to Kant, we simply cannot *spatially localize* the soul.

Despite his criticism, Kant argued that we can interpret Sömmering's work purely physiologically and thus prevent a transgression into the domain of metaphysics. The proper physiological question that must be asked concerns the matter that makes the combination of all sense-perceptions in the mind possible. Kant emphasizes that in this context the term 'mind' must be understood as the *faculty* that effects the combination of representations. This term does not refer to any *substance* with a nature different from matter, such as the soul of metaphysics.[7] What is Kant's opinion on this supposedly purely physiological question?

Kant argues that it is possible to maintain Sömmering's hypothesis that the fluid contained in the ventricles of the brain enables the combination of sense-representations propagated through the nerves.[8] According to Kant, this fluid is water. However, here a problem arises. It is not clear whether a fluid can be regarded as *organized*. Yet only organized bodies can be regarded as candidates for being the *sensorium commune*. Kant explains the term 'organization' by stating that bodies are organized if their parts are purposively arranged and if the form and arrangement of these parts is *persistent*. Since rigid bodies are characterized by the resistance to any change of their internal configuration, they can properly be called

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[3] Sömmering 1796, 31.

[4] Reil 2005, 153, cites Johann Wolfgang von Goethe, who took issue with Sömmering's use of the word 'soul', claiming that "the philosopher knows nothing about it, and the physiologist should not even think about it." This is Kant's critique of Sömmering in a nutshell.

[5] AA: 13: 399, 401, 405–406.

[6] AA: 12: 31–32, 35.

[7] AA: 12: 32, 35n.

[8] AA: 12: 32–33.

organized. In contrast, fluids are characterized by a frictionless displacement of their parts and hence it is problematic to call them organized (the arrangement of their parts is not persistent).[9]

Kant does not explain why one would assume that only purposive bodies that are *rigid* can be candidates for being the *sensorium commune*. The underlying premise might be that only purposively arranged bodies (organs) capable of *consistently* performing their function can account for the lawlike manner in which representations are combined in human beings. In virtue of their persistent form, *rigid bodies* are bodies that are typically capable of consistently performing a function. This fact may explain Kant's association of organization and rigidity. In his drafts to his essay, Kant suggests that if one takes the fluid contained in the ventricles to be the *sensorium commune*, the abiding disorganisation among the materials comprising the fluid might result in insanity.[10] This suggests that if we construe a body as the *sensorium commune*, this body must have a persistent purposive organization in order to account for the regular functioning of the sensory apparatus of human beings. This leaves Sömmering's theory with the problem of how a *fluid* can be regarded as organized, i.e., as consistently performing a function.

In order to save Sömmering's theory, Kant proposed the following hypothesis. Although a fluid cannot be regarded as "mechanically organized", i.e., as a machine understood as having a purposive and rigid internal configuration, we might interpret fluids as being "dynamically organized".[11] The dynamical organization of fluids is taken to rest on *chemical principles*.

In explaining his hypothesis, as Friedman has shown,[12] Kant alludes to the anti-phlogistic chemistry of his day. He argues that chemical division can proceed *in indefinitum*. To elucidate this claim, he states that pure common water, which was for a long time interpreted as an *element*, can be separated through pneumatic experiments into two types of air.[13] Here, Kant is referring to traditional Stahlian chemistry, in which water was regarded as a chemical element, its subsequent overthrow by (Lavoisier's) anti-phlogistic chemistry and the finding of chemists that water can be separated into hydrogen gas and oxygen gas.[14] Kant continues by stating that each of these types of air, outside of its basis, contains caloric, i.e., in line with the anti-phlogistic chemistry hydrogen gas is construed as a composite of hydrogen base and caloric whereas oxygen gas is construed as a composite of oxygen base and caloric. Finally, Kant suggests that the matter of heat (caloric) may be decomposed by nature into a light material (i.e., light-ether) and other matter, just as light can be decomposed into colours.

In this manner, Kant illustrates the decomposition of fluids *in indefinitum*. He states that the nerves that lead to the water in the ventricles in the brain find within

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[9] AA: 12: 33.

[10] AA 13: 399.

[11] AA 12: 33.

[12] Friedman 1992a, 288–289.

[13] AA 12: 33.

[14] Cf. Friedman 1992a, 288–289.

this water a manifold of *instruments* (*Werkzeuge*). If we think that the capacity of the mind to analyze and combine representations of the senses is based on some capacity of the nerves, we may conjecture that different nerves decompose the water contained in the ventricles of the brain in different fundamental materials, such as caloric or light, and in different ways. As such, the nerves may give rise to a play of different sensations, e.g., a sensation of light through the stimulated nerve of sight, a sensation of sound through the simulated nerve for hearing, etc.[15] We can thus understand the water contained in the ventricles of the brain as being *continually subject to organization*. This water is continually organized in accordance with chemical principles and capable of performing a function in a regular manner in virtue of the regularity of chemical decomposition,

In elaborating this hypothesis, Kant emphasizes that it is only by means of this interpretation that Sömmering's anatomical research can have any bearing on the question concerning the location of the *sensorium commune*. Kant takes pride in incorporating recent chemical findings in this physiological investigation and he regards the hypothesis that he develops to have no bearing on problematic metaphysical questions concerning the soul.[16]

Kant's hypothesis can be read in line with the methodological requirements of the third *Critique*, according to which one must always further the search for mechanical explanations in biology *given* the assumption of the purposeful organization of the object of investigation. Thus, Kant states that his account of the decomposition of water by means of the action of the nerves, a process that gives rise to various sensations, requires that the separated materials, such as light, caloric, hydrogen gas, and so forth, must *recombine* immediately if the nerves stop being stimulated.[17] This makes sense, for how should we otherwise understand the short period in which we have sensations on the proposed hypothesis? In his drafts Kant develops this point in more detail. He argues that the nerves acting on the fluid should not effect *permanent disorganization*. Rather, the fluid must be thought of as a body that constantly *reorganizes* itself in accordance with *vital laws*.[18] Hence, *reorganization* or *regeneration* is central to Kant's account. This phenomenon must be understood teleologically. The constant reorganization of the fluid ensures that we are consistently capable of combining sensory data. In this manner, Kant took mechanical laws to be subordinated to teleological principles.

I have analyzed Kant's hypothesis of a dynamical (chemical) organization of the fluid contained in the brain ventricles as being in line with the idea that in biology we must subordinate mechanism to teleology. Kant's hypothesis is nevertheless strongly mechanist. He applies principles of chemistry in order to explain physiological phenomena. This gives rise to the following question: what are the limits of mechanical explanation in the life sciences? If fluids can be dynamically organized, why can we not explain organism purely materialistically?

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[15] AA 12: 33–34.

[16] Ibid.

[17] AA 12: 34.

[18] AA 13: 399–400.

In Kant's time, this materialistic line of thought was (to some extent) accepted.[19] Johann Christian Reil, for example, argued that the nutrition and growth of organisms occurs by the attraction of external substances to the right parts of bodies in accordance with chemical affinities and by a subsequent process of animal crystallization.[20] In a similar vein, the development of a foetus was conceived of as a process of crystallization.[21] Kant's views on biological method do not entail a rejection of this type of procedure. Reil is simply trying to provide a mechanical explanation of organic processes.[22] However, if we rigorously apply Reil's mechanistic methodology, why would we not allow for the generation of organisms from unorganized matter?[23] This is a view Kant explicitly rejected in the third *Critique*, in which the limits of mechanical explanation are always clearly described. How did Kant construe the limits of mechanical explanation in his late works?[24]

In the *Opus postumum*, there are several passages that seem to be related to his encounter with the work of Sömmering. In his reflections on natural machines (organisms), Kant remarks that objects conceptualized as machines must be thought of as consisting of *solid or rigid parts*.[25] This seems to refer to the problem of whether fluids can be thought of as organized. In his response to Sömmering, Kant entertained the possibility that fluids can be dynamically organized. Whether Kant still accepts this possibility in the *Opus postumum* is not clear. For our purposes, it is important to note that Kant makes these remarks when rejecting the materialist position according to which inert matter can give rise to organized bodies. Hence, it is likely that Kant's encounter with Sömmering led him to reflect on the problem of materialism. Moreover, the views espoused within the *Transition* itself also lead Kant to reaffirm his anti-materialism and to give a precise account of the distinction between organic and inorganic bodies. Let us treat the relevant passages of the *Opus postumum* in more detail.

In fascicle 12, sheet I (May-Aug 1799), Kant remarks that the organic body is thought of "as a *solid body*" and "as rigid".[26] Immediately preceding these remarks, Kant introduces a distinction between organic and inorganic natural bodies:

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[19] I say 'to some extent' because virtually nobody, including Reil, allowed for the view that organisms ultimately arise from mere inert matter.

[20] Reil 1796, 66–69. Cf. Richards 1998, 709, who stresses the importance of the idea of crystallization in the work of Reil.

[21] Reil 1796, 80.

[22] However, Kant would add that we conceive of such processes in teleological terms, i.e., as serving a purpose. As we shall see in the following, it is precisely this perspective that grounds the distinction between organic and inorganic bodies.

[23] Richards 1998, 710 notes that even Reil did not allow for such a possibility. This view was extremely contentious in Kant's time.

[24] Guyer 2001 also argues that in the *Opus postumum* Kant develops mechanistic accounts of organisms.

[25] AA 21: 193; AA 22: 283; 22: 547.

[26] AA 22: 547.

> Matter (natural material) can be termed neither organic nor inorganic. Such a concept is a contradiction with itself (*sideroxylon*). For, in this concept, one abstracts from all form (figure and texture) and thinks in it only a *material* (*materia ex qua*), which is capable of various forms. Thus, it is only to a body (*corpus physicum*) that one can attribute one of these predicates. And this division [into organic and inorganic] necessarily belongs to the transition from the metaphysical foundations of natural science to physics […]. (AA 22: 546)

The general argument seems clear enough. In thinking of matter, we abstract from all form (from the inner form of bodies or 'texture' and from the outer form of bodies or 'figure'). Hence, it does not make sense to apply predicates such as 'organic' or 'inorganic' to matter. We only apply these predicates to *bodies*. Yet, what is the aim of these remarks?

As indicated in the previous chapter, the distinction between matter and (physical) body is central to Kant's *Transition*. The term 'matter' is often applied to the ether, a universal, *formless*, and imponderable matter filling space. The different states of matter are explained in terms of the action of the ether.[27] In particular, fluid bodies are mixtures of inhomogeneous parts resulting from the penetration of ether. When the ether is released from this mixture, a process of crystallization occurs which gives rise to rigid or solid bodies. This is a process through which bodies obtain a particular *figure* and (rigid) *texture*.[28] In this manner, the ether or caloric serves as a 'formative means' (*Bildungsmittel*) for the formation of bodies in nature.

Hence, through the action of the ether solid bodies are formed. All rigid bodies have a crystalline structure due to the ether and this is also true of the rigid parts of organisms. Kant's *Transition* thus specifies the nature and physical manner of formation of the parts (fluids and solids) of which all organisms are ultimately composed. Given this view on the fundamental materials of organisms (indeed: of all bodies), one might subsequently proceed to a higher level of analysis, searching for a purely mechanical account of organic phenomena such as nutrition, growth etc. Once again: Kant's view on biological method, which directs us to always try to provide mechanical explanations of organic phenomena, does not exclude such an approach. Ultimately, however, such a strong stress on mechanical explanation may lead to a form of materialism. How do we exclude the idea that life has arisen from the lifeless?

In the *Opus postumum*, Kant is thus forced to exclude materialism and to specify the difference between inorganic and organic bodies. In fascicle 12, sheet II (a passage occurring just after the passage cited above) he gives the following argument:

> An organic natural body is thus thought of as a *machine* (a body arranged *intentionally* as to its form). Under no circumstance can it be a property of matter to have an *intention* […]. Thus, such a body cannot derive its organization merely from the moving forces of *matter*. A single (thus, immaterial) being must be assumed as the *mover* outside or within this body […]. (AA 22: 548)

[27] See Carrier 2001a.

[28] See for example AA 22: 213.

This argument rehearses one of the central claims of Kant's philosophy of organic nature. Although we must always attempt to provide mechanical explanations of organisms and organic processes, organisms are *purposive* wholes. We cannot explain the purposiveness of organism mechanically, i.e., in terms of the moving forces of matter *alone*. Rather, the idea that organisms are purposive is a *presupposition* of biological inquiry. In this manner, materialism is rejected. That Kant repeated this critique of materialism is due to the fact that in his encounter with Sömmering and in the *Transition* he developed mechanistic explanations of organisms that forced him to reassert his anti-materialism.

The above argument also adds another claim, namely: that the ground of the purposiveness of organisms must be *immaterial*. These kind of claims have led Adickes to argue that in the *Opus postumum* Kant reverts back to a dogmatic metaphysical position. I will deal with these passages in the following section.

8.2 On Souls and Immaterial Principles in the *Opus postumum*

In the previous section, we have discussed why Kant reasserted his anti-materialism in the *Opus postumum*. In the present section, I will analyze reflections suggesting that Kant adopted a dogmatic metaphysical position on the nature of organisms. I am especially concerned with the view that organisms have an *immaterial ground*.

