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KANT ON PROPER SCIENCE

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VRIJE UNIVERSITEIT

Kant on Proper Science

Biology in the Critical Philosophy and the *Opus postumum*

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. L.M. Bouter,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de faculteit der Wijsbegeerte
op maandag 14 maart 2011 om 13:45 uur
in de aula van de universiteit,
De Boelelaan 1105

door

Hein van den Berg

geboren te Amsterdam

promotor: prof.dr. W.R. de Jong
copromotor: dr. E.-O.J. Onnasch

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The present dissertation was written within the research project "The Quest for the System in the Transcendental Philosophy of Immanuel Kant", granted by NWO, Netherlands Organisation for Scientific Research (NWO/Innovational Research Incentives Scheme), supervised by Ernst-Otto Onnasch.

Acknowledgments

When I started work on the present dissertation, the idea was to provide a historical study of the so-called *Selbstsetzungslehre* of Kant's last projected work, the *Opus postumum*. Having written my masters thesis on transcendental arguments in Kant's first *Critique*, I was attracted to the idea of studying one of Kant's lesser known and researched works. The study of the *Opus postumum* proved to be rather tough however. In the first year of work, I tried to analyze the mass of reflections and drafts contained in the *Opus postumum* and to relate the so-called *Selbstsetzungslehre* to the general project Kant undertakes in the *Opus postumum*, namely: to provide a transition from the metaphysical foundations of natural science to physics. This in turn required a thorough analysis of the contents of Kant's *Metaphysische Anfangsgründe* and of the relation of the latter work to Kant's other critical writings. In addition, the study of the *Selbstsetzungslehre* necessitated the study of Kant's philosophy of organic nature as presented in the *Kritik der Urteilskraft*. In this manner, I gradually worked my way back in time and was confronted with the problem of understanding the relationship between Kant's conception of proper science, as presented in the *Metaphysische Anfangsgründe*, and his conception of (what we now call) biology, as presented primarily in the *Kritik der Urteilskraft*. The present dissertation focuses on this last problem, while also providing an analysis of Kant's conception of biology articulated in the *Opus postumum*. In the end, I have not managed to provide an analysis of the *Selbstsetzungslehre* but hope to do so in the future.

It is often remarked that writing a dissertation is a lonely task. This is of course true. However, in writing this dissertation I have received enormous support from quite a number of people. Here I would like to acknowledge my debt to these people.

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Note on citation and translation

Citations from the *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): *Kant's 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.

Introduction

The status of biology in Kant's philosophy of science is often deemed to be highly 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, constituting the object of biological investigation, 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 profound discrepancy between Kant's views on biology and his views regarding proper natural science. This raises the question how these two sets of views are precisely related.

The main aim of this dissertation is to analyze Kant's philosophical views regarding biology from the point of view of his conception of proper natural science. I aim to show how Kant's conception of proper natural science and method, as articulated most explicitly in his *Metaphysische Anfangsgründe* of 1786, influences his conception of biological science and methodology as articulated in the *Kritik der Urteilskraft* of 1790 and in the *Opus postumum* of 1796–1803. In doing so, I relate two strands of Kant's philosophy of science

[1] Zammito 2006, 763. Cf. Guyer 2001.
[2] Zammito 2003, 102.

that have separately received a lot of attention but are seldom 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 properly understand his views relating to biology on the basis of this model.

The present study contains three main sub-arguments. Given the scope of the study, it is useful to briefly present them:

First (i), I explicate Kant's conception of proper natural science. Kant is shown to adopt a traditional ideal of scientific explanation. Scientific explanation consists in providing an explanative demonstration, i.e., a demonstration showing *why* things are such and such. This ideal of explanation leads Kant to privilege so-called mechanical explanations. Insofar biology contains proper scientific explanations, they are mechanical explanations. Teleology is not explanatory in biology. However, teleology is a necessary presupposition of biology insofar it allows us to determine and delimit the object or domain of biology.

Second (ii), Kant construed physics as a science that should constitute a systematic unity. Biology is a part of physics. In particular, it is a part of physics traditionally called *physica specialis*, which was conceptualized as being grounded in the universal doctrine of nature (*physica generalis*). For Kant physics does not reduce to mathematical (Newtonian) physics. As a part of *physica specialis*, biology must ultimately be grounded in *physica generalis*. As such, biological phenomena must ultimately be explicable in terms of more fundamental physical laws or forces. Kant did not and could not specify how biology is grounded in other more fundamental sciences. However, the idea that biology should be grounded in more fundamental physical sciences is a persistent methodological ideal.

Third (iii), Kant construes both 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 criticizes several biological theories of his contemporaries insofar as he takes them to go beyond the domain of science into the domain of metaphysics.

The result of my analysis is that although biology does not satisfy all of Kant's prescriptions for proper natural science, Kant did articulate a method for biology that in many ways conforms to these prescriptions. By the standards of the *Metaphysische Anfangsgründe*, biology is not a proper natural science simply because it is not a mathematical science. However, by em-

phasizing that teleology determines the object or domain of biology, Kant specified the conditions under which biology can be taken to have a determinate object of investigation. By construing mechanical explanations as ideal forms of explanation, and allowing for mechanical explanations in biology, Kant allows for the possibility of objective and explanative demonstrations in biology. Finally, by treating biology as a part of physics grounded in more fundamental sciences, Kant's treatment of biology conforms to the ideal that physics should constitute a systematic unity. Kant's views on proper natural science thus strongly determine his views of biological methodology and there is no fundamental discrepancy between these two sets of views.

Kant's philosophy of natural science has, as is the case for Kant's philosophy in general, received enormous scholarly attention. The literature on the topic is vast and sometimes hard to survey. There also exist numerous different strands of interpretation concerning Kant's philosophy of natural science (each with its own history), which, given the amount of literature on this topic, are not always easily identifiable. Roughly, we may say that a dominant strand of interpretation has focused on Kant's philosophy of what we may call the physical sciences. Within this strand, in which the *Metaphysische Anfangsgründe* is taken as 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 (more recently) his views on chemistry, have received much attention.[3] A different strand of interpretation has focused more on Kant's inquiries in the life and human sciences. In the last decades, interest in Kant's views on such sciences as psychology, anthropology and history has steadily increased.[4] This is also true of Kant's philosophy of

[3] Erich Adickes provided one of the first comprehensive historical analyses of Kant's philosophy of nature and science (spanning Kant's pre-critical writings up until the *Opus postumum*). Cf. Adickes 1924–25. Influential systematic treatments of Kant's philosophy of natural science have been given by Plaaß 1965; Buchdahl 1969; Gloy 1976; Hoppe 1969; Brittan 1978; Cramer 1985; Butts 1984; Friedman 1992a; Falkenburg 2000. Carrier 1990, 2001a, and Friedman 1992a provide analyses of Kant's views on chemistry. More recently, Konstantin Pollok has provided a formidable critical commentary of Kant's *Metaphysische Anfangsgründe*, which includes a 13 page biography of secondary literature relating to the latter work. Cf. Pollok 2001.

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

biology, a topic which has been intensively researched in the past decades.[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 positioning the present work with respect to two dominant 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 strongly affirms the autonomy of biology. Biology is presented as an autonomous science, with its own particular standards and methodology, which is irreducible to physics. Thus, 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 a teleological point of view. In effect, teleology is assigned some kind of explanatory function in natural science. 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* 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* a certain range of phenomena or facts. To cite an example from 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 line of interpretation, arguing that teleology enables us "to regard

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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. Cf. Lenoir 1980, 1981, 1989. Lenoir's work has given rise to much debate and has spawned historical and systematic research on Kant's philosophy of biology. Influential discussions include: Löw 1980; Zumbach 1984; McLaughlin 1990; Zammito 1992, 2003, 2006; Larson 1994; Richards 2000, 2002; Ginsborg 2001, 2004; Guyer 2001, 2005; Sloan 2002, 2006.

6 Zumbach 1984, 92.

7 *Ibid.*, 87–92.

8 *Ibid.*, 110n.

9 *Ibid.*, 123.

10 AA 5: 360.

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]

A second line of interpretation concerning Kant's philosophy of biology, of which John Zammito is one of the most influential spokesmen[13], adopts a more skeptical stance towards the status of biology. As said, Zammito argues that Kant denies that biology can ever be reconciled with his prescriptions for science. Organisms are anomalies that threaten the ideal of science as constituting a systematic unity. The mechanical inexplicability of organisms implies that organisms cannot be properly explained. Finally, there is a fundamental discrepancy between Kant's views on biology and that of his contemporary life scientists. As Zammito forcefully puts it: only "by misunderstanding Kant did biology as a special science emerge at the close of the eighteenth century".[14] Or as Robert Richards argues, the reception of Kant's third *Critique* by late eighteenth-century biologist and conversely Kant's reception of late eighteenth-century biological theories is a case of a 'historical misunderstanding'.[15]

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 object or domain of biology. It is only *because* we conceptualize certain objects of nature teleologically that biology has a distinct object of scientific investigation. This view, I argue, conforms to a conception of teleology implicit in eighteenth-century biology, articulated most explicitly by Johann Friedrich Blumenbach, according to which teleology is taken to be operative in determining the domain of biology (Chapter 3). Moreover, it is not only contained in Kant's third *Critique*, but also in the *Opus postumum*, a text hardly ever analyzed in relation to Kant's views on biology (Chapter 5).

In contrast to the first line of interpretation, however, I argue that Kant denies teleology any explanatory function. The reason is simply that he adopts a very strict conception of proper explanation in natural science. This becomes clear if we, in contrast to the mentioned authors, relate Kant's views on biology to his views on proper natural science. In Chapter 1, I argue that according to

[11] Ginsborg 2001, 248.
[12] Quarfood 2006, 738.
[13] Zammito 1992, 2003, 2006.
[14] Zammito 2006, 765.
[15] Richards 2000. Cf. Richards 2002, 229.

Kant fundamental judgments of a proper science must *objectively ground* non-fundamental judgments. The idea of objective grounding is related to Kant's views on proper explanation. In providing a proof of a non-fundamental judgment, we must provide an explanative demonstration of this judgment, i.e., a deductive demonstration specifying the objective ground(s) for *why* something is the case. In Chapters 2 and 3, I show that this conception of scientific explanation informs Kant's views on mechanical explanation, as articulated in the third *Critique*. Proper explanations in biology are mechanical explanations and teleology is denied any explanatory function.[16] As such, Kant's views on proper natural science and scientific explanation are shown to strongly influence 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 especially highlighted the sometimes problematic relationship between Kant's philosophy and eighteenth-century biology. However, the negative assessment of Kant's views regarding the scientific status of biology expounded within this strand of interpretation is (I maintain) not based on a thorough analysis of Kant's views regarding proper natural science. In Chapters 1 and 2, I show that Kant's views on proper scientific explanation inform his views on mechanical explanation. Moreover, organisms allow (in certain respects) of mechanical explanation. As such, Kant's views regarding proper natural science and proper explanation determine his conception of biological methodology. There is no fundamental discrepancy between these two sets of views.

In line with his unitary conception of proper scientific methodology and explanation, Kant treats biology as a part of physics grounded in more fundamental physical sciences. Biological phenomena, though necessarily viewed from a teleological perspective, must be explained in terms of more fundamental physical (or physico-chemical) laws and forces (Chapters 4 and 5).

[16] Note that Zumbach does seem to interpret teleology as explanatory in the sense that I have specified. Thus, he 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*). Cf. Kreines 2005, 272–273. In my view, Kant never takes teleology to explain *why* something is the case (Chapter 2 and 3).

As such, although Kant never fully explicated the manner in which biology is grounded in other sciences, it is not the case that biology is an anomaly within Kant's theory of science threatening the ideal of science as a systematic unity. Finally, an analysis of Kant's *Opus postumum* (Chapter 5) shows that Kant, up to the end of his life, was engaged in providing a philosophical interpretation of late eighteenth-century biological theories. Although there exist, as Richards and Zammito emphasize, great differences between Kant's views and those of his contemporary biologists, it is not the case that Kant's reception of these theories is a case of a historical misunderstanding. Rather, Kant tried to integrate fundamental biological concepts in his philosophy on the basis of doctrines developed in the third *Critique*.

Apart from analyzing Kant's conception of biological method on the basis of his views on proper natural science, the present study adds to existing interpretations by taking into account the *Opus postumum*. In discussions on Kant's views on biology, the latter work is hardly ever taken into account. In studies of the *Opus postumum*, Kant's reflections on organic nature are often treated only marginally and not in relation to his views on biology or 18th century biological theories.[17] In my view, our understanding of Kant's views on biology can be increased by taking into account the *Opus postumum* (Chapters 4 and 5). In this projected work, we find clear expression of the idea that teleology determines the object and 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 tried to provide a philosophical interpretation of late eighteenth-century biological theories. Hence, the relationship between Kant's views on biology and late eighteenth-century biological theories becomes clearer by taking this work into account, even if, as I argue, Kant's position in the *Opus postumum* is substantially the same as his position adopted in the *Kritik der Urteilskraft*.

[17] Erich Adickes 1920, providing the first comprehensive historical analysis of the *Opus postumum*, does treat of Kant's reflections concerning organic nature, but not in relation to his views on biology and eighteenth-century biological theories. The same is true of Tuschling 1968, Mathieu 1989 and Hoppe 1969. Eckart Förster 2000, one of the most influential interpreters of the *Opus postumum*, typically treats of the reflections on organic nature contained in Kant's last projected work as mere preliminaries to the *Selbstsetzungslehre*. Michael Friedman 1992a, in his discussion of the *Opus postumum*, entirely abstracts from any discussion relating to biology. The same is true of Edwards 2000 and Emundts 2004. Noteworthy exceptions to this dominant trend of interpretation include Heimsoeth 1940, Löw 1980 and to a lesser extent Guyer 2001.

The method employed in this study is a combination of 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. However, I confront these texts from a general perspective. In explicating 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 topics relating to biology throughout the whole of his philosophical career.[18] A study of 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 focused on continuities in Kant's thought. In this manner I identify core Kantian views regarding proper natural science and biology. 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. In my view, Kant's views on proper natural science, scientific method and biological method conform to traditional ideals of scientific rationality that were widespread in the modern period. Hence, 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. The *ideengeschichtlich* character of this study is reflected in Chapter 1, in which I employ the Classical Model of Science as developed by de Jong & Betti in order to analyze Kant's conception of proper natural science.[19] In addition, Kant's views on objective grounding and on the role of mathematics in natural science are analyzed in relation to the works of Christian Wolff and Isaac Newton. In Chapter 2, Kant's views on mechanical explanation are analyzed in relation to Christian Wolff's views on scientific explanation. Chapter 3 analyzes Kant's views on teleology on the basis of the views of

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

[19] De Jong & Betti 2010.

Alexander Gottlieb Baumgarten's conception of teleology, and his views on biology on the basis of ideas of the biologist Johann Friedrich Blumenbach. In Chapter 4, Kant's conception of physics, as expounded in his critical works and in the *Opus postumum*, is studied in relation to the construal of physics given in eighteenth-century textbooks. Finally, Chapter 5 discusses Kant's reflections concerning biology in the *Opus postumum* on the basis of his early essays concerning biological issues, the third *Critique* and then contemporary biological theories and metaphysical interpretations thereof.

The *ideengeschichtlich* method provides a novel perspective on Kant's philosophy of natural science and biology. In particular, it provides a novel perspective on Kant's views on grounding in natural science, which in turn allows us to better understand Kant's views on the role of mathematics and metaphysics in natural science. Whereas the notion of grounding is typically comprehended in epistemic terms,[20] I relate this notion, also taking into account the philosophy of Christian Wolff, to the idea of objective scientific explanation (Chapter 1). In addition, Kant's philosophy of biology has to my knowledge never been related to Christian Wolff's views on scientific explanation and biological methodology. There are some 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, even those espoused in the late third *Critique* (Chapter 2). The same is true of Kant's views on teleology, which can be profitably understood by taking into account the views on teleology by Alexander Gottlieb Baumgarten (Chapter 3). Finally, Kant's views on biology espoused in the *Opus postumum* have rarely been investigated in relation to then contemporary biological theories and metaphysical interpretations thereof. The present study aims to do just that (Chapters 4 and 5).

Before presenting an overview of the structure and contents of this dissertation, 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 emphasized that the use of the term 'biology' is slightly

[20] Cf. Friedman 1992b.

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.[21] 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 employ this term as referring to various disciplines dealing with organic nature, e.g., zoology and botany (two realms of natural history), physiology, embryology, (comparative) anatomy.[22] In the present study I follow this usage of the term biology.

Given the scope of the present study, it is useful to provide a detailed account of the structure and contents of this dissertation. This account provides the reader with a guiding thread in order to comprehend the argumentative structure of the dissertation.

In **Chapter 1**, 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.

Kant's notion of systematicity (i) is treated in relation to his views on the ordering of concepts. A system of concepts is a homogeneous ordering with specified bounds, in which concepts are ordered through definitions and through the specification of their extension by means of logical division. 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 a traditional Aristotelian ideal of scientific explanation, i.e., the idea

[21] Cf. Hodge 1971, 323–352; Theunissen & Visser 1996; Richards 2000, 12. Note however that earlier uses of the term have been described by historians of science. McLaughlin 2002, mentions Karl Friedrich Burdach's use of the term in 1800, Theodor Georg August Roose's use of the term in 1797, and even Michael Christoph Hanov's use of the term in 1766.

[22] Cf. Zumbach 1984, Richards 2000.

that in science we should provide a demonstrative syllogism or a *demonstratio propter quid*. This is a demonstration providing the reason *why* things are such and such. Finally, the notion of apodictic certainty (iii) primarily 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 condition 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 the very same 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 in justifying scientific cognition. Mathematics and metaphysics are also necessary because they allow us to provide objective scientific demonstrations.

In **Chapter 2**, some of Kant's views on proper natural science are applied 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 the second 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 roughly construes a mechanical explanation as an explanation of the features of a whole in terms of its parts. In order to understand what this entails, I analyze Christian Wolff's views on scientific explanation. I argue that part/whole conceptualizations figuring in Wolff's logic and metaphysics influence his view on scientific explanation in natural science. In logic, definitions are construed as explanations of wholes in terms of their parts and mode of composition of these 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. In this manner, the ideal of objective scientific explanation is associated with explanations of wholes in terms of their parts: through cognition of the parts of a thing and their mode of composition we can explain *why* a thing has certain attributes. This idea of explanation is extended into the domain of

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 the field of biology, arguing that we can only specify the true *ground* of the growth, nutrition and propagation of plants and animals on the basis of cognition of their parts and mode of composition.

Kant is shown to adopt a rather similar view on mechanical explanation. As in the case of Wolff, this view is based on part/whole conceptualizations employed within logic. As such, the notion of mechanical explanation is based on a philosophical interpretation of what constitutes proper explanation and proper method in science. This allows us to understand why Kant treats the prescription that one should always explain objects of nature mechanically as a *regulative maxim*: we are dealing with a prescription concerning proper method in natural science that does not have ontological implications. Finally, I argue that Kant's claim that organisms defy mechanical explanation concerns one particular feature: the order and unity of the parts of organisms. We cannot mechanically explain *why* the parts of organisms exhibit a harmonious unity.

Chapter 3 contains an analysis of Kant's views on the role of teleology in biology. The main thesis of this chapter is that Kant does not assign any explanatory role to teleology. However, teleology is assigned a role in determining the object or domain of biology.

In the first part of Chapter 3, I investigate Kant's teleology from a historical perspective. I analyze Alexander Gottlieb Baumgarten's construal of the concept 'purpose' in his *Metaphysica*. Baumgarten treats of the concept purpose while discussing various types of *causes*. He discusses the *genus* (i) cause, and the *species* (ii) efficient cause, (iii) usefulness or utility and (iv) purpose. Baumgarten construes the connection between efficient causes and effects (the *nexus effectivus*) to be an objective relation obtaining between existing objects. This relation is objective not only in the sense that it obtains between existing objects, but also in the sense that it is a relation taken to obtain between objects irrespective of the manner in which these objects are represented or conceptualized by some cognitive (volitional and intellectual) subject. The latter is not true of the connection between means and purposes (the *nexus finalis*). An object is a purpose only relative to some cognitive subject that *represents* this object as good and tries to obtain this good by *employing* certain means. Purposes and means only exist relative to some cognitive subject capable of acting in accordance with representations.

Kant's conception of 'purpose' is shown to be similar to that of Baum-

garten. This partly explains why Kant does not assign any explanatory role to teleology in natural science or biology. 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. Purposes are subjectively ascribed to objects of nature and are not objective grounds in terms of which we can explain *why* something is the case. In biology, proper explanations are mechanical explanations, which are associated with explanations in accordance with the *nexus effectivus*. In contrast to efficient causes, final causes do not specify the objective grounds of processes such as (e.g.) regeneration and do not provide insight into the *working* of such processes.

In the second part of this chapter, I argue that teleology determines the object or domain of biology. By conceptualizing organic bodies as *natural purposes*, we take them to be characterized by properties and relations that we do not ascribe to inorganic bodies. As such, the *method* that we employ in investigating organisms determines how we understand the object of biology.

I first show that according to Kant the *mechanical method* of investigating organic bodies determines how we understand the nature of organisms. The regulative ideal of mechanical explanation, i.e., the methodological claim that on should explain wholes in terms of their parts, leads us to view organisms as wholes consisting of relatively simple parts. This claim does not imply the ontological thesis that organisms exist of simple elements.

Kant's views on how *teleology* determines the object of biology are analyzed by taking into account the manner in which the biologist 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, teleology is assigned a crucial role in distinguishing organic from inorganic bodies.

Kant is shown to assign a similar role to teleology in natural science. In the *Kritik der Urteilskraft*, he treats reproduction, growth and nutrition, and regeneration as *distinguishing traits* of organisms. These traits are described in teleological terms and teleology can be taken to determine and delimit the object of biological investigation. However, Kant retains committed to the idea that we should *explain* all organic phenomena mechanically. The proper method of biology is taken to consist in the *subordination* of mechanism to

teleology. Through teleology, we determine how we understand and delimit the object of biological investigation. In particular, by conceptualizing organisms teleologically, we comprehend them as having a structure adapted to performing organic functions such as (e.g.) growth and nutrition. Given this teleological characterization of the object of biological investigation, we must, however, try to provide mechanical explanations of such processes as growth and nutrition, i.e., explanations specifying the objective grounds (reasons *why*) of such processes.

Finally, I emphasize that it is in its *regulative use* that teleology determines the object or domain of biology. Both mechanism and teleology constitute regulative methodological maxims that determine how we construe the object of biological investigation. Again, they do not constitute or imply ontological claims.

In **Chapter 4**, we turn our attention to Kant's *Opus postumum*. The *Opus postumum* is a collection of reflections composed for a work originally entitled "Transition from the Metaphysical Foundations of Natural Science to Physics". The main objective of this chapter is to explain what this *Transition* project entails. This objective is attained by analyzing the meaning of the concept 'physics' in the writings of Kant and in eighteenth-century textbooks on physics. I argue that Kant's *Transition* must be understood as an extension of Kant's *Metaphysische Anfangsgründe* of 1786 and that this project is informed by a traditional view on how to ground physics as a systematic science. Biology is shown to be construed as a part of physics.

In the first part of Chapter 4, I analyze Kant's views on physics as articulated in the critical period. Kant adopts a broad Aristotelian conception of physics as a science of nature incorporating any doctrine of nature, including the study of organisms (biology) and mind (psychology). He also adopts a more restricted conception of physics as a doctrine of *corporeal nature*. The latter doctrine includes mathematical physics, chemistry and topics pertaining to biology, while excluding psychology. Hence, it is problematic to equate Kant's notion of physics with mathematical (Newtonian) physics.

Kant further distinguishes between rational (a priori) and empirical physics. On the basis of an analysis of the *Metaphysische Anfangsgründe*, Kant is shown to be aware of the existence of explanatory gaps between rational and empirical physics. Nevertheless, physics should be a systematic science. As such, the necessity of the *Transition*, constituting a transition from rational to empirical physics in order to establish physics as a system, is already apparent in the *Metaphysische Anfangsgründe*.

In the second part of Chapter 4, I analyze how the concept of physics is employed in some eighteenth-century textbooks on physics. The textbooks

I discuss emphasize that one should try to establish physics as a systematic science. Physics is established as a systematic science by grounding *physica specialis*, the special part of physics containing (e.g.) discussion of fluid and solid bodies, chemical topics, electricity, magnetism, in *physica generalis*, a *universal* doctrine of nature containing (e.g.) discussion of the laws of motion and Newton's theory of universal gravitation. The distinction between *physica generalis* and *physica specialis* was conceptualized as a distinction between a priori and empirical physics. In addition, various topics pertaining to biology were rubricated under *physica specialis*. In eighteenth-century textbooks, we are thus confronted with a broad conception of physics as a systematic science comprising multiple doctrines of nature.

In the third part of Chapter 4, I discuss Kant's *Transition*. The *Transition* has the task of grounding physics as a systematic science. The project of effecting a transition from the metaphysical foundations of natural science to physics corresponds to the traditional project of exhibiting the systematicity of physics by grounding *physica specialis* in *physica generalis*. Note that the *Transition* is not identical to the project of grounding *physica specialis* in *physica generalis*. The project of providing the metaphysical foundations of natural science (the *Metaphysische Anfangsgründe*) led to Kant to strictly distinguish between a pure a priori part of physics (rational physics) and an empirical part, and to take certain topics traditionally discussed within *physica generalis*, e.g., cohesion and the law of gravitation, as pertaining to empirical physics. Nevertheless, a study of the project of grounding *physica specialis* in *physica generalis* shows how philosophers and scientists in the eighteenth century tried to establish physics as a systematic science. Kant's *Transition*, which similarly has the task of establishing physics as a systematic science, can be profitably understood against this background.

Through his *Transition*, Kant hopes to bridge explanatory gaps obtaining between rational physics and empirical physics. These gaps were evident to Kant in his *Metaphysische Anfangsgründe* of 1786. In eighteenth-century textbooks on physics, the existence of gaps between *physica generalis* and *physica specialis* is also clear. Kant's *Transition* is thus an extension of his *Metaphysische Anfangsgründe* of 1786 and is a project similar to a traditional project of grounding the systematicity of physics. Finally, since biological topics were rubricated under *physica specialis*, the *Transition* also incorporates discussion of biology, which is construed as a part of physics.

Chapter 5 contains an analysis of Kant's reflections regarding biology in the *Opus postumum*. I argue that these reflections must be read in the context of late eighteenth-century biological theories and metaphysical interpretations thereof. I further argue that Kant's views on biology as articulated in the *Opus*

postumum build upon his position developed in the *Kritik der Urteilskraft*. Kant reaffirms his critical position with respect to biology partly because of his encounter with particular biological theories and problematic metaphysical interpretations of the latter. Central to Kant's thought remains the idea that mechanism and teleology are regulative methodological maxims guiding scientific inquiry that do not have ontological implications.

In the *Opus postumum*, Kant reinterprets the theory of vital force espoused by the biologist Johann Friedrich Blumenbach. Blumenbach posited vital forces, constituting teleological agents in nature, in order to account for organic processes such as nutrition, reproduction and generation. Kant accepts Blumenbach's doctrine of vital force insofar as it gives expression to the idea that we must understand organisms and organic processes in teleological terms. However, he does not argue for the existence of vital forces in nature. This is to transgress the realms of proper science and to affirm the dogmatic metaphysical position of vitalism or hylozoism. Vital forces are reinterpreted as regulative posits, ascribed to organisms by analogy with human purposive action.

The *Opus postumum* further develops the idea that it is by conceptualizing certain objects (organisms) in teleological terms that we determine and delimit the object of biology. The distinction between inorganic and organic nature is not an ontological distinction. Rather, this distinction is an *a priori presupposition* of physics: a distinction preceding empirical investigation through which organic nature becomes a distinct object of scientific investigation. Once again, however, proper explanations in biology are always mechanical explanations. Biology is a part of physics and explanations of processes as (e.g.) nutrition, reproduction, etc., require the specification of physical and chemical causes of such processes, even if the nature of these causes is unknown to Kant and his contemporaries.

As in the third *Critique*, the *Opus postumum* contains a rejection of materialism and hylozoism. Materialism and hylozoism are dogmatic metaphysical theories denying respectively affirming the existence of purposiveness in nature. Kant's critique of materialism in the *Opus postumum* is shown to be related to his encounter with Samuel Thomas Sömmering's *Über das Organ der Seele* (1796), in which Sömmering provides a physiological investigation into the organ or seat of the soul. Kant criticized Sömmering for conflating metaphysical and physiological questions and for adopting a materialistic conception of the soul. Kant's critique of hylozoism in the *Opus postumum* is shown to be 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 constituting the ground of

organic and inorganic bodies, of the life of animals and of understanding and reason in humans. According to Kant, this is a transgression from the field of biology to dogmatic metaphysics, i.e., hylozoism. The critique of materialism and hylozoism in the *Opus postumum* shows that this work cannot be interpreted, as is sometimes claimed, as a relapse into dogmatic positions.

Finally, I discuss Kant's reflections concerning natural history in the *Opus postumum* on the basis of his earlier views on natural history. I argue that Kant has a moderately positive view of natural history, i.e., the historical and developmental study of changes within nature and its (organic) objects. Natural history aims to provide causal explanations of present effects (e.g., specific 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, Kant argued that certainty cannot be obtained in natural history. In addition, he denied that natural history can ever support the idea that organisms are generated from unorganized matter (which leads to materialism) and he was skeptical of ideas affirming the transformation of species. Finally, Kant thought that the results of natural history should be in conformity with viewing man as the ultimate and final end of nature. Kant thus placed severe restrictions on natural history. These restrictions can also be located in the *Opus postumum*.

In a study of Kant, one is always confronted with a vast research tradition to which one positions oneself and to which one is indebted. In conclusion, I would like to mention my main intellectual debts. In studying Kant's views on natural science and the methodology of natural science, I have greatly benefited from the work of Brigitte Falkenburg, Michael Friedman, Willem de Jong, Béatrice Longuenesse and Konstantin Pollok. In studying Kant's philosophy of biology, I have benefited from the work of Hannah Ginsborg, Timothy Lenoir, Peter McLaughlin, Marcel Quarfood, Robert Richards, Philip Sloan, John Zammito and Clark Zumbach. Finally, in studying Kant's *Opus postumum* I have benefited from the work of Erich Adickes, Dina Emundts, Eckart Förster and Michael Friedman.

1 | 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 at specifying 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 did not take an active interest in natural description, natural history, chemistry and empirical psychology. Recent research has shown that Kant, throughout his life, provided significant philo-

[1] AA 4: 467–471.

sophical analyses of these sciences.[2] This raises the question 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 & Betti (2010).

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]

In the present chapter, I will relate Kant's conception of proper science to conditions (2a) and (2b), concerning the order of concepts by means

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

[3] De Jong & 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 & Betti, cf. De Jong & Betti 2010, 197–201.

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 (3b)) takes centre stage. I will argue that Kant adopted an idea of scientific explanation conforming to the traditional Aristotelian idea of a demonstration of the reasoned fact. This conception of scientific explanation must be distinguished from his ideas on 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 (§1.1). Kant's conception on 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 (§1.2). This claim is sometimes interpreted as stating that any proper science must have a priori principles.[4] In my opinion, it can be 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 (§1.3). 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 in light of Kant's claim that scientific cognition must be apodictically certain (§1.4). Finally, in section five I will discuss Kant's claim that any proper natural science must be based on metaphysical principles (§1.5). Metaphysical principles of natural science provide fundamental propositions or judgments of natural science and secures that they are apodictically certain, i.e., known to be true. This section relates Kant's views on providing metaphysical foundations of natural science to condition (3a), (3b) and (6) of the Model.

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

1.1 Systematicity

The first condition that any proper science must satisfy is that of systematicity.[5] In the *Kritik der reinen Vernunft* Kant explicates the concept of system as follows:

> If we survey the cognitions of our understanding in their entire range, then we find that what reason quite uniquely prescribes and seeks to bring about concerning it is the **systematic** in cognition, i.e., its interconnection based on one principle. This unity of reason always presupposes an idea, namely that of the form of a whole of cognition, which precedes the determinate cognition of the parts and contains the conditions for determining *a priori* the place of each part and its relation to the others. Accordingly, this idea postulates complete unity of the understanding's cognition, through which this cognition comes to be not merely a contingent aggregate but a system interconnected in accordance with necessary laws. (*KrV*, *A* 645/*B* 673, original emphasis)

These remarks require explanation. First, note that the systematic unity of cognition is said to be brought about by the *faculty of reason*. This follows from Kant's conception of reason as a faculty that organizes cognition. In particular, reason logically orders cognition and thus unifies it.[6] The term 'cognition' refers to both *concepts* and *judgments*.[7] In this section, I will restrict my discussion to concepts. Second, Kant claims that the unity of cognition effected by reason is based on an idea of the "form of a whole of cognition" which postulates a "complete unity" of cognition. Hence, a system of cognition is taken to constitute a complete whole. Finally, Kant claims that the place of the parts (cognitions) within a system of cognition and the relation of these parts to each other is *determined a priori* in accordance with certain conditions. In the following, we will see that Kant takes a system of cognition to be constructed by following certain logical rules establishing 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. When Kant speaks of 'conditions' in accordance with which we determine the place of cognitions in a system he refers among others to these rules. In short, a

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[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 greatly benefited.

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

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

system is a complete whole composed of parts that are necessarily related to each other in accordance with rules. As such, it is distinguished from a contingent aggregate. I will first discuss the rules in accordance with which we establish a system of cognition. I will then explain how we should understand Kant's claim that a system is complete.

If we turn our attention to the discussion of systematicity in the *Jäsche Logik*[8], it becomes clear that systematicity must be understood as a *logical* requirement concerning the form of cognition.[9] In particular: in a system of concepts the ordering of concepts is a logical one, meaning by this that concepts are ordered through definitions and through the specification of their extension. The requirement of systematicity is explicated in the Doctrine of Method of the *Jäsche Logik*, which specifies the conditions of scientific cognition in general. The requirement of systematicity, together with the requirements of distinctness (*Deutlichkeit*) and thoroughness (*Gründlichkeit*), are described as *logical perfections*. These perfections provide ideals of scientific cognition.[10]

With respect to the ideal of systematicity, it is remarked that the combination of cognitions 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] When Kant speaks of that which is contained in a concept, he refers to the totality of partial concepts comprising the intension (*Inhalt*) of this concept.[13] Thus, for example, the partial

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[8] The *Jäsche Logik* (1800) is a textbook treating Kant's logic, edited by Gottlob Benjamin Jäsche (1762–1842). It draws on Kant's notes of his lectures on logic and probably on student transcripts of these lectures. The publication of the *Jäsche Logik* was authorized by Kant. Nevertheless, it cannot be considered Kant's own text. Cf. Boswell 1988, 193–203. Despite problems involving the authenticity of the text, the *Jäsche Logik* provides an important (and often used) resource for analyzing Kant's philosophical and logical concepts. I will frequently employ this work, as well as various student transcripts of Kant's lectures on logic, when analyzing Kant.

[9] This is also emphasized by Longuenesse 1998, 149–153.

[10] AA 9: 139–140.

[11] *Ibid.*

[12] See, for example, Meier's discussion of concepts in his *Auszug aus der Vernunftlehre* (1752). AA 16: 549–563. Georg Friedrich Meier's (1718–1777) *Auszug aus der Vernunftlehre*, a shortened version of Meier's *Vernunftlehre* (1752), was employed by Kant as a compendium for his lectures on logic, which he taught from 1755/1756 up until 1796. As such, it provides an important reference for understanding Kant's views on logic and his logical terminology. The *Auszug* is published in volume 16 of the Akademie-Ausgabe, to which I will refer when employing this text. On Meier's logics, cf. Pozzo 2005, 185–202.

[13] AA 9: 95.

concepts 'animal', 'rational' and 'mortal' are *contained in* the concept 'man'. Conversely, when Kant speaks of that which is *contained under* a concept, he refers to the totality of concepts comprising its extension (*Umfang*). For example, the concepts 'gold', 'silver', 'copper' and so forth are contained under the concept 'metal', functioning as a characteristic (*Merkmal*) of these concepts.[14] Finally, a concept is distinct if we possess a clear representation of its characteristics, i.e., if we are conscious of the partial concepts *contained in* this concept. A concept is made distinct by analyzing it.[15]

The claim that the connection of cognitions into a systematic whole requires the distinctness of concepts in regard to what is *contained in* and *under* them can now be understood as follows: systematicity is brought about both by the determination of the intension of concepts and by the specification of their extension.[16] The distinctness of concepts in regard to what is contained in them, i.e., in regard to their *intension*, is promoted by means of definitions of these concepts.[17] The distinct consciousness of the extension of concepts is promoted by their logical division.[18] Thus, through definitions and logical division we establish a systematic order among concepts. Let us first consider Kant's views on definitions.

In the first *Critique*, Kant remarks that we define a concept if we specify clear and sufficient marks. If we specify clear and sufficient marks of a concept it is complete (*ausführlich*). In addition, in giving a definition it is required that the specification of marks be precise.[19] This view on definitions can be understood on the basis of a traditional account of definitions contained, for example, in the writings of Christian Wolff.[20] In his *Deutsche Logik*, Wolff construes a definition as a clear (*klar*), distinct (*deutlich*) and complete (*ausführlich*) concept.[21] 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 distinct concept is complete if the marks that we have cognition of are sufficient for cognizing the things represented by the concept and distinguishing them from other things. Kant requires that a definition specifies clear marks. Hence, through its definition we render a concept distinct. These marks must be sufficient,

[14] AA 9: 96.
[15] AA 9: 61–62.
[16] Cf. Longuenesse 1998, 150–151.
[17] AA 9: 141.
[18] I will return to this notion below.
[19] *KrV*, A 727/B 755. Cf. AA 9: 140.
[20] A quite similar account of definitions can be found in Meier's *Auszug aus der Vernunftlehre*, AA 16: 316–358. I am grateful to Job Zinkstok for helpful discussion on the topic of definitions.
[21] Wolff 1978 [1754], 141.

i.e., the specified marks must allow us to distinguish things represented by the defined concept from other things. The requirement of precision adds that we must not specify more marks than necessary for completeness.[22] 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.

In the *Logik*, a distinction is made between synthetic and analytic definitions.[23] 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 (marks), e.g., the concept 'square' is defined through the combination of 'four-sided', 'equilateral' and 'rectangle'.[24] In this manner, a mathematical definition provides a precise specification of clear and sufficient marks of a concept. Through mathematical definitions we define a concept in terms of more fundamental concepts. In the *Critique*, Kant notes that the synthesis of mathematical concepts can be constructed a priori.[25] Mathematical definitions are thus construed as constructive definitions. Here, we are dealing with 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.[26] 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 clear on what he takes to be the fundamental concepts of mathematical doctrines. In his *Untersuchung über die Deutlichkeit der Grund-*

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

[23] AA 9: 141.

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

[25] *KrV*, A 729/B 757. In the *Logik*, there is no strict distinct between the view on synthetic definitions as resulting from an arbitrary combination of concepts and constructive definitions. Cf. AA 9: 141. In the *Critique*, as noted, Kant treats mathematical definitions as constructive definitions. Wolff 1999 [1750], 11–13, and Meier in his *Auszug aus der Vernunftlehre* 1752, AA 16: 563–572, take the construction to prove the possibility of the thing falling under the concept defined through the arbitrary combination of concepts. As Meier puts it: definitions obtained through arbitrary combination of concepts need to be proven. In mathematics this can be done through construction. Thus, mathematical definitions through the arbitrary combination of concepts constitute nominal definitions, whereas constructive definitions constitute real mathematical definitions.

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

sätze der natürlichen Theologie und der Moral (1764), Kant does recognize that mathematics contains only a few primitive concepts.[27] Moreover, in Kant's time constructive mathematical definitions were often taken to proceed from a number of primitive concepts. For example, in his *Anfangs-Gründe aller Mathematischen Wissenschaften* (1750), Christian Wolff takes constructive definitions to provide real definitions, showing how a thing is possible.[28] He argues that in geometry real definitions are easily obtained, for the motion of points given lines, the motion of lines gives planes and the motion of planes gives solids. Wolff states that if we combine points, lines, and planes in a sensible manner, and ascribe them all possible types of motion, we obtain the different geometrical definitions.[29] 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. [30] In this manner, the method of providing constructive definitions that was common in Kant's time captures condition (2a) of the Model.

We may now turn to analytic definitions. 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 have other concepts contained under themselves, which are called lower relative to the former.[31] Following de Jong, we may clarify Kant's conception on the containment relations of concepts by means of conceptual hierarchies called *porphyrian trees* (see Figure 1).

Porphyrian trees provide a paradigmatic example of a system of concepts.[32] In porphyrian trees species are specified in terms of a common genus and mu-

[27] AA 2: 279–280.
[28] Wolff 1999 [1750], 12–13.
[29] Wolff 1999 [1750], 16.
[30] Cf. Shabel 2003, 49–57, for an account of this procedure.
[31] AA 9: 146–147.
[32] 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 and 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 of such judgments as synthetic.

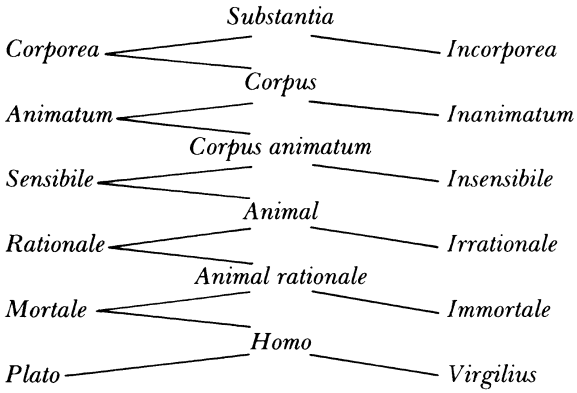

Figure 1: Porphyrian tree.[33]

tually exclusive *differentiae*. In this particular tree we specify, e.g., the species "body" in terms 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., in Kant's terms 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 a species of a distinct genus and *differentia* in a different porphyrian tree. Porphyrian trees have a highest genus, in this case the concept substance.[34] In the above tree, the individual concepts 'Plato' and 'Vergilius' are taken as lowest species. However, Kant denies the existence of an *infima species*. In principle, the specification of any concept can proceed indefinitely. *Infima species* are specified by convention [35]

For our present purpose, it is important to note that according to Kant analysis provides us with the marks (e.g., "substance" and "corporeal") of a species ("body") in terms of which the latter can be defined. Analysis is a procedure through which we successively render the marks of a concept clear.[36] In this manner, analysis allows us to provide an *analytic definition*. Insofar as we can in principle successively define lower concepts (species)

[33] Taken from De Jong 1995, 624. 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.

[34] De Jong 1995, 625.

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

[36] AA 9: 142.

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

Here a note of caution is required. The foregoing shows that Kant's model of analytic definitions, which can be traced to Wolff's and Meier's views on definitions, presupposes that concepts *must* be defined in terms of fundamental concepts. However, in the *Logik*, it is argued that if we define concepts analytically, we cannot be certain whether we have specified *all* the marks of a given concept. In the Doctrine of Method of the first *Critique*, Kant makes a similar point, exhibiting epistemic difficulties in the mode of defining concepts through analysis.[37] The claim that one should specify *all* the marks of a given concept, points to Kant's requirment that concepts be defined in terms of primitive concepts (a porphyrian tree should terminate in a highest genus). Kant can then be taken to argue that through analysis we cannot be certain to have identified fundamental concepts. I will not further discuss the epistemic difficulties Kant associates with the method of analysis of concepts. For our purposes, it is crucial to emphasize that Kant always requires that in any science concepts are defined in terms of fundamental concepts.

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 mathematical, constructive definitions, we proceed from fundamental concepts. Through their arbitrary combination we define complex, non-fundamental concepts. As such, we systematically relate all mathematical concepts by means of definitions (proceeding from fundamental concepts to more and 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 order among concepts (proceeding from more complex concepts to more and more fundamental concepts).

Systematicity also requires the specification of the extension of concepts. Take once again the example of a porhyrian tree. 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

[37] *KrV*, A727–732/B 755–760.

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.[38] In a logical 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.[39] These rules of specification also govern the manner in which we establish a systematic order among concepts.

Note that the example of the porhyrian tree given above (Figure 1) satisfies (a)–(c), though not all species of genera are specified.[40] 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 made between a subdivision, i.e., a (vertical) division of species into sub-species and so-forth, and a co-division, a (horizontal) division of different species of a genus.[41] Of both subdivisions and co-divisions it is said that they can proceed *ad infinitum*.

That subdivisions can proceed *ad infinitum* makes sense in light of Kant's denial of the existence of an *infima species*. Co-divisions can also proceed *ad infinitum*, for in the *Jäsche Logik* it is claimed, with special reference to empirical concepts, that one cannot exhaustively describe all the relations of concepts.[42] This last point expresses, I think, an epistemic difficulty that can be elucidated by taking into account divisions in natural history, which in the *Jäsche Logik* are described as *polytomies* (hence, I take the claim that co-divisions can proceed *ad inifinitum* to apply to polytomies rather than dichotomies).[43] Take, for example (mine!), a division in which we specify the higher concept of amphibians into the lower concepts of frogs, toads, salamanders, etc. The claim in the *Jäsche Logik* seems to be that in these divisions we cannot be certain, partly because these divisions are based on

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[38] AA 9: 146–147.

[39] *Ibid.*

[40] Although of course 'Plato' and 'Vergilius' do not comprise the total extension of 'man'. But recall that Kant denied the existence of a lowest species altogether.

[41] AA 9: 147.

[42] *Ibid.*

[43] In the *Jäsche Logik* it is explained that in a *Polytomie* we specify a concept into more than two members. If we specify two members, we obtain a dichotomy. Polytomies provided in natural description (Kant's term for natural history) are said to be based on empirical intuition. AA 9: 147–148.

empirical intuition[44], that we have specified the total extension of a higher concept. In this manner, the specification (subdivision and co-division) of concepts is presented as a continuously ongoing process. The same holds for the construction of a system of concepts.

Kant's conception of systematicity is exemplified by hierarchical systems of concepts (trees), proceeding from elementary concepts to more specific and complex concepts. In the appendix to the Transcendental Dialectic of the first *Critique* Kant endorses a similar conception. There Kant provides a general discussion of the logical principles by means of which we establish systematic unity among cognitions. The specified logical principles function as rules for the construction of systems and are described by Kant as principles of (i) homogeneity, (ii) specification, and (iii) continuity.[45] Rule (i) directs us to subsume any concept under a higher and more general concept. Rule (ii) directs us to divide or specify any given concept into more particular concepts. Finally, by means of rule (iii) we postulate that different levels of concepts within our classification are continuously related, guiding the attempt to specify continuous transitions from one level of concepts to another. By following these principles we order concepts in terms of their extension and intension and obtain a hierarchy of concepts with the "greatest unity alongside the greatest extension".[46] Note that this account of how systematicity is established is similar to the account given in the *Logik*, in which a system of concepts was taken to be brought about by means of definitions in terms of more fundamental concepts (capturing (i)), and by the specification of concepts through logical division (capturing (ii)).

If, as we have seen, the specification of concepts can be indefinitely continued, how should we understand Kant's claim that a system of cognition should be complete? An answer to this question is given in the *Metaphysik Volckmann*. There, it is argued that the completeness of any system requires (a) the specification of upper and lower bounds (*terminus a priori* and *terminus a posteriori*) , and (b) 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.[47] Similarly, in constructing a system of concepts we can specify a highest genus and a lowest species (*infima species*) and relate them in terms of their extension or intension by means of the logical

[44] AA 9: 147.

[45] *KrV*, A 657–658/B 685–686. In this context, Kant further argues that the application of logical rules (i)–(iii), presuppose *transcendental* principles of homogeneity, specification and continuity. In the following, I will abstract from this argument.

[46] *KrV*, A 643/B 671.

[47] AA 28: 355–356.

rules (i)–(iii).[48] Recall, however, that Kant denies the existence of an *infima species*. *Infima species* are specified by convention. Kant also claims that the assumption of the existence of a highest genus is one of *reason*, for we cannot empirically identify a highest genus. Hence, although in constructing a system we specify upper and lower bounds we cannot establish their objective reality. The *ordo cognoscendi* does not necessarily mirror the *ordo essendi* completely.

Let us return to the description of the concept 'system' given in the beginning of this section. There, a system was described as a whole consisting of parts. This description secures the generality of the notion of a system, for 'parts' can refer to concepts, judgments or material parts. In addition, Kant stated that a system is complete and that the parts of a system must be necessarily related to each other and to the whole in accordance with certain conditions. On the basis of our discussion we can now claim that these conditions comprise (i) logical rules or principles 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. Hence, to say that a system is complete does not mean that we have exhaustive knowledge of all the parts of a system (e.g., concepts). Rather, a system is a homogeneous ordering with specified bounds, in which the relation of the parts is determined in accordance with logical (a priori) rules or principles. Kant puts the point aptly in the architectonic of pure reason of the first *Critique*:

> I understand by a system, however, the unity of the manifold of cognitions under one idea. This is the rational concept of the form of a whole, insofar as through this the extension of the manifold as well as the position of the parts with respect to each other is determined a priori. (*KrV*, A 832/B 860, amended translation)[49]

Finally, some remarks on the term 'logical principle' are in order. In the first *Critique*, Kant described these principles as principles of 'homogeneity', 'specification' and 'continuity', through which we specify relationships among concepts. The rules of logical division, conditions (a)–(c) above, provide rules that guarantee a determinate order of concepts. By specifying that species must have a common genus, that specified species must exclude each other, and that species must constitute the total extension of the divided genus, they provide, in Kant's terms, conditions for determining "the place of each part

[48] Or, in terms of the *Logik*, by means of definitions and the rules governing logical specification.

[49] The Cambridge Translation renders *Umfang* as 'domain', instead of as 'extension'.

and its relation to the others."[50] In both cases, the term 'logical principle' is employed to denote that we construct systems of concepts in accordance with rules that guarantee a determinate order among genera, *differentiae* and species. This is a broad use of the term 'logical', a term encompassing what we would call methodological rules in science.[51]

Apart from the mentioned logical (methodological) principles, other types of principles can also figure in the construction of a system of concepts. For example, Kant took the classifications of Linnaeus to be *systems*. In his 1788 essay on teleological principles, Kant stated 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 (*Befruchtungstheile*) in vegetables."[52] This refers to Linnaeus's method of employing the structure of the sexual organs of plants, i.e., the number of pistils and stamina, as a principle for classifying plants.[53] This principle does not directly conform to the mentioned logical principles: it specifies an empirical criterion for classifying plants. Nevertheless, Linneaus' method of classification does proceed, in Kant's terms, *in accordance* with mentioned logical rules. For example, Linnaeus's classifications can be taken to be constructed in accordance with the rules of logical division (a)–(c), trying to find a complete specification of distinct species under a common genus. As such, they are constructed in accordance with the logical rules of division and provide us with a determinate ordering of concepts.

1.2 Objective grounding

The requirement of systematicity provides a condition that any science must satisfy. In the Preface to the *Metaphysische Anfangsgründe* (1786) Kant takes natural description, natural history, and chemistry to be systematic doctrines. However, he denies them the status of a *proper* science.[54] Hence, systematicity is not sufficient for distinguishing science from science proper. To make this distinction, Kant adds a second condition that any proper science must

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

[51] Hence, it is no surprise that for example the rules for logical division (a)–(c), discussed above, are treated in the so-called *Allgemeine Methodenlehre* of the *Jäsche Logik*.

[52] AA 7: 161.

[53] On Linnaeus's method and Kant's conception of Linnaeus, cf. Oittinen 2009, 51–77. See also Anderson 30, 63–69.

[54] AA 4: 467–468, 471.

satisfy. According to Kant, any proper science must be systematically ordered and constitute an interconnection of *grounds* and *consequences*. This condition provides a basis for distinguishing mere science from rational science, where being a *rational* science must be understood as a necessary but not sufficient condition for being a *proper science*:

> Any whole of cognition that is systematic can, for this reason, already be called science, and if the connection of cognition is an interconnection of grounds and consequences, even *rational* science. (AA 4: 468)

In other words, any rational science is a system of cognition containing some kind grounding-relation.[55] 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.[56] In the Model the proof postulate is related to the order of propositions or judgments. As we will see below, Kant takes a grounding-relation to obtain between *both* concepts and judgments. The grounding-relation obtaining between concepts may be related to the composition postulate of the Classical Model of Science (2b), according to which non-fundamental concepts of a science are composed of (or definable from) fundamental concepts (see §1.1).[57]

In the following, I will try to identify some core elements of Kant's conception of grounding by analyzing passages from both his pre-critical and critical writings. I will argue that Kant entertains a conception of grounding capturing the idea that scientific demonstrations are explanatory if they represent the objective order of grounds and consequences. This interpretation differs from the interpretation of Kant's views on grounding famously given by Michael Friedman, who, in a nutshell, takes grounding to be a relation between the a priori principles of a science and (empirical) laws proven on

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

[56] De Jong & Betti 2010, 186.

[57] *Ibid.*

the basis of these principles.[58] That Kant thinks that scientific cognition must allow of proof from a priori principles is certainly true (cf. §1.3). However, I take Kant's views on grounding to capture the different claim that proper scientific explanations must reflect the order of nature.[59] In short: I take Kant's views on grounding to show that for Kant proper scientific explanations are demonstrations *propter quid*. The notion of *demonstratio propter quid* can ultimately be traced to Aristotle's conception of a demonstrative or scientific syllogism.[60] Hence, the consequence of my argument is that Kant's view on scientific explanation is more Aristotelian than is often thought.

Kant provides an extensive discussion of the concept 'ground' (*ratio*) in his *Nova dilucidatio* (1755).[61] Here, a ground is defined as that "which determines a subject in respect of any of its predicates".[62] In addition, Kant describes 'to determine' as "to posit a predicate while excluding its opposite".[63] Hence, a ground is a reason for predicating some concept *P* of a subject-concept *S*, while excluding predication of *not-P*. Cognition 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 cognition there would be no knowledge of truths, since all judgments would be merely taken as possibly true: we would have no reason

[58] Friedman 1992b. Friedman does not provide a detailed analysis of the notion of 'grounding'. However, he does show concretely, with reference to Kant's views on Newton's deduction of the law of gravitation, how Kant takes inferences in natural sciences to be based on a priori principles. In addition, Friedman also allows for the possibility that empirical propositions may ground each other. 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 proper scientific explanation (cf. §1.5). Falkenburg 2000, 367–373, has provided 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. As I will argue in more detail below, Kant's ideas on 'grounding' cannot fully be understood in terms of derivability.

[59] De Jong & Betti 2010, 187, note that conditions (1)–(5) of the Classical Model of Science relate primarily to the *ordo essendi*, whereas conditions (6)–(7) typically regard the *ordo cognoscendi*. In relating Kant's views on grounding to (3b) of the Model, I also take Kant's conception of grounding to relate to the *ordo essendi*: proper scientific explanations must reflect the order of nature.

[60] Cf. De Jong & Betti 2010, 190; Dear 1998.

[61] Longuenesse has provided detailed accounts of the concept 'ground' in Kant's pre-critical and critical writings. Cf. Longuenesse 1998, 345–358, Longuenesse 2001. Different from Longuenesse I focus on the role of this notion in Kant's views on scientific explanation.

[62] AA 1: 391–392.

[63] *Ibid.*

to assert the truth of a judgment while taking its contradiction to be false.[64] This claim concerns the epistemic function of cognition of grounds but does not fully capture Kant's grounding condition.

In the *Nova dilucidatio*, Kant 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*.[65] Any structure of concepts or judgments can thus *express* a grounding-relation. For example, Kant takes a grounding-relation to be expressed in the judgment "a triangle has three sides".[66] The subject concept 'triangle' provides us with a reason for predicating 'three-sidedness' of triangles because a triangle is defined as a three-sided figure.

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* (*ratio cur*), while the latter is a ground of cognition, the reason *that* (*ratio quod*).[67] 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).[68] The eclipses of Jupiter's satellites are a consequence of the finite velocity of light and allow us to demonstrate this fact ($c \rightarrow r$).[69] 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's 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 ($g \rightarrow r$).

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64 AA 1: 393–394.

65 Many commentators, in discussions of Kant's views on the foundation of scientific cognition, focus exclusively on relations between *judgments*. Cf. Guyer 2005, 11–55; Friedman 1992b. This is not incorrect but does not do justice to the fact that conceptual orderings can also satisfy grounding relations. This is for example the case, as we will see in more detail below, for systems of classification given in natural description, though these systems do not express relations obtaining between real grounds and real consequences.

66 AA 1: 392.

67 AA 1: 391–392.

68 AA 1: 392–393.

69 *Ibid*. Cf. Longuenesse 2001, 69.

The distinction between an antecedently determining ground (ground of being or becoming) and a consequentially determining ground (ground of cognition) can be related to the traditional distinction between *demonstratio propter quid* and *demonstratio quia*. Since Descartes's hypothesis identifies the ground of becoming of the finite velocity of light, his account of the velocity of light reflects the objective order of ground and consequence and allows us to give a *demonstratio propter quid* of this phenomenon. 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 for the truth of judgments, i.e., a ground for some phenomenon (described by a judgment) to obtain, whereas a consequentially determining ground (ground of cognition) "does not bring the truth into being; it only displays it".[70]

Now, although this is not obvious from Kant's discussion in the *Nova dilucidatio*, an antecedently determining ground can also function as a ground of cognition. If we can, e.g., demonstrate that light has a finite velocity on the basis of Descartes's hypothesis ($g \rightarrow r$), assuming this hypothesis to be true, then Descartes's hypothesis also displays the truth of the proposition that light has a finite velocity. In fact, as will become more clear in the following, I take it that for Kant such scientific demonstrations are proper scientific explanations. In the following, we will also see that, in his critical period in particular, Kant typically identifies objective grounds of natural phenomena with *causes*. Hence, in natural science judgments can be taken to express a relation between objective ground and consequence when they express a relation between cause and effect.[71]

[70] AA 1: 394.

[71] I stress that Kant identifies objective grounds of phenomena with causes in his critical period in particular for the following reasons. As we have seen, in the *Nova dilucidatio* (1755) Kant takes the so-called 'ground of becoming' (*ratio fiendi*) and the 'ground of being' (*ratio essendi*) to be objective grounds providing reasons *why* something is the case. Descartes's hypothesis is taken to specify the ground of becoming or the *cause* of the finite velocity of light. Hence, in the *Nova dilucidatio* Kant takes as an example of a proper explanation in natural science an explanation that proceeds from cause to effect. However, the 'ground of being' (*ratio essendi*) provides us with a problematic case. Here, Kant seems to adopt Wolff's view that the *essence* of a thing provides an objective ground (reason why) for explaining why things have certain attributes. I will treat Wolff's conception of essence in detail in Chapter 2 (§§2.3–2.6). There, we will see that that Wolff takes the essence of a thing to provide the reason why for the attributes or *propria* of this thing (the *propria* of a thing are consequences of its essence). In my view, Kant comes to reject Wolff's use of the concept of essence in the course of his philosophical career. For Wolff, the essence of a thing is given (employing Kant's ter-

In the *Nova dilucidatio*, Kant took grounding to be a relation that can be expressed by relations holding between concepts and between judgments. This view is retained in the critical period. In the *Jäsche Logik*, it is argued that a concept can be taken as a *ground of cognition* with respect to the set of representations comprising its extension.[72] For example, the concept 'metal' functions as a ground of cognition with respect to the concepts 'gold', 'silver', etc. The idea is that a genus can function as a ground of cognition for its species: the relation of species to genus provides a ground for cognizing *that* gold is a metal. Given that a species is composed of the concepts contained *in* it (including its genus), we can, as said at the start of this section, take the composition postulate of the Classical Model of Science (2b) to capture a grounding-relation holding between concepts. In the following, we will see that the conception of genera providing grounds of cognition for the concepts comprising their extension can be related to Kant's conception of natural history.

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minology) by its logical essence. Thus, for example, 'extension' is part of the essence of 'body' ('extension' is the specific difference of 'body'). From the judgments that (i) bodies have extension, and (ii) whatever has extension is divisible, we can derive (iii) bodies are divisible. Through this derivation, we derive, from judgments (i) and (ii) in which we explicate the (complex) intension of the concept 'body' (and its constituent concepts), a judgment (iii) in which we predicate a *proprium* of bodies (divisibility). From Kant's perspective, (i) and (ii) are analytic judgments. They merely explicate the (complex) content (intension) of the concept 'body': 'extension' is the specific difference of 'body', whereas 'divisibility' is contained in the concept of 'extension' and thus also contained in 'body'. Judgment (iii) is thus analytically derived from the (logical) essence of the concept 'body': it allows of proof merely by analysis of the concept 'body' and by means of the principle of noncontradiction ('divisibility' may accordingly be called an analytic attribute of 'body'). I maintain that in the course of his career, Kant gradually came to adopt the view that through such purely analytic inferences we do *not* specify the objective ground (reason why) for many attributes or *propria* of things (see §2.7 for examples. Kant comes to call these *propria* 'synthetic attributes'. Cf. AA 11: 34–35). Hence, whereas in the *Nova dilucidatio* (1755) Kant still adopts the Wolffian concept of essence as providing a reason why, he does not do so in later works. In his *Untersuchung über die Deutlichkeit* (1764) Kant distances himself from Wolff's views on philosophical method and argues that the proper method in both metaphysics and natural science consists in the combined analytic-synthetic method (AA 2: 277, 286). In his *Ueber eine Entdeckung* (1790), Kant distinguishes analytic attributes from synthetic attributes (the latter being expressed by synthetic judgments a priori) and assigns a far greater importance to the latter. Most importantly, judgments predicating synthetic attributes are, in contrast to judgments predicating analytic attributes (see above), not merely analytically derivable in accordance with the principle of noncontradiction (cf. AA 8: 229–231).

[72] AA 9: 96.

First, however, I will try to answer the difficult question how Kant understood the relation holding between ground and consequence in the case where a grounding-relation is taken to obtain between propositions or judgments. In the first *Critique*, when explicating what he calls the logical use of reason, Kant describes the relation between ground and consequence in terms of *inference*:

> 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 an inference to be a function of thought that relates *true* judgments and shows that the truth of the conclusion follows from the premise(s). As types of inference Kant lists logical inferences: 'immediate inference', i.e., subalternation, contraposition and the like, and 'mediate inference', i.e., inferences of reason (typically syllogistic inferences).[73] If we employ modern terminology and strictly distinguish between logical inference and logical derivability (which Kant does not), we may be inclined to think that Kant takes a valid logical inference to express a relation of logical derivability holding between (the content of) true judgments and that the grounding-relation can be fully understood in terms of derivability. This is problematic as the notion of grounding is stronger than that of derivability. Grounding p means providing an explanative demonstration of p.[74] 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*, as is clear from the above quotation and as I will stress in the following).

These two difficulties can be partially resolved by employing Kant's distinction between grounds of cognition, which merely *display* truths, and objective grounds that are the source of truths. In Kant's view, I take it, the logical derivation of a true judgment β from a true judgment 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 specifies 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 this (G_2), that must obtain between scientific cognitions, since science must provide objective explanations representing the order of

[73] *KrV*, A 303/B 360.
[74] Cf. De Jong & Betti 2010, 190–191.

nature. Thus, we may distinguish between two types of grounding: (G_1) and (G_2). (G_2) captures the idea that science must provide demonstrations *propter quid*.[75] In the following, I will argue that although (G_1) and (G_2) must be distinguished in the manner described above, (G_2) is a special case of (G_1) in the following sense: α provides an explanative demonstration of 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 (ii) implies that α and β are true. Thus, (G_2) is a stronger notion than (G_1).

The interpretation that (G_1) and (G_2) must be distinguished from one another (i.e., that the grounding relation cannot be fully understood in terms of derivability) is supported by Kant's lectures on metaphysics, the *Metaphysik Volckmann*. Here, a ground is defined as that which, if it is posited, something else is posited. A distinction is made between the relation holding between a logical ground and logical consequence, and that holding between a real ground and real consequence.[76] The first relation obtains within analytic judgments, e.g., in the hypothetical judgment "if a being is an animal, it is mortal".[77] In such cases, the relation between ground and consequence can be established by means of the principle of identity, i.e., it is analytical.[78] 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, however, not specified by this logical proof. In the *Metaphysik Volckmann* this is explicated by stating that the concept of ground, as pertaining to *logic*, is "treated in so far it is a ground of cognition".[79] To emphasize the importance of this point, we may give another example. In the *Metaphysische Anfangsgründe*, Kant notes that the concept of impenetrability is contained *in* the concept of matter.[80] Thus, 'matter is impenetrable' is an analytic judgment,

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[75] In construing the relation of grounding in terms of (G_2), I deviate from Falkenburg, who explicates Kant's notion of grounding (as I have called it) in terms of derivability between truths. Falkenburg 2000, 368- 370. Hence, Falkenburg's conception of grounding corresponds to my (G_1).

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

[77] AA 28: 397.

[78] AA 28: 402.

[79] 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.

[80] AA 4: 509.

the truth of which allows of logical proof by means of the principle of identity (or contradiction). However, Kant also argues that the objective ground of matter's impenetrability is given by a repulsive force constitutive of matter.[81] The truth of this claim cannot be established analytically. Thus: derivability of β from α is not sufficient to establish that α specifies the objective ground of β .

The discussion of the concepts logical ground and logical consequence in the metaphysics lectures focuses on analytic judgments provable on the basis of the principle of identity. It can be taken to support the more general interpretation that Kant accepted something like (G_1): the logical derivation of a true judgment β from true judgment α establishes that α specifies a *ground of cognition* for the truth of β. But if we understand Kant's notion of logical inference as derivability 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 *truth* of the latter, whereas the relation of derivability can hold between false judgments. However, Kant, in contrast to our modern views on derivability, typically construes valid inferences as inferences for which the premises are *true*.[82] For this reason, Kant 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.

What about (G_2)? We have construed (G_2) as capturing the idea that a proper scientific demonstration of β from α, requires that α specifies the objective ground for what is asserted by β. However, does (G_2) also require that β is derivable from α? If so, (G_2) is a stronger rendering of (G_1), adding the condition that the premises of a scientific demonstration must provide insight into the objective grounds of what is asserted in the consequence. This question is not easy to answer. Kant's famous distinction between real grounds and real consequences sometimes suggests that judgments that are not derivable can also satisfy a grounding-relation. Take, for example, the relation between real ground (cause) and real consequence (effect), expressed in the hypothetical 'if I have been exposed to the cold, I will come down with the flu'. This relation is synthetic and cannot be proven in accordance with the principle of identity. We require experience in order establish to relation. This view points to the more general problem that causality cannot be construed logically.

Nevertheless, Kant stems from a philosophical tradition in which it was common to treat scientific judgments as being derivable from other judg-

[81] AA 4: 508.
[82] Cf. *KrV*, A 303/B 360. Cf. also AA 9: 121.

ments. Moreover, scientific demonstrations in which, through a series of inferences, propositions were shown to be derivable from certain (true) propositions, were taken as paradigmatic examples of proper scientific demonstrations.

In the *Jäsche Logik*, we find passages that support the idea that Kant adopted such a conception of scientific demonstration. Here, the so-called 'principle of sufficient reason' is presented as providing a positive criterion for establishing truths.[83] 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 suggest that Kant thought that in order to have a criterion for taking cognitions to be true, cognitions (including scientific judgments) must be derivable from other cognitions. Moreover, in the Introduction to the second edition of the *Critique*, Kant famously argues that though the principles (*Grundsätze*, axioms) of mathematics (geometry) can not be cognized *from* the principle of contradiction (i.e., are synthetic, not analytic), a synthetic proposition can be comprehended *in accordance with* the principle of contradiction, only if "another synthetic proposition is presupposed from which it is deduced (*gefolgert*), never in itself."[84] Thus, Kant allows for the possibility that synthetic judgments (e.g., mathematical, geometric propositions) can be logically inferred from each other.[85] These passages render it probable that Kant accepted (G_2) as a stronger rendering of (G_1), i.e., α provides an proper, explanative scientific demonstration of 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 (ii) implies that α and β are true.

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[83] AA 9: 51–52. It is this passage on which Falkenburg 2000, 368–370 bases her reading of grounding as derivability between truths.

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

[85] Note, however, that this passage also suggests, as mentioned above, that Kant allowed for propositions that are *grounded* by other propositions yet not *derivable* from other propositions. Kant emphasizes that the axioms of mathematics (geometry) cannot be proven logically (from the principle of contradiction). Indeed, as axioms they do not require proof. However, quite generally, Kant takes the possibility of mathematics to be grounded in transcendental philosophy, which shows how all mathematical propositions (including axioms) can be *applied* to empirical objects (cf. for example *KrV*, A 733–734/B 761–762). Importantly, the application of mathematical propositions to empirical objects is a condition for their truth. This points to the problem of grounding between different sciences, a problem which I cannot discuss in detail in the present context.

A nice example of how judgments or propositions in natural science were taken to be derivable from other judgments or propositions is given by Christian Wolff.[86] We can significantly increase our understanding of Kant's conception of grounding through a discussion of this example. In §25 of chapter 4 of the *Deutsche Logik* (1754), Wolff explains that syllogistic inferences enable us to provide proofs in natural science in accordance with the mathematical (geometric) method. Wolff 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. The experiment suggest, or so Wolff claims, 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 are proven through new inferences. The major is proven by means of an inference where the middle term provides the *definiens* of expensive 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 is a definition. The minor 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 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*]

[86] Wolff 1978 [1754], 176–178. For a brief discussion of the first step of Wolff's argument, cf. Anderson 2005, 39–40.

Like proposition [2*], proposition [3*] is treated as a fundamental principle (*Grundsatz*). Proposition [4*] is taken to be true on the basis of experience. In particular: it is taken to be true on the basis of Wolff's interpretation of our initial experiment.

Through this series of syllogisms, we have specified, Wolff claims, the matter that allows us to prove the proposition 'air has an expensive force' in accordance with the mathematical method. In this penultimate proof, Wolff presents [7*] as following from [1*]–[4*].[87] [1*] can be taken to provide a nominal definition of expansive force. As such, it provides according to Wolff a true ground on the basis of which we can give proofs.[88] [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*]–[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."[89]

I do not wish to argue that Kant accepted Wolff's views on the proper, i.e., *mathematical*, method of providing demonstrations in natural science. First, we may note that Wolff's demonstration treated above provides us (at least from Kant's perspective) with an instance of what I have called (G_1) and not of (G_2). In other words, we are dealing with a demonstration that exemplifies (mere) derivability from truths. Wolff's demonstration does not, as I will argue in more detail below, exemplify a demonstration in which propositions *objectively ground* each other (G_2). Since, as I have argued, Kant adopted a conception of objective grounding in terms of (G_2), he would criticize Wolff on this count. I will return to this topic later on in this section. Second, we may note that in the Doctrine of Method of the first *Critique*, Kant famously denied that the mathematical method, based on definitions, axioms and mathematical demonstrations, can be imitated in philosophy.[90] Some of his reasons for denying that the method of mathematics is applicable in philosophy also apply to Wolff's method of demonstrating propositions of

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[87] 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*].

[88] Wolff 1978 [1754], 145–146.

[89] Wolff 1963 [1728], 17.

[90] *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.

natural science in a mathematical fashion. In the following, I will first specify two of these reasons.

(i) In the previous section, we have seen that Kant did not take analysis to be a proper method for identifying the primitive concepts of a science. Analytic definitions do not necessarily provide proper definitions, i.e., definitions on the basis of a limited number of primitive concepts. Employing this strict conception of definitions, Kant, in the Doctrine of Method, even denies that empirical concepts can be defined. For Kant, definitions of empirical concepts are not obtained through analysis but through synthesis, since in defining concepts as 'air', 'fire', etc., one should not analyze what is contained *in them*, but investigate through experience what belongs to them.[91] However, this implies that we are not sure that we have adequately specified the marks of empirical concepts. Through new observations, we can both take away and add marks of an empirical concept, and therefore "the concept never remains within secure boundaries."[92] Wolff's proposition [1*] is taken to provide a definition of the concept of expansive force. Presumably, although Wolff of course does not say so, [1*] is an analytic definition. This would explain why Wolff takes [1*] to be a certain and immutable principle. Kant denies that we can analytically define empirical concepts as 'expansive force'. It is through experience that we must investigate the certainty of propositions such as [1*]. In short: Kant would deny that [1*] is a definition and that it is therefore a certain and immutable principle. This is to deny that the mathematical method, in which we start with definitions[93] and proceed from certain and immutable principles, can be imitated in natural science

(ii) Kant would further take issue with Wolff's construal of [2*] and [3*] as fundamental propositions (*Grundsätze*). For Wolff, fundamental propositions are propositions that can be immediately derived from definitions.[94] This allows us to entertain them without proof. For example, in his *Anfangs-Gründe aller mathematischen Wissenschaften* (1750), Wolff takes the definition of a circle, i.e., that figure described by moving a straight line around a fixed point, to directly imply the proposition that all lines drawn from the centre of a circle to the periphery are equal. This type of fundamental proposition, which states what is the case, is called an axiom. Fundamental propositions that state

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[91] AA 9: 141.

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

[93] Cf. *KrV*, A 730/B 759.

[94] Wolff 1999 [1750], 16.

what can be done are, in contrast, called postulates.[95] Here we have Wolff's construal of the traditional mathematical notions of axioms and postulates.

Wolff treats [2*] and [3*] as fundamental propositions (axioms) merely because he entertains them without proof. He recognizes that, in contrast to axioms in mathematics, they allow of proof and are taken to be certain on the basis of experience. In short: Wolff does not seem to treat [2*] and [3*] as real axioms. He merely states that although they allow of proof, they are sufficiently clear from experience and hence, following the example of Euclid, we can call them axioms and refrain from giving the cumbersome proof.[96] Kant is more strict in his terminology. In the doctrine of method of the first *Critique*, Kant defines axioms as synthetic a priori principles that are immediately certain, and argues that axioms only exist in mathematics.[97] Given that Wolff acknowledges that [2*] and [3*] are merely treated as axioms, this difficulty seems merely terminological. However, [2*] and [3*] are assigned the term 'axiom' to emphasize that they constitute certain, true propositions. Kant would question this point because they are merely justified empirically. From Kant's perspective, then, [1*]–[4*] are all empirical propositions and this means that they lack adequate epistemic justification. As we shall see in the next section (§1.3), Kant argues that the fundamental propositions of a science, and the fundamental propositions on the basis of which we give proofs in science, must be known a priori. It is only on the basis of proofs from a priori principles that we have adequate epistemic justification for taking the proven theorems to be true. In §1.4 and §1.5, we will consequently see that Kant argues that both mathematics and metaphysics provide a priori principles for physics. In conclusion: Kant would criticize Wolff for not specifying the true a priori principles (grounds) of proofs in natural science.

It is clear that Kant would have objected to Wolff's construal of [1*]–[4*]. For our present purposes, however, it is important to note that Wolff's treatments of proofs in natural science shows how judgments in natural science were taken to be derivable from each other. Hence, although the evidence is somewhat sparse, it seems likely, also given the historical context, that Kant did conceive of judgments in (natural) science as being ordered in terms of the relation of derivability, i.e., took (G_1) and (G_2) as entailing that judgments in science must be derivable from other judgments.[98]

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[95] Wolff 1999 [1750], 16–17.

[96] Wolff 1978 [1754], 177.

[97] *KrV*, A 732–733/B 760–761.

[98] Although, to emphasize this point again, the relation of derivability should not be *identified* with (G_2). Below we will see that from Kant's point of view Wolff's proof is *not* an instance of (G_2), i.e., is not an instance of a demonstration *propter quid*.

There are more lessons to be learned from Wolff's example. In finding a proof of the proposition 'air has an expansive force', Wolff seems to give prominence to hypothetical syllogisms. All three syllogisms treated above can be taken (or reconstructed) as hypothetical, i.e., in Wolff's terms, they are inferences under conditions (in this case: when *A* is the case *B* is the case, *A* is the case, hence *B* is the case)[99] In the *Jäsche Logik*, hypothetical inferences of reason are similarly construed as having a hypothetical proposition as major, expressing a relation of consequence between two propositions (the *antecedens* and *consequens*). In the major, the *antecedens* is treated as a problematic condition. In the minor, the *antecedens* is asserted categorically, and we infer through *modus ponens* (or, alternatively, through *modus tollens*).[100] Note that this conception of a hypothetical syllogism does not fully adequately capture the syllogisms treated above. These syllogisms typically move from a hypothetical major to a minor in which the *antecedens* is said to be true of some particular.[101] In the following, we will provide more examples of demonstrations in natural science, mainly taken from Newton's *Principia*, that can also be interpreted as having this type of structure. Although it is not unproblematic to construe these types of inferences as hypothetical syllogisms, it is understandable in light of the syllogistic logic available to the likes of Wolff and Kant.

Propositions [1*]–[4*] provide a sufficient ground for establishing the truth of [7*]. Given that [7*] is a consequence of [1*]–[4*], it makes sense to treat [1*]–[4*] collectively as constituting a complete ground, whereas taken individually [1*]–[4*] constitute partial grounds for the truth of [7*].[102] This, to be sure, is merely suggested by Wolff's example of a demonstration of [7*]. However, other passages in Wolff's writing also suggest a distinction between partial grounds and complete grounds. In his *Discursus praeliminaris* (1728), Wolff distinguishes philosophical from historical knowledge by noting that the latter provides knowledge of the bare fact, whereas the former exhibits the reason (ground) of the fact, so that it is understood why something is

[99] Wolff 1978 [1754], 169–170.

[100] This treatment conforms to that of Meier given in his *Auszug aus der Vernunftlehre* (1752). Cf. AA 16: 745–747.

[101] From our modern perspective, we would construe the hypothetical major 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.

[102] The notions of complete and partial grounds, as employed here, 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 developing 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".

or occurs.[103] In this context, the notion 'reason' refers to objective grounds in nature. To elucidate this distinction, Wolff states that it is "one thing to know that water flows in the bed of the river", while it is another thing to know "that this occurs because of the slope of the bottom and because of the pressure which the lower water sustains from the higher."[104] Here, we have a conjunction of two partial reason explaining why water flows in the bed of a river. Wolff also applies the single term cause to a complex of partial reasons. He notes that the cause of the elliptical motion of the comets, primary planets and secondary planets is an 'impressed force', by which he means the force upon which a planet strives to move through a tangent at a point of its orbit,[105] *and* the centripetal force of gravity.[106] Hence, in specifying the reason for why a thing is or occurs, we try to specify the complete reason (ground) for why a thing is or occurs, which is often a complex of partial reasons. In providing a proper scientific proof for why a thing is or occurs, we then specify a collection of propositions, constituting a complete ground from which a consequence (theorem) can be derived.

Kant can also be taken to distinguish between partial and complete grounds while affirming that proper proofs in science must proceed from premises constituting a complete ground of a consequence. In the fourth section of the transcendental doctrine of method of the first *Critique*, Kant argues that in science direct or ostensive proofs (proofs via *modus ponens* or hypothetical syllogisms) are preferable to apagogic proofs (i.e., proofs from the falsity of a consequence derived from a cognition to the falsity of the cognition, often construed as proof by contradiction).[107] The reason given is that direct or ostensive proofs provide insight into the 'sources' of a truth, i.e., provide "comprehensibility of the truth in regard to its connection with the grounds of its possibility", whereas apagogic proofs do not.[108] This argument once again shows Kant's commitment to the idea that proper scientific explanations are explanations from grounds to consequences. Kant continues by stating:

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[103] Wolff 1963 [1728], 5.
[104] *Ibid.*
[105] Wolff 1963 [1728], 8.
[106] Wolff 1963 [1728], 5.
[107] *KrV*, A 789–794/B 817–822. Cf. AA 9: 5–53.
[108] Recall that in the *Nova dilucidatio*, Kant described an antecedently determining ground as the *source* for the truth of judgments, whereas a ground of cognition (consequentially determining ground) was not a source of truth but merely displays it. In the passage of the first *Critique* now under discussion, ostensive proofs are taken to prove insight into the sources of truths, whereas apagogic proofs (proofs by contradiction) merely show cognition to be certain (i.e., display truths).

> The real cause for the use of apagogic proofs in various sciences is probably this. If the grounds from which a certain cognition should be derived are too manifold or lie too deeply hidden, then one tries whether they may not be reached through their consequences. […] instead of having to run through the entire series of the grounds in a ostensive proof that can lead to the truth of a cognition by means of a complete insight into its possibility, one need only find a single false one among the consequences flowing from its contrary, and then the contrary is also false, thus the cognition that one had to prove is true. (*KrV*, A 790–791/B 818–819)

Certain or true cognitions can have manifold (partial) grounds from which they should be derived. In an ostensive proof we should run through the entire series of (partial) grounds, providing us with a *complete* insight into the possibility of a true cognition. In other words, in an ideal scientific explanation we should specify the totality of grounds (judgments), i.e., the complete ground, from which the truth of a cognition can be derived. This discussion concerns the *ordo cognoscendi* but can, as in the case of Wolff, be related to the *ordo essendi*, in which, e.g., an effect can result from multiple causes.

Let us return to Wolff's proof of [7*] from [1*]–[4*]. Can we, abstracting for the moment of the Kantian difficulties specified in (i) and (ii) and treating [1*]–[4*] as true cognitions, treat this proof as an instance of a proper scientific demonstration in the sense of a demonstration *propter quid*? The answer is clearly negative. For 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*]. A demonstration *propter quid*, by contrast, proceeds from cognition of an objective ground to cognition of its consequences. For example (returning to our previous case): a hypothetical syllogism with a major stating that if the globules of the atmosphere in which light is propagated are elastic, light has a finite velocity. A minor asserting the antecedent of the major, and the inferred conclusion that light has a finite velocity.

In this context, we may note that in the *Prolegomena* Kant cites the judgment "air is elastic" as an example of a judgment of perception, i.e., a merely subjectively valid judgment, formed on the basis of perceptions.[109] In the *Metaphysische Anfangsgründe*, Kant remarked that the "expansive force of matter is also called *elasticity*."[110] Hence, the judgment "air is elastic" is none other than Wolff's proposition [7*]. Whether or not Kant actually has Wolff in mind remains a question. However, the proof of [7*] involves a crucial appeal to observation and experiment, and the characterization of "air is elastic" as a judgment of perception makes sense. Importantly, in the dynamics of the

[109] AA 4: 298–299.
[110] AA 4: 500.

Metaphysische Anfangsgründe, Kant adopts a causal and mechanical account of the elasticity of air, 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.[111] It is only through such judgments trying to identify the objective grounds (causes, e.g., heat) of effects (e.g., the elasticity of air) that we can provide demonstrations *propter quid*.

In the preceding, we have construed objective grounds as causes, and consequences as effects. In the critical period, when dealing with natural science, Kant takes judgments of natural sciences 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., 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*.[112] In light of the foregoing we can thus conclude: in natural science α provides a proper explanation of

[111] AA 4: 522. Cf. AA 4: 530.

[112] AA 28: 355. The same conception of scientific demonstration, entitled 'dogmatic proof', is articulated in the *Danziger Physik*. AA 29: 103–104. The *Danziger Physik* stems from 1783, i.e. just before the publication of the *Metaphysische Anfangsgründe* (1786). In both these works from the critical period, Kant adopts a view of proper scientific explanation as proceeding from causes to effects (see also 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. For example, whereas (as we have seen) Kant cites an instance of proper explanation in natural science in the *Nova dilucidatio* (1755) that should be interpreted as an explanation proceeding from cause to effect, 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). In many of his other writings, however, Kant seems to adopt a conception of proper explanation in natural science as proceeding from causes to effect. The passage cited from the *Untersuchung über die Deutlichkeit* need not be inconsistent with this position, since Kant also ascribes to Newton the combined analytic-synthetic method, which is traditionally conceived of as a method proceeding (first) from effect to cause and (second) from cause to effect.

β, if β is derivable from α and α specifies the cause of β, where β is derivable from α implies that α and β are true.

Let us finally return to the *Metaphysische Anfangsgründe*. In the Preface to this work, natural description is denied the status of a proper science on the basis of Kant's grounding condition.[113] This doctrine does not provide "cognition through reason of the interconnection of natural things".[114] I take this to mean that natural description does not provide demonstrations *propter quid*. Natural description is defined as a "system of classification for natural things in accordance with their similarity".[115] Kant employs this notion to characterize classifications of natural kinds 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 genera provide grounds of cognition of species. However, this taxonomy does not provide us with an objective ground for *why* lions are feline. Linnaeus's taxonomy does not provide us with 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.

The status of natural history is problematic. In his 1788 essay on teleological principles Kant construes natural history as a discipline investigating relations between present properties of natural objects and their historical causes.[116] Causal regularities relating present effects with 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 similar effects as 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.[117] However, Kant emphasized that inferences by

[113] 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.

[114] AA 4: 467–468.

[115] *Ibid.*

[116] AA 8: 61–62.

[117] 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 (causal) explanations. Cf. Sloan 2006, 629. On natural history, see §5.8.

analogy merely provide empirically (non-apodictically) certain cognition[118] and stressed that natural history is a novel science in need of further development.[119] This may explain why natural history is classified as a *doctrine* rather than a *science* of nature.

1.3 Apodictic certainty

The third and final condition that any system of cognitions must satisfy in order to be a proper science as presented in the *Metaphysische Anfangsgründe* is that its cognitions are apodictically certain, i.e., that we are conscious of their necessary truth:

> What can be called *proper science* is only that whose certainty is apodictic; cognition that can contain mere empirical certainty is only *knowledge* improperly so-called. (AA 4: 468)

In the *Logik*, Kant defines knowledge (*Wissen*), opinion (*Meinung*) and belief (*Glaube*), as modes of holding-to-be-true (*Fürwahrhalten*). Holding something to be true is, in turn, defined as a judgment through which something is *subjectively* "represented as true".[120] In other words, opinion, belief and knowledge are terms that 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 relates to the *ordo cognoscendi* and states that any proposition of a science is known to be true.[121] In Kant's work the *Knowledge Postulate* is related to the *Necessity Postulate* of the Classical Model of Science (condition (5)), which states that all propositions or judgments of a science are necessary, since he argues that we only have knowledge of a proposition or judgment 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

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[118] AA 9: 133.
[119] AA 8: 62.
[120] AA 9: 65–66.
[121] De Jong & 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 discussed in section 2, which relates to the *ordo essendi*.

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.[122] 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)".[123] 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.[124]

In the *Logik*, a distinction is made between two types of sources of knowledge: experience, the source of empirical cognition, and reason, the source of rational knowledge. Rational knowledge is apodictically certain and can be divided into knowledge that is mathematically (intuitively) certain or philosophically (discursively) certain.[125] This distinction relates the epistemic status of mathematical and philosophical cognition to the methods of proof employed within mathematics and philosophy. Mathematical knowledge is intuitively certain because it is proven on the basis of a priori construction in pure intuition. In particular, mathematical theorems are mediately certain synthetic a priori propositions demonstrated from immediately certain (intuitive) synthetic a priori principles (axioms). Philosophical propositions are mediately certain propositions derived from (discursive) synthetic a priori principles. Both mathematical theorems and philosophical propositions are apodictically certain because they are proven on the basis of a priori principles. Empirical cognition, 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".[126] Thus, if empirical cognition can be cognized from (proven from) a priori principles, this cognition is apodictically certain and we obtain knowledge. Something

[122] *KrV*, A 820–22/B 848–850.
[123] *KrV*, A 829/B 857.
[124] Cf. Falkenburg 2001, 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, i.e., have *knowledge* of these propositions.
[125] AA 9: 70–71.
[126] AA 9: 71.

can therefore be cognized with apodictic certainty even if this cognition is partially based on empirical evidence.

The foregoing shows that the epistemic justification that we have for judgments in a particular science is determined by the relation of these judgments to the *principles* (fundamental judgments) of this science. In particular, 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 only provide us with *knowledge*, 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 will 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 do not play any 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 a proof from a priori principles.

Kant's conception of 'proper science' can now be summarized as follows: in order to be a proper science, any body of cognition must be (i) systematically organized, (ii) express relations between objective grounds and consequences, (iii) have a priori principles on the basis of which the non-fundamental judgments of a science can be proven. These conditions comprise Kant's model of 'proper science'.

Though (i)–(iii) comprise Kant's views on proper science, the Preface to the *Metaphysische Anfangsgründe* is infamous for a further claim. This is the claim that any proper natural science must contain mathematics, which Kant employs to deny that chemistry and psychology are natural sciences proper. In the next section I will deal with Kant's requirement that any proper science must contain mathematics. I will argue that the latter requirement follows from the requirement that any proper science must have a priori principles. Such a view is suggested by Kant's criticism of chemistry as presented in the *Metaphysische*

Anfangsgründe. Kant argues that because the principles of chemistry are not mathematical, we lack a priori cognition of the principles underlying chemical appearances.[127] It is because of the latter reason that chemistry is denied the status of a proper science.

It is not immediately clear why Kant thinks that mathematics is required to provide an a priori foundation of sciences. Kant's view becomes clearer if we take into account that he takes mathematization to be a necessary condition of the scientific status of doctrines of *nature*. Kant takes this view because he interprets mathematics as a science that provides us with a priori cognition of individual *corporeal* objects. In particular, mathematics provides a priori *grounds of cognition* that ground apodictic certain cognition of corporeal objects. As such, mathematics allows us to give an a priori foundation of natural sciences. Before developing this interpretation, I will first discuss a more instrumental interpretation of Kant's requirement that proper natural science must contain mathematics.

1.4 Mathematics, a priori justification and grounding

The requirement that a proper natural science must contain mathematics (what I will call the requirement of mathematization) is sometimes taken to be equivalent to the requirement that the concepts of such a science be quantifiable. Kant's claim that "in any special doctrine of nature there can be only as much *proper* science as there is *mathematics* therein",[128] is accordingly read as stating that only doctrines dealing with measurable magnitudes qualify as proper natural sciences.[129] Kant's mathematization requirement is thus simply taken to express the importance of measurability.

This reading certainly captures part of Kant's intentions in emphasizing the importance of mathematics within natural science. In the modern period mathematics was often thought of as providing a quantitative description of

[127] AA 4: 470–471.

[128] *Ibid*.

[129] This view has been endorsed by several commentators. Cf. Okruhlik 1986, 313; Nayak and Sotnak 1995, 133–151. The latter authors assume that, according to Kant, the purpose of the application of mathematics within natural sciences is to allow for the *measurability* of the objects of these sciences. In the following I will argue, in contrast, that mathematics is in the first place assigned a foundational function with respect to natural science because it provides a priori principles securing the apodictic certainty of cognitions pertaining to the natural sciences.

(empirical) objects.[130] Nevertheless, I do not think this reading can explain Kant's mathematization requirement completely. A difficulty confronting the above reading is that it conflates the notion of mathematization and that of measurability.[131] It is true that Kant thought that the mathematical representation of magnitudes enables the measurement of magnitudes. Nevertheless, one should carefully distinguish the notion of mathematization from that of measurability. In the *Kritik der Urteilskraft*, Kant states that we measure natural objects by assigning numbers to particular objects and that measurement requires the selection of a unit of measurement. The selection of a unit is *arbitrary* or context dependent.[132] In a purely mathematical context we can, e.g., represent numbers and their relations in terms of relations between line segments. In measuring natural objects we empirically specify a particular kind of object as unit of measurement. Hence, mathematics does not by itself provide a measurement procedure. Consequently, we must distinguish between Kant's conception of mathematization and that of measurability.

If we focus on Kant's argument for the claim that proper natural sciences require mathematics, it becomes clear that considerations concerning measurability do not play any role. This argument, contained in Preface to the *Metaphysische Anfangsgründe*, 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".[133] Kant continues his argument by stating that "to cognize something a priori means to cognize it from its mere possibility".[134] I take this to mean that cognition of the possibility of an object can be gained a priori by means of the analysis of its concept. However, according to Kant such a procedure does not enable us to cognize "the possibility of determinate natural things".[135] From this it is concluded that "in order to cognize the possibility of determinate natural things, and thus to cognize them a priori, it is still required that the intuition corresponding to the concept be given a priori, that is, that the concept be constructed".[136]

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

[131] Nayak and Sotnak conflate these two conceptions. Cf. Nayak and Sotnak 1995, 113, 142, 144.

[132] AA 5: 251.

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

[134] *Ibid.*

[135] *Ibid.*

[136] *Ibid.*

And this is a task for mathematics, since mathematical cognition is defined as cognition obtained through the construction of concepts.[137]

In order to understand Kant's position we must explain why only mathematical construction allows us to have a priori cognition of determinate natural things. I take Kant to hold that in order to have (i) a priori cognition of determinate natural objects, one needs (ii) singular and immediate, a priori representations of these objects. In order to have (ii) mathematics is required (according to Kant). This reading follows from the claim that a priori cognition of determinate natural things requires the *construction* of their concepts.

In the Discipline of Pure Reason of the first *Critique*, Kant explains that mathematical reasoning is based on the construction of concepts, which is defined as follows: "to *construct* a concept means to exhibit a priori the intuition corresponding to it".[138] The term 'intuition' refers to a particular instance of a concept. In contrast to concepts, i.e., general representations representing their object mediately (via intuitions), Kant further interprets intuitions as *singular* representations that represent their object *immediately*.[139] Hence, mathematical cognition, based on the construction of concepts, concerns singular and immediate representations of objects (the term 'object' is explicated below). Moreover, since within mathematics the constructed intuition is exhibited a priori, which is to say that singular representations employed within mathematical demonstrations (e.g., an isosceles triangle) can represent all intuitions falling under the same concept (all isosceles triangles),[140] a characteristic of mathematical demonstration securing the universality of what is demonstrated, mathematics provides *a priori* cognition of objects.

With which objects is mathematics concerned? Kant accepts the traditional conception of (pure) mathematics as a science of magnitude. Geometry, for example, is construed as providing a priori cognition of space and spatial

[137] Falkenburg 2000, 289, and Pollok 2001, 86–87, take this argument as asserting that a proper 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. Kant argues that a proper science must contain mathematics because any proper science must be based on a pure part, i.e., on a priori principles that lie on the basis of the empirical part. This suggests that Kant assigns a specific, a priori foundational function to mathematics with respect to natural science. I will explicate this function in the following. The main focus of Kant's remarks concerning mathematics in the Preface to the *Metaphysische Anfangsgründe* seems to be that mathematics secures the *apodictic certainty* of judgments of natural science.

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

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

[140] *KrV*, A 713–714/B 741–742.

relations and thus concerns continuous magnitude. How, then, does mathematics provide a priori cognition of *natural* objects? In the first *Critique*, Kant argues that mathematical concepts relate to "data for experience" by means of the *a priori* construction of figures or images.[141] A figure or image is an intuition: it is a particular (sensible and concrete) instance of a concept. In the *Prolegomena*, Kant further explains that (geometrically) constructed images agree with empirical phenomena.[142] 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. That Kant entertains this position is not surprising, for his views on mathematics stem from a tradition that took mathematical cognition to be descriptive of the empirical world. For example, Christian Wolff, in his *Mathematisches Lexicon*, defines geometry as "a science of the space taken up by corporeal things in their length, breadth, and width".[143] Moreover, since all things occupy space, Wolff argues, geometry is applicable to all objects and provides cognition of the latter. This position is similar to that of Kant, for Kant took geometry, insofar as it provides cognition of the structure of space, to provide cognition of the formal features of perceptible spatiotemporal objects. The general conception motivating Kant's views on mathematics is thus that mathematics provides knowledge of the formal (spatiotemporal) features of corporeal objects.

In order to substantiate the present reading we can cite Kant's well-known claim that in mathematical problems the question is not about "existence as such at all, but about the properties of the objects in themselves".[144] Thus, Kant does not attribute existence to mathematical objects (pure intuitions). In a similar vein, Kant states:

> Through determination of the former [pure intuition] we can acquire *a priori* cognitions of objects (in mathematics), but only as far as their form is concerned as appearances; whether there can be things that must be intuited in this form is still left unsettled. Consequently all mathematical concepts are not by themselves cognitions, except insofar as one presupposes that there are things that can be presented to us only in accordance with the form of that pure sensible intuition. Things in space and time, however, are only given insofar as they are perceptions (representations accompanied with sensation), hence through empirical representation. *(KrV*, B 147)

[141] *KrV*, A 240/ B 299.
[142] AA 4: 287.
[143] Wolff 1965 [1716], 665. On Wolff's views on mathematics in relation to Kant see Shabel 2003.
[144] *KrV*, A 719/B 747.

This passage conveys Kant's view that the objective reality of mathematical concepts, i.e., the *possible existence* of objects falling under such concepts, requires their possible application to *empirical intuitions*, i.e., to perceivable empirical objects, a view that implies that mathematics yields a body of truths only insofar as it is applicable to empirical objects.[145] Hence, when Kant claims that by means of mathematical construction we cognize the form of objects (appearances), he is referring to the form of empirical objects (phenomena). Note that Kant thinks that cognition of the objective reality of mathematical concepts requires a *philosophical* justification.[146] The construction of mathematical concepts in pure intuition (space and time) guarantees their objective reality if we presuppose that "there are things that can be presented to us only in accordance with the form of that pure sensible intuition". This supposition requires the philosophical justification, given in the Transcendental Aesthetic, that space and time are pure forms of sensible intuition. Given the truth of this supposition mathematical construction establishes the objective reality of mathematical concepts. In particular, by means of mathematical construction we show the possible existence of empirical objects, the form of which is given by the construction. A different way of putting this is that mathematics provides a priori models that possibly represent (formal features of) existing and empirically given natural objects. With this in mind we can turn to the foundational role that Kant attributes to mathematics.

Kant's view on the role of mathematics in natural science is exemplified, I take it, by Newton's use of mathematics in his *Philosophiae Naturalis Principia Mathematica* (1687[1]).[147] Newton's rational mechanics, as presented in the *Principia*, provides a clear example of a science that, in Kant's terms, *contains* mathematics. 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.[148] The relation of mathematics to natural

[145] On these and the following points, see: Thompson 1992, 97–101; Parsons 1992a, 69–75; Friedman 1992a, 98–104.

[146] I will return to this view on the subordination of mathematics to philosophy in §1.5.

[147] 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 that are relevant to understanding Kant.

[148] Newton 1999 [1726], 382. Cf. the introductory remarks to Book 3, in which Newton claims that he will exhibit the system of the world from the mathematical principles of natural philosophy. Newton 1999 [1726], 793.

science (physics), is described by Newton in the Scholium of section 11 of Book I:

> 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 1999 [1726], 589)[149]

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, describes areas around that point proportional to the times (i.e., satisfies Kepler's law of areas), then that body is subject to a centripetal force tending toward that point.[150] In Proposition 1 of Book III (in which 'we are coming down to physics'), we can compare this mathematical principle to the phenomena. In particular: we compare it to what is called phenomenon 1, which tells us (among others) that the satellites of Jupiter describe areas proportional to the times, i.e., their motion satisfies Kepler's law of areas.[151] 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 are maintained in their orbits are centripetal forces, i.e., are directed toward the centre of Jupiter.[152] Finally (having arrived at the level of physics) we argue concerning the physical species and causes of these forces (accelerations), e.g., we take the force of gravity as a cause of celestial motions. 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, I will argue, to Kant's conception of the use of mathematics in physics. In a single phrase: mathematics enables deductive demonstrations from a priori principles in natural science.

Of course, the term 'mathematics' is here used in a rather broad sense. At the very least, we are not merely dealing with pure mathematical concepts. Newton is quite aware of this fact. In definition 8 at the beginning of the

[149] 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.
[150] Newton 1999 [1726], 446.
[151] Newton 1999 [1726], 797.
[152] Newton 1999 [1726], 802.

Principia, in line with the remark quoted above, Newton notes that he employs words signifying attraction, impulse, or any sort of propensity toward a centre, considering "these forces not from a physical but from a mathematical point of view".[153] Hence, 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 mathematical points)".[154] In short, Newton's mathematical principles can be treated as kinematic principles, in which, e.g., the notion of a centripetal force can be treated as signifying a centripetal acceleration. These principles allow of application to nature and, through their application, provide an instrument in obtaining cognition of physical forces or reasons. Let us now return to Kant.

A nice illustration of the foundational role of mathematics Kant assigns to mathematics can be found in §38 of the *Prolegomena*.[155] In this section Kant gives various examples that elucidate the transcendental claim that the understanding prescribes a priori laws to nature. The *pièce de résistance* is an example taken from physical astronomy: "a physical law of reciprocal attraction, extending to all material nature, the rule of which is that the attractions decrease inversely with the square of distance from each part of attraction."[156] In other words, the main focus of §38 is some version of the law of gravitation. Note, that Kant focuses on the dependency of gravitation on distance, i.e., the fact that gravity is an inverse-square force ($1/r^2$). How is this law prescribed to nature by the understanding?

The first example of §38 is mathematical. Kant refers to Proposition 35 from Book III of the *Elementa* of Euclid, stating that if two straight lines intersect one another in a circle at point E, and intersect the circle at *A*, *C* and *B*, *D*, it holds that $AE \times EC = BE \times ED$. According to Kant, this law is dependent on the understanding because it can be demonstrated "only from the condition on which the understanding based the construction of this figure, namely, the equality of the radii".[157] Hence, the proof of the above law

[153] Newton 1999 [1726], 408. Cf. Cohen 1980, 68–78; See also Friedman 1992a, 227–234.
[154] *Ibid*.
[155] This section has been subjected to a very detailed and subtle interpretation by Friedman, to which my interpretation is indebted. Cf. Friedman 1992a, chapter 4. I employ §38 of the *Prolegomena* as providing an example that allows us to understand (i) the particular foundational role that Kant assigns to mathematics with respect to physics (which Friedman does not fully explicate), and (ii) Kant's claim that *only* mathematical natural sciences constitute *proper* natural sciences.
[156] AA 4: 321.
[157] *Ibid*.

is based on the condition that all straight lines from the centre of the circle to its boundary are equal, a condition expressed in Euclid's definition of a circle. The second example is construed by Kant as a generalization of the above property of circles to conic sections. This proposition states that chords intersecting in a conic section intersect in such a way that the rectangles from their parts "stand to one another in equal proportions".[158] Thus, the products of the lengths of the segments of the chords of any conic section stand to one another in equal proportions. If we let chord AC intersect chord BD at E, and let chord $A'C'$ intersect chord $B'D'$ at E', then for all conic sections $(AE \times EC) : (BE \times ED) = (A'E' \times E'C') : (B'E' \times E'D')$.[159] It is precisely this property of conic sections that Kant presents as a basis for inferring that gravity is an inverse-square force (emphasizing the intimate link between mathematical principles and what is called the physical law of gravity).[160]

This choice of inference is understandable if we, following Friedman[161], consider the Newtonian background of Kant's argument. In particular, we must take into account Newton's derivation of the inverse square law given in Propositions 11–13 of Book I of the *Principia*. In Proposition 11 Newton employs an instance of the property of conic sections described above to prove that: if a body P moving along an ellipse is subject to a force f centrally directed toward a focus S, then f is inversely proportional to SP^2.[162] In Propositions 1 and 2 of Book I, Newton had shown that a force acting on a body with uniform linear motion is centrally directed towards a given point *if and only if* this motion describes equal areas in equal times with respect to that point (i.e., satisfies Kepler's empirical law of areas).[163] Hence, Newton's proof of Proposition 11 shows that if a body moving along an elliptical orbit describes equal areas in equal times with respect to the focus of the ellipse, it is subject to a central force that is inversely proportional to the square of the distance from that focus. In Propositions 12 and 13 Newton proves that the same holds for hyperbolic and parabolic orbits. Moreover, in Corollary 1 of Proposition 13, Newton conversely proves that a moving body subject to a centripetal inverse-square force will orbit along a conic section. In short, Propositions 11–13 of Book I prove that orbital motion along a conic section satisfying the law of areas implies an inverse-square force (and vice versa). Kant's argument in §38 suggests that he had this derivation in mind.

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[158] *Ibid.*
[159] Cf. Friedman 1992a, 191.
[160] AA 4: 321.
[161] Friedman 1992a, 191–194.
[162] Newton 1999 [1726], 462–463.
[163] Newton 1999 [1726], 444–448.

Newton's Propositions 11–13 provide us with mathematical demonstrations of particular equivalences. Kant suggests that these demonstrations allow us to infer that gravity is an inverse-square force. This is understandable if we recognize that the mathematical principles developed in Book I provide a basis for Newton's derivation of the law of gravitation in Book III of the *Principia*.[164] In particular, Kant seems to envision an argument along the following lines. Newton's Proposition 11 of Book I proves that if a body moves in an ellipse and satisfies the law of areas, this motion is governed by an inverse-square centripetal force. We know empirically, by means of Newton's "phenomena", that the satellites of primary bodies orbit in an ellipse and satisfy Kepler's law of areas with respect to their primary bodies situated at a focus. Hence, we can infer mathematically that these satellites are subject to an inverse-square force directed towards their primary bodies. Newton himself employs this type of reasoning in the first three propositions of Book III, insofar as he applies mathematically demonstrated relations, obtaining between centrally directed inverse-square forces maintaining a body in orbit and this motion satisfying Kepler's laws, to phenomena. These relations allow him to infer that the satellites of Jupiter and Saturn are subject to an inverse-square force directed toward the center of their primary planets (Proposition 1)[165], that the planets are subject to an inverse-square force directed towards the sun (Proposition 2), and that the moon is subject to an inverse-square force directed towards the earth (Proposition 3). These propositions provide us with the first steps in Newton's argument for the law of gravitation and allow him to conclude that gravity is an inverse-square force.

The use of mathematics within natural science described above suggests that mathematics can be interpreted as providing models of the physical world, by means of which we cognize quantitative relations obtaining between individual objects. This is a three step procedure: (i) we mathematically establish that motion along a conic section satisfying (one of) Kepler's laws implies a centripetal inverse-square force; (ii) we empirically observe that heavenly bodies orbit in a conic section and satisfy (one of) Kepler's laws; (iii) we infer

[164] As Newton puts it himself in the Introduction to Book III, the task of Book III is to "exhibit the system of the world from these same principles." The locution 'same principles' refers to the mathematical principles of philosophy expounded in Books I and II. Newton 1999 [1726], 793.

[165] Newton does not, however, employ Proposition 11 of Book I, but Proposition 2 of Book I, allowing us to use the law of areas to infer the existence of a centripetal force, and Corollary 6 of Proposition 4 of Book 1, allowing us to use the harmonic law to infer the existence of an inverse-square force. For an analysis of Newton's argument: Harper 2002, 174–201.

the existence of a centripetal inverse-square force. Kant took mathematics as providing models of physical objects and would have interpreted Newton's application of mathematical principles to phenomena accordingly. In this case, a mathematically constructed conic section functions as a model of the motions of heavenly bodies, enabling the inference from (i) and (ii) to (iii) by subsumption.

Note that this inference is successful because we have a fit between our mathematical model and observable phenomena. This fit need not always obtain. In his discussion of the mathematical-mechanical mode of explanation in the *Metaphysische Anfangsgründe*, a mode of explanation he attributes to Descartes, Kant states that this mode is based on concepts that can be mathematically represented (e.g., 'extension', 'corpuscle', 'space').[166] According to Kant we can, then, construct mathematical models on the basis of concepts central to the mathematical-mechanical mode of explanation. Nevertheless, this mode of explanation is rejected since it employs empty concepts such as 'void space' or 'absolute impenetrability', i.e., concepts the object of which cannot be cognized as existing since their instances are not observable. Consequently, mathematical models based on empty concepts are not, as I will call it, *adequate* to particular existing objects, i.e., they are incorrectly applied to particular empirical objects (a critique that can be understandably directed at Descartes). Although the construction of a mathematical model secures its objective reality, i.e., its possible application to objects, construction does not establish to which particular empirical objects these models can legitimately be applied.[167] In the next section, I will treat this difficult topic in more detail.

For Kant, mathematics, when correctly applied to nature, provides a priori justification of physical cognition. The derivation of the inverse-square law, discussed above in relation to §38, allows us to see this. For the claim that gravity is an inverse-square force is based on mathematically demonstrated (a priori cognizable) relations. We apply these relations to observable phenomena in order to infer mathematically that, e.g., the planets are subject to an inverse-square force directed towards the sun. The latter claim is thus proven

[166] AA 4: 524–525.

[167] Hence, I cannot follow commentators who interpret Kant's mathematization requirement as following solely from his view that the mathematical construction of the concepts of a science secures their *objective reality*. Cf. Falkenburg 2000, 289; Pollok 2001, 86–87. This reading does not fully explain why mathematics is necessary in order to secure the *apodictic certainty* of judgments in physics. Moreover, as is now clear, although constructability secures objective reality, it does not secure that mathematical models are *adequate* to particular natural objects. This adequacy is required, however, if mathematics is supposed to provide a priori justification of scientific cognitions.

on the basis of a priori principles and is accordingly *apodictically certain*. Note, moreover, that it provides cognition of a specific quantitative relationship obtaining between individual objects. Hence, mathematics allows us to obtain a priori grounded cognition of *determinate natural things*.

We may relate Kant's views on the role of mathematics in natural science to his conception of grounding explicated in §1.2. According to Kant, I take it, mathematics provides a priori *grounds of cognition* of determinate natural things. Mathematics does not, by itself, specify objective grounds of phenomena. Recall, for example, Newton's demonstration of Proposition I of Book III (partially treated above).[168] This demonstration is based on Proposition 2 of Book I, which showed that if the motion of a body, with respect to some point, satisfies Kepler's law of areas, it experiences a centripetal force toward that point. This, according to Newton himself, is a mathematical (kinematical) proposition, in which we abstract from physical forces, causes, etc. Thus, we show that a body moving in accordance with Kepler's law of areas experiences a centripetal acceleration. We do not specify a relation between cause and effect. Although it is of course possible to demonstrate mathematically quantitative relations between cause and effect, mathematical demonstrations themselves are not sufficient for establishing causal relations. The inference to the existence of the physical force of gravitation, which can be construed as the cause (objective ground) of celestial motions, requires, apart from the mathematical principles demonstrated in Book I and Book II, the application of these principles to phenomena *and* application of the laws of motion. Mathematics itself is not sufficient to infer to the existence of gravitation.

Kant has a similar conception of kinematics. In the Phoronomy of the *Metaphysische Anfangsgründe*, which deals with kinematics, Kant argues that in phoronomy we merely provide a mathematical analysis of motion. We abstract from the concepts of force, mass and physical body, and consequently do not treat of causal relations (a relation between existents).[169] More generally, as we have already seen, Kant argues that in mathematics we are not concerned with *existence*. Mathematics does not allow us to infer to the existence of objects.[170] In natural science, in order to infer to the existence of a physical force being the cause of motion, we require the application of the laws of motion, which for Kant are *metaphysical* principles. In short: it is only through a combination of

[168] I will fully treat this demonstration below.
[169] AA 4: 480.
[170] *KrV*, A 719/B 747. See also §1.5, in which I will return to these points.

mathematical, empirical and metaphysical principles that we obtain cognition of the existence of causes.

The upshot of our discussion is that, for Kant, mathematics primarily fulfills an *epistemic* function with respect to physics, while mathematics alone is not sufficient to explain natural phenomena. Such a reading is confirmed by the fact that Kant occasionally describes mathematics as an *organon* of the sciences, which is to say that mathematics is an instrument for bringing about certain cognition.[171] In short, mathematical demonstration of judgments in natural science secures *knowledge* but does not by itself guarantee that judgments ground each other, i.e., express objective relations between grounds and consequences.[172]

We may deepen our understanding of Kant's construal of mathematics as an *organon*, i.e., an instrument (heuristic) for bringing about certain cognition, by looking once more at Newton's use of mathematical principles in Book III of the *Principia*. As said, in Propositions 1–3 of Book III Newton employed mathematically demonstrated propositions and empirically established phenomena to infer that the planets and satellites are subject to a central, inverse-square force. In Proposition 4, Newton famously showed that the force maintaining the moon in its orbit can be identified with terrestrial gravity, while Proposition 5 generalizes this result, showing that the satellites of Saturn and Jupiter gravitate toward their primary planets, the primary planets gravitate toward the sun, and that (by the third law of motion) "there is gravity toward all planets universally".[173] Proposition 6 shows that for all bodies gravitating toward planets, the weight of these bodies is proportional to their quantity of matter (mass), whereas Proposition 7 demonstrates that gravity toward the planets is proportional to the mass of the planets (the attracting body).[174]

The method employed in this deduction from the phenomena is aptly described by Newton in the *Author's Preface to the Second Edition*: we employ mathematically demonstrated propositions (of Book I and II), in order to

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

[172] However, as we will see below, mathematics can be taken to supplement or 'perfect' our knowledge of objective grounds, and is thus instrumental to providing objective explanations in natural science.

[173] Newton 1999 [1726], 806.

[174] Newton 1999 [1726], 806–811. For a detailed account of Newton's entire argument, cf. Harper 2002.

derive the gravitational forces by which bodies tend toward the sun and toward individual planets *from* celestial phenomena.[175] Hence, Newton, as he indicates himself, employs the *analytic method*: we reason from effects (celestial phenomena) to their causes (gravitational forces).[176] Since the discovery of true causes is partly based on the application of mathematically demonstrated propositions, mathematics can, from Kant's perspective, be regarded as an *organon* of natural science: mathematics provides a priori principles on the basis of which we can reason, with *certainty*, from effects to causes.

After deducing the causes by analysis, we apply the *synthetic method*.[177] In his *Author's Preface* Newton states that 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."[178] A concrete example of the application of this method is given in Proposition 13 of Book III. There, 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 satisfy the law of areas was accepted in Newton's discussion of celestial phenomena. However, Newton states that "now that the principles of motion have been found, we deduce the celestial motions from these principles a priori."[179] In providing this a priori deduction, Newton refers to the established result that the "weights of the planets toward the sun are inversely as the squares of the distance from the center of the sun".[180] Hence, the 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.[181] Call this demonstration [A*].

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[175] Newton 1999 [1726], 382.

[176] 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 1999 [1726], 386.

[177] 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).

[178] Newton 1999 [1726], 382.

[179] Newton 1999 [1726], 817.

[180] *Ibid*.

[181] 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

We may note the similarities between this a priori deduction and the deductions from phenomena given in Propositions 1–3 of Book 3, which demonstrated the existence of central inverse-square forces acting on the satellites of Jupiter and Saturn, the planets and the moon. Take, once again, Newton's 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.[182] In Propositions 1 and 2 of Book I, Newton mathematically demonstrated 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 Kepler's law of areas. In Corollary 6 to Proposition 4 of Book I, Newton demonstrated that if a body in circular motion satisfies Kepler's harmonic law, it is subject to a centripetal inverse-square force.[183] 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 Kepler's law of areas and Kepler's harmonic law.[184] Call this demonstration [B*].

Both [A*] and [B*] are based on the application of mathematically demonstrated propositions. Given that, from Kant's perspective, [A*] and [B*] are based on mathematical, a priori propositions, both demonstrations warrant us to assign apodictic certainty to the inferred conclusions. In addition, both may be reconstructed as logically valid inferences. However, in [B*] we infer from effect to cause. In contrast, in Newton's a priori (synthetic) deduction of planetary motion satisfying the law of areas [A*], 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 demonstration providing an instance of grounding (G_2), as explicated in §1.2. This shows that proper scientific demonstrations (i.e., explanative demonstrations) proceed synthetically.

Let us summarize our results and show how our interpretation of Kant's conception of the role of mathematics in natural science explains why (for Kant) *only* natural sciences that contain mathematics are proper sciences.

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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 1999 [1726], 818. Cf. Cohen 1999, 231–233.

[182] Newton 1999 [1726], 802.

[183] Newton 1999 [1726], 451.

[184] Newton 1999 [1726], 797. Cf. Harper 2002, 175–177.

According to Kant, it is mathematics alone that provides insight of specific quantitative properties of individual physical objects on the basis of a priori principles. This is a consequence of the fact that mathematics, through mathematical *constructions*, provides a priori models (individual and concrete representations) of physical objects. Philosophy or metaphysics provide *discursive* a priori principles valid for natural objects. In contrast to mathematics, philosophical or metaphysical cognition is not based on the construction of concepts. Consequently, it does not provide a priori models of individual physical objects that can be applied to nature in order to obtain apodictically certain cognition of specific relations obtaining between the quantities of individual objects. To refer once more to Newton, only mathematics allows an inference from orbital motion along a conic section according to the law of areas to an inverse square force on the basis of a priori (mathematical) propositions. The use of these propositions in scientific demonstrations (e.g., in [A*] and [B*]) secures that inferred consequences are inferred from a priori propositions, and can thus taken to be apodictically certain. In terms of the classical model of science, only if natural science contain mathematics can they satisfy condition (6), i.e., can we know propositions concerning specific features of determinate, individual objects.

We have taken Kant to assign a primarily epistemic foundational function to mathematics. Can we relate Kant's requirement that natural sciences must contain mathematics to condition (3b) of the classical model of science, i.e., to the requirement of objective grounding specified in §1.2? As I have stressed, mathematics does not specify objective grounds of phenomena, rather it provides grounds for cognizing phenomena. Nevertheless, in Kant's time it was common to conceive of mathematics as providing insight into the quantitative features of objective grounds, which, in turn, allows us to understand how specific consequences follow from grounds. As such, mathematics is often taken to be necessary (though not sufficient) for providing explanatory demonstrations in natural science. For example, Christian Wolff takes mathematics to provide (i) certitude or certainty of physical knowledge (a view, which, as we have seen, Kant shares), and (ii) to perfect our insight into the grounds of phenomena.[185]

In order to understand (ii), I may 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.,

[185] Wolff 1963 [1728], 15, 18–21.

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".[186] Thus, the hexagonal grid is optimal.[187] Exactly the same example is given by Wolff in the eighteenth century[188]:

> […] 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 1963 [1728], 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). In this example, it is stressed that 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. In our Newtonian demonstration [B*], which I have construed as providing a demonstration *propter quid*, mathematics can be taken to fulfill a similar role. Only be means of mathematical knowledge of the quantitative features of gravity (the objective ground of celestial motion), e.g., knowledge of the fact that it is a centripetal, inverse-square force, can we objectively demonstrate that the motion of planets satisfies Kepler's laws of areas. Hence, although this is not obvious in Kant's writings and we lack hard evidence, it is probable that Kant, like Wolff, inter-

[186] Lyon & Colyvan 2008, 228–229

[187] Mancosu 2008.

[188] Mancosu bases himself on the work of Lyon & 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 not found any mention of Wolff however.

preted mathematics as necessary for providing explanative scientific demonstrations.

In conclusion: Kant adherence to the idea that in science we must provide objective, explanative demonstrations (condition (3b) of the Model), and the idea that scientific cognition must be apodictically certain or constitute knowledge (condition (6) of the Model) can explain why Kant thought that proper natural sciences must contain mathematics.

1.5 Metaphysics, a priori justification and objective grounding

In the previous section we have discussed the foundational role Kant assigned to mathematics in natural science. To conclude this chapter we may inquire into Kant's views on the relation between metaphysics and natural science. The aim of the *Metaphysische Anfangsgründe* is to specify the metaphysical principles of natural science. These principles are part of a *special* (*besondere*) metaphysics of corporeal nature, which is contrasted to *general* metaphysics (the transcendental part of metaphysics of nature).[189] A *proper* natural science must be based on metaphysical (a priori) principles, pertaining to special metaphysics. This requirement, like the requirement that a proper science must be mathematical, follows from the condition that scientific cognition must be apodictically certain (discussed in §1.3), which demands that scientific cognition is demonstrated on the basis of a priori principles. In terms of the Model, the requirement that natural science must be based on metaphysical principles follows from condition (6). However, this requirement can also be related to the idea that the propositions (judgments) of a science must be grounded in fundamental propositions (judgments), i.e., conditions (3a) and (3b) of the Model.

In the Preface to the *Metaphysische Anfangsgründe*, Kant expresses the requirement that natural science be based on metaphysical principles by stating that all proper natural sciences must be based on a *pure cognition of nature*: "All *proper* natural science therefore requires a *pure* part, on which the apodictic certainty that reason seeks therein can be based".[190] Since both metaphysics, described as "pure rational cognition from mere concepts"[191], and mathematics, described as pure rational cognition from "the construction of con-

[189] AA 4: 469–470.
[190] AA 4: 469.
[191] *Ibid.*

cepts"[192], provide (different forms of) a priori (pure) cognition of nature[193], proper natural science must be based on both metaphysical and mathematical principles. The need for a metaphysics of nature is subsequently argued for as follows:

> *Properly* so-called natural science presupposes, in the first place, metaphysics of nature. For laws, that is, principles of the necessity of the which belongs to the *existence* of a thing, are concerned with a concept that cannot be constructed, since existence cannot be presented *a priori* in any intuition. Thus proper natural science presupposes metaphysics of nature. (AA 4: 469)

Kant is contrasting metaphysics and mathematics. In the previous section (§1.4), we noted that Kant argued that the mathematical construction does not (by itself) establish the *existence* of objects corresponding to this concept. In the first *Critique*, Kant thus claims that in mathematical problems the question is not about "existence as such at all, but about the properties of the objects in themselves".[194] It is only on the basis of *philosophical* justification, i.e., the proof that space and time are pure forms of sensible intuition, that we can take mathematical constructions to secure the objective reality of concepts, i.e., that we are justified in taking mathematical concepts to apply to empirical objects. In the remark quoted above, Kant claims that only if natural science is based on a metaphysics of nature, can we have cognition of laws of nature, which are represented by judgments expressing a relation between an *existing* object and (one of) its necessary characteristics. In the following, we will see *in concreto* how metaphysics fulfills this task.

Kant's conception of the role of metaphysics with respect to natural science is too complex to be dealt with in full in this chapter. Moreover, it has given rise to various debates that lie beyond the scope of our present investigation. In the current section, I will restrict myself to a general discussion of four topics that allow me to relate Kant's views to the classical model of science. First (i), I will 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 (ii), I will discuss Michael Friedman's interpretation of Kant's views on the role of metaphysics in natural science and relate these views to my conception of grounding. Third (iii), I will relate Kant's views on metaphysics in natural science to conditions (3a) and (3b) of the Model, i.e., explain how metaphysics helps natural science

[192] *Ibid.*
[193] AA 4: 468.
[194] *KrV*, A 719/B 747.

to provide explanative demonstrations. Finally (iv), I will specify how we should understand the relationship between a special metaphysics of corporeal nature and mathematics.

(i) Kant's claim that the apodictic certainty of natural science requires metaphysical foundations must be read in its historical context. In the Preface to the *Metaphysische Anfangsgründe*, Kant notes that mathematical physicists have always "made use of metaphysical principles", even if they "guarded against all claims of metaphysics upon their science"[195] Nevertheless, these physicists acknowledged that they could not base concepts of the proper object of physics (matter), i.e., concepts of motion, of inertia, etc, on empirical principles, for this is inconsistent with taking scientific cognition to be apodictically certain. Hence, they preferred to *postulate* principles governing these concepts, without "investigating them with regard to their a priori sources".[196]

Newton is the likely target of the above criticism. In a remark to his proof of the third law of mechanics, i.e., the law of the equality of action and reaction, Kant criticizes Newton for appealing to experience in order to substantiate its validity rather than proving it a priori.[197] Moreover, Newton treated the three laws of motion as axioms. In contrast, for Kant only pure mathematical judgments can be axioms, i.e., immediately (intuitively) certain judgments (evident judgments).[198] In (natural) philosophy, according to Kant, axioms have no place. Finally, in the Scholium to the laws of motion Newton appealed to empirical evidence for these laws, citing (e.g.) experiments with colliding pendulums and machines to show the certainty of the third law of motion.[199] This appeal to experiment can, in Kant's opinion, only establish the empirical certainty of the laws of motion. It does not demonstrate the apodictic certainty of these laws, i.e., provide a justification for taking them to be necessarily true. The laws of motion thus require a priori proof.

Kant attempts to provide such an a priori proof in the Mechanics chapter of the *Metaphysische Anfangsgründe*. The principles of natural science (laws of motion) are proven on the basis of a priori principles of transcendental philosophy (analogies of experience).[200] In these proofs, we specify (instantiate) the

[195] AA 4: 472.
[196] AA 4: 472.
[197] AA 4: 549.
[198] *KrV*, A 732–733/B 760–761. Cf. Falkenburg 2000, 290.
[199] Newton 1999 [1726], 424–430.
[200] 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

principles of transcendental philosophy with respect to corporeal nature, thus providing a transition from general metaphysics to a special metaphysics of corporeal nature.[201] For example, Kant proves the law of inertia, according to which every change in matter has an *external* cause[202], on the basis of the transcendental proposition that every change has a cause. Kant bases his argument on the premise that all determinations of matter are determinations of external relations in space. It follows that all changes in matter occur by means of motion (the change of external relations to a given space).[203] The causal principle of general metaphysics tells us that all changes have a cause, hence all changes in matter must have a cause. Finally, these changes can not be due to an internal cause, for matter has no absolutely internal determining grounds (i.e., desires, intentions, etc.). Hence, all changes in matter (occurring via motion) are due to external causes. In a similar fashion, Kant provides an a priori proof of the law of action and reaction by instantiating the third analogy of experience in relation to corporeal nature.

The details and validity of Kant's procedure of inferring metaphysical principles of natural science on the basis of transcendental principles are beyond the scope of our present investigation.[204] It suffices to note that this procedure justifies taking fundamental principles of natural science (e.g., the laws of mechanics) to be necessarily true, i.e., *apodictically certain*. Other fundamental principles of natural science that Kant specifies, e.g., principles underlying the mathematical (kinematic) analysis of velocity, the dynamic forces of attraction and repulsion (explaining how matter can fill a space), are also justified a priori. In this manner, the apodictic certainty of the principles of natural science is guaranteed.

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applying them to the empirical concept of matter, Kant 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.

[201] On the relation between general and special metaphysics, cf. Kramer 1985; Friedman 2001.

[202] 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.

[203] AA 4: 482, 543.

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

In §1.3, we have seen that Kant allowed empirical knowledge to be apodictically certain "insofar as we cognize an empirically certain proposition from principles a priori".[205] Newton's laws of motion provide a nice example. Whereas Newton, as Kant recognized, justified these laws empirically, thus obtaining an empirically certain cognition, Kant proves these propositions from a priori, transcendental principles (principles of general metaphysics), thus allowing us to take them to be apodictically certain. This line of thought may be extended to non-fundamental cognitions of natural science. Insofar as these cognitions can be cognized on the basis of the apodictically certain principles of special metaphysics (i.e., the metaphysical principles of natural science, including Kant's laws of mechanics) they, in turn, can be taken to be apodictically certain.

To summarize: the a priori principles of general metaphysics allow us to prove the principles of a special metaphysics of corporeal nature, which constitute the fundamental principles of natural science by means of which non-fundamental cognitions of natural science are proven. It is only through such a hierarchy of sciences that condition (6) of the classical model of science can be taken to be satisfied with respect to natural science.

(ii) The foundational role of metaphysics with respect to natural science has been beautifully analyzed by Michael Friedman. Friedman has identified a clear example of a non-fundamental cognition that is cognized on the basis of a priori principles in natural science. This is the law of gravitation. Friedman has argued that according to Kant the law of gravitation, an empirical law deduced from phenomena, can be attributed a 'material necessity', insofar as its grounds are cognized a priori.[206] These grounds comprise the a priori cognizable laws of mechanics (demonstrated on the basis of the analogies of experience), the Newtonian mathematical principles of natural philosophy, and the fundamental force of attraction (taken, in contrast to Newton, to be essential to matter). As such, Friedman takes the law of gravitation (and ultimately all empirical laws) to be 'a priori grounded'.[207]

As said, this conception of grounding is different from the notion of objective grounding explicated in §1.2. Friedman's notion of grounding is strictly epistemic. It highlights that we can take scientific cognition to be necessarily

[205] AA 9: 71.

[206] Friedman 1992a, 175–177. Cf. Friedman 1992b, 175–167, As we have seen, Kant's logic lectures support this view, although there Kant employs the more familiar term of apodictic certainty instead of 'material necessity'.

[207] Cf. Friedman 1992b, 175–186.

true (apodictically certain) if we cognize it from a priori principles. In contrast, the notion of objective grounding explicated in §1.2 (called G_2) highlights that proper scientific demonstrations are explanatory if they represent the objective order of grounds (causes) and consequences (effects). Hence, my interpretation of Kant's conception of grounding is more narrow than that of Friedman.

On Friedman's reading, who takes any relation between a priori principles and empirical cognition as a grounding relation, natural science is a priori grounded by mathematics. In §1.4, we have seen that Kant interpreted mathematics as providing a priori principles (a priori grounds of cognition) on the basis of which scientific cognition can be demonstrated. The demonstrated judgments are thus apodictically certain. However, as also indicated in §1.4, mathematical principles do not themselves specify *objective grounds* of particular consequences. Mathematics provides an instrument for reasoning with certainty from cause of effect or vive versa. Recall the honeycomb example. The explanation of why hive-bee honeycombs have a hexagonal structure refers to: (a) evolutionary facts (providing the objective ground), and (b) the mathematical demonstration that the hexagonal tiling is optimal. In this manner, mathematics allows us to provide demonstrations *propter quid* (it completes, in Wolff's terms, our knowledge of objective grounds). However, cognition of (a) is not provided by mathematics. Mathematical principles alone cannot be taken to objectively ground scientific cognition in my sense of the term (though, to be sure, they figure in explanative demonstrations).

Like mathematical principles, the laws of motion (metaphysical principles of natural science) fulfill an epistemic role in securing the apodictic certainty of scientific cognitions. Demonstrations of scientific cognitions on the basis of the laws of motion need not be explanative demonstrations in the sense that they specify the relationship between objective ground and consequence. To see this, we may once again focus on Newton's demonstration [B*] (cf. §1.4) of the fact that the satellites of Jupiter are subject to a centripetal inverse-square force.[208] Recall that this demonstration was based on mathematically demonstrated propositions, relating centripetal forces to Kepler's law of areas and motion satisfying Kepler's harmonic law to inverse-square forces, and an empirically established phenomenon telling us that the motion of the satellites of Jupiter satisfies Kepler's law of areas and Kepler's harmonic law.[209]

In [B*], mathematical principles are applied to empirical phenomena. Recall also that in several passages of the *Principia* Newton states that the

[208] Newton 1999 [1726], 802.
[209] Newton 1999 [1726], 797.

analyses of motion given in Book I are purely mathematical and abstract from any considerations concerning physical nature, i.e., concerning the existence of physical bodies with physical characteristics, physical forces, etc.[210] Thus, sticking to our example, by merely applying mathematical principles (of Book I) to phenomena, a procedure described above, we would provide a mere kinematical analysis of the motion of the satellites of Jupiter.[211] In other words, we would merely be able to conclude that these satellites are subject to a centripetal acceleration that is inversely proportional to the square of the distance to Jupiter, without being able to conclude to the existence of an actual *physical* force that is the cause of their motion. In order to legitimately infer to an actual physical force, we need to derive forces from motions by applying Newton's laws of motion.[212]

Kant entertains a similar conception of the laws of motion. Recall that the laws of motion instantiate the analogies of experience. In the first *Critique*, Kant described the analogies of experience as dynamical principles (as opposed to mathematical principles) that are concerned with the *existence* of appearances and their relation to one another with respect to their existence.[213] In addition, analogies are regulative principles providing universal rules for relating existents given empirically.[214] The laws of motion can similarly be interpreted as providing (a priori) rules for relating existents. This is clear from Kant's chapter on phenomenology of the *Metaphysische Anfangsgründe*. In Proposition 2 of the Phenomenology, Kant analyzes curvilinear motion as a continuous change of rectilinear motion, i.e., as a continuous arising of new motions. By applying the law of inertia, Kant concludes that "every body in circular motion manifests (*beweiset*), by its motion, a moving force".[215] Thus, the law of inertia allows us to infer to the existence of an actual physical force

[210] Cf. Definition 8, Newton's introduction to the section 11 of Book I, and the introductory remarks to Book III. Newton 1999 [1726], 407–408, 561, 793. On Newton's construal of these mathematical principles, and his procedure of study of increasingly complex mathematical systems providing increasingly better representations of the physical world, see: Cohen 1980, 61–68; Cohen 2002, 78–80.

[211] Cf. Friedman 1992a, 227–237.

[212] Cf. Friedman 1992b, 177–178; Friedman 1992a, 229–230. Friedman especially stresses the importance of applying Newton's third law of motion, which shows that physical bodies are mutually attracted and thus highlights that a pure mathematical (kinematic) treatment of centripetal attraction as motion towards an immovable centre is inadequate for determining the true motions of physical bodies. In the following, I will abstract from the third law of motion.