In many passages in the *Opus postumum*, Kant seems to argue that organisms have an immaterial ground. For example:

> A natural thing which, as the movable in space, is an object of the outer senses (outer perception), that is, *matter*, cannot be *self-organizing* through its own forces and form organic bodies. For, since this requires a composition of the material according to purposes, matter would have to contain a principle of the absolute unity of the efficient cause – which, as present in space, would be an atom. Now all matter is divisible to infinity, and atomism, as a ground of explanation for the composition of bodies from smallest parts, is false. Hence, only an immaterial substance can contain the ground of the possibility of organic bodies. (AA 22: 506–507)

Kant somehow reasons from the fact that organic bodies are purposively arranged composites of parts to the fact that organic bodies must have a single and unitary efficient cause. This somehow leads to the conclusion that an *immaterial substance* contains the ground of the possibility of organic bodies. In other passages, Kant identifies this immaterial principle with a *soul*.[29]

Did Kant adopt the metaphysical position that souls *exist* and constitute an immaterial ground of the purposiveness of organisms. This is highly doubtful. Many passages in the *Opus postumum* are in line with his critical philosophy. For example, he repeatedly claims that we necessarily *conceive* of organisms as having an

[29] AA 22: 97, 373, 418, 469.

immaterial ground yet cannot have knowledge of this ground.[30] What is, however, the point of this argument? How should we understand the claim that organic bodies must be viewed as having an immaterial principle as their ground? In the *Opus postumum*, Kant does not explain why this is the case. In order to understand this claim, we must focus on the *Kritik der Urteilskraft*. Kant's position can be understood on the basis of his conception of purposiveness, his critique of Spinoza, and his critique of Hume.

In the Dialectic of Teleological Judgment, Kant presents Spinoza as adopting the metaphysics of *idealism* of purposiveness, i.e., as affirming that the causality of nature is identical with the mechanism of nature (unintentional).[31] Spinoza is criticized for failing to explain why we make teleological judgments concerning natural objects. According to Kant, Spinoza denies the reality of natural purposes by treating organisms not as *products* of an original being, but as *accidents* inhering in this being. This being is not regarded as a *cause* but as a *substratum* in which all natural things *subsist*. In addition, Spinoza is said to remove all understanding from the original ground of natural things (God).[32]

According to Kant, Spinoza captures one condition for understanding the purposiveness of organisms insofar as he "secures for the natural forms the unity of the ground".[33] In the third chapter, we saw that Kant argued that the necessary and purposive unity of organisms defies mechanical explanation and can only be understood in teleological terms. The parts of organisms constitute a contingent unity since we cannot relate them to a single mechanical ground. Although the form of organisms defies mechanical explanation, the parts of organisms must be interpreted as constituting a necessary unity. We understand this unity by construing organisms as purposes. This allows us to interpret the unity of the parts of organisms as a necessary unity insofar as we ascribe them the function of bringing about a *single* purpose. As in the case of mechanical science, the necessary unity of a multiplicity of consequences (parts) is thus understood by relating them to a single ground. Spinoza's theory of a single ground in which natural things inhere captures the idea that the unity of natural things is based on a single ground.

However, Kant rejects Spinoza's theory of an original being because it cannot explain why we take certain objects of nature to exhibit a 'unity of purpose',[34] i.e., why we construe natural objects as purposively arranged wholes. The 'unity of purpose' of objects implies that we conceive of these objects (a) as effects of a substance that is a *cause*. This substance must (b) be conceived as a cause operating through its *understanding*.[35] Kant defined a purpose as the object of a concept insofar as the latter is regarded as the cause of the former.[36] This conception of purpose

[30] Cf. AA 22: 56, 59, 100.

[31] AA 5: 390–391.

[32] AA 5: 393.

[33] Ibid. Cf. AA 5: 421.

[34] AA 5: 393.

[35] Ibid.

[36] AA 5: 220.

is modelled on intentional agency. Conditions (a) and (b) spell out the implications of conceptualizing an object as a purpose.

According to Kant, Spinoza's metaphysical doctrine of an original being is inconsistent with (a) and (b), since this being is not a cause and is denied understanding or intelligence.[37] Hence, Spinoza's conception of purposiveness is faulty. Moreover, Spinoza's metaphysics was essentially fatalist. It took all unity of objects to be the effect of a blind necessity.[38] Hence, Spinoza could not explain why objects appear as purposive and why we judge them teleologically.

For Kant, interpreting natural objects as purposes implies interpreting these objects as the product of intentional agency. In §80 of the third *Critique*, Kant discusses possible objections to his view. He refers to an argument of Hume in Part IV of his *Dialogues Concerning Natural Religion*.[39] There, the argument from design is taken to imply the view that the Divine Mind and the mind of the human artificer are similar or alike. The sceptic Philo rejects this view, as Kant points out.[40] Philo argues that this position leads to an infinite regress. If we infer from the order found in the material world to design, we should also take the order of ideas existing in the Divine Mind, an order ascribed to the Divine Mind due to its likeness with the human mind, to be the product of design. This argument can be reiterated indefinitely.[41]

In response to Hume, Kant argues that we employ teleological principles in judging organisms, and thus regulatively presuppose an architectonic understanding, in order to specify a ground of the combination of the manifold of elements of organisms that exist *external to one another*.[42] If this ground "is posited in the understanding of a productive cause as a simple substance",[43] Philo's objection is adequately answered. Kant's point is that the order of ideas need not resemble the order of material objects.[44] The parts of the latter exist external to one another, i.e., they are spatially separated. We invoke teleology to comprehend the order of these separated parts. However, there is no reason to think of ideas as being similar to the parts of material objects, for we can doubt whether ideas are spatially separated.

Kant also blocks Hume's regress by conceptualizing the productive cause of organisms, the existence of which is regulatively assumed, as a simple or

[37] Whether this is a correct interpretation of Spinoza is doubtful. Kari Marx has pointed out to me that it would be more appropriate to say that Spinoza's original being is not an intentional cause, i.e., its causality is not based on a concept of the intended effect. On the inadequacy of Kant's interpretation of Spinoza, cf. Zammito 1992, 248–259

[38] AA 5: 391–394.

[39] AA 5: 420–421.

[40] AA 5: 420.

[41] Hume [1779] 1998, 28–33.

[42] AA 5: 420.

[43] AA 5: 421.

[44] In the *Dialogues*, Philo argues that experience does not find any material difference between the world of ideas and the material world. He finds these worlds "to be governed by similar principles". Hume [1779] 1998, 30. By denying this claim, Kant blocks Hume's regress.

non-composite substance.[45] If we take a simple substance with understanding to be the cause of organisms, we think of a single ground of organisms that allows us to understand the unity of the composition of their parts. If this cause is “sought merely in matter”, the “unity of the principle for the intrinsically purposive formation” of organisms is entirely lacking.[46] In other words, matter does not provide us with a *single* ground for understanding organisms. We comprehend the order of the parts of organisms by interpreting them teleologically. This interpretation involves the regulative claim that organisms are produced by a single and *simple* cause.

To summarize: in the *Kritik der Urteilskraft*, Kant argues that if we conceive of natural objects as purposes we make the regulative assumption that these objects are produced by (i) a single ground or substance, (ii) a substance that has understanding, and (iii) a simple substance. Claim (iii) implies that this substance is immaterial, for matter is composite. Hence, it is no surprise that Kant in the *Opus postumum* argues that “only an immaterial substance can contain the ground of the possibility of organic bodies”.[47] The arguments in the *Opus postumum* concerning an immaterial ground of organisms can be fully understood on the basis of third *Critique*.

Of course, according to the third *Critique* the assumption of an immaterial ground or substance of organisms must be regulative. We cannot claim any objective validity for this assumption, nor do we have any determinate knowledge of such an immaterial substance. This position is maintained in the *Opus postumum*. Immediately after arguing that organic bodies are possible through an immaterial substance, Kant states:

> One is not, however, for that reason, entitled to assume this efficient cause to be a soul inherent in the body or a world-soul belonging to the aggregate of matter in general; it is rather, only an efficient cause on the analogy with an intelligence: that is, a cause which we can represent to ourselves in no other way, since there may be quite other kinds of forces (and laws by which those forces act) than those of our thought. (AA 22: 507)

In other words: the assumption of the existence of an immaterial substance or ground of organisms is a regulative assumption. We do not claim objective validity for this assumption.

8.3 Anti-hylozoism in the *Opus postumum*

In the previous sections we have interpreted Kant’s reflections on organic nature in the *Opus postumum* highlighting his anti-materialism. Another important theme in the *Opus postumum* is anti-hylozoism.

The problem of hylozoism is related to the topic of vital forces. In the previous chapter, we saw that Herder used the biological concept of a vital force to argue

[45] Hence, on this level there is no order of composite parts that requires explanation by teleological principles or an appeal to design.

[46] AA 5: 421.

[47] AA 22: 507.

for hylozoism (the self-organization of matter). In the *Opus postumum*, Kant reinterpreted vital forces as regulative posits. He rejected any position that affirms the objective reality of teleological causation in nature. Kant was thus aware of illegitimate metaphysical interpretations of the concept of vital force.

In the present section, I argue that in the 1790s Kant was again confronted with a metaphysical and hylozoistic interpretation of the concept of a vital force. Kant became acquainted with the hylozoist doctrine of the world-soul articulated by Salomon Maimon. This doctrine is rejected in the *Opus postumum*.[48] I show that Blumenbach's doctrine of the *Bildungstrieb* informed Maimon's metaphysical doctrine of the world-soul. Maimon's theory of the world-soul and Kant's critique must thus be understood in light of eighteenth-century developments in biology. I then discuss Kant's conception of life as articulated both in his critical works and in the *Opus postumum*. I relate this conception to the use of the concept of life by some eighteenth-century biologists. This will show that at the turn of the eighteenth century many biologist assigned the concept of life a crucial role within their discipline. In the *Opus postumum*, Kant tries to do justice to this fact while also interpreting this concept in a manner that does not imply hylozoism.

8.3.1 Maimon's Theory of the World-Soul

The concept of a world-soul is rarely discussed in Kant's writings. In some of his pre-critical writings and lectures on metaphysics, Kant discusses the 'system of a world-soul' of stoic philosophy, as Düsing has shown.[49] In these writings, Kant construes this doctrine as implying the heterodox idea that God and the world are reciprocally dependent on each other. In the third *Critique*, he describes the world-soul as a posit of hylozoism.[50] Hylozoism aims to explain the *objective reality* of purposiveness by ascribing life to matter. Hylozoists can either take matter itself to be alive or assume an animating principle, such as a world-soul.

In the *Opus postumum* the notion of a world-soul is frequently discussed. The occasion for Kant's interest in this concept is probably the publication of Salomon Maimon's *Ueber die Weltseele* (*Entelechia universi*) in 1790.[51] This is not, however, the opinion of some commentators. Eckart Förster argues that the introduction of the term world-soul in the *Opus postumum* is "occasioned by F.W.J. Schelling's *Von der Weltseele*, *eine Hypothese der höheren Physik zur Erklärung des allgemeinen*

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[48] Klaus Düsing 1968, esp. 172–197, has nicely discussed Kant's conception of the world-soul in the *Opus postumum*. Though Düsing discusses passages in which Kant is critical of this notion, he argues that Kant ultimately accepted the theory of the world-soul. I cannot follow Düsing, since Kant almost always rejects this theory. In contrast to Düsing, I will further consider the biological background to the debate on the world-soul.

[49] Düsing 1968, 173–175.

[50] AA 5: 392, 394–395.

[51] Maimon's work was published in the *Berlinischen Journal für Aufklärung*. Düsing 1968, 175, also cites Maimon as the principle cause of Kant's renewed interest in the world-soul.

Organismus, published in 1798".[52] However, it is doubtful whether Kant had a thorough knowledge of Schelling's work.[53] In contrast, Kant was familiar with the ideas of Maimon, and the manner in which the notion of a world-soul is discussed in the *Opus postumum* is reminiscent of the manner in which Maimon construes this notion.

In a letter to Kant of Mai 1790, Maimon communicated his conviction of the objective reality of a world-soul, presenting arguments that are contained *verbatim* in his publication.[54] Maimon defines the world-soul as a force acting on matter, the effects of which differ in accordance with the different modifications of matter. The world-soul is the ground of the particular mode of composition of both inorganic and organic bodies, of the life of animals, and of understanding and reason in humans. More generally, Maimon defines the world-soul as the ground of the form of matter, which enables matter to adopt higher forms of organization.[55] Since Maimon is afraid of being called a Spinozist, he finally argues that the world-soul should not be identified with God. Rather, it is an understanding or intelligence, which is somehow related to the world of corporeal bodies.[56]

This doctrine of the world-soul would certainly be categorized as hylozoistic by Kant. By treating the world-soul as the ground of the mode of composition of inorganic and organic bodies, Maimon gives up the strict distinction between the domains of inorganic and organic nature familiar from the third *Critique*. Moreover, by asserting the existence of the world-soul Maimon asserts the objective reality of teleological causality in nature. Maimon's hylozoism is thus very similar to the hylozoism of Herder.