[213] *KrV*, A 178/B 220.

[214] *KrV*, A 179–180/B 222–223.

[215] AA: 4: 557.

(cause) from the curvilinear motion of bodies (effect). Here, we have a clear example of the manner in which, according to Kant, metaphysical principles (the laws of motion) allow an inference to the *existence* of a force, an inference which cannot be made on the basis of mathematics or kinematics alone.

If we interpret Newton's proof of Proposition 1 of Book III from Kant's perspective, we may conclude that this proof is (i) deductively valid, (ii) based on mathematical principles, and (iii) insofar as we take the laws of motion to be a priori true, this proof allows us (via the application of the laws of motion) to conclude to the existence of an actual physical force that is the cause of the centripetal acceleration of the satellites of Jupiter. In this manner, the judgment that the satellites of Jupiter are subject to an centripetal inverse-square force is cognized on the basis of empirical phenomena and a priori principles, and can thus be taken to be apodictically certain. This is all in line with Friedman's rendering of Kant's views on the role of the laws of motion. Nevertheless, in contrast to Friedman's views on grounding as a relation between a priori principles and empirical cognition, it is quite clear that such a demonstration does not specify the objective relation between ground and consequence, for once again we infer causes from effects. In §1.2, we have seen that Kant construes explanative demonstrations as proceeding by the *a priori* method, in which we proceed from cognition of the ground to cognition of its consequence. Newton's [B*] does not fit this model. Hence, in these deduction we cannot speak of cognitions objectively grounding each other.

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

We have seen that a special metaphysics of corporeal nature specifies apodictically certain principles of physics. In particular, as said, the *Metaphysische Anfangsgründe* specifies principles or grounds of (a) phoronomy (kinematics), (b) dynamics and (c) mechanics. (a)–(c) provide fundamental principles of physics, capturing condition (3a) of the Model. They are principles on the basis of which all non-fundamental propositions or judgments are demonstrated. As such, (a)–(c) constitute grounds for cognizing the non-fundamental propositions of physics.

However, we have also seen that demonstrations based on the laws of motion (c), need not be demonstrations *propter quid*. The most perspicuous

example is perhaps Newton's deduction of the law of universal gravitation itself, which is based on the application of mathematical principles and the laws of motion, yet is a deduction *from* phenomena (from effects to causes). In phoronomy (kinematics) (a), moreover, we are merely concerned with providing a mathematical analysis of motion. Here, we abstract from the concepts of force, mass and physical body.[216] As a consequence, in phoronomy we do not treat relations between causes (objective grounds) and effects (consequences).

It is in the *Dynamics* of the *Metaphysische Anfangsgründe* that Kant specifies objective grounds of natural phenomena. Here, Kant introduces the concept of force and consequently the concept of cause. In the first proposition of the Dynamics, Kant argues, against corpuscular accounts of matter, that matter fills a space, i.e., resists other matters striving to penetrate the space it occupies, not though its mere existence, but through a particular *moving force*, i.e., a force that is the *cause of motion*.[217] In particular (Proposition 2), matter fills a space through the repulsive forces of all of its parts.[218] This fundamental repulsive force, construed as an inverse-cube force acting in contact, is taken to contain the *ground* of the (relative) impenetrability of matter, a universal characteristic of material bodies.[219] The fundamental force of repulsion is counteracted by a fundamental force of attraction, construed as an inverse-square, long-range force, which is the cause of weight (*Schwere*).[220] Roughly, if there is a balance between the fundamental forces of attraction and repulsion, matter of a determinate extension is generated.[221]

For our present purposes, it is important to note that Kant construes the possibility of matter as resting on the fundamental forces of attraction and repulsion. Hence, attraction and repulsion belong to the *essence* of matter.[222] Traditionally, i.e., in the writings of Wolff and Baumgarten, the essence of a thing is construed as that which contains the *ground* (the reason why) of necessary characteristics of a thing. This view fits Kant's construal of the fundamental forces of attraction and repulsion as pertaining to the essence of matter. Attraction and repulsion are constitutive of matter. Moreover, Kant argues that attraction provides the objective *ground* for the weight of material bodies whereas repulsion provides the objective ground for the relative impen-

[216] AA 4: 480.
[217] AA 4: 497.
[218] AA 4: 499.
[219] AA 4: 508.
[220] AA 4: 534.
[221] For a detailed account of Kant's dynamical theory of matter, cf. Carrier 2001a, 206–212; Carrier 1990, 170–210.
[222] AA 4: 511.

etrability of material bodies, both weight and impenetrability being necessary, universal characteristics of matter.[223] The fundamental forces of attraction and repulsion thus provide the reason *why* of universal characteristics of matter, i.e., they enable explanative demonstrations.

The fundamental 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 the Dynamics, Kant extends his dynamical theory, aiming to provide an account of the *specific variety* of matter, e.g., an account of density differences among material bodies in terms of the fundamental forces of attraction and repulsion, the aggregate states of matter, etc.[224] In this manner, non-fundamental propositions or judgments are explained in terms of fundamental grounds (conditions (3a) and (3b) of the Model).[225] In the present context I cannot argue for this point in more detail. However, it seems clear that Kant's treatment of the fundamental forces of attraction and repulsion in the Dynamics nicely fit his views on explanative demonstrations expounded in this chapter.

Kathleen Okruhlik has described Kant's *Metaphysische Anfangsgründe* as an attempt to 'ground' physics (especially mechanics) in an 'ontology of forces'.[226] However, she does not explain how we should understand the notion 'grounding'. More recently, Eric Watkins has emphasizes Kant's indebtedness to the Leibnizian-Wolffian tradition, which intended to develop an adequate ontology providing a foundation of physics.[227] When reading Kant,

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[223] AA 4: 518.

[224] AA 4: 523–535. For details, cf. once again Carrier 2001a, 212–215.

[225] As Friedman has emphasized, Kant also seems to argue, in Observation 2 to Proposition 7 of the 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 points to Proposition 7 of Book III of Newton's *Principia* in which Newton, in order to develop a method for determining the masses of bodies in the solar system, aims to show the proportionality of gravitational attraction to mass, but in which (according to Friedman's construal of Kant's argument) Newton *assumes* the essentiality and universality of gravitational attraction. In this manner, then, Kant's fundamental force of attraction is related to Newton's deduction of the law of gravity. Friedman 1992a, 153–159. Carrier 2001b, has, in line with Friedman, argued that Kant takes gravitation to provide a universal basis for measurements of mass, while emphasizing, in contrast to Friedman, that Kant takes this measurement to be based on terrestrial, rather than astronomical, effects of gravitation.

[226] Okrhulik 1983, 251–268, esp. 256–261.

[227] Watkins 2001a, 138–139. Cf. Watkins 2001b.

the notion ontology should of course be used with care. However, my account of Kant's metaphysical foundation of dynamics stresses, similar to Okruhlik and Watkins, that Kant intended to specify objective grounds (forces) that allow us to explain various characteristics of matter. Moreover, we now have an account of grounding that (at least partially) allows us to understand why Kant intended to ground physics on the basis of a limited number of fundamental forces. Physics should aim at providing demonstrations *propter quid*, and this requires the specification of fundamental, objective grounds on the basis of which propositions in physics are objectively explained.

(iv) For Kant, mathematics and special metaphysics (of corporeal nature) comprise the pure part of natural science. In conclusion of this chapter, we may explicate how these two are related. In the Preface to the *Metaphysische Anfangsgründe*, Kant states that "in order to make possible the application of mathematics to the doctrine of body", we require metaphysical principles for the "*construction* of the concepts that belong to the possibility of matter".[228] Hence, whereas proper natural science presupposes mathematics, the application of mathematics to the doctrine of body in turn presupposes metaphysical principles. Mathematics is thus subordinated to metaphysics. How should we understand Kant's line of thought?

In (ii) and (iii), we have seen that according to Kant cognition of laws concerning *existing* objects must be based on metaphysical principles (e.g., the laws of motion). Whereas it is possible to demonstrate that, say, the satellites of primary bodies are subject to inverse-square forces (accelerations) toward their primary bodies, on the basis of *mathematical* principles, the inference to the existence of an actual force as a cause of motion requires the application of the laws of motion (i.e., *metaphysical* principles).[229] This shows why Kant takes metaphysics to be necessarily presupposed in natural science. However, it does not fully explain Kant's remark (cited above) that metaphysics is necessary for the *application* of mathematics to the doctrine of body. In fact, at first sight this remark is somewhat strange. Kant takes the problem of the *application* of mathematics to be solved in the first *Critique*, in particular through the proof that space and time are pure forms of intuition. What, then, is the function of a special metaphysics of corporeal nature in securing the application of mathematics to the doctrine of body? Kant's remarks in the Preface to the *Metaphysische Anfangsgründe* suggests that one should distinguish between problems involving the general applicability of

[228] AA 4: 472.
[229] Cf. Friedman 1992a, 227–231.

mathematics (a topic treated in the first *Critique*), and problems involving the specific application of mathematics in natural science. In the following, I will argue that Kant takes metaphysical principles to govern this specific application of mathematics in natural science.

In §1.4, I argued that mathematics provides a priori models of physical objects, thus enabling a priori cognition of specific relationships obtaining between quantities of individual objects. However, mathematics only allows us to demonstrate particular characteristics of physical objects if our model is *adequate* to specific physical objects. For Kant, I will argue, the adequacy of mathematical models requires the proper metaphysical explication of the concept of matter, comprising the proper object of physics.

To be sure, the term 'adequacy' is not one that Kant employs in this context. However, the point can also be put in terms of Kant's modal categories of possibility and actuality. In 'The postulates of empirical thinking in general' of the first *Critique*, Kant states that (a) "whatever agrees with the formal conditions of experience (in accordance with intuition and concepts) is possible", while (b) that "which is connected with the material conditions of experience (of sensation) is actual".[230] Thus, an object of a concept is possible (or alternatively: the concept of this object is objectively real)[231] if this object can be represented as given in space and time and as subject to the principles of the understanding (i.e., causality, interaction, etc.). For Kant, the construction of geometric concepts in space, which is the formal a priori condition of outer experience[232], demonstrates the objective reality of these concepts, i.e., their possible *application* to objects. However, mathematical construction of concepts does not demonstrate the existence of objects corresponding to mathematical concepts, for as (b) makes clear, the existence of objects can only be shown on the basis of *empirical intuition* or sensation. The notion of the 'adequacy of mathematical models' can now be construed as highlighting that mathematical models must represent existing objects in the above sense of the term. Put differently: the notion of adequacy highlights that in natural science mathematics must be correctly applied to empirically given, existent objects.

In applying mathematical constructs or models to given objects, various considerations play an important role. Recall that Newton described mathematics as being concerned with the investigation of those quantities of forces and their proportions that follow from any supposed conditions. In physics, these proportions must be *compared with the phenomena*, in order to determine

[230] *KrV*, A 218/B 265–266.
[231] *KrV*, A 220/B 268.
[232] *KrV*, A 223–224/B 271

which conditions or laws of forces apply to attracting bodies. How do we compare mathematical models with phenomena, and what kinds of difficulties confront us in this process?

Let us return to the oft mentioned example of Proposition 1 of Book 3, in which Newton demonstrates (among others) that the satellites of Jupiter are maintained in their orbits by centripetal forces.[233] As said, this demonstration is based on Proposition 2 of Book I. This proposition, spelled out in detail, shows that if a body, moving in some curved line described in a plane with respect to a point that is *either unmoving or moving uniformly forward with a rectilinear motion*, describes areas around that point proportional to the times, then that body is subject to a centripetal force tending toward that point.[234] In Proposition 1 of Book 3, Newton applies this result to the motion of the satellites of Jupiter with respect to Jupiter. Hence, as William Harper emphasizes, we treat Jupiter's centre as inertial (in Newton's terms: as moving uniformly forward) and ignore the centripetal acceleration of Jupiter toward the sun.[235] We are, however, justified in treating the centre of Jupiter as inertial. Newton's Corollary 6 to the Laws of Motion provides the implication that *if* bodies move in any way with respect to one another and are urged by equal accelerative forces along parallel lines, they will continue to move with respect to one another as they would "if they were not acted upon by those forces".[236] Since the antecedent is true of the motion of Jupiter and its satellites, the Jupiter system can be treated as unperturbed by the accelerative forces exerted by the Sun.[237] Moreover, Corollary 4 of the Laws of Motion tells us that the common centre of gravity of two or more bodies is either at rest or moves uniformly straight forward.[238] Since the centre of Jupiter approximates the centre of mass of the Jupiter system, we can treat this centre as inertial.[239]

The foregoing illustrates that Newton conceived of mathematical constructs as idealizations of physical nature[240], and that various conditions must be satisfied in order to adequately apply these constructs to nature. Kant does not, to the best of my knowledge, provide a detailed analysis of conditions

[233] Newton 1999 [1726], 802.
[234] Newton 1999 [1726], 446.
[235] Harper 2002, 176. In the following, I base myself on Harper's account.
[236] Newton 1999 [1726], 423.
[237] Harper 2002, 176.
[238] Newton 1999 [1726], 421.
[239] Harper 2002, 176.
[240] Cf. Cohen 1980, 61–68, who in this context consistently emphasizes that Newton's mathematical constructs, forming the basis of his physical inquiries, are "simpler" than nature.

that must be satisfied in order to adequately apply mathematics to nature. In Newton's terms, Kant does not extensively discuss how we compare mathematics with phenomena. In the first *Critique*, Kant argues that construction in pure intuition secures *that* mathematics is applicable to nature. In particular: through mathematical construction the objective reality of mathematical concepts is guaranteed. However, the specific manner in which we apply mathematics to specific existent objects (*how* we apply mathematics) is not a topic of extensive discussion.

Nevertheless, in the *Metaphysische Anfangsgründe* Kant does seem to allow for the possibility that mathematics can be inadequately applied to nature. This emerges from Kant's discussion, mentioned in §1.4, of the 'mathematical-mechanical mode of explanation', given in the General Remark to the Dynamics. Kant argues that this mode of explanation employs concepts the *possibility* of which "can be verified with mathematical evidence".[241] This follows from the fact that basic concepts of the mathematical-mechanical mode of explanation can be geometrically constructed. However, Kant rejects this mode of explanation because it involves empty, metaphysical concepts ('void space' and 'absolute impenetrability'). These metaphysical concepts do not apply to existing objects (their objects are not given in empirical intuition). As a consequence, the mathematical-mechanical mode of explanation is deemed to be an inadequate mode of explanation.

Kant describes the mathematical-mechanical mode of explanation as 'atomism' or 'corpuscular philosophy', which is said to be "the most tractable for mathematics" and which mechanically explains the manifold of nature from the *shapes* of primary parts.[242] This type of natural philosophy is rejected in favor of a dynamical natural philosophy. As a representative of the mathematical-mechanical mode of explanation Kant mentions Descartes. Cartesian physics is thus construed as a mathematical physics based on a false metaphysics, i.e., a physics based on empty metaphysical concepts such as absolute impenetrability. In discussing Kant's critique of corpuscular philosophy in light of his views on chemistry, Martin Carrier has further pointed to the influence of the so-called structural chemistry of the period, according to which chemical properties are based on the shape of particles, chemical compounds are comprehended in terms of geometric fit of particles, and chemical reactions occur according to the (changes of) geometrical fit of specific particles.[243]

[241] AA 4: 525. For a historical account of Kant's distinction between the mathematical-mechanical and the metaphysical-dynamical mode of explanation, with emphasis on the mathematical-mechanical views of Lambert, see: Warren 2001, 93–116.

[242] AA 4: 532–533.

[243] Carrier 2001a, 222–224.

Kant's problem with this type of chemistry, as Carrier emphasizes, is that it employs occult qualities or fictitious constructions. Indeed, it can be taken to employ fictitious mathematical (geometric) constructions. Here we have an example of a corpuscular science, in which mathematical constructs are wrongly applied to specific objects (in this case: specific geometric constructs are wrongly taken to represent the structure of matter). This faulty, fictitious use of mathematics, is, in Kant's view, the result of adopting false metaphysical assumptions. Corpuscular natural science employs empty metaphysical concepts, and should be replaced by a dynamical natural science.

The foregoing provides a possible interpretation of Kant's claim that "in order to make possible the application of mathematics to the doctrine of body", we require metaphysical principles.[244] If Kant was merely emphasizing that the possibility of the application of mathematics to empirical nature requires philosophical justification, it is not clear, given that this problem was solved in the first *Critique*, why the application of mathematics to nature must be based on a *special* metaphysics of corporeal nature (as outlined in the *Metaphysische Anfangsgründe*). However, Kant can be interpreted as arguing that the correct (adequate) use of mathematics in natural science is dependent on metaphysics. Whereas Newton's mathematical models are adequate to the objects to which they are applied, this is not the case for (say) the mathematical physics of Descartes. Insofar as Kant, in the *Metaphysische Anfangsgründe*, aims to provide the correct metaphysical explication of the concepts of natural science that are mathematically constructed (e.g., of 'motion', 'extension', 'inertia'), metaphysics can be taken to fulfill an important function in securing the adequacy of mathematical models in natural science.

1.6 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 of mathematization and 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 individual corporeal objects. As such, mathematics provides a priori princi-

[244] AA 4: 472.

ples 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 fulfill an important role in providing 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). Finally, true metaphysical principles provide a necessary condition for taking mathematical models to adequately represent existing objects. For this reason, mathematics presupposes metaphysics.

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), incorporating condition (2) of the Classical Model of Science, secures that 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 (4) 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 Chapter 2. Since the form of organisms defies mechanical explanation, we cannot provide explanative demonstrations of their form. Rather, we comprehend organisms in teleological terms. This will be the focus of Chapter 3.

2 | Mechanical explanation and grounding

In the first chapter we have analyzed Kant's conception of proper science. The current chapter aims to apply some of Kant's views concerning proper science to his views concerning the possibility of scientific cognition of organisms, constituting the subject matter of what we may call biology. In discussing Kant's views on the possibility of knowledge of organisms, his position as articulated in the *Kritik der Urteilskraft* (1790) constitutes the main focus of our inquiry.

A proper science satisfies the conditions of systematicity, objective grounding and apodictic certainty. Kant does not systematically discuss the possibility of cognition of organisms in light of these three conditions. In the *Kritik der Urteilskraft*, Kant does argue that organisms defy mechanical explanation. The notion of mechanical explanation has been extensively analyzed in recent literature. However, the fact that Kant construes mechanical explanation as an instance of proper scientific explanation and the reasons for why he endorsed such a view are rarely discussed. In the present chapter I aim to show why Kant took mechanical explanation to be a proper scientific explanation by relating this type of explanation to his views on objective grounding as discussed in the previous chapter. Mechanical explanations are construed as proper explanations because they specify objective grounds (the reason *why*) of phenomena.

In order to relate Kant's views on mechanical explanation to his views on objective grounding, I first discuss Christian Wolff's views relating to mechanical explanation. This will allow us to provide a more precise determination of the notion of mechanical explanation than currently presented in the literature (in which the views of Wolff are not discussed). I argue that part/whole

conceptualizations adopted by Wolff in his writings on logic and metaphysics provide the background for his conception of scientific (mechanical) explanation. Wolff's views will also allow us to understand why mechanical explanation is construed as a proper form of explanation. Kant's views on mechanical explanation can be profitably understood on the basis of our discussion of Wolff.

In §2.1, I will first discuss two influential interpretations on Kant's views on mechanical explanation. In the next sections, I discuss various part/whole conceptualizations that will allow us to determine the nature of mechanical explanation. §2.2 provides an analysis of traditional part/whole conceptualizations within logic and conceptions of methodology, constituting the background to the views of Wolff and Kant. I then turn to Wolff's use of part/whole conceptualizations in his writings on logic (§2.3), metaphysics (§2.4), and biology (§2.5). §2.6 provides a concluding account of Wolff's conception of mechanical explanation. In §2.7, I argue that Kant's views on mechanical explanation strongly resemble those of Wolff, and that they can be understood on the basis of a similar use of part/whole conceptualizations. In Kant's case, these part/whole conceptualizations figure most clearly in his writings on logic. Kant does however reject Wolff's methodology of explaining wholes in terms of their parts in metaphysics. §2.8 provides an analysis of two examples of mechanical explanation in the work of Kant, who is shown to adopt a rather broad conception of mechanical explanation. This conception is quite similar to Wolff's scheme of mechanical explanation and encompasses explanations in chemistry *and* biology. In §2.9, I turn to the question of the properties of organisms that Kant took to defy mechanical explanation. The concluding §2.10 shows that Wolff's conception of mechanical explanation allows us to understand why Kant treated the mechanical principle of scientific investigation as a regulative maxim, and discusses some of the differences between Kant's conception of mechanical explanation and that of Wolff.

2.1 Understanding mechanical explanation

In §75 of the Dialectic of Teleological Judgment of the *Kritik der Urteilskraft*, Kant famously argues that it is absurd to hope that there may arise a natural scientist who will make comprehensible the generation of organized beings from mechanical principles:

> For it is quite certain that we can never adequately come to know the organized beings and their internal possibility in accordance with merely mechanical principles

> of nature, let alone explain them; and indeed this is so certain that we can boldly say that it would be absurd for humans even to make such an attempt or to hope that there may yet arise a Newton who could make comprehensible even the generation of a blade of grass according to natural laws that no intention has ordered; rather, we must absolutely deny this insight to human beings. (AA 5: 400)

Given the constitution of our human (discursive) understanding, we necessarily conceive of organized beings (organisms) as natural purposes, i.e., conceive of them in teleological terms, and we cannot explain their possibility purely mechanically. In short: organisms do not allow of mechanical explanation.

This claim is well known. Less known is the fact that Kant treats what we have called mechanical explanation as an ideal of scientific explanation. Thus, in the Dialectic Kant also states that "in natural science we are far from being satisfied with an explanation of the products of nature by means of causality in accordance with ends".[1] Rather, one must always pursue the maxim of reflecting on products in accordance with the 'principle of the mechanism of nature', for if this principle "is not made the basis for research then there can be no proper cognition of nature."[2] In short: mechanical explanation is taken to provide proper scientific cognition of nature. This raises the following questions: (a) what is mechanical explanation? (b) Why does mechanical explanation constitute an ideal of scientific explanation of nature? The nature of mechanical explanation (a) has been much debated in recent scholarship. In contrast, the question why Kant construes mechanical explanation as an ideal of explanation (b) is rarely treated. In the current chapter questions (a) and (b) will be the focus of inquiry.

In recent years, the notion of mechanical explanation has been the subject of considerable discussion. This is understandable given the fact that Kant employs the term 'mechanical' and its cognates in a great variety of ways.[3] A

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[1] AA 5: 408.

[2] AA 5: 387.

[3] Ginsborg 2001, 238–240 provides a classification of the different ways in which Kant employs the term 'mechanical' and 'mechanism'. These are: (i) 'mechanical' as referring to the mechanical laws of motion, which concern the *communication* of motion of moving bodies, as distinct from chemical and dynamical laws, in which we do not need to view bodies as moved. (ii) 'Mechanical' defined as the capacity (of matter) of motion or capacity to impart motion. In this sense, dynamical and chemical laws can be said to be mechanical, insofar as they describe forces that can be taken to impart motion. (iii) 'Mechanical' as non-teleological. (iv) 'Mechanical' as natural or non-artificial (not designed). (v) Mechanical as being in conformity with the causal principle established in the first *Critique*. In the following, I will not discuss all of these meanings, but provide a historical account that sheds light on Kant's conception of mechanical explanation.

very influential account of Kant's view on mechanical explanation has been given by Peter McLaughlin. According to McLaughlin, giving a mechanical explanation consists in specifying a causal relation between the parts of a thing and the whole. 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".[4] Hence, a mechanical explanation can be understood in terms of the following two conditions:

M_1 An explanation of a whole in terms of its parts.

M_2 An explanation in which we merely employ properties that the parts have on their own, i.e., independently of the existence of the whole.

The importance of (what I have rendered as) M_2, is explained by McLaughlin by noting that the question is whether "the *parts* can have properties *in* the whole and *due* to their presence in the whole which they would not (did not) have independently of their existence in the whole."[5] If the parts of an object have properties in the whole and due to their presence in the whole which they do not have independently of their existence in the whole, this object cannot be mechanically explained.

Conditions M_1 and M_2 can, according to McLaughlin, be satisfied in explaining the functioning of a *machine*. For example, we can explain the functioning of a watch in terms of its gears, levers, etc, which have their properties (e.g., rigidity) independently of their existence in the whole.[6] However, these conditions cannot be satisfied in giving an explanation of organisms, since, according to McLaughlin's interpretation of Kant, the existence of the parts of organisms is dependent on the existence of its other parts and on the existence of the whole. In particular, the parts of organisms have properties due to their presence in the whole which they would not have independently of their existence in the whole. Hence, condition M_2 cannot be satisfied in the case of organisms and organisms should be mechanically inexplicable.

The textual evidence that McLaughlin cites for his interpretation is derived from the Dialectic of Teleological Judgment. In §77, Kant notes that:

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4 McLaughlin 1990, 140–44.

5 *Ibid*. Cf. Allison 1991; Guyer 2001. See Ginsborg 2004, 33–39, for a discussion of these various interpretations.

6 Thus, McLaughlin models his account of mechanical explanation on how he conceives of the explanation of machines. This is emphasized by Ginsborg, who argues that McLaughlin takes the "non-machine-like" character of organisms to be the ground of the mechanical inexplicability of organisms. Ginsborg 2004, 34–36.

> […] if we consider a material whole, as far as its form is concerned, as a product of the parts and of their forces and their capacity to combine themselves (including as parts other materials that they supply to one another), we represent a mechanical kind of generation. (AA 5: 408)

McLaughlin's supposition is that we provide a mechanical explanation of an object if we show how a whole can be mechanically generated from its parts. Kant's text seems to support this supposition, for immediately preceding the quote above Kant states that the constitution of our understanding is such that a "real whole of nature is to be regarded only as the effect of the concurrent moving forces of the parts."[7] Further evidence for McLaughlin's interpretation (not cited by himself) is contained in the first unpublished introduction to the *Kritik der Urteilskraft*. Here, Kant states that it is "contrary to the nature of physical mechanical causes that the whole should be the cause of the possibility of the causality of the parts, rather the latter must be given first in order for the possibility of a whole to be comprehended from it […]."[8] These remarks suggest that Kant understands mechanical explanation as an explanation of a whole in terms of its parts, thus supporting McLaughlin's interpretation. However, note that none of the cited passages explicitly refers to McLauglin's condition M_2.

Recently, Hannah Ginsborg has challenged McLaughlin's interpretation in two penetrating articles.[9] According to Ginsborg, a mechanical explanation should not primarily be understood as an explanation of a whole in terms of its parts. Rather, we provide a mechanical explanation of an object when "we explain its production as a result of the unaided powers of matter as such."[10] In providing her account of Kant's views on mechanical explanation, Ginsborg bases herself on two pre-critical writings of Kant: *Allgemeine Naturgeschichte und Theorie des Himmels* (1755) and *Der einzig mögliche Beweisgrund zu einer Demonstration des Daseins Gottes* (1763). The former work aims to provide a *mechanical* account of the formation of the celestial system.[11] This requires explaining the order existing in the celestial system from the universal and essential properties of matter, i.e., from the attractive and repulsive forces fundamental to matter. As Ginsborg puts it: the existence and motions of celestial bodies are "accounted for in terms solely of the fundamental forces of matter, without need to suppose any special arrangement of matter, or

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7 AA 5: 407.
8 AA 20: 236.
9 Ginsborg 2001, 231–259; Ginsborg 2004, 33–65.
10 Ginsborg 2004, 42.
11 AA 1: 221–223.

to make any appeal to chance."[12] Such an account is a properly mechanical account. In the *Allgemeine Naturgeschichte*, Kant further claims that we cannot provide a mechanical account of the production of organisms, arguing that we will sooner understand "the origin of the entire present arrangement of the world-edifice, than we will come to know distinctly or completely the production of a single herb or of a caterpillar from mechanical grounds."[13] These remarks, and similar remarks from *Der einzig mögliche Beweisgrund*, provide Ginsborg with textual evidence for her interpretation.

In short, Ginsborg analyzes a mechanical explanation as:

G_1 An explanation in terms of the fundamental forces of matter

G_2 An explanation in which one does not take into account any special arrangement of matter.

This conception of mechanical explanation is strongly modeled on Kant's account of the formation of the celestial system, that is (roughly): an account of the coming to be of an ordered system from an original, unorganized state. The consequence of G_2, as Ginsborg notes, is that the notion of mechanical explanation invoked by Kant is extremely strong: most things of nature do not allow of mechanical explanation.[14] However, Ginsborg also argues that Kant allows for the possibility of mechanically explaining organisms in a more liberal sense. Hence, Ginsborg distinguishes between two types of mechanical explanation (a strong and a weak type). To cite Ginsborg's example: the (strong) account of mechanical explanation implies that Kant denies that the origin of a bird can be explained by the powers of unorganized matter, e.g., the powers of an egg after it has been beaten. However, presupposing an original organization we can mechanically explain the origin of a bird, e.g., as a consequence of an arrangement of matter found in an intact egg.[15] This second type of mechanical explanation is thus distinguished from the first (strong) type of mechanical explanation, insofar as in the former we *do* take into account the arrangement of matter. As Ginsborg puts it, in the second (weak) type of mechanical explanation of organic phenomena we appeal "not just to the powers of matter as such", but also "to the way in which the matter comprising the organism at any given time is arranged".[16] Unfortunately,

[12] Ginsborg 2004, 40.
[13] AA 1: 230.
[14] Ginsborg 2001, 242–243.
[15] Ginsborg 2001, 242–243. Cf. Ginsborg 2010, 462–463.
[16] Ginsborg 2004, 53.

Ginsborg does not fully explain in what sense this second type of explanation is mechanical.

The analyses of McLaughlin and Ginsborg have significantly increased our understanding of Kant's conception of mechanical explanation. Both analyses are based on Kant's own remarks on mechanical explanation. In the following, I will present a different perspective on the notion of mechanical explanation by taking into account the views on scientific explanation of Christian Wolff. Apart from increasing our knowledge of the historical background of Kant's views, this procedure will allow us to determine more precisely the nature of a mechanical explanation. In my view M_1 identifies core aspects of how Kant understands a mechanical explanation. However, the idea of an explanation of a whole in terms of its parts is rather rough. Via an analysis of Wolff we can construe a mechanical explanation as an explanation of a whole in terms of (i) its parts, (ii) the mode of composition of its parts and (iii) forces acting on the parts. We will also understand on the basis of which views Wolff comes to understand mechanical explanation in terms of (i)–(iii), how Wolff applies (i)–(iii) in articulating the proper method of biological investigation, and (importantly) why an explanation in terms of (i)–(iii) constitutes an *ideal of scientific explanation* (topics that are not discussed by McLaughlin or Ginsborg). Kant, I will argue, adopts a rather similar conception of mechanical explanation.

My conception of mechanical explanation differs from Ginsborg's strong analysis of mechanical explanation in terms of G_1 and G_2, but conforms to her weak account of mechanical explanation. In line with Ginsborg's criticism of McLaughlin, I reject McLaughlin's condition M_2 which implies that it is impossible to mechanically explain organisms in any manner.[17] Moreover, although Ginsborg's strong account of mechanical explanation is too strong to fully capture Kant's ideas on mechanical explanation, it correctly emphasizes an important feature of his views: the fact that he assigns priority to the notion of 'force' in providing mechanical explanations. In these respects, my account of mechanical explanation conforms to that of Ginsborg.

Nevertheless, as McLaughlin correctly points out, Kant does treat mechanical explanation as some form of an explanation of a whole in terms of its parts. Hence, I do not think that Ginsborg's dissociation of mechanical explanation from an explanation of a whole in terms of its parts is justified.[18]

[17] Cf. §2.9.

[18] In Ginsborg's analysis, contrary to that of McLaughlin, the notions 'part' and 'whole' do not play any significant role. In contrast, I take these notions to be crucial to Kant's conception of mechanical explanation.

Through analysis of the similarities and differences between the views of Wolff and Kant on mechanical explanation, we can understand both why Kant (in conformity with Wolff) construed mechanical explanations as explanations of wholes in terms of their parts, while also assigning priority to the notion of 'force'. The conception of mechanical explanation that I distill from Wolff thus combines elements of the views on mechanical explanation identified by both McLaughlin and Ginsborg.

My analysis further adds to the interpretations of McLaughlin and Ginsborg insofar as I, with respect to both Wolff and Kant, point to the influence of (a) certain philosophical or metaphysical views, and (b) views articulated within the domain of logic, on the understanding of mechanical explanation. In discussing (a) and (b), we will see that both Wolff and Kant, within metaphysics and logic, heavily deploy part/whole conceptualizations. These part/whole conceptualizations strongly influence their understanding of mechanical explanation in natural science. In the following I am thus primarily concerned with a particular *philosophical* interpretation of 'mechanism' or 'mechanical explanation'.[19]

It is important to stress that the notion of scientific or mechanical explanation that I distill from Wolff and locate in Kant, i.e., mechanical explanation as an explanation of a whole in terms of (i) its parts, (ii) the mode of composition of its parts and (iii) forces acting on the parts, is strongly based on philosophical views (and views on logic). This partly explains why the notion of mechanical explanation is not reducible to conceptions on scientific explanation that we can locate within particular historical traditions in natural philosophy. It also allows us to understand why Kant entertained a very broad conception of mechanical explanation. For example, the idea of mechanical explanation, as we shall see in §2.10, clearly has its historical roots in the Cartesian mechanical natural philosophy. In the *Metaphysische Anfangsgründe*, Kant rejected what he calls the *mechanical natural philosophy* (attributed to Descartes), arguing

[19] This is important to emphasize. Renate Wahsner 2009, 165–168, criticizes McLaughlin's interpretation of mechanism by noting that he does not adequately distinguish between the modern science of mechanics and the mechanistic worldview. In particular: Wahsner argues that McLaughlin's association of mechanics with the technical generation of artifacts is incorrect and that mechanics (as a science) is not reductionist as McLaughlin claims. This critique may be correct. However, I am, as noted, concerned with a philosophical interpretation of mechanism, that, I argue, is very dominant in the writings of both Wolff and Kant. Moreover, my analysis does not merely rest on the association of mechanism with the generation of artifacts. I stress the ubiquity of part/whole conceptualizations in both Wolff's and Kant's views on various sciences.

for the primacy of a (Newtonian inspired) *dynamical natural philosophy*.[20] Nevertheless, as we shall also see in §2.8, Kant still seems to qualify explanations given within a dynamical natural philosophy as 'mechanical'. This shows the broad application of the terms 'mechanical', 'mechanism' and 'mechanical explanation'.[21] We can gain more insight into this broad conception of mechanical explanation by taking into account the philosophically inspired views on mechanical explanation articulated by Christian Wolff. Finally, as I argue in §2.10, Wolff's philosophical interpretation of mechanical explanation allows us to partly understand why Kant treated the mechanical principle of scientific investigation as a *regulative* maxim.[22]

2.2 A tradition of part/whole conceptualizations

In the following I analyze several works of Christian Wolff and sketch a historical background from which we can understand Kant's views on mechanical explanation. I will argue that the notions of 'part', 'whole' and 'force', as initially developed in Christian Wolff's metaphysics and logic, provide Wolff with an ideal of scientific explanation. This ideal constitutes the basis for his conception of proper method and explanation in the biological sciences. In addition, the notions 'part', 'whole' and 'force' provide us with a conception of 'mechanism' that figures in Wolff's writings. Kant's views on mechanical explanation and mechanism can be understood on the basis of these Wolffian views.

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[20] AA 4: 532–533.

[21] Thus, Tonelli 1974, 245 correctly remarks: "it is important to realize in general that a "mechanical" explanation, for Kant, did not necessarily mean an "impulsionistic" explanation […]. The notion of "mechanicism", in fact, had undergone in general some basic changes after Newtonian attractionism had been generally accepted." I owe this reference to Cinzia Ferrini 2000, who also stresses this fact in her discussion of mechanical explanation in Kant's pre-critical writings.

[22] There is one aspect of the notion of 'mechanical explanation' or 'mechanism' that I will not discuss in the following, namely: the association of mechanism with mathematics and a mathematical science of nature (note that Ginsborg and McLaughlin also do not discuss this aspect). Kant associates mechanism and mathematics in the General Remark to the Dynamics of the *Metaphysische Anfangsgründe*, where he speaks of a 'mathematical-mechanical mode of explanation', However, in the third *Critique*, which constitutes the focus of this chapter, the notion of mechanical explanation is not related to mathematics. Moreover, Kant gives examples of mechanical explanation in biology, which at the time was a thoroughly non-mathematical science (§2.8). I believe that the account of mechanical explanation that I distill from Wolff in this chapter can be related to ideas of mathematization. However, I will not argue for this at present.

Part/whole conceptualizations figure heavy in my analysis of Wolff and Kant. It must be noted, however, that these conceptualizations are part of a long philosophical tradition. Hence, although I point out similarities between the use of the part/whole scheme by Wolff and Kant, I do not think Kant's use of this scheme was merely due to the influence of Wolff. In the current section I will, as a prelude to our discussion of Wolff and Kant, briefly describe some traditional part/whole conceptualizations

Already in Boethius' tract *De divisione* (written between 505 and 509) we find the part/whole scheme applied in the domain of logic. In this tract, Boethius distinguishes the division of a genus into its species from the division of a whole into its parts.[23] A whole is divided into its parts when we resolve something into the things of which it is composed. For example, the parts of *man* are the particulars (individuals) Cato, Vergil, Cicero, etc., who are joined together and make up the quantity of *man* as a whole. Here, the genus is treated as a whole. From our modern perspective, we might say that particulars (Cato, Vergil, etc.) are parts of the extension of the genus 'man'. As we shall see, Kant similarly adopts the view that concepts comprising the extension of a concept can be construed as parts of the latter.[24]

Boethius treats a division of a whole into its parts as a division made in respect of *quantity*. In contrast, a division of a genus into its species is made in respect of *quality*.[25] In the former division, the genus is treated as a whole. However, Boethius notes that in a *definition* a genus is treated as a part.[26] In a definition (the composition of a whole), parts join together to make a whole. These parts comprise genus (e.g., 'animal') and various *differentiae* ('rational', 'mortal'), in terms of which we define a species ('man'). In this case, then, the genus and *differentiae* are taken to be parts of the species *man*.[27] In our discussion of Wolff and Kant, we will see that both authors adopt the view that genus and *differentiae* can be taken to constitute parts of a composite concept.

Jumping to the seventeenth century, we find applications of the part/whole

[23] Boethius 1988 [505–509], 13–14. Boethius also treats the division of an utterance into its significations. This type of division is not relevant for our present purposes.

[24] There is an important difference. Boethius takes *individuals* (Plato, Vergil, etc.) to be parts of the genus 'man'. Kant takes *concepts* comprising the extension of a concept to be its parts. Whether or not Kant takes individuals to be included in the extension of a concept is not clear.

[25] Boethius 1988 [505–509], 17.

[26] Boethius 1988 [505–509], 31.

[27] *Ibid.*

scheme that resemble those of Boethius. For example, in the chapter "On method" of Thomas Hobbes' *De corpore* (first published in 1655), we read:

> […] 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 1962 [1839], 66–67)

In what follows Hobbes explains that he applies the term 'whole' to those things that have less universal names (also called singulars) and 'parts' to those things which have more universal names (also called universals). In particular: 'parts' is applied not to the (material) parts of things themselves but to the parts constituting their nature.[28] This view is similar to Boethius' treatment of *genera* and *differentiae* as parts. In Hobbes terms, 'being animate' and 'being rational' can be taken to constitute parts of the whole idea of man.

Hobbes further argues that, considering the *ordo cognoscendi*, the whole is usually said to be better known to us than the parts, whereas, considering the *ordo essendi*, the causes of the parts are better known to nature than the cause of the whole.[29] This remark occurs in the context of a discussion of the resolutive (analytic) and compositive (synthetic) method. Traditionally the analytic method was conceived as a method proceeding from the effect to the cause, whereas the synthetic method was conceived to proceed from the cause to the effect. The synthetic method was also, as we have seen in Chapter 1, associated with the notion of providing a demonstration *propter quid*. In the present context, Hobbes thus associates the analytic method with a resolution of a whole into its parts, and the synthetic method with a composition of a whole from its parts. In the sciences, Hobbes claims, the causes of the parts are (or should be) better known than the causes of the whole. For the cause of the whole *consists of* the (sum of the) causes of the parts. Hence, it is necessary that the components be known earlier than the composite.[30] Proper scientific explanation is thus associated with proceeding from the parts to the whole, a method resembling the *ordo essendi*. This view on proper scientific explanation we will also find in the works of Wolff and Kant.

Finally, it is worth noting that Isaac Newton, like Hobbes, construes the analytic method as a method in which we resolve a whole into its parts. In Query 31 of the *Opticks* (1704[1]), after noting that in natural philosophy the

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[28] Hobbes 1962 [1839], 67.
[29] *Ibid.*
[30] Hobbes 1962 [1839], 66–68.

investigation of difficult things by the method of analysis ought to precede the method of synthesis, Newton says:

> 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 1952 [1730], 404)

Through analysis we resolve a compound (whole) to ingredients (parts). Newton further introduces the notion of 'force', characterizing the method of analysis as proceeding from motions to the forces (causes) producing them. In our discussion of Wolff and Kant, we will also see that the notion of force is intimately related to part/whole conceptualizations as they figure in science. Let us now turn our attention to Wolff.

In discussing the writings of Wolff, I will adopt the following structure. In §2.3, I focus on the distinction between nominal- and real definitions formulated in Wolff's *Deutsche Logik* (1713). Here, Wolff introduces several key ontological concepts, namely those of 'part', 'whole' and 'essence', which will constitute the focus of our attention. In addition, we will be able to appreciate the broad domain of application of notions 'part' and 'whole' as they figure in Wolff's writings. In §2.4, I discuss several passages of the *Deutsche Metaphysik* (1751). In this work Wolff defines the ontological notions of 'part', 'whole', and 'essence'. In addition, Wolff's metaphysics allows us to understand why explanations of wholes in terms of their parts constitute an ideal of explanation. In §2.5, I discuss some passages from Wolff's *Deutsche Physik* (1723). Here, we will encounter how explanations of wholes in terms of their parts figure in natural science, in particular in Wolff's writings on biological topics. Finally, in §2.6, I present a description of how Wolff conceptualizes explanations of wholes in terms of their parts in natural science.

2.3 Parts, wholes and definitions

In the first chapter of the *Deutsche Logik*, entitled "On the Concepts of Things", Wolff distinguishes between nominal and real definitions (*Wort- und Sach-Erklärungen*). According to Wolff, nominal definitions specify properties of a thing by means of which we can distinguish it from other things, whereas real definitions show the manner in which a thing is possible.[31] Real definitions are taken to provide cognition of the essence (*Wesen*) of a thing. This is

[31] Wolff 1978 [1754], 143–44.

a consequence of the fact that one comprehends the essence of a thing if one comprehends the manner in which a thing is possible.[32] Wolff provides the following example to elucidate the concept of essence:

> I understand the essence of a clock if I comprehend distinctly from what kind of wheels and other parts it is composed and how every part is put together with another. For these parts are not necessarily with one another, rather it can merely happen that in a thing they are simultaneously next to one another; and as soon as I know this, I am in the position to indicate the true ground of all the effects and accidents that a clock can have. (Wolff 1978 [1754], 147)[33]

Thus, 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. If (a) and (b) are satisfied, we can specify the proper ground for occurrences of the clock. For example, cognition of the mainspring, gear train, balance wheel, etc. of a clock and their necessary mode of composition allows the specification of the proper ground of the movement of its dials. In a similar fashion, Wolff argues, cognition of the essence of the eye and of the human body requires cognition of their parts and of the necessary mode of composition of these parts.[34] In short: by comprehending a thing (whole) in terms of its parts and their necessary mode of composition we obtain cognition of its essence. A real definition provides us, by showing the manner in which a thing is possible, with cognition of the essence of a thing. Wolff's views thus strongly suggest that real definitions explicate wholes in terms of their parts. In the following, we will see that definitions in general (whether real or nominal) can be taken to explicate wholes in terms of their parts.

According to Wolff, a definition is a clear (*klar*), distinct (*deutlich*) and complete (*ausführlich*) concept.[35] A concept is clear if we can recognize the things to which it applies. A clear concept is distinct if we have cognition of (some of) its marks or characteristics, and a distinct concept is complete if the marks that we have cognition of are sufficient for cognizing and distin-

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[32] *Ibid*, 146–47.

[33] Original: "Ich Verstehe das Wesen einer Uhr, wenn ich deutlich begreife, aus was für Rädern und anderem Zugehöre dieselbe zusammengesetztet, und wie jedes an das andere gefüget werde. Denn diese Theile sind nicht notwendig bey einander, sondern es kann bloß geschehen, daß sie zugleich in einem Dinge neben einander sind; und so bald ich dieses weiß, bin ich in dem Stande, von allen Würckungen und Zufällen der Uhr, die sie haben kann, richtigen Grund anzuzeigen."

[34] Wolff 1978 [1754], 147.

[35] Wolff 1978 [1754], 141.

guishing the things signified by the concept.[36] A clear and distinct concept can fail to be complete if we lack cognition of a sufficient number of its marks to cognize and distinguish things falling under this concept. For example, Wolff argues that the concept of 'body' entertained by the Cartesians, i.e., an extended being with length, breadth and depth, is distinct yet not complete. It is distinct since the Cartesians have cognition of some of the marks of the concept 'body', yet it is not complete since cognition of these marks is not sufficient to distinguish bodies from space or spatial objects (e.g., the objects of geometry).[37] In order to have a complete concept of body, we would have to specify additional marks (e.g., motive force).

The foregoing implies that we are in the possession of a definition of a concept if and only if we cognize marks of this concept that allow us to identify and distinguish the things comprising its extension. Such definitions can be given by means of the traditional method of specifying the *genus proximum* and *differentia specifica*, e.g., by defining the concept 'square' in terms of the genus 'rectangle' and the difference 'with four equal sides'. In this simple case, we represent the concept 'square' in terms of two marks that are sufficient for identifying squares and distinguishing them from other objects. These marks are (employing Kant's terminology) partial concepts *contained in* a composite concept. For our present purpose, it is important to note that in the eighteenth-century, the relation between marks (characteristics, partial concepts) and composite concepts is often conceived as a relation between parts and whole.[38] Hence, in giving a definition of a concept we are specifying a relation between a whole (a composite concept) and its parts (its marks, characteristics, partial concepts). In addition, in giving a definition we specify a relation between genus and specific difference and thus specify a relation between the parts (marks, characteristics, partial concepts) of a whole (composite concept). In Wolff's terminology, we specify the mode of composition of these parts. Hence, a definition can be taken to explicate a whole in terms of its parts and their mode of composition.

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[36] Wolff 1978 [1754], 128–30. The notions 'clear' and 'distinct' can be traced to Leibniz's conception of clear and distinct ideas, as worked out in his "Reflections of Knowledge, Truth, and Ideas" of 1684.

[37] Wolff 1978 [1754], 130.

[38] In his lectures on logic, Kant often conceptualizes the relation between partial concepts and composite concepts in this manner. In particular, he argues that concepts *contained in* another concept (comprising its intension) are parts of the latter. Cf. L 63–64; AA 16: 345–46; AA 24: 342–43, 568, 753, 910. This point is also made by De Jong, who notes that Leibniz, Reimarus and Crusius apply the part-whole scheme to relations of concepts. Cf. De Jong 1995, 627 and references.

Note that the part/whole scheme can be applied to both nominal and real definitions. Wolff himself takes the definition of a square as a figure that has four equal sides and angles, a definition that we have treated above as a definition explicating a composite concept (whole) in terms of its partial concepts or marks (parts), to be a *nominal* definition.[39] He notes that through nominal definitions we can specify essential features of a thing, e.g., specify that a triangle has three sides, but do not show the manner in which this thing is possible.[40] In contrast, a real definition must provide insight into the manner in which a thing (the object of a concept) is possible. In the case of, e.g., real definitions of mathematical concepts, this means that we ought to specify a procedure for *constructing* the object of our concept, thus exhibiting the manner in which this object is possible.

In §1.1, we distinguished between analytic and synthetic definitions. Analytic definitions are obtained through the analysis of given composite concepts, by means of which we cognize partial concepts contained in composite concepts. Synthetic definitions are obtained through the arbitrarily combination of partial concepts, by means of which we define a composite concept. We can now say that in both types of definitions we specify a relation between a whole and its parts.

Mathematical definitions are typically construed as constructive definitions, through which we show the possibility of a thing falling under a concept defined synthetically through an arbitrary combination of concepts. Can constructive definitions also be understood in terms of the part-whole scheme? Although Wolff is not explicit on this point, I think this is the case. To give one example, Wolff, in giving a definition of a circle, commonly states that we describe a circle if we let a straight line AB move around a point A.[41] This account provides a definition of a circle, for it provides a procedure by means of which a circle can be generated, i.e., a procedure that shows how a circle is possible. As such, this procedure provides a *real definition* of a circle. 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). Constructive mathematical definitions can thus be interpreted as providing another instance that can be analyzed in terms of the part/whole scheme. This, in any case, is what one would expect given the idea that real definitions explicate wholes in terms of their parts.[42]

[39] Wolff 1999 [1750], 6.
[40] Wolff 1978 [1754], 147.
[41] Cf. Wolff 1978 [1754], 148; Wolff 1999 [1750], 12–13.
[42] In this context, we may note that Lisa Shabel, while analyzing Euclid's definitions concerning planar geometry, notes that these definitions introduce the idea that "the objects

Let us summarize the results of our analysis. I have argued that, according to Wolff, definitions provide explications of wholes in terms of their parts. This shows that the idea of explaining wholes in terms of their parts is not restricted to the natural sciences. Wolff's conception of definitions shows that this idea figures in both logic and mathematics.[43] I have also noted that in definitions we take into account relations between parts, e.g., the relation between genus and specific difference. 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. Hence, strictly speaking definitions can only be said to explain a whole in terms of its parts if we construe relations between parts as parts of the whole. Wolff might be interpreted to allow for such a possibility, for in the next section we will see that he adopts a very broad conception of the notion 'part'. However, Wolff always makes a strict conceptual distinction between the parts of a whole and their mode of composition, taking cognition of the latter to be essential to any kind of explanation. Attending to this distinction is necessary for coming to grips with Wolff's conception of scientific explanation, as we shall see in detail in the next sections.[44]

2.4 Parts, wholes and explanatory ideals

If we turn our attention to the *Deutsche Metaphysik* (1751), it becomes clear that the notions 'whole' and 'part' occupy a central role in Wolff's philosophical thought. In the second chapter of this work, Wolff defines the notions 'part' and 'whole'. He states that if many things *(Dinge)* together constitute a unity, this unity is called a whole. The many things constituting a unity are called parts relative to this whole.[45] Thus, for example, a dollar is a whole

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of geometry can be analyzed into part/whole relations". Hence, the idea that mathematical definitions explicate part/whole relations can be traced to Euclid, and it is likely that Wolff entertained a similar conception. Cf. Shabel 2003, 13–17.

[43] Recall that McLaughlin construes mechanical explanations as explanations of wholes in terms of their parts. Since explanations of wholes in terms of their parts also figure in logic and mathematics, it is now clear that this conceptualization is not sufficient for capturing the distinctive idea of mechanical explanation in *natural science*. In the following, I will describe additional distinguishing features that capture the latter idea.

[44] In the next sections, we will see that similar questions can be raised with regard to the notion 'force', as employed in explanations in natural science. It will become clear that McLaughlin's general idea of an explanation of a whole in terms of its parts is too coarse to capture Wolff's and Kant's views on explanation in natural science.

[45] Wolff 2003 [1751], 13–14.

having a hundred cents as parts and arm, legs, head, etc. are part of the human body.

That the notions 'whole' and 'part' are defined in terms of the notion of a thing (*Ding*) is significant. Wolff defines a 'thing' as "everything that can be", i.e., a thing is a possible object.[46] The notions 'part' and 'whole' are thus defined relative to the class of possible objects. This definition secures the wide application of the notions 'part' and 'whole', for (briefly) every object the concept of which does not contain contradictory marks or determinations is possible (possible concepts correspond to possible objects).[47] For Wolff possibility is, apart from the conditions codified in the definition of 'whole' and 'part', the only condition that must be satisfied in order for something to be considered a whole or a part. This explains why the notions 'whole' and 'part' can (as we have seen in our discussion of Wolff's logic) be applied diversely to possible concepts, to mathematical objects (which Wolff seems to interprets as possible and not actual objects) and to actual (existing) objects, the class of which constitutes a subset of the class of possible objects.[48]

In the *Deutsche Metaphysik*, Wolff elucidates why one should strive at explaining wholes in terms of its parts and their mode of composition, i.e., why explanations of wholes in terms of parts constitute an *ideal of explanation*. In discussing the *Deutsche Logik*, we have seen that Wolff argues that if we have cognition of the parts of a thing and of their mode of composition we comprehend its essence (*Wesen*). This view is spelled out in detail in the second chapter of the *Deutsche Metaphysik*. Here, Wolff explains in detail how the notions 'essence', 'ground' (*Grund*), 'possibility' and the mereological notions 'part' and 'whole' are related.

Wolff describes a ground as that from which one can know why something is.[49] The concept 'essence' is defined in terms of the concept 'ground': the essence of a thing is that which contains the ground (the reason why) for its internal and necessary determinations. It follows that if we cognize the essence of a thing, one can specify the ground of its internal and necessary determinations.[50] That which is grounded solely in the essence of a thing

[46] Wolff 2003 [1751], 9–10.
[47] Wolff 2003 [1751], 7–8. Cf. Hettche 2006.
[48] Cf. Wolff 2003 [1751], 9–10.
[49] Wolff 2003 [1751], 15–16.
[50] Wolff 2003 [1751], 18–19; 23. In describing Wolff's position, I have added the term 'internal determinations', which derives from Baumgarten's explication of 'essence'. Baumgarten defines the internal determinations of a thing that are grounds of its other internal determinations as 'essential parts' (*essentialia*). The sum total of essential parts of a thing is its essence. The term 'internal determinations' is employed to emphasize that we are

is called a 'property' (*Eigenschaft*).[51] Hence, the properties or *attributa* of a thing are grounded in its *essentialia*. To employ a famous example from Locke: the essence of gold grounds the internal and invariable determinations (properties) of gold, such as malleability, fusibility, etc. In a similar manner, Wolff argues, that the capacity for sight is a property grounded in the essence of an animal that has eyes, that the property of being the wisest is grounded in the essence of God, that the property expressed by Pythagoras' theorem is grounded in the essence of a right-angled triangle, etc.[52]

In the *Deutsche Metaphysik,* Wolff states that if one cognizes the manner (*Art und Weise*) in which a thing is possible, one comprehends the essence of a thing.[53] Abstracting from any reference to the *ordo cognoscendi*, Wolff also states that the essence of a thing consists in the manner in which it is possible.[54] In the *Logik*, Wolff argues that we cognize the possibility of a thing if we have knowledge of its parts and their mode of composition. This argument is made more explicit in the *Deutsche Metaphysik*. Wolff first introduces the technical concept of a 'composite thing', i.e., a thing that has multiple distinct parts that are connected in a certain manner and have a particular order.[55] A composite thing is possible by means of the specific mode of composition (*Art der Zusammensetzung*) of its parts. Since the essence of a thing consists in the manner in which it is possible, the essence of a composite thing consists in the mode of composition of its parts. Hence, cognition of this mode of composition yields cognition of its essence.[56] From this it follows, because the essence of a thing is that which contains the ground of its internal determinations, that cognition of the mode of composition of the parts of a composite thing provides us with cognition of the ground of its (internal or non-relational) properties or attributes.[57]

At this point we clearly see why an explanation of a whole in terms of

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dealing with one-place predicates and *not* with relations or external determinations, i.e., determinations that cannot be ascribed to a thing if it is considered by itself. AA 17: 35–36. Cf. Baumgarten 1783, 13–15. I will further discuss this notion below.

[51] Wolff 2003 [1751], 23.

[52] *Ibid*. I owe these last two examples and the accompanying references to Longuenesse, who mentions them in her discussion of categorical and hypothetical propositions in Wolff. Longuenesse 1998, 99–101.

[53] Wolff 2003 [1751], 19.

[54] Wolff 2003 [1751], 29.

[55] Wolff 2003 [1751], 26.

[56] Wolff 2003 [1751], 29.

[57] Compare Wolff's remark in the *Deutsche Logik*, treated above, that if we have cognition of the parts of a clock and their mode of composition, we are capable of specifying the *proper ground* for each occurrence of the clock.

its parts and their mode of composition constitutes an ideal of explanation: cognition of the parts of a composite thing and their mode of composition yields cognition of the *ground* of the internal properties of a composite thing. In Chapter 1, we have seen that both Wolff and Kant took explanation to consist in the specification of objective grounds (reasons *why* something is). In Wolff's terms, the principle of sufficient reason secures that every thing (*Sache*, *Ding*) β has an objective ground α, and we provide an explanation of β if we correctly represent this objective grounding relationship. If we have cognition of a ground α from which it is possible to know why β is, we can provide an explanation of β that yields understanding of β.[58] This is the ideal of explanation that Wolff adopts and an explanation of a whole in terms of its parts and their mode of composition yields just this kind of explanation.[59] In short: the ideal of explanation as a demonstration *propter quid* is intimately associated with explanations of wholes in terms of their parts and mode of composition.

In conclusion to this section, we may point to an interpretative difficulty. I have argued that, for Wolff, explanation of wholes in terms of their parts and their mode of composition constitutes an ideal of explanation because it provides cognition of the essence of a thing and thus of the grounds of its properties (*Eigenschaften*, *attributa*). I have noted, with reference to Baumgarten, that the term '*attributa*' can be interpreted as referring to internal, as opposed to relational, determinations of a thing. Wolff himself construes the term *Eigenschaften* (*attributa*) as necessary determinations of a thing that are *solely* grounded in its essence.[60] In the *Deutsche Metaphysik*, Wolff unfortunately provides little further explanation of this term. In this respect, Baumgarten's *Metaphysica* is more insightful. Baumgarten distinguishes, among others, between the following determinations of a thing: (i) properties or *attributa*, (ii) contingent qualities (*modi*), and (iii) relations.[61] Properties are affections or internal determinations of a thing that have the essence of this thing as its sufficient ground. In contrast, contingent qualities are affections or internal

[58] Cf. Wolff 2003 [1751], 36–7. Wolff employs the term "*verständlich erklären*". The context makes clear that Wolff is thinking of explanation that yields understanding. In the present context, it seems reasonable to suppose that, according to Wolff, one understands a thing if one has cognition of the composition of its parts or of how a thing comes to be from its parts. Thus, watch-makers can be taken to truly understand watches, while this need not be the case for philosophers who invoke watches in design-arguments.

[59] Cf. Wolff 2003 [1751], 47.

[60] Wolff 2003 [1751], 23.

[61] AA 17: 37–38. Cf. Baumgarten 1783, 16.

determinations of a thing for which the essence of a thing is an *insufficient ground*.[62] Hence, cognition of the essence of a thing is not sufficient for cognizing why a thing has its contingent qualities. The same seems to hold for cognition of relations of a thing.

We can increase our understanding of the above line of thought by considering the so-called *theory of predicables* as discussed in eighteenth-century German philosophy. The theory of predicables, which goes back to Boethius, Porphyry and Aristotle, discusses the various ways in which concepts may be predicated of a subject concept.[63] The following predicables were usually distinguished: *genus*, *differentia*, *species*, *attribute* or *proprium* and *accident*. *Genus* and *differentia* were treated as parts of a species. In particular: *genus* and *differentia* are *essential* parts: they are part of the essence of a species and the complex of essential parts is called 'essence'. Attributes or *propria* were taken to be consequences of the parts of an essence (essential parts), i.e., essential parts are grounds of attributes or *propria*.[64] The notion of 'property' (*Eigenschaft*, attribute) discussed above, thus conforms to the notion of a *proprium* as discussed in the theory of predicables.

Importantly, *propria* (*Eigenschaften*, attributes) were construed as necessary marks of a thing that are *derivable*, by logical (syllogistic) inference, from essential parts (*genus*, *differentia*).[65] Through such an inference, in which we explicate a composite concept (species) in terms of its parts or partial concepts, we thus (at least according to the likes of Wolff and his contemporary pre-Kantian philosophers) *objectively ground* a judgment predicating a *proprium* of a concept, for the essence or complex of essential parts provides the *reason why* for a thing having certain attributes (*propria*).[66] An objective demonstration

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[62] *Ibid*.

[63] Cf. De Jong 1995, 632–638, for a discussion of the theory of predicables in relation to Kant. Cf. also Anderson 2005, 48–50. I owe the references in the following discussion to Job Zinkstok.

[64] Cf. Meier's *Auszug aus der Vernunftlehre* 1752, AA 16: 311–312. In Kant's lectures on logic, the so-called *Vienna Logic*, we find a similar conception. There, essential marks are construed as marks of a concept that are *grounds*. In contrast, *attributa* are construed as *derived* from essential marks (grounds). Attributes belong to the essence, but not as constituent parts of the essence (as essential marks are), but rather as consequences. Finally, 'essence' is defined as the complex of essential marks. Cf. AA 24: 838–839.

[65] Cf. Meier's *Vernuftlehre* 1752, 178–180.

[66] A typical example of such an inference would be: bodies have extension, whatever has extension is divisible, hence bodies are divisible. Here, 'extension' is an essential part of 'body', while 'divisibility' is an attribute or *proprium* of 'body'. Through such an inference, in which we explicate a whole in terms of its parts, we would thus, according to Wolff, provide the reason *why* for the truth that bodies are divisible.

of the attributes (*propria*) of things can thus, as we have also seen above, be understood as an explanation of a whole in terms of its parts and their mode of composition. However, these types of demonstrations do not allow us to ground judgments predicating contingent qualities of things (e.g., the *paleness* of some humans) or judgments predicating relations of things, for, as we have seen above, the essence (complex of essential marks) was understood as an *insufficient ground* for predicating contingent qualities or relations of a thing.

These facts seem to restrict the scope of explanations of wholes in terms of their parts and their mode of composition, for contingent qualities and relations constitute important objects of scientific explanation. To give one example: *motion*, defined as a change of place, is construed by Baumgarten as a change of relation.[67] Hence, if relations cannot be accounted for in terms of the parts of a thing and their mode of composition, the same would hold of the motion of objects. This suspicion is confirmed in the writings of Wolff, who explicitly denies that the essence of bodies is the ground of their motion. Rather, the ground of motion of bodies is their motive force.[68] This shows that explanations of wholes in terms of their parts and mode of composition are of limited use in natural science. However, as we shall see in more detail in the next sections, Wolff's conception of proper explanations in natural science is an extension of the idea of explaining wholes in terms of their parts and the mode of composition of these parts. In particular: a proper explanation in natural science is an explanation of wholes (corporeal objects) in terms of (i) their parts; (ii) the mode of composition of these parts; and (iii) the forces acting upon these parts. This presents us with the following picture: an explanation of a whole in terms of (i) and (ii) allows us to objectively explain the attributes (*propria*) of things, but is insufficient to account for its contingent qualities and relations. In order to provide an objective explanation of the contingent qualities and relations that a thing has, for example the motion of a thing (change of relation), we need to specify additional grounds, which Wolff subsumes under the title 'force'. Thus, an explanation of a whole in terms of (i)–(iii) can be sufficient for explaining at least some contingent qualities and relations of things, i.e., can provide a sufficient (complete) ground for predicating some contingent qualities and relations of things.

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[67] AA 17: 87. Cf. Baumgarten 1783, 82.

[68] Wolff 2003 [1751], 382–382. Kant seems to have adopted a similar view, at least insofar as he treated the concept of motion as *extraessential* to that of body (i.e., as not pertaining to the essence of the concept of body). In the *Vienna Logic*, we read: "essential marks are *constitutiva* of the thing. Extension *ad essentiam corporis pertinens est*. Movement is extra-essential and an *accessio* to the concept body". AA 24: 838.

I will return to notions (i)–(iii), in particular the importance of (iii), in §2.6. First, however, we may turn our attention to Wolff's conception of the method of biological science. This will allow us to determine the considerable extent in which the idea of explaining wholes in terms of their parts and the mode of composition of these parts influences Wolff's idea of proper biological method, as well as providing some examples of explanations of this kind.

2.5 Parts, wholes and explanation in biology

In his writings on natural science, Wolff introduces the idea of explaining a whole in terms of its parts and their mode of composition as an ideal of scientific explanation of *nature*. For example, in the very first paragraph of his *Deutsche Physik* (1723), he notes that corporeal objects, constituting the object of natural science, are composite objects consisting of parts. It follows that one comprehends the essence of corporeal objects if one understands how their parts can have a determinate order and constitute a whole.[69] Here, we have a clear example of the manner in which Wolff's metaphysical views on the essence of objects figure in his conceptualization of the objects of natural science.

In order to appreciate Wolff's conception of biological method, it will be useful to briefly consider Wolff's discussion of plants. This discussion is contained in the fourth part of the *Deutsche Physik*, entitled "On Plants, Animals and Man". In line with a common train of biological thought in the Eighteenth-century, Wolff takes *growth*, *nutrition*, and *propagation* to be the principal phenomena of study of biological investigation.[70] In the *Deutsche Physik*, Wolff provides extensive discussion of the then contemporary scientific theories and experimental data concerning the growth, nutrition and propagation of plants, animals and man.[71] In introducing his discussion of the growth of plants, Wolff presents the following methodological considerations:

> We find that all plants are composed from certain parts and every part consist 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

[69] Wolff 2003 [1723], 1–2.

[70] On the prominence of these topics as subject of biological investigation in the seventeenth and eighteenth century, cf. McLaughlin 2001, 173–179.

[71] The bulk of part four consists in a discussion of growth, nutrition and propagation of organisms. However, Wolff also devotes a chapter to the senses (chapter 14) and to the motion of animals and man (chapter 15).

> 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 2003 [1723], 600–601)[72]

Thus, we cognize the essence of plants (composite corporeal objects) 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)[73], we can specify the proper grounds of the nutrition, growth and propagation of plants, i.e., we can cognize *why* nutrition, growth and propagation are characteristic features of plants. In this manner, Wolff's metaphysical views on the explanation of wholes in terms of their parts find application in biology. On the basis of these views, Wolff also determines what he takes to be the correct methodology for the scientific investigation of plants. Valuable scientific cognition of plants is obtained, Wolff argues, by primarily anatomical research into the *parts* of which plants and their parts are composed, and the *mode of composition* of these parts.[74]

In discussing the growth of plants, Wolff carefully follows his methodological prescriptions. He first specifies the parts that can be discerned in every plant, 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.[75] This analysis provides the basis for understanding the growth of plants.

For example, after distinguishing the main parts of plants, Wolff notes

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[72] 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)."

[73] At some level of analysis we normally take parts to be basic. Cf. §3.7, in which Leibniz's theory of organic form, to which Wolff's views are indebted, is briefly discussed.

[74] Wolff 2003 [1723], 600–602. Wolff praises, among others, the anatomical and experimental research on plants of Malphighi, Grevv, van Leeuwenhoek and Thümmig, and dismisses the 'ancients' who did not care for anatomical research.

[75] Wolff 2003 [1723], 603–613.

that the root of a plant consists of three main parts: (a) the bark (*Rinde*), (b) the wood (*Holtze*), and the pith (*Marcke*).[76] It is dangerous (because anachronistic) to apply modern anatomical terminology to Wolff's analysis. However, it is likely that he is providing a description from the outermost to the innermost layers (cellular tissues) of plant-roots. As a rough indication, then, the term 'bark' (*Rinde*) can be taken to refer to the *epidermis* and the *cortex* of roots, the term 'wood' can be taken to apply to the *phloem* and *xylem* of roots, and 'pith' (*Marcke*) can be taken to apply to the central or innermost cellular tissue of roots. In a similar manner, Wolff determines the parts of the parts of the stem, also consisting of (a) bark, (b) wood, and (c) pith, and determines the parts of leaves.

In several cases, this analysis of the parts of plants is extended to an even more fundamental level. For example, after specifying the parts of the roots of a plant ((a)–(b)), Wollf specifies the parts of these parts. For example, the bark (*Rinde*) of a root is taken to consist in: (α) a membrane (*Hautlein*), and (β) a spongy substance (*schwammichten Substanz*).[77] The membrane is said to be porous and the spongy substance is taken to absorb water. Following Grevv, Wolff calls this spongy matter, which he also locates in the pith, *parenchyma*. This term is now employed to denote the common ground tissue that forms (among others) the *cortex* and *pith* of stems and the *cortex* of roots. Wolff, of course, did not posses our modern knowledge of parenchyma cells. However, it seems likely that he employed the term *parenchyma*, when applied to the spongy substance of the bark of a root, to the matter comprising the *cortex* of roots.

Through this continual analysis of parts and subparts of plants, Wolff aims to establish a framework for coming to understand the growth and nutrition of plants. For example, after identifying water as the primary source of nutrition of plants, Wolff aims to explain how water is taken up by roots. Wolff 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.[78] In order to explain the absorption of water by the roots, we require, apart from cognition of the parts and sub-parts of the roots, cognition of physical laws governing the movement of water. Wolff provides the following explication of this process of absorption: the root is that part of a plant which lies under

[76] Wolff 2003 [1723], 603–604.
[77] *Ibid.*
[78] Wolff 2003 [1723], 603–605, 626–627.

the surface of the soil or earth.[79] If the earth is wet, it contains droplets of water. The bark of the root of a plant, consisting of the membrane and spongy substance, contains a large quantity of air. If the earth is wet the droplets of water will, due to its greater weight than air, move downward while the air contained in the bark will move upward.[80] 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 plant-roots.

After accounting for the absorption of water by plant-roots, Wolff continues his investigation by inquiring how the leaves of a plant obtain water, how water is transformed into a nutrient ('nutritious fluid'), how this nutritious fluid is transported through the plant, etc., admitting that a full understanding of some of these topics will require further research.[81] All of these accounts proceed on the basis of Wolff's analysis of the parts and subparts of plants. Thus, for example, the spongy substance of the bark of the root and stem of plants is identified as the primary location in which water is transformed into a nutrient, and parts of the stem, analyzed as consisting of two types of tubes (*Safft-Röhren* and *Luft-Röhren*), are taken to enable the transportation of fluids through the stem. Through these various inquiries, we can deepen our insight of how plants obtain and transport nutrition, and thus ultimately of the process of growth of plants.

This account nicely illustrates Wolff's proposed methodology for the scientific investigation of plants. In the investigation of plants, and of organic phenomena in general, we identify wholes, analyze these wholes into parts, analyze these parts into their subparts, etc. The identification of the whole and of the parts relative to this whole is mainly determined by our scientific interests, i.e., by what we take to be the *explanans*. Thus if we try to explain the absorption of water by roots, we take the root of a plant as a whole and explain its absorption of water in terms of (among others) the structure of its parts, parts that are relevant to our understanding of the process under investigation.[82] In different contexts, different wholes, parts and subparts will emerge as relevant for understanding natural phenomena. However, if we aim to explain highly complex phenomena, such as the nutrition and growth of

[79] Wolff 2003 [1723], 603.

[80] Wolff 2003 [1723], 626–627.

[81] Cf. Wolff 2003 [1723], 628–636.

[82] Cf. Wolff 2003 [1751], 379. Wolff argues that if one has as a goal the specification of the grounds for the occurrences in the human body, one has to inquire into its parts, their constitution and the relation of these parts. The body is dissected in order to obtain this goal.

plants (phenomena analyzable into multiple complex sub-processes), we must base our investigation (as Wolff aims to do) on a thorough analysis of the relevant parts and subparts of plants and their mode of composition. This analytical approach will yield increasingly more insight into the essence of plants. By following this procedure, we hope to gain a proper understanding of the general phenomena characteristic of organisms: nutrition, growth and propagation.

The foregoing shows how the idea of explaining a whole in terms of its parts and their mode of composition determines Wolff's views on biological method and explanation. However, it is also clear that in order to explain the various processes necessary for understanding the working of organisms (e.g., the nutrition and growth of plants), the appeal to parts and their mode of composition does not suffice. For example, in explaining how plant-roots absorb water, Wolff appeals to the parts of roots, their mode of composition, and the fact that the weight of water is greater than that of air. This relates to our discussion in §2.4, in which it became clear that the appeal to the parts and their mode of composition can explain the essence and attributes (*propria*) of a whole. It does not, however, provide an account of contingent qualities of a whole and its relation to other wholes. Most importantly, the *motion* of a whole cannot be explained in terms of its parts and their mode of composition. In order to explain motion, we require the notion of force (as is the case in Wolff's account of the absorption of water in roots). This notion will be the focus of discussion in the next section, in which we aim to arrive at a definite account of Wolff's views of mechanical explanation.

2.6 Wholes, parts and forces: mechanical explanations in Wolff

In the preceding sections, I have indicated how, according to Wolff, explanations of wholes in terms of their parts and mode of composition figure in diverse sciences such as logic, mathematics and biology. It remains to explain more specifically how such explanations figure in natural science in general. As emphasized, the notions of 'whole' and 'part', being applied to *possible objects*, have a broad application. This explains why explanations of wholes in terms of their parts have their use in diverse sciences. However, it is clear that in different sciences the notions 'whole' and 'part' are applied to different types of objects. Hence we may inquire how these notions are interpreted in natural science. We have already seen that some features of objects cannot be explained in terms of their parts and mode of composition. The motion of

objects constitutes a prime example. In the present section, we will see that Wolff incorporates the notion 'force' in his account of scientific explanation in order to characterize the objects of natural science and in order to explain motion.

According to Wolff, the wholes with which we are concerned in natural science are bodies (*Cörper*).[83] A body is a composite thing, i.e., a whole consisting of parts with a particular order.[84] Hence, the properties (*propria*) of composite things, e.g., figure, quantity, divisibility, the filling of a space (properties or attributes grounded in the essence of a composite thing), also pertain to bodies.[85] Moreover, as is the case for composite things, the essence of a body is contained in the mode of composition of its parts.[86]

These characteristics are not sufficient for determining the meaning of 'body'. Up to this point we have not specified any characteristic allowing us to differentiate between, e.g., geometric objects and corporeal bodies. The distinguishing feature of bodies is given by the concept 'force': all bodies (but not all composite things) have a force. In addition, corporeal bodies are constituted by *material parts*. For, Wolff argues, it is in virtue of material parts that bodies have an extension and a force to resist (change of) motion.[87] In natural science, which is concerned with corporeal bodies, the term 'parts' thus refers to material parts. These considerations provide us with the following conception of 'body': (i) a body is a composite object, the essence of which consists in the mode of combination of its parts. The essential parts of the concept of a composite object, e.g., 'compoundness' or 'extension', thus also apply to bodies. In addition, bodies can be ascribed properties (*propria*) that necessarily pertain to composite objects. These properties include those that we ascribe to mathematical (geometric) objects, such as figure, divisibility, etc; (ii) bodies, as extended and inert beings, consist of matter; (iii) bodies are characterized by a force. Thus, essence, matter and force are the terms in which we understand corporeal bodies.[88]

How should we understand the notion 'force' in this context? In the *Deutsche Metaphysik*, Wolff defines 'force' as a source of change that exists in any substance (*vor sich bestehende Dinge*). In particular, changes of substances are grounded in their force and can accordingly be treated as acts of these

[83] Cf. Wolff 2003 [1723], 1–3.
[84] Wolff 2003 [1751], 26.
[85] Wolff specifies this list of attributes or *propria* of composite things in Wolff 2003 [1751], 35. They are predicated of bodies in Wolff 2003 [1751], 374–375.
[86] Wolff 2003 [1751], 375.
[87] Wolff 2003 [1751], 374–377.
[88] Cf. Wolff 2003 [1751], 382–383.

substances.[89] This is Wolff's metaphysical explication of the concept 'force', which is akin to Leibniz's notion of primitive force construed as the metaphysical ground of the activity of substances.[90] For our present purposes, this topic is not very relevant, since the notion of 'force' that Wolff employs in characterizing corporeal bodies is not identical to this metaphysical conception of force.

In his discussion of *corporeal bodies* Wolff introduces the concept 'force' while determining the nature of matter. Wolff notes that all corporeal bodies have a force to resist motion, i.e., a force of inertia.[91] He then argues that the extension and the inertia of corporeal bodies are grounded in the extension and the force of inertia of *matter*. [92] Thus, characteristics of the whole are grounded in characteristics of the parts and their forces. Since matter is characterized by a force of inertia, bodies, composed of material parts, cannot move themselves. Hence, the motion of corporeal bodies must have an external cause. These considerations provide the basis for affirming Newton's first law of motion, according to which every body continues in its state of rest, or of uniform motion in a straight line, unless compelled to change that state by forces impressed on it.[93] After discussing the law of inertia, Wolff notes that if a moving body *A* collides with a body at rest *B*, the resulting motion of *B* is caused by *A*. This implies that *A* must contain the ground for the motion of *B*.[94] However, since matter is merely inert or passive, the matter of *A* cannot be the ground for the motion of *B*. Neither can the essence of *A*, the mode of composition of its parts, be the ground for the motion of *B*. Consequently, we must attribute a (Newtonian) *motive force* to *A*, which is the ground of motion.[95]

Wolff thus construes the motive force of bodies as the ground of (change of) motion of other bodies. This argument is based on a particular conception of the constitution of bodies: bodies are constituted by matter which is inert. This conception also informs Wolff's claim that the essence of bodies does not contain the ground for the communication of motion. The essence of bodies, the composition of its parts, contains the ground for some of its

[89] Wolff 2003 [1751], 60–61.
[90] On Leibniz's notions of force, see for example Garber 2009, Chapters 2 and 3.
[91] Wolff 2003 [1751], 375–377. Wolff does not explicitly employ the term inertia in this context. However, the current discussion is followed by a discussion of Newton's law of inertia.
[92] Wolff 2003 [1751], 376–77.
[93] This is a formulation based on Newton. Wolff provides a slightly different formulation, although referring to Newton's *Principia*. Wolff 2003 [1751], 377–378.
[94] Wolff 2003 [1751], 381.
[95] Wolff 2003 [1751], 382–383.

properties, e.g., its extension, figure, divisibility (essential parts and *propria*). However, insofar as corporeal bodies are construed as wholes composed of inert material parts, the mode of composition of these parts cannot explain the communication of motion between different bodies. Hence, if we construe bodies as wholes and material parts as parts, we have to conclude that the communication of motion between bodies cannot be explained in terms of their parts and their mode of composition. This is precisely what Wolff claims. It follows that we require the posit of motive forces, which, since they are no material parts, are not conceptualized as parts of a whole.[96]

In virtue of having a motive force bodies have a *nature*, as opposed to merely an *essence*. Hence, if we assign forces to objects, these objects can be taken to have a nature. Wolff notes that that which has its ground in the *essence* and *force* of body is called *natural* and constitutes the object of natural science (*Naturwissenschaft*). In Wolff's precise terms: natural science is a science of that which is possible through the essence and forces of corporeal things.[97] It follows that in the scientific explanation of corporeal things (bodies) one must take into account its essence, i.e., its parts and their mode of combination, and forces acting upon bodies and their parts. To employ Kantian phraseology: the concept of force is constitutive of the object of natural science.

As an example of something 'natural' constituting an object of scientific explanation Wolff cites the vaporization of water in hot air, which is taken to be grounded in both the essence and force of water and hot air.[98] In the fifth chapter of the third part of the *Deutsche Physik*, Wolff presents us with an account of the vaporization of water.[99] Roughly, this descriptive 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.[100] If these globules expand enough, their density will be lesser than that of both the water and the surrounding air and, consequently, they will separate from the water and rise up in the air, i.e., they become vapours (*Dünste*). This rise will continue as long as the density of the vapours is lesser than that of the surrounding air. Following Wolff's cue, we can indeed argue that in this account both the essence and the forces

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[96] Of course, if we adopt a more general notion of 'part' and 'whole', forces may also be construed as parts, e.g., as parts active between multiple bodies which are conceptualized as a composite whole. My point is that Wolff's specific conception of corporeal bodies led him to deny that forces are parts of a whole.

[97] Wolff 2003 [1751], 384–385.

[98] *Ibid.*

[99] Wolff 2003 [1723], 333–348.

[100] Wolff 2003 [1723], 337–338.

of corporeal bodies are employed to explain the vaporization of water. For example, in explaining the formation of globules we utilize cognition of the parts of water (air or oxygen), i.e., the matter of water, 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 the scientific explanation of corporeal objects of nature: (i) we explain them in terms of the parts; (ii) the mode of composition of these parts (comprising the essence of any object); and (iii) the forces acting upon these parts.

Scientific explanations in terms of (i)–(iii) constitute, paradigmatic cases of *mechanical explanations*. To understand this, we require some analysis of the notions 'machine' and 'mechanism' as employed by Wolff. In the fourth chapter of the *Deutsche Metaphysik*, entitled "On the World", Wolff provides the following definition of a machine: a machine is a composite thing, a composite product of art (*zusammengesetztes Werck*), the motions of which are partly grounded in the mode of composition of its parts.[101] A clockwork provides a perfect example (and Wolff heavily employs it). In explaining the functioning of a clockwork, we can plausibly say that we take into account (i) its parts, (ii) their mode of composition, and (iii) the motive forces acting on these parts.

Wolff introduces the definition of a machine while arguing that the world is a machine. Like a machine, the world is a composite thing. Its essence is comprehended by cognizing the mode of composition of its parts, and the changes that occur in the world are partly grounded in this mode of composition.[102] Not only is the world a machine. According to Wolff, all composite things are machines.[103] Hence, *corporeal bodies*, composite things constituting the domain of natural science, are machines. It follows that an explanation of corporeal bodies, as can be taken to be the main purpose of (natural) science, is an explanation of machines. Here, then, we are confronted

[101] Wolff 2003 [1751], 336–337. The term 'partly' is introduced by myself. 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 account of *motion* requires the introduction of the notion of 'force' (hence the mode of composition of parts only seems to provide a partial ground of the motion of machines). As we will see below, Wolff treats all composite things (and hence bodies) as machines. This suggests that Wolff already treats something as a machine if we understand it in terms of (i) its parts, and (ii) the mode of composition of its parts. For my present purposes, it is merely important to note that Wolff treats corporeal bodies as machines, and hence explanations of bodies in terms of (i)–(iii) count as explanations of machines.

[102] Wolff 2003 [1751], 335–337.

[103] Wolff 2003 [1751], 337–338.

with the manner in which an explanation of a whole in terms of (i)–(iii) can be termed a mechanical explanation: it is an explanation *of* machines. Moreover, it is also completely clear that explanation in terms of (i)–(iii), i.e., mechanical explanations, constitute an ideal of explanation in natural science. All corporeal bodies are machines, and hence all objects constituting the object of inquiry in natural science, must allow of mechanical explanation. As we have seen in our discussion of Wolff on plants, this is also true of the machines that we now call organisms.

2.7 Parts, wholes and the order of concepts in Kant

The ideal of mechanical explanation distilled from the writings of Wolff provides us with the background for understanding Kant's idea of mechanical explanation. In the following, we will see that (i) Kant, even more poignantly than Wolff, conceptualized relations between concepts in terms of part/whole relations. This view provides the basis for Kant's views on mechanical explanation, as given in natural science, expounded in the Dialectic of Teleological Judgment of the third *Critique*. In addition, we will see (ii) that Kant, like Wolff, takes mechanical explanation to constitute an ideal of scientific explanation because it provides cognition of *objective grounds* for natural phenomena. Finally (iii), we will distil two examples of mechanical explanations from Kant's writings. (iii) will be the focus of the following section. In the current section, (i)–(ii) will be the focus of inquiry.

(i) In our discussion of Wolff's view on definitions, we noted that Wolff entertained the idea that in defining a concept we specify a relation between a whole (a composite concept) and its parts (its marks, characteristics, partial concepts). Kant likewise conceived of concepts contained in a concept (marks, characteristics, partial concepts) as parts of a composite concept. For example, in the *Wiener Logik* we read:

> […] if a concept contains something that is common to several things, it is itself contained in other possible concepts [;] it is a part of them, but contains only that which they have in common and omits what is different in them. Every universal concept is contained in the concepts from which it is abstracted, then. E.g., the concept *metal* belongs to gold, copper, etc. (AA 24: 910)

Hence, concepts contained in other concepts constitute parts of the latter, e.g., the genus metal is a part of the species gold, copper, etc. Although the

given example merely specifies a relation between genus and species, this view suggests that *differentiae* also comprise parts of the concepts contained under them. Throughout several of Kant's lectures of logic, the relation of concepts contained in other concepts is construed as a relation of partial concept (part) to composite concept (whole).

The totality of partial concepts contained in a concept comprise the intension (*Inhalt*) of this concept. Hence, concepts comprising the intension of a concept are part of the latter. Interestingly, Kant also seems to apply the part-whole scheme to relations obtaining between concepts comprising the extension of a concept and this extension itself, where the extension of a concept must be understood as the totality of concepts contained *under* it. This view, which we did not find in Wolff, emerges in the discussion of disjunctive judgments in the *Jäsche Logik*.

In a note to §29 of the *Jäsche Logik*, entitled "Peculiar character of disjunctive judgments", we read that in a categorical judgment "the thing whose representation is considered as a part of the sphere of another, subordinated representation is considered as contained under this, its higher concept".[104] In other words, in a categorical judgment, the representation contained under the subject concept is construed as a part of the extension (sphere) of the subject concept. The subject concept, can, in turn, be construed as part of the extension of the predicate. Hence, in the "subordination of the spheres, the part of a part is compared with the whole."[105] The application of the part/whole scheme to the extension of concepts is even more predominant in the characterization of disjunctive judgments.

A judgment is taken to be disjunctive if "the parts of the sphere of a given concept determine one another in the whole or toward a whole as complements (*complementa*)".[106] Thus, for example, in the disjunctive judgment 'a learned man is learned either historically or in matters of reason', we specify concepts that are parts of the extension (sphere) of 'learned man'.[107] Put differently: in a disjunctive judgment we *divide* the extension of a concept, e.g., of 'learned man' (here we are dealing, employing the ideas of Boethius discussed in §2.2, with a quantitative division of a whole into its parts). Taken together, the specified parts (concepts) of the extension of a concept must be complete, i.e., they must equal the extension of the divided concept. The parts of the sphere of a cognition are *complements* of each other toward the whole

[104] AA 9: 107.
[105] *Ibid.*
[106] AA 9: 106.
[107] AA 9: 107. The example is taken from the *Jäsche Logik*

and the totality of parts should equal the whole extension of this cognition. In addition, the specified parts of the extension of a concept should not be part of each other, i.e., if the extension of a concept is divided in *b* and *c*, *b* and *c* should not be part of one another.[108] From the satisfaction of these two conditions the precise determination of a disjunctive judgment follows: a complex judgment in which one and only one of the disjuncts is true. Hence, the application of the part/whole relation to relations obtaining between concepts comprising the extension of a concept and this extension itself seems to ground Kant's views on disjunctive judgments in a profound manner.

We may now focus on Kant's remarks relating to mechanical explanation contained in the Dialectic of Teleological Judgment of the third *Critique*. In §2.1, we saw that §77 of the Dialectic contains important textual data for understanding the notion of 'mechanical explanation'. Kant claims that if we regard a material whole as a "product of its parts and of their forces and their capacity to combine by themselves", we "represent a mechanical kind of generation."[109] It seems plausible to suppose that if we succeed in representing a mechanical kind of generation of natural objects, we mechanically explain the formation of these objects. Kant's claim, however, is the conclusion of a complicated argument in which he discusses a special characteristic of our discursive understanding.[110] This characteristic is explicated in the following manner:

> 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,

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[108] *Ibid.*

[109] AA 5: 408.

[110] Still one of the most useful treatments of this argument is contained in the classic work of Düsing 1968, who interprets (as I will) Kant's characterization of our discursive understanding in light of his views on containment relations among concepts. A very concise treatment of this argument is found in Guyer 2001. I will merely focus on this argument insofar as it sheds light on the notion of mechanical explanation.

> 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)

Kant characterizes our discursive understanding as characteristically proceeding from the parts to the whole. In contrast, an intuitive understanding is characterized as proceeding from the whole to the parts.[111] The notions 'analytic universal' and 'synthetic universal' are logical notions.[112] In the *Jäsche Logik*, both terms apply to *rules*, i.e., to concepts or judgments.[113] A universal rule is 'analytic universal' if it "abstracts from differences (*Verschiedenheiten*)" and it is 'synthetic universal' if it does not.[114] Any concept and any judgment is abstract insofar as we, in employing concepts and judgments, abstract from differences of objects to which these concepts and judgments can be applied.[115] However, when we consider our use of concepts and judgments, we can distinguish between different degrees of abstractness.[116] If, for example, we consider a tree of concepts, the more abstractly employed concepts will approach the place of the highest genus (*genus summum*) in the tree, whereas concepts employed concretely will approach individual representations (intuitions) of thoroughly determined individual objects.[117] This characterization is in conformity with the claim that through logical abstraction we obtain higher concepts , i.e., marks or partial concepts of concepts falling *under* them (the latter concepts comprising the extension of the former), whereas through logical determination we obtain lower concepts.[118] Hence, partial concepts contained *in* the concepts falling under them, the totality of partial concepts comprising the *intension* of the concepts falling under these partial concepts, are more abstractly employed than the concepts comprising its extension.

The foregoing suggests that when Kant, in the *Kritik der Urteilskraft*, characterizes the human understanding as proceeding from the analytic universal to the particular, he thinks of a process of logical determination in which we proceed from partial concepts to composite concepts. By now, it should come as no surprise that Kant characterizes our understanding as proceeding from parts to whole. For, as we have seen in our preceding discussion of Wolff and

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[111] Kant also states that our understanding, in contrast to an intuitive understanding, is a faculty of concepts (a discursive understanding) which proceeds from "the universal to the particular and thus to the individual (through concepts)" AA 5:406.

[112] This is stressed by Düsing 1968, 90–92. Cf. Friedman 1992a, 307–308.

[113] AA 9: 102–103.

[114] *Ibid*.

[115] For the notion of abstraction discussed in relation to concepts, cf. AA 9: 94–95, 99–100.

[116] AA 9: 99–100.

[117] AA 9: 99.

[118] *Ibid*.

Kant, the relationship between partial concepts and composite concepts is understood as a relationship between parts and wholes.

Of course, Kant's notion of explanation of wholes in terms of their parts (mechanical explanation) is not merely based on his view on logical relations between concepts. Recall that this was also the case for Wolff, who, defining the notions 'whole' and 'part' relative to the class of possible objects, took explanations of wholes in terms of their parts to exist in such diverse disciplines as logic, mathematics and natural science. In natural science, when explaining *natural objects*, we explain natural objects in terms of their parts, the mode of composition of these parts and the forces acting on these parts. The notion of force is crucial: the fact that objects have a force makes them natural objects comprising the domain of natural science.

Kant's notion of 'mechanical explanation' should likewise be interpreted as a type of explanation that is characteristic of natural science. This is clear from Kant's terminology. In giving a mechanical explanation we represent a *real whole of nature* as the effect of the concurrent *moving forces* of the *parts*. Like Wolff, Kant frequently employs the term 'whole' in a general mereological sense referring to possible objects. A *real whole of nature*, however, must be interpreted as an existing object subject to natural laws. This characterization excludes mathematical objects as the object of mechanical explanation, for according to Kant mathematical objects have an essence (are possible objects) but not a nature, since strictly speaking mathematical objects do not exist.[119] Similarly, causal relations only obtain between objects of nature and forces can only be attributed to natural objects. Kant thus characterizes the idea of mechanical explanation in terms of notions that restrict the domain of application of mechanical explanations to nature. The notion 'force' is one of these notions and thus constitutes a crucial component of a mechanical explanation.[120] Kant's views on mechanical explanation hinted at in the Dialectic of Teleological Judgment thus appear quite similar to those distilled from Wolff.

[119] AA 4: 467n. Cf. *KrV A* 719/ *B* 747. See also Kant's definition of 'nature' in §14 of the *Prolegomena*: "*Nature* is the *existence* of things, in so far as it is determined by universal laws" (AA 4: 294). In general, Kant always relates the notions 'existence' and 'causality' to objects of nature.

[120] McLaughlin occasionally abstracts from the notion 'force' in characterizing Kant's conception of mechanical explanation, arguing, e.g., that a mechanical explanation consists in a "reduction of a whole to the independent properties of its parts." McLaughlin 1989, 139. This characterization is too general to allow us to distinguish between the mechanical explanation of natural objects and explanation of wholes in terms of their parts as given in logic or mathematics.

(ii) In our discussion of Wolff, we have seen that explanations of composite things (wholes) in terms of their parts and their manner of combination provide cognition of the grounds (reasons why) of properties of composite things. In natural science, explanations of wholes in terms of their parts, mode of composition and forces acting between parts supply us with cognition of grounds. For this reason such explanations constitute an ideal of scientific explanation.

In §77 of the *Kritik der Urteilskraft*, Kant, like Wolff, relates explanations of wholes in terms of parts to cognition of grounds. As we have seen, Kant, referring to relations among concepts, notes that our understanding characteristically progresses from the parts "as universally conceived grounds, to the different possible forms, as consequences, that can be subsumed under it."[121] In the *Jäsche Logik* it is argued that a concept can be taken as a *ground of cognition* with respect to the totality of representations making up its extension.[122] Genera function as a ground of cognition for the species and sub-species of which they are predicated. Hence, the part/whole relation existing between partial concepts and composite concepts can be construed as a relation between grounds of cognition and consequences cognized through these grounds.

At this point a crucial difference between the views of Wolff and Kant arises. It is useful to describe this difference is some detail. For Kant, a genus can function as a *ground of cognition* for cognitions contained under it (comprising its extension), i.e., it provides a reason for cognizing *that* such and such is the case. As we have seen in §2.4, the *genera* and *differentia* contained in a concept were traditionally taken to constitute the essence of the latter, i.e., they constitute *essential parts* of a concept.[123] Moreover, as we have also seen, *propria* were traditionally taken to be logically derivable from essential parts (*genus*, *differentia*). In our discussion of Wolff, we have seen that cognition of the essence of a thing provides cognition of the reason (ground) *why* for the properties (*propria*) of this thing. Hence, Wolff would take the logical (syllogistic) inference of a judgment predicating a *proprium* of a species, an inference in which we employ premises that merely explicate the content (intension) of the species concept, to provide us with a *reason why* for the

[121] AA 5: 407.

[122] AA 9: 96. See also the discussion of the distinction between ground of being and ground of cognition in §1.2.

[123] Cf. also Kant's *Über eine Entdeckung* (1790), AA 8: 229–230, in which 'extension' is treated as an essential part of the subject 'body'. See also Kant's letter to Reinhold of 1789, AA 11: 35–36.

truth of this judgment. Here is a standard example of such an inference: from the judgments that (i) bodies have extension, and (ii) whatever has extension is divisible, we derive (iii) bodies are divisible. Through this derivation, we derive, from judgments (i) and (ii) in which we explicate the (complex) intension of the concept 'body', a judgment (iii) in which we predicate a *proprium* or attribute of bodies (divisibility).[124] In this example, 'extension' is part of the essence of 'body' given that it is the specific difference of 'body' (it is an essential part), whereas 'divisibility' is *contained in* the concept 'extension' and thus also contained in the concept 'body'. Wolff would take this inference as providing a demonstration explaining *why* bodies are divisible.

Kant adopts a more complex view. In his *Ueber eine Entdeckung* (1790) Kant, discussing the proposition 'every body is divisible', emphasizes that this proposition is analytic a priori.[125] The predicate 'divisible' is an attribute (*proprium*) because it can be derived from an essential part of 'body', namely the concept 'extension'. However, Kant makes it clear that this predicate is an *analytic attribute*. For Kant, (i)–(iii) are all analytic a priori judgments: they merely explicate the complex content (intension) of the concept 'body'. Judgment (iii) is thus analytically derived from the essence of the concept 'body': it allows of proof merely by analysis of the concept 'body' (and its constituent concepts) and by means of the principle of noncontradiction. The concept 'extension' can accordingly be described as constituting (part of) the *logical essence* of bodies.[126]

Importantly, Kant distinguishes analytic attributes from *synthetic attributes*. In *Ueber eine Entdeckung*, he emphasizes that the predicate of a synthetic judgment a priori is an attribute. These attributes are (of course) not analytic attributes but synthetic attributes that can *not* be derived analytically according to the principle noncontradiction.[127] As an example of a synthetic judgment a priori predicating an attribute Kant gives the judgment 'every substance is permanent' (i.e., the first analogy of experience of the *Kritik der reinen Vernunft*). From the perspective of Kant's transcendental philosophy, which provides us with a system of synthetic judgments a priori, the notion of a synthetic attribute is of course much more important than that of an analytic attribute. At this point it is clear that Kant conception of essence and attributes is more complex than that of Wolff. What is the significance of this

[124] The example is given by Kant. AA 8: 229. Cf. AA 11: 35
[125] AA 8: 229–231.
[126] Cf. AA 11: 37.
[127] AA 8: 229–230.

point for the idea of objective grounding and the associated idea of explaining wholes in terms of their parts?

As said, Wolff takes analytic inferences in accordance with the principle of noncontradition to provide demonstrations showing *why* something is the case (recall the proof of 'bodies are divisible' above). In my view, as argued for in Chapter 1, Kant entertains a more restricted conception of what constitutes a demonstration *propter quid*: α objectively grounds β only if (a) β is derivable from α, and (b) α specifies the objective ground of what is asserted by β. Let us give an example fitting the present context. In §2.6, I noted that Wolff took the concept of filling a space to be a *proprium* of composite things. Hence, we can derive this *proprium* from the essential parts of the concept of composite things, essential parts that we identify through the analysis of the concept of a composite thing. Given that all bodies are composite things, it thus seems to follow purely analytically (in accordance with the principle of noncontradiction) that bodies fill a space. In my opinion, Kant would argue that in this derivation we do not specify the objective ground of bodies filling space (i.e., this derivation does not satisfy condition (b)). The essence of the concept of a composite thing that is at issue here is (as we have seen) entitled 'logical essence' by Kant, i.e., the complex of marks that first constitute (are contained in) a certain concept.[128] The logical essence provides a logical ground, i.e. as *reason that*, for the truth of judgments. In order to objectively demonstrate that bodies fill a space, we need to specify the *objective ground* of bodies filling a space. In the Dynamics of the *Metaphysische Anfangsgründe*, Kant provides this objective ground, arguing that matter fills a space through a particular moving (repulsive) force. This example further suggests that Kant took the class of properties (*propria*) that are analytically derivable from the essential parts of concepts of things to be smaller than Wolff did. After all, the property of 'filling a space' is, according to Kant, not a property that can be analytically derived from the concept of a composite thing.

The above example shows that Kant, in contrast to Wolff, does not treat the filling of space as a *proprium* in the traditional sense (i.e., as an analytic *proprium*). This is also suggested by Kant's remarks in the *Metaphysische Anfangsgründe*. There he remarks, arguing against "Lambert and others", 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

[128] AA 24: 839.

> 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 *proprium* of the concept body (or matter), it could be analytically derived from the essence of the concept 'body' and thus allow of a proof merely by means of analysis of the concept 'body' and by means of the principle of noncontradiction. Kant denies that the latter is possible. Given that Kant distinguishes between analytic and synthetic attributes or *propria*, we may presume that according to Kant 'filing a space' is a synthetic *proprium*. It is only through a *synthetic judgment a priori* (developed in the *Metaphysische Anfangsgründe*) that specifies that material bodies are constituted by repulsive force that we can objective explain *why* material bodies fill a space.

In conclusion, Kant would criticize Wolff for treating synthetic attributes as analytic attributes and thus for attempting to prove propositions analytically (merely in accordance with the principle of noncontradiction) that are not so provable. How does this point relate to the idea of explaining characteristics of wholes in terms of their parts? As said in §2.4, while discussing Wolff's metaphysics, Wolff understands objective demonstrations of the attributes (*propria*) of things as explanations of wholes in terms of their parts and mode of composition. The demonstration of a proposition predicating a *proprium* of a subject (e.g. 'filling a space' of 'bodies' or 'divisibility' of 'matter') simply *is* an explanation of a whole in terms of its parts and mode of composition. Although Kant accepts the existence of analytic attributes, we know now that he would reject Wolff's methodology of explaining wholes in terms of their parts in metaphysics, for Wolff's explanations (based merely on the analysis of concepts) do not ground judgments predicating *synthetic attributes* of subjects. The merely provide proofs of analytic judgments a priori. It is, however, with synthetic judgments a priori that philosophy or metaphysics is mainly concerned in the eyes of Kant. Hence, Kant seems to reject the Wolffian methodology of explaining wholes in terms of their parts and mode of composition in the domain of metaphysics. Nevertheless, as we have seen in the preceding, Kant does seem to accept this methodology in the realms of (general) logic and natural science. In the following, I will primarily focus on natural science.

Having treated the differences between Kant and Wolff, we may continue our analysis of Kant's argument in §77 of the Dialectic of Teleological Judgment. In this section, Kant makes the crucial claim that we must regard real wholes of nature as the effect of the moving forces of its parts. Here, our

conceptualization of a whole in terms of its parts and their forces is taken as representing an *objective causal relation* between parts and wholes (not a relation between concepts). By representing wholes as the effect of their parts and their moving forces we are representing a relation between objective grounds and consequences. This, as we have seen in §1.2, is equivalent to providing a demonstration *propter quid* of the consequences. This type of demonstration, by providing cognition of *why* things are such and such, constitutes the proper form of scientific explanation. Although Kant thus seems to adopt a more narrow conception of what constitutes a proper scientific demonstration, he does ultimately, similar to Wolff, conceptualize explanations of wholes in terms of their parts and forces as ideal types of scientific explanation.

Further evidence for this interpretation is given by the fact that Kant relates the activity of our understanding of progressing from parts to whole with *determining judgment*. In the first introduction to the *Kritik der Urteilskraft*, Kant states that the determining power of judgment would "like to know everything to be traced back to a mechanical sort of explanation"[129], i.e., an explanation of a whole in terms of its parts and forces. In §77 of the Dialectic, Kant argues that if we judge products of nature in a manner appropriate for the determining power of judgment we judge in a manner adequate to the things themselves.[130] It is this type of judgment that is required in natural science (*Naturkunde*).[131]

Kant thus argues that explanations of wholes in terms of their parts and forces are appropriate for natural science because they provide insight into the objective nature of natural products. In other words: explanations of wholes in terms of their parts and forces provide us with an explanation reflecting the order of nature, i.e., they provide demonstrations *propter quid*. The upshot is that mechanical explanation constitutes an ideal of explanation in natural science. Any other type of explanation (assuming that the term 'explanation' applies) is not appropriate to the aims of natural science. As Kant states with respect to what we might call teleological explanation: "in natural science we are far from being satisfied with an explanation of the products of nature by means of causality in accordance with ends."[132] The reason is that, in judging (explaining) natural objects teleologically, we do *not* judge products of nature in a manner adequate to the things themselves.

[129] AA 20: 218.
[130] AA 5: 408.
[131] *Ibid.*
[132] *Ibid.*

2.8 Two examples of mechanical explanation

In the present section, I will describe two concrete examples of what Kant interprets as mechanical explanations of natural phenomena. First, I will describe Kant's account of crystallization or solidification, as presented in the third *Critique* and the *Opus postumum*. Second, I will very briefly describe Kant's famous description of a possible mechanical account of the generation of the variety of species, as presented in §80 of the "Critique of Teleological Judgment". In both cases, we will see that what Kant describes as a mechanical explanation conforms to our account of mechanical explanation presented in the previous sections. In addition, both examples show that Kant adopted a broad conception of mechanical explanation. The Wolffian account of mechanical explanation is thus shown to be widely applicable.

In §58 of the Critique of Aesthetic Judgment of the third *Critique*, Kant cites the "free formations" (*freien Bildungen*) of nature as natural objects that are mechanically generated.[133] Kant applies the term 'free formations of nature' to crystalline solids. These formations of nature appear purposive to us. In particular, Kant notes that the production of these *beautiful* formations (like the beautiful formations in realm of organic nature, e.g., flowers, blossoms, etc.) appears to be based on an idea of the beautiful. In other words: it appears to be the case that these beautiful formations are objective purposes that are designed or selected "for our own taste" or that have been made "for the aesthetic use of our power of judgment".[134] Here we are confronted with an inference from the appearance of beauty of natural objects to the design of these objects. Kant discusses the formation of crystals in order to argue that this inference is incorrect. In Kant's terms, the formation of crystals, which are mechanically generated, shows that nature has a "faculty for forming itself aesthetically and purposively in its freedom".[135] The formation of beautiful natural objects can be explained *mechanically*: one does not need to presuppose that they are designed for our contemplation of beauty.

After noting that the mere mechanism of nature is sufficient for the production of the free formations of nature, Kant determines the term 'free formation'. He takes free formations to be the result of a phase transition called crystallization. The notion 'free formation' is explicated 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

[133] AA 5: 348–350.
[134] AA 5: 347–348.
[135] AA 5: 349.

> the caloric (*Wärmematerie*)), the rest assumes upon solidification a determinate shape or fabric (figure or texture) which, where there is a specific difference in the matter, is different, but if the matter is the same is exactly the same. (AA 5: 348)

This analysis of the term 'free formation' is similar to the standard description of crystals in Kant's time.[136] For example, J.S.T. Gehler, in his *Physikalisches Wörterbuch* (1787–1796), defines crystals as substances, the parts of which are ordered in a manner so that they constitute regularly structured solid masses (*regelmäßig gebildete feste Massen*).[137] Gehler emphasizes that the regular structures of crystals can be considered geometrically, and he mentions several geometrical structures of crystals (e.g., hexagonal, rhombohedral, etc.).[138] It is this feature of crystals that Kant seems to be alluding to while emphasizing the determinate shape or figure of 'free formations'. Gehler further defines crystals as the result of crystallization, i.e., as the result of a phase transition from the fluid to the solid state resulting in the formation of regular structures or shapes.[139] Kant, immediately following his remark quoted above, 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)

From this passage it is clear that Kant incorporates the theory of heat in order

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[136] Cf. Fritscher 2009, 243–248. Fritscher has provided an extensive account of Kant's views on crystals in light of eighteenth-century crystallography. In this context he discusses the important influence of René-Just Haüy (1743–1822), Johan Gottschalk Wallerius (1709–1785), Johann Heinrich Zedler (1706–1751), and Johann Samuel Traugott Gehler (1751–1795). I will merely focus on the remarks on crystals and crystallization in Gehler's dictionary in order to elucidate Kant's views.

[137] Gehler 1787–1796, Bd. 2, 819.

[138] Cf. Gehler 1787–1796, Bd. 2, 819–820, 829–830.

[139] Gehler 1787–1796, Bd.2, 825.

to explicate the process of crystallization. In particular, the matter of heat (*Wärmestoff* or caloric)[140] is construed as the cause of maintaining bodies in a fluid state. In his example, Kant further invokes the notion of latent or bound heat, i.e., heat that is bound (chemically combined) with a particular substance, that has no perceivable effect on the temperature of a substance (Kant emphasizes this point in the quotation above), and is the cause of the state or phase (solid, liquid, gaseous) of the substance to which it is bound.[141] According to the doctrine of latent heat, the states of aggregation of a substance depend on the quantity of latent heat combined with this substance and phase transitions can (as Kant does) be explained in terms of the combination of heat with a substance (vaporization or liquefaction) or in terms of the separation of heat from a substance (solidification). The matter of heat is taken to combine with particular substances in accordance with their (variable) specific heat, i.e., the chemical affinity that material substances possess for the matter of heat (also called heat capacity). In short, the chemical combination of the matter of heat with a substance is the cause of liquefaction and maintains this substance in a fluid state, whereas the release of heat results in the solidification of this substance, a transition which is called crystallization.

The theory of latent and specific heat, and the associated conception of heat as a particular material substance, provide us with cognition of (some of) the physico-chemical laws that govern crystallization. However, an explanation of crystallization in which we merely take into account the action of the matter of heat is insufficient. This point can be made clear if we again turn our attention to Gehler. Although Gehler takes the matter of heat to be the cause of fluidity and takes phase transitions to involve the combination or release of

[140] One should be careful with 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 primarily in the new language of antiphlogistic chemistry. It is not clear, however, whether Kant fully adopted the chemistry of Lavoisier while writing the *Kritik der Urteilskraft*. Friedman cites the passage above as evidence that Kant adopted the advances within the science of heat, in particular the doctrine of *latent heat*. However, he refrains from arguing, on the basis of this textual evidence, to argue that Kant was fully committed to Lavoisier's systematic chemistry at this point in time (1790). According to Friedman, by 1790 Kant adopted the first two stages of the chemical revolution (the new developments in pneumatic chemistry and the advances in the science of heat). Kant fully adopted Lavoisier's systematic chemistry by 1795 at the latest. Cf. Friedman 1992a, 281–290.

[141] For this notion, as construed in Kants time, see Gehler's article on *Wärme* in his *Physikalisches Wörterbuch*. Gehler 1787–1796, bd. 4, 533–568. See also Friedman, who provides a clear account of the advances of the science of heat in this period and of the incorporation of the doctrine of latent heat in Lavoisier's chemistry. Friedman 1992a, 269–280.

heat, he does not think that crystallization can be understood solely in terms of the action of heat. In his discussion of crystallization, Gehler criticizes the chemists who apply the term 'crystallization' to any transition from the fluid to the solid state. Crystallization must be understood as a particular type of phase transition, resulting in the formation of masses of regular structure.[142] This formation of crystalline structures must be understood in terms of the tendency of the parts of solid bodies to combine with one another. This tendency is dependent on the shape of the parts and appears to be at its strongest at the sides of the parts that have the largest surface.[143] The process of crystallization can thus be understood as resulting from the release of a fluid (e.g., caloric) from a body, which separated the parts of the body, and the ensuing tendency of the parts of this manner to regularly combine themselves in accordance with their shape.[144]

Kant's views on crystallization are developed most fully in the *Opus postumum*. These views are quit similar to those of Gehler though they differ in one fundamental respect: Kant treats solidification and crystallization as identical processes.[145] Hence, Kant adopts a position that Gehler criticizes. Like Gehler, however, Kant does not take the release of heat (caloric)[146] to be sufficient for crystallization or solidification.[147] Kant defines a fluid as a substance that is dissolved in the matter of heat and which is cohesive but does not resist the displacement of its parts.[148] He further states that the release of heat is not the sufficient cause for the solidification of fluids.[149] In order to explain solidification, we need to presume that fluids consist of heterogeneous components of distinct density.[150] If heat (a solvent) is released from the fluid, these heterogeneous components are segregated and, in accordance with their chemical affinities,[151] form aggregates with an inner texture resisting the

[142] Gehler 1787–1796, Bd.2, 825–826.
[143] *Ibid*.
[144] *Ibid*.
[145] AA 22: 232. Cf. Fritscher 2009, 250.
[146] In the *Opus postumum*, Kant does employ the term 'caloric', a simple linguistic fact providing evidence that Friedman is correct in arguing that Kant adopted Lavoisier's 'antiphlogistic system' at this stage of his life.
[147] AA 21: 276–280; 452–453.
[148] AA 21: 276–280. A very similar account of fluids is articulated in the *Metaphysische Anfangsgründe*. Cf. 4: 526–529. Kant's account of solidity or rigidity, as given in the *Opus postumum*, has been nicely analyzed by Carrier 1991, 218–21, Carrier 2001a, 213–215.
[149] AA 21: 276.
[150] AA 21: 452–453. Cf. Carrier 2001a, 214.
[151] Cf. Fritscher 2009, 253.

displacement of its parts. Hence, the heterogeneous composition of fluids is essential in accounting for crystallization or solidification.

How does this account of crystallization or solidification relate to Kant's views on mechanical explanation? First, we may note that since Kant's account of crystallization is based on the notions of latent (bound) and specific heat, on the idea that heat is a particular material substance that allows of chemical combination with other substances, and on the idea of chemical affinities operative in the forming of a rigid inner texture of bodies, this account invokes cognition of chemical laws or regularities. For this reason, Bernhard Fritscher states that the process of crystallization requires a "chemical-dynamical explanation" and not merely a "mechanical-mathematical one".[152] This is of course true. However, we have also seen that Kant takes crystalline solids to be mechanically generated. In §80 of the Critique of Teleological Judgment, Kant explicitly claims that *mechanical laws* are at work in the production of crystals.[153] This suggests that Kant has a rather broad view of 'mechanical law'. Already in his *Der einzig mögliche Beweisgrund* Kant construed laws concerning chemical, magnetic and electric phenomena as mechanical.[154] Hence, explanations in chemistry, magnetism and the theory of electricity count as mechanical.

Second, Kant's explanation of crystallization can be understood as an explanation of a whole in terms of its parts. Kant construes the matter of heat as a *part* of fluids.[155] As we have seen, the matter of heat is conceived as a substance that is capable of chemical combination, that is attributed a strong expansive force and is taken to be the cause of fluidity. This conception of heat is anathema to anyone who accepts a fully mechanical or kinetic theory of heat. Nevertheless, the matter of heat is construed as a part of fluids. Here we see how the notion of 'part' is adjusted to the specific scientific insights of Kant's time, in particular to caloric theories of heat. We may further note that Kant's account of crystallization or solidification can be interpreted in terms of Wolff's scheme of an explanation of wholes in terms of their parts. Kant's account is based primarily on (a) the characterization of fluids as consisting of heterogeneous ingredients of distinct density dissolved in the matter of heat;

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[152] Fritscher 2009, 241.

[153] AA 5: 419.

[154] Cf. AA 2: 113. This is also emphasized by Ginsborg 2001, 241–241. These passages present a problem for the more restricted interpretation of 'mechanism' given by Breitenbach, who characterizes mechanical laws as "empirical *instantiations* of the a priori laws of mechanics" and as empirical applications of "the pure laws of science concerned with the interaction of the powers of matter." Cf. Breitenbach 2006, 702–703, 705.

[155] AA 5: 348.

(b) a caloric conception of heat as a particular substance possessing strong repulsive forces that is the cause of fluidity; (c) an account of the causal process, involving the release of heat and the formation of rigid textures from heterogeneous ingredients in accordance with chemical affinities, underlying crystallization. In Wolff's terms, we explain crystallization in terms of the mode of composition of the parts of liquids and the forces acting between these parts. The broad application of the Wollfian scheme of mechanical explanation thus allows us to partly understand why Kant could treat (dynamical) explanations in chemistry as mechanical.

The foregoing shows that Kant's conception of mechanical explanation often does not conform to Ginsborg's strong account of mechanical explanation in terms of G_1 and G_2, although it may be taken to be in conformity with Ginsborg's weak account of mechanical explanation (cf. §2.1). With respect to Ginsborg's account of mechanical explanation in terms of G_1 and G_2, we may note that it is not entirely correct to suggest, as Ginsborg does, that an explanation of a whole in terms of its parts is something distinct from an explanation of (properties of) material objects in terms of the forces of matter (whether fundamental or not).[156] Kant himself states that we *represent* a mechanical kind of generation, and thus can be taken to provide a mechanical explanation, if we consider a material whole "as a product of *the parts* and of *their forces*". This characterization captures the type of explanation that is involved in mechanical explanations of processes such as crystallization, whereas Ginsborg's account of mechanical explanation, which abstracts from the notions 'part' and 'whole', does not. In addition, our analysis of Kant's views on crystallization shows that it also incorrect to argue, as Ginsborg strong account of mechanical explanation implies[157], that according to Kant mechanical explanation does not "presuppose a specific set of initial conditions", i.e., that the issue is whether we can explain material objects "without appeal to any particular arrangement" of material objects.[158] For the most intuitive manner in which one can understand the appeal to (a) in explaining crystallization is as an appeal to a particular arrangement (mode of composition) of fluids.[159] In general, Kant's conception of mechanical explanation is much weaker than Ginsborg's construal of mechanical explanation in terms of G_1 and G_2 suggests.

[156] Cf. Ginsborg 2004, 35–39.
[157] Ginsborg 2001, 241–43.
[158] Ginsborg 2001, 242.
[159] The same is true for the account of crystallization given by Gehler, who, as we have seen, appeals to the shapes of the parts of bodies and their tendency to combine with one another in order to account for the formation of crystalline structures.

Finally, it is important to emphasize that Kant also allows of the possibility of mechanical explanation, quite similar to the type discussed, in the biological sciences.[160] In §80 of the Methodology of Teleological Judgment, Kant argues that in investigating organized beings one must *subordinate* the principle of mechanism to a teleological principle.[161] This implies that one must assume some 'original organization', which "uses that mechanism itself in order to produce other organized forms or to develop its own into new configurations".[162] Kant applies this method to the explanation of both similarities and differences among the structure of organisms of different species. The similarities existing between members of various species (e.g., qua skeletal structure) might be explained by assuming that they have been generated from a common ancestor, whereas the observable differences between the various species might be accounted for in terms of *mechanical variations* among the *parts* of animals. These mechanical variations, e.g., the shortening or elongation of parts giving rise to different structures, can then, assuming hereditability, account for differences among the anatomical structures of members of different species. Here, we have a case of explaining the generation of different organic structures on the basis of variations in the mode of composition of parts. Once again: mechanical explanation is understood in terms of an explanation of wholes in terms of parts and their (in this case variable) mode of composition.

In conclusion: a study of two instances of mechanical explanation in the work of Kant suggests that he adopted a conception of mechanical explanation conforming to Wolff's scheme of mechanical explanation. This scheme is sufficiently general to capture (dynamical) explanations in chemistry (e.g., of crystallization), i.e., the latter are mechanical explanations. Finally, Kant allowed for mechanical explanations in biology. This is not surprising, given that mechanical explanations are treated as ideals of explanation in natural science. This suggests that proper explanations in biology are mechanical explanations, a view further developed in the next chapter.

2.9 The inexplicable explanandum: unity

Now that we have discussed Kant's views on mechanical explanation, we may ask what features of organisms Kant took to be mechanically inexplicable.

[160] This is also stressed by Ginsborg 2010, 463.

[161] In the following, I will merely provide a very brief description of Kant's argument in §80. I will return to this paragraph in Chapter 5.

[162] AA 5: 418.

Recall McLaughlin's interpretation of mechanical explanation given in §2.1, according to which mechanical explanation consist in the reduction of a whole to the properties of its parts that they have independently of the whole (M_1 and M_2). This view seems to imply that any feature of organisms is mechanically inexplicable. If a mechanical explanation is an explanation in terms of the properties of parts that they have independently of the whole, and if the properties of the parts of organisms are dependent on the whole, then no feature of organisms allows of mechanical explanation.

I do not think this interpretation of Kant's view is fully correct. First, note that in our extensive discussion of mechanical explanation, the idea that this is an explanation of a whole in terms of properties of parts that are independent of the whole (M_2) simply did not figure. We have further seen that Kant treats mechanical explanation as an ideal of explanation. Finally, at the end of the previous paragraph, we have noted that according to Kant the proper method for investigating organisms consist in subordinating mechanism to teleology. In this context, Kant remarks that it is rational and meritorious to "pursue the mechanism of nature, for the sake of an explanation of the products of nature, as far as can possibly be done",[163] and he proceeds, as we have seen, to sketch possible mechanical explanations of biological phenomena.

With respect to the current question I am in agreement with the interpretation of Ginsborg, who allows for the possibility that some features of organisms can be mechanically explained. In her discussion, Ginsborg refers to Kant's precritical *Der einzig mögliche Beweisgrund* (1763), and argues that it is (what she calls) the composite character of organisms that defies mechanical explanation (a feature that organisms have in common with artifacts).[164] This, I think, is completely correct. Ginsborg does not, however, treat Kant's arguments contained in *Der einzig mögliche Beweisgrund* in detail. I will present these arguments in the following.

In the present section, I will extensively discuss Kant's arguments as contained in *Der einzig mögliche Beweisgrund* and relate them to his views in the *Kritik der Urteilskraft*. The claim that organisms are mechanically inexplicable primarily concerns one particular feature: the unity of the parts of organisms. In *Der einzig mögliche Beweisgrund*, Kant attempts to show how 'unity in the manifold of the essences' of (i) geometric objects and (ii) objects studied within natural science can be demonstrated. This leads him to investigate (iii) how we should conceive the unity of the manifold of organisms.

[163] AA 5: 418.
[164] Cf. Ginsborg 2004, 44.

Through discussion of (i)–(iii), we will see that whereas Kant thought that the unity of geometric or inorganic objects can be understood without recourse to teleological considerations, this does not hold for organisms.

(i) In the First Reflection of section 2 of *Der einzig mögliche Beweisgrund*, Kant aims to explain how "the unity in the manifold of the essences of things is demonstrated by appeal to the properties of space".[165] The issue is how we are to understand the "unity in the manifold of the essences" of geometric objects. Recall that Wolff employed the term 'essence' (*Wesen*) to refer to the mode of composition of the parts of composite things. Kant aims to explain how we can understand that the parts of geometric objects constitute a determinate unity. He claims that if we consider the necessary determinations of space studied by the geometer, we come to notice that *order* and *harmony* "prevail throughout space, and that concord (*Zusammenpassung*) and unity prevail throughout its immense manifold."[166] The purpose of this discussion is to "draw attention to the existence, in the necessary properties of space, of unity alongside the highest degree of complexity, and of the connection between things which all seem to have their own separate necessity."[167] What does Kant mean when he refers to the harmonious unity of geometric objects and how do we know this unity?

In order to explain this unity, Kant focuses on the figure of a circle, which has "infinitely many properties of which only a small member is known."[168] He cites various geometric theorems concerning circles to illustrate these complex properties. Kant notes that a circle is constructed by moving a straight line around a fixed point.[169] This is the standard definition of a circle.[170] He continues by stating there is no apparent reason to suppose that "such a simple construction should conceal something highly complex which is itself subject, in virtue of that very construction, to major rules of order."[171] However, the various theorems of Euclidean geometry show that this is the case.

Kant cites Propositions 35 and 36 of Book III of Euclid's *Elements* as examples of theorems providing insight into the order and unity of the manifold of

[165] AA 2:93.
[166] *Ibid.*
[167] AA 2: 95.
[168] *Ibid.*
[169] AA 2: 93.
[170] Cf. Wolff 1965 [1716], 354–357.
[171] AA 2: 93–94.

circles.[172] For example, Proposition 35 states that if two straight lines (line *AC* and line *BD*) intersect one another in a circle at point *E*, and intersect the circle at *A*, *C* and *B*, *D*, it holds that $AE \times EC = BE \times ED$. This proposition holds for any two straight lines intersecting in a circle and points out a particular *order* and *unity* existing between the segments (*parts*) of straight lines intersecting within a circle. This order and unity is a result of the construction of the circle.[173] In §38 of the *Prolegomena*, Kant makes a similar point while discussing the same proposition, claiming that it can be demonstrated "only from the condition on which the understanding based the construction of this figure, namely, the equality of the radii".[174] The demonstration of Proposition 35 is based on the equality of the radii of a circle, a feature employed in Euclid's proof of this proposition that is a trivial consequence of defining a circle as constructed by moving a straight line around a fixed point. In *Der einzig mögliche Beweisgrund*, Kant similarly stresses that by means of geometrical constructions, and demonstrations based on these constructions, we can explain and understand why geometric objects exhibit a particular harmonious unity among their manifold parts.

(ii) In the second part of the First Reflection to the second section of *Der einzig mögliche Beweisgrund*, Kant develops a similar argument (as expounded in (i)) with respect to natural objects that allow of mechanical explanation. Kant argues that the "unity of the manifold of the essence" of natural things can be demonstrated in terms of natural laws.[175] He notes that in nature we often encounter "extensive adaptedness (*Zusammenpassung*) and natural harmony", which indicates that "there is a unity to be found in the possibility of things".[176] How should we understand this claim?

While discussing the harmonious unity of geometric objects, we have seen that Kant applies the terms harmony and unity to individual objects and their parts (e.g., the unity of the segments of intersecting lines in a circle). In the present context, when discussing natural objects, Kant is concerned about the harmony and unity existing between different objects, or, more precisely, harmony and unity existing between *ground* and *consequences*. For example, Kant describes the relation between the atmosphere (he also speaks of the

[172] AA 2:94. Kant provides a plethora of examples all meant to bring out the point that geometric objects, or determinations of space in general, exhibit "unity alongside the highest degree of complexity". Cf. AA 2: 94–96.
[173] This is emphasized twice at AA 2:94.
[174] AA 4: 321.
[175] AA 2:96.
[176] AA 2:96–97.

nature or essence of the atmosphere) and its various natural consequences, in terms of harmony and unity:

> […] we saw that 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 (*Ubereinstimmung des Mannigfaltigen in Einem*) is thus in no way contingent, and it is, therefore, not to be attributed to a moral ground. (AA 2: 101)

The claim that the harmony of the manifold in one is not to be attributed to a moral ground means that this harmony is not to be regarded as dependent on God's will.[177] Kant argues that the multiplicity of consequences or uses of the atmosphere, the possibility of respiration, pumps, etc., can be (mechanically) explained and depend on a single ground. Hence, we do not need to attribute the multiplicity of wonderful consequences of the atmosphere to a moral ground. The phrase "harmony of the manifold in one" refers to the harmony of the natural consequences of the (properties of) the atmosphere and their ground (the elasticity and pressure of the atmosphere). In other words, we are dealing with a relation between a single ground and its multiple consequences:

> My only concern here is the relation which holds between the essence of the atmosphere, or of any other thing at all, and the possible production of so many excellent consequences. That is to say: I am merely considering the *adaptedness* (*Tauglichkeit*) of their nature to so many purposes. The harmony of a single ground with so may possible consequences makes unity in such a case necessary; and to that extent the possible consequences are inseparable from each other and from the thing itself […]. (AA 2:101)

There exists a relationship of harmony or adaptedness between the essence of the atmosphere (a single ground) and its consequences. Kant claims that the harmony of a ground with its consequences makes "unity in such a case necessary, and to that extent the possible consequences are inseparable from each other and from the thing itself."

We can distinguish between two types of necessary unity: (a) a necessary unity existing between the ground and the consequences, and (b) a necessary unity existing between the consequences themselves. (a) is a consequence of affirming the harmony between a ground and its consequences. The necessary unity between the consequences themselves (b) exists in virtue of the fact that

[177] Cf.: "I designate that dependency of a thing upon God *moral* when God is the ground of that thing through his will. All other dependency is *non-moral*." AA 2: 100.

all these consequences have a single common ground. Kant explicates (b) by discussing the relationship between the self-same (*eben dieselbe*) elasticity and pressure of the air and its consequences, noting that if multiple consequences have a single common ground, it "is necessary that, as soon as the ground of even merely one of them [one of the consequences; van den Berg] be present, the ground of the others should also be present."[178] Hence, various natural phenomena (respiration, winds, etc) are necessarily related to each other because they are consequences of a common ground. In a similar fashion, Kant claims that gravity is a single cause or ground in virtue of which a multiplicity of consequences constitute a necessary unity.[179] For example, we may construe the fact that all possible orbits of the heavenly bodies are conic sections as a necessary unity existing between all of these orbits. Gravity constitutes the objective ground for this necessary unity.[180] Note that we are here dealing with the *ordo essendi*: the necessary unity existing between consequences is an objective feature of these consequences due to their having a common ground. In (natural) science we aim to represent this objective order. Newton himself provided the most perfect mechanical explanation of the necessary unity existing the orbits of the heavenly bodies.

(iii) Geometry and the natural sciences study wholes, the term 'whole' being applicable to both individual objects and complexes of objects that, in virtue of a single ground, constitute a necessary unity. We can have insight in this unity by explaining these wholes through mathematical demonstration or through mechanical explanation (in natural science). The question now arises whether we can have insight into the necessary unity of organisms, or, more specifically, since organisms are composite objects, into the necessary unity of the parts of organisms. Not surprisingly Kant denies this.

In *Der einzig mögliche Beweisgrund*, Kant cites organisms as objects that constitute a *contingent unity*. Kant applies the term 'contingent unity' to laws concerning consequences that (α) inhere in an individual being and (β) do not have a common ground.[181] If some set of consequences satisfies both (α) and (β), the agreement of laws concerning these consequences "is contingent, and the unity which prevails among these laws is merely contingent."[182] Kant

[178] AA 2: 106.
[179] AA 2: 106–107.
[180] This is how Kant himself describes the splendid consequences with respect to the "manifold of its harmony and its regularity" of the physical law of gravitation in §38 of the *Prolegomena*. Cf. AA 4: 321.
[181] AA 2:106.
[182] *Ibid.*

takes (*α*) and (*β*) to be satisfied with respect to the parts of organisms (and parts of parts):

> 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 faculties of seeing, hearing, etc., are grounded in different properties of different organs, these faculties constitute a contingent unity. Likewise, different parts of the human eye, i.e., the iris, lens and cornea and the retina, have different grounds and thus constitute a contingent unity. Following this argument Kant contrast the *contingent unity* of the parts of organisms with the *necessary unity* of effects of the single cause gravity:

> On the other hand, it is not one set of causes which gives the earth its spherical form, and another which prevents bodies from flying of the earth as a result of the centrifugal force of its rotation, and yet again others which keep the moon in its orbit. Gravity by itself (*die einzige Schwere*) is a cause which is, of necessity, sufficient to produce all these effects. (AA 2: 107)

Hence, organisms, in contrast to other objects of scientific study such as geometric or natural objects (as discussed in (i) and (ii)), present us with a particular explanatory problem. Because there is no (or at least we do not know of any) single, natural ground of the different parts of organisms, we cannot take these parts to constitute a necessary unity.[183] This is not the case for other areas of science, in which we can provide a (mechanical or mathematical) explanation of wholes and thus gain insight into the necessary unity of their parts. This is an issue for concern. Organisms are objects of nature and we should treat them similar to other objects of nature. Kant emphasizes this point in *Der einzig mögliche Beweisgrund*, noting that in the scientific investi-

[183] Note that in the quote taken from *Der einzig mögliche Beweisgrund*, Kant infers from the contingent unity of organisms to their artificial union. This ultimately amounts to an inference to divine design. This inference is not made in the third *Critique*. However, in the latter work Kant does infer from the mechanical inexplicability of organisms (which indicates that we cannot comprehend their unity) to the claim that we must interpret organisms by means of the reflective concept of a 'natural purpose'.

gation of nature one must "presume that the necessary unity to be found in nature is greater than strikes the eye."[184] Moreover, this assumption "must be made not only in the case of inorganic nature, but also in the case of organic nature."[185] Hence, already in *Der einzig mögliche Beweisgrund*, Kant thinks that one should strive to find a natural ground for the necessary unity of the parts of organisms. The problem is that we do not know of such a ground. We cannot provide a mechanical account of the necessary unity of organisms.

To summarize: in *Der einzig mögliche Beweisgrund* Kant treats organisms as contingent unities. In biology, we lack cognition of objective natural grounds that allow us to (mechanically) explain why the parts of organisms are related to one and another as they are. However, Kant did think that in natural science this type of cognition is required. The theory of universal gravitation provides a paradigm example of a theory that specifies objective grounds (e.g., gravity) that allow us to explain the necessary unity existing between parts of complex systems (e.g., the heavenly bodies). This type of theory is not available in biology, which is to say that there is no Newton of a blade of grass.

If we now focus on Kant's arguments in the *Kritik der Urteilskraft*, it becomes clear that, as was the case in *Der einzig mögliche Beweisgrund*, the necessary unity of the parts of organisms defies mechanical explanation:

> […] if one adduces, e.g., the structure of a bird, the hollowness of its bones, the placement of its wings for movement and of its tail for steering, etc., one says that given the mere *nexus effectivus* in nature, without the help of a special kind of causality, namely that of ends (*nexus finalis*), this is all in the highest degree contingent: i.e., that nature, considered as a mere mechanism, could have formed itself in a thousand different ways without hitting precisely upon the unity in accordance with such a rule, and that it is therefore only outside the concept of nature, not within it, that one could have even the least ground *a priori* for hoping to find such a principle.(AA 5: 360).

It is a structural feature of organisms, namely: the relationship that the parts of organisms have to one another, that does not allow of mechanical explanation, i.e., explanation in accordance with the *nexus effectivus*. We cannot identify a mechanical principle in terms of which we can explain the necessary unity of the various parts of a bird. Because of this explanatory deficit, we try to understand the unity of the parts of organisms in terms of the relationship between these parts and the (subjectively imposed) *purpose* of the whole. It is only when we posit the concept of flight as a purpose, that we can investigate

[184] AA 2: 126.
[185] *Ibid.*

and understand the manner in which the particular configuration of a bird's anatomy, its hollow bones, the placement of its wings etc, contributes to the achievement of this purpose (i.e., why a bird has this configuration). Positing a purpose allows us to argue that there exists, relative to a purpose, a necessary relation between the parts of the bird, whereas, from the perspective of the *nexus effectivus*, the unity of these parts is merely contingent.