The notion of a world-soul as employed in the *Opus postumum* strongly resembles Maimon's construal of a world-soul. In the fifth fascicle, Kant describes the world-soul as an immaterial being in space, which is the ground of organization in nature and acts in accordance with different modifications of matter.[57] This suggests that Kant's remarks on the world-soul in the *Opus postumum* are related to his encounter with Maimon. If Maimon's doctrine of the world-soul is a form of hylozoism, we would expect Kant to reject this doctrine. This is indeed the case.

How does Kant reject Maimon's views? In discussing the notion of the world-soul, Kant often stresses that the question whether an immaterial world-soul constitutes the ground of organization in nature lies beyond the borders of our cognition.[58] In this manner, the world-soul is treated as a posit of dogmatic metaphysics. Maimon argued for the objective reality of a world-soul and thus adopted a metaphysical position that cannot be theoretically justified.

[52] Förster 1993. 274.

[53] Onnasch 2009. Onnasch argues that Kant was probably familiar with some of Schelling's ideas through discussion of these ideas in his circle of philosophical friends.

[54] AA 9: 174–176.

[55] Maimon 1790, 48–49. Cf. AA 11: 174.

[56] AA 11: 175

[57] AA 21: 569

[58] AA 21: 569–570; 22: 548

Kant also takes the notion of a world-soul to be inconsistent. Maimon's world-soul is a force inherent in nature. It is a force acting on matter, the effects of which differ in accordance with the different modifications of matter. Hence, the world-soul seems to be a physical and material force. The question then arises whether we can consistently hold the view that the world-soul is also an immaterial substance endowed with understanding. In the *Opus postumum*, Kant denies that an immaterial substance with understanding, which we interpret as constituting the ground of organization in nature, can be identified with a world-soul:

> There is no spontaneity in the organization of matter but only receptivity from an immaterial principle of the formation of matter into bodies, which indicates [*geht auf*] the universe, and contains a thoroughgoing relation of means to ends. An understanding (which, however, is not a world-soul) [is] the principle of the system, not a principle of aggregation. (AA 22: 78)

Kant argues that the systematic organization of organisms must be taken to be based on an immaterial ground since matter cannot organize itself. He acknowledges that we take an immaterial substance with understanding to be the ground of organization in nature. However, he denies that such an understanding can be a world-soul. This makes sense, for how can a physical and material force be an immaterial substance with understanding? In other passages Kant explicitly considers the problem of whether understanding can be attributed to the world-soul.[59] Kant's critique of Maimon can be summarized by means of the following dilemma: either the world-soul is treated as an immaterial substance with understanding and Maimon cannot affirm the objective reality of such a being (which he does), or the world-soul is treated as a physical and material substance and Maimon cannot assign immateriality and understanding to such a being (which he does).

How does Maimon's doctrine of the world-soul relate to biological theories? Maimon cites Blumenbach's doctrine of the *Bildungstrieb* as evidence for his theory. The opening sections of *Ueber die Weltseele* contain a long discussion of the difference between epigenetic and evolutionary or prefomationist theories of generation.[60] Following Blumenbach quite literally, Maimon discusses several versions of the theory of evolution or preformation. He cites Blumenbach's experiments concerning the regeneration of organic parts, quotes Blumenbach's definition of the *Bildungstrieb*, and paraphrases Blumenbach's empirical evidence disconfirming preformationism.

The purpose of Maimon's discussion is to show that the biological question concerning the generation of organisms is related to the metaphysical question concerning the existence of a universal world-soul.[61] Maimon interprets Blumenbach's theory of epigenesis as entailing that matter itself cannot give rise to organization and that organic forms cannot evolve from one another in accordance with

[59] A 21: 570; AA 22: 548.

[60] Maimon 1790, 52–63.

[61] Maimon 1790, 52–53, 63–64.

natural laws.[62] Hence, we must take the ground of organization to be external to matter, e.g., by taking organization to be possible through the *Bildungstrieb*. The theory of the *Bildungstrieb* is taken to support the metaphysical (Aristotelian) views that matter and form are heterogeneous, that matter is passive, and that the generation of organic forms can only be explained by assuming the existence of a universal form external to matter, which communicates to particular bodies their particular organization.[63] Maimon thus takes the doctrine of the *Bildungstrieb* to support the metaphysical doctrine of a world-soul because both share the view that the organization (form) of material objects has an external ground.

Maimon also presents another argument for claiming that the theory of the *Bildungstrieb* supports the theory of a world-soul. He claims that a *Bildungstrieb* cannot be thought without a formative force (*bildende Kraft*). He then argues that we should assume the existence of only *one* such force in nature. The variety of different types of natural formations can be explained in terms of the action of this force and their different material composition.[64] Hence, an appeal to parsimony leads Maimon to assume a single formative force in nature (the world-soul).

This argument refers to the third chapter of the second edition of *Über den Bildungstrieb*. There, Blumenbach distinguishes between formative forces (*bildenden Kräften*) operative in inorganic and organic nature and the *Bildungstrieb*.[65] Blumenbach argues that one can point to phenomena of inorganic nature in order to elucidate phenomena of organic nature. Various types of crystallizations provide evidence for the existence of *formative forces* in the realm of inorganic nature. This fact supports the assumption of the existence of the *Bildunsgtrieb* in the realm of organic nature, Blumenbach argues.

Blumenbach emphasizes, however, that the *Bildungstrieb* should not be identified with a formative force of inorganic nature, e.g., a force of crystallization. The *Bildungstrieb* is a *vital force* and does not exist within inorganic nature. Hence, the appeal to inorganic formative forces does not provide sufficient evidence for the existence of the *Bildungstrieb*. Rather, this appeal is meant to *elucidate* (*Erläuteren*) the hypothesis of the *Bildungstrieb* by analogy. Only observations concerning the (re-)generation of organism provided objective evidence for this hypothesis. Maimon distorts Blumenbach's argument by claiming that the hypothesis of the *Bildungstrieb* only makes sense in light of the existence of formative forces in inorganic nature. In addition, Maimon does not distinguish between physical and vital forces, construing the world-soul as the single formative force of nature. Maimon thus reinterpreted Blumenbach's theory of the *Bildungstrieb* in order to arrive at his hylozoist doctrine of a world-soul.

Kant was aware of the use to which Maimon put Blumenbach's theory. In his letter to Kant, Maimon said that it was by reading Blumenbach that he came to his

[62] Maimon 1790, 64–65.

[63] Maimon 1790, 65.

[64] Maimon 1790, 89–90.

[65] Blumenbach 1789, 71–74.

theory of the world-soul (he read Blumenbach because of Kant's praise of Blumenbach in the third *Critique*).[66] After his encounter with Herder, Kant was thus once again confronted with someone who utilized biological theories employing vital forces to arrive at a hylozoist position. This may have lead Kant to treat the concept of a vital force more systematically in the *Opus postumum* and to treat this concept as a regulative idea (see Chap. 7). For if it is clear that if vital forces are regulative ideas, the inference from the *objective reality* of vital forces to the truth of hylozoism is blocked.

8.3.2 The Concept of Life in the Opus postumum

The debate on hylozoism concerns the proper scope of the concept of life. In order to deepen our understanding of this debate, it is useful to consider the manner in which biologists in the late eighteenth century employed this concept. Kant's concept of life has been nicely analyzed by Löw and Ingensiep.[67] In the present section, I will show that at the end of the eighteenth-century biologists often assigned the concept of life a much wider scope than Kant allowed for. Kant's reflections on life in the *Opus postumum* can be understood in this context.

In order to understand Kant's views on the concept of life, we must first determine how he construes this concept in his critical writings. In the mechanics chapter of the *Metaphysische Anfangsgründe*, Kant rejects hylozoism because he interprets the law of inertia as implying that matter is *lifeless*. The concept of life is defined as: (i) the faculty of a *substance* to determine itself to act from an internal principle; (ii) the faculty of a *finite substance* to determine itself to change; (iii) the faculty of a *material substance* to determine itself to motion or rest.[68] Hence, in natural science 'life' is applied to substances that are capable of *self-motion*.

In the *Kritik der praktischen Vernunft*, Kant defines life as "the power of a being to act in accordance with the laws of the faculty of desire". The faculty of desire is "the faculty for being through one's representations the cause of the reality of the objects of these representations".[69] Hence, only beings that have desire or that act in accordance with representations are alive. Kant allowed for the attribution of desire to animals.[70] Animals have a lower faculty of desire, in which desires, which are grounds of action, are determined by the feeling of pleasure or displeasure. In contrast, humans can be attributed a higher faculty of desire, in which desires are

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[66] AA 9: 174.

[67] Löw 1980, 153–168. Ingensiep 2001, 2004, 2006, 2009. Cf. Zamitto 2006, 761–764. Ingensiep distinguishes between a transcendental, metaphysical, physical, psychological, anthropological, medical and ethical concept of life. He also stresses, importantly, that the concept 'life' and 'organism' are not co-extensive.

[68] AA 4: 544.

[69] AA 5: 9.

[70] Ingensiep 2009, 102.

determined by the moral law.[71] Kant does not ascribe desire to plants.[72] Hence, Kant does not attribute life to plants although plants are of course organic bodies.

Kant's concept of life was more restricted than the concept of life entertained by many of his contemporary biologists. Let us treat a few illustrative examples. In his *Über das Kantische Prinzip für die Naturgeschichte* (1796), Christoph Girtanner assigns the concept of life a prominent role in the study of organic nature. Organized bodies are defined as bodies consisting of organized or *living* matter, which is distinguished from dead (unorganized) matter.[73] This distinction is meant to show that in organic bodies matter is subject to different laws than in inorganic bodies. In living bodies, physical, chemical, and mechanical laws are *subordinated* to the laws of organization. Life is defined as the efficacy of matter in accordance with laws of organization. Organization is in turn defined as the arrangement of a body in virtue of which every part is both end and means of another part.[74] It is in virtue of *life* that the parts of a body are teleologically related to one another and constitute a structure that is adapted to performing the functions of generation, growth and nutrition, and regeneration. Since these organic functions are characteristic and differentiating features of organic bodies, the concept of life can be taken to determine the object of biology. Finally, vital forces are responsible for the fact that in organic bodies chemical and physical laws are subordinated to the laws of organization. Since Girtanner explicates the concept of organization in terms of the concept of life, 'life' should be attributed to all organized bodies, including plants. Hence, the term 'life' has a wider application than Kant allowed for. In employing the term life in this fashion, Girtanner followed a line of thought already pursued by Blumenbach. For the *Bildungstrieb*, a vital force responsible for the generation, nutrition, and regeneration of organisms, was attributed to all types of organisms. If the attribution of vital forces to all organisms implies taking them to be alive, we should conceive of both animals and plants as being alive.

Girtanner stresses that he employs the concept of life in a *physical* or non-metaphysical sense.[75] Girtanner's position is similar to the views on life articulated by the Scottish physiologist John Brown (1735–1788). In his *Elementa medicinae* (1780),[76] Brown defined the state of life, through which living beings are differentiated from dead matter, as a property to be determined by external actions (e.g., heat, different types of nutrition) in a manner resulting in the characteristic phenomena of

[71] AA 5: 177–179.

[72] Ingensiep 2009, 103.

[73] Girtanner 1796, 13–14. Note that dead matters (e.g., hairs, nails) are also parts of organized bodies.

[74] Girtanner 1796, 13–14, 17.

[75] Girtanner 1796, 14. Alternatively, Kant's conception of life was still wedded to traditional metaphysical ideas concerning the (intellectual) soul. Ingensiep 2009, 99–100. Hence, we once again discern a tension between Kant's concept of 'life' and that of contemporary biologists.

[76] A German translation of Brown's work appeared in 1795. I have consulted the German Translation by Röschlaub of 1806.

life (e.g., contraction, sensation, etc.).[77] In short, living bodies are characterized by excitability. This property is the basis for the characteristic phenomena of life, which result from external stimulation. Brown notes that the conception of life as a state resulting from the property of excitability and external stimulation also applies to plants.

Finally, we may refer to Gehler's *Physikalisches Wörterbuch* of 1798–1801. In his lemma on plants, Gehler discusses F.A. von Humboldt's *Aphorismen aus der chemischen Physiologie der Pflanzen* (1794). Following von Humboldt, Gehler describes plants as organized bodies that have life and he takes the terms 'organization' and 'life' to be co-extensional (*gleichbedeutend*). Moreover, various parts of plants (i.e., their cellular tissue, various vessels) are irritable, although plants do *not seem* to have nerves. The parts of plants that are irritable are assigned a vital force and plants are assigned life (although no sensation or volitional movement).

Kant was most likely aware of these developments. He was certainly aware of Brown's work.[78] In his reflections on medicine (1798), Kant praised Brown's theoretical presentation of the moving forces of human life.[79] In his proclamation to *Zum ewigen Frieden* (1796), Kant follows Brown when he defines life as consisting in the action of stimulating forces and the capacity to react on such forces.[80] Finally, as Ingensiep points out, Kant was aware of discussions concerning the irritability and (even) sensibility of plants.[81] In the *Physische Geographie* (1802), Kant speaks of *planta sensitiva*, which, when touched, drops its twigs and leaves *as if* having sensations.[82]

In the *Opus postumum*, the concept of life is also discussed. In the fifth fascicle (leaves of Mai-Aug 1799) Kant states that "life in the strictest meaning of the term is the capacity of spontaneity of a physical entity to act in accordance with certain of its own representations".[83] This definition conforms to the critical view that only beings that have desire are alive. It occurs in a passage in which Kant distinguishes between inorganic and organic bodies and takes organic bodies to consist of either mere vegetative or living bodies. In other passages, Kant similarly makes a strict distinction between what he calls vegetative and vital forces operative in organic bodies.[84] Hence, in various passages Kant still denies life to plants.

However, in other passages Kant does attribute life to plants (although never any soul). For example, in fascicle 10 Kant speaks of vegetative life.[85] Fascicle 11 contains

77 Brown 1806, 5–7. On Brown, cf. Löw 1980, 96–97.

78 Löw 1980, 156–161, has shown the influence of Brown on Kant in the late 1790.

79 AA 15: 963–964.

80 AA 8: 413. Cf. Löw 1980, 157.

81 Ingensiep 2009, 103.

82 AA 9: 364.

83 AA 21: 566.

84 AA 21: 558, 22: 547.

85 AA 22: 283. Cf. 22: 499, 23: 483.

the remark that organic bodies (which include plants!) contain a principle of life.[86] In fascicle 7 (leaves of April-December 1800) Kant states that organic bodies (again: including plants) have life.[87] In addition, Kant attributes vital forces to both vegetative and animal bodies. In fascicle 2, for example, Kant claims that the productive force of the unity of organic bodies is 'life'.[88] In short: in the *Opus postumum* Kant frequently changed his views on the concept of life. This fact can best be understood against the background of contemporary biological conceptions of life.

The problem confronting Kant is the following: how can we reconcile the definition of life as the spontaneity of a being to act in accordance with its own representations with the wide application of the concepts of life and vital force in biology? It is important to recognize that Kant does not want to sever the intimate relationship between his critical views on life and the concept of life and vital force as employed in biology. Life points to action in accordance with purposes. Vital forces are similarly conceived as forces acting in accordance with purposes. The term *Lebenskraft* was, at least from Kant's perspective, well chosen: without the epithet 'vital', we would not construe this force as purposive. This line of thought also lead Kant, as we saw in the previous chapter, to construe vital forces as regulative posits being ascribed to organisms by analogy with ourselves. The tendency in the late eighteenth century to treat the terms organism and life as being coextensive may have reinforced Kant's view that life can be ascribed to organisms only by means of analogy. Otherwise, we would objectively ascribe the capacity to plants to act in accordance with representations. Kant's remarks in the *Physische Geographie* (1802), seem to support this interpretation. The so-called *planta sensitiva* are treated *as if* having sensations (*Empfindungen*), i.e., as moving in accordance with representations. We do not affirm that this is objectively the case.

8.4 Revisiting Mechanical Explanation in the *Opus postumum*

8.4.1 Construing Biology as a Part of a Unified Physics

In the third chapter we have considered Kant's views on mechanical explanation. Mechanical explanations provide cognition of the objective grounds of properties of natural objects. In biology, as we have seen in the fifth chapter, we should also try to provide mechanical explanations of the functioning of organisms. This position is maintained in the *Opus postumum*. In fascicle 2, for example, Kant argues that

[86] AA 22: 481.

[87] AA 22: 99.

[88] AA 21: 210–211.

organic bodies must be assessed according to their mechanical relationships and must be explained mechanically.[89]

Paul Guyer has argued that in the *Opus postumum* Kant allowed for the unlimited mechanical explanation of organisms and gave up the strict distinction between organic and inorganic nature.[90] According to Guyer, Kant's newfound views result from introducing the ether as a necessary principle of explanation in physical science. The ether functions as the basis for formulating a system of moving forces of matter. However, the ether must also be regarded as a principle of explanation for organic phenomena. As Guyer puts it: the ether can be considered as a "*vis vivifica*, a life-force that is apparently sufficient to explain the phenomenon of organic life".[91] This situation leads Kant to reconsider his argument contra hylozoism as presented in the third *Critique*, or so Guyer argues.

Guyer's interpretation is partly correct and partly incorrect. He is correct in arguing that according to Kant we must always explain organisms and their features mechanically. It is also true that Kant seems to interpret the ether as a principle of explanation in biology (see below). However, as we have seen in the previous sections, Kant insists on the incorrectness of hylozoism in the *Opus postumum*. Kant did not reconsider his position with respect to hylozoism in his last work.

Guyer argues that Kant drops the strict distinction between the organic and the inorganic because he came to recognize that even the motion of inorganic matter cannot be fully explained by mere mechanical forces.[92] Rather, the motion of inorganic matter requires some self-moving or non-inertial principle, such as the ether. Thus: inertia is no longer taken to be the defining characteristic of matter, and the strict distinction between inorganic nature and organic or living nature is dropped. As evidence for his reading, Guyer cites the following claim:

> All matter must have repulsive forces, since otherwise it would fill no space; but attractive force must also be attributed to it, since otherwise it would disperse into the infinity of space – in both cases space would be empty. Consequently, one can think of such alternating impacts and counterimpacts [as existing] from the beginning of the world, as a trembling (oscillating, vibrating) motion of the matter which fills the entire universe, includes within itself all bodies, and is both elastic and at the same time attractive in itself. These pulsations constitute a living force and never allow dead force by pressure and counterpressure (i.e., absolute rest inside this matter) to occur.
>
> […]
>
> The reason to assume such a hypothesis is that, in the absence of such a principle of the continual excitation of the world-material, a state of lifeless stasis would come about from the exhaustion of the elastic forces in the unceasing universal attraction, and a complete cessation in the moving forces of matter would occur. (AA 21: 310)

In this argument, Kant intends to provide an argument for the existence of the ether. We must assume the existence of an ether, construed as a continually vibrating or oscillating matter that fills the entire universe and communicates its motion to

[89] AA 21: 186.

[90] Guyer 2001, 272–276.

[91] Guyer 2001, 263.

[92] Guyer 2001, 272–274.

other matters through impact, in order to explain why a complete cessation of moving forces of matter, i.e., of motion of physical bodies in the universe, cannot occur.

According to Guyer, Kant thus assumes a non-inertial source of motion in the physical world. This undermines Kant's claim that the motion of matter is governed by inertia alone. I do not think that Kant's argument has such a wide scope. Kant never questions the universal validity and applicability of the law of inertia. As Martin Carrier has already shown, Kant's remarks must be understood against the background of views entertained by Newton.[93] Newton argued that because of the continual dissipation of energy in the universe, the universe was steadily moving towards a state of stasis. In addition, he argued that due to the influence of gravitational attraction the various heavenly bodies would ultimately collapse unto the center of gravity of the universe. These outcomes are prevented through the action of God. Kant provides a more naturalistic account for the conservation of motion. He argues that the cessation of motion in the universe does not occur because of the continual mechanical communication of motion from the ether to other bodies through impact. This suggests, as do our analyses given in the previous sections, that Kant still takes matter to be essentially lifeless and maintains his strict distinction between inorganic (dead) and organic (living) nature.

Nevertheless, Guyer is correct in arguing that in the *Opus postumum* Kant comes to treat of the ether as a principle for explaining organic phenomena. This is strongly suggested by the following remarks of Kant[94]:

> The skilful initiator [*Kunsturheber*] of motions for the preservation of vital force is called a *physician* (town or country doctor), and his branch of the study of nature is called zoonomy, and rests on the employment of four animal powers [*animalische Potenzen*]: (1) on nervous power as a principle of excitability (*incitabilitas Brownii*), (2) on muscular power (*irritabilitas Halleri*), (3) on a force which preserves all the organic force of nature as a constant alteration of the former two, of which *one* phenomenon is heat; (4) on the organization of a whole of organic beings of different species, for each other, serving for the species preservation. (AA 22: 300).

And similarly:

> Zoonomy contains three vital powers [*Lebenspotenzen*]: *nervous power*, as a principle of excitability (*incitabilitas*); *muscular power* (*irritabilitas Halleri*); and a *third one* which brings both forces into active and reactive, constantly alternating, play: one all-penetrating, all moving etc. material, of which heat is one phenomenon […]. (AA 22: 301)

Kant's remarks are hopelessly obscure. The sources of Kant's remarks are also unknown. Förster argues that Kant bases himself on the work of Albrecht von Haller (1708–1777), Erasmus Darwin (1731–1802), who published his *Zoonomia*, *or Laws of Organic Life* in 1794, and the physician John Brown (1735–1788).[95] Kant indeed refers to these persons. However, there is little further evidence linking Kant's remarks to the works of the former. The only thing we can say with relative certainty is that Kant seems to invoke the ether as a principle that governs the powers of

[93] Carrier 1991, 223–227.

[94] Guyer 2001, 278.

[95] Förster 2000, 108.

sensibility and irritability. What might be the significance of this speculation? Let us try to unravel its significance step by step.

In Chap. 3, we saw seen that Kant took proper explanations in biology to be mechanical explanations. Moreover, in Chap. 5 we saw that Kant took chemistry to provide partial grounds for providing objective explanations of organic phenomena, e.g., explanations of processes such as nutrition and growth. The introduction of the ether as a principle for explaining organic phenomena fits this line of thought quite nicely, for the ether or caloric is a fundamental principle of physics and chemistry. By introducing the ether as a principle for explaining organic phenomena, Kant can thus be taken to make explicit a relation between the doctrine of organic nature and higher natural sciences such as chemistry.[96] Recall also that in the 1790s Kant emphasized the close relationship between chemistry and the study of organic phenomena. In his encounter with Sömmering, Kant invoked the chemistry of his day to defend the hypothesis that the *sensorium commune* is located in the fluid contained in the ventricles of the brain. In short: in his later writings Kant attempted, in line with his methodological prescriptions, to specify the mechanical grounds of organic phenomena.

The above interpretation is consistent with the interpretation of the status of biology given in Chap. 6. As I have argued, biology was construed as a part of physics, even though the relation between biology and other parts of physics or natural science, such as chemistry, was obscure. Nevertheless, biology was conceptualized by Kant as being grounded in other (higher) sciences of physics. Kant's intention in the *Opus postumum* is to establish physics or natural science as a systematic whole. He tried to accomplish this objective by introducing the ether as a principle that allowed for a unified account of topics pertaining to what was traditionally called *physica specialis*. Given that biology constituted a part of *physica specialis*, it is not surprising to find Kant to interpret the ether as a ground of organic phenomena.

The above remarks provide a certain rationale for introducing the ether as a principle for explaining organic phenomena. However, in the passages cited above Kant refers specifically to irritability and sensibility as phenomena grounded in the actions of the ether. It is very unlikely that Kant envisioned a purely chemical account of such phenomena. As we have seen in Sect. 7.2, for example, Brandis did not think the contraction or irritability of organic matter can be explained in terms of chemical forces, e.g., by the release of caloric or the matter of heat. For the speed of the contraction of for example the muscles is much higher than the speed of contraction observed in bodies that is due to the penetration and subsequent release of caloric.

While discussing irritability and sensibility, and relating these phenomena to the action of the ether, it is probable that Kant is thinking of the theory of galvanism or animal electricity, established by the physician Luigi Galvani (1737–1798). Galvani famously showed that the muscles of decapitated frogs could be contracted under the influence of static electricity. Briefly, Galvani explained muscular motion in terms of electrical currents. He hypothesized that animals possessed an innate

[96] What exactly constituted lower and higher science in the late eighteenth century is by no means clear. I will say a bit more on this problem in the following.

electrical fluid contained in the muscle fibers. The normal contraction of muscles was explained in terms of electrical currents, ensuing from the brain through the nerves to the muscles.[97] In the first fascicle of the *Opus postumum*, Kant sometimes refers to the doctrine of galvanism. He seems to argue that this theory provides an explanation of the sensibility of nerves.[98] Hence, we may conjecture that Kant thought that the doctrine of animal electricity may provide a correct explanation for such phenomena as sensibility and irritability.

What is needed, then, is to link the concept of the ether to theories of electricity. Kant never fully develops this link. However, in the fifth fascicle of the *Opus postumum* Kant does argue that the matter of heat or caloric is itself a part of an electric matter.[99] At other passages Kant describes the matter of heat (caloric), the matter of electricity, and the matter of magnetism as penetrating fluids. This suggests that Kant relates the concept of the ether, which is an imponderable fluid, to these various types of matters, and perhaps even somehow identifies caloric with a matter of electricity (just as Kant identifies caloric with a light-ether).[100] The ether may then be taken as a ground of various electric phenomena. It must be admitted that Kant's views on electricity are not worked out in the *Opus postumum*. However, that Kant somehow took his conception of the ether to relate to phenomena of electricity seems certain. In this way, perhaps, the ether can be taking as a principle grounding doctrines such as chemistry and electricity, which in turn ground biology.