Kant often identifies the relationship that the parts of organisms have to one another as the inexplicable *explanadum* of mechanical explanations, while allowing that other features of organisms can be mechanically explained:

> It might always be possible that in, e.g., an animal body, many parts could be conceived as consequences of merely mechanical laws (such as skin, hair, bones). Yet the cause that provides the appropriate material, modifies it, forms it, and deposits it in its appropriate place must always be judged teleologically, so that everything in it must be considered as organized, and everything is also, in a certain relation to the thing itself, an organ in turn. (AA 5: 377).

Thus, several features of organisms were taken to allow of mechanical explanation. The feature of organisms that is denied to allow of mechanical explanation is the structural relation of the parts of an organism to one another.

2.10 Mechanism as method and changes in the concept of mechanical explanation

In this final section we may relate the results we have obtained. On the basis of our analysis of Wolff we concluded that a mechanical explanation is an explanation of whole in terms of (i) its parts; (ii) the mode of composition of these parts, and (iii) the forces acting upon these parts. Kant, we have seen, adopts a rather similar conception of mechanical explanation. In this section, I will first show how Wolff's philosophical conception of mechanical explanation provides a background for understanding why Kant treated the mechanical principle, which states that one should always try to explain natural objects mechanically, as a *regulative* maxim. Second, I will treat some problematic applications of the Wolffian idea of mechanical explanation, problems which partly explain why Kant (slightly) modified the traditional scheme of mechanical explanation.

Wolff's views on mechanical explanation in natural science are, as we have seen, *fundamentally based* on the idea of explaining wholes in terms of their parts and mode of composition within the domains of *metaphysics* and *logic*.

The principle that one should explain wholes in terms of their parts and mode of composition can be construed as a principle that determines what counts as proper *method* in diverse sciences such as metaphysics, logic, and natural science. It functions as a principle *common* to logic and natural science and must be distinguished from principles that are internal and specific to such sciences. Let us treat this idea in somewhat more detail.

It is important to stress that the notions of 'part' and 'whole', as well as the idea of explaining a whole in terms of its parts and their mode of composition, are introduced in Wolff's metaphysics.[186] In particular, they are introduced within *ontology*. Ontology or first philosophy grounds logic, insofar as (at least some) principles employed within the latter are established in the former. Thus, for example, Wolff expounds the principle of contradiction in ontology, a principle which grounds the certainty of inferences in logic.[187] In a similar manner, we can treat the ideal of explaining wholes in terms of their parts and mode of composition as being introduced in ontology and governing method in logic, in which procedures for giving definitions are specified and where definitions must be understood as explanations of wholes in terms of their parts and mode of composition. Similarly, the ideal of explaining wholes in terms of their parts and mode of composition, as established in ontology, governs method in natural science or biology, where (e.g.) we aim to specify the true ground of the growth, nutrition and propagation of plants by investigating their parts and mode of composition.[188] In short: the idea of explaining a whole in terms of its parts and mode of composition is established in ontology, and *as such* functions as a principle *common* to subordinate sciences such as logic and natural science.

Wolff's full account of mechanical explanation as an explanation of a whole in terms of (i) its parts, (ii) the mode of composition of its parts and (iii) forces acting upon its parts, where the notion 'force' is constitutive of the object of *natural* science, is also established in philosophy. In particular, it is established in chapter 4 of the *Deutsche Metaphysik*, entitled *Von der Welt*, which deals with general cosmology.[189] In §5 of his *Vorbericht* to the fourth edition of his *Deutsche Metaphysik*, Wolff explicitly claims that it was his intention in this work to provide a philosophically thorough concept of 'mechanism'. The idea of mechanical explanation is established in philosophy (general cosmology) and determines what counts as proper method and explanation in natural

[186] Cf. §2.4. On Wolff's views on the different parts of philosophy, cf. Blackwell 1961.
[187] Wolff 2003 [1751], 6. cf. Wolff 1978 [1754], 165.
[188] Cf. §2.5.
[189] Cf. §2.6.

science. Here, we clearly see how notions such as 'mechanism' and 'mechanical explanation' are treated as particular *philosophical* notions (a point I have stressed throughout this chapter). Once again: the idea of explaining wholes (corporeal bodies) in terms of (i)–(iii) is established in philosophy (general cosmology), and *as such* functions as a principle common to the natural sciences.

The foregoing shows, expressed generally, that the ideal of explaining wholes in terms of their parts is a philosophical ideal determining what counts as proper method and explanation in subordinate sciences such as logic and natural science. Wolff's views on proper method and explanation in science are, however, strongly informed by ontological commitments. In the second chapter of his *Deutsche Metaphysik*, dealing with ontology, Wolff argues that all composite or compound consist of simples, which are constituents of the former.[190] This suggests that Wolff's views on proper explanation in science as an explanation of a whole in terms of its parts are informed by adopting a form of ontological reductionism, according to which wholes are constituted by simples and ontologically reduce to their parts. This background allows us to understand Kant's views on mechanical explanation.

In my view, Kant adopts the view that mechanical explanation, a form of explaining wholes in terms of parts, is an ideal of scientific explanation in natural science determining proper method and explanation. However, contrary to Wolff, Kant does not base the idea of mechanical explanation on ontological convictions and he denies that this idea has any ontological implications. Mechanical explanation is a *methodological ideal* of explanation in natural science and nothing more. It is this view which lies at the heart of Kant's view that the mechanical principle that one should explain natural objects (in particular: organisms) mechanically is a *regulative maxim*. This view fits the circumstance that, as said in §2.7, Kant rejects Wolff's methodology of explaining wholes in terms of their parts *in metaphysics* (which, from Kant's point of view, must establish synthetic judgments a priori). Nevertheless, as we have also seen, Kant does adopt the methodology of explaining wholes in terms of their parts in logic and natural science. Hence, for Kant, as is the case for Wolff, the idea of explaining wholes in terms of their parts functions as a common principle, even if it is hardly applicable to metaphysics.[191] We might

[190] Wolff 2003 [1751], 35–39.

[191] I say 'hardly' because Kant still seems to leave room for the derivation of analytic attributes in philosophy. More generally: analytic judgments still play a (methodological) role in philosophy or metaphysics, even if philosophy should constitute a system of synthetic judgments a priori.

thus say that for Kant the idea of explaining wholes in terms of their parts is a purely *logical* principle (taking 'logic' in the broad sense encompassing methodology) that determines proper method in natural science.

In the Dialectic of Teleological Judgment of the third *Critique*, Kant presents the mechanical principles as a regulative maxim of scientific investigation: "All generation of material things and their forms must be judged as possible in accordance with merely mechanical laws".[192] The same holds for the teleological principle: "Some products of material nature cannot be judged as possible according to merely mechanical laws (judging them requires an entirely different law of causality, namely that of final causes".[193] On the basis of Wolff's conception of mechanical explanation, we can understand, at least in part, why Kant treats the mechanical principle as a regulative maxim.

As said, the principle (expressed generally) that one should explain a whole in terms of its parts is a principle determining what counts as proper *method* and *explanation* in natural science. It is a principle *common* to sciences such as logic and natural science. In particular, the principle that one should explain a whole in terms of its parts directs us to explicate composite concepts in terms of partial concepts, to objectively ground judgments in natural science, etc. As such, it directs us to establish a systematic order among concepts and to ground judgments in more fundamental judgments. This function ascribed to the common principle of explaining whole in terms of its parts conforms rather nicely to Kant's description of regulative maxims in the first *Critique*.

In the first *Critique*, regulative maxims of reason are described as subjective principles that are not drawn from the object, but are drawn from the interest of reason in the *perfection* of cognition.[194] One of the highest perfections of cognition is systematicity (of concepts and judgments).[195] Reason itself is a faculty that "never applies directly to experience or to any object", but rather gives unity to "the understandings manifold cognitions".[196] The methodological ideal of explaining wholes in terms of their parts can thus be adequately described as a regulative maxim of reason. For it is an ideal that directs us to establish a systematic unity among concepts and judgments (ordered by grounding relations). Moreover, it is a principle *common* to sciences as logic and natural science, and can thus be adequately described as a principle of reason ordering cognitions of the understanding. In this manner, the Wolffian conception of explaining wholes in terms of their parts and mode of composi-

[192] AA 5: 387.
[193] *Ibid.*
[194] *KrV*, B 694.
[195] AA 9: 140.
[196] *KrV*, A 302/B 359.

tion, which determines the idea of mechanical explanation in natural science, allows us to partly understand why Kant construes the mechanical principle as a *regulative maxim*. The idea of mechanical explanation, a form of explaining wholes in terms of their parts, simply captures a *methodological ideal* of proper explanation.

In stark contrast to Wolff, however, Kant strips the idea of mechanical explanation of any ontological implications. In particular: he does not base the idea of mechanical explanation on an ontology of compounds constituted of simples endowed with force. In the third *Critique*, Kant states:

> […] 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 wholes (corporeal bodies) mechanically, i.e., in terms of their parts, mode of composition, and forces acting upon the parts, does not imply that bodies ontologically reduce to parts and forces (similarly, the teleological principles does not imply that objects of nature, e.g. organisms, are not so ontologically reducible). Neither is the idea of mechanical explanation based on ontology as is the case for Wolff. According to Kant, 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".[197] Our understanding is *discursive*, which is to say that it proceeds from the universal to the particular, i.e., from the *part* to the *whole*.[198] This circumstance is cited by Kant to explain why mechanical explanation is an ideal of explanation in natural science. However, this does not, again, imply that bodies ontologically reduce to their parts and forces. This is a second reason why Kant treats the mechanical principle as a *regulative* principle or maxim.

In conclusion of this chapter, we may discuss some problems confronting Wolff's idea of mechanical explanation as an explanation of features of a corporeal body in terms of (i) its parts, (ii) mode of composition, (iii) forces acting

[197] AA 5: 408.
[198] Cf. AA 5: 407–409.

upon the parts. These problems lead Kant, as we will see in the following, to sometimes slightly modify Wolff's scheme of mechanical explanation.

In order to determine some problematic applications of Wolff's scheme of mechanical explanation, we must first recall what feature of organisms Kant took to be mechanically inexplicable. Kant treats organisms as contingent unities. We cannot mechanically explain why the various parts of an organism constitute a necessary unity, i.e., why these parts are related to one another as they are. Kant can thus be taken to argue that the mode of composition (ii) of the parts of organisms itself defies mechanical explanation: we cannot specify a mechanical ground that explains why the parts of organisms have the particular order or structure that they have.

Although Kant has a conception of mechanical explanation that is rather similar to that of Wolff, it is also true that Kant assigns priority to the notion of force (iii). This becomes clear if we recall Ginsborg's strong interpretation of Kant's notion of mechanical explanation in terms of G_1. According to Ginsborg, a mechanical explanation is an explanation in terms of the *fundamental forces of matter* in which one does not take into account any special arrangement of matter. As said, my account of mechanical explanation, based on Wolff, differs from Ginsborg's account of mechanical explanation in terms of G_1. However, the latter account correctly points to the fact that Kant assigns priority to the notion of 'force' in providing mechanical explanations. Ginsborg does not, however, explain why this is the case.

In this final section, I will argue that Kant assigns priority to the notion of force because he ultimately thinks that the mode of composition of an object must be explicable in terms of the action of forces. Employing our scheme from Wolff: (ii) is ultimately explained in terms of (iii). In the following I will identify two possible sources for this view.

In arguing that the unity of organisms is mechanically inexplicable, Kant adopts a traditional objection against fully mechanist accounts of organic phenomena. Consider, for example, Descartes's famous description of his mechanical physiology at the end of his *Traité de l'homme* (1664):

> I should like you to consider, after this, all the functions I have ascribed to this machine – such as the digestion of food, the beating of the heart and arteries, the nourishment and growth of the limbs, respiration, waking and sleeping, the reception by the external sense organs of light, sounds, smells, tastes, heat and other such qualities […]. I should like you to consider that these functions follow from the mere arrangement of the machine's organs every bit as naturally as the movements of a clock or other automaton follow from the arrangement of its counter-weights and wheels. (Descartes 1985 [1664], 108)

The physiological functions of man are to be explained by taking into account the arrangement or disposition of organs. These functions follow from the arrangement of organs as the movements of automata follow from the arrangement of its parts. In Wolff's terms, we explain physiological functions of the human body (at least in part) by taking into account the mode of composition of its parts. Not surprisingly, there is considerable continuity between Wolff's views on mechanical explanation and traditional mechanist views.

Descartes had no qualms in applying his mechanist doctrines to the thorny subject of embryological development. In his *De la formation de l'animal*, he developed a mechanistic interpretation of epigenesis, according to which embryos are generated through a gradual development from unorganized material. The generation of embryos, which Descartes treated as a type of growth, was taken to follow from the mixing of male and female semen, which result in a type of fermentation process producing heat. Through the action of heat, particles are then combined to form the various parts of embryos.[199] This epigenetic account of embryological development was quickly criticized. For example, Malebranche, in his *Entretiens sur la métaphysique et sur la religion* (1688), objected to Descartes:

> The rough sketch given by this philosopher may help us to understand how the laws of motion are sufficient to bring about the gradual growth of the parts of the animal. But that these laws could form them and link them together is something that no one will ever prove. (Quoted from Roe 1981, 5)

The formation of the parts of animals and the manner in which they are related to one another cannot be explained by mechanical laws. Once again: the *mode of composition* of the parts of organisms defies mechanical explanation. In the middle of the eighteenth century alternative versions of mechanistic epigenesis were popular. Thus, in his *Vénus physique* (1745), Maupertuis proposed, adopting the model of gravitational attraction of astronomers in explaining the movement of heavenly bodies, an attractive, cohesive force to account for generation.[200] On this account, when male and female fluids mix, a special cohesive force is active among the particles of the seminal matter, resulting in the gradual formation and union of the parts of a foetus. However, this account faced the same objection levelled against Descartes: how could a simple, blind attractive force account for the determinate, unified form of the

[199] In this brief description, I follow Roe 1981, 4 and Gaukroker 2002, 190–196.
[200] Cf. Roe 1981, 13–15.

foetus?[201] Apparently taking this objection to heart, Maupertuis modified his account in his *Systême de la nature* (1751), adding a principle of intelligence to the particles of organisms.[202]

Kant accepted the common criticism of mechanist versions of epigenesis. In *Der einzig mögliche Beweisgrund* (1763), he notes that the structure of plants and animals displays a constitution "which cannot be explained by appeal to the universal and necessary laws of nature".[203] With respect to mechanist theories of epigenesist, Kant, also referring to Buffon's account of generation in terms of the *moule intérieur* and specific penetrating, attractive forces, states:

> The internal forms proposed by *Buffon*, and the elements of organic matter which, in the opinion of *Maupertuis*, join together as their memories dictate and in accordance with the laws of desire and aversion, are either as incomprehensible as the thing itself, or they are entirely arbitrary inventions. (AA 2: 115)

Kant's critique of Buffon and Maupertuis is not wholly unambiguous. In the remainder of this passage, he notes that the failure of their theories does not necessitate one to adopt the (apparently even more absurd) occasionalist theory that all organic individuals are of supernatural origin. Moreover, Kant also notes, with respect to still other preformationist theories, that the "natural order of unfolding (*Auswickelung*)" is a "futile method of evading the issue", since "not the least degree of an immediate divine action is thereby spared."[204] Following this critique, Kant suggests that a form of epigenesis might be admissible and preferable to other theories of generation, arguing that we must grant the initial organization of plants and animals a capacity

[201] Roe cites René Réaumur as one of the main objectors against this account. In his *Art de faire éclore et d'élever en toute saison des oiseaux domestique de toute espèces* (1749), Réamur notes: "how will attractions be able to give such and such a mass the form and structure of a heart, to another that of a stomach, to a third one that of an eye, and to another that of an ear? [A]ll their tendency will amount barely to the reunion of the similar parts into solid masses. What law of attraction shall one imagine for the making of that small bone of the ear, whose figure makes it to be called the stirrup? How shall so many different organs be place and assembled in their proper order?" Roe 1981, 14. Because of its clear formulation of the objection against mechanist epigenesis, and because Kant seems to endorse a similar critique, I give the citation in full.

[202] Ginsborg 2004, 45, cites Maupertuis as arguing that organisms do not allow of mechanical explanation.

[203] AA 2: 114.

[204] AA 2: 115. Cf. §81 of the third Critique, in which Kant argues that both occasionalists and adherents of preformation excessively appeal to the supernatural (AA 5: 423–424).

to not merely develop (*entwickeln*), but truly generate themselves.[205] Hence, the germs of Kant's full acceptance of epigenesis seem to be present in *Der einzig mögliche Beweisgrund*.[206] Nevertheless, Kant's continued insistence in this work that plants and animals cannot be mechanically explained, coupled with his critique of Buffon and Maupertuis, surely suggests that he had no use for *mechanistic* varieties of epigenesis: simple attractive forces of nature cannot account for the determinate unity found in organic bodies.

How does the foregoing relate to our discussion of Wolff's views on explanation? Wolff did not adopt any variety of epigenesis, rather he adopted a spermist variety of preformationism. In chapter 16 of the *Deutsche Physik*, while discussing the generation of man and animals, Wolff rejected the existence of female semen, arguing that we can explain conception without it.[207] Conception occurs through the fertilization of the egg through sperm. He then argues explicitly against epigenesis, stating that a foetus does not come to be through the mixing of the male and female semen (a position that according to Wolff has been dominant up until Harvey and that, as we have seen, was adopted by Descartes). More generally: from a mere unformed matter, present in the egg, a foetus cannot be formed.[208] In the egg, therefore, there must be something "composed from members", and, according to Wolff, this composite is introduced in the egg through the male semen.[209] All parts of a body are thus contained in small in the sperm (*Saamen-Thierlein*), although, Wolff emphasizes, not in exactly the same proportion as in a grown body.[210] This specific proportion arises gradually through nutrition and growth.

For our present purposes, it is important to note that Wolff's rejection of (mechanist) epigenesis, and his endorsement of preformationism, fits his model of explanation. A whole is explained in terms of its parts and mode of composition of parts. If we want to obtain cognition of these parts, we once again specify its parts and their mode of composition. Embryological devel-

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[205] AA 2: 115. In the third *Critique* Kant explicitly embraced the theory of epigenesis, which he then takes to be most thoroughly developed by Blumenbach. However, this was not a strictly mechanical variant of epigenesis such as initially proposed by Descrates, Buffon or Maupertuis.

[206] According to Sloan 2002, Kant fully embraced epigenesis in the 1780s. In the 1770s, Sloan argues (also referring to the passages currently under investigation), Kant adopted a middle way between mechanistic epigenesis and strong preformationism. My analysis suggests that Kant, in *Der einzig mögliche Beweisgrund*, was critical of both positions, yet already tilting towards some form of epigenesis.

[207] Wolff 2003 [1723], 713–714.

[208] Wolff 2003 [1723], 718.

[209] Wolff 2003 [1723], 719.

[210] Wolff 2003 [1723], 722.

opment is likewise analyzed in terms of parts and their mode of composition, in particular: in terms of a composite structure of bodily parts contained in semen. The versions of (mechanist) epigenesis we have discussed, however, do not nicely fit Wolff's views on explanation. Here, a particular composite structure is taken to arise from an unorganized structure through the action of some sort of attractive force. In the course of the eighteenth century, preformationist accounts of embryological development were largely abandoned in favor of epigenetic accounts (though in general not of a mechanist variety). Kant himself also eventually fully adopted epigenesis.[211] As we have seen, already in *Der einzig mögliche Beweisgrund*, Kant, though critical of the theories of Buffon and Maupertuis, seemed to prefer epigenesis to preformationism on methodological grounds. Here, we have a likely source for Kant's construal of mechanism in terms of parts and forces: the rise of (mechanist) epigenetic theories of generation, which did not neatly fit Wolff's scheme of explaining a whole in terms of its parts *and* their mode of composition. In epigenetic theories, the mode of composition of parts is itself accounted for in terms of forces.

Another source for Kant's construal of mechanical explanation as an explanation in terms of parts and forces is Kant's own dynamical conception of 'force'. Already in his very first work, the *Gedanken von der wahren Schätzung der lebendigen Kräfte* (1747), Kant argued that it is only because of an essential force of substances in virtue of which they can act outside themselves that these substances are related and constitute an *order*.[212] The term order is technical, and is employed by Wolff to denote an ordering generated by specific relations (e.g., spatial and temporal) among distinct parts constituting a unity (whole).[213] Hence, the fact that Kant takes forces of substances to constitute determinate *relations* among substances and thus an ordering, suggests that forces determine (in our terms) the specific mode of composition of objects.

Of course, Kant's views of dynamics and his conception of force change immensely during the course of his philosophical career. Yet, I suggest that the general view that the mode of composition of wholes is (ultimately) explained in terms of forces is a continuous element in his thought. We have already encountered this view in *Der einzig mögliche Beweisgrund*. There, Kant's treats gravity as an objective ground (cause) giving rise to a necessary unity of effects. Thus, for example, the composition of the system of bodies in the solar system, i.e., their relations to one another and change of relations, is determined by

[211] Cf. Sloan 2002.
[212] AA 1: 23.
[213] Wolff 2003 [1751], 68–71.

the action of gravity. Finally, Kant asserts the priority of the notion of force in the *Metaphysische Anfangsgründe*, when contrasting the *mechanical* natural philosophy with the *dynamical* natural philosophy:

> The mode of explaining the specific variety of matters by the constitution and composition (*Zusammensetzung*) of their smallest parts, as machines, is the *mechanical natural philosophy*. But that which derives this specific variety from matters, not as machines, that is, mere instruments of external moving forces, but from the moving forces of attraction and repulsion originally inherent in them, can be called the *dynamical natural philosophy*. (AA 4: 533)

Kant describes a mechanical explanation in familiar terms: an explanation in terms of the nature and mode of composition of parts. Moreover, these parts are machines, which is to say that we attribute the parts forces in virtue of their figure and motion. In contrast, a dynamical mode of explanation is based on the dynamical forces of attraction and repulsion inherent in matter. In the Dynamics of the *Metaphysische Anfangsgründe*, Kant aims to show that extension, impenetrability and density of matter are grounded in the action of the fundamental forces of attraction and repulsion. For Kant, then, the notion of force is primitive and can be said to explain the form or mode of composition of material bodies. This, I take it, is the second source that allows us to understand Kant's construal of mechanical explanation as an explanation of a whole in terms of its parts and forces.

The foregoing shows that Kant, partly under the influence of scientific developments in the middle of the eighteenth century, partly because of his dynamical conception of force, ultimately took the mode of composition of objects to be explicable in terms of the action of forces. As a consequence, he slightly adjusted the scheme of mechanical explanation that we have found in (e.g.) Wolff. This is confirmed by Kant's construal of mechanical explanation in the *Kritik der Urteilskraft*, which he often describes as an explanation of a real whole in terms of its parts and forces (thus abstracting from the notion 'mode of composition').

It does not follow, however, that Kant completely abandoned Wolff's scheme of mechanical explanation. We have already seen that Kant's conception of mechanical explanation is often virtually identical to that of Wolff, also taking into account the mode of composition of the parts of a whole. Moreover, an explanation of a whole in terms of its parts and forces (e.g., Kant's dynamical explanation of why matter has a determinate extension) is still an explanation of a whole in terms of its parts. The appeal to force, construed (e.g.) as determining relations between objects, simply has the

function of showing why a determinate whole exists. Thus, although Kant adjusted Wolff's scheme of mechanical explanation, he did not abandon it. The present chapter provides an answer for why this is the case: the ubiquity of part/whole conceptualizations that inform both Wolff's and Kant's views on mechanical explanation. Given this background, one can understand that mechanical explanation was conceived of as a variety of an explanation of a whole in terms of its parts.

2.11 Conclusion

In the present chapter we have analyzed Kant's conception of mechanical explanation by focusing on the views on scientific and mechanical explanation articulated in the works of Christian Wolff. Mechanical explanations are taken to be explanations of features of corporeal bodies (wholes) in terms of their parts, the mode of composition of these parts, and forces acting upon bodies and their parts. The notion of mechanical explanation is treated as providing a *philosophical* interpretation of what constitutes a proper explanation within natural science. This notion is strongly influenced by part-whole conceptualizations employed within metaphysics, logic and mathematics.

In our discussion of Wolff, we have seen that nominal and real definitions are treated as instances of explanation 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 notion 'essence'. If we have cognition of the parts of a thing and their mode of composition, we comprehend its essence, which contains the ground (*reason why*) of its necessary determinations. In particular: by means of cognition of the essential parts (*genus*, *differentia*) of a concept, we can derive a judgment predicating a *proprium* or attribute of a concept and thus (according to Wolff) objectively *ground* this judgment. Cognition of the parts and mode of composition of the parts of a whole does not, however, allow us to provide objective explanations of contingent qualities or relations of things (most importantly: the motion or change of motion of composite things). In order to objectively explain why a thing has certain contingent qualities or relations, we must introduce the notion 'force'. In natural science, we explain determinations of things (corporeal bodies), by taking into account (i) its parts, (ii) the mode of composition of these parts, and (iii) forces acting upon bodies and their parts. Explanations in terms of (i)–(iii) are *mechanical explanations* and provide ideals of explanation in physics. In biology, we also try to explain features of organisms in terms of (i)–(iii). In particular, if,

according to Wolff, we aim to specify the true, objective ground of organic features such as growth, nutrition and propagation, we must try to explain these features in terms of (i)–(iii).

Like Wolff, Kant treats mechanical explanations as explanations in terms of (i)–(iii). This view of mechanical explanation is based, again similar to Wolff, on the idea of treating relations between partial concepts and composite concept as a relation between parts and whole. In addition, Kant applies the part-whole scheme to relations obtaining between concepts comprising the extension of a concept and this extension itself (a quantitative division of a whole into its parts). However, Kant rejects the Wolffian methodology of explaining wholes in terms in their parts in metaphysics.

In natural science, explanations of wholes (corporeal bodies) in terms of (i)–(iii) can be taken to constitute demonstrations *propter quid*. The appeal to forces of nature is necessary in order to specify the objective ground of determinations of an object. This also holds for certain determinations that Wolff treated as *propria*, i.e., as merely analytically derivable from the essential parts of the concept of a thing. For example, whereas Wolff treated the filling of a space to be a *proprium* of the concept of a composite thing, and thus of corporeal bodies, Kant argues that we can only have insight into the objective ground of bodies filling a space if we treat a moving (repulsive) force as the cause of bodies filling a space. In this manner, Kant assigns to the notion of force even more importance than Wolff did.

The conception of mechanical explanation in terms of (i)–(iii) can be traced to Kant's views on the proper, mechanical explanation of crystallization and to his views on the mechanical explanation of the generation of a variety of species. Hence, mechanical explanations are introduced in biology. The feature of organisms that, according to Kant, defies mechanical explanation is their unity, i.e., the mode of composition of their parts. We cannot objectively explain *why* the parts of organisms are related to each other as they are. Whereas in astronomy we can identify the force of gravity as an objective ground of the order found in the planetary system, we lack cognition of such an objective ground when it comes to explaining the order of the parts of organisms. Finally, Wolff's philosophical interpretation of mechanical explanation provides a background against which we can understand why Kant treated the mechanical principle as a regulative maxim.

3 | Teleology and biology

As we have seen in the previous chapter, Kant treats a mechanical explanation as an explanation of a whole in terms of its parts, the mode of composition of its parts, and the forces acting upon these parts. He takes the mode of composition of the parts of organism to be mechanically inexplicable. In other words: we cannot specify objective grounds explaining why an organism has its particular systematic structure. In line with this view, Kant argues that questions concerning the ultimate origin of organisms, or the origin of life, defy scientific treatment.[1]

What, then, is the status of biology? As stated in the Introduction to this work, many recent commentators take Kant's discussion of organic nature in the third *Critique* to imply that biology cannot be a proper science. This claim is partly based on a strong interpretation of the mechanical inexplicability of organisms. If not only the origin and structure, but also the functioning and capacities of organisms resist mechanical explanation, and if in natural science we must provide mechanical explanations, biology can never constitute a proper science. John Zammito presents organisms as constituting a capital anomaly in Kant's philosophy, not fitting his system of science.[2] How can we coherently think of science as a systematic unity, as Kant does, if organisms present us with such an anomaly?[3]

With respect to a positive Kantian influence on the development of biol-

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1 On Kant's critical stance toward the latter topic, cf. Steigerwald 2006, 713–716.
2 Cf. Zammito 2006, 763
3 Cf. Guyer 2001.

ogy, John Zammito draws a sceptical conclusion: "only by misunderstanding Kant did biology as a special science emerge at the end of the eighteenth century".[4] In the terms of Robert J. Richards: the third *Critique* provided "a profound indictment of any biological discipline attempting to become a science".[5] The claims of Zammito and Richards provide a critique of a more traditional interpretation of Kant's influence of the development of biology, which can be traced to the work of the historian of science Timothy Lenoir.[6] According to Lenoir, Kant provided a philosophical underpinning for the 'teleomechanistic' research program of the so-called Göttingen School, which included such prominent late eighteenth-century biologists as Johann Friedrich Blumenbach (1752–1840), Johann Christian Reil (1759–1813), Karl Friedrich Kielmeyer (1765–1814) and Alexander von Humboldt (1769–1859). According to Lenoir, Kant provided a philosophical theory of teleomechanism: what is distinctive of biology is the combination of teleology and mechanism. This idea, Lenoir claims, had a significant impact on the development of late eighteenth-century biology.

As also said, other recent commentators evaluate Kant's views on biology more positively. Thus, Clark Zumbach argues that according to Kant biology is an autonomous science having its own particular mode of explanation.[7] This mode of explanation, distinguished from the mechanical mode of explanation, is teleological. Teleology allows us to unify regularities within the domain of biology. More recently, Hannah Ginsborg and Marcel Quarfood have argued along similar lines, taking teleology as enabling us to regard biological regularities as lawlike or necessary and as allowing for the unification of regularities that cannot be explained mechanically.[8]

In the present chapter, I will argue, similar to Lenoir, that Kant saw the combination of teleology and mechanism to be distinctive of biological method. Hence, the present chapter will focus on Kant's conception of proper biological method, which is construed as consisting in the subordination of mechanism to teleology. However, as the remarks of Richards and Zammito indicate, Lenoir's interpretation has been the subject of much criticism.[9] This critique stems from (i) viewing the actual method of eighteenth-century biologists to be inconsistent with Kant's methodological prescriptions con-

4 Zammito 2006, 765.
5 Richards 2000, 26. Cf. also Bird 2010, 405.
6 Lenoir 1989.
7 Zumbach 1984, 92.
8 Ginsborg 2001; Quarfood 2004 and 2006. Cf. §3.1.
9 Cf. Richards, 1998, 2000. Cf. also Caneva 1990; Beiser 2006, 9.

cerning biological method in the third *Critique*, and (ii) ambiguities in the term teleomechanism. In this chapter I mainly focus on the manner in which Kant himself conceives of the combination of teleology and mechanism in biology (relating to (ii) and not to (i)). Lenoir is not clear on the meaning of the notion 'teleomechanism', employing it interchangeably with terms as 'vital materialism' or 'emergent vitalism'.[10] With respect to Kant the latter terminology is unfortunate, for he would regard materialism and vitalism to be dogmatic metaphysical theories. Hence, the question arises how Kant himself conceived of the relation of mechanism and teleology. In a letter to Blumenbach of 5 August 1790, Kant praised Blumenbach for uniting the 'physico-mechanical' and teleological 'principle', noting that he himself had been occupied with the same problem.[11] What does this mean for Kant? This question will constitute a main focus of this chapter. In contrast to Lenoir, I will thus be mainly concerned with Kant's own views and not with his influence on biological practice.

On the basis of an analysis of Kant's conception of biological method, I argue that Kant does not, as Richards and Zammito claim, provide a profound indictment of any biological discipline becoming a science. In line with the interpretations of Zumbach and Quarfood, I argue that teleology, in addition to having a descriptive function, determines the domain of biology and determines what we take as an object of explanation in biological theories. Thus we can say that in biology the *explanandum* is comprehended in teleological terms. However, in contrast to the interpretations of Zumbach, Ginsborg and Quarfood, I argue that Kant denies teleology any explanatory function. Explanations in biology must be mechanical explanations. As we may also put it, the *explanans* in biology must be some kind of mechanism. It is in this manner that in biology we combine teleology and mechanism. Kant can thus be taken to specify a method by means of which biology can become a proper science. We can argue that late eighteenth-century biologists did not follow this method. However, this does not determine how Kant himself thought about the possible scientific status of biology.

In arguing that explanations in biology are mechanical explanations, I will treat Kant's views on propagation (reproduction), growth and nutrition and regeneration. In the eighteenth century, these characteristics were treated as fundamental distinguishing traits of organisms and as constituting main topics of investigation within biology.[12] In discussions of Kant's view on these

[10] Cf. also Lenoir 1980, 1981.
[11] AA 11: 185.
[12] Cf. McLaughlin 2001, 173–179, who traces the discussion of these features to Locke.

traits, various commentators treat these traits as resisting mechanical explanation. Thus, Paul Guyer argues that reproduction, growth and nutrition and regeneration are paradigmatic organic processes that "cannot be understood by our ordinary, mechanical conception of causation".[13] While discussing these organic processes, John Zammito makes the stronger claim that the question of how 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".[14] Organisms or natural purposes are "*inexplicable* by all the sources of science according to the *nexus effectivus*", i.e., they are mechanically inexplicable.[15] Finally, Hannah Ginsborg argues, with respect to the mechanical inexplicability of organisms, that what calls (in vain) for explanation is "not the particular historical event of a certain quantity of matter coming to be arranged in such-and-such a configuration", but the "order and regularity manifested by that and similar configurations" and the "processes through which they maintain and replicate themselves".[16] These latter processes, e.g., reproduction, growth and nutrition, etc., do not hold "in virtue of the kinds of regularities studied within physics and chemistry". Rather, teleology must be taken as the *ground* of "biological regularity".[17]

In contrast to the above line of interpretation, I argue that Kant argues that processes such as reproduction, growth and nutrition must be explained mechanically. To be sure, as is emphasized by the above authors, these processes must be comprehended or *described* in teleological terms. Thus, reproduction, growth, nutrition, etc., are conceptualized as goal-directed processes, e.g., as serving the maintenance and preservation of organisms. In addition, sub-processes involved in (e.g.) growth and nutrition, are conceptualized as being conducive to or good for a goal. To put the point generally: the parts of a whole are construed as means to an end. However, irrespective of teleological *description*, the above mentioned organic processes must be *explained* mechanically (in terms of mechanisms). The problem in interpreting Kant is simply that he (and his contemporaries) lacked adequate knowledge of the mechanisms involved in processes such as reproduction, growth and nutrition and regeneration. However, Kant did construe mechanical explanations as an ideal of explanation in natural science (cf. Chapter 2). In his writings on biological topics he, I contend, stayed true to this ideal. In his discussion of nutrition and growth, it becomes especially clear that Kant thought that the

[13] Guyer 2001, 264.
[14] Zammito 2006, 758.
[15] Zammito 2006, 758–759.
[16] Ginsborg 2001, 245.
[17] Ginsborg 2001, 246.

latter must be explained (at least in part) in terms of *chemical* processes or mechanisms. To put the point in terms of terminology introduced in §1.2: chemistry provides *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. In addition, Kant does not, as Ginsborg claims, regard biological regularities as lawlike or necessary in virtue of teleological grounds. To put the point generally: biology is (just as chemistry) a part of physics and as such explanations in biology (*mechanical explanations*) invoke propositions established in higher physical sciences (such as chemistry).

The current chapter is divided in two parts. §3.1 provides an introductory discussion of recent interpretations of Kant's teleology. According to these interpretations, Kant assigns teleology (a) a descriptive, (b) an explanatory, or (c) an identificatory function in natural science. I maintain that teleology serves (a) a descriptive and (c) an identificatory function (a position developed throughout the whole chapter).

In Part 1 of this chapter, I elucidate Kant's views on teleology from a historical perspective. §3.2 contains an analysis of the use of teleological notions in the works of Baumgarten and Wolff. In §3.3, I relate the views on teleology expounded in Kant's metaphysics lectures to the views of Baumgarten and Wolff. §3.4 analyses Kant's views on teleology expounded in his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788) and the *Kritik der Urteilskraft* (1790) relative to the views of Baumgarten and Wolff. §3.5 summarizes why purposes cannot be genuinely explanatory in natural science, while §3.6 discusses Kant's views on the concepts of utility and purpose (once again relative to the views of Baumgarten and Wolff).

Kant's views on teleology are hardly ever discussed in light of the views of his predecessors. However, such a discussion sheds light on the historical background against which Kant assigns teleology a *regulative* function. Kant's regulative interpretation of teleology implies that teleology does not have any explanatory function in natural science (b). However, because teleology has a regulative function, Kant can argue, contrary to his predecessors, that teleology does fulfil other crucial functions in natural science or more specifically: biology.

In part 2, I specify the role of teleology with respect to biology. Teleology is, in conformity with reading (a), assigned to have a descriptive function in biology. In conformity with reading (c), teleology is taken to have an important function in construing the domain of biology. In §3.7, I argue that for Kant the method by means of which we investigate organisms deter-

mines how we conceive their mode of composition. Hence, how we construe the subject matter of a doctrine is dependent on our method. This is true of both the *mechanical* method of investigating organisms (the subject of §3.7) and of the teleological method of investigating organisms (the subject of subsequent paragraphs). In §3.8 I discus how Kant's contemporary biologist Johann Friedrich Blumenbach construes the domain of natural history and distinguishes between organisms and minerals in terms of both empirical features of organisms and *teleological* presuppositions. Here, we are confronted with an example of how teleology determines the object of biology. In §3.9 I will argue that for Kant, similar (though not identical) to the position of Blumenbach, both empirical features and teleological presuppositions figure in demarcating the domain of organic from inorganic nature, i.e., in determining the domain of biology. However, *explanations* in biology are always construed as mechanical explanations. This is argued for by analyzing Kant's views on the organic processes of reproduction, nutrition and growth and regeneration. Hence, the proper method of biology consists in subordinating mechanism to teleology. §3.10 provides a concluding analysis of how the method of biology determines its domain.

3.1 Recent interpretations of Kant's teleology

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

We may ask why Kant thought that organisms must be understood in teleological terms. In the recent literature on Kant there is some consensus on this point. The general idea is that Kant took organisms to be objects in which (i) the whole is determined by the parts, (ii) the parts seem to be dependent on the whole, and (iii) the parts seem to be reciprocally dependent on each other. Thus, organisms seem to exhibit various forms of reciprocal dependence or causality: between whole and parts and between the parts themselves. Kant takes this feature of organisms to necessitate the introduction of teleology, although (to be sure) teleology only has a regulative status.[18] Briefly: if we merely adopt a model of efficient causality to understand organisms, we can

[18] For this reading, see for example Guyer 2001; McLaughlin 1989, 2001; Steigerwald 2006.

make sense of the idea that the parts of organisms determine the whole (i), but not of the idea that the whole conversely determines the parts (ii). However, if we also regulatively adopt a model of final causality, we can take the whole to be the final cause of the parts, thus coming to terms with case (ii). Case (iii) can be similarly understood in terms of a model combining efficient and final causality. I will return to and further elaborate these ideas in the course of this chapter.

What further role does teleology play in the investigation of organisms? Some commentators deny any further role to teleology. For example, Peter McLaughlin argues that teleology has a mere *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".[19] In short: Kant rejects holism. The whole is not an actual cause of the parts, rather we understand organisms as determined by a representation of the whole. The implication, according to McLaughlin, is that teleology is not explanatory but only "*phenomenally* or *descriptively satisfying* in the case of organisms".[20] We can adequately describe organisms, characterized by various forms or reciprocal dependence, in teleological terms but nothing more.

Other commentators assign a more substantial role to teleology in Kant's philosophy of organic nature. Clark Zumbach assigns biology a particular mode of teleological explanation.[21] Hannah Ginsborg has more recently 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, Kant takes the concept of purpose to express normative constraints in order to explain that regularities displayed by organisms are *lawlike*, i.e., these regularities exhibit normative lawlikeness. Although biological regularities are mechanically inexplicable, Kant can thus argue, utilizing the concept of 'purpose', that biological regularities are necessary in virtue of *teleological grounds*.[22] In Ginsborg's reading of Kant, teleology assumes some kind of explanatory role in biological science, although (as is the case for Zumbach) this notion of explanation must be distinguished from how we understand explanation in relation to physico-mechanical sciences.

Marcel Quarfood has partially followed Ginsborg's interpretation. In a

[19] McLaughlin 2001, 178–179.
[20] *Ibid*, 19.
[21] Zumbach 1984.
[22] Cf. Ginsborg 2001, 248–54.

recent article, he describes the problem of interpreting Kant's view on the role of teleology in biology 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 aims to provide a twofold solution to this problem. First, he follows Ginsborg in arguing that teleology has some kind of explanatory function (distinct from mechanical explanation), serving as a substitute for mechanistic explanations.[23] In particular, purposes provide a substitute for ordinary (mechanical) laws of nature in cases "where we find no other way to unify the regularities that cry out for explanation."[24] Second, Quarfood argues that 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".[25] On this level, Quarfood claims, teleology has a *constitutive* function: it demarcates the subject-matter of biological science. In contrast, on a meta-level of philosophical reflections concerning the ultimate ground of the existence and organization or organisms (a topic on which we must remain agnostic), teleology has a mere *regulative* function.[26] In his 2004 *Transcendental Idealism and the Organism: Essays on Kant*, Quarfood puts the point as follows:

> Aristotelian functions […] are to be seen as valid at the *object-level* of biological investigation. The denial of their objectivity takes place at a further *meta-level* of reflection. For the biologist, organisms exhibit functions as a matter of course. It is in an ontological perspective, which is of no great importance for the practice of biology, that functions are assigned a merely regulative status. (Quarfood 2004, 152–153)

In the ensuing two parts of this chapter, I will position myself with respect to these authors. In part 1, I will describe Kant's use of the teleological notion 'purpose' in light of the views of Baumgarten and Wolff on 'purpose'. The

[23] Quarfood 2006, 737.
[24] Quarfood 2006, 738.
[25] Quarfood 2006, 736.
[26] *Ibid.*

upshot of this discussion is, contrary to the views of Zumbach, Ginsborg and (partially) Quarfood, that Kant does not assign any explanatory role to teleology. As I have argued in the previous chapter, only mechanical explanations constitute proper explanations for Kant. The manner in which Kant employs the concept of purpose substantiates this view. Kant thus simply adopts a very strict conception scientific explanation in natural science and in light of this conception teleology is not explanatory.

This does not mean that teleology merely serves a descriptive function, as McLaughlin argues. To be sure, teleology is assigned a descriptive function by Kant. Organisms are described as purposive wholes and the parts of organisms are construed as having a certain purpose. However, though we employ teleology to describe organisms, I am in agreement with Quarfood that teleology also has (what he calls) an identificatory function. Quarfood develops his interpretation primarily on the basis of §66 and §68 of the Critique of Teleological Judgment. In part 2 I develop this interpretation in more detail, employing works of Kant's contemporary biologists, showing precisely how teleology functions in demarcating the subject matter of biology, or (in my terms): in determining the *domain* of biology.

The foregoing does not imply that teleology can be taken to be *constitutive* of biology as Quarfood claims. To say that teleology is constitutive is to say that we can objectively predicate teleological notions of organism, and this is denied by Kant. Moreover, to say that teleology is constitutive leaves room for the view that teleological notions can have an explanatory role, something which Kant denies. Rather, teleology allows us to determine the domain of biology in its *regulative* employment. As such, regulative principles function in specifying the domain of a science, and thus do not *merely* have a descriptive function, whereas they are denied any explanatory role.

3.2 Baumgarten and Wolff on 'purpose': some classical teleological vocabulary

Kant argues that organisms are natural objects whose possibility we can comprehend only by judging them as natural purposes. Nevertheless, the concept 'natural purpose' is not a constitutive concept of determining judgment. Rather, it is a regulative concept for the reflecting power of judgment. 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)".[27] However, one can also call objects purposive if their "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."[28] This is the case for organisms. According to Kant, we conceive of organisms as purposes by analogy with human purposive action, which provides instances of a causality in accordance with ends. However, this analogy is limited and the idea of organisms as purposes serves a merely regulative function.

This argument is well-known.[29] In the current section I discuss some of its sources. I will take into account the views articulated by Alexander Gottlieb Baumgarten on the notion 'purpose'. This notion figured in Baumgarten's discussions on various types of causes, a discussion pertaining to ontology. The upshot of this discussion is that the concept purpose can only be predicated of objects relative to some cognitive subject that conceptualizes an object as a purpose and employs means to obtain this purpose. In short: purposes only exist relative to cognitive, volitional subjects. In the next section, I will argue that Kant adopts a similar view on 'purpose'. Hence, there is considerably more continuity between Kant's views on teleology and that of his direct predecessors than is often recognized.[30] The manner in which Baumgarten employs teleological notions is similar to that of Christian Wolff. In discussing Baumgarten, we will thus also refer to Wolff's writings.

At this point a note of caution is required. In claiming that there are con-

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[27] AA 5:220.

[28] *Ibid*.

[29] For some recent discussion, see Guyer 2001, 264–267; Beiser 2002, 519–520; Steigerwald 2006, 716–727.

[30] In the discussion of the third *Critique* in his classical *Kant's Life and Thought*, Cassirer presents a common view when claiming that Kant's views on teleology constitute a revolution with respect to the earlier (Wolffian) conception of teleology. In the following, I hope to present a more nuanced position. Cf. Cassirer 1981, 334–360 and §3.6.

tinuities between Kant's views on teleology and the views of his predecessors, most importantly Baumgarten, I evidently do not whish to claim that Kant's views are identical to those of Baumgarten. Baumgarten's discussion of final causes occurs within *ontology*. In Kant's transcendental philosophy, there is no room for traditional ontology in Baumgarten's sense. However, in claiming that purposes (final causes) only exist relative to a cognitive, volitional subject, something that is *not* true of efficient causes, Baumgarten does articulate a view that informs Kant's construal of the concept of purpose as a *regulative* concept with respect to natural science. In a nutshell: in contrast to efficient causes, purposes simply have a special and problematic status in eighteenth-century German philosophy. This status is reflected in Kant's treatment of 'purpose' as a regulative concept with respect to natural science, a view espoused (to be sure) within transcendental philosophy.

In Alexander Gottlieb Baumgarten's *Metaphysica*, which Kant used as a textbook on metaphysics[31], the concept 'purpose' (*finis*) is discussed in section seven, chapter three of part I (*Ontologia*). This chapter deals with the relative predicates of beings, i.e., with relations.[32] Section seven, entitled "on the remaining types of causes", is preceded by discussion of the concept 'cause' in section four, the concept 'efficient cause' in section five, and the concept 'usefulness' or 'utility' in section six. Baumgarten takes a purpose to be a type of cause. In fact, a purpose is a final cause (*causa finalis*).[33] The concept 'purpose is explicated in terms of the concepts (i) 'cause', (ii) 'efficient cause', and (iii) 'utility'. In the following, we will discuss the manner in which Baumgarten construes (i)–(iii). This allows us to understand his discussion of 'purpose' (iv).

(i) Baumgarten defines the concept 'cause' by means of the concepts 'ground' (*ratio*) and 'source' (*principium*)[34]. A ground is construed as that from which

[31] 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 the German translation by Meier of 1783. This is a partial translation that is occasionally somewhat loose. Hence I have compared the relevant passages with the Latin fourth edition of the *Metaphysica*. In the references, when possible, I refer to both works.

[32] AA 17: 82.

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

[34] I here follow Meier's German translation of *principium* as *Quelle*. In his notes to Baumgarten's *Metaphysica*, Kant also employs this translation. Cf. AA 17: 94. This translation may strike one as odd. However, it seems to reflect the idea, as will be more clear in the following, that in the present (ontological) context the notion of a principle is applied to *substances*.

it is possible to know *why* something is.[35] A source is that which contains the ground of something else, while that which is grounded in that source is called *principiatum*.[36] Hence, if α is the source of β, α contains the ground from which it is possible to know why β is the case. Baumgarten further distinguishes between the source of the possibility of a thing (*principium essendi*), the source of the reality or existence of a thing (*principium existentiae*), and the source of the coming to be of a thing (*principium fiendi*).[37] 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), Christian Wolff provides the following example elucidating 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.[38] In Baumgarten's terminology: the air is the source for the reality or the source for the coming to be of the increased speed of the growth of plants.

The concept 'cause' (*causa*) is juxtaposed to "that which is caused" (*causatum*). The term '*causatum*' is construed as that which is grounded in a cause.[39] Baumgarten stresses that a connection obtains between *causa* and *causatum*, the *nexus causalis*.[40] The term 'connection' (*nexus*) in general denotes a relation obtaining between *things*.[41] The notion of a 'thing' refers to possible objects.[42] Hence, a connection can obtain between possible objects (whether actual or not).[43] However, a *nexus causalis* merely obtains 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 existing objects. Finally, in considering the *nexus causalis* we can, according to Baumgarten, consider this relation from the perspective of the antecedent or consequence. Thus, returning to our previous example: the hot air (the cause) *brings about*

[35] Baumgarten 1783, 6. AA 17: 27–28.
[36] Baumgarten 1783, 88. AA 17: 94.
[37] AA 17: 94–95.
[38] Wolff 2003 [1751], 15–16.
[39] Baumgarten 1783, 88. AA 17: 94
[40] Baumgarten 1783, 90. AA 17: 95.
[41] Baumgarten 1783, 6. AA 17:27. Cf. Wolff 2003 [1751], 332.
[42] Cf. Baumgarten 1783, 3–4. AA 17: 24. Cf. Wolff 2003 [1751], 9.
[43] For Wolff, every actual object is possible but not every possible object is actual. Cf. Wolff 2003 [1751], 7–9.

the increased speed of the growth of plants, whereas, conversely, the increased speed of the growth of plants is *dependent* on the hot air.

(ii) Baumgarten's concept of 'efficient cause' builds on his account of 'cause'. An efficient cause (*causa efficiens*) is the cause of a reality by means of an act.[44] An effect is that which is caused by an efficient cause. The term 'act' is technical. It denotes a change of state of a substance by means of its own force.[45] A force, in turn, is defined as the ground of the actuality of accidents of substances.[46] Baumgarten further notes that, properly speaking, efficient causes are substances. Hence, a substance that contains a force which is the ground of the actuality of accidents of a substance, where these accidents can be accidents of itself or of another substance, is the efficient cause of these accidents. This conception of efficient cause is similar to that of Wolff. Wolff defines an efficient cause as that, which, through its act (*Thun*), generates the actual or real from the possible, whereas an effect is that which "arrives at its actuality" (comes to be) by means of an act.[47] For example: if the sun melts wax, this occurs through the continuous heating of the sun. In this example, the heating of the sun is the *act* of the sun, the melting of the wax is the *effect* and the sun itself is the *efficient cause*. This example illustrates a conception of efficient cause shared by both Wolff and Baumgarten.[48] Finally, 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*.[49] In light of the foregoing, this *nexus* can be interpreted as an objective relation obtaining between substances and accidents.

(iii) After discussing the notion 'efficient cause' Baumgarten turns to a discussion of "usefulness". He construes that which is useful as "that which

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[44] Baumgarten 1783, 92. AA 17: 96–97.
[45] Baumgarten 1783, 58. AA 17: 70.
[46] Baumgarten 1783, 55. AA 17: 68.
[47] Wolff 2003 [1751], 62–3.
[48] 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*. However, Baumgarten places heavy emphasis on the notion *actio immanens*. He first defines the notion '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 a possible accident of itself 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. Cf. Wolff 2003 [1751], 61–62.
[49] Baumgarten 1783, 92. AA 17: 99.

is good for something else", that which is not useful as "that which is not good for something else" and that which is harmful as "that which is bad for something else".[50] He further defines 'usefulness' (*utilitas*) as a good that pertains to things relationally. In particular, usefulness is a determination of a thing insofar as this thing is considered in relation to other things.[51] 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 relation of usefulness, i.e., the relation *x* is useful (good) for *y*, seems to be construed as an objective relation between things, i.e., a relation that can exist whether or not some cognitive subject takes something to be useful. To substantiate this claim, we may consider Christian Wolff's definition of usefulness. In the *Deutsche Metaphysik*, Wolff distinguishes between the concepts 'intention' (*Absicht*) and 'usefulness' (*Nutzen*). An intention is that which we try to obtain by our will.[52] Hence, only volitional entities can have intentions. The notion 'usefulness' is explained by referring to the use or usefulness of artefacts. The usefulness of a thing is a "consequence (*Folgerung*) of its essence (*Wesen*)".[53] This consequence need not have been foreseen when we set out to produce the artefact. To give an example (my own): cigarette lighters are designed to create a flame. When a lighter is designed by a designer, she *intends* lighters to produce flames. However, unforeseen many lighters also turn out to be *useful* for opening beer bottles (this, at least, is known to most Dutch college students). Wolff would probably argue that the usefulness of lighters for opening beer bottles is an objective property of lighters, it is a consequence of its essence (mode of composition). Hence relations of usefulness obtain between objects due to their objective properties and not because of any subjective ascription of usefulness to objects.

Baumgarten's discusses 'usefulness' (*utilitas*) while considering different types of causes. We may ask how that which is useful can be a cause. Evidently, the relation of usefulness is not a causal relation. Some object *x* may be useful for *y* without being the cause of *y*. However, when some subject recognizes the usefulness of *x* for *y* and puts it to use, *x* is causally efficacious in bringing about *y*. If the usefulness of something is made actual, we *employ* that which is useful: employment is the actualisation of usefulness (*Usus est utilitatis actuatio*).[54] Through this employment that which is useful functions as a cause. Baumgarten thus seems committed to the following two claims: (a) usefulness

[50] Baumgarten 1783, 97. AA 17: 99.
[51] Baumgarten 1783, 13–14. AA 17: 99–100.
[52] Wolff 2003 [1751], 563.
[53] Wolff 2003 [1751], 634–635.
[54] Baumgarten 1783, 98–99. AA 17: 100.

is an objective relation pertaining between objects. The connection between an object *x* that is useful for *y* can be termed the *nexus utilitatis*.[55] (b) The employment of that which is useful renders that which is useful a cause. Hence, although usefulness is an objective relation, it is only relative to some cognitive subject that can *recognize* and *employ* the usefulness of an object, that usefulness can be treated as a cause. The usefulness of *x* for *y* only plays a causal role in bringing about *y* if some cognitive subject recognizes the usefulness of *x* for *y* and employs *x* to bring about *y* (e.g., we actually employ a lighter to open beer bottles). This consideration leads to Baumgarten's discussion of purpose.

(iv) Recall that to employ something is to make real or actual 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 we try to realize is a *purpose*.[56] The representation of this purpose (of that which appears to us as good) is called an intention (*intentio*).[57] Finally, those things by means of which we make actual or realize the purpose are the means. Hence, an object is a purpose only relative to some cognitive subject that represents this object as good and tries to obtain this good by employing some means. Something is a purpose only relative to cognitive subjects that have *intentions* and are capable to act on them. 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). These different relations of usefulness are, in Wolff's terms, consequences of the essence of a branch. However, we can take one of the things for which the branch is useful, e.g., walking, to be good for us and employ the branch to achieve this good, i.e., 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.

The connection between means and purposes is the *nexus finalis*.[58] Since

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[55] *Ibid.*

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

[57] This definition of *intention* is somewhat different from, yet consistent with the definition given by Christian Wolff, i.e., that which we try to obtain by means of our will. Here we may also consider the first paragraph of Wolff's *Vernüfftige Gedancken von den Absichten der natürlichen Dinge*, in which he defines an intention as that which a rational and free being tries to obtain by means of its will or desire, thus making room for interpreting natural objects as divine intentions. Wolff 1980 [1726], 1–2.

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

means are that which some cognitive subject employs to achieve a purpose, what is true of purposes also holds of means: something is a means only relative to the actions of a cognitive subject having intentions. It follows that although the *nexus finalis* is a relation taken to obtain between objects, it is, contrary to the *nexus effectivus*, a relation only attributed to objects relative to our conceptualization and employment of objects. If intentional subjects that can act in accordance with their intentions do not exist, means and purposes do not exist. We may also note that Baumgarten 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, i.e., the source of realizing the use of that which is useful in order to achieve the purpose.[59] Thus, once again, final causes can be said to exist but, in contrast to efficient causes, only relative to the actions of intentional agents that try to achieve a good.

This sketch of Baumgarten's and Wolff's conception of 'purpose' provides a background from which we can try to comprehend Kant's conception of purpose and natural purposes. At this point, we can already construct an argument elucidating why, from Kant's point of view, the concept of purpose can only be problematically (regulatively) ascribed to nature by analogy with human purposive action. Recall that for Baumgarten the genus 'cause' is either a source of the existence (*principium existentiae*) or of the coming to be (*principium fiendi*) of a thing. As such, a cause contains the ground for *why* something exists or comes to be. It follows that in some cases, final causes can also be cited as providing a ground for why something exists or come to be. Recall also, however, that final causes only exist and actually function as a cause relative to some cognitive, volitional subject.

The foregoing suggests that final causes can be cited as providing reasons or grounds why for the existence or becoming of a thing in cases where we are dealing with human purposive action. For example, the income that we can obtain by letting a house may be represented by us (cognitive, volitional subjects) as a good that we wish to realize, i.e., the possible income is a purpose that directs us to *employ* certain means to construct a house. As such, our representation of a certain effect (a purpose) guides our actions in constructing a house, and the purpose partly explains *why* we build a house. However, this type of reasoning can, at least from Kant's point of view, only be problematically applied to nature. For example, plants (as far as we know) do not have an intellect, a will, etc. Hence, plants do not have representations that guide their action, i.e., they do not have purposes. The biologist cannot

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

therefore objectively attribute purposes to plants, providing a reason *why* for their so-called actions. Neither do we, from Kants perspective, have sufficient theoretical grounds to argue that a divine intellect constructed plants in a manner enabling the obtainment of certain purposes (i.e., we cannot objectively claim that certain organic traits, e.g. self-maintenance, are purposes relative to a divine intellect). Hence, according to Kant, if we ascribe purposes to plants, this is a problematic (regulative) ascription based on an *analogy* of certain organic processes or phenomena with human purposive actions. In the following sections, I will provide a more detailed comparison between Kant's views on teleology and those of Baumgarten and Wolff. In discussing Kant the following points constitute the focus of inquiry:

(a) According to Baumgarten and Wolff, objects are purposes or means relative to a cognitive subject that conceptualizes and employs these objects as purposes and means. In contrast, objects are the efficient cause of the change of state of an object in virtue of forces they exert. The ontological status of the *nexus finalis* is thus significantly different from that of the *nexus effectivus*. In my view, Kant adopts the views on the ontological status of the *nexus finalis* articulated by Baumgarten and Wolff. These views can be interpreted as providing a basis for Kant's claim that the concept 'natural purpose' is a regulative concept of reflective judgment and not a constitutive concept of determining judgment. To deny that the concept 'natural purpose' is a constitutive concept of determining judgment is (among others) to deny that we have grounds for taking purposiveness to be an objective property of objects of nature. This claim is not surprising given the ontological assumptions, explicated in this section, that form the background for Kant's thoughts on purposiveness.

(b) The complex manner in which the notion 'good' figures in Baumgarten's analysis of both 'usefulness' and 'purpose' allows us to understand why purposiveness is not an objective property of natural objects. Baumgarten takes usefulness to be an objective relation. An object is, in virtue of its properties and composition, useful or good for some other object. In this context, the notion 'good for' can be read as 'conducive to': it is an objective fact that some object x is conducive to (good for) bringing about y. The concept 'purpose' is defined as something that appears as good. Here, in contrast to the notion of usefulness, that which is good is specified relative to some cognitive subject. We *represent* something, such as walking, to be *good* for us and on this basis take a branch, being good for walking, to have the purpose of enabling us to walk. Hence, something is a purpose relative to our valuation of this thing. This helps us to understand why purposes only exist relative to some cognitive subject. As we will see, Kant provides a similar type of argument in the *Kritik der Urteilskraft*. For he thinks that assigning a purpose to an object involves

making a (subjective) normative claim concerning this object. This is one of his reasons for arguing that the concept 'natural purpose' is a *regulative* as opposed to a *constitutive* concept.

(c) Finally, both Baumgarten and Wolff, in their discussion of 'usefulness' and 'purpose', are concerned with relations between different objects. A means-purpose relation obtaining between different objects is rubricated by Kant under the concept of "relative" or "external" purposiveness, which must be distinguished from the "internal" or "intrinsic" purposiveness of single organisms. Kant's distinction between relative and internal purposiveness can be profitably understood on the basis of Baumgarten's and Wolff's conception of usefulness or utility.

3.3 Kant on purpose, *nexus effectivus* and *nexus finalis*: the metaphysics lectures

In order to consider 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 extant student transcripts of the metaphysics lectures contain a section on ontology with a subsection devoted to the concepts 'cause' and 'effect'.[60] In these subsections the discussion follows Baumgarten in distinguishing various types of causes, while devoting considerable attention to the distinction between the *nexus effectivus* and the *nexus finalis*. From these discussions, we can distil three main claims.

First (1), in the *Metaphysik von Schön* (1785–1790) it is claimed that the *nexus finalis* is not properly a subject of ontology. The reason 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.[61] This claim seems to be presented as a criticism of Baumgarten, who does treat of the *nexus finalis* within ontology. However, Kant's apparent claims regarding the *nexus finalis* merely explicate a line of argument contained in Baumgarten's *Metaphysica*. Baumgarten construed a purpose as something that we represent as good and that we try to obtain by employing some means. The purpose is a final cause because it is a source of employing some means to obtain a purpose. 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

[60] AA 28: 522–524. Cf. AA 28: 571–575.
[61] AA 28: 524.

the coming to be of this object. The example of a *nexus finalis* given in the *Metaphysik von Schön* further shows this indebtedness to Baumgarten. The relation between pack animals (*Lastthiere*) and the nutrition and clothing of humans is presented as an instance of the *nexus finalis*.[62] This example makes sense on Baumgarten's reading of the *nexus finalis*. The relation between live stock 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 only attributed to objects relative to our conceptualization and employment of objects.

Second (2), in the *Metaphysik L2* (1790–1791) it is argued that the proper method of philosophy consists in the specification of the *nexus effectivus*.[63] In philosophy, and science in general, we aim to explain how something comes about and this requires cognition of the relation between efficient causes and effects. In contrast, a mere appeal to the *nexus finalis* does not provide objective explanations of how something comes about.

The *nexus effectivus* is described, in contrast to the *nexus finalis*, as a connection of causes and effects through which one can cognize *how* some event occurs.[64] For example, confronted with the question 'why does a wound in a body heal?', the specification of efficient causes will provide us with cognition that explains how wounds heal, thus explaining how the process of healing in animal bodies *works*. This is not the case if we specify a final cause for the healing of wounds, i.e., if we account for such a process in terms of the *nexus finalis*. For example, we might answer the above question by stating that wounds heal because this is so "arranged by providence (*Vorsicht*)".[65] This is an answer that appeals to the *nexus finalis*. It does not provide us with any insight into how natural processes (such as regeneration or healing) work. For this reason 'true philosophy' consists in understanding the *nexus effectivus*.[66] Indeed, in philosophical research the appeal to the *nexus finalis*, if one completely bypasses the search for true (efficient) causes, is characterized as a "*Polster der faulen Philosophie*".[67] The treatment of the notions '*nexus effectivus*' and '*nexus finalis*' in the metaphysics lectures thus strongly suggests that Kant identifies proper scientific method with the search and specification

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62 *Ibid.*
63 AA 28: 574–575.
64 AA 28: 574.
65 *Ibid.*
66 *Ibid.*
67 *Ibid.*

of efficient causes for natural phenomena. In terms of the previous chapter: the appeal to the *nexus effectivus* is supposed to enable us to provide a mechanical, objective explanation of phenomena.[68]

Finally (3), in the metaphysics lectures it is claimed that final causes are not objects of perception. This claim can also be found in a note to Kant's copy of the first Introduction to the third *Critique*: "We put, it is said, final causes into things, and do not as it were draw them out of our perception."[69] Final causes are *ascribed* to things, not perceived in them. Kant employs this claim to argue that purposiveness is not an objective property of natural things. For example, in the published Introduction of the third *Critique*, Kant argues that the "purposiveness of a thing […] is also not a property of the object itself (for such a thing cannot be perceived)".[70] Thus, the fact that we cannot perceive the purposiveness of an object is a reason for denying that purposiveness is a property of this object. Here we are confronted with an epistemic argument for a conviction already contained in the work of Baumgarten: purposes only exist relative to a cognitive subject that conceptualizes objects as purposes.

Points (1)–(3) are not merely contained in the student transcripts of Kant's metaphysics lectures. They are also articulated in various published writings. For example, in his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant associates proper scientific method with the specification of

[68] For the connection (if not identification) of the idea of mechanism and *nexus effectivus*, cf. AA 28: 1069–1070. Note that the example treated in the metaphysics lectures, i.e., that of the healing of a wound, is an example of organic *regeneration*. In the Introduction to this chapter, I noted that this characteristic trait of organisms is sometimes interpreted by commentators on Kant as resisting mechanical explanation. However, the metaphysics lectures suggest that we must explain this trait mechanically.

[69] AA 20: 220. In an editorial note to the English translation of the first Introduction, Guyer remarks that this sentence is written in a hand that does not appear to be either Kant's or Kiesewetter's (who according to Guyer produced the fair copy of the first Introduction, containing corrections and additions in Kant's hand). However, the fact that similar remarks occur throughout Kant's lectures on metaphysics suggests that we are at least dealing with a statement to which Kant would subscribe.