On the basis of the above series of speculations, we can thus draw the following picture. In the *Opus postumum*, Kant took the concept of an ether to ground physics as a systematic science. In his reflections on organic nature, Kant extends his speculations and also takes the ether to provide a principle for providing mechanical explanations of organic phenomena. Kant never fully explains how the ether is supposed to provide explanations of organic phenomena. All we have is the speculations cited above, speculations that we can only make sense of by providing many speculations of our own.

At the end of the eighteenth century, the idea of grounding biology as a science was construed as an important scientific ideal, espoused most famously by Schelling.[101] Schelling took biology to be a proper rational science. Extending

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[97] Here I follow Richards 2002, 317–318. Richards discusses the influence of Galvani's experiments on the work of Alexander von Humboldt, who took Galvani's doctrine of animal electricity to solve the problem of the nature of 'vital forces'. For von Humboldt, animal electricity is a vital force.

[98] Cf. AA 136–137. In these passages, Kant also equates transcendental philosophy with galvanism, arguing (in a nutshell) that without galvanisms nerves are not susceptible to impressions, that without the latter there is no sensation, and hence no self-consciousness or intuition of one-self. For a charitable reading of these passages, cf. Dietzsch 2009. I am inclined to agree with Adickes 1920, 470–471, who suggests we do not take these passages seriously. They do show that Kant was aware of the theory of galvanism.

[99] AA 21: 515. Cf. Adickes 1920, 468–469.

[100] AA 23: 468. On Kant's identification of caloric with a light-ether, cf. Friedman 1992a, 323.

[101] The following brief account of Schelling's views is based on Friedman 2006, 51–79; Beiser 2002, 506–550, 2006, 7–26.

Kant's project of the *Metaphysische Anfangsgründe*, he tried to explain organic phenomena in terms of chemical, electrical, and magnetic forces, which in turn were taken to be explicable in terms of the fundamental dynamical forces of nature. Through a long grounding-chain proceeding *a priori* from first grounds, he thus synthetically tried to ground biology as a rational science.

Note that Schelling's project of grounding biology provides us with a radically novel perspective on the hierarchy of (natural) sciences. Biology is subordinated to higher sciences such as chemistry, electricity, and magnetism, which in turn are subordinated to a fundamental dynamical theory of nature. In the previous chapter, we have sketched a more traditional conception of physics, in which *physica generalis* was taken to ground *physica specialis*. The specific relationship between sciences pertaining to *physica specialis* (such as biology, chemistry, magnetism, etc.) was not systematized within this perspective.

Kant did not develop the project of grounding biology as Schelling ultimately did. All he provides in the third *Critique* and the *Opus postumum* are methodological prescriptions concerning proper biological method and a few speculative comments treated above. However, Kant's conception of proper biological method did imply the methodological ideal that biology should be grounded in higher sciences, so as to ultimately ground physics as a unified systematic science. In this respect, Kant's views are in line with those of Schelling.

Ernst-Otto Onnasch has shown that Schelling was aware of the fact that Kant was working on a *Transition* from metaphysics to physics, even though he of course never read any of Kant's work.[102] Schelling thought that Kant's *Transition* contained an attempt to ground the doctrine of organic nature, because Kant's views on organic nature were treated *in isolation from the general doctrine of science* in the third *Critique*. This assessment is correct. Kant's *Opus postumum* shows that he wanted to establish a connection between, in Schelling's terms, the general doctrine of science and biology, even if he did not have the capacity to fulfill this project. It was up to the likes of Schelling to forge such a connection. I am sure that even if he might have appreciated Kant's intentions, Schelling would have been mightily disappointed had he read the *Opus postumum*.

8.5 Kant on Natural History

In the previous sections, we have discussed Kant's reflection on organic nature in the *Opus postumum* in relation to eighteenth-century biology. To conclude this chapter, I will treat Kant's views on natural history or 'archaeology of nature' in a similar manner.[103] There are several reflections in the *Opus postumum* related to

[102] Onnasch 2009, 310.

[103] AA 5: 428.

natural history. These reflections have not received much attention. One of the few commentators who has discussed these reflections is Klaus Düsing.[104]

Düsing interprets the passages relating to natural history in the *Opus postumum* as developing further Kant's account of natural history of the third *Critique*. He takes Kant to provide a developmental account of the origin of varieties in species and of species themselves, thus anticipating (Darwinian) evolutionary ideas.[105] Düsing relates Kant's position in the *Opus postumum* to that of Herder, who allowed for the transmutation of species. Although Kant rejected Herder's views in the 1780s, Düsing claims that in the third *Critique* and in the *Opus postumum* Kant adopted a position that was very close to that of Herder.

Düsing's account is inconsistent with the dominant modern interpretation of Kant's views on natural history. According to this interpretation, Kant consistently rejected the views of Herder and the encounter with Herder led Kant to become skeptical of the discipline of natural history. John Zammito has rejected the idea that Kant anticipated what he calls the teaching of evolution. Kant precisely rejected Herder's views because he was convinced of the fixity of species.[106] Philip Sloan has recently argued that the encounter with Herder in the late 1780s led Kant to weaken the epistemic status of natural history.[107] Although I deviate from Sloan in certain respects, I agree that Kant adopted a somewhat skeptical stance with regard to natural history. There is no reason to suppose that Kant changed his views in the *Opus postumum*.

In the following, I will first, building on the work of Zammito and Sloan, describe Kant's systematic views on natural history preceding the *Opus postumum*. I argue that Kant took natural history to be a legitimate scientific discipline, which aims to cite the historical causes of present properties of organisms. As such, natural history aims to be a genuine *explanatory* science. Nevertheless, Kant limited the scope of natural history. In particular, he argued that natural historians cannot allow for the possibility of *generatio equivoca*, i.e., the generation of organized beings from unorganized matter, nor for the possibility of *generatio heteronyma*, i.e., the generation of organic beings from other organic beings that are *specifically different* from each other (e.g., aquatic animals gradually transforming into amphibians).[108]

Second, I discuss the reflections relating to natural history contained in the *Opus postumum*. I argue that these reflections are in line with Kant's position in the third *Critique*. Kant took natural history to be a legitimate discipline as long as the reality of *generatio equivoca* and *generatio heteronyma* was not affirmed. Kant's remarks on

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[104] Düsing 1968, 133–142, 154–169.

[105] Düsing 1968, 141. This idea seems to have been first articulated by Bauch 1917, 453–457. In line with Zammito 1992, 199–213, 215, I take this idea to be wrong. Kant was committed to the fixity of species and did not allow for speciation. In the following, I will refrain from comparing any of Kant's views to those of Darwin.

[106] Zammito 1992, 199–213, 215.

[107] Sloan 2006, 627–648.

[108] Cf. AA 5: 419–420.

natural history in the *Opus postumum* can be best understood on the basis of his views on external teleology espoused in the third *Critique*, according to which we must be able to view mankind as the ultimate and final end of nature.

8.5.1 Natural History: Kant's Positions Predating the **Opus postumum**

In order to understand Kant's views on natural history, it is useful, following the lead of Sloan,[109] to take into account some of his earlier writings on the topic. Kant was one of the first to distinguish 'natural description' from 'natural history'. Roughly, 'natural description' signified the classification of natural things in accordance with their similarity, whereas 'natural history' signified the historical and developmental study of changes within nature and natural objects.[110] As such, Kant employed the latter notion in a sense that became *en vogue* at the end of the eighteenth century. Kant first distinguished natural history from natural description in his *Von den verschiedenen Racen der Menschen* (1775)[111]:

> We generally take the designations *description of nature* and *natural history* to mean the same. Yet it is clear that the cognition of natural things as they *are now* always leaves us desirous of the cognition of that which they once *were* and of the series of changes they underwent to arrive at each place in their present state. *Natural history*, which we still lack almost entirely, would teach us about the changes in the shape of the earth, likewise that of its creatures (plants and animals) that they have undergone through natural migrations and the resultant degenerations [*Abartungen*] from the original form of the stem genus [*Stamgattung*]. It would presumably trace a great many of seemingly different kinds to races of the same species and would transform the school system of the description of nature, which is now so extensive, into a physical system for the understanding. (AA 2: 434)[112]

Natural description provides cognition of natural things as they are at present. In particular, it provides a scholastic or classificatory system of natural things. A scholastic division (*Schuleinteilung*) of natural things is "based upon classes and divides things up according to similarities".[113] Hence, classifications of natural things in accordance with similar morphological characteristics, as provided for example by Linneaus's artificial natural system, pertain to natural description. In contrast, natural history provides hypotheses on how natural things formerly were and attempts to detail through what changes they have arrived at their present state. As such, we aim to provide a historical account of, for example, the current form of organisms.

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[109] Sloan 2006.

[110] Cf. AA 5: 428.

[111] Cf. Sloan 2006, 629–635, on the influence of Buffon on this distinction.

[112] I have, with debts to Philip Sloan 2006, 635, slightly modified the Cambridge Translation, which renders *Abartungen* as 'subspecies' and *Stammgattung* as 'phyletic species'.

[113] AA 2: 429. Cf. Zammito 1992, 199–201.

This type of doctrine would provide cognition of changes of the form of the earth and changes of organisms due to natural migration.

According to Kant, natural history does not provide cognition of a scholastic genus (*Schulgattung*). Rather, it provides insight in the natural genus (*Naturgattungen*). The term 'natural genus' relates to Buffon's species concept, according to which individuals pertain to the same species if they are of common descent and can produce fertile offspring. As such, natural history aims to provide a natural division of organisms which "is based upon the common stem, which divides animals according to kinship from the standpoint of generation",[114] transforming the scholastic system of natural description into a physical system for the understanding. As Kant final remarks make clear, the particular application of natural history is to be found is his theory of race.[115] Races must be taken to pertain to the same species. However, we can explain the existence of different races, the existence of variations (*Abartungen*)[116] from the original form of the stem genus, through (among others) the effects of natural migrations of organisms.

In his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant reacted to Georg Forster's critique of his notion of natural history. Kant describes natural history as a discipline that consists in "tracing back, as far as the analogy permits, the connection between certain present-day conditions of the things in nature and their causes in earlier times according to the laws of efficient causality, which we do not make up but derive from the powers of nature as it presents itself to us now".[117] According to Kant, natural history is *not* a science of the ultimate origins of organisms. If natural history is understood as providing an account of the first appearance of plants and animals, it aims to provide cognition to which human reason cannot extend, constituting a science for gods (as Forster had objected to Kant).[118] Properly understood, natural history aims at cognition of relations between present properties of natural objects and their historical causes. Causal regularities that relate present effects with earlier causes are derived from the

[114] AA 2:429.

[115] Cf. Zammito 1992, 199–202.

[116] The term *Abartung* is technical. In this period, *Abartung* commonly refers to (hereditable) variations among the individuals of a species. More specifically, it can refer to: (i) *Rassen*, i.e., hereditable modifications of individuals of a species that are maintained under different environmental conditions. These individuals produce half-breeds in the circumstance of interbreeding (e.g., negros and whites produce mulattos). (ii) *Spielarten*, i.e., hereditary modifications of individuals of a species that are maintained under different environmental conditions but that do *not* produce half-breeds when reproducing (e.g., the children of parents that have blond and brown hair themselves have blond or brown hair, not some middle type of hair color). (iii) *Varietäten*, i.e., hereditable characteristics that are not invariably hereditable (e.g., hereditable diseases). (iv) *Varietas nativae*, i.e., modifications that are the result of environmental conditions. Girtanner 1796, 5–8. Kant strictly employs the term *Abartung* in order to refer to invariably *hereditable* characteristics of individuals of the same species. In practice, he often identifies *Abartungen* with races. AA 8:163–164. Cf. Zammito 2003 and Sloan 1973.

[117] AA 8: 162–163.

[118] Ibid. See also Sloan 2006, 638–640.

observation of forces presently operative in nature and inferences by analogy. On the basis of such inferences we can claim that these forces have been operative in the past and have produced similar effects as presently observed.

In order to better understand Kant's views on natural history, it is useful to describe an example of the manner in which natural history is conducted by biologists in the late eighteenth century. A good example is contained in Blumenbach's *Beyträge zur Naturgeschichte* (1790).[119] In his *Beyträge*, Blumenbach argued against the view of physico-theologians that species cannot become extinct and that nature does not allow for the coming into existence of new species.[120] Blumenbach does allow for the possible extinction of species and the coming to be of new species.

In order to substantiate his claims, Blumenbach cited various fossil findings.[121] The multiplicity of petrified sea creatures, ammonites, and belemnites, for which one could not find any original in nature since their form differed greatly from existing creatures, provided evidence for the claim that many natural species have become extinct. In order to explain this extinction, Blumenbach hypothesized that due to a particular catastrophe or revolution a whole organized "pre-adamitic creation" had ceased to exist on earth.[122] This catastrophe destroyed the surface of the earth which lay fallow until it was suited for bringing forth new vegetation and animal creatures. At this point, the same forces of nature that had brought about organic kingdoms in the pre-adamitic world, most importantly the *Bildungstrieb*, also brought forth new organic kingdoms. After the catastrophe, the *Bildungstrieb* was efficacious in altered circumstances and worked on modified materials. Hence, in generating new species the *Bildungstrieb* took a direction that differed from when it generated species in the pre-adamitic world.[123] This explained why various petrifactions exhibited a form and structure that is specifically different from that of currently existing organic creatures. However, since the same *Bildungstrieb* was efficacious before and after the catastrophe, we can also explain why currently existing organic creatures and ancient organic creatures are of a similar type.

Blumenbach argued that new species could not have come into existence as a result of a long process of variation within a species.[124] The difference between, e.g., fossilized and currently existing *conchylia* is too great to be the consequence of a variation (*Abartung*) of an original stem. For the same reason, the structure of currently existing organic creatures cannot be explained as a contingent monstrosity (*zufällige Monstrosität*). Although Blumenbach allowed for the formation of new species, he did not allow for a transmutation of species. Nevertheless, his natural

[119] Blumenbach's *Beyträge* is instructively discussed by Richards 2000, 20–22, who argues that Blumenbach's views are influenced by those of Herder and are at odds with the views of Kant. I agree with this assessment (see below). In the following, I will, however, mainly focus on the logic of Blumenbach's arguments in order to elucidate Kant's notion of natural history.

[120] Blumenbach 1806, 1–5. I have consulted the second edition of Blumenbach's *Beyträge*.

[121] Blumenbach 1806, 6–12.

[122] Blumenbach 1806, 13–18.

[123] Blumenbach 1806, 19–20.

[124] Blumenbach 1806, 21–23.

history did form an impetus for allowing for the transmutation of species. For example, Karl Friedrich Kielmeyer adopted Blumenbach's idea of a formative force altered in its direction by changes in the earth to argue that species have emerged from other species in a manner similar to the emergence of butterflies form caterpillars. These new species were "originally developmental states and only later achieved the rank of independent species".[125]

Blumenbach's theory provides a good example of the nature of natural history. Natural history is fundamentally a historical science. It aims to provide cognition of relations between present properties of natural objects and their historical causes. Note that Blumenbach heavily employs inferences by analogy when constructing his arguments. As we have seen above, Kant took analogical inferences to be central to natural history. Finally, note that questions concerning the extinction of species, the formation of new species, and the transmutation of species figure heavily in natural history. In the following we will see that Kant rejected the idea of a transmutation of species. According to Kant, natural history is a legitimate discipline provided that it does not aim to provide cognition of the ultimate origins of organisms or propose the idea of a transmutation of species. In other words, Kant denied the reality of *generatio equivoca* and *generatio heteronyma*. As such, Kant restricted the scope of natural history and limited the pretensions of this discipline.

In order to asses Kant's views on the scientific status of natural history, we can relate his account of natural history to the conditions a proper natural science must satisfy (expounded in Chap. 2).[126] In my view, Kant gives preference to natural history over natural description because the former satisfies his grounding condition whereas the latter does not. In particular, natural history aims to provide causal explanations of present effects in terms of historical causes or grounds that show *why* something is the case. In contrast, natural description merely provides subjective grounds of cognition for present effects, such as the properties of organisms. It is a merely descriptive discipline which shows *that* something is the case. However, natural history is problematic insofar as it does not satisfy the epistemic condition a proper science must satisfy. Natural history does not provide us with *apodictically certain* cognition.

The epistemic problems confronting natural history become clear if we consider the limits of inferences by analogy. In the *Kritik der reinen Vernunft*, Kant explicated the relevant sense of 'analogy' when distinguishing mathematical from philosophical analogies.[127] Mathematical analogies are formulas asserting the identity of two quantitative relations (*Größenverhältnisse*), so that when three members of a proportion are given the fourth can be constructed. Analogies employed in philosophy and natural science specify an equality between two *qualitative* relations. They allow us to cognize, from

[125] Quoted in Lenoir 1981, 163.

[126] In the following I deviate from Sloan 2006, who presents Kant's encounter with Herder in the 1780s as contributing to his scepticism with regard to natural history. Larson 1994, 170–174, has argued that Kant gave preference to natural history because science was supposed to reflect natures plan. My position agrees with that of Larson.

[127] *KrV*, A 178–180/B 221–222.

three given members, the *relation* to a fourth member. However, in contrast to mathematical analogies, they do not give the fourth member itself. Rather, philosophical analogies provide a rule for seeking the fourth term in experience and, as such, are *regulative*. Hence, by means of such analogies we seek to establish cognition concerning the *relation* between existents. They do not provide a certain existential inference, for existence claims must always be based on observation. As Kant puts the point: although "we could succeed on this path in inferring to some existence or other, we still would not be able to cognize it determinately […]".[128]

We can apply Kant's notion of analogy to the reasoning underlying Blumenbach's arguments in his *Beyträge*. This reasoning proceeds as follows: we observe that currently existing organism exhibit a specific organization and take the *Bildungstrieb* to be the causal agent responsible for this organization. We then observe various petrifactions of organisms that are currently extinct, but whose organization exhibits similarities with currently existing organisms, i.e., various currently existing organisms and extinct organisms are of a similar type although they exhibit a specific difference. Hence, we infer that the *Bildungstrieb* was also responsible for the generation of organisms in ancient times. After this inference by analogy, we explain differences between the organization of currently existing organisms and that of extinct organisms in terms of a modified action of the *Bildungstrieb*.

On the basis of such an argument, we 'infer to some existence though we cannot cognize it determinately'. Hence, we cannot conclude, for example, that the *Bildungstrieb* efficacious in ancient times has the same intensity as the *Bildungstrieb* now operative in nature.[129] Indeed, even the inference to the existence of the *Bildungstrieb* in ancient times remains problematic. This claim requires observational support which is hard to come by in natural history. For these reasons, it is no surprise that in §83 of the *Kritik der Urteilskraft* Kant claims with respect to the 'archeology of nature' that although its subject of investigation provides "no hope for certainty, there is reasonable ground for making conjectures".[130]

As Sloan points out, Kant's claim that natural history should not be a science of origins can be regarded as a condemnation of much eighteenth-century research within natural history.[131] For example, in his *Epochs of nature* (1779), Buffon provided a developmental account of the history of the earth and its inhabitants, proceeding from the formation of the earth and the planets to the spontaneous generation of fishes, bivalves, and shell-bearing creatures. This certainly was a science of origins and Kant could not accept it. To a certain extent, Kant could also

[128] *KrV*, A 178/B 221.

[129] This is also stressed by Sloan 2006, 629, who notes that Kant's 'natural history' must not be confused with later versions of 'uniformitarianism' in which observations of presently operative forces were taken as a basis for inferring to the existence of similar forces in the past acting with the same intensity.

[130] AA 5: 428. A view already contained in Kant's discussion of proper science in the *Metaphysische Anfangsgründe*.

[131] Sloan 2006, 636–640.

not adopt the views espoused by Blumenbach in his *Beyträge zur Naturgeschichte*.[132] For Blumenbach seemed to interpret the *Bildungstrieb* as acting on raw materials in order to explain the first formation of organisms after the catastrophe had annihilated the pre-adamitic creation. Both Buffon and Blumenbach thus seemed to endorse the possibility of spontaneous generation and *generatio equivoca*, ideas which Kant vehemently rejected. Although Kant took natural history to be a legitimate discipline, he severely restricted its scope and pretensions.

These considerations lead us to Kant's most famous statement concerning the limitations of natural history, expounded in §80 of the *Kritik der Urteilskraft*.[133] In this paragraph, Kant acknowledges that in natural science the search for a mere mechanical explanation of natural objects is unrestricted. He associates the search for a fully mechanical account of the structure of organism with the research of comparative anatomists and archeologists of nature:

> The agreement of so many genera of animals in a certain common schema, which seems to lie at the basis not only of their skeletal structure but also of the arrangement of their other parts, and by which an admirable simplicity of basic design has been able to produce such a great variety of species by the shortening of one part and the elongation of another, by the involution of this part and the evolution of another, allows the mind at least a weak ray of hope that something may be accomplished here with the principle of the mechanism of nature, without which there can be no natural science at all. This analogy of forms, insofar as in spite of all the differences it seems to have been generated in accordance with a common prototype, strengthens the suspicion of a real kinship among them in their generation from a common proto-mother, through the gradual approach of one animal genus to the other […]. (AA 5: 419)

Through comparative anatomy we establish structural similarities between animals pertaining to different species. This *analogy of forms* leads to the idea of a real kinship among these forms, i.e., we take different species to be related by generation. The similarities existing between a great variety of species might be explained by assuming that they have been generated from a common proto-mother, whereas the observable differences between the various species might be accounted for in terms of mechanical variations among the parts of animals. In short, Kant is discussing a possible mechanical account of what he calls *generatio heteronyma*: the generation of organisms from other, specifically different organisms.

In the continuation of the quoted passage, Kant sketches how this account can be extended in an attempt to explain the origin of organisms from the forces governing raw matter. He thus considers the possibility of *generatio equivoca*, i.e., the generation of organisms from unorganized matter. Kant notes that although the archeologist is free to frame a developmental account of the great family of organized creatures (formulate a theory of *generatio heteronyma*) he cannot conjecture a transition from the inorganic to the organic (*generatio equivoca*) in order to explain the first origin of organisms. Rather, the archeologist must "attribute to this universal

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[132] Cf. Richards 2000, 20–22.

[133] This passage has been stressed by commentators eager to interpret Kant as anticipating Darwinism. As said, I agree with Zammito in taking §80 to reject any doctrine implying the transformation of species. Zammito 1992, 214–219. Cf. Richards 2000, 27–28.

mother an organization purposively aimed at all these creatures", for otherwise we would not be able to understand the purposive form of the products of the vegetable and animal kingdoms.[134] In other words: although we must always try to explain phenomena mechanically (which is proper method), this may not lead us to become materialists (which is bad metaphysics).

Kant's position is further clarified in the footnote added to this passage, where he states that the only type of generation that is known through experience is *generatio homonyma*, i.e., the generation of a product that is *homogeneous* qua organization with that which has generated it.[135] Hence, Kant was also very skeptical about the reality of *generatio heteronyma*. Indeed, in his 1788 essay on teleological principles, after his encounter with Herder, Kant emphatically claimed that the preservation of the *form* of species is a law of nature.[136] Hence, Kant restricted the scope of natural history by excluding the possibility of *generatio equivoca* and by rendering highly problematic the idea of the transmutation of species.

In the final paragraph of §80 concerning biology, Kant gives an example of research conducted within natural history that he find useful and does not transgress the limits of adequate natural science. In this paragraph he provides a restatement of his theory of race that he developed in the 1770s and in his 1788 essay on the use of teleological principles.[137] In the latter essay, Kant defined a race as an invariably hereditable variation (*Abartung*, *progenies classifica*) of individuals of a species. These variations occur within a single lineage or stem. They must not be confused with degenerations (*Ausartung*, *degeneratio*, *progenies specifica*) or different species. In order to explain the generation of different races, Kant postulated germs (*Keime*) and natural predispositions (*Natürliche Anlage*).[138] Germs and natural predispositions determine the developments of organisms and as such account for the generation of races.

In §80 of the third *Critique*, Kant explains that the assumption of natural predispositions is based on *teleological principles*. Permanently hereditable variations, such as racial features, must, although they are the result of mechanical causes,[139] be judged as an "incidental development of a purposive predisposition to the self-preservation of the kind that was originally present in the species".[140] Thus, in order to understand that variations are *permanently hereditable*, we have to assume that these variations are a consequence of a predisposition that *serves* the preservation of a species. In this manner, we base our investigation of the mechanism of heredity on the condition that we only take features to be heritable that "belong to one of the undeveloped original predispositions" of a system of ends, such as the end of

134 AA 5: 419–420.

135 Ibid.

136 AA 8: 164.

137 On these earlier theories, cf. Zammito 1992, 199–213.

138 On the precise meanings of these terms, cf. Sloan 2006; Zammito 2003, 80–98.

139 Cf. Zumbach 1984, 102; Zammito 2003, 84.

140 AA 5: 420.

self-preservation.[141] Kant's account of the generation of races thus provides another instance of what he takes to be the correct methodology of biology: the subordination of mechanism to teleology.

Research concerning the generation of races certainly belongs to natural history. However, it is no surprise that Kant condoned this research. In the investigation of races, we refrain from giving an account of the ultimate origin of organized beings and we refrain from affirming the reality of *generatio heteronyma*. We merely investigate the coming to be of variations pertaining to individuals within a single species. This is an instance of proper research within natural history, one that does not lead to all kinds of speculative fancy.

8.5.2 Natural History and External Teleology

In the previous section, we saw that Kant's views on natural history do not always harmonize with those of his contemporary biologists and philosophers, who allowed for the possibility of *generatio equivoca* and sometimes of *generatio heteronyma*. In the present section, I will consider Kant's views on natural history as articulated in the *Opus postumum*.

Before turning to the *Opus postumum* it is useful to note that Kant was aware of research conducted within natural history at the end of the eighteenth century. As we have seen, Blumenbach argued that an ancient catastrophe had destroyed a whole 'pre-adamitic' organized creation. The invocation of catastrophes was rather common in the late eighteenth century. For example, in an article for the Academy of Science in St. Petersburg, the Dutch anatomist Petrus Camper (1722–1789) stated that he was convinced that the earth has been prey to various catastrophes.[142] However, these catastrophes must have taken place before man was created, for although Camper had the opportunity to observe various petrified bones of mammoths, elephants, rhinoceroses, etc. he had yet to observe any petrified human bone.