[70] AA 5: 189. Cf. AA 5: 396, 399. In the latter sections, Kant argues that the concept of a *natural purpose*, applied to organisms, is not abstracted from experience but is employed by judgment in its reflection on objects of nature. The claim that the concept of a natural purpose is not abstracted from experience is central to Kant's philosophy. In Chapter 5, we will see that this concept is treated as *a priori*. Note, however, that to argue for the regulative status of the concept of a natural purpose on the basis of the claim that we do not perceive final causes in nature, as Kant sometimes seems to do (see above), is rather unfortunate. We do not perceive pure concepts of the understanding (categories) in nature, yet the latter are constitutive of experience.

efficient causes (2) while also maintaining that purposes only exist relative to cognitive subjects (3). In the *Kritik der Urteilskraft*, we find further arguments for (1)–(3). It is to these writings that we shall now turn.

3.4 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*[71] as a response to criticism from Georg Forster. In the same magazine, Forster had published a critique of the specifics of Kant's theory of race and of Kant's methodology in articulating this theory, objecting that Kant allows for teleological and even theological explanations in natural science.[72] The details of the encounter between Forster and Kant, concerning Kant's theory of race, need not concern us here.[73] It suffices to note that Kant vehemently defends himself against the charge that he introduces foreign elements in natural science.

Kant repeatedly affirms that, contrary to Forster's claims, he has always adhered to the principle that everything in natural science must be explained naturally.[74] In the opening passages of his essay, Kant juxtaposes the 'theoretical' and the 'teleological' method for the investigation of nature (*Naturforschung*).[75] He claims that one should follow the theoretical method while investigating nature but that employment of the teleological method is justified in case the theoretical method does not suffice. Nevertheless, the teleological method does not solve any deficiencies of the theoretical method. In particular, the teleological method, even if we have a clear conception of the adequacy of investigating nature in terms of final causes, does not provide us with insight of efficient causes.[76] Kant thus associates the search for efficient causes with what he calls the theoretical method, providing natural explanations. In other writings, he often associates the term 'theory' or 'theoretical'

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

[72] Cf. Forster 1786, 73–80. On the historical context of this debate, cf. Zammito 1992, 205–13.

[73] For a discussion of Kant's theory of race, cf. McLaughlin 1989, 28–31; Zammito 1992, 199–213; Bernasconi 2001, 10–36.

[74] Cf. AA 8: 178.

[75] AA 8: 159.

[76] *Ibid.* I will deal with the positive function Kant ascribes to teleology in natural science in Part 2 of this chapter.

with the idea of demonstrative science.[77] Hence, in conformity with our analysis of the metaphysics lectures (§3.3), Kant associates demonstrative natural science with a science that provides insight in the efficient causes of natural phenomena.

In the final sections of his essay, Kant presents an argument directed against attempts to invoke, independent of experience, fundamental forces of matter that explain the possibility of organized beings (organisms). In short: he presents an argument against *hylozoism*, the view that unorganized matter can organize *itself*.[78] This argument is preceded by noting that the possibility of organized beings cannot be understood physico-mechanically, but requires teleology.[79] Here, then, we have a case in which the theoretical method does not suffice, and where we can legitimately appeal to the teleological method. A discussion of this argument will elucidate Kant's conception 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, this force must be construed as being efficacious in accordance with purposes, i.e., these purposes "must be assumed as the basis for the very possibility of its efficacy".[80] Thus, a force construed as a cause of organization must have this particular organization as its purpose (e.g., a force causing embryological development must have a mature organism as its goal). However, Kant argues that we only have cognition of these types of forces *from ourselves*, i.e., by means of cognition of our *will* and *understanding*. The 'will' is defined as a force or capacity which, if determined by an idea of the understanding, produces "something in accordance with an idea, which is called purpose."[81] We experience such forces in ourselves when we are aware of our own *goal-directed action*, e.g., in the production of an artifact (*Kunstwerk*). Kant criticizes hylozoism since it is a position that posits the existence of fundamental forces effecting organization without being determined or guided by some *idea*. We have no empirical support for assuming the existence of such

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77 In the *Jäsche Logik*, the term 'demonstrated theory' (*demonstrirte Theorie*) is employed to signify demonstrative science. Cf. AA 9: 14–15. More generally, Kant frequently associates theoretical cognition with science and theoretical philosophy with philosophy of nature. Cf. *KrV*, *B* 20; AA 20: 195. Finally, in the first Introduction to the third *Critique*, Kant simply identifies 'theory' with 'knowledge of nature'. Cf. AA 20: 199.

78 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.

79 AA 8: 179.

80 AA 8: 181.

81 *Ibid.*

forces.[82] Hence, hylozoism does not abide the strictures of proper scientific methodology.

Kant thus construes a purpose as something brought about by our will which is determined by an idea of that something. In the *Kritik der Urteilskraft*, he similarly 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)".[83] Given this account of purpose, it is no surprise that Kant concludes his argument contra hylozoism by remarking that "purposes have a direct relation (*gerade Beziehung*) to reason", where the term 'reason' can refer both to human or foreign reason.[84] As already noted in our discussion of Baumgarten and Wolff: *purposes only exist relative to some intellect*.

Kant's argument against hylozoism further shows that it is human purposive activity, i.e., our activity in accordance with ideas, which provides the model of purposiveness attributed to natural objects such as organisms.[85] In the third *Critique*, Kant explains that this model implies that we can conceive series of causes and effects in accordance with the *nexus finalis*, so that a thing that is called the effect of something can also be called the cause of that something.[86] For example, the house is the cause of the sums taken as rent, whereas the representation of this income is the (final) cause for the construction of the house. Kant emphasizes that it is by *analogy* with human purposive activity that we construe organisms as natural purposes and judge them in accordance with the *nexus finalis*.[87] The causality according to ends is the causality inherent in human purposive action, i.e., action in accordance with ideas, of which the production of a house provides a particular instance. Kant acknowledges that this analogy is remote. Nevertheless, on the basis of this analogy we consider organisms in accordance with the *nexus finalis*.[88]

We may explicitly relate Kant's conception of 'purpose' to that of Baum-

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

[83] AA 5: 220.

[84] AA 8: 182.

[85] This is stressed by Beiser 2006, 12–13, in his reading of Kant's 1788 essay on teleological principles.

[86] AA 5: 372.

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

[88] Thus, Kant claims that the concept of a natural purpose is a regulative concept for the reflecting power of judgment for guiding research into organisms in accordance with a "remote analogy with our own causality in accordance with ends." (AA 5: 366). On the scope of Kant's analogy, see Steigerwald 2006, 725–727; Zammito 2006, 760–761.

garten. As we have seen, Kant takes a purpose to be something brought about by our will, which is determined by an idea of that something. More generally, a purpose is construed as the object of a concept insofar as the latter is regarded as the cause of the former. Note the similarity with Baumgarten's notion of purpose as an object *represented* as good, where this representation functions as a ground for bringing about this good. Kant's construal of the *nexus finalis* also builds on Baumgarten's views. For Baumgarten, the *nexus finalis* is a means-end connection, i.e., a relation between something (the means) that a subject employs to achieve something represented as good (the purpose). In Kant's example, the representation of income obtained through letting a house is a purpose, leading to the building of the house (the means).

As we have further seen, Kant stresses that in a causal connection thought in accordance with purposes (a concept of reason), the effect of something can also be named the cause of that something. Hence, in considering a connection of cause (a) and effect (b) according to the *nexus finalis*, (b) can also be taken as the cause of (a). This is only legitimate due to the fact that we construe (b) as the *purpose* of (a). The sums taken in as rent (b) are not the *real* cause of the house (a). However, when (b) is construed as a purpose that can be obtained by means (a), (b) can be treated as an *ideal* (final) cause of (a). Kant thus calls the *nexus finalis* a connection of *ideal causes*.[89] In contrast, when we are dealing with the *nexus effectivus*, the effect of a cause cannot be treated as itself a cause of the former. This connection Kant calls a connection of *real causes*. Hence, like Baumgarten, Kant distinguishes the ontological status of the *nexus finalis* from that of the *nexus effectivus*. The former is a connection taken to obtain between objects due to our conceptualization of these objects as means and purpose, whereas the latter is a connection objectively obtaining between objects (irrespective of our conceptualization of them).

Finally, we may note that the third *Critique* also provides a version of the argument, encountered in the metaphysics lectures, that teleology is not explanatory in natural science or biology because it does not provide insight into how natural or organic processes (e.g., nutrition and growth, regeneration, etc.) *work*. Insight into how organic processes work is obtained by providing a mechanical explanation in accordance with the *nexus effectivus*, i.e., by specifying a mechanism. In the third *Critique*, this argument is developed (different from the argument contained in the metaphysics lectures) by arguing that the introduction of a divine architect does not contribute anything to explanations in natural science:

[89] AA 5: 372–373.

> As soon as it is granted to us that a higher architect immediately created the forms of nature as they have always existed or has predetermined those which in their course are continuously formed in accordance with one and the same model, our cognition of nature is not thereby in the least advanced, because we do not know the *mode of action* of such a being and the ideas which should contain the principles of the possibility of natural beings at all […]. (AA 5: 410, emphasis mine)

In the following paragraph, Kant then argues that teleology is not explanatory in natural science. Here, we once again see that Kant associates proper explanations in biology with explanations that show how certain organic processes work. This insight is not obtained by merely considering nature teleologically or by treating organisms as divine creations. Rather, we need to specify the operating mechanisms.

In conclusion: for both Baumgarten and Kant, purposes and connections between means and purpose are only taken to exist relative to some cognitive subject. Now, of course, Kant construes organisms as natural purposes in the *Kritik der Urteilskraft*. He assigns teleology a central role in the biological investigation of organisms and in this respect his position differs from that of Wolff and Baumgarten.[90] Nevertheless, Kant's conception of the teleological notion 'purpose' is quite similar to that of Wolff and Baumgarten. 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 articulated 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."[91] It is this view that lies at the heart of Kant's claim that the concept of 'purpose' or purposiveness' is a *regulative* as opposed to a *constitutive* concept.

3.5 Purposes as explanatory?

From our analysis in §§3.2–3.4 it becomes clear that Kant, contrary to the interpretations of Zumbach, Ginsborg and Quarfood (§3.1), does not assign *any* explanatory role to teleology in natural science. This simply follows from

[90] Cf. my discussion of Wolff's views on the scientific investigation of plants in Chapter 2, which are thoroughly mechanist.

[91] AA 20: 200–1.

the fact that Kant has a rather strict conception of scientific explanation (cf. Chapters 1 and 2). In both his metaphysics lectures and his published writings, Kant associates proper scientific method with the search for efficient causes (the *nexus effectivus*). This is because proper explanations in natural science consist in the specification of objective grounds of certain effects. Since teleological notions do not specify any objective properties or relations of natural objects, but are only subjectively ascribed to natural objects relative to some subject endowed with intellect, they cannot serve any explanatory function in natural science. In addition, teleology does not provide insight into how organic processes *work*. In short: the concept of a purpose does not specify any objective ground of organic processes providing insight into the workings of the latter. Therefore the concept of a purpose cannot explain anything in natural science (purposes are not real but ideal grounds).

In the First Introduction to the *Kritik der Urteilskraft*, Kant describes the concept 'purpose' as a concept expressing a normative claim (see below). This claim leads Ginsborg to interpret Kant as holding that teleology has some kind of explanatory function. In contrast, I take this claim as further elucidating the view that purposes exist relative to subjects endowed with intellect and are thus non-explanatory in natural science. Kant claims that in a teleological judgment, i.e., a judgment concerning the purposiveness of things in *nature* (natural purposes or organisms)[92], 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 5: 240)

Hence, in construing a natural object as a purpose we make the normative claim that there is something that it ought to be. This passage is highlighted by Ginsborg to argue that Kant takes the concept of purpose to express normative constraints, a reading that is certainly correct.[93] However, as we have already seen, Ginsborg also 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., these regularities exhibit normative lawlikeness.[94]

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[92] Cf. AA 20: 232.
[93] Cf. Ginsborg 2001, 248–54.
[94] *Ibid.*

In short: the fact that the concept 'purpose' expresses an 'ought' allows us to regard biological regularities, which are contingent with respect to mechanical laws, as lawlike or necessary. As such, the concept of purpose is ultimately ascribed an explanatory role in biology. I do not think this interpretation is correct.

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 a purpose we judge that it ought to be suitable for seeing. As such, we judge that the structure of the eye must be such that it enables sight. 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 based on an *a priori* principle. In particular: our judgments concerning the eye are based on a concept of its purpose that is employed a priori. 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 "teaches only what things are".

It is important to note that though the concept of a purpose can be assigned to natural objects a priori, Kant takes such a concept to be employed regulatively, not constitutively. Kant stresses this in the present context, claiming that all judgments concerning the purposiveness of nature are "merely reflecting and not determining judgments"[95], i.e., are *subjective* judgments for our reflection on objects and do not determine anything with regard to the constitution of this object. That the concept of a purpose, when ascribed to natural objects, expresses an 'ought' allows us to understand why this is the case. A judgment that specifies what a natural object ought to be is not derived from nature. Hence, 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.[96] This is one reason for denying that the concept of purpose is a constitutive concept. Once again, this view is in line with Baumgarten's concept of 'purpose', who argued that objects are purposes relative to our subjective valuation of them as good and thus held the view that purposes are subject dependent.

The foregoing shows why it is problematic to interpret Kant as assigning an 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

[95] AA 20: 241.

[96] For a similar modern argument concerning the ontological status of functions, cf. Searle 1995, 13–23.

objective grounds of consequences. It is clear that purposes do not constitute objective grounds or causes. Rather they are subjectively ascribed to natural objects and thus only function as subjective *grounds of cognition*.[97] Kant sometimes expresses this by claiming that the concept of purpose leads us outside the concept of *nature*. For example, in §61 of the Critique of Teleological Judgment, Kant notes that the unitary structure of a bird is contingent with respect to the *nexus effectivus*, and is only comprehensible in terms of the *nexus finalis*, i.e., by appealing to ground (a purpose) lying outside the concept of nature.[98] The conception of purpose as expressing an 'ought' nicely fits this view. Yet, construed as such it is clear that purposes are not properly explanatory.

In conclusion of this section, we may note that Kant also employs the traditional distinction between the concepts 'purpose' (*Zweck*) and 'intention' (*Absicht*) in his account of purposiveness. Kant's use of this distinction again shows why purposes are only regulatively ascribed to natural objects and are not objective properties of natural objects. In addition, Kant's use of the notions 'purpose' and 'intention' will allow us to specify the particular differences between his views and those of Wolff.

Recall that Wolff defined an 'intention' as that which we try to bring about by means of our will. This notion can also be taken to signify that which is the *product* of the will, i.e., that which is produced by substances endowed with intellectual capacities. In the third *Critique*, Kant invokes the latter notion of 'intention' and argues that it is legitimate to conceptualize natural objects as *purposes*, whereas it is illegitimate to construe them as *intentions*. For experience "certainly exhibits ends, but that these are at the same time intentions cannot be proved in any way".[99] Hence, Kant strictly distinguishes between the notions of 'purpose' and 'intention'.

Kant claims that in contrast to the concept of a natural purpose, which belongs to the *reflecting power of judgment*, the concept 'intention' is a concept belonging to the *determining power of judgment*, which introduces a *new causality* into natural science, i.e., an intentionally acting cause.[100] In other words, Kant claims that to conceptualize natural objects as 'intentions' is to take them as the product of some agent endowed with a will, i.e., these objects are objects of *design*. If we take natural objects to be intentions, we

[97] AA 5: 373.
[98] AA 5: 360.
[99] AA 20: 234.
[100] Cf. AA 20: 234–236; AA 5: 360–361.

take purposiveness to be an objective property of these objects, i.e., we assign the same ontological status to the *nexus effectivus* and the *nexus finalis*. According to Kant, however, we have no grounds for construing natural objects as intentions. If we take natural objects to be intentions, we "introduce a new causality in natural science, which, however, we merely borrow from ourselves and ascribe to other beings […]."[101] At most, we have objective grounds for *reflecting* on natural objects as purposes, which, as we will see below, is the case for organisms. Kant thus employs the distinction between 'purpose' and 'intention' to make the claim, central to the third *Critique*, that although it may be epistemologically (subjectively) necessary to conceptualize organisms in terms of purposes, this does not imply the ontological claim that objects *objectively are purposes*, i.e., objects brought about through an idea of this object, which is to treat objects as intentions.

In strictly distinguishing between the notions of 'purpose' and 'intention', and denying that the latter conception plays *any* role in natural science, Kant distanced himself from traditional Wolffian philosophy. For Wolff treated objects of nature as intentions of God.[102] In particular: Wolff treated all the necessary consequences of the essence of things as God's intentions, and thus affirmed the objective reality of intentions in nature.[103] Kant denied that we have objective grounds for affirming the objective reality of intentions in nature, although we do reflect on organisms in terms of purposes. In conclusion: Wolff (as we have seen in the previous chapter) adopted a thorough mechanist account of biological science, while arguing that we have objective grounds for taking objects of nature to be intentions (objects of design). In contrast, Kant, while affirming that only mechanical explanations are proper explanations, does assign a significant role to teleology in natural science, while denying that we have objective grounds for treating natural objects as intentions.

3.6 Utility and purpose in Kant

In conclusion of part 1 of this chapter, I will discuss once more the relation between Kant's views on teleology and traditional views on teleology as contained in the writings of Wolff and Baumgarten. In our discussion of Baumarten and Wolff we have devoted considerable attention to the distinction between the *nexus utilitatis* and the *nexus finalis*. In both his pre-critical and

[101] AA 5: 361.
[102] Wolff 2003 [1751], 633–634. Cf. also §3.6.
[103] *Ibid.*

critical writings, Kant stresses that relations of usefulness can be explained naturally, without recourse to teleology. This view can, as I will show in the present section, be profitably understood on the basis of the traditional distinction between the *nexus utilitatis* and the *nexus finalis*. In addition, Kant's view that relations of usefulness can be explained without recourse to teleology allows us to specify more precisely the similarities and differences between Kant's conception of teleology and those of his predecessors.

We may first focus on Kant's discussion of physico-theology in the second section of *Der einzig mögliche Beweisgrund* of 1763. 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 (thus) the product of choice.[104] If we discover it to be the case that *x* is useful for *y*, we infer that *x* has the purpose of bringing about *y* and take *x* to exists *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)

Kant's remarks suggest that, like Baumgarten and Wolff, he takes it to be an objective fact that objects stand to one another in relations of usefulness. For Wolff, the utility of an object is a consequence of its essence. Kant identifies the usefulness of an object *x* (its 'thousand uses') with its natural effects or consequences. 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 counties, etc.[105] These consequences of the elasticity and pressure of the atmosphere 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*, i.e., from objective relations obtaining between objects to a single means-end relation that arises when we identify a purpose of an object.

[104] AA 2: 96.
[105] AA 2:97–98.

Kant denies the legitimacy of inferring that the atmosphere has a particular purpose on the basis of the appearance of usefulness of the atmosphere. 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."[106] The variety of uses of the atmosphere (respiration, suction, pumps, etc) are a consequence of 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 in terms of mechanical laws of nature and there is no need to appeal to any purposively arrangement of nature. In accordance with this view, Kant also 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*.[107] For this fact can be explained in terms of mechanical laws. Employing Baumgarten's terminology: the *nexus utilitatis* can be perfectly well explained in terms of the *nexus effectivus*.

A similar argument can be discerned in §63 of the Critique of Teleological Judgment. In this paragraph, in which the notion of relative purposiveness is discussed, Kant inquires whether relations of usefulness or advantageousness justify teleological explanations.[108] 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 the specification of *y* as a goal of nature, which implies the claim that *y* has to exist. Under this condition, one can take *x*, being advantageous or useful for *y*, as a means that exists for the sake of *y*.[109] Thus, Kant envisions the following

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[106] AA 2: 98.

[107] 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.

[108] On this point, see also McLaughlin 1989, 40–41; Kreines 2005, 275–277.

[109] "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.

type of account: (i) sandy soils are advantageous for pine trees; (ii) pine trees are a goal of nature; (iii) Hence, sandy soils are means that exist because of their advantageousness for pine trees.

Kant takes the above type of explanation to be highly *problematic* (once again: strictly speaking teleological explanations do not exist). Kant holds that if *y* is a goal of nature, we can account for the existence of its (necessary)[110] means *x* in terms of *y*. However, he argues that 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 the terminology of Baumgarten: if we take advantageousness or usefulness as a ground for teleological explanation, thus construing relations of advantageousness or usefulness as means-end relationships, we mistakenly identify the *nexus utilitatis* with the *nexus finalis*.

The foregoing again shows Kant's affinity with the Wolffian tradition in his employment of notions such as 'utility' and 'purpose'. However, Kant's arguments also point to distinctive differences with the Wolffian tradition. To elucidate these differences, consider the following remark by Ernst Cassirer, who in his classical work on Kant contrasts Kant's conception of teleology with the general enlightenment view on teleology:

> The whole teleology of the Age of Enlightenment is characterized by the thoroughgoing confusion of the idea of finality with that of general utility. The profounder elements of the Leibnizian concept of purpose were degraded by Wolff into an insipid utilitarian outlook and calculation. The universal metaphysical ideas of theodicy had here become lost in a narrow and pedantic pettiness, which sought to detect in every single feature of the course of the universe the advantage of mankind and hence the wisdom and goodness of the Creator. Wolff even bestows on sunlight a teleological justification of this kind […]. (Cassirer 1981, 338)

Cassirer is right if he thinks that Kant rejects the inference from an object being useful for man to its being designed for this purpose. This is the upshot

[110] Evidently, the inference from the premise that *y* necessarily exists to the conclusion that the means for *y* exist is only valid if these means are taken to be necessary for the existence of *y*. Kant sometimes, but not always, makes this point explicitly.

of claiming that relations of usefulness can be accounted for in terms of the *nexus effectivus*. Moreover, Cassirer is also right that Kant, in this respect, distanced himself from Wolff. Wolff himself conceived of teleology in general as a part of physics in which we derive the intentions of God from natural phenomena.[111] This traditional conception of teleology is rejected by Kant. However, Cassirer is certainly wrong in stating that the whole teleology of the age of Enlighment is characterized by a confusion of finality with utility. As we have seen, Wolff and Baumgarten distinguished between utility and finality, and took great care in distinguishing different teleological notions, such as purpose and intention. Kant generally followed these conceptual distinctions, though he used them to draw different philosophical conclusions from them than Wolff and Baumgarten. Kant took the traditional view that purposes only exist relative to cognitive subjects to imply that the concept of purpose is regulatively ascribed to natural objects, while abandoning the inference of divine intentions from natural phenomena. This is ultimately a shift of focus from the divine intellect to the human intellect, a hallmark of Kant's transcendental philosophy.

[111] Cf. McLaughlin 2001, 22, for a useful short history of the term 'teleology'.

PART 2 THE METHOD AND DOMAIN OF BIOLOGY

In Part 1 I discussed traditional views on teleology in relation to Kant. The upshot of our discussion was that teleological relations were only taken to exist relative to a cognitive subject. This explains, at least in part, why Kant denied that the concept 'purpose' can be constitutive of objects of nature and is ascribed (by analogy with human purposive action) problematically to nature. Nevertheless, Kant argued that we do ascribe this concept to nature. Organisms, constituting the paradigmatic subject of investigation of biology, are *natural purposes*.

The ascription of the concept 'natural purpose' to a certain class of natural objects has implications for how we must understand the domain of biology. 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. As such, the method that we employ for investigating organisms determines how we understand the domain of biology. In the following, I will distinguish the manner in which, according to Kant, our conceptualization of organisms determines the manner in which we understand the nature of organisms.

The main thesis of my discussion will be that Kant takes the method of biology to determine its domain. This interpretation is akin to that of Marcel Quarfood, who, as mentioned in §3.1, interprets Kant as holding that teleology demarcates the subject-matter of biology. However, Quarfood does not relate his thesis to the central Kantian view that the method of a science determines the object of a science, and consequently does not discuss Kant's views on biological method, nor does he relate Kant's views on the domain biology to views entertained within (late) eighteenth-century biology. By paying attention to these last two topics, we can significantly increase our understanding of Kant's views on the role of teleology in biology. Hence, in the following I extensively discuss Kant's views on method in biology, which is understood as consisting in the subordination of mechanism to teleology, while also relating Kant's views to that of eighteenth-century biological developments.

In §3.7, I first discuss Kant conception of organisms in the *Kritik der reinen Vernunft*. In the first *Critique*, Kant criticizes Leibniz's conception of organisms as infinitely complex machines. This critique shows that he takes our conceptualization of organisms as determining how we view their composition. In particular: the ideal of mechanical explanation, an explanation of a whole in terms of its parts, leads us to view organisms as wholes consisting of

(relatively) simple parts. Here, we thus have a clear (though non-teleological) example of how our method of investigating natural objects (here: the *mechanical* method of investigation) determines our view of the nature of these objects.

In §3.8, I discuss the manner in which Kant's influential contemporary biologist Johan Friedrich Blumenbach conceived of the domain of (what he calls) natural history. In determining this domain, Blumenbach referred to characteristic empirical features of organisms, i.e., reproduction, growth and nutrition, in terms of which organic bodies are distinguished from inorganic bodies, and to teleological presuppositions of natural historians. §3.9 shows that Kant, similar to Blumenbach (and, we might add, to most late eighteenth-century biologists), took reproduction, nutrition and growth, and varieties of 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 Kant's views on proper method in biology, consisting in the subordination of mechanism to teleology. Finally, in §3.10 we will see how Kant's conception of biological method determines his conception of the object of investigation of biology.

Before turning to Kant some remarks concerning the notion 'domain of biology' are in order. The phrase 'domain of biology' is slightly anachronistic, for neither Kant nor his direct contemporaries employed the term 'biology'. It is well known that in the beginning of the nineteenth century, through the works of Jean-Baptiste de Lamarck and Gottfried Rainhold Treviranus, the term 'biology' came to be applied to various disciplines that were construed as dealing with *living nature*.[112] The coming to prominence of the term 'biology' is nicely illustrated by the title of Treviranus' influential *Biologie, oder Philosophie der lebenden Natur*, first published in 1802 just before Kant's death in 1804.

This notion of biology is foreign to Kant. In his discussion of biological topics, Kant often reflects on research undertaken by comparative anatomists, physiologists and natural historians. However, Kant did not take 'life' to be a concept in terms of which we can define a broad domain of natural objects constituting the subject of investigation of biological sciences. For example, in his discussion of biological topics Kant frequently discusses the investigation

[112] Cf. Hodge 1971, 323–352; Lenoir 1989; Theunissen & Visser 1996; Richards 2000, 17–18; Cunningham & Williams 2003, 234–235.

of plants undertaken by anatomists and physiologists. However, Kant typically does not attribute 'life', defined as the faculty of a substance to act from an internal principle such as *desire* or *thought*[113], to plants.[114] The concept of an organized body (plants and animals) and the concept of a living being are not coextensive.

Nevertheless, already in the second half of the eighteenth century there was widespread recognition that (what we call) biology is a science with a determinate and distinct subject-matter.[115] Most scientists in this period believed in the existence of a fundamental distinction between organic and inorganic nature. Organic nature was taken to be characterized by various features, most importantly phenomena of regeneration (brought to prominence by the research of Abraham Trembley, 1710–1784) and irritability (brought to prominence by Albrecht von Haller, 1708–1777), which do not pertain to inorganic objects.

Kant similarly conceived of the study of organic nature as a particular and distinct subject of scientific investigation. However, it is important to note that he did conceive of (what we call) biology as pertaining to physics. The study of organic nature was conceptualized as a *second topic* pertaining to physics.[116] This characterization of biology is consistent with one of my main theses argued for in Chapter 2 and in the following: that proper explanations in biology are mechanical explanations. In discussing Kant's views on nutrition and growth, we will see that chemical processes (allowing for mechanical explanations) should be invoked to explain organic nutrition and growth. Hence, regularities pertaining to chemistry (a part of physics!) can be taken to provide (objective) grounds on the basis of which we explain organic phenomena. More specifically: chemistry provides *partial grounds* for explanations in biology. In addition, as we will also see in the following, Kant did not take the distinction between organic and inorganic nature to be an ontological one. Characteristic of Kant's thought, and this distinguishes him from several of his contemporary biologists, is that the distinction between organic and inorganic nature is understood in terms of distinct methodological presuppositions lying at the basis of natural science.

In conclusion, although Kant did not employ the term biology he and his contemporaries did think that disciplines such as physiology, comparative anatomy, natural history, etc. are related. A common feature of these disci-

[113] AA 4: 544.
[114] On this topic, cf. Ingensiep 2004, 107–136.
[115] Here I follow Theunissen & Visser 1996, 46–50.
[116] It is precisely in these terms that Kant characterizes the study of organic nature in the *Opus postumum*. Cf. §5.4.

plines, as construed by Kant and his contemporaries, is that they study the structure and properties of *organized beings* (organisms): objects characterized (as we shall see in detail below) in terms of organic functions such as reproduction, nutrition, growth, and self-maintenance, by means of which they are distinguished from inorganic objects. In light of this conception, I think it is historically justified to employ the term biology in our discussion for Kant. The phrase 'biology' can then be understood as referring to the study of *organic nature*. In turn, the set of organized beings can be taken to constitute the *domain* of biology.

3.7 Kant's critique of Leibniz: parts, wholes and organisms

In the resolution of the second antinomy, presented in the Transcendental Dialectic of the *Kritik der reinen Vernunft*, Kant criticizes Leibniz's view that organisms are infinitely complex natural machines. Through this critique we are confronted with the manner in which Kant understands organisms. Leibniz construes organisms as intrinsic unities, the parts of which are organized into infinity. Hence, organisms are wholes consisting of parts which are themselves wholes consisting of parts, etc. Kant rejects Leibniz view.

Kant's critique of Leibniz has been discussed by McLaughlin and Ginsborg.[117] 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 ultimately composed of *inorganic parts*. Ginsborg denies this, arguing that Kant held that fundamental parts of organisms are *organic* and irreducible to inorganic matter. In contrast to both of these authors, 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 is necessary in order to explain wholes in terms of their parts. This argument can thus be taken to support a form of reductionism, insofar as Kant 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. To put the point more generally: McLaughlin and Ginsborg focus on ontological distinctions between organic and inorganic bodies. This perspective, as I argue in the following, is of little interest to Kant.

As said, Leibniz construes organisms as unities the parts of which are organized to infinity. Although Kant's rejects this view, part-whole considerations also figure heavily in his characterization of organisms. For Kant,

[117] McLaughlin 1989, 100–103; Ginsborg 2004, 46–50, especially note 26.

organisms are wholes produced out of the causality of their parts. How should we understand the notions 'whole' and 'part' in this context? Kant's critique of Leibniz shows that the conceptualization of natural bodies as organized implies that we interpret these bodies as consisting of simple parts. Hence, the parts of organized bodies are relative simples. We take these parts to be (relatively) simple with respect to our explanatory interests, i.e., relative to our specification of a whole as *explanandum*. In the investigation of organisms, we thus subjectively specify what is a whole and what are its parts. This view can be related to a view on scientific explanation that was common in Kant's time: the view that scientific explanation consists of explanation of wholes in terms of their parts.[118] This topic will constitute the focus of the present section. In order to understand Kant's critique of Leibniz, we must first consider Leibniz's claim that organisms are infinitely complex natural machines.

Leibniz construed organic bodies as true substantial unities, juxtaposing organic bodies to aggregates. An aggregate can be considered as a collection of parts having accidental unity, i.e., an entity united by accident or aggregation.[119] 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.

The unity of aggregates exists by *opinion* or *convention*.[120] Their parts posses a mere conventional unity and lack true order. Organic bodies are not aggregates. They are taken to have a true, substantial unity. Organic bodies are not genuine unities merely because of the purposeful arrangement of their parts, for Leibniz construes artifacts (*artificial automata*) as aggregates even though their parts are purposefully arranged.[121] Rather, organic bodies are complex bodies that possess unity in virtue of their soul or substantial form, which creates substantial unity among the parts of the organism.[122] Hence,

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[118] Cf. Chapter 2.

[119] GP II, 58. 'GP' designates: Leibniz, G.W. (1875–1890). *Leibniz: Die philosophischen Schriften* (7 vols.). Edited by Gerhardt, C.I. Berlin: Weidman. For a thorough discussion of Leibniz notion of an aggregate see: Lodge 2001, 467–486.

[120] Cf. GP II, 76, 101.

[121] 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. Cf. Garber 2009, 67.

[122] 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. Cf. 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 that is

Leibniz provides a metaphysical explanation of the unity of organic bodies (as we shall see in the following, such a view 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 (*artificial automata*). Nevertheless, insofar as organic bodies are construed as machines, organisms are akin to artifacts or automata. How do we distinguish organisms from artifacts? We have seen that organisms, as opposed to artifacts, are substantial unities and not aggregates. In the *Monadology*, Leibniz also argues that though organic bodies are machines, they differ from them because they are *infinitely complex* machines. Organic bodies and artifacts also differ in respect of the organization of their parts:

> 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 1991 [1720], 25)

In contrast to artificial automata, organic bodies are automata of which all parts are machines and so on to infinity. Leibniz takes all the parts of organic bodies to be purposefully arranged, these parts containing further parts all purposefully arranged, *ad infinitum*. In contrast, not all the parts of parts of artificial automata, such as the parts of the tooth on a brass wheel, are taken to be purposefully arranged, since we do not perceive all these parts 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, in contrast to artifacts, are complexes of machines nested within each other to infinity.

Leibniz's views on organic bodies are consistent with the idea that organic bodies should be explained mechanically. Like any proponent of the mechanical philosophy, he was convinced that natural phenomena should

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its entelechy. An organism is an *animal* if its central monad is a *soul.* Hence, animals are distinguished as a species of organisms in virtue of the fact that they have a soul. Organisms that are not animals, i.e. plants, do not have a soul but only an entelechy. It is not very clear whether Leibniz attributes life to plants.

be mechanically explained.[123] In the case of organic bodies, conceptualized as 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.[124] By following this method, Leibniz thought that one could discover true mechanical reasons for organic processes.

Leibniz's conception of organic bodies also nicely fits a preformationist account of organic generation. 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 organism, in turn, contains or encases all of its descendents. The preformationist account of embryogenesis, in particular the encasement (*emboîtment*) theory as developed by Malebranche[125], was influential in the late seventeenth and early eighteenth century. Hence, Leibniz could cite scientific support for his conception of organic bodies.[126]

3.7.1 Organisms and their relative simple parts

Kant rejected Leibniz's view that organic bodies are complex machines organized to infinity. This rejection was probably partly motivated by scientific

[123] Leibniz writes to Arnauld, after affirming the reality of substantial forms, that he is as corpuscular as one can be in the explanation of natural phenomena, and that one must always explain nature along mathematical and mechanical lines. Cf. GP II 58. Although Leibniz accepts substantial forms in order to account for the unity of bodies, he does not assign them an explanatory role in science and is committed to the principles of mechanical philosophy.

[124] In this brief description of Leibniz's proposed method for analyzing organic phenomena, I follow Duchesneau 2003, 378–409.

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

[126] 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 1991 [1720], 26–27. Thus, Leibniz accepts the basic tenets of preformationism. However, as Duchesneau notes, Leibniz was hesitant in accepting a particular form of preformationist theory. In particular, Leibniz refrained from defending either ovist or animalculist (spermist) pre-existence. Duchesneau 2003, 401–402.

developments taking place within biology. From the middle of the eighteenth century preformationist accounts of organic generation gradually fell into disrepute and were replaced in favor of epigenetic theories.[127] 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).

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. Kant treats the representation of a body as organized, through which a whole is represented as divided into members, as 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 as determined (finite) and equal to a number. An analysis of the notion *quantum discretum* may thus shed further light on Kant's argument.

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.[128] 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

[127] Cf. Grene & Depew 2004, 96–97.

[128] On the notion 'quantity' in the modern period and in Kant, cf. Shabel 2005, 29–32.

can be quantitatively determined.[129] 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.[130] 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*. Kant's concept of continuity thus corresponds to what we now call denseness.[131] 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*.[132] The following example, taken 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)[133]

When 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* quantitatively by assigning a number to it that represents the multiplicity of parts of the *quantum*.

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[129] Cf. *Metaphysik Herder*, AA 28: 21; *Metaphysik Volckman*, AA 28: 422–23. Kant's use of the concept 'quantity', especially as employed in the lectures on metaphysics, has been thoroughly analyzed by Parsons 1992b, 135–158 and Longuenesse 1998, 263–271. My account is indebted to both authors. Longuenesse highlights the difference between *quantum* and *quantitas*.

[130] *Metaphysik Pölitz*, AA 28: 560. Cf. Longuenese 1998, 264.

[131] 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*, in Kant, to mean 'infinitely divisible'. Longuenesse 1998, 264. See also Friedman 1992a, 60–62.

[132] Cf. Longuenesse 1998, 264–265.

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

The fact that we can represent continuous quantities as discrete is important, since this allows the measurement of continuous quantities.[134] Kant takes physical bodies, since they are given in space, to be continuous.[135] Hence, the assignment of numbers to physical bodies, with numbers interpreted as representations of discrete quantities, 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 *representing* an hour as composed of minutes, where the minute as opposed to some other *quantum* is taken as a simple part or 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 corporeal body, including organic bodies, 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 consisting of a determinate or finite multiplicity of parts. This is the case when we describe an object as an organic (organized) body. As Kant puts it in the previously quoted passage: "In the case of an organic body articulated to infinity […] the whole is represented *through this very concept* as already divided up".[136] 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. This shows, according to Kant, that Leibniz's view that organisms are infinitely organized machines is contradictory, for Leibniz takes organisms to be organized, implying that we conceive of them as consisting of a finite number of parts, while also conceiving of organisms as consisting of an infinite multiplicity of complex parts. If we adopt Leibniz's conception of organic bodies, Kant argues that we contradict ourselves, 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."[137]

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[134] On this point, cf. Parsons 1992b, 144–46.

[135] Kant clearly states this point in the section containing his critique of Leibniz's conception of organisms. He argues that the division of bodies is "grounded on the divisibility of space, which constitutes the possibility of the body as an extended whole. The latter is thus divisible to infinity […]." *KrV*, A 525/B 553.

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

[137] *Ibid.*

Kant's critique of Leibniz 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. Moreover, if we conceive of an object as an organized body we arbitrarily take a certain collection of its parts to be simple, just as, when representing a continuous quantity as discrete, we arbitrarily pick out a unit of measurement in order to determine its quantity.[138] Note that Kant does not claim that organized bodies in fact 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). Properties attributed to the central class of objects of the biological sciences (organisms) are thus, at least in part, the result of our conceptualization of these objects. In the following sections we will further see how our conceptualization of organisms determines what properties we assign to them.

In conclusion I will comment on the reasons motivating Kant's critique of Leibniz. It is not yet clear why Kant argued that organized bodies must be taken to have simple parts. A possible answer to this question emerges if we recognize that Leibniz's view of organisms as infinitely complex machines is difficult to square with allowing for the possibility of determinate knowledge of organisms. It 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.[139]

It is also difficult to understand how Leibniz's conception of organic bodies can be squared with scientific practice in general. In the scientific investigation of natural objects, we can explain wholes in terms of their parts while abstracting from the fact that these parts are composite. Kant's conception

[138] In the argument under consideration Kant is quite clear that he takes organized bodies to be discrete quantities. Organized bodies function as examples of discrete quantities, in which the multiplicity of parts is "detached with certainty in a given whole" and are thus not taken to be infinitely divisible. Cf. *KrV*, A 526/B 554.

[139] This problematic feature of Leibniz's thought is noted by Duchesneau 2003, 405.

of organic bodies can be interpreted as consistent with this type 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. In this context, we may focus on an argument from Christian Wolff. In his *Deutsche Metaphysik*, Wolff provides a general analysis of the method of explaining properties of natural objects. His argument thus does not merely concern organic bodies but corporeal bodies in general. Nevertheless, this argument is relevant for our present discussion. Wolff notes that in the scientific explanation of corporeal bodies (which are composite objects), we explain a whole in terms of its parts while abstracting from the complex nature of these parts themselves:

> But it is well to note that in the essence of bodies, since we cannot come up to the elements in the composition […], we stop at the composite, i.e., at the bodily parts. That is to say, with respect to natural things we proceed just as in art. When we whish 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 2003 [1751], 378)[140]

This view on scientific explanation is consistent with Kant's idea that organic bodies must be conceptualized as having simple parts. It is also a general view on scientific explanation that is plausible given the view on mechanical explanation explicated in Chapter 2, i.e., (roughly) an explanation of a whole in terms of its parts.

In the scientific investigation of bodies (whether organic or inorganic), similar to the case of Wolff's clock, 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 being (relatively) simple. Wolff argues that the identification of a collection of parts, providing us with an *explanans*, is dependent

[140] Original: "Es ist aber wohl zu mercken, daß, da wir in der Zusammensetzung nicht bis auf die Elemente kommen können […], 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 […]."

on that which we want to explain (the *explanandum*). Thus, if one wants to explain the functioning of a clock we identify its wheels or other parts, parts that are relevant to understanding the functioning of a clock, as simple parts. The complete material constitution of these wheels is left out of account, because at a certain level of analysis cognition of this constitution does not contribute to our cognition of the functioning of the clock. Similarly, we might argue that in the case of organized bodies what we take as its simple parts will depend on the object, constituting the *explanandum*, that we describe as organized. For example, if we aim to explain the organization of the eye, we can take the cornea, aqueous humor, lens, etc. as its simple parts, and explain the organization and function of the eye in terms of these parts. If, however, we proceed to a lower level of analysis, e.g., 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 explanation. Kant's conception of organic bodies, of objects that are conceptualized as wholes having simple parts, nicely captures these facets of the scientific explanation of bodies. In this manner, the mechanical method of investigating and explaining natural objects (e.g., organisms) determines how we construe these objects.

3.8 Blumenbach on the domain of natural history

In the previous section I argued that for Kant our understanding of the constitution of objects comprising the domain of biology is partly determined on the basis of our conceptualization of these objects as organized beings. This line of thought will be developed in the following sections. I explicate how Kant understands objects comprising the domain of biology by analyzing his views on organized beings as developed in the Critique of Teleological Judgment. This requires an analysis of the concept 'natural purpose' (*Naturzweck*). The concept 'natural purpose' is a technical concept instantiated by 'organized beings', i.e., organisms. By conceptualizing organisms as natural purposes we construe the domain of biology. Importantly: by conceptualizing organisms as natural purposes we take teleological relations to obtain between (i) organisms and their parts and (ii) the parts of organisms. These relations are not objective properties of organisms and their parts. Rather, they are subjectively attributed to them.

In dealing with the question how Kant construes the domain of biology, it is useful to first consider the manner in which some of his contemporary biologists specified their object of investigation. An illustrative example is pro-

vided by Johann Friedrich Blumenbach in his *Handbuch der Naturgeschichte* (1779–1780; and eleven subsequent editions). I have consulted the English translation by R.T. Gore of the tenth edition (1825). Clearly, Kant did not have knowledge of this edition of the *Handbuch*. However, this late edition is of interest because Blumenbach articulates, partly under the *influence* of Kant, a conception of proper biological methodology. Hence, through a study of this edition we can gain more insight into Kant's views on proper biological method.[141]

I will focus on the manner in which Blumenbach distinguishes organic from inorganic bodies. The method by means of which Blumenbach introduces this distinction can also be found in earlier versions of his *Handbuch*.[142] Hence, I identify a rather standard conception of how to construe the domain of (what we may call) biology. It is important to note, however, that I do not wish to argue for any concrete influence of Blumenbach on Kant. First of all, Kant did not have knowledge of the tenth edition of Blumenbach's *Handbuch*. In addition, apart from similarities, there are (I maintain) considerable differences between Kant's views and those of Blumenbach. These will be spelled out at the end of this section. The study of Blumenbach's late (tenth) edition of the *Handbuch* is also of interest because it allows us to specify these differences.[143]

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 construed as referring

[141] Lenoir 1980 argues that Kant's philosophy influenced Blumenbach's biological theories. The tenth edition of the *Handbuch* certainly 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.

[142] Cf. Blumenbach 1782, 1–27, Apart from the distinction between organic and inorganic bodies, there are considerable differences between these various editions.

[143] The question of whether the views of Blumenbach and Kant on biology and biological method are similar or not is much debated among historians of science and philosophy. As said in the introduction to this chapter, 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). Lenoir thus argues for continuity between the views of Kant and 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. My position is simply that Kant adopted some views on biological method that are highly similar to Blumenbach, while he rejected other tenets of Blumenbach's thought.

to the study of the three kingdoms of nature, i.e., the study of animals, plants and minerals.[144] 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".[145] 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".[146] The latter bodies are excluded from the domain of natural history. Blumenbach distinguishes between classes of natural bodies by noting the differences among these bodies with respect to (i) their origin, (ii) their growth and (iii) their structure.[147]

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."[148] Further (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*."[149] Finally (iii), Blumenbach argues that the propagation, nutrition and growth of plants and animals presupposes a specific purposive *organization or structure* of these natural bodies:

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[144] This use of the term 'natural history' is quite common in eighteenth-century Germany. For example, J.C.P. Erxleben, in his *Anfangsgründe der Naturgeschichte* (1768), defines natural history as the physics of the three kingdoms of nature, and takes anatomy and physiology to be disciplines pertaining to natural history. A similar conception is entertained by W.J.G. Karsten in his *Anleitung zur gemeinnützlichen Kenntniß der Natur* (1787). Cf. AA 29: 175. At the turn of the eighteenth century this general conception of natural history seems to be abandoned, partly under the influence of Kant. Thus, G.C. Lichtenberg, in his *Physik-Vorlesung*, follows Kant in distinguishing between 'natural description' (a mere 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). Anatomy and physiology are defined independently of both natural description and natural history. Cf. Lichtenberg 1808, 5–6.

[145] Blumenbach 1825, 1–2.

[146] Blumenbach 1825, 1. Blumenbach notes that the terms 'essential alteration' and 'designed' are relative. In some respects, a mule or carib might be included among artificial bodies, in other respects among natural bodies. He further notes that it is sometimes quite difficult to distinguish between natural bodies and products of art because of their close resemblance.

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

[148] Blumenbach 1825, 2.

[149] *Ibid* (emphasis mine).

> 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)

Organic growth (via nutrition) and the reproduction of plants and animals presupposes that the parts of plants and animals are *suitably connected* and *adapted* to the reception of fluids, the assimilation of nutriments and the production of offspring. Hence, 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 fundamental to biological inquiry. In the *Kritik der Urteilskraft*, Kant expresses the same point with great clarity: if the "investigator of nature is not to work entirely in vain", he must, in judging organized beings, base his judgments "on some original organization".[150]

The attribution of vital forces to organisms is necessary because Blumenbach takes the particular functions and properties characteristic 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*, conceived of as rendering possible the peculiar vital properties of organism, and *physical* and *mechanical* forces, conceived of as causes of properties possessed by both inorganic and organic bodies.[151] Consequently, vital forces are, in contrast to physical or mechanical forces, taken to be efficacious only within the domain of organic nature. In his manual on natural history, Blumenbach notes with respect to the propagation and growth of organized bodies:

> 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)

Here, we once again see that the capacity of organisms to propagate, grow and nourish themselves is taken to presuppose an organization of their struc-

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[150] AA 5: 418.

[151] Cf. Blumenbach's account of vital force in his *Institutiones physiologicae* 1817, 16–17. See also the definition of the *Bildungstrieb* given in his tract *Über den Bildungstrieb und das Zeugungsgeschäfte* 1781, 11–13. I return to this topic at §5.2.1.

ture adapted to the performance of these functions. In addition, vital forces are attributed to parts of plants and animals, accounting for the sensibility and capacity for motion of these parts without which nutrition or growth is impossible.

As an example of a vital force responsible for motion 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.[152] Apart from assigning vital forces to parts of organized beings (e.g., contractility, irritability, 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*,[153] construed as a cause of the form of organisms, their preservation and their regenerative capacities.[154] In his manual, Blumenbach argues that the posit of the *Bildungstrieb* allows for an explanation of the origin of organized bodies by the "*progressive formation* (epigenesis) of the seminal matter".[155] In short: the *Bildungstrieb* allows for an epigenetic account of embryological development. The proper account of epigenesis is, according by Blumenbach, given by the following remarks:

> 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 here construed in teleological terms. In contrast to mechanical formative forces, the *Bildungstrieb* forms organizable seminal matter, more generally: guides embryogenesis, in accordance with the endless variety of *purposes* that organisms and their parts are taken to have. Mechanical

[152] Cf. Blumenbach 1817, 18.

[153] 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 (tenth) edition. As I will argue below, the concept of vital force also does not play a significant role in Kant's reflections on biological method in the third *Critique*.

[154] On Blumenbach's *Bildungstrieb* and his conception of vital forces, cf. Larson 1979; Lenoir 1980, 1981; Richards 2000. Cf. §5.2.1.

[155] Blumenbach 1825, 10.

formative forces are not, by themselves, capable of producing the variety of purposive forms characteristic of organisms. For example, 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".[156] In contrast, bodies of animals and plants must, in order to "render them suitable to their destined offices" (i.e., purposes), be molded into an "incalculable number of forms with endless varied outlines".[157] Blumenbach thus distances himself from mechanical theories of epigenesis, some of which we have briefly mentioned in the previous chapter (e.g., of Descartes, Maupertuis).[158] The purposive form of organisms cannot be accounted for purely in terms of mechanical forces, e.g., merely as a result of chemical affinities or crystallization. For how such forces give rise to the systematic and purposive organization among the parts of an organism is incomprehensible. We thus require the *Bildungstrieb* understood as a force efficacious in accordance with purposes, i.e., we require *teleology*.

The foregoing does not imply that mechanical forces do not play any role in the formation of embryos or, more generally, that Blumenbach denies mechanism to play any role in biology. As said, Blumenbach takes mechanical forces to be efficacious in organic bodies. Moreover, Blumenbach (following Kant) hails his methodology as effectuating a combination of the 'mechanical' and the 'teleological' principle of biological inquiry.[159] How this combination is effectuated *in concreto* remains a mystery since Blumenbach does not specify any clear mechanism operative in, e.g., the generation of embryos. I will return to this topic in the final chapter. Here we may note that the general idea seems to be that mechanical forces in organisms are subjected to vital forces, the latter governing the workings of the latter. This may allow us to consider mechanical forces as operating in accordance with purposes, and as being modified in accordance with the particular purposes of organized bodies.

The above line of thought allows us to understand why Blumenbach, as we have seen above, argues that vital forces are necessary to understand the

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[156] Blumenbach 1825, 11.

[157] *Ibid.*

[158] Cf. §2.10. Blumenbach 1825, 10, explicitly distances himself from the epigenetic theory of Mazini, who "supposed that the progeny was formed at its conception by a kind of crystallization."

[159] 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. I have not found this manner of describing the method of biology in Blumenbach's 1782 edition of the *Handbuch*.

"mutual influences of the parts for the support of the whole, and the contrary" in organisms.[160] The parts of organisms can, in line with the idea of a mechanical generation, be taken to produce the whole, whereas the introduction of teleology via the idea of vital force allows us to take the whole as a purpose (final cause) which is to be produced by the parts. As we shall see, the idea that organisms seems to exhibit a reciprocal dependency between the whole and its parts is crucial in Kant's understanding of organisms (natural purposes).

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, i.e., the invariable production by other bodies of the same form and kind, and (ii) nutrition and growth. In addition, (i) and (ii) presuppose an organization of structure (iii) *adapted* to performing the functions (i) and (ii) and lead to the posit of vital forces. (i)–(iii) allow Blumenbach to distinguish the classes of plants and animals (organized bodies) from the other class of natural history, i.e., the class of 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)

In contrast to plants and animals, which nourish themselves through the reintegration of external substances and grow from *within*, the growth of minerals is not the result of organic assimilation. Rather, mineral growth is the effect of mechanical laws of aggregation, i.e., the addition of particles from *without*. A similar argument applies to the origin of minerals, which can be explained through the aggregation of inorganic materials, and are not, as in the case of organic bodies, 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. This is not the case for organized beings. For example, the propagation of humans presupposes some kind of *adaptedness* of the human reproductive organs. In addition, 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

[160] Blumenbach 1825, 8. The formulation is again taken from Kant, as Blumenbach refers to the third *Critique* in a note accompanying his remark.

of attraction, affinity, plastic force, etc."[161] These are the considerations 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 nutriment. Plants absorb nutritious fluids by means of their roots without the aid of voluntary motion, whereas animals introduce their food (which may be of various kinds), via their mouth into their stomach by means of voluntary motion.[162]

In conclusion: Blumenbach delineates the three kingdoms of nature with which natural history concerns itself by distinguishing natural bodies from artificial bodies, by distinguishing organized from inorganic bodies, and by distinguishing plants from animals. The distinction between organized and inorganic bodies occurs by means of the specification of empirically observable traits of organisms, namely: the capacity of propagation and the related physiological functions of nutrition and growth.[163] Teleology also figures heavily in Blumenbach's distinction between organized and inorganic bodies. The explanation of growth and propagation of organisms requires reference to their particular purposive organization, which is not the case for 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 on biological method in general, and on the method of distinguishing organic from inorganic bodies in particular, relate to Kant? As we will see in the following section, Kant, similar to Blumenbach and (we may add) other biologists of the eighteenth century,[164] took propagation, nutrition and growth to be distinguishing features of organisms. In

[161] Blumenbach 1825, 3.

[162] *Ibid*, 2–3.

[163] 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 empirical 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, as she acknowledges, not only organisms are mechanically inexplicable. 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.

[164] Cf. McLaughlin 2001, 173–179.

this context, regeneration, i.e., the capacity to regenerate injured or lost parts, was also frequently cited as a distinguishing trait of organisms.[165] 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, etc. Kant adopts a similar idea. In the third *Critique*, Kant praised Blumenbach for *beginning* all physical explanations of organic formations with *organized matter*, i.e., in biology we presuppose some original purposive organization.[166] That Kant is attracted to this idea makes sense. In Chapter 2, we have seen that he denied that the particular structure of an organism (the mode of composition of its parts) can be mechanically explained. We cannot specify why the parts of organisms are composed as they are. Hence, that organisms have such a (purposive) structure is simply presupposed in biological inquiry. In these respects, Kant's views are quite similar to those of Blumenbach.

Given this 'inscrutable principle of an original organization' lying at the basis of biological investigation, we must, however, always explain organic phenomena mechanically according to Kant. The proper method of biology consists in the association or subordination of mechanism to teleology.[167] Kant thus stresses the necessity of providing mechanical explanations much more clearly than Blumenbach. In the next section, we will see that Kant argued that processes such as (e.g.) growth and nutrition must be explained *mechanically* by taking into account chemical processes involved in the obtainment of nutrients. Kant's views further differ from those of Blumenbach insofar as the concept of a vital force does not have a significant function in the third *Critique*. This is not surprising. To affirm the existence of vital forces in nature is, according to Kant, dangerously close to adopting the dogmatic metaphysical position of hylozoism. Although Kant, similar to Blumenbach, 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 (in the third *Critique*). Rather, we delimit the domain of biology by (regulatively) conceptualizing organisms as natural purposes. In a nutshell: whereas Blumenbach ultimately seems to interpret the distinction between organic and inorganic bodies *ontologically* (in terms of the distinction between vital and physical-mechanical

[165] Cf. Blumenbach 1782, 20–22.

[166] 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. In this respect, Kant is thus clearly influenced by Blumenbach.

[167] AA 5: 421–424. I developed this idea more fully in the following.

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. In these respects, Kant's position differs from that of Blumenbach.

3.9 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 instantiating the concept of a natural purpose. In Kant's terms, organized beings must be thought of as natural purposes, thus providing "objective reality for the concept of a **purpose** that is not a practical purpose but a purpose of **nature**".[168] Because organized beings must be conceptualized as natural purposes they "provide natural science with the basis for a teleology".[169] Hence, we conceptualize organisms as natural purposes and therefore understand them in teleological terms.

Kant's most detailed account of the concept 'natural purpose' is given in §§64–65 of the Analytic of Teleological Judgment. In §64, Kant 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 and indeterminate expression.[170] The discussion of the concept 'natural purpose' in §65 suggests that this phrase is meant to capture the idea of reciprocal causality between a whole and its parts.[171] Hence, 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

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[168] AA 5: 375–76.
[169] *Ibid.*
[170] AA 5: 372.
[171] McLaughlin has stressed the importance of understanding organisms in terms of this idea. McLaughlin 1989, 47. Cf. Guyer 2001, 264–267; Quarfood 2006, 737–738.

with it "descending as well as ascending dependency"[172], 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 […]."[173] More generally, the connection of *real* causes (*nexus effectivus*) does not allow that the effect of a cause is conversely its cause. The connection of real causes is construed as a connection of efficient causes and, as we have seen in Part 1 of this chapter, physical-mechanical causes are a species of efficient causes. Hence, organisms, which seem to exhibit reciprocal causation between whole and parts, necessitate the appeal to the connection of *ideal* causes, i.e., the *nexus finalis*.[174] This allows us to treat the representation of a whole as the final cause of its parts, which conversely are the efficient causes of the whole.

In order to elucidate the claim that organisms are conceived as 'cause and effect of itself', Kant cites several features of organisms. These features, comprising *propagation*, *growth*, the capacity for *nourishment* and *self-preservation*, are similar to the traits specified by Blumenbach in order to delineate the domain of natural history. Kant treats these features as various modes of generation (*Zeugung*).[175] 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, stating that:

> 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)[176]

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[172] AA 5: 373.

[173] AA 20: 236.

[174] 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 part 1 of this chapter.

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

[176] 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."

Kant's claim is that these traits lead us to think of organisms as cause and effect of themselves, i.e., as wholes of parts where we take the whole and its parts to be reciprocally dependent. 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 said in the Introduction to this chapter, several commentators, insisting that Kant takes not merely the origin or systematic structure of organisms to be mechanically inexplicable but also their functioning, interpret these paradigmatic organic traits to be mechanically inexplicable. Thus, John Zammito argues that organisms are simply mechanically inexplicable *tout court*.[177] Hannah Ginsborg, arguing that not only the origin but the functioning of organisms resists mechanical explanation, states that biological regularities do not hold in virtue of regularities of physics and chemistry but in virtue of teleological grounds, and strongly dissociates the domain of physics and chemistry on the one hand and biology on the other.[178] 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 (moreover) these explanations can invoke chemical regularities, which provide *partial grounds* for explanations in biology. I will argue that Kant's discussion of the traits of organisms is in conformity with his conception of proper method in biology, consisting of the subordination of mechanism to teleology.

3.9.1 Reproduction and species

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

[177] Zammito 2006, 758–759.
[178] Ginsborg 2001, 246.

Kant's example as most opaque.[179] John Zammito objects that Kant, in asserting the reciprocity of cause and effect, slides between the type or species tree and its individual tokens.[180] The historical sources of Kant's remarks are also unclear. Hans Werner Ingensiep has argued that Kant stress on the capacity of the species tree to preserve itself via reproduction, where preservation can be construed as the purpose of 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.[181] In contrast, Tobias Cheung has argued that Kant's position can be traced to Bonnet's views on palingenesis.[182] These accounts increase our knowledge of the possible historical sources of Kant's position but leave Zammito's problem unaddressed. In the following, I will try to provide an account of Kant's example that elucidates why, as Zamito objects, it is *natural* for Kant to slide between the species tree and individual trees.

Kant's views become clear, I think, if we take into account another possible historical source of his species concept. In his 1775 announcement for his anthropology lectures *Von den verschiedenen Racen der Menschen*, Kant, restricting himself to a discussion of the animal kingdom, positively discusses Buffon's species concept according to which animals that produce fertile young with one another "belong to the same physical genus (*physisches Gattung*)", irrespective of any difference in form between these animals.[183] Kant distinguishes the 'physical' or 'natural' genus or species, which divides animals from the standpoint of generation, from the 'scholastic' genus or species, which is based on classes and divides things in accordance with their similarities. Moreover, Kant gives preference to the idea of a physical genus or species, arguing that in the animal kingdom the division into species is based on a law of common propagation, i.e., we divide animals into species taking generation or reproduction as our criterion of species division. Note that Kant's discussion of Buffon's species concept is restricted to the domain of animals. However, the idea of a physical species, defined in terms of reproduction, is sufficiently general to also capture species in the vegetable kingdom. As Ernst Mayr has noted, already toward the end of the seventeenth century John Ray introduced reproduction in a general species definition for organic nature. Ray argued with respect to plants that all variants are members of a species

[179] Guyer 2001, 264.
[180] Zammito 2006, 757.
[181] Ingensiep 2009, 95–96.
[182] Cheung 2009, 32–34.
[183] AA 2: 429.

if they sprung "from the seed of one and the same plant" or, with respect to animals, are members of a species if they have been produced by the same parents.[184]

The foregoing suggests that Kant accepted something like the genealogical species concept of Buffon, and applied this concept to both the animal and vegetable kingdom. This would imply that Kant does not primarily take species to be universals (e.g., types, classes or sets). According to Buffon's views, species are sequences of reproducing organisms connected by genealogy. In addition, as we have seen, the ability to reproduce fertile offspring is a criterion for taking organisms to be members of the same species.[185] Buffon defines a species as follows: a species is "neither the number nor the collection of similar individuals which forms the species; it is the constant succession and uninterrupted renewal of these individuals which constitutes it."[186] Hence, a species may be described as an *individual* historical entity rather than as a class, type or set.[187]

In the remarks quoted above, Kant, like Buffon, associates the idea of a species with the idea of 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 qua species, 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 (the coming to be of offspring requires the existence of progenitors).

Importantly, Buffon's species allows us to take individual organisms, constituting a link in a genealogical chain of organisms, as *representatives* of the species.[188] The distinction between individual organisms and species is loose (as Zammito rightly remarks). Kant adopts a similar view in his description of the reproduction of trees. If a tree generates another tree it "generates itself as far as the species is concerned". A tree generates itself (is cause of itself) *qua species*. Moreover, a generated tree is effect of itself *qua species*. Trees are cause and effect of themselves *qua species*. This view is understandable if we

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

[185] On Buffon's species concept, cf. Grene & Depew 2004, 79–82. Cf. also Gayon 1996, 220–227.

[186] Quoted from Sloan 2008.

[187] Grene & Depew 2004, 80.

[188] *Ibid.*

take Kant to have adopted Buffon's species concept, according to which (i) a species is an individual lineage of reproducing organisms and (ii) particular organisms are *representatives* of the species. Kant can characterize the process of a tree generating another tree as a process in which trees are cause and effect of themselves *qua species*, simply because a species is nothing more than a chain of reproducing organisms.

Recall that for Kant a thing exists as a natural purpose if it is 'cause and effect of itself', since herein lies a causality that we can only understand in teleological terms. Hence, the fact that trees are, *qua species*, cause and effect of themselves forms a basis for introducing teleology. In his analysis of the reproduction of a tree, Kant seems to construe the continual preservation of the species tree as the *purpose* of reproduction. As such, reproduction is understood in *teleological* terms. To put the point differently: the preservation of the whole (species) is the purpose of the parts (individual organisms).

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 also be related to Buffon's species concept. Buffon himself defined species as wholes.[189] Hence, it seems reasonable to construe organisms as part of the whole or species. The part/whole scheme, I take it, can adequately describe Buffon's species concept. The mereological notion of a whole can be interpreted as applying to concrete, individual lineages, whereas it is not easy to see how notions such as 'class' or 'type', which are abstract entities, can be so interpreted.[190] We can also 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. Here, 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) which preserve the species. Here the whole determines the parts. Insofar as Kant conceives of the parts (organisms) to be determined by the whole (species), he seems, as we have seen, to attribute 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.

[189] Cf. Gayon 1996, 221–222, 224.

[190] 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.

In the present context, Kant does not claim that the reproduction of organisms is mechanically inexplicable. The fact the phenomena of organic reproduction and species preservation are adequately described in teleological terms does not imply that these phenomena resist any type of mechanical explanation, i.e., that mechanical explanations are useless in biology. Kant suggests such a reading 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 although Blumenbach rightly rejects the idea that "life should have arisen from the nature of the lifeless", and thus acknowledges that we have to presuppose an "inscrutable principle of original organization" in biological inquiry, he does not think that in biology we refrain from searching for mechanical explanations.[191] Hence, Kant certainly attributes mechanism and mechanical explanation an important role in coming to terms with phenomena of organic generation. More generally: the correct methodology of biology aims at effectuating a *combination* of the mechanical and the teleological principle of biological inquiry.

Kant makes the same point in §80 of the Methodology of Teleological Judgment, while discussing a possible mechanical (natural historical) account of similarities among members of a species. The production of a manifold of species may allow of mechanical explanation. Kant warns us, however, that this production of species (und ultimately the origin of species) cannot be understood materialistically, i.e., we cannot claim that raw matter formed organized beings. Here too we subordinate mechanism to teleology, or, as Kant also puts it, presuppose an inscrutable principle of original organization. In short, Kant rejects a materialistic interpretation of mechanism, while consistently emphasizing that in biology we must always strive to give mechanical explanations of phenomena. This view is consistent with his remarks concerning reproduction and species preservation analyzed above. Although we conceptualize reproduction and species preservation in teleological terms, this does not mean that we should not aim to increase our understanding of these phenomena by specifying relevant mechanisms. What Kant rejects is a materialistic interpretation of mechanism, not the search for mechanical explanation *tout court*.

[191] AA 5: 424.

3.9.2 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 self-generation qua 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 organisms from inorganic bodies. In particular: plants and animals nourish themselves and grow through the assimilation or reintegration of external substances, i.e., they grow from within (by *intussusceptio*), whereas, e.g., 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 the 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, as well as the remark that the matter that a tree adds to itself in order to grow can not 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.[192] Marcel Quarfood, for example, argues that Kant remarks concerning nutrition and growth highlight a vitalist strand in his thought.[193] Hans Werner Ingensiep also stresses these remarks and interprets Kant as modernizing the traditional Aristotelic-scholastic notions of the *vis nutritiva* and *vis augmentiva*, where

[192] Cf. the authors mentioned in the Introduction to this chapter.
[193] Quarfood 2006, 743.

the first force is taken to be responsible for the nutrition and the second force for the growth of organisms.[194]

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. As we have constantly emphasized, in biology mechanism is subordinated to teleology. This does not, however, imply that mechanical explanations play no role in biology (quite the contrary). Second, it is worth noting that while discussing the nutrition and growth of plants in his *Deutsche Physik*, Christian Wolff already stated that we lack sufficient knowledge of the chemical processes involved in the assimilation of nutrients of plants. This does not imply, however, that chemical process play no role. Quite the contrary, Wolff is convinced that they do and remains wedded to his mechanist conception of the explanation of organisms. The same is true for Kant, as I will argue below. Third (and most importantly), I take Kant to distinguish, like Blumenbach, organic growth as a form of self-generation (from within), from growth through aggregation (from without). However, the former type of growth, as we shall see in the following, can be understood in terms of chemical processes. In Chapter 2, I argued that Kant adopts a rather broad (Wolffian) conception of mechanical explanation, which encompasses explanations in terms of chemical processes. Hence, insofar nutrition and growth must be explained in terms of chemical processes, Kant seems to allow that nutrition and growth can (and should) be explained *mechanically* (at least in part).[195]

In order to comprehend 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[196] and also adopted by Kant. In the first *Critique*, Kant, elucidating the concept of a system, states that an animal body is a whole that is "articulated (*articulatio*) and not heaped together (*coacervatio*)", that grows "internally (*per intus susceptionem*) but not externally (*per appositionem*)".[197] This suggest that Kant would have distin-

[194] Ingensiep 2010, 96–97. Ingensiep states that these organic functions are also contained in Blumenbach's concept of *Bildungstrieb*.