Kant was aware of both the views of Blumenbach and Camper. In the *Kritik der Urteilskraft* (1790), he stated that the first organic productions of nature had been destroyed. However, he added that "the human being was not included in these revolutions, as the most meticulous examinations of the remains of these natural devastations seems to prove (according to the judgment of Camper)".[143] In *Der Streit der Facultäten* (1798), Kant attributed to both Blumenbach and Camper the view that a revolution of nature had extinguished the plant- and animal kingdom before man had come into existence. Finally, in the *Opus postumum* (Juli 1797- August 1799) Kant cites Camper's claim that the revolutions of nature took place before humans existed.[144]

[141] AA 5: 420.

[142] Cf. Adickes, AA 14:619n and Förster 1993, 265, who refer to Camper's writing.

[143] AA 5: 428.

[144] AA 21: 213.

In the *Opus postumum*, Kant is quite positive on the archeological research of nature conducted by Camper and Blumenbach. He (a) took fossil findings to provide evidence for the earlier existence and extinction of organisms that are not similar to currently existing and observable organisms,[145] and (b) he allowed for the coming to be of new species in the course of nature's history.[146] This raises the question whether Kant also modified his views on *generatio equivoca* and *generatio heteronyma*, adopting a position akin to that of Herder.

There are several passages in the *Opus postumum* that seem to relate to natural history. For example, in the fifth fascicle (May-August 1799), Kant writes:

> The class of the kingdom of plants (vegetating bodies) is in its great diversity determined for animals of different species (living bodies) (e.g. the moss of wastes for the reindeer); finally these animal species devoid of reason are determined for humans – these are perhaps still determined intentionally with respect to the peculiarities of races [...]: so that a universal inner system of organization and an active principle directed at establishing such a system grounds the Linnean nominal system of external designations. (AA 21: 567)[147]

It is quite natural to interpret this passage in line with Kant's views on natural history. In particular, the distinction between a (Linnaean) nominal system of species and a "system of organization" might be interpreted as referring to the transition from an artificial division of natural species to a *physical* division of natural species based on relations of generation.[148] As we have seen, such a transition is precisely brought about when we shift from natural description to natural history. In the remainder of this passage Kant states that the earth can itself be seen as an organic body which brings forth purposeful productions.[149] This clearly alludes to the description of natural history in §80 of the third *Critique*, in which Kant describes the archaeologist of nature as letting the great family of species originate from the "maternal womb of the earth".[150] In other passages of the *Opus postumum*, Kant similarly speaks of our celestial body as organic and organically formative.[151] These passages may be taken to suggest, as Düsing claims, that Kant's position is very close to the position of Herder.

[145] AA 21: 215, 566; 22: 549.

[146] AA 22: 241.

[147] Original: "Die Classe des **Pflanzenreichs** (der vegetirenden) ist in ihrer großen Mannigfaltigkeit für **Thiere** von verschiedener Species (der lebenden Körper) (z.B. das Moos der Eiswüsten fürs Renthier): endlich diese Vernunftlose Thierspecies für Menschen – diese vielleicht absichtlich noch zu Eigenheiten der Raçen (deren manche untergegangen seyn mögen bis sie den jetzigen Platz machten) bestimmt: so daß dem Linnäischen Nominalsystem der äußeren Bezeichnungen ein allgemeines inneres Organisations System und ein darauf abzweckendes actives Princip zum Grunde liegt." (AA 21: 567).

[148] This is how Düsing interprets these passages, cf. Düsing 1968, 158–163.

[149] AA 21: 567–568.

[150] AA 5: 419.

[151] AA 21: 215.

In another passage, Kant cites fossil evidence for the extinction of species and remarks:

> Nature organizes matter in manifold fashion – not just by kind, but also by stages. Not to be comprehended [*Nicht zu gedenken*]: That there are to be discovered, in the strata of the earth and in mountains, examples of former kinds of animals and plants (now extinct) – proofs of previous (now alien) products of our living, fertile globe. That its organizing force has so arranged *for one another* the totality of the species of plants and animals, that they, together, as members of a chain, form a circle (man not excepted). *That they require each other for their existence*, not merely in respect of their nominal character (similarity), but their real character (causality) […]. (AA 22: 549, emphasis mine)

Once again, we seem to be confronted with a transition from considering species nominally (in accordance with their similarity), to considering them in accordance with causal relations. All of these passages can thus be interpreted, in line with Düsing, as implying that Kant provides a further and positive elucidation of natural history, ultimately adopting a position akin to that of Herder. Nevertheless, I do not think such an interpretation is correct.

Herder argued for the reality of *generatio equivoca and generatio heteronyma*. In the *Opus postumum*, Kant clearly rejects the possibility of *generatio equivoca*, i.e., the generation of organized beings from unorganized matter. This is already implied by the fact that Kant consistently rejects materialism and hylozoism in the *Opus postumum* (Sects. 8.1, 8.2, 8.3, and 8.4). In addition, in the passages in the *Opus postumum* in which Kant speaks of the earth as an organic body bringing forth purposeful productions, he attributes to our earth an "organization purposively aimed" at the production of organic creatures.[152] Hence, a complete materialist or hylozoist explanation of organisms from inorganic matter remains impossible.

Did Kant then allow for the reality of *generatio heteronyma* in the *Opus postumum*? There is no concrete evidence that he did. I do not even think that the above passages imply that Kant took different species to be connected by relations of *generation*. In §80 of the third *Critique*, Kant argued that the *analogy of forms* observed between different natural species may lead us to conjecture that there exists a kinship between these various natural species, i.e., we conjecture that the observed analogy of forms is due to the fact that the species are of common descent. In the *Opus postumum*, Kant does not refer to this analogy of forms. Moreover, in the third *Critique* Kant provided a possible mechanical account of *generatio heteronyma*, suggesting that the generation of organisms from organisms that are specifically different qua form may be a result of mechanical variations among the parts of ancestor organisms (giving rise to variable structures that are presumably passed on to later generations through reproduction). Once again, there is no hint of such a mechanical account of *generatio heteronyma* in the *Opus postumum*.

The only thing Kant explicitly states in the passages from the *Opus postumum* cited above is that we take relations of *relative purposiveness* (means-end relationships) to

[152] Cf. AA 21: 566.

obtain between different species of kingdoms: plants are there *for the sake of* animals, animals are there *for the sake of* mankind. What is the point of introducing external teleology and what is the relationship between natural history and external teleology? The question to this answer is not contained in the *Opus postumum*. In order to find some answers to these questions, we must return to the third *Critique*.

In the third *Critique*, Kant discusses both natural history and external teleology in §§82–84. These sections, which have been thoroughly analyzed by Paul Guyer, contain Kant's argument from moral teleology, which aims to show that our teleological conception of nature allows us to conceive of natural laws as enabling the highest good as object of morality and thus also the realization of human happiness.[153] In §82, Kant reintroduces the concept of external or relative purposiveness. *If* a natural object is judged as a purpose, other natural objects can be taken to be means relative to that purpose or end.[154] The latter are thus judged as *existing for the sake of* the former. The fact that we necessarily take some natural objects to be purposes allows us to conceive of the whole of nature as ordered according to relative means-end relationships.[155] Since teleological wholes are collections of parts serving a purpose, the conception of nature as a teleological whole leads us to ask about the end or purpose of nature.

Kant distinguishes between an 'ultimate end' (*letzter Zweck*) and 'final end' (*Endzweck*).[156] The term 'ultimate end' refers to the last object (the last node, so to speak) of means-end relations within the world. For example, the vegetable kingdom can be taken to exist for the sake of the animal kingdom, etc. up to the ultimate end. The final end of nature is an unconditioned end of unconditional value. It is conceptualized as providing the reason why an intentional acting cause created the world. As Kant puts it in §84, the final end refers to the final end of the existence of a world or of creation itself.[157]

According to Kant, we have sufficient cause to take the human species (mankind) to be the ultimate end of nature, since man is "the only being on earth who forms a concept of ends for himself" and who can make "a system of ends out of an aggregate of purposively formed things".[158] In §83, Kant considers what in mankind constitutes a suitable candidate for constituting the ultimate end of nature. This is the human culture of will, i.e., the "aptitude for setting himself ends at all" and for "using nature as a means appropriate to the maxims of his free ends in general".[159]

[153] The following account is indebted too Guyer 2005, 314–342. I will only treat those passages relevant to our understanding of Kant's view of natural history.

[154] AA 5: 425.

[155] Kant also puts the point differently: the fact that we judge organisms *as if* they are the product of design, leads us to conceive of them as serving a purpose since designs of intelligent agents always serve a purpose. AA 5: 434. See Guyer 2005, 328–329.

[156] AA 5: 426.

[157] AA 5: 434. Cf. Guyer 2005, 366.

[158] AA 5: 426–427.

[159] AA 5: 431–432.

Hence, the expression and realization of the free will is the ultimate end of nature, and we can conceive of nature as promoting this end.

In §84, Kant concludes that this ultimate end can be identified with the *final end* of nature, i.e., an end in itself of unconditional value. For the free positing of ends must happen in accordance with the *moral law*, which is of unconditional value. Since the highest good, as object of morality, is the object posited by free human beings as moral beings, nature can be seen, through the identification of the ultimate and final end, as promoting the highest good and as promoting human happiness.[160] In Kant's terms: the existence of the human being as moral being contains "the highest end in itself" to which he can subject "the whole of nature".[161]

In constructing this argument, Kant has to consider natural history because the results of this doctrine may be incompatible with considering mankind as the *ultimate* end of nature. In particular, natural history might support the view that all of organic nature is subject to the mechanism of nature without any end or purpose.[162] Thus, although the habitat of organized beings may appear purposive for the latter, natural history shows this habitat to be the result of an entirely unintentional mechanism. Indeed, natural history may even aim to provide a materialist or hylozoist account of the generation of organisms.[163] This, however, would block Kant's argument for moral teleology, since we are only authorized to view the whole of nature as teleologically organized because we conceive of particular objects (organisms) as purposes. Hence, Kant rejects the claim that organisms can have no other origin than in the mechanism of nature, arguing that given the limits of our understanding, we necessarily conceive of organisms as purposes.[164]

This context may explain Kant's remarks relating to natural history in the *Opus postumum*. For Kant cites the results of his contemporary natural historians, in particular fossil findings establishing the extinction of certain species, precisely when arguing that we can conceive of natural species as constituting a teleological whole (ordered in accordance with means-end relationships). The results of natural history must be consistent with the teleological conception of nature and with interpreting mankind as the ultimate end of nature. This is especially clear in a passage from the second fascicle, in which Kant, first noting that classes of organic bodies can be taken to exist for the sake of one another, refers to the revolutions of the earth (which were taken to explain the extinction of lower species) as perhaps occurring *for the sake* of the perfection of the human species.[165] Here we see clearly how Kant interprets the results of natural history. In contrast to taking natural history to support the view that all of organic nature is subject to the mechanism of nature without any end or purpose, Kant interprets, or perhaps reinterprets, the results of natural history as contributing to a purpose: the perfection of human beings.

[160] AA 5: 433–436.

[161] AA 5: 435.

[162] AA 5: 427. It is precisely in this context that Kant mentions the research of Camper.

[163] AA 5: 427–428.

[164] AA 5: 428–429.

[165] AA 21: 212.

In conclusion, we can say that Kant took natural history to be a legitimate doctrine on the conditions that (i) it does not attempt to give a purely materialist account of the generation of organisms, which leads to hylozoism and obviates the necessity of conceptualizing them as purposes (thus blocking Kant's argument from moral teleology), and (ii) its results are consistent with conceptualizing mankind as the ultimate end of nature.

In my view, Kant was opposed to the idea of a transmutation of species (*generatio heteronyma*) precisely because he thought it was difficult to reconcile with taking mankind to be the ultimate end of nature. Already in Kant's article on race from 1785, we read:

> But I am confronted with another maxim […] namely, that throughout all of organic nature in all changes of individual creatures their species is preserved unchanged (according to the school formula: *quaelibet natura est conservatrix sui*). Now it is clear that if the magic power of the imagination or the human artifice with respect to animal bodies were granted a faculty to alter the generative power itself, to reshape the originary model of nature, or disfigure it by means of additions which afterward would yet be permanently preserved in subsequent generations, one would no longer know at all from which original nature had started, or how far its alteration could go, and into which distorted shape [*Fratzengestalt*] the species and kinds might finally degenerate given that the human imagination knows no boundaries. (AA 8: 97)

This remark must be read in the context of Herder's allowance of the transmutation of species (*generatio heteronyma*), which Kant rejects.[166] One of the problems of allowing for *generatio heteronyma*, and with a radical form of natural history espoused by Herder, is that one does not know into what grotesque forms (*Fratzengestalt*) the genera and species might be degenerated. To transpose this remark into our present context: if we allow for the transmutation of species, mankind may just be a passing whim of nature. This is difficult to reconcile with the view that mankind is the ultimate end of nature, and thus with the view that nature is conducive to the ends of morality and to human happiness. This thought influenced Kant's reception of theories pertaining to natural history. It partly explains why he always restricted the scope of research conducted within natural history and why he could not endorse the ideas of Herder. In the *Opus postumum*, as I have argued, Kant retained this sceptical distance to natural history.

8.6 Conclusion

In the *Opus postumum* Kant rejected materialism and hylozoism. In the 1790s, as I have argued, Kant was confronted with biological and physiological theories, and philosophical interpretations of these theories, that he took to have materialist and/or hylozoist implications. In addition, Kant himself constructed some thoroughly mechanist explanations of organic phenomena in the *Opus postumum*.

[166] On this background, see Sloan 2006, 638–639.

These circumstances led Kant to reaffirm his anti-materialism and anti-hylozoism, and to argue that the necessity of searching for mechanical explanations in biology does not imply the truth of materialism or hylozoism. In addition, Kant remained committed to his views on natural history, as these were articulated in the third *Critique*. Studying the natural history of organisms is a useful enterprise, as it directs us to provide causal explanations of present properties of organisms. However, Kant did not accept the reality of *generatio equivoca* and *generatio heteronyma*. Kant thus took natural history to be a useful discipline, although he also insisted that certain topics of research were off limits.

In general, Kant's reflections on organic nature contained in the *Opus postumum* do not fundamentally diverge from his views espoused in the third *Critique*. His conception of proper biological method, as we have also seen in the previous chapter, remains unaltered. The *Opus postumum* does show that, right up to his death, Kant tried to take into account biological developments of the late eighteenth century. Kant interpreted these developments on the basis of his philosophy of biology developed in the *Kritik der Urteilskraft*.

In particular, Kant retained committed to the view that biological research is based on teleology. In biology we presuppose that organisms are purposive wholes in which everything is both end and means. On the basis of this teleological principle, the object or domain of biology is determined. The distinction between organic and inorganic nature is not an ontological distinction, but a distinction based on the (teleological) method on the basis of which we investigate natural objects (plants and animals).

Fundamental to Kant's philosophy is the idea that the teleological maxim that provides the foundation of biological research is a methodological maxim that should not be conflated with ontological claims affirming the objective reality of teleological causation in nature. The same is true of the mechanical maxim, which does not imply the non-existence of teleological causation in nature. More generally: Kant insists on strictly distinguishing methodological presuppositions guiding scientific (biological) research, and metaphysical (ontological) theories.

In the *Opus postumum*, Kant upholds this insight. He rejects the illegitimate ontological assumptions contained in (e.g.) Blumenbach's theory of vital force. We can only problematically ascribe vital forces to organisms (plants and animals), an ascription that allows us to treat the latter (by analogy with ourselves) as purposive wholes capable of purposive actions. Kant further criticizes biological theories that imply materialism, e.g., Sömmering's theory which leads to a materialistic conception of the soul, and biological theories and philosophical interpretations thereof that imply hylozoism, e.g., Maimon's theory of the world-soul or theories pertaining to natural history that lead to hylozoism. Finally, in the *Opus postumum* Kant invoked the ether as a principle for explaining organic phenomena. As such, he attempted to ground biology by means of a principle that he took to ground physics or natural science as a whole as a systematic science. This foundational project was, however, never fully developed. For Kant, the relationship between biology and other disciplines pertaining to physics remained obscure.

Chapter 9
Concluding Remarks

In the present work, I have analyzed Kant's views on biology and biological methodology from the perspective of his conception of proper science and methodology. I have argued that Kant's conception of biological science and methodology is profoundly influenced by his conception of proper science. In this final chapter, I present a brief overview of my main arguments and provide some general considerations on the status of biology in Kant's philosophy of science.

Kant has a complex notion of proper science in general and of proper natural science in particular. A proper science must satisfy the conditions of systematicity, objective grounding, and apodictic certainty. The concepts and judgments of a science must constitute a hierarchically ordered systematic whole in which a clear distinction is made between fundamental and non-fundamental concepts and judgments. Concepts are ordered through definitions, logical analysis, and logical division. Judgments are ordered by means of relations of grounding. The more fundamental judgments of a science must *objectively ground* less fundamental judgments. A proper scientific proof is a deductive demonstration in which we proceed from premises specifying objective grounds to a conclusion specifying some consequence. Such a demonstration is an explanative demonstration, i.e., a demonstration specifying the reasons for *why* something is the case. Finally, the judgments of a proper science must be apodictically certain. This implies that the non-fundamental judgments of a science must allow of proof from *a priori* principles. According to Kant, these conditions imply that proper natural sciences must be based on mathematics and metaphysics, which are *a priori* sciences. Mathematics and metaphysics secure the apodictic certainty of judgments of natural science and aid in providing objective explanative demonstrations in natural science.

It is not the case that only individual sciences should be systematically ordered. Science as a whole should be a system. The sciences are hierarchically ordered and certain sciences can be said to be subordinated to other sciences. The hierarchy of sciences is nicely illustrated by Newton's use of mathematics in natural science. In his *Principia*, Newton applies mathematical propositions to phenomena or empirical generalizations in order to provide demonstrations and explanations in natural science.

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Hence, we can say that natural science is subordinated to mathematics. Kant aimed to show that *metaphysics* grounds natural science. He argued that the principles of general metaphysics, as developed in the *Kritik der reinen Vernunft*, ground propositions of a special metaphysics of corporeal nature, which is developed in the *Metaphysische Anfangsgründe der Naturwissenschaft*. Thus, for example, the analogies of experience, which are a priori principles of transcendental philosophy, allow us to prove the laws of motion, which Kant construes as metaphysical principles of natural science. The laws of motion, in turn, are required to demonstrate the law of gravitation, which is an empirical law of mathematical physics. According to Kant, disciplines such as chemistry and biology are also part of physics or natural science as a whole. These disciplines were often taken to belong to what was called *physica specialis*. *Physica specialis* was a part of physics that was taken to be subordinated to what was called *physica generalis*, i.e., the part of physics dealing with the universal laws and properties of natural objects which typically contained many doctrines treated within Newton's mathematical physics. Hence, the whole of natural science was construed as a systematically ordered hierarchy, in which we can use propositions of the more fundamental sciences in order to prove propositions of the less fundamental sciences.

Kant's views on proper science and objective grounding determine his views on biological explanation and biological methodology. According to Kant, explanations in biology must be *mechanical* explanations. He construes mechanical explanation as an ideal of explanation in biology because mechanical explanations are understood as demonstrations *propter quid*, i.e., as explanatory demonstrations that specify objective grounds for why something is the case. These explanations reflect the order of nature. In contrast, teleology cannot properly explain anything in natural science. If we appeal to purposes or final causes in natural science we are lead beyond the order of nature. Purposes are simply not objective grounds that explain why something is the case.

Mechanical explanations in natural science are deductive demonstrations proceeding from more universal premises or regularities to more particular consequences, i.e., they proceed from part to whole. Kant thought that mechanical explanations can be given in biology. To be sure, the purposiveness of organisms is mechanically inexplicable. The biologists must take the purposiveness of organisms and their parts as given. That organisms and their parts are purposive is thus a fundamental and irreducible principle of biological inquiry. However, given this principle, the biologist must provide mechanical explanations of organic phenomena and processes. Thus, for example, the biologist may construe processes such as nutrition and growth as purposive and consequently appeal to propositions of chemistry in order to partly explain such processes. The proper method of biology consists in the *subordination* of mechanism to teleology.

Kant's conception of objective scientific explanation also shapes his characterization of natural description and natural history. Natural description is a mere descriptive and non-explanatory discipline. Within natural description we do not specify *objective grounds* of traits of organisms. In contrast, natural history tries to provide causal explanations of present effects, such as traits of organisms, in terms of historical causes. Hence, natural history can in principle be an explanatory science. However, natural history is not a proper natural science since it is fundamentally based on analogical inferences and its propositions are not *certain*.

Finally, it must be noted that Kant's philosophy of biology is shaped by the idea that biology is a part of natural science as a whole and should be grounded in other natural sciences. To say that we must always aim to provide mechanical explanations in biology is ultimately to say that we must use propositions of physics, chemistry, or other superordinate sciences in order to explain organic phenomena and processes. This view on the place of biology in the hierarchy of sciences is fully explicit in the *Opus postumum*. In his last projected work, Kant attempted to demonstrate the unity of natural science as a whole. Kant's project is similar to the traditional project of grounding *physica specialis*, containing discussions of chemical topics, electricity, magnetism, and biological topics, in *physica generalis*, the general part of physics containing discussions of kinematics, mechanics, and Newton's law of gravitation. This meant that Kant had to show how biology is *grounded* in other natural sciences.

The problematic status of biology within Kant's philosophy of science emerges if we take into account his idea that the judgments of a science must be apodictically certain, i.e., provable on the basis of a priori principles. As we have seen, it is on the basis of this condition that Kant argues that natural sciences must be based on mathematics and metaphysics.

In Kant's time biology was anything but a mathematical science. This means that judgments of biology lack apodictic certainty. Moreover, mathematics is also often needed in order to provide explanatory demonstrations in natural science. In the second chapter, I gave the example of providing an objective explanation of why hive-bee honeycombs have a hexagonal structure. In order to provide this explanation, we may refer to the fact that bees that use less wax and spend less energy have a better chance at being selected, while also showing mathematically that the hexagonal structure is optimal or most convenient. It is only through the use of mathematics that we can fully understand *why* hive-bee honeycombs have a hexagonal structure. Hence, the fact that biology was a non-mathematical science in the eighteenth century limited its potential to provide genuine explanations.

Similar problems emerge if we take into account the relationship between biology and the metaphysical principles of natural science. In his *Metaphysische Anfangsgründe*, Kant specified the a priori metaphysical principles of phoronomy, dynamics, and mechanics. This work provided the fundamental metaphysical principles grounding a mathematical science of nature. In the critical period, the relationship between the *Metaphysische Anfangsgründe* and biological doctrines was never specified, despite Kant's view that physics should be a systematic science. Thus, the relationship between the fundamental principles of natural science and biology was obscure. In the *Opus postumum* Kant attempted to solve this problem by showing how natural science as a whole can constitute a unity. However, this project failed. Kant never succeeded in specifying the precise relationship between biological sciences and other disciplines pertaining to physics. It was up to the likes of Schelling to give a more precise account of the place of biology in the sciences.

How should we evaluate Kant's philosophy of biology? As noted in the first chapter, Kant's philosophy is sometimes praised because it aims to demonstrate the autonomy of biology. Thus, Mayr states that Kant showed that biology is fundamentally different from physics. Zumbach stresses that Kant argued that biology is irreducible to physics.[1] These interpretations are valid but must be qualified. After all, Kant argued that only mechanical explanations are genuine explanations in natural science and biology. There is no doubt that Kant took explanations in (Newton's) mathematical physics to be paradigmatic mechanical explanations. Moreover, Kant thought that biology should be grounded in other natural sciences. Hence, strictly speaking biology is not an autonomous science. Kant did insist that biology is not *reducible* to the physical sciences. He argued that biology is based on fundamental and irreducible teleological concepts and principles. Indeed, Kant never adopts a reductionist position within his philosophy of science. The fundamental principles of a natural science are peculiar to that science. For example, although Kant thought that the laws of motion can be proven on the basis of the principles of transcendental philosophy, he denied that they are in any way reducible to these principles. Similarly, although we can use propositions of the physico-chemical sciences in order to provide explanations in biology, we can never explain anything in biology in terms of such propositions alone. Kant's anti-reductionism appealed to the likes of Mayr and Zumbach, who were fighting the residues of a logical positivist ideal of the unity of science.

Modern historians of science, such as Richards and Zammito, evaluate Kant's philosophy of biology more negatively. They stress that Kant denied that the purposiveness of organisms can be explained and highlight the differences between Kant's views on biology and those of his contemporary biologists. This interpretation is valid but must again be qualified. It is of course true that Kant denies that the purposiveness of organisms cannot be explained. However, contrary to what Zammito claims, Kant did allow for the possibility of providing explanations in biology. In addition, Kant assigned biology a special domain of investigation consisting of objects that are able to reproduce, grow, and maintain themselves, even if he argued that the domain of biology is in part theoretically constructed. Finally, we have seen that there are indeed fundamental differences between Kant's views on biology and the views entertained by his contemporary biologists. However, these differences often resulted from Kant's understandable endeavor to *demarcate* biology and metaphysical doctrines such as theism, hylozoism, and materialism.

From our modern perspective, one of the main shortcomings of Kant's philosophy of biology is that he categorically denied that the purposiveness of organisms can in any way be explained. Zammito and Richards quite rightly point out that it is one of the central tasks of biology to explain natural purposiveness. Kant adopted this position because he thought that explanations in natural science are always mechanical explanations. However, in order to explain natural purposiveness, we must, as Mayr notes, treat organisms as the result of a long historical process and appeal to evolutionary and historical causes. This historical conception of nature and scientific explanation was largely foreign to Kant.

[1] Mayr 1982, 36; Zumbach 1984.

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