[195] 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.

[196] Cf. Gehler 1798–1801, Bd. 3, 388–389.

[197] *KrV*, A 833/B 861.

guished between minerals (inorganic objects) and organisms in a manner similar to Blumenbach.

Here, however, the similarity between Blumenbach and Kant seems to end. As said, Blumenbach takes the growth of minerals to be the effect of physical, i.e., *chemical and mechanical*, laws of *aggregation* (the addition of homogeneous particles from without).[198] He posits vital (teleological) forces to account for the nutrition and growth of organisms. Hence (at the very least) the role of physical laws in the nourishment and growth of organisms is obscure. Here, then, we have a vitalist strand in the thought of Blumenbach (an objection Quarfood mounts against Kant).[199]

In apparent *contrast* to Blumenbach, Kant introduces the term *Intussusception* (*intus*, inside; *suscipio*, to take up) in the context of a discussion of *chemistry*. In the General Remark to the 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 uniform mixtures of ingredients. As Kant explains, chemical penetration does not obtain when parts of a dissolved matter remain separate small clots (moleculae).[200] 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".[201] 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 uniform mixtures that occupy a space through *intussusception*.[202]

As Martin Carrier explains, 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 sep-

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[198] Blumenbach 1825, 2.
[199] Quarfood 2006, 743.
[200] AA 4: 530. In the passage under consideration, Kant argues for the possibility and intelligibility of chemical penetration.
[201] *Ibid.*
[202] AA 4: 531.

arately in the compound and the latter is conceived of a particle aggregate kept together by geometrical fit.[203] Hence, transposing ourselves to the present context, on the corpuscularian account chemical compounds are conceived of as mechanical *aggregates* of corpuscles, they are (we may say) aggregated *per appositionem*. This is not, however, the conception of chemical compounds that Kant adopts, who treats the latter as homogeneous uniform mixtures filling a space through *intussusception*.

Let us now return to Kant's remarks on the growth and nutrition of organisms, cited at the beginning of this section. As said, Kant takes organisms to nourish themselves and grow internally through *intussusception*. Given the chemical context in which Kant introduces this term, it is likely that this also incorporates nourishment and growth through particular chemical processes (I will argue for this in more detail below). When Kant argues that the growth of organisms is distinct from the increase in *magnitude* in accordance with mechanical laws, I think he has in mind (in this respect similar to for example Blumenbach) 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, for according to the broad conception of mechanical explanation espoused in Chapter 2, explanations in terms of chemical processes are mechanical explanations.[204]

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. Gehlers's *Physikalisches Wörterbuch*, it becomes clear that at least from the 1780s onwards, considerable scientific discussion existed concerning elements of the phenomena of organic nutrition

[203] Carrier 2001a, 223.

[204] Recall that the conception of mechanical explanation espoused in Chapter 2 captures the idea of explaining features of wholes in terms of their parts, mode of composition and forces acting upon parts. Although I cannot argue for this in detail, this idea also applies to Kant's understanding of chemistry and (more particular) chemical compounds. As Carrier 2001a, 223–224 explains, Kant maintains that chemical compounds are uniform mixtures, while also arguing that "reagents are actually part of the compound – if only infinitely dispersed". The reagents must be actual parts present in the compound, because the latter owes its property to its parts. As Carrier puts it: ordinary salt "is assumed to be composed of the principles salt and water. The former owes its solidity to the salt principle and its solubility to the water principle. The characteristics of the complex substance reflect the properties of its ingredients". In Wolffian terms: we explain the properties of a whole in terms of its parts and their mode of composition.

and growth. In his article on plants[205], 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's description, 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, under the influence of light, is exuded as oxygen gas (oxygen base plus caloric). Gehler states that this theory, or at least the claim that plants in sunlight have the capacity to transform carbon dioxide gas into oxygen gas, has sound experimental support.[206] 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), who, in contrast to Senebier, 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.[207]

The above theories provide examples elucidating 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, oxygen, are drawn from the realm of inorganic nature, i.e., from inorganic compounds such as carbon dioxide gas. Kant also emphasizes this, stating with respect to a tree that "as far as the components (*Bestandtheile*) that it receives from nature outside of itself are concerned, it must be regarded only as an educt".[208] 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

[205] 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. Of course, 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 (in conjunction with Ingenhouß) is discussed in Karsten's *Anleitung zur gemeinnützlichen Kenntniß der Natur* 1787. Cf. AA 29: 573–576. In short: I employ Gehler to point to theories common in the 1790s that can *elucidate* Kant's claims and I do not argue for any concrete historical influence.

[206] Gehler 1798–1801, Bd 5, 683–684.

[207] Gehler 1798–1801, Bd 5, 686.

[208] AA 5: 371.

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.[209] In Kant's lectures on metaphysics, a distinction is made between matter *tanquam eductum* and matter *tanquam productum*.[210] 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 or generated. Given Kant's remarks on nutrition and growth, it seems likely that he treats plants and their newly produced parts as matter *tanquam productum*. For our present concerns, it is important that the distinction between matter as educt and as product is treated as a distinction made *within* chemistry. This distinction is certainly not meant to distinguish chemical processes from non-chemical processes. As we have seen above, Kant takes the *chemical composition* of the material by which plants develop to be their own *product*. This confirms our suggestion that Kant took chemical processes, as investigated for example by the likes of Senebier and Girtanner, 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. Kant, like Blumenbach, 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 phenomenon of the growth of organisms elicit a teleological description? Kant's treatment of the capacity of plants to grow highlights that we conceptualize organisms (in this case plants) as objects in which a reciprocal dependency obtains between parts and whole. In Kant's treatment of organic growth and nutrition, 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

[209] Zamitto 2003, 90–92; Zammito 2006, 757–758.
[210] AA 28, 684; AA 29: 760–761. Cf. Zamitto 2003, 90–91.

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 and growth may be construed as means for the preservation of individual organisms (if the latter is construed as a purpose), just as reproduction is a means for preservation of the *species* (§3.9.1). This is, we may note, precisely what Blumenbach does in discussing the nutrition and growth of organisms. He introduces the *Bildungstrieb*, a teleological force or drive, while emphasizing that nutrition and growth enable the *preservation* or *maintenance* of individual organisms.

In the first edition of his *Über den Bildungstrieb und das Zeugungsgeschäfte* (1781), Blumenbach, while discussing nourishment and growth, notes that what is characteristic of organic bodies is their continuous change and renewal.[211] The fluid parts of organic bodies evaporate while 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 partly 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 helps us to understand 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 whether he allowed for the existence of vital forces). In this sense, teleology is, for Kant, a *presupposition* of biological inquiry: mechanisms are construed as means for a certain purpose. Biological inquiry is always conducted from a teleological perspective. What distinguishes Kant's views from Blumenbach is that he stresses that, although we always first conceptualize organisms and organic processes teleologically, we must also subsequently specify the nature of the mechanisms involved in organic processes such as nutrition and growth. The specification of these mechanisms constitutes the explanatory work of biologists.[212]

[211] Blumenbach 1781, 69–73.

[212] Recall that in the third *Critique* Kant praised Blumenbach for adopting a principle of original organization (AA 5: 424). Hence, we might say that Kant praised Blumenbach for emphasizing that biological inquiry is always conducted from a teleological point of view. This reading is certainly correct, as witnessed by Blumenbach's treatment of phenomena

Hence, returning to Kant's account of the nutrition and growth of plants, although teleology provides an adequate *description* of the nutrition and growth of plants, and although biological inquiry is always conducted from a teleological point of view, a proper scientific *explanation* of these phenomena must be framed in terms of mechanisms. From our modern vantage point, this would be an explanation in terms of processes involved in photosynthesis, requiring, e.g., cognition of how energy from light is absorbed by proteins containing chlorophyll in chloroplasts, cognition of the light-dependent reactions of photosynthesis occurring at the thylakoid membranes of chloroplasts, etc. Our modern theory of photosynthesis explains photosynthesis in terms of multiple sub-processes, i.e., in Kant's terms, proceeds mechanically from the parts to a whole. Of course, Kant and his contemporaries did not have such a theory at their disposal (as we have seen, their knowledge of processes such as nutrition and growth is extremely limited). However, this theory might be interpreted as providing a mechanical explanation, an explanation of a whole in terms of its parts, and thus as specifying *objective grounds* for the properties of the whole. In this case: objective grounds for the process of nutrition in plants, i.e., the assimilation and transformation of inorganic compounds into organic compounds. For Kant, it is precisely the fact that mechanical explanations specify objective grounds of phenomena that leads him to privilege such explanations.

In conclusion: I take Kant to maintain that nutrition and growth are described in teleological terms, while retaining the idea that nutrition and growth should be explained mechanically (e.g., in terms of chemical processes). As such, his treatment of these phenomena again shows that in biology we should combine mechanism and teleology, or more specifically: that we should subordinate the principle of mechanism to teleology. Recall that Blumenbach argued that understanding organic growth and nutrition requires the presupposition that organisms have a structure adapted to performing these functions. Kant's views fit this line of thought, for, as we have seen in the previous chapter, he holds that the specific organization or structure of organisms resists mechanical explanation. Hence, the fact that, say, plants are organized in such a manner so as to enable growth and nutrition is mechanically inexplicable. Nevertheless, if we presuppose that the organization of plants is adapted to performing the functions required for obtaining nutrition

such as nutrition and growth. What Kant adds (and what is not evident in the work of Blumenbach) is that we must always specify the nature and workings of the mechanisms involved in organic processes. This is what the subordination of mechanism to teleology amounts to.

and growth, and that mechanisms involved in processes such as nutrition and growth serve a *purpose* (i.e., we comprehend these mechanisms from a teleological point of view), we can and should investigate which mechanical processes underlie nutrition and growth and how they work.

3.9.3 Self-preservation and regeneration

The final phenomena that Kant describes in §64 of the Analytic of Teleological Judgment are supposed to highlight, in addition to the oft mentioned reciprocal dependency of whole and parts, that the *parts* of a tree are 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, in Kant's view, a teleological description.[213]

Kant's discussion of self-preservation (b) shows that organisms are taken to exhibit a reciprocal dependency between whole and parts and between the parts themselves. As Kant puts it with respect to a tree: "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."[214] For example: "the leaves are certainly products of the tree, yet they preserve it in turn, for repeated defoliation would kill it, and its growth depends on their effect on the stem."[215] Here, 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, according to Kant, a teleological description in which the whole or a part is construed as a purpose (final cause).

Kant further cites the capacity of organic regeneration (c) and the "self-help of nature" (d), where in case of injury "the lack of a part that is necessary for the preservation of the neighboring parts can be made good by the others", as features of organisms showing that the individual parts of organisms can be understood as being reciprocally dependent.[216] Once again, these phenomena can be adequately described in teleological terms. The phenomena of regeneration and what Kant calls the self-help of nature strongly suggest that the parts of organisms are supposed to preserve other parts and the whole. This feature

[213] In the following, I will abstract from a discussion of (a). For a helpful discussion of (a)–(d), also in terms of modern biological terminology, cf. Ingensiep 2010, 97–98.
[214] AA 5: 371
[215] *Ibid.*
[216] AA 5: 372.

can be expressed by stating that the maintenance of the whole organism is the purpose of its parts.

In focusing on self-maintenance and the regenerative powers of organisms Kant was not original. It is well known that these features were extensively analyzed throughout the eighteenth-century, playing a significant role in debates on preformationism and epigenesis.[217] In Kant's time Blumenbach's theory of the *Bildungstrieb* was often taken to provide a proper analysis of organic regeneration. The *Bildungstrieb* was taken as a ground for attributing to organisms a self-maintaining capacity enabling them to restore their initial organization.[218] Blumenbach juxtaposed his theory to existing preformationist theories 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).

Blumenbach's theory of regeneration, cast in terms of the teleological *Bildungstrieb*, can lead us to interpret organic regeneration in teleological terms, i.e., we take the parts of organisms to have the function of maintaining the whole. This interpretation provides a reason for cognizing *that* organisms are capable of regeneration, i.e., for cognizing *that* the parts of organisms are regularly regenerated or that other parts regularly take up the function of an injured part. Once again, however, Kant does not believe that teleology provides us with an objective explanation, a reason *why*, of the capacity of organic regeneration. This would require a mechanical account of regeneration. As we have seen in Part 1 of this chapter, this position is expressed in Kant's metaphysics lectures when it is claimed that a proper scientific answer to the question 'why does a wound in a body heal?' must appeal to efficient, mechanical causes.[219]

In conclusion, the study of Kant's views on reproduction, nutrition, growth and regeneration provides the following results. Kant, like most eighteenth-century philosophers and biologists, treated these traits as characteristic features of organisms, traits in terms of which we distinguish organic from inorganic bodies. These traits are described teleologicallly, i.e., in analyzing these traits of organisms we represent the whole as determining the parts (in Kant's terms: we take the idea of the whole to determine the parts). Teleology is a fundamental presupposition of biological inquiry. The structure of

[217] Cf. Lenoir 1981; Richards 2000, 16–20; Zammito 2006, 758.
[218] Cf. Blumenbach 1781, 73–85.
[219] AA PM: 73–75.

organisms, which Kant takes to be mechanically inexplicable, 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), providing partial grounds for explanations in biology. The proper method of biology thus consists in subordinating mechanism to teleology.

3.9.4 Kant on purpose and natural purpose: determining the proper method of biology

After discussing the phenomena of organic reproduction and species preservation, growth and nutrition, and self-preservation, Kant proceeds to give a general account of the concept 'natural purpose' in §65 of the Critique of Teleological Judgment. In this section, 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".[220] 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 reproduction and species preservation, as well as that of nutrition and growth above. The possibility of the reproduction of organisms (*parts*) presupposes the species as a *whole*. With respect to organic growth and nutrition, the assimilation and transformation of inorganic compounds by organisms, resulting in the generation of new organic *parts*, presupposes an organic structure (*whole*) adapted to assimilating nutriments. In both examples, parts are taken to be possible through their relation to the whole. Hence, there is a great affinity between Kant's general discussion of the concept 'natural purpose' and the preceding discussion of empirically observable, organic phenomena that lead us to conceptualize natural objects in teleological terms.[221]

Kant notes that not only organisms but also artifacts satisfy condition (i).

[220] AA 5: 373.

[221] 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*.

An artifact is the product of a rational cause (the artificer) distinct from the matter or parts, who, in producing the artifact, is guided by an idea of the whole. For example, the watchmaker produces and combines springs, gears, and so forth on the basis of some plan of construction. Here, as in the case of organisms, we can say that the existence and form of the parts is possible through their relation to the whole. The parts of a watch were produced and combined by the watchmaker because they make a particular whole possible.

Although both organisms and artifacts satisfy condition (i), and are thus *purposes,* organisms (*natural* purposes) are not artifacts. Kant's condition (ii) stresses that organisms are *natural* purposes and thus distinct from artifacts:

> But if a thing, as a natural product, is nevertheless to contain in itself and its internal possibility a relation to ends, i.e., is to be possible only as a natural end and without the causality of the concepts of a rational being outside of it, then it is required, **second**, that its parts be combined into a whole by being reciprocally the cause and effect of their form. For in this way alone is it possible in turn for the idea of the whole (conversely) to determine the form and combination of all the parts: not as a cause – for then it would be a product of art – but as a ground for the cognition of the systematic unity of the form and combination of all of the manifold that is contained in the given material for someone who judges it. (AA 5: 373)

If a thing is to be a *natural* purpose, it is required that the parts themselves determine the form of each other and that the parts themselves bring about the whole. Kant also 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*.[222] Natural purposes (organisms) are, in contrast to artifacts, self-generating natural objects.

The claim that the parts of natural purposes reciprocally determine each other's form strongly resembles Kant's discussion of the self-preservation of trees, where it was argued that the parts of the tree are reciprocally dependent on each other. However, all of the organic phenomena that Kant discusses, i.e., generation, nutrition and 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 to be 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 simply an artifact. Rather, the idea of a whole is a ground for cognizing the systematic unity of the parts of natural purposes. The idea of a whole functions as a ground of cognition (*Erkenntnißgrund*), not as an objective

[222] AA 5: 373.

ground (ground of becoming or being), of the systematic form of organisms (natural purposes).

Let us return, one last time, to the topic of mechanical explanation. Recall that according to Peter McLaughlin a mechanical explanation consists in (a) an explanation of a whole in terms of the properties of its parts, where (b) we employ properties that the parts have on their own, independent of the existence of the whole. McLauglin's position can be interpreted as follows: according to Kant condition (b) cannot be satisfied in the explanation of organisms because either condition (i), or condition (ii), or both, are inconsistent with condition (b).[223] Let us first discuss the possible inconsistency of conditions (b) and (i).

Prima facie, Kant's acceptance of condition (i), satisfied by organisms, is inconsistent with condition (b). Condition (i) tells us that the parts of organisms are, qua existence and form, dependent on the whole, while condition (b) suggests that we can only mechanically explain organisms in terms of parts that are, qua existence and form, independent of the whole. Hence, McLaughlin's account seems to imply that organisms resist mechanical explanation *tout court*.

In the previous chapter, I have, in contrast to McLaughlin, argued that condition (b) is not incorporated in Kant's conception of mechanical explanation. Hence, the fact that the parts of organisms are dependent on the whole does not itself imply that organisms are mechanically inexplicable. In the previous section I have, while discussing Kant's views on reproduction, nutrition and growth and self-preservation, similarly argued that in biology Kant insists on the subordination of mechanism to teleology, i.e., while we construe organisms as natural purposes (comprehend their possibility in teleological terms), we must always strive to find mechanical explanations of organic phenomena. In short: I do not think that Kant's acceptance of (i) entails that organisms are mechanically inexplicable *tout court*. Apart from my interpretation of mechanical explanation developed in the previous chapter, I will cite two more reasons for taking Kant to believe that the dependency of the parts of organisms on the whole does not imply that they are mechanically inexplicable in every respect.

First, we may note that according to Kant condition (i) is satisfied by both

[223] McLaughlin 1990, 140–144, suggests that condition (ii) implies the mechanical inexplicability of organisms. Yet, his account of mechanical explanation also suggests (at least implicitly) that condition (i) implies the mechanical inexplicability of organisms. In the following, I will focus on both conditions.

artifacts and organisms. For both types of objects, we take it to be the case that the parts, qua existence and form, are possible through their relation to the whole. Importantly, in Chapter 3 we have seen that the explanation of the functioning of an artifact (e.g., a clock) in terms of the movement of its parts (e.g., gears, levers, etc) was interpreted as an instance of mechanical explanation. Hence, the fact that objects satisfy condition (i) does not itself imply that they are mechanically inexplicable.

The second reason for interpreting Kant to deny that condition (i) implies the mechanical inexplicability of organisms is based on Kant's conception of space and spaces (parts of space). In the Transcendental Aesthetic of the first *Critique*, Kant argues that space is not a general *concept* of relations of things, but rather a pure *intuition*. Space, as a pure intuition, is an individual *whole*, while spaces are *parts* of this whole. These parts are not constituent of the single space in the sense that they *precede* the latter, rather parts of space are introduced through limitations (constructions) in the single all-encompassing space.[224] In short: the relation between space as a pure form of intuition and spaces is a relation between whole and parts and the parts are only possible in relation to the whole.

Kant emphasizes the last point in the Dialectic of Teleological Judgment of the third *Critique*, noting that no part of space can be determined except in relation to the whole, the representation of which "is the basis of the possibility of the parts".[225] In this respect, the relation between organized beings and their parts is similar to the relation between space as a pure intuition and its parts. Nevertheless, in Chapter 2 we have seen that constructive (real) definitions in geometry (of geometric objects that are, of course, themselves limitations of the whole space as a pure intuition) can be profitably understood as explanations of wholes in terms of their parts. This view on definitions provides, I have argued, a conceptual background for conceiving mechanical explanations as explanations of wholes in terms of their parts. Once again, therefore, satisfaction of condition (i) does not seem to imply that wholes cannot be explained in terms of their parts, i.e., that mechanical explanations are impossible.

We may now consider whether condition (ii) implies the mechanical inexplicability of organisms. According to McLaughlin this is indeed the case. He argues that it is the self-generating or self-organizing nature of organisms, which distinguishes them from artifacts or machines, that implies their

[224] *KrV*, A 24–25/B 39.
[225] AA 5: 409.

mechanical inexplicability. According to McLaughlin, Kant suggests such a reading in §65 of the third *Critique*, noting:

> 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)

However, Kant's remarks do not imply that organisms are mechanically inexplicable *tout court*. For he makes only explicit that the self-generating or self-formative nature of organisms cannot be explained through mechanism *alone*. Although mechanism is not sufficient for explaining the self-organizing nature of organisms, it plays, I contend, a crucial role in our understanding of the nature of organisms.

Recall that Kant elucidates the self-generating (self-organizing) nature of organisms though his discussion of the phenomena of reproduction, nutrition, growth and regeneration. As we have seen, the proper scientific method of investigating these phenomena consists in the subordination of mechanism to teleology. Thus, in investigating the manner in which plants nourish themselves and grow, we presuppose that plants have a structure adopted to performing the functions required for obtaining nutrition and growth. In other words: we comprehend plants teleologically, as wholes with a structure adapted to performing certain functions. This presupposition makes sense in light of Kant's view, expounded in Chapter 2, that the particular structure of organisms (the mode of composition of their parts) 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, with respect to the phenomena of nutrition and growth, be taken to have the following form:

(a) We assert that plants (e.g., a tree) ought to have the capacity for obtaining nutrition via the transformation of inorganic into organic compounds, i.e., we construe this process of nutrition as a *purpose* of the whole. (b) Given Kant's conception of purpose, i.e., an object in which the parts are possible through their relation to the whole, (a) allows us to conclude that a tree must have parts enabling the obtainment of nutrition via the transformation of inorganic into organic compounds. (c) Hence, we conclude that trees have parts enabling the formation of nutrition via the transformation of inorganic into organic compounds. This teleological 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 (in Kant's terms) as a *ground of cognition*, i.e., a ground for cognizing *that* organisms have a systematic structure or form adopted to obtaining a purpose. However, purposes provide no insight in the *objective grounds* (causes), i.e., reasons *why*, that govern the obtainment of nutrition and growth. In order to cognize these objective grounds, the physiologist must 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 they have a heuristic function.[226] However, only cognition of the relevant mechanical processes allows us to provide proper explanations in the domain of biology.[227]

Once again: the proper method of biology thus consist in subordinating mechanisms to teleology as explicated above. Note that this basically amounts to claiming that in biology we should follow the analytic/synthetic method. In biology we ascribe purposes to wholes, purposes functioning as grounds of cognition which are commonly construed as *effects*, and try to discover the causes of these effects. Hence, we reason analytically from effects (or wholes) to causes (or parts). We subsequently try to find a mechanical explanation of these effects, i.e., we reason synthetically from objective grounds or causes (or parts) to effects (wholes). In this respect, the methodological structure of biology is, in Kant's opinion, not different from that of other doctrines or sciences.

In conclusion of this section, we may relate the interpretation developed here to the one developed by Lenoir, who, as mentioned in the introduction, takes Kant to provide a philosophical account of teleomechanism. In construing the method of biology as consisting of the subordination of mechanism to teleology, I am in agreement with Lenoir in treating the combination of teleology and mechanism to be crucial for understanding Kant's views on biology. We

[226] Compare, for example, Kant's remark: "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 constituition through observation […]". AA 5: 389.

[227] 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". In my view Kant denies that teleological explanations are proper scientific explanations (or: there are no teleological explanations).

now have a precise characterization of this method. In 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. As such, we construe the *explanandum* in teleological terms: mechanical processes are construed as a means for achieving a certain purpose (e.g., growth, nutrition, etc.). This view is in line with the idea (further developed in the next section) that the object of biological investigation is understood teleologically. More generally: we construe the domain of biology in teleological terms. However, as far as we have *explanations* in biology these are always mechanical explanations.

The foregoing points to a difference between Kant's conception of biological method, as developed in the third *Critique*, and that of Blumenbach. In §3.8, we have seen that Blumenbach invoked teleological presuppositions, in particular *vital forces* such as the *Bildungstrieb*, in order to construe the domain of natural history. That teleology figures in construing the domain of the biological sciences is an idea that Kant endorses. However, in the third *Critique* Kant is 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 specific, ultimately *ontological*, convictions guiding the investigation of biological inquiry. Moreover, for Blumenbach vital forces also seem to 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.[228] Whether Kant would have accepted such a use of vital forces is unlikely, given his regulative doctrine of teleology and his conviction that explanations in biology must be mechanical.[229] 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 actual biological scientific investigation and the specific assumptions employed in this investigation.[230]

We can now point to the shortcomings of Lenoir's interpretation of Kant. Lenoir explicates the idea of teleomechanism, as described to Kant, 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

[228] Cf. Richards 2000. The fact that Blumenbach treats the *Bildungstrieb* as a cause is the reason for Blumenbach to deny that the assumption of the existence of such a force is consistent with a Kantian position.

[229] I return to this topic in Chapter 5.

[230] AA 5: 417. See also the next paragraph.

> 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, throughout the third *Critique*, when discussing the combination of teleology and mechanism, Kant almost never speaks of purposive *agents* or of specific *forces* constituting an object of study for the biologists (yet not for the physicist). To suggest that Kant endorsed such ideas is to confuse Kant's philosophical analysis of the methodological presuppositions founding biological inquiry, with specific scientific, ontological assumptions made within biological research. Moreover, given that Blumenbach treated the *Bildungstrieb* as an explanatory principle, Lenoir's analysis suffers from the false implication that Kant allows of non-mechanical (teleological) *explanations* in biology. 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. We should distinguish principles in terms of which we construe the domain of a science from principles that figure in scientific explanations, something which Lenoir fails to do.

3.10 Construing the domain of biology

In the previous sections, we 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, as I will argue in more detail in the next chapter, Kant takes the method of a science to determine how we construe its objects of investigation. Hence, how we understand the domain of a science is (partially) dependent on its method. A method thus does not have a mere instrumental, but an objective function.[231]

We have encountered the objective function of (the mechanical) method in §3.7. There we saw that the view of treating scientific explanation as an explanation of wholes in terms of their parts, i.e., a conception of mechanical

[231] I am grateful to Christian Krijnen for emphasizing the importance of the Kantian conception of method. Krijnen discusses what he calls the objective function of method in his work on the philosophy of economics, cf. Krijnen 2007a, and Krijnen 2007b.

explanation, leads Kant to conceptualize organic bodies as wholes having (relatively) simple parts. Nevertheless, Kant does not wish to 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. Let us inquire further into how Kant takes the method of biology, consisting of a subordination of mechanism to teleology, to determine the object of biology.

Recall that Kant cited reproduction, organic growth and nutrition, and self-preservation or self-maintenance as features characterizing organized beings, while employing these features to distinguish organic bodies from non-organic bodies. In our discussion of Blumenbach's *Handbuch der Naturgeschichte*, we saw that Blumenbach specified similar features of organized bodies in order to determine the domain of natural history. In fact, these features of organisms were commonly taken to be characteristic of organisms within the eighteenth-century life-sciences. To give an earlier example, Christian Wollf, in his *Vernünfftige Gedancken von den Würckungen der Natur* (1723), treated of plants, animals and humans by respectively discussing the growth, generation or reproduction, nutrition and specific type of motion of plants, animals and humans.[232] Kant, by citing several of these features, thus places himself within an influential tradition of the eighteenth-century life-sciences. These features function as empirical criteria for differentiating organisms from inorganic bodies. In addition, as we have seen, Kant argues that these features lead us to consider organisms as wholes that are reciprocally dependent on their parts and thus 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"[233], i.e., in organisms we take nothing to be in vain or purposeless. This principle, Kant argues, is *occasioned* by scientific observation. In addition, it functions, because it is taken to universally apply to (the parts of) organisms, as an *a priori* maxim. This maxim is presupposed, e.g., by the anatomists of plants and animals in order to investigate their structure and in order to understand for what

[232] Wolff 2003 [1723], chapters 10–16. McLaughlin 2001, 173–174, notes that the discussion of these features in the eighteenth century all center on the notion 'reproduction', which was taken to be the characteristic feature of organisms. Locke is taken as a central figure in introducing this idea of reproduction.

[233] AA 5: 376.

reason plants and animals have a particular disposition and combination of parts.[234] Note that this description conforms nicely to the role Kant (and we may add Blumenbach) assigns to teleology in biology: we presuppose that organisms have a structure adapted to performing certain organic functions (e.g., reproduction, nutrition, etc.). 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 (§3.1). I agree with this interpretation. However, Quarfood does not discuss the specific role Kant assigns to teleology within biological method (understood in terms of the subordination of mechanism to teleology). In addition, he does not discuss the empirical criteria, i.e., reproduction, nutrition and growth and self-maintenance, which, as we have seen, figure in demarcating the domain of biology. The study of these features *occasions* (in Kant's terms) the application of the teleological maxim to organisms.[235] Strictly speaking, then, we do not identify organisms merely on the basis of teleology, but on the basis of empirical features and teleological principles.

What are the implications of construing natural bodies teleologically? In §66 Kant 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".[236] Traditionally, the notion 'order' is employed when discussing the *order of nature*. Wolff, for example, construes the notion 'order of nature' as referring to the "rules, in accordance with which changes in nature occur and corporeal things are composed."[237] Hence, we may interpret Kant as affirming that conceptualizing objects as natural purposes leads to a distinctive conception of the manner of their composition. A conception of their composition that 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. We have seen that, according to Kant, construing objects as natural purposes involves conceptualizing the existence and form of the parts of these objects as possible in relation to the whole. The whole is

[234] *Ibid.*

[235] Cf.: "[…] we find within nature and the course of its generation products generated in accordance with the known laws of experience within it, in accordance with which natural science must judge its objects and thus seek within itself for their causality in accordance with the rule of ends." AA 5: 382.

[236] AA 5: 376. This passage is also emphasized by Quarfood 2006, 743.

[237] Wolff 2003 [1751], 448–449.

taken to precede and determine the parts, contrary to the mechanical conception of the parts preceding and determining the whole. Kant further argues that judging 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), which is, however, not sufficient (for it could also be an instrument of art, and thus represented as possible at all only as a purpose); rather it must be thought of as an organ that produces the other parts (consequently each produces the others reciprocally), which cannot be the case in any instrument of art, but only of nature, which provides all the matter for instruments: only then and on that account can such a product, as an organized and self-organizing being, be called a natural purpose. (AA 5: 373–372, amended)

Kant elucidates his position by stressing the difference between artifacts and organisms:

> In a watch one part is the instrument for the motion of another, but one wheel is not the efficient cause for the production of the other: one part certainly exists for the sake of the other (*um des anderen willen*) but not through it (*durch denselben*). Hence, the producing cause of the watch and its form is not contained in the nature (of this matter), but outside of it […]. Thus one wheel in the watch does not produce the other, and even less does one watch produce another, using for that purpose other matter (organizing it); hence it also cannot by itself replace parts that have been taken from it, or make good defects in its original construction by the addition of other parts, or somehow repair itself when it has fallen into disorder: all of which, by contrast, we can expect from organized nature. (AA 5: 374)

If we think of an object as a natural purpose, we conceive of two different relations holding between its parts. The first (teleological) relation, 'existing for the sake of others', applies to the parts of both artifacts and organisms, whereas the second relation, 'existing through others', is particular to the parts of organisms.

The relation 'existing through others' is construed as a form of efficient causality. Some part *y* exists through *x* if *x* is the efficient cause of *y* and if *x* produces *y*, i.e., *x* is the efficient cause for the production of *y*.[238] This charac-

[238] Kant cannot be thinking of final causality in this context, for final causes do not produce anything (only efficient causes do). See part 1 of this chapter for this view on final causes or purposes. In part 1 of this chapter, we have also seen that Baumgarten construes a cause as the source of the existence (*principium existentiae*) or coming to be (*principium fiendi*) of a thing. This conception of 'cause' seems to inform Kant's discussion.

terization allows us to distinguish organisms from artifacts. The parts of, say, a watch, in contrast to that of organisms, do not produce one another and hence they do not *exist* through one another. For this reason we take the efficient, producing cause of a watch, in contrast to that of organisms, to be contained outside of nature. Note that characterizing the parts of organisms as *producing* one other is not unproblematic, for there are many types of organized objects (e.g., individual organs such as the human eye) in which this does not seem to be the case. Of course, Kant, in this context, is emphasizing particular characteristics of organism that distinguish them from artifacts, such as growth, reproduction and various phenomena of regeneration. Kant's claim that the parts of organisms produce one another may thus be interpreted as a way of describing the relations of maintenance and regeneration that obtain between parts of organisms.

Let us turn to the relation 'existing for the sake of others', which applies to the parts of artifacts and organisms. I take it to be the case that it is the attribution of this (teleological) relation to the parts of organisms that, in Kant's terms, leads us to think of "an order of things entirely different from that of a mere mechanism of nature".[239] Kant holds that the relation 'existing through others' is characteristic of *objects of nature* such as organisms. In contrast, the relationship 'existing for the sake of others' applies to both non-natural artifacts and organisms.

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 elucidates this relation in the case of a watch, by noting that the parts of a watch exist for the sake of (i.e., are instruments for) the motion of another. For example, the mainspring of a mechanical watch is an instrument for the motion of its various wheels or gears, which is an instrument for the motion of the balance wheel, and so forth. The parts of the watch stand to one another in this relation in order to keep time, which is the purpose of the watch.

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 ought to be."[240] For example, if we construe the human eye as a purpose, we judge that it "ought to have been suitable for seeing."[241] 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" (is an instrument for) to the parts

[239] AA 5: 376.
[240] AA 20:240.
[241] *Ibid.*

of the eye. Thus, we might say that the cornea exists for the sake of the iris, the iris for the sake of the retina, and so forth, all parts existing for the sake of enabling sight. The attribution of instrumental relations between the parts of an organism 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.[242]

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 (to exist for the sake of) obtaining the purpose of the whole. In contrast, if we consider a whole in purely mechanical terms, we do not construe the whole as purpose nor take the parts to exist for the sake of this purpose. The moon does not, for example, orbit in a conic section for the sake of the earth-moon system.

On my interpretation, then, 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.[243] 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). As we have seen, the proper method in biology consists in the subordination of mechanism to teleology. This means that although we aim to explain organic phenomena mechanically, we view mechanisms as serving some purpose (existing for the sake of a purpose). Biological investigation is always conducted in light of a teleological perspective.

Why is the foregoing relevant to our understanding of the domain of biology? The answer, I take it, consists in the fact that for Kant the method of a science is one of its fundamental distinguishing features. If we, for example, attempt to differentiate biology from chemistry in terms of different sets of objects studied within these sciences, we would, in virtue of the fact that both sciences can be (and often are) concerned with the same objects, not get very far. What distinguishes biology from chemistry are their respective methods. Different sciences can thus be concerned with the same objects, but at the same time they are, in virtue of differing methods, concerned with a different scientific topic. For Kant, the unifying feature of what we now call biological

[242] 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.

[243] Cf. Kant's description of both maxims in the Dialectic of Teleological Judgment: AA 5: 386–388.

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 (recall: the method of biology consists in the subordination of mechanism to teleology. Hence, the mechanical maxim also plays a fundamental role in biology. It is the particular use of the teleological maxim in biology, extensively discussed in the foregoing, that distinguishes biology from other sciences or doctrines of nature).

It is essential that the teleological and mechanical maxims are construed as *regulative* maxims, or, adopting the terminology of the third *Critique*, they are maxims of the reflecting power of judgment (guiding our reflection on objects).[244] If the teleological and mechanical principles are treated as constitutive, or as objective principles of determining judgment, they would "contradict one another" and hence one of them would "necessarily be false".[245] If we treat the mechanical principle as a regulative maxim, we 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".[246] However, we do not make the constitutive claim that all these events and forms "**are possible only in accordance with such laws**".[247] The same is true for the teleological principle, which leads us to *judge* (or reflect on) some products of nature in accordance with final causes. However, Kant stresses that we "can by no means prove the impossibility of the generation of organized products of nature through the mere mechanism of nature".[248]

The teleological principle is thus necessary for our human cognitive faculties, not for the object itself. The advantage of treating the mechanical and teleological principles as regulative principles is that Kant is not committed to any ontological commitments. The metaphysical questions whether, for example, man is merely the result of mechanical processes (say, a chemical laboratory) or an actual purpose (an object of design, in which, say, the whole causally determines the parts, the whole is genuine unity and more then the sum of its parts, etc.) is placed beyond the limits of reason. The teleological and mechanical principles determine our conceptualization of objects of nature and our method of investigating them. They do not, however, have any ontological status.

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[244] Cf. AA 5: 387–388.
[245] AA 5: 387.
[246] *Ibid.*
[247] *Ibid.*
[248] AA 5: 388.

My interpretation that the teleological principle governs biological method, and, as such, allows us to determine the subject matter of biology, is similar to the interpretation of Marcel Quarfood, who assigns teleology an identificatory function.[249] However, we have seen that this fact leads Quarfood to assign teleology a *constitutive function* on the object-level of biological science, whereas on a meta-level of philosophical reflection teleology has a mere *regulative* function. This view, in my opinion, is incorrect and distorts Kant's intentions while discussing teleology and its role in biology. In conclusion of this chapter, I will present my objections to the view of Quarfood.

Kant does not, in the manner which Quarfood does, distinguish between an object-level and a meta-level of philosophical reflection when discussing teleology. In my view, he has important reasons for not doing so. According to Kant teleology is employed within natural science: natural science must, confronted with reproducing, growing, and regenerating natural objects, seek "within itself" for a causality in accordance with ends.[250] However, Kant continuously insists that teleology, even within natural science, has a merely regulative function. If we assign teleology a constitutive function, we would treat purposes as objective properties of natural objects, whereas as we have seen we merely reflect on natural objects in accordance with purposes (cf. part 1 of the current chapter).

More generally: Kant treats both the mechanical and the teleological principle as regulative maxims. To treat them as constitutive, would, as we have seen, commit Kant to ontological claims that he does not want to make. On Quarfood's interpretation, the biologist would be justified in asserting the objective reality of, say, a holistic causal influence of wholes on their parts, whereas on a meta level of philosophical interpretation, we recognize that this is a dogmatic metaphysical claim. This (contradictory) consequence is unacceptable for Kant. Quarfood's interpretation boils down to allowing the biologist to make unacceptable metaphysical claims on the basis of his conception of biological method, i.e., the biologist confuses natural science with metaphysics. Kant's intention in treating the mechanical and teleological principle as regulative is, on the contrary, to strictly distinguish 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 explicit in §79 of the

[249] Cf. §3.1. Quarfood 2006.
[250] AA 5: 382.

Methodology of Teleological Judgment, claiming that teleology as a science belongs to the *critique* of the power of judgment:

> Teleology, as a science, thus does not belong to any doctrine at all, but only to critique, and indeed to that of a particular cognitive faculty, namely that of the power of judgment. But insofar as it contains *a priori* principles, it can and must provide the method for how nature must be judged in accordance with the principle of final causes; and thus its methodology has at least a negative influence on procedure in theoretical natural science […]. (AA 5: 417)

The critique of judgment thus provides a proper account of teleology, showing that teleology has a necessary regulative function, and thus provides a *philosophical* foundation of the use of teleology within natural science (biology). If we, as Quarfood claims, interpret Kant as distinguishing a meta-level of reflection (philosophy) from an object-level of reflection (biology), we should note that the former provides the foundation for the latter. Hence, these levels cannot provide contradictory interpretations of teleology.

In line with the above objection, Quarfood's interpretation also leads, in Kant's views, to a confusion of teleology with theology. One of Kant's reasons for taking teleology (or more specifically: the concept of a natural purpose) to be regulative, is that a constitutive interpretation of teleology ultimately leads to taking organisms as objects of design. Yet, we have no evidence that organisms are actually designed. More generally: Kant insists on the regulative status of the notion of a 'natural purpose' in order to curtail the physico-teleological proof for the existence of God. To take the concept of a natural purpose to be constitutive at the object level of biology, as Quarfood argues, is thus once again to confuse problems pertaining to natural science with metaphysical-theological problems. Kant expresses this point with exemplary clarity:

> In order to avoid even the least suspicion of wanting to mix into our cognitive grounds something that does not belong to physics at all, namely a supernatural cause, in teleology we certainly talk about nature as if the purposiveness in it were intentional, but at the same time ascribe this intention to nature, i.e., to matter, by which we would indicate that this term signifies only a principle of the reflecting, not of the determining power of judgment, and is thus meant not to introduce any special ground for causality, but is only meant to add to the use of reason another kind of research besides that in accordance with mechanical laws […] (AA 5: 383)

To argue that teleology is constitutive at the object level of biology, is ultimately simply to introduce a new causality, and a special ground for this causality, in physics (natural science): a relapse into the traditional physico-teleology that Kant had abandoned.

3.11 Conclusion

Kant's conception of biology is heavily debated. A common modern view is that Kant's philosophy, developed in the third *Critique*, implies that biology cannot be a science. Organisms are simply inexplicable within science. This interpretation contradicts a more traditional interpretation, according to which Kant provided a philosophical basis for the development of biology as a science. Still other commentators assign a more positive role to teleology in natural science, ascribing teleology some sort of explanatory function.

In the present chapter I have argued that Kant's views in the third *Critique* correspond to the common late eighteenth-century view that the study of organic nature constitutes a special scientific discipline with a particular subject matter. Kant's reflections on teleology in the third *Critique* provide a philosophical basis for conceiving biology as a science with a specific domain of its own. As such, one of Kant's primary interests lies in the method of demarcating organic from inorganic nature, i.e., in the manner in which we can construe the domain of biology.

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 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. Hence, in terms of the criteria of proper science expounded in Chapter 1, we can say that Kant allows for the possibility of biology as a systematic science with a particular domain. In addition, proceeding from the teleological determination of the object of biology, he allows for the idea of objective scientific explanation in biology. These objective explanations must be specified (in part) by showing how biological regularities are grounded in laws of physics and (importantly) chemistry. Even if (as must be admitted) Kant hardly had the resources to specify how biological regularities are grounded in laws of physics and chemistry, and lacked knowledge of the actual mechanisms involved in organic processes, the idea that the biologists must accept such a procedure is certainly adopted by Kant as a methodological ideal. Biology does not, however, satisfy the other criteria of proper science specified in Chapter 1. Kant simply 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 be possible). In addition, biology is, in Kant's time, a non-mathematical science. Hence, ultimately biology remains an improper science for Kant. Nevertheless, it is clear

that Kant's conception of proper science profoundly influences his conception of biology and biological method.

An analysis of Kant's views on teleology in light of the employment of teleological concepts by Baumgarten and Wolff, provides insight in the historical background of Kant's view that teleology has a regulative function. Kant was highly critical of traditional teleological, or physico-teleological, arguments that took relations of usefulness obtaining between natural objects as evidence for divine design. In this respect, Kant distanced himself from the Wolffian tradition. However, Kant shared the conviction of Wolff and Baumgarten that purposes only exist relative to some cognitive subject. This conviction provided a reason for denying that purposes or purposive relations can be objectively predicated of natural objects, i.e., they have a regulative function. However, given that teleological notions are regulative ideas, Kant could argue, in contrast to the likes of Wolff, who conceived of the study of organisms as a strictly mechanical affair, that teleology has a specific function in natural science or biology.

Teleology has a specific function in construing the domain of biology. This idea is premised on Kant's thought that the method of a science determines how we construe its domain. The method of biology consists in the subordination of mechanism to teleology. Organisms are conceived of in teleological terms, i.e., as having a purposeful structure adapted to performing certain (organic) functions. Given the teleological presupposition, in Kant's terms: the presupposition of an original organization, we must investigate the mechanical processes operative in organisms that govern their functioning. Teleology allows a conceptualization of a certain class of natural objects, in virtue of which we assign certain properties and relations to them. In terms of these properties and relations organic nature is distinguished from inorganic nature. Hence, teleology determines the construction of the domain of biology, although explanations in biology are always mechanical explanations. The regulative interpretation of teleology enables the determination of the domain of biology in terms of its methodological presuppositions, as opposed to ontological convictions concerning the distinction between organic and inorganic objects. To interpret teleology as constitutive is to confuse teleology as a philosophically justified methodology in natural science with teleology as ontology.

4 | The *Opus postumum*: Kant on the systematicity of physics

Having treated Kant's views on biology as articulated in his critical writings, we may turn our attention to Kant's *Opus postumum*. Kant's views on organic nature in the *Opus postumum* are treated in the next chapter. In the present chapter, I will try to shed light on the philosophical project Kant undertakes in the reflections comprising the *Opus postumum*: the project of effecting a *transition* from the metaphysical foundations of natural science to physics.

The status of Kant's last unpublished work has been the subject of considerable controversy. While some commentators view the *Opus postumum* as articulating doctrines that are fundamentally at odds with his critical philosophy, others view the *Opus postumum* as an extension of his critical undertakings. In the present chapter I argue for the correctness of the latter interpretation. Although the *Opus postumum* contains substantial revisions of Kant's earlier views, the transition project articulated in the *Opus postumum* can be best understood as an extension of his project undertaken in the *Metaphysische Anfangsgründe* of 1786. In particular: Kant's project in the *Opus postumum* is to show how a philosophical foundation of physics, construed as a systematic empirical science of nature, is possible.

The *Opus postumum* contains reflections and drafts for a work that Kant originally intended to give the title: *Übergang von den Metaphysische Anfangsgründe der Naturwissenschaft zur Physik*. In the following I will, when referring to this work, speak of Kant's transition project or simply *Transition*. As Kant's projected title indicates, any interpretation of the *Opus postumum* must give an account of the relationship between Kant's *Metaphysische Anfangsgründe* and (what he calls) physics, or (in other words): an account of the relationship

between the rational part of physics and physics. In the present chapter, I will provide such an account by analyzing the meaning of the term 'physics' in Kant's critical writings, in eighteenth-century textbooks on physics, and in the *Opus postumum*.

The nature of the relationship between the *Metaphysische Anfangsgründe* and Kant's transition project has been the subject of almost all recent works on the *Opus postumum*.[1] In his influential studies, Burckhard Tuschling has argued that Kant's transition project resulted from recognizing that the project of the *Metaphysische Anfangsgründe*, a work that was supposed to provide an a priori foundation of physics, was flawed.[2] According to Tuschling, Kant's transition project constitutes a novel (*transcendental*) foundation of physics. Within this project, Kant articulated a new theory of matter while also revising central tenets of his transcendental philosophy, allowing for the possibility of providing transcendental (a priori) proofs for the existence of forces in nature.[3] The thrust of Tuschling's studies is articulated clearly by Kenneth Westphal, who (agreeing with Tuschling) states that there is no place for Kant's transition project "within the framework of the classical Critical Corpus". Hence, the "very fact that Kant even contemplates a "Transition" indicates that he thinks something is seriously wrong with the Critical philosophy".[4] In contrast to both authors, Michael Friedman does not take Kant's transition project to result from flaws in the *Metaphysische Anfangsgründe*. Rather, the *Transition* is an extension of the latter work, motivated by developments in natural science, that is meant to provide a foundation of the experimental sciences, most importantly the new chemistry developed by Lavoisier.[5]

I will position myself with respect to the above mentioned authors in the course of this chapter. Here, it is important to note that I interpret Kant's transition project from a different and more general perspective, employing an *ideengeschichtlich* method. In contrast to Tuschling, I will not discuss particular problems confronting Kant's *Metaphysische Anfangsgründe*, nor the

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1 For a brief survey of the most important studies, cf. §4.1.

2 Tuschling 1971, 1989, 1991, 2001.

3 In Tuschling 1991, it is also argued that Kant modified his transcendental philosophy in favor of a form of transcendental idealism akin to that developed by Schelling. Cf. Edwards 2000b; Förster 1990. For a convincing critique of these positions, see Onnasch 2009. In the present chapter, I will not deal with the notion of transcendental philosophy as developed in the *Opus postumum*, nor with the general question whether the latter is consistent with Kant's position articulated the critical period. My sole concern will be with determining how we should understand the project of a transition from the metaphysical foundations of natural science to physics.

4 Westphal 2004, 224.

5 Friedman 1992a, chapter 5; Friedman 2006.

manner in which these problems influence Kant's position in the *Opus postumum*. In contrast to Friedman, I will not detail the (late) eighteenth-century developments in chemistry influencing Kant's views in the *Opus postumum*. Rather, I interpret Kant's transition project by comparing the views on physics articulated in the *Opus postumum* to his views on physics articulated in the critical period and to views on physics articulated in eighteenth-century textbooks on physics. I argue that the purpose of Kant's *Transition* conforms to a traditional eighteenth-century ideal of establishing physics as a systematic science. The manner in which Kant construes his transition project, and the manner in which he tries to ground physics as a systematic science, can be profitably understood by investigating both the similarities and differences between Kant's views on physics and those adopted by his contemporaries.

On the basis of my analysis, I argue that the *Transition* must be understood as an extension rather than a revision of the project of the *Metaphysische Anfangsgründe*. The transition project is analogous with (though certainly not identical with) the traditional project of establishing physics as a systematic science by *grounding* the special doctrine of nature or *physica specialis* in the universal doctrine of nature or *physica generalis*. In the *Metaphysische Anfangsgründe* such a project had not been fully developed. Hence, we may grant (with Tuschling) that the *Metaphysische Anfangsgründe* was in certain respects flawed, and we may grant (with Friedman) that developments within chemistry influenced Kant's transition project. However, irrespective of these circumstances, a comparison between Kant views on physics and his contemporaries, shows that the *Transition* was a project that Kant had to undertake in order to complete his project of providing a thorough philosophical foundation of physics.

Finally, although considerations concerning biology are not central to this chapter, I will emphasize that Kant and his contemporary physicists adopted a broad conception of physics, which is taken to embrace the study of organic nature. Hence, the project of providing a transition from the metaphysical foundations of natural science to physics has ramifications for his views on biology. Many commentators on Kant identify physics with mathematical physics, while commentators on the *Opus postumum* take biological topics to be of peripheral concern in the transition project. Through an analysis of Kant's notion of physics and that of his contemporary scientists, I hope to show that this reading is not entirely correct (an interpretation to be further developed in the next chapter)

In §4.1, I will discuss some of the most important interpretations of Kant's *Opus postumum*. In §4.2, I discuss the *differentiae* in terms of which, according to Kant, we understand a science and delimit it from other sciences. §4.3

provides an analysis of Kant's views on physics, as articulated in the critical period, in terms of these *differentiae*. In §4.4, I focus on the notion of physics as employed in eighteenth-century German textbooks that Kant was familiar with. The importance of these textbooks for Kant's thought, many of which he employed in his lectures on physics, is well known. However, an analysis of the similarities and differences between the views on physics contained in these textbooks and Kant's views on physics expounded in the *Opus postumum* has not yet been given. In §4.5, I will interpret Kant's transition project, in particular his conception of physics, in light of the views on physics expounded in the earlier sections.

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*. This transition project is itself conceptualized as an a priori science. The writings pertaining to Kant's transition project (or: *Transition*) are recorded in volumes 21 and 22 of the Academy edition of *Kant's gesammelte Schriften* by the Prussian Academy of Science.[6] Although the chronological order of Kant's manuscript has been established by Erich Adickes, the Academy edition does not present Kant's writings chronologically.[7] This circumstance provides a hindrance for interpretation of the *Opus postumum*. Other hindrances include: the unfinished nature of the work, the lack of structure normally supplied by chapters, sections, paragraphs as well as chapter and section headings, and the frequent absence of punctuation in Kant's sentences. Given these circumstances, it is no surprise that Kant's *Opus postumum* is a contentious work within Kant's philosophical oeuvre.

In the present section I will describe three lines of interpretation concerning the *Opus postumum*. To begin we may specify when Kant first conceived of the idea of his transition project. 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

[6] For a description of the history and state of the manuscript that we call *Opus postumum*, see Adickes 1920, 1–35. See also Förster's introduction to the English translation of the *Opus postumum* in *The Cambridge Edition of the Works of Immanuel Kant*.

[7] Adickes chronology is, however, printed at the end of volume 22 of the Academy edition.

contain the transition from your *Metaphysical Foundations of Natural Science* to physics itself, which I await eagerly".[8] Given that Kiesewetter studied with Kant in 1788–89 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".[9]

Although there exist numerous incompatible interpretations of Kant's transition project, we can distinguish three main lines of interpretation. The first line of interpretation has been developed by Burckhard Tuschling.[10] Tuschling argues that the idea of a *Transition* resulted from Kant's recognition that the project of the *Metaphsische Anfangsgründe* of 1786 is flawed and in need of revision. A premise of Tushling's argument is that the *Metaphysische Anfangsgründe* does not allow of an extension (transition) of metaphysics to physics. The latter work immediately adjoins physics, where 'physics' is understood as a mathematical doctrine of nature.[11] The mere fact that Kant envisioned a transition project thus already points to possible deficiencies in Kant's *Metaphysische Anfangsgründe*.[12]

Tuschling specifies two problems afflicting the *Metaphysische Anfangsgründe*. First, Tuschling argues that Kant's proof of Proposition 1 of the Dynamics of the *Metaphysische Anfangsgründe* is problematic. This proposition, essential to Kant's dynamic theory of matter, aims to show that matter fills a space through a special moving force.[13] According to Tuschling, the proof of this proposition is based on an illegitimate mode of inference. In the 1790s, Kant recognized that this mode of inference is problematic. Hence, Tuschling argues, Kant now believed that the *Metaphysische Anfangsgründe* did not succeed in introducing moving forces of matter. Rather, the only

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8 AA 12: 23.

9 Förster 2000, 3.

10 Cf. Tuschling 1971, 1991, 2001. Tuschling's views have been defended and developed by Edwards 2000, Westphal 1995b, 2004. Förster 2000, also adopts certain lines of thought of Tuschling, although he rejects several main theses of Tuschling's interpretation.

11 Tuschling 1991, 107.

12 Cf. also Westphal 2004, 224: "There is no place for Kant's proposed "Transition from the Metaphysical Foundations of Natural Science to Physics" within the framework of the classical Critical Corpus […]. Hence, the fact that Kant even contemplates a "Transition" indicates that he thinks something is seriously wrong with the Critical philosophy." In the present chapter I argue that even if one grants that the content of the *Metaphysische Anfangsgründe* is problematic in several respects (as Tuschling and Westphal rightly claim) there *is* a place for Kant's *Transition* from the perspective of the *Metaphysische Anfangsgründe*.

13 AA 4: 497.

legitimate content of this work is contained in phoronomy or kinematics, i.e., the content of this work reduces to phoronomy.[14]

I cannot here treat the problems Tuschling identifies in Kant's proof of Proposition 1 of the Dynamics in detail.[15] We may briefly note that, according to Tuschling, Kant illegitimately employs the results of phoronomy (established in the first chapter of the *Metaphysische Anfangsgründe*) in this proof. In the proof of Proposition 1 of the Dynamics Kant appeals to the (sole) Proposition of the Phoronomy, which provides Kant with a means for showing how two motions of one and the same point (motions regarded as occurring simultaneously) can be composed, i.e., *added together*.[16] In phoronomy (what we would call kinematics), Kant is concerned precisely with showing how two speeds can be added together. Phoronomy provide a purely mathematical (a priori) analysis of motions and their combinations. What is at issue is the composition of *directions* and *speeds* of *points*. We abstract from the empirically given qualities of physical bodies, from forces and (more generally)

[14] Tuschling 1971, 93–98. Tuschling articulates these ideas in chapters 3 and 5 of his 1971 work. Cf. also Westphal 2004, 185–190. Both Tuschling 1971, 47–49, and Westphal 2004, 189, 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 the Dynamics. Kant was aware of this review, paraphrasing it at AA 21: 415. Kant was thus certainly aware of problems confronting his *Metaphysische Anfangsgründe*. Friedman 1992a, 222–237, provides a critique of Tuschling but does *not* discuss the status of Kant's proof of Proposition 1 of the Dynamics. The problem identified by Tuschling is a real one. The question remains, however, how it influenced Kant's transition project in the *Opus postumum*.

[15] Partly because Tuschling's arguments are not always perspicuous. However, his arguments have been further developed with great clarity by Westphal 2004. Moreover, there seems to be consensus among commentators that Kant's proof of Proposition 1 of the Dynamics is problematic. Cf. Carrier 1990, 181; Pollok 2001, 234–235. In the following description, I primarily base myself on the accounts of the latter three authors.

[16] The Proposition of the Phoronomy reads: "The composition of two motions of one and the same point can only be thought in such a way that one of them is represented in absolute space, and, instead of the other, a motion of the relative space with the same speed occurring in the opposite direction is represented as the same of the latter." (AA 4: 490). Kant emphasizes that the application of this principle presupposes a principle of the relativity of motion, which is expounded earlier in the Phoronomy as a principle according to which every motion can be viewed *arbitrarily* "as motion of the body in a space at rest, or else as rest of the body, and, instead, as motion of the space in the opposite direction with the same speed." (AA 4: 487). This principle of relativity, as Kant also explains, is only valid for *rectilinear motions* (AA 4: 488). It is precisely this fact which, as we shall see in the following, makes the application of Kant's phoronomic proposition in the proof of Proposition 1 of the Dynamics problematic.

from causal considerations.[17] Kant's analyses in phoronomy are only taken to hold of *rectilinear* motions.[18] However, when appealing to the phoronomic proposition in the proof of Proposition 1 of the Dynamics, Kant relates the phoronomical proposition to *accelerations* and thus also *curvilinear* motions, i.e., Kant applies this proposition to cases for which it is not valid.[19] Hence, Kant's appeal to phoronomy in his proof is illegitimate and the proof fails.

Second, Tuschling argues that in 1792 Kant came to recognize that his explanation of differences in the density of matters, presented in the Dynamics of the *Metaphysische Anfangsgründe*, is circular.[20] In the Dynamics, Kant proposed an explanation of these differences in terms of the fundamental forces of attraction and repulsion. Kant takes matter to fill a space in a determinate degree in virtue of the balancing of the fundamental forces of attraction and repulsion. Differences in density were taken to be explicable in terms of the variable ratios of the intensity of the forces of attraction and repulsion.[21] In a letter to Jacob Sigismund Beck of October 16, 1792, Kant noted that this account was circular.[22] According to Tuschling, these two problems necessitated Kant to revise his theory of matter presented in the *Metaphysische Anfangsgründe*, a project undertaken in the *Opus postumum*.

A different interpretation of Kant's transition project is provided by

[17] Cf. AA 4: 486–487.

[18] AA 4: 488.

[19] Cf. Carrier 1990, 181; Pollok 2001, 234–235.

[20] Tuschling 1971, 46.

[21] For a more elaborate account, cf. Carrier 2001a, 208–212. As Carrier explains: the intensity of the fundamental force of attraction is determined by the quantity of matter (mass), whereas the intensity of repulsion is fixed otherwise. It follows that the degree of repulsion may be different in pieces of matter of equal mass. This explains differences in density. As Kant puts it: repulsion may be "*originally different* in degree in different matters whose attractive force is the same." (AA 4: 533–534) In a nutshell, the variable intensity of repulsion in different matters shows how matters of equal mass can have a 'different degree of expansion', i.e., volume, and thus different densities, whereas differences in the density of matters having the same volume can be accounted for in terms of different degrees of attractive force (different masses). (AA 4: 534)

[22] 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 first discussed by Adickes. Cf. AA 14: 337–339. Later, Adickes 1924, 215, argued that the alleged circularity did not constitute a significant problem for Kant's theory of matter. Many commentators on the *Opus postumum* discuss this problem of circularity and take it to necessitate some kind of revision of the theory of the *Metaphysische Anfangsgründe*. Cf. Förster 2000, 33–37, 41–45; Westphal 2004, 191–197; Emundts 2004, 74–117. 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.

Michael Friedman.[23] 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'. The transition project thus derives:

> […] from one of the most important foundational problems facing eighteenth-century science. Newton had discovered the most general laws governing any forces whatsoever (the laws of motion); he had also established, by a most remarkable "deduction from the phenomena," the laws of one particular fundamental force: the universal attraction of gravity. […]. Yet how was this brilliant successful Newtonian paradigm to be extended beyond astronomy and terrestrial mechanics? How, in particular, were the laws of other types of attractions, such as those responsible for cohesion or chemical affinities, possibly to be discovered? (Friedman 1992, 240)

According to Friedman, Kant become convinced of the possibility of providing a foundation of experimental physics due to developments within chemistry, in particular the advent of the so-called chemical revolution in the late eighteenth century. In line with the important status of chemistry, Friedman construes the transition project as providing a foundation of Lavoisier's chemistry. He argues that in the course of the early 1790s Kant rejected the phlogistic chemistry of Stahl in favor of the new chemistry of Lavoisier. The *Transition* is accordingly supposed to "explain the a priori foundations of this new science".[24]

Recently, Dina Emundts has provided an interpretation of Kant's *Transition* incorporating strands of both lines of interpretation mentioned above.[25] In line with Friedman, Emundts rejects the idea that the *Transition* constitutes a fundamental revision of the project of the *Metaphysische Anfangsgründe*. However, in contrast to Friedman Emundts argues that the project of providing a foundation of empirical physics (as she calls it) is already contained in the latter work. According to Emundts, Kant attempted to ground empirical physics in the General Remark to the Dynamics of the *Metaphysische Anfangsgründe*.[26] However, because Kant recognized a circularity within his theory of matter (noted above) he was forced to provide a new foundation of

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[23] Friedman develops this interpretation in chapter 5 of his 1992a work. Cf. also Friedman 2006.

[24] Friedman 2006, 60.

[25] Emundts 2004.

[26] AA 4: 523–535.

empirical physics. This foundation is provided by the *Transition*. In a nutshell: the *Transition* supplants the General Remark to the Dynamics.

The third line of interpretation has been developed by Vittorio Mathieu.[27] In line with an early interpretation of the *Opus postumum* by Gerhard Lehmann,[28] Mathieu interprets Kant's last work in relation to the *Kritik der Urteilskraft* (as opposed to the *Metaphysische Anfangsgründe*). Mathieu interprets the *Transition* as explaining how physics can constitute a system. As such, the *Transition* should take up a line of thought developed in the third *Critique*. In the latter work, Kant had specified a subjective principle of the purposiveness of nature, which allows us to view nature as systematic. However, according to Mathieu, in the *Transition* Kant comes to believe that the unity of the laws and phenomena of nature cannot be merely grounded on *subjective* principles. As Mathieu puts it, the unity of nature cannot depend on a principle that merely directs us to treat nature *as if* it is systematic. The *Transition* is then supposed to ground the systematicity of the laws of nature categorically. Hence, the *Transition* project arises because Kant comes to reject his views expounded in the third *Critique*.

In the following, I will develop an interpretation of Kant's *Transition* that is in line with the interpretations developed by Friedman and Emundts. I reject Mathieu's idea that Kant's *Transition* must be interpreted in light of Kant's recognition of problems in the third *Critique*.[29] Rather, as the projected title of Kant's last work suggests, the *Transition* must be interpreted in light of Kant's *Metaphysische Anfangsgründe*. Moreover, I interpret the *Transition* as an extension the *Metaphysische Anfangsgründe*, rather than a rejection of the latter work (as Tuschling claims). Although the problems Tuschling identifies are real, the transition project has a general aim that cannot be understood solely in terms of problems affecting the *Metaphysische Anfangsgründe*.

Friedman's interpretation of the *Transition* is based on an analysis of Kant's reception of the developments in chemistry in the second half of the eighteenth century. Emundts focuses on the status of empirical physics in Kant's *Metaphysische Anfangsgründe*. I will provide a different perspective on Kant's

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[27] Mathieu 1989, 42–45.

[28] Lehmann 1939.

[29] As Förster 2000, 5–11, has persuasively argued, the project of the third *Critique* seems to be a necessary presupposition of Kant's *Transition*. In a nutshell, the third *Critique* provides a priori justification for taking nature to be systematic. On the basis of this presupposition, we then try to establish a systematic science of nature within the *Transition*. In any case, in the *Opus postumum* I find no endorsement of the idea that the regulative principle of the purposiveness of nature (established in the third *Critique*) is transformed into a constitutive principle (as one would expect on Mathieu's reading).

Transition by taking into account Kant's conception of physics in his critical period, and the conception of physics articulated in eighteenth-century textbooks on physics. As we shall see, Kant's *Transition* project can be quite explicitly related to the views on physics articulated in eighteenth-century textbooks on physics. In particular: Kant's *Transition* project, which aims to ground physics as a systematic science by explicating the relationship between rational en empirical physics, is analogous to (though, as we shall see, certainly not identical with) the enterprise of establishing physics as a systematic science by grounding *physica specialis* in *physica generalis*. The topics Kant treated in the *Metaphysische Anfangsgründe* conform (roughly) to topics traditionally treated within *physica generalis*. However, the topics traditionally treated within *physica specialis* were not sufficiently treated within the *Metaphysische Anfangsgründe*. Here, there remained a task for Kant within his project of providing a foundation of physics as a systematic science (as we shall see in the following, Kant's concept of physics as employed in the *Opus postumum* encompasses *physica specialis* as well as topics of *physica generalis* that require an empirical treatment).

The methodology I am following is indebted to the work of Konstantin Pollok. In his impressive commentary on the *Metaphysische Anfangsgründe*, Pollok has stressed the importance of textbooks on physics for Kant's philosophy of nature.[30] He does not, however, discuss Kant's *Opus postumum*.

4.2 Three distinguishing features of a science

In order to determine Kant's views on physics, it is first necessary to consider the method according to which Kant differentiates between different sciences. In the *Prolegomena*, Kant argues that in order to present a body of cognition as a science one must specify its distinguishing feature. This allows us to treat a science as having a particular nature on the basis of which it can be distinguished from other sciences:

> 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)

[30] Pollok 2001.

We can differentiate sciences in terms of (i) the set of objects with which the concepts and judgments of a science are concerned. In addition (ii), we can differentiate sciences by focusing on differences regarding the sources of cognition, i.e., whether a science provides us with cognition having its source in reason (*a priori*) or having an empirical source (*a posteriori*). Finally (iii), we can focus on differences regarding the type of cognition (*Erkenntnissart*). As we shall see in the following, differences regarding the type of cognition constitute differences concerning the *method* through which cognition is obtained. We can thus distinguish a particular science from another science in terms of their varying method.

Kant remarks that we have to employ several of these *differentiae* in order to distinguish sciences from one another. This view is motivated by the denial that sciences can be adequately differentiated 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.[31] The reason is that philosophy and mathematics can have a common object of investigation. Philosophy, like mathematics, 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.[32] Philosophical cognition is defined as 'rational cognition from concepts', whereas mathematical cognition is defined as 'rational cognition from the construction of concepts'.[33]

The *differentiae* described above determine, what Kant calls, the idea of a possible science and its *territory*. The use of the term 'territory' is significant. Kant employs this term analogous to the notion of the *domain* of a science. According to the *Classical Model of Science*, introduced in Chapter 1, a proper science must satisfy the Domain Postulate: all propositions and all concepts (or terms) of a science concern a *specific set of objects* or are about a *certain domain of being(s)*. This postulate prescribes a certain homogeneity to sciences, a unity in terms of which sciences can be delimited from one another.[34]

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

[31] *KrV*, A 714–715/B 742–743.
[32] Cf. also *KrV*, A 844/B 872.
[33] *KrV*, A 713/B 741. Cf. AA 4: 266; AA 9: 23.
[34] Cf. De Jong & Betti 2010, 1, 5.

are concerned to be a sufficient criterion for delimiting sciences from one another. For this reason, I suggest, Kant employs the notion 'territory of a science' (*Boden*, *territorium*). 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. Let us investigate this idea in more detail.

We may first note that what constitutes 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 we can have cognition of.[35] He notes that the territory of philosophy is given by the "set of objects of all possible experience."[36] Any theoretical science is concerned with objects of experience, for we can only have *knowledge* of objects of experience. Insofar as the territory of (the concepts 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*. Kant's use of the notion 'territory' thus places restrictions on how we construe the subject matter of a theoretical science: any theoretical science must deal with objects that conform to the conditions of experience specified in the *Critique of Pure Reason*.[37] These conditions determine what can count as the territory of a science. In further distinguishing the territories of different sciences, we must focus on (i)–(iii), as will become clear in the following.

Kant takes the territory of a science to depend on its distinguishing features. This suggests that the territory of a science depends on its particular mode of justifying cognition (a priori or empirical) and on its characteristic method. We can illustrate this point with an example. In The Discipline of Pure Reason in Dogmatic Use of the first *Critique*, Kant distinguishes two procedures for proving geometric theorems, e.g., 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."[38] The first procedure is

[35] AA 5: 174.

[36] *Ibid*.

[37] This is a common train of thought in Kant's philosophy. In line with this view, he 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. Cf. *KrV*, B 798; AA 9: 85. On this topic, cf. also Butts 1961; Butts 1962; Butts 1984, 223–244.

[38] Euclid 1956, 316–317.

empirical. Here, the geometer determines its object in accordance with the conditions of empirical intuition, yielding "only an empirical proposition (through measurement of its angles), which would contain no universality, let alone necessity […]".[39] The second, properly mathematical, procedure amounts to proving theorems of geometry via construction in pure intuition. This procedure is a priori, yielding universal and necessary truths.

As Lisa Shabel has shown, Kant's conception of the empirical procedure for proving geometric theorems can be traced to Wolff, who acknowledged the existence of a *demonstratio mechanica* in mathematics.[40] In such a demonstration, as Wolff puts it, one "investigates by means of necessary instruments that which is to be proved and finds it correct."[41] Euclid's Proposition I.32 provides an example of a theorem that can be demonstrated mechanically. Wolff sketches the empirical procedure of employing a compass to measure the interior angles of a constructed triangle, which shows that these angles "fill a half circle and are equal to two right angles."[42] The empirical features of the constructed triangle, its specific size and shape, thus play a role in the mechanical demonstration of Euclid's theorem I.32. For this reason, Kant claims that mechanical demonstrations fail to yield proper (necessary and universal) mathematical cognition.[43] In contrast, the demonstration of Euclid's theorem proceeding on the basis of construction in pure intuition yields a priori (universal and necessary) cognition, i.e., yields proper mathematical cognition. Kant takes this type of demonstration to be exemplified by the Euclidean demonstration of Proposition I.32.

For our present purposes, we may note that both the mechanical and the Euclidean demonstration can be interpreted as having a common object. Nevertheless, only the Euclidean demonstration is taken to yield proper mathematical cognition. This is because the Euclidean demonstration differs from the mechanical demonstration with respect to: (ii) the mode of justifying the

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[39] *KrV*, A 718/B 746.

[40] Cf. Shabel 2004, 195–215. The following account is indebted to Shabel's lucid discussion. Cf. also Shabel 2003, 96–101.

[41] Wolff 1965 [1716], 506–07.

[42] Wolff 1965 [1716], 507.

[43] This should not be understood as a criticism of Wolff. Like Kant, Wolff distinguished mechanical demonstrations from proper (Euclidean) geometric demonstrations. Mechanical demonstrations are assigned a didactic purpose for novices in geometry. 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 1965 [1716], 507.

proposition under consideration (a priori or a posteriori), and (iii) the method of cognizing its object.

My suggestion is that though both the mechanical and the Euclidean demonstration have a common object, Kant would ague 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, in accordance with Euclid's definitions and postulates, and is dealt with in a manner that secures proper (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, are, in contrast to the case of a mechanical demonstration, not taken into account. The mode of justification (ii) and method of cognizing its object (iii) characteristic of a science determine which features of the object under consideration are taken into account: they determine how we understand the object of a science and thus determine its territory.

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 cognizing its object. In the following sections, we will see how these ideas figure in Kant's conception of physics.

4.3 Kant's varieties of physics

In the previous section we considered the *differentiae* that, according to Kant, allow us to delimit sciences from one another. The present paragraph will be concerned with Kant's conception of physics (*Physik*). If we wish to understand Kant's reflections in the *Opus postumum*, which is supposed to provide a transition from the metaphysical foundations of natural science to physics, we need to understand his views on (a) the metaphysical foundations, (b) physics, and most importantly (c) the relationship between the metaphysical foundations of natural science and physics. Since Kant construes the metaphysical foundations of natural science as a *rational physics*,[44] which is contrasted with other parts of physics, the main question guiding our inquiries will be: what, according to Kant, is physics and how does he distinguish between different parts of physics?

[44] *KrV*, A 846/B 874.

Kant has a differentiated conception of physics. Several elements of his view on physics follow from his restrictions on what proper science is (Chapter 1). The view that natural science (physics) must be based on a priori principles,[45] 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.[46] 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, as a science, must be a system. Hence, if we are to provide a philosophical foundation of physics, we must show how physics is possible as a system. In a system we determine *a priori* "the extension (*Umfang*) of the manifold as well as the position of the parts with respect to each other".[47] In other words: if physics is to constitute a system, we must determine a priori the domain of physics and its parts (sub-disciplines), and the relation of these parts to one another. Kant's idea of systematicity thus provides us with the problem of specifying the relation between the a priori and empirical part of physics, a problem extensively investigated in the *Opus postumum*.

In the present section I will employ the three distinguishing features of a science discussed in the previous section to illustrate his understanding of physics and its parts. First, I discuss Kant's views on the object of (universal) physics. Second, I consider Kant's distinction between different parts of physics, i.e., between the a priori (rational) and empirical part of physics, in terms of the sources of cognition. Finally, I consider Kant's distinction between *physica generalis* and *physica rationalis*, a distinction between the mathematical and the metaphysical part of physics that is based on a distinction between different types of cognition.

4.3.1 On the object of universal physics

Let us 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*. In particular, universal physics in the strict sense is a science that concerns objects of the outer senses (objects of physics) and objects of inner

[45] For an answer to the question why natural science must be based on a priori principles, cf. §1.3.

[46] On the role of mathematics and metaphysics in natural science, cf. §1.4 and §1.5.

[47] *KrV*, A 832/B 860. Cf. §1.1.

sense (objects of psychology).[48] The term 'universal physics' thus provides us with an Aristotelian conception of physics, i.e., a science of nature that incorporates any doctrine of nature, including the study of organized beings (biology) and of the mind (psychology).[49] Kant also allows for the use of the term universal natural physics in a *non strict sense*, in which the study of objects of inner sense (psychology) is excluded. In the following, I will elucidate how Kant precedes from an Aristotelian conception of universal physics as a science of nature as a whole, and distinguishes between different doctrines within universal physics in terms of: (a) the object of these doctrines, (b) the type of cognition (*Erkenntnissart*) characteristic of these doctrines, (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.[50] They constitute *transcendental* principles, providing a priori conditions for the possibility of experience of any empirical object (of outer or inner sense). Hence, transcendental principles (pertaining to transcendental philosophy) ground universal physics in both the strict and non strict sense, i.e., *any* science of nature presupposes transcendental philosophy.

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*.[51] The latter principles comprise *mathematical* principles (applied to appearances) and *philosophical* (discursive) principles. The philosophical (discursive) principles are those developed in the *Metaphysische Anfangsgründe* (providing a special metaphysics of *corporeal* nature). These are distinguished from mathematical principles of natural science in virtue of the fact that they are discursive, i.e. provide a priori cognition from concepts, whereas mathematical principles provide a priori cognition from the *construction* of concepts (a distinction qua *Erkenntnissart*). The philosophical principles of natural science developed in 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

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48 AA 4: 295.

49 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. As we shall see in the following, this conception of physics conforms to that of Kant.

50 AA 4: 295.

51 *Ibid.*

the basis of an empirical concept (i.e., 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) and based on *empirical principles*, i.e., physics is construed in terms of its object and its a posteriori source of cognition.[52] In this manner, (a)–(c) allow Kant, proceeding from a general Aristotelian conception of physics, to distinguish different parts of physics.

According to Kant, universal physics (in the strict and non-strict sense) is based on transcendental principles. Universal physics is concerned with nature. 'Nature' is a technical term for Kant. The word 'nature' can have both a formal and material meaning.[53] If we take 'nature' in its formal meaning it signifies the "*conformity to law* of the determinations of the existence of things in general".[54] 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*."[55] In the *Metaphysische Anfangsgründe*, Kant takes the doctrine of nature to be concerned with nature in its material meaning. Hence, the object of the doctrine of nature is restricted to *objects of experience* and non-sensible objects are excluded as an object of study.[56]

In §36 of the *Prolegomena*, Kant asks how nature itself is possible. The answer is that nature in the material sense is possible "by means of the constitution of our sensibility"[57], 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" as explicated in the Transcendental Logic of the first *Critique*.[58] Hence, to construe universal physics as a science of *nature* is to say that it is concerned with objects that conform to the transcendental (a priori) conditions of experience expounded in the *Kritik der reinen Vernunft*: universal physics is concerned with *objects of experience*. What counts as an object of experience is determined by the pure forms of intuition (space and time) and the principles of the understanding (i.e., by the constitution of sensibility and understanding). The latter provide distinct transcendental (a priori) *sources* of cognition. Hence, the pure forms of intuition and the principles of the understanding determine (we might say) the *territory* of *universal physics*, i.e., determine the objects of which scientific knowledge is possible (they deter-

[52] AA 4: 295. Cf. AA 4: 470; *KrV*, A 847–848/B 875–876.
[53] Cf. AA 4: 294–96; 4: 467; A 418/B 446n.
[54] AA 4: 295.
[55] *Ibid.*
[56] AA 4: 467.
[57] AA 4: 318.
[58] *Ibid.*

mine what nature is). In short: transcendental principles are constitutive of nature and as such provide principles of (universal) physics.

At this point, we may inquire into the relation of biology 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. Biology is also a part of universal physics taken in the non-strict sense. The territory of universal physics in the non-strict sense, i.e., excluding objects of inner sense (psychological phenomena), 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. Biology, understood as a doctrine concerning organic bodies, simply constitutes a part of the study of corporeal nature.

To be sure, Kant's *Metaphysische Anfangsgründe* (providing what Kant calls *rational physics*) is properly understood as providing a foundation of mathematical (Newtonian) physics. Kant represents objects of outer sense, comprising the object of physics, by means of the empirical concept of matter, defined as impenetrable, lifeless extension.[59] Kant certainly took this concept of matter to be fundamental to Newtonian mathematical physics, given that he took the lifelessness of matter to be implied by the law of inertia.[60] However, this fact itself does not exclude biology from physics.[61] It merely shows that Kant's *Metaphysische Anfangsgründe* is concerned with providing a foundation of mathematical physics. Nothing is said concerning the relation of biology to physics (Kant is simply not concerned with this question in the *Metaphysiche Anfangsgründe*).

The conception of physics as a general science of nature (including biology) is also present in Kant's lectures on physics. In the *Danziger Physik* of 1785, the term 'physics' is introduced as a 'universal doctrine (or science) of nature' containing mathematical physics, chemistry and natural description (Kant's alternative notion for what was traditionally entitled natural history). In addition, the universal doctrine of nature is construed as providing grounds

[59] *KrV*, A 848/B 876.

[60] Cf. AA 4: 544.

[61] In this context, we may note that in the Paralogisms of Pure Reason of the first *Critique*, Kant notes that "that which is an object of outer sense is called "body"" (*KrV*, A 342/B 400). Once again: organisms simply are bodies, namely: organic bodies (in the previous chapter the content of this concept has been explicated).

for chemical and organic phenomena.[62] Hence, in his lectures Kant rejects the identification of physics with what he calls mathematical physics, i.e., those doctrines of nature that allow of mathematical treatment. Psychology is however, in contrast to chemistry and biology, again excluded from physics. Consequently, the term 'physics' is defined (in conformity with the above accounts) as a science of *corporeal nature*.[63]

In Chapter 1, 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. Hence, insofar as chemistry and biology are non-mathematical sciences they are non-proper natural sciences. As we have also seen in Chapter 1, apart from the epistemic requirement of apodictic certainty, Kant 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 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, as I will argue, one of the main philosophical tasks that Kant sets himself in the *Opus postumum* even if he did not bring this task to completion.

4.3.2 Rational and empirical physics

Having treated Kant's conception of universal physics, we may turn to the distinction between *rational* and *empirical* physics. The latter can be construed as parts of universal physics dealing with corporeal nature. The distinction between rational and empirical physics is made in terms of the mode of justification (a priori or a posteriori) characteristic of a body of cognition, i.e., it is a distinction in terms of the *sources of cognition*.

In the *Prolegomena*, Kant distinguishes 'pure natural science', grounded on a priori principles, from physics grounded on empirical principles.[64] Kant's lecture notes on physics, the *Danziger Physik*, 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 ra-

[62] AA 29: 97–99.
[63] AA 29: 100.
[64] AA 4: 295.

tional cognition of nature the grounds for explaining natural phenomena are *merely* a priori. These grounds can be *metaphysical* or *mathematical*.[65] 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* provide us with a rational physics (i).[66] 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).[67] Newton's mathematical physics as presented in (the latter parts of) his *Principia*, in which, on Kant's view, we apply both metaphysical and mathematical principles to empirical propositions, provides an instance of (iii).

Note that the possibility of applying a priori principles to empirical propositions (iii) is of importance for Kant. It is this fact that, as we have seen in Chapter 1, secures the apodictic certainty of propositions in natural science. In the First Introduction to the *Kritik der Urteilskraft*, Kant elucidates case (iii) as follows:

> If what is to be found is merely the ground for the explanation of that which happens, then this can be either an empirical principle, or an *a priori* principle, or even a composite of the two, as one can see in physical-mechanical explanations of events in the corporeal world, which find their principles in part in the general (rational) science of nature, and partly in those sciences which contain the empirical laws of motion. (AA 20: 237)

Thus: explanations in natural science or physics can be based on a composite of a priori and empirical principles.

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 concerned with corporeal nature (objects of outer sense) and not with thinking nature (objects of inner sense).[68] The same is true of empirical physics and cognition of nature obtained through the application of a priori principles. However, (i)–(iii) can

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[65] AA 29: 99.
[66] Cf. *KrV*, A 846/B 874; AA: 4: 470
[67] AA 4: 468.
[68] A 846/B 874.

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).

We may ask how the distinction between rational and empirical physics figures in Kant's *Metaphysische Anfangsgründe*. In the Dynamics chapter, Kant distinguishes between properties of matter that are cognized *a priori*, allowing of *metaphysical* treatment, and properties that are cognized empirically (*a posteriori*), requiring *physical* treatment.[69] This distinction parallels the distinction between rational and empirical physics. As Kant puts the point:

> The *action* of the universal attraction immediately exerted by each matter on all matters, and at all distances, is called *gravitation*; the tendency to move in the direction of greater gravitation is *weight* (*Schwere*). The action of the general repulsive force of the parts of every given matter is called its *original elasticity*. Hence, this property and weight constitute the sole universal characteristics of matter, which are comprehensible a priori (*die a priori einzusehenden allgemeinen Charaktere der Materie*), the former internally; and the latter in external relations. For the possibility of matter itself rests on these two properties. *Cohesion*, if this is explicated as the mutual attraction of matter limited solely to the condition of contact, does not belong to the possibility of matter in general, and cannot therefore be cognized a priori as bound up with this. This property would therefore not be metaphysical but rather physical, and so would not belong to our present considerations. (AA 4: 518)

How is it possible to distinguish between universal properties of matter that are comprehensible a priori and those that are comprehensible a posteriori? In the main body of the Dynamics, Kant argued that the possibility of matter filling a determinate region of space must be explained in terms of the balancing of an inverse-square force of attraction and an inverse-cube force of repulsion.[70] The concepts of these fundamental forces are primitive concepts, in terms of which we try to explain the properties of matter. The a priori comprehensible properties of matter are those ascribed to matter in virtue of understanding the possibility of the latter in terms of the fundamental forces of attraction and repulsion. I will explicate this idea in more detail in the following.

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[69] This distinction 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. Emundt's interpretation, as we have seen, takes the General Remark to the Dynamics of the *Metaphysische Anfangsgründe* to constitute Kant's treatment of empirical physics. The *Transition* constitutes a revision of this project.

[70] AA 4: 517, 521. For a clear account cf. Carrier 2001a, 208–210.

Kant takes the fundamental forces of attraction and repulsion to belong to the *essence* of matter.[71] They provide grounds for essential properties of matter. Thus, matter's filling a space (an essential property of matter) rests on the fundamental force of repulsion. This force is called *original elasticity*.[72] Hence, matter is originally elastic and original elasticity is treated as an a priori comprehensible universal characteristic of matter. In a similar fashion, *Schwere*, having the fundamental force of attraction as its ground, is construed as an a priori comprehensible characteristic of matter.[73]

Kant cites cohesion (*Zusammenhang*), in contrast to *Schwere* and original elasticity, as a property of matter that is not a priori comprehensible. In the General Remark to the Dynamics, Kant argues that cohesion is no "fundamental force of matter, but only a derivative one (*abgeleitete Kraft*)".[74] According to Kant, a *fundamental force* is a force that cannot be derived from any other force.[75] Hence, as the name suggests, a derivative force (such as cohesion) is one that can be derived from or is reducible to other forces. In the metaphysics lectures, a derivative force is similarly described as a force that is actually identical with another force, but *appears* to be an independent existing force.[76] We thus *treat* cohesion as an independent force, whereas it is

[71] AA 4: 511.

[72] AA 4: 500.

[73] It is not quite clear how we should construe the concept of *Schwere*. Kant sometimes employs this concept to denote a force, and sometimes to denote an acceleration. In then contemporary textbooks we find a similar use of the term. Lichtenberg 2007 [1808], 61, 67, construes what he calls the *Schwere der Körper* (*gravitas*) as an acceleration. In addition, *Schwere* is construed as a force causing acceleration. The Cambridge Translation of Kant's *Metaphysische Anfangsgründe* (by Michael Friedman) construes *Schwere* as 'weight', which suggests that we are dealing with a force. However, in the passage quoted above, *Schwere* is construed as the tendency of a body to move in the direction of greater gravitation. This corresponds to the use of the term in his lectures on physics, the *Danziger Physik* (AA 29: 80–81, 128–129). Here, *Schwere* denotes the centripetal acceleration of bodies directed towards a centre of gravitation (centre of mass). *Schwere* is said to be equal in all bodies and is described as gravitation as encountered on earth. All of this suggest that, employing the modern measure, *Schwere* denotes the acceleration of gravity *g*. According to Pollok, who also treats Kant's lectures on physics in this context, Kant construes gravitation as the *effect* of the fundamental force of attraction, while *Schwere* is the manner in which attraction manifests itself. This ultimately suggests (like Friedman) an identification of *Schwere* and the force of gravity. Cf. Pollok 2001, 316–318.

[74] AA 4: 526.

[75] AA 4: 512.

[76] Cf. the *Metaphysik von Schön*, AA 28: 512. Compare also the *Metaphysik Volckman*, AA 28: 431–432. In these lectures, natural science is ascribed the task of reducing derivative forces to fundamental forces.

actually reducible to another force.[77] Unfortunately, as will become clear in the following, the problem with cohesion is that we do not known to which force cohesion is reducible (we do not know its ground or cause). In the *Metaphysiche Anfangsgründe*, Kant argues that cohesion is not derivable from or reducible to the fundamental force of attraction (in contrast to *Schwere*). For this reason, cohesion is (in contrast to *Schwere*) not an a priori comprehensible characteristic of matter.

Given that the *Opus postumum* is concerned with the relation between rational and empirical physics, we may look at the phenomena of cohesion in more detail and explain why cohesion is a characteristic of matter that is not a priori comprehensible. In the *Metaphysische Anfangsgründe*, Kant notes that attraction, insofar as it is thought merely as active in contact, is called cohesion.[78] Thus, we *think* of cohesion as an attractive contact force. Kant is cautious in his description of cohesion, and we may presume that this is due to the fact that he does not want to treat cohesion as an independent force.[79] In the General Remark to Phenomenology, Kant thus notes that the composition of matter is poorly understood. He allows that the "*attraction* assumed in order to explain the cohesion of matter" may be only *apparent*, and not a *true* attraction. This would be the case if cohesion is merely the "effect, say, of a *compression* by external matter (the aether)", brought to this compression by gravitation.[80] Finally, Kant takes pains to distinguish cohesion from attraction (gravitation) as discussed in the main text of the *Dynamics*. The fundamental force of attraction is construed as a long-range penetrating force (*durchdringende Kraft*), the intensity of which is proportional to quantity

[77] In a reflection of the 1770s, Kant makes this explicit, arguing that cohesion is not the effect of an independent force since cohesion is not proportional to mass. Cf. AA 14: 138. Pollok 2001, 319, 353–360, provides a thorough discussion of Kant's conception of cohesion, which includes discussion of the *Reflexionen*. He argues that Kant's theory of cohesion, as developed in the *Metaphysische Anfangsgründe*, exhibits a tendency (not made explicit by Kant) to explain cohesion as the effect of the pressure of an ether. For our purposes, it is important to note that in the *Opus postumum*, Kant *explicitly* argues that cohesion must be explained in terms of the action (impact) of the ether.

[78] AA 4: 526.

[79] Thus, Kant speaks of the force, which in contact is *called* cohesion, and of attraction that I *think* of as active in contact. Cf. AA 4: 526.

[80] AA 4: 563–564. Note, however, that Kant asserts the possibility of explaining the cohesion of matter through the pressure of an ether as a mere possibility. In the *Opus postumum*, Kant does invoke the ether in order to explain cohesion, but not in terms of the pressure it exerts. Hence, he does not adopt the possible explanation suggested here.

of matter (mass).[81] In contrast, cohesion is thought of as a short range contact force (*Flächenkraft*) that is neither proportional to mass nor to density.[82]

Kant particularly stresses that the intensity of cohesion is not proportional to density. This is significant, for Kant had previously argued that the density of matter (and density differences) can be explained in terms of (variable intensity ratios of) the fundamental forces of attraction and repulsion. Hence, the fact that the intensity of cohesion is supposedly not systematically related to density, itself explicable in terms of attraction and repulsion, shows that cohesion is a property that is not (directly) related to the fundamental forces of attraction and repulsion.[83] This is why Kant assumes that cohesion is not an a priori comprehensible characteristic of matter.

Kant's analysis shows that the property of cohesion confronts us with an explanatory deficit. The difficulties involved in giving an explanation of cohesion were clearly recognized in the late eighteenth century. For example, J.T.S. Gehler, in his *Physikalisches Wörterbuch* (1787–1796), notes:

> Of the cause of the cohesion of bodies we know nothing at all, and if I here call cohesion, following Newton's disciples, *attraction*, I am not of the opinion to *explain* it from attraction as a physical cause. Rather, I merely employ the not wholly adequately chosen word attraction as a general name to refer to various similar phenomena, which express themselves in different manners. (Gehler 1787–1796, Bd. 1, 514)[84]

Thus, 'attraction' merely provides a general name for designating phenomena such as cohesion. It does not constitute a physical cause in terms of which cohesion can be explained. This view, I take it, is quite similar to Kant's view that cohesion is a derivative force and is not explicable in terms of the force of attraction.

The foregoing shows why Kant thinks of cohesion as a property of matter that is not a priori comprehensible and thus as a property requiring physical (as opposed to metaphysical) treatment. As such, the treatment of cohesion does not pertain to *rational physics*. Above we distinguished (i) rational physics, (ii) empirical physics, and (iii) cognition of nature obtained through the application of a priori principles to empirical principles. Although Kant is not

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81 AA 4: 516.

82 AA 4: 516, 526.

83 On these points, cf. Carrier 2001a, 210–212.

84 Original: "Von der Ursache des Zussammenhangs der Körper wissen wir gar nichts, und wenn ich ihn hier mit Newtons Schülern *Attraction* nenne, so ist meine Meinung nicht, ihn aus der Attraction, als einer physischen Ursache, zu *erklären*; vielmehr brauche ich das nicht ganz bequem gewählte Wort Attraction nur dazu, um mehrere ähnliche Phänomene, die sich in verschiedenen Fällen äußeren, mit einem allgemeinen Namen belegen zu können."

explicit on this point in the *Metaphysische Anfangsgründe*, cohesion seems to be a property properly discussed in (ii) and not in (iii).[85]

To understand the last point, consider, for example, Newton's derivation of the law of gravitation, which according to Kant's view is derived by means of the application of both mathematical and metaphysical (a priori) principles to empirical principles or phenomena. The law of gravitation thus provides us with an instance of (iii). In contrast, as we have seen, cohesion is not systematically related to the fundamental, a priori cognizable force of attraction. As such, the relation of cohesion to the *metaphysical* principles of natural science is obscure. In addition, whereas the intensity of the force of gravity, i.e., the fact that gravity is an inverse-square force, is determined via the application of mathematical principles to phenomena, this is not the case for cohesion. The only manner in which we can try to determine the intensity of cohesion is by means of experiment.

This last point becomes clear if we once again focus on Gehler's *Physikalisches Wörterbuch*. In the lemma on cohesion, Gehler provides a brief description of how we experimentally try to determine the intensity of cohesion of matters.[86] According to Gehler, in trying to determine the cohesion of a particular material, 'cohesion' is defined as the resistance to being torn apart under the influence of some external force. The degree of cohesion of materials, for example that of various metals, is then measured by attaching different weights to parallelepipeds of equal volume cast of various metals. In this manner we learn, for example, that the intensity of cohesion of German iron, torn apart by a weight of 1930 pounds, is greater than that of Swedish copper, torn apart by a weight of 1054 pounds. As such, we determine the intensity of cohesion of a specific kind of metal relative to that of another. The necessity of taking recourse to such purely experimental methods is probably another reason why Kant argued that cohesion, in contrast to attraction or gravitation, is a property of bodies that must be dealt with physically.

The foregoing makes plausible that Kant took cohesion to be a property of matter that is not explicable in terms of the fundamental forces of attraction and repulsion. As such, the discussion of cohesion in the General Remark to the Dynamics points to a gap between rational and empirical physics. Kant was aware of the existence of such gaps. In the General Remark to the

[85] At least in the *Metaphysische Anfangsgründe*. As we shall see in the following, in the *Opus postumum* Kant specifies what he takes the a priori cognizable ground of cohesion and the treatment of cohesion may be assigned to (iii).

[86] Gehler 1787–1796, Bd.1, 518–521.

Dynamics, while introducing the problem of explaining the *specific variety* of matter, he remarks:

> Instead of a sufficient explanation for the possibility of matter and its specific variety from these fundamental forces, which I cannot provide, I will present completely, so I hope, the moments to which its specific variety must collectively be *a priori* reducible (albeit not conceivable in regard to its possibility). (AA 4: 525).

The notion 'moments' refers to the concepts discussed in the General Remark to the Dynamics. There are four of these moments. (1) A brief discussion of the concepts of a physical body (as opposed to matter), volume and density. (2) A discussion of cohesion (treated above), and the distinction between fluid and solid (rigid) bodies. (3) A discussion of elasticity (spring-force), which is divided in expansive and attractive elasticity. (4) A discussion of chemical interactions, i.e., dissolution and decomposition.

A notable feature of the discussion of these moments is that they present us with explanatory gaps. For example, when dealing with the distinction between fluid and solid bodies (2), Kant argues that the difference between them cannot be located in the different intensity of cohesion of their parts.[87] Rather, Kant identifies friction, construed as a resistance to the mutual displacement of material parts (a resistance that cannot be accounted for in terms of cohesion), as the feature that characterizes solid or rigid as opposed to fluid bodies. However, he also notes that friction "presupposes the property of rigidity". Hence, "how [..] rigid bodies are possible […] is still an unsolved problem".[88]

Similarly, in his discussion of elasticity (3), Kant distinguishes between attractive elasticity (e.g., of a bent sword-blade, where the parts strive to assume their previous proximity) and expansive elasticity (e.g., of air that, when compressed, strives to regain a previously greater volume).[89] *Attractive elasticity* is, like cohesion, treated as a *derivative* force. *Expansive elasticity* can be either original or derivative.

Kant distinguishes between the "derivative elasticity" of air, due to the action of the matter of heat, and original elasticity as a universal property of bodies, due to the fundamental force of repulsion.[90] Here, we are confronted with an explanatory gap between the fundamental forces of matter and the specific (derivative) elasticity of particular bodies (e.g., air). For the *Metaphy-*

[87] AA 4: 527.
[88] AA 4: 529.
[89] AA 4: 529–530.
[90] AA 4: 530.

sische Anfangsgründe provide no insight into the relationship between, e.g., the matter of heat, responsible for the elasticity of air, and the fundamental forces of attraction and repulsion.

In conclusion: Kant's General Remark to the Dynamics shows that there are gaps between rational and empirical physics. It is no surprise that Kant notes that he cannot provide a "sufficient explanation for the possibility of matter and its specific variety from these fundamental forces". At the same time, however, Kant notes with respect to natural science that "the most important of all its tasks" is that of "explaining a potentially infinite *specific variety of matters*".[91] If physics is to be a system, we require an account of the manner in which rational and empirical physics are related. At the level of dynamics we are thus confronted with the task of explaining the specific variety of matter on the basis of the metaphysical principles of dynamics, i.e., the fundamental forces of attraction and repulsion. The *Metaphysische Anfangsgründe* provides no concrete insight into how Kant's dynamics is to be further developed so as to enable an account of the specific variety of matter. However, that we require such an account is, given Kant's demand that any science must constitute a system, inevitable. The necessity of the transition project that Kant undertakes in the *Opus postumum*, which is a transition from the metaphysical foundations of natural science (rational physics) to (empirical) physics, is thus already apparent in the *Metaphysische Anfangsgründe*. Finally, anticipating our analysis of the *Opus postumum*, we may note that the distinction between (ii) empirical physics and (iii) cognition of nature obtained through the application of a priori principles to empirical propositions, is not strict. As we shall see, in the *Opus postumum* Kant comes to treat empirical physics as based on both a priori and empirical principles. In effect, empirical physics is treated as an instance of (iii).

4.3.3 *Physica rationalis* and *physica generalis*

In conclusion of this section, we may consider how Kant distinguishes between different types of physics in terms of different types of cognition, i.e., in terms of the differing method in which cognition of nature 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."[92] *Physica rationalis* provides a priori *meta-*

[91] AA 4: 532.
[92] *KrV*, A 847/B 875n.

physical 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 run together. For the advantage of the sciences it is "of the greatest importance to separate homogeneous principles from one another", in order to "guard against the uncertainty arising from mixing things together".[93] Hence, it is necessary to present the metaphysical (non-mathematical) principles of natural science *separately* in a system. 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*.

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* (see below), Kant does not provide a precise description of how he understands the term. We can increase our understanding of the notion *physica generalis* if we, following Konstantin Pollok, consider a popular textbook on physics in the eighteenth century.[94] In this textbook (and in other textbooks, as will become clear in the next section) the notion of a *universal part of the doctrine of nature* (corresponding to Kant's term *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.[95] The particular part of the doctrine of nature treats of particular parties of bodies, i.e., properties pertaining to particular classes of objects. Here Eberhard discusses, for example, the distinction between fluid and solid bodies, various types of fluids and solids, etc. Kant's notion of *physica generalis*, corresponding to Eberhard's universal

[93] AA 4: 472–473.

[94] Pollok 2001, 122–126, provides an analysis of the notion *physica generalis*. My account agrees with that of Pollok.

[95] 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, like the second, ordered in two parts. The first part discusses universal properties of bodies, the second part specific properties of bodies. The list of universal and particular properties closely corresponds to that of the second edition.

part of the doctrine of nature, can be construed as a doctrine concerning the universal properties of bodies: it is a universal doctrine of nature.[96]

The topics that Eberhard treats under the rubric of the particular part of the doctrine of nature correspond to the topics Kant treats in the General Remark to the Dynamics. In contrast, Kant's discussions of the metaphysical foundations of phoronomy, dynamics, and mechanics, provide a *metaphysical* analysis of the *universal* properties of matter comprising the subject of *physica generalis*. As we have seen, Kant prides himself in strictly distinguishing between metaphysical, mathematical and empirical principles of natural science. His presentation is stricter than that of Eberhard, in which *physica generalis* constitutes an amalgam of metaphysics, mathematics and specific experiments. Kant can strictly distinguish between the metaphysical and mathematical principles of natural science because he, in contrast to Eberhard, focuses on the *type of cognition* (*Erkenntnissart*) characteristic of different disciplines.

In Kant's lecture notes of physics, the *Danziger Physik*, the notion *physica generalis* is also discussed. Here, *physica generalis* is construed as a 'mathematics of nature', which provides "cognition of nature from mathematical grounds or the construction of concepts".[97] As such, *physica generalis* signifies a body of cognition of nature obtained by a particular, mathematical *method*, as distinct from the method of metaphysics. It is likely that Kant is here referring to the mathematical method of natural philosophy as employed by Newton, who described the *Principia* as developing a *mathematical science* concerned with the forces that are required for motions and with demonstrating the effects or motions of forces.[98]

This interpretation is confirmed in the Preface to the *Metaphysische Anfangsgründe*, where Kant argues that one should distinguish the metaphysical principles of natural science (*physica rationalis*) from the mathematical

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[96] Johann Christian Polykarp Erxleben, in his *Anfangsgründe der Naturlehre* (1772), 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, in contrast to Erxleben and Kant, 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, however, employ the Latin terms.

[97] AA 29: 101.

[98] Newton himself employs the term 'rational mechanics', which proceeds "rigorously through demonstrations" and is defined as "the science, expressed in exact propositions and demonstrations, of the motions that result from any forces whatever and of the forces that are required for any motions whatever." Newton 1999 [1726], 381–82.

principles (contained in *physica generalis*) of natural science.[99] Kant criticizes natural philosophers employing the mathematical method for not making this distinction, and for rejecting metaphysics while implicitly making use of metaphysical principles (in the following, we will see that this critique is also articulated in the *Opus postumum*). The target of Kant's criticism seems to be Newton, who, in the definitions and scholia of the *Principia*, introduced metaphysical principles (e.g., absolute space, inertial force, etc.) without subjecting these principles to a proper metaphysical analysis.[100] In the *Principia*, then, we have a mixing of metaphysical and mathematical principles (both pertaining to *physica generalis*). The purpose of the *Metaphysische Anfangsgründe* is, as said, to provide a distinct exposition of the metaphysical (a priori) principles grounding the mathematical cognition of nature.

4.4 Physics as presented in eighteenth-century textbooks

In the previous sections I have discussed Kant's conception of physics. In the next sections I discuss some views on physics adopted by German scientists in the latter half of eighteenth century. This discussion will allow us to determine how Kant understands physics in the *Opus postumum*.

I analyze two textbooks on physics and one dictionary, spanning the second half of the eighteenth century. These are: 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* (1787–96). I have referred to these writings in the preceding discussion of Kant. However, a more detailed discussion of these works, specifically: of the conception of physics articulated in these works, will be useful for assessing Kant's transition project in the *Opus postumum*.

Kant was familiar with all three cited works. He employed Eberhard's textbook in his lectures on physics in the 1750s and 1760s.[101] After adopting Erxleben's *Anfangsgründe der Naturlehre* from 1772 to 1783[102], Kant lectured on physics following Karsten's *Anleitung* in 1785. Both Kant's lectures, recorded as the *Danziger Physik*, and Karsten's *Anleitung* are printed in the

[99] AA 4: 472–473.
[100] Cf. Pollok 2001, 124.
[101] For an overview of Kant's activity as a lecturer and of the textbooks employed in his lectures, see Naragon 2009.
[102] I briefly mention Erxleben's *Anfangsgründe der Naturlehre* below, 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.

Akademie-Ausgabe (to which I refer). 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 and to the beginning of the nineteenth century as containing the origins of modern science.[103] It is argued that in this period the word 'science' became restricted to the investigation of nature, referring only to *natural sciences*. In addition, we witness radical developments within various experimental sciences. Here one may think of developments within chemistry associated with the so-called chemical revolution. One may also think, however, of the creation of biology and geology as autonomous sciences. In short, we witness the proliferation, differentiation and specialization of various natural 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 were trying to come to grips with the scientific developments within the natural sciences. In particular, they asked themselves how, in light of the differentiation of natural sciences, it is possible to still understand physics as a unified whole. It is precisely this topic that constitutes the subject of Kant's *Opus postumum*. Through the study of these textbooks we can (I contend) gain insight into several discussions concerning physics that inform Kant's transition project in the *Opus postumum*.

In the following, I describe some of the controversies concerning the nature of physics that come to the fore within the mentioned sources. These include 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 focus on the conception of organic nature articulated by these various authors. As we shall see, although the study of organic nature is not assigned a central place within physics, it is typically treated as a part of physics (although, to be sure, the study of organisms is still placed under *natural history*).

4.4.1 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 required the delimitation of physics from other sciences, most importantly pure and applied mathematics, and a precise account of the content of physics. In specifying the content of physics,

[103] Cf. Cunningham and Williams 2003, 218–246.

Eberhard employs a number of important conceptual distinctions that will constitute the focus of inquiry in what follows.

In the Introduction to Eberhard's *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.[104] As such, it is distinguished from pure and applied mathematics.[105] In contrast to the doctrine of nature, pure mathematics is concerned with abstract representations of bodies, i.e., bodies considered merely in accordance with their extension and quantity, and not with actual given bodies. The doctrine of nature is also distinguished from applied mathematics. Applied mathematics does, in contrast to pure mathematics, consider actual given bodies (e.g., in optics or astronomy). However, applied mathematics is taken to consist in the *mere mathematical treatment* of forces of material bodies: it does not investigate (or it abstracts from) the *causes* of phenomena, as in the doctrine of nature.

As we have seen, Eberhard distinguishes between a general and a special part of physics, which I will respectively describe (employing the Latin terms) as *physica generalis* and *physica specialis*. This distinction informs the structure of the textbook. Eberhard introduces this distinction by noting that in the doctrine of nature, we consider either (a) the universal properties of bodies, or (b) the particular phenomena 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*, whereas all special or particular bodies must be learned *a posteriori*, i.e., these properties are determined *solely* on the basis of *experience*.[106]

In line with the distinction between universal and particular properties of natural bodies, we can divide the doctrine of nature 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* 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 a *physica specialissima*.[107] Thus, moving from the universal to the more particular we have: *physica generalis*, *physica specialis*, *physica specialissima*.

Insofar as special properties must be learned a posteriori, *physica specialis*

[104] Eberhard 1774, 2.
[105] Eberhard 1774, 2–4.
[106] Eberhard 1774, 6.
[107] Eberhard 1774, 11–12.

can be described as *empirical physics*. Eberhard describes empirical physics as the part of the doctrine of nature in which we determine properties and effects of bodies, as well as the forces of corporeal nature, from experience. In contrast, *physica rationalis* is that part of the doctrine of nature in which the phenomena of corporeal nature are derived from the forces of bodies.[108] 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 first grounds, whereas empirical physics proceeds analytically from effects given in experience. 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). In short: *physica generalis* grounds *physica specialis* (see also below).

Within *physica generalis*, the first part of Eberhard's *Naturlehre*, Eberhard discusses (i) 'extension', (ii) 'impenetrability', (iii) 'divisibility', (iv) 'movability' and (v) 'force'. These are the universal properties of matter. (i)–(iii) contain many metaphysical discussions concerning the nature of material bodies. (iv) primarily contains discussions pertaining to kinematics and discussion of (Newton's) laws of motion.[109] In (v), Eberhard argues that attractive force is essential to matter. Here, Eberhard considers among others cohesion, Newtonian universal attraction or gravitation, weight and free fall and the motion of pendulums.[110]

In *physica specialis*, the second part of his *Naturlehre*, Eberhard considers particular properties of matter with respect to specific classes of material objects. *Physica specialis* is treated in four parts: a 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. (1) contains a discussion of the properties of fluid bodies in general,

[108] Eberhard 1774, 11.

[109] Eberhard 1774, 47–112. Note, however, that 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, while Newton's parallelogram rule for motions, which in the *Principia* is presented in Corollary 1 to the second law of motion (Newton 1999, 417), is presented as a separate law of motion. In general, Eberhard's presentation of physics seems to differ quite substantially from that of Newton.

[110] Eberhard 1774, 133–161.

containing discussion of, e.g., droplet-forming fluidity, the motion of fluids in capillary tubes, and of specific fluid bodies: (1a) air, (1b) heat and light, (1c) cooling matter (*kaltmachende Materie*), (1d) electricity or electric matter, (1e) magnetism or magnetic matter, (1f) water. Part (2) contains a discussion of specific solid bodies: *elastic* solid bodies and *brittle* solid bodies. In (3), Eberhard provides a discussion of various chemical topics, e.g., the dissolution of salts, sugar, and gummi in water. I will return to the content of (4) below.

In introducing the second part of his *Naturlehre*, Eberhard notes that in the special or particular 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. Hence, in *physica specialis* we must, in order to cognize the nature of special or particular bodies, determine on which forces the particular properties of specific material bodies depend.[111]

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 attractive force (more specifically: cohesion) treated in *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 dependent on (and explicable in terms of) attractive force.[112] Here we see how Kant's programme, undertaken in the *Metaphysische Anfangsgründe*, of explaining the specific variety of matter in terms of fundamental forces conforms to the presentation of physics in contemporary textbooks on physics (although, of course, there are substantial differences in the exposition of this programme).[113] The idea informing these programs is that of physics as a *unified*, *systematic whole*.

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[111] Eberhard 1774, 162–163.

[112] *Ibid.*

[113] To note some of these differences: one of Kant's central claims in the *Metaphysische Anfangsgründe* is that repulsive force is essential to matter. This was a highly contentious claim, not shared, for example, by Eberhard. In addition, whereas Eberhard takes cohesion, construed as an attractive contact force, to be essential to matter, Kant (as we have seen) 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 of gravitation. This presentation has the purpose of eradicating common (mechanist) objections with respect to Newtonian gravitation. Kant, however, reverses this presentation. He first argues that universal Newtonian gravitation is essential to matter, and subsequently treats of cohesion.

In conclusion, it is important to note that part (4) of *physica specialis*, containing a discussion of specific phenomena of specific types of bodies, provides 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, zoology.[114] Plants (lifeless bodies having a regular structure and organization) and animals (bodies having a regular structure and 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, with respect to plants Eberhard discusses Linné's classification of plants according to the *methodus sexualis* in (a). (b) contains a discussion of the structure found in any plant, e.g., root, stem, etc. In (c), Eberhard argues that the structure of plants derives from God. To assume a formative force in nature, responsible for the structure of plants, is considered absurd. Finally, in (d) the process of nutrition, in particular the modification of water in oily and salty parts (providing nutriments) is discussed. The discussion of animals follows the same structure.[115]

Note that Eberhard's treatment of topics (a)–(d) can be related to our discussion of biological topics given in the preceding chapters. Thus, (a) relates to our discussion of Kant's views on classifications in (what he calls) natural description treated in Chapter 1, while the method of specifying the structure of organisms (b) is similar to Wolff's method of investigating organisms treated in Chapter 2. In Chapter 3, we have seen that the investigation of (c) the origin and (d) the nourishment and growth of organisms constituted central concerns of biologists in the eighteenth century. Finally, the claim that one should not assume a formative force in nature to account for the structure of organisms relates to the topic of *vital forces* discussed in Chapter 3 with respect to Blumenbach (although Eberhard does not refer to Blumenbach's theory of the *Bildungstrieb* in this context, since this theory was not yet published). Hence, central eighteenth-century biological topics were treated as a part of physics by Eberhard.

Eberhard's presentation of physics in his *Naturlehre* was common in the latter half of the eighteenth century. For example, Friedrich Albrecht Carl Gren, in his *Grundriß der Naturlehre* (1793[3]) also structured his textbook in accordance with the distinction between a universal and a particular part of the doctrine of nature.[116] 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 *An-*

[114] Cf. Eberhard 1774, 4–5.
[115] Eberhard 1774, 762–781.
[116] Gren 1793.

fangsgründe der Naturlehre (1772), the universal doctrine of nature (*physica generalis*) is describes as considering the properties of bodies in general. This *physica generalis*, treated in the textbook, encompasses Eberhard's *phsyica generalis* and (!) *physica specialis*. In addition, Erxleben, once again in contrast to Eberhard, defines natural history as *physica specialis*.[117] Hence, although there existed considerable agreement with respect to the content of scientific topics treated in these textbooks, there was some confusion concerning the proper definition of physics.

4.4.2 Karstens's *Anleitung zur gemeinnützlichen Kenntniß der Natur*

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 several of Karsten's views and those of (e.g.) Eberhard. What distinguishes Karsten's work, however, is his great stress on the importance of chemistry. 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 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 applied mathematics, according to Karsten, is a mere doctrine of magnitude. As such, applied mathematics does not provide any insight into the nature or properties of material bodies.[118] It is the ultimate goal of physics, however, to provide us with this insight.

Karsten's description of applied mathematics conforms to other descriptions of applied mathematics in eighteenth-century textbooks. As we have seen, in his *Naturlehre* Eberhard defined the doctrine of nature as a science of the properties and effects of given, *actual* bodies, and of the *causes* of natural phenomena. As such, it is distinguished from pure mathematics, which is not concerned with actual given bodies, and from applied mathematics, which does not investigate the *causes* of phenomena. In Gehler's *Physikalisches Wörterbuch*, we are confronted with the broad application of the term applied mathematics. Applied mathematics is described as the application of pure mathematics to actual objects of nature. It is a science that does not have any

[117] Erxleben 1772, 8–9.
[118] AA 29: 173–174.

strict limits: it can contain as many sciences as there are objects that allow of mathematical treatment. However, the usual objects of investigation of applied mathematics are (i) the forces and motions of bodies, (ii) light and (iii) celestial bodies. Hence, applied mathematics is usually taken to consist of the mechanical, optical and astronomical sciences.[119]

Karsten is critical of applied mathematics. I would suggest that Karsten's statements are directed against the Newtonian tradition of natural philosophy. Newton is sometimes interpreted as believing that phenomena can be explained merely by determining how they follow from a law of nature (with an appropriate mathematical structure).[120] For example, in his *Untersuchung über die Deutlichkeit* (1763), Kant takes Newton's method in natural science to consist in finding the rules in accordance with which phenomena occur. In respect to this method, Kant notes that "even if one does not discover the fundamental principle of these occurrences in the bodies themselves, it is nonetheless certain that they operate in accordance with this law."[121] In this sense, 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 may be interpreted as criticizing these kinds of explanations for not taking into account the physical nature or inner constitution of bodies. Newtonian natural science might then be construed as a form of applied mathematics, a mere *Größenlehre*, in which we do not investigate the causes of phenomena. From our modern perspective, it is somewhat strange to interpret Newton, e.g., in his *Principia*, to provide a mere *Größenlehre*.[122] However, Karsten's remarks certainly suggest that he interprets Newtonian science in such a manner, an interpretation perhaps partly motivated by a traditional mechanistic critique of Newton.

(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.[123]

Karsten's criticism of the traditional conception of physics seems to be

[119] Gehler 1787–1796, Bd. 3, 157–158.

[120] Whether this interpretation is correct is another issue, which I will not discuss in the present context.

[121] AA 2: 286.

[122] Cf. for example Friedman 1992a, 226–231, who would certainly object to such a characterization.

[123] This is a view that is certainly not explicit in the textbook of Eberhard.

primarily motivated by his recognition of the fundamental importance of chemistry for physics. Throughout his textbook, Karsten stresses the importance of interpreting chemistry as a part of physics. Physics should be developed into a mathematico-chemical physics. Karsten's emphasis on the importance of chemistry must be understood against the background of the developments taking place within the theory of heat and chemistry in the eighteenth century (often referred to as 'The Chemical Revolution'). Michael Friedman has given a detailed exposition of the development of chemistry in the late eighteenth century and of its reception in Germany (also briefly discussing Karsten's work).[124] For us, it is merely important to note that these scientific developments led Karsten to argue that a 'true physics' must include chemical doctrines.

(iii) Finally, Karsten criticizes the traditional 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.[125] A proper presentation of natural history, in particular of mineralogy, requires chemical knowledge. Alternatively, a chemist cannot analyse the basic materials found in nature without somehow basing himself on the classifications of materials provided by natural history. Thus, chemistry and natural history are intimately related.[126] Similarly, as stated in (ii), 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 specifies the general grounds and principles of (mathematical) physics, chemistry and natural history, explains some of their fundamental theories, and explicates the relationships between these three disciplines. As such, the *Anleitung* is meant to provide a presentation of the doctrine of nature which allows to understand this doctrine as a single whole, consisting of various interrelated disciplines. According to Karsten, such a conception of the doctrine of nature, in contrast to the standard presentation of the natural sciences, is in harmony with the contemporary practice of the natural sciences and anticipates future developments of these sciences.[127]

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[124] Friedman 1992a, 264–290.
[125] AA 29: 175.
[126] *Ibid.*
[127] AA 29: 174–175.

The main points of Karsten's criticism of the traditional conception of physics can be summarized as follows: the recent advancements within the experimental sciences, and in particular within chemistry, require a re-evaluation of the traditional understanding of physics. In light of these advancements, the distinction between physics and chemistry can no longer be upheld. Chemistry constitutes an integral part of physics. This conception of physics also implies that physics cannot be interpreted as a form of applied mathematics. Finally, the contemporary practice within the natural sciences requires us to give up our understanding of physics, chemistry and natural history as distinct disciplines. Rather, we must recognize that these disciplines are related to each other in fundamental ways. It should be the goal of any scientist to investigate and explain the relations obtaining between these disciplines, and to strive for a doctrine of nature constituting a unified systematic whole. It is clear: Kant's conception of physics as a unified, systematic science was not abandoned by his contemporary physicists.

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.[128] This suggests that a unified doctrine of nature should include what would later be construed as the study of organic nature or biology. 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, the study of plants and animals is, as was the case for Eberhard, taken to constitute an integral part of physics.

4.4.3 Gehler's *Physikalisches Wörterbuch*

Gehler's conception of physics is both similar to and distinct from that of Karsten. Gehler (like Karsten) takes chemistry to constitute a part of physics. However, Gehler rejects Karsten's negative construal of applied mathematics. In addition, Gehler notes the difficulties in conceiving of physics as a unified science of nature as a whole. The ideal of a unified physics is not abandoned by Gehler. However, he is very sensitive to the fact that, in the late eighteenth century, different doctrines of nature become more and more specialized. Various doctrines of nature are described as *fragments* that are not systematically

[128] AA 29: 187–188.

related to each other. Hence, although the ideal of a unified physics is not abandoned, Gehler recognizes that this ideal is extremely difficult to realize.

In the lemma on *Physik*, Gehler first defines physics, in the most general sense of the term, as the doctrine of corporeal nature.[129] In this sense, physics is understood as the sum of all empirical cognition of nature. This definition is criticized. Not because it is incorrect, but because it is unfit for didactical purposes: we cannot teach physics as the sum of empirical cognition of nature.[130] Hence, Gehler proposes (in conformity with common practice) to differentiate between different particular sciences of nature in order to arrive at a definition of physics proper. He considers some standard classifications, yet criticizes them as arbitrary. Ultimately, as we shall see, Gehler recognizes that he is unable to give a precise definition of physics.

Gehler scrutinizes the common classification of doctrines of nature based on the 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 taken to be a mere descriptive (historical) discipline, concerned with the classification of natural kinds. Applied mathematics is defined as the quantitative study of nature, consisting in the application of pure mathematics to nature and comprising the mechanical, optical and astronomical sciences. Finally, 'physics' is simply what remains if we treat natural history and applied mathematics as distinct autonomous 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)[131]

This description of physics may be related to the conception of physics of Eberhard. Recall that Eberhard divided physics in a universal and particular part. In the universal doctrine of nature we treat universal properties of corporeal bodies. In the special doctrine of nature, we treat (merely empirically cognizable) properties of corporeal bodies that are peculiar to specific classes

[129] Gehler 1787–1796, Bd. 3, 489.
[130] *Ibid.*
[131] 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".

of objects. Gehler's description of physics, treated as that which remains if we isolate natural history and applied mathematics, thus roughly conforms to a combination of universal and special physics in Eberhard's sense. Gehler notes the existence of gaps (*Lücken*) between these various doctrines of nature, i.e., between the universal and particular doctrines of nature. These gaps require bridging. Here we see how Gehler is both sensitive to the specialization of distinct doctrines of nature, while also maintaining the idea of physics as a unified, systematic science. In our discussion of the *Opus postumum*, we will see that Kant was similarly concerned with bridging gaps within natural philosophy, specifically: between rational and empirical physics.

Is the strict distinction between natural history, applied mathematics, and physics justified? Gehler argues that it is not. The isolation of physics from applied mathematics and natural history is motivated by the thought that the latter two disciplines are not genuinely explanatory. Here, scientific explanation is understood as a type of causal explanation. Natural history is not explanatory since it only provides a systematic classification of natural bodies and does not specify any cause of the origin or structure of a natural body. Similarly, applied mathematics does not provide us with any cognition of the properties of natural bodies nor with insight into their causes (this last claim strongly resembles Kartsen's critique of applied mathematics treated in the previous section).[132]

Gehler rejects this argument and thus rejects the strict division between natural history, applied mathematics and physics. In addition, the strict division of scientific disciplines does not, according to Gehler, do justice to the nature and practice of contemporary science. 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 rubricated under the name applied mathematics (e.g., optics and astronomy) thus provide us with an ideal of scientific knowledge and should be taken to form an integral part of physics.[133]

(b) The inclusion of applied mathematics within the scope of physics goes hand in hand with a critique of the view of scientific explanation on which the classification of sciences given above is based. This view of scientific explanation is too strict. Understanding scientific explanation as a form of causal

[132] Gehler 1787–1796, Bd. 3, 494.
[133] Gehler 1787–1796, Bd. 3, 492–93.

explanation does not harmonize with scientific practice, or so Gehler argues. Scientific explanation is often understood in purely deductive terms, i.e., a particular event is scientifically explained if it can be derived from natural laws. It is this view of scientific explanation which, according to Gehler, conforms to the dominant contemporary scientific method, as introduced by Bacon and Newton.[134]

(c) The inadequacy of the idea of causal explanation shows the inadequacy of conceiving physics as a science concerned with the investigation of the causes of phenomena. Defining physics in this manner would, given the fact that we hardly have any knowledge of the true causes of phenomena,[135] deprive physics of any genuine content. That is to say, physics would merely provide us with a collection of speculative hypotheses and could not teach us any truths.[136]

(d) Finally, Gehler rejects the considered division of natural sciences because it does no justice to the fact that natural history, applied mathematics and physics are *interrelated disciplines* which cannot be treated in isolation. In addition, it does not enable us to properly classify chemistry.[137] In this context, Gehler, similar to Karsten, emphasizes the importance of including chemistry within physics. The reason is (briefly) that chemistry has significantly increased our cognition of the nature of the fluid bodies, air and heat, topics which were traditionally rubricated under (special) physics. Hence, chemistry is indispensable for physics.[138]

In light of the numerous interrelationships between various doctrines of nature, Gehler adopts a liberal and pragmatist stance toward the definition of physics. He admits that he is unable to give a precise definition.[139] 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 is taken to pertain to physics is to be decided on the basis of didactical grounds or on the basis of specific scientific needs, since, given the present state of the physical sciences, a precise definition and classification of physics cannot be given.[140]

In conclusion, we may inquire into Gehler's presentation of the study of organic nature. In the lemma on natural history, Gehler distinguishes be-

[134] Gehler 1787–1796, Bd. 3, 456–57.
[135] Gehler 1787–1796, Bd. 3, 496.
[136] Gehler 1787–1796, Bd. 3, 490.
[137] *Ibid.*
[138] Gehler 1787–1796, Bd. 3, 491, 493.
[139] Gehler 1787–1796, Bd. 3, 494.
[140] Gehler 1787–1796, Bd. 3, 489.

tween a universal and a special natural history.[141] Universal natural history is defined as a descriptive account of objects on earth. In this very broad sense, it includes, e.g., the historical account of heavenly bodies, the natural history of the earth (physical geography), and classifications of materials and bodies pertaining to chemistry and physics. Special natural history is the study of the three kingdoms of nature, i.e., the kingdom of plants (*regnum vegetabile*), animals (*regnum animale*), and of minerals (*regnum minerale*).

Importantly, Gehler defines plants and animals as species of the genus *organized bodies* (plants being non-sensitive organized beings, animals being sensitive) while minerals are non-organized bodies. Organized bodies are those that have an *organic structure* (*organischer Bau*), i.e., a structure which enables the obtainment of specific *purposes*, e.g., the structure of the eyes, ears of sensitive animals.[142] Here, we are confronted with (in Kant's terms) the principle of original organization lying at the basis of what we now call biology (Chapter 3). It is this organic structure which constitutes the basis for distinguishing plants and animals from minerals. Moreover, in virtue of this organic structure 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*).[143]

In Gehler's dictionary we thus find a characterization of organisms in teleological terms, and a distinction between organic and non-organic bodies in terms of the organic functions of nutrition and growth. As we have seen in the previous chapter, Kant and Blumenbach also characterize and delimit organic nature in these terms. Gehler's dictionary provides a characterization of organisms common in the late eighteenth century.

In conclusion, the study of the works of Eberhard, Karsten and Gehler provide the following results. All three authors adopt the ideal of establishing physics as a systematic unified science, although in the work of Gehler (at the end of the eighteenth century) this ideal was taken to be almost impossible to realize. Eberhard and Karsten aim to strictly distinguish physics from mathematics and applied mathematics, construing physics (in contrast to the former two disciplines) as a science concerned with actual physical bodies and with the *causes* of natural phenomena. In contrast, Gehler rejects any attempt to strictly distinguish physics from applied mathematics and scientific explanation is

[141] Gehler 1787–1796, Bd. 3, 312–313.
[142] Gehler 1787–1796, Bd. 3, 388.
[143] Gehler 1787–1796, Bd. 3, 388–389.

not understood as explanation in terms of causes.[144] All three authors adopt a rather broad conception of physics, i.e., as including (parts of) Newtonian physics and mechanics, chemistry and the study of organic nature (rubricated under natural history). However, the importance of chemistry is increasingly stressed towards the end of the eighteenth century. Moreover, both Karsten and Gehler stress the fact that physics, chemistry and natural history are interrelated disciplines. Finally, although all three authors include the study of organic nature in physics, and Eberhard and Gehler in particular discuss paradigmatic eighteenth-century topics of biological investigation (e.g., structure, growth and nutrition), 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.

With respect to our discussion of Kant's *Opus postumum*, it is especially important to keep in mind the problematic status assigned by Gehler to the ideal of a systematic physics. Physics is characterized as a collection of poorly connected fragments, and there exist gaps between *physica generalis* and *physica specialis*. Hence, although distinct sciences should constitute a unity and are fundamentally interrelated, the question how they are related is difficult to specify. These problems (as we will also note in the following) already affected Eberhard. Although he presented *physica generalis* as grounding *physica specialis*, the specific relation between these two parts of physics is never specified. It is against this background that Kant wrote both his *Metaphysische Anfangsgründe* of 1786 and the reflections contained in the *Opus postumum* in the 1790s. As we shall see in the following sections, Kant presents his *Transition* as a part of natural science that connects the metaphysical foundations of natural science (rational physics) with physics as an empirical doctrine, and thus establishes physics as a systematic science.[145] That Kant undertakes such a program is, given the background sketched in the present section, not very surprising. In §4.3.2, we have seen that the relation between rational and empirical physics was also discussed within the *Metaphysische Anfangsgründe*. However, Kant acknowledged the existence of explanatory gaps between rational and empirical physics. Hence, an additional project was necessary.

[144] Note that this conception of scientific explanation is quite different from the conception of explanation ascribed to Kant in Chapter 1, i.e., explanation as a derivation from premises specifying the objective grounds (in natural science: causes) of phenomena, or: explanations proceeding from cause to effect. In this respect, Kant's position is akin to that of Eberhard and Karsten.

[145] Kant presents the *Transition* as a part of natural science in a letter to J.G.C. Kiesewetter of October 14, 1798 (AA 12: 258). I will treat the other determinations of Kant's *Transition* in the following section.

4.5 Kant's transition (*Übergang*) to physics

In the previous sections, I discussed Kant's conception of physics and that adopted by several contemporary eighteenth-century scientists. In the following, I will relate these various conceptions on physics to Kant's transition project developed in the *Opus postumum*.

In §4.5.1, I show that Kant's transition from the metaphysical foundations of natural science to physics is supposed to ground the systematicity of physics. To establish physics as a system was, as we have seen, an ideal of both Kant and many physicists in the eighteenth century. In §4.5.2, we will see that Kant construes physics as empirical physics and that this notion corresponds to what was traditionally termed *physica specialis*. Hence, the project of a transition from the *Metaphysische Anfangsgründe* to physics is analogous to the project of grounding propositions of *physica specialis* in propositions of *physica generalis*, a project through which physics as a whole is established as a systematic science. §4.5.3 contains a discussion of various scientific topics in the *Opus postumum*, and aims to illuminate how precisely Kant tries to ground the systematicity of physics. In §4.5.4, I discuss the relationship between the a priori and the empirical within Kant's transition project. §4.5.5 relates the interpretation I have developed to the various interpretations of Kant's *Transition* project discussed in §4.1. Finally, §4.5.6 shows that Kant's *Transition* project has ramifications for Kant's views on the status of biology. Biology is a part of physics and should therefore be treated within the *Transition*.

4.5.1 Kant's transition project and the systematicity of physics

With the so-called *Oktaventwurf* (1796), a term introduced by Erich Adickes, systematic work on the *Transition* is usually taken to begin.[146] In one of the first drafts of a preface contained in the *Oktaventwurf*, Kant introduces his *Transition*, which itself is an a priori science, by distinguishing the metaphysical foundations of natural science from 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)

[146] Adickes 1920, 54–86.

The notion '*philosophia naturalis*' denotes a science of corporeal nature as a whole. In familiar fashion, Kant distinguishes between the metaphysical foundations of natural science and physics by focusing on their peculiar mode of justifying cognition (a priori versus a posteriori). The metaphysical foundations are interpreted as providing a priori (metaphysical) 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 (empirical physics, *physica empirica*), 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, i.e., as explicating 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)

And similarly, Kant remarks with respect to the relation between the metaphysical foundations of natural science and physics:

> […] there can be a relationship of the one form of knowledge to the other which rests neither entirely on principles *a priori*, nor on empirical principles, but simply on the transition from one to another; [it shows] how it is possible for us to collect and order the elements of a doctrine of nature to be based on experience, and to arrange them with the completeness required for systematic classification. Thus one attains a *physics* which is a comparatively complete whole. (AA 21: 402–403)

In the first passage, the necessity of a transition from the metaphysical foundations of natural science to physics is taken to be prescribed by the doctrine of method (*Methodenlehre*). For Kant, as we know from the *Jäsche Logik*, the doctrine of method specifies the conditions of scientific cognition in general. In particular: it specifies how logical perfections of cognition, such as *distinctness* (*Deutlichkeit*), *thoroughness* (*Gründlichkeit*), and *systematicity* are to be obtained.[147]

Given this conception of the doctrine of method, it is no surprise to read in the second passage above that the transition from the metaphysical foundations of natural science to physics, prescribed by the doctrine of method,

[147] AA 9: 139–140. Cf. §1.1.

is necessary in order to show how physics can constitute a *systematic* whole. The aim of the transition is to ground physics as a systematic science.[148] Moreover: 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 systematic whole. In addition, by providing a transition from rational to empirical physics it shows how natural science in general (*philosophia naturalis*), encompassing both rational and empirical physics, can constitute a systematic whole.

In the first 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.[149] Insofar as the structure of a system, i.e., the relation of its parts, 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".[150] In the *Opus postumum*, Kant frequently 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. That is, 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 therefore an impossibility: a system requires a priori foundation.[151] 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: we would

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[148] This aspect of Kant's thought in the *Opus postumum* has, in more recent discussions, received marginal attention. However, it is stressed by Gloy 1976, 175–218; and Hoppe 1969.

[149] For further details, cf. §1.1.

[150] *KrV*, A 833/B 861.

[151] On this topic, cf. for example AA 21: 402 (1796); AA 21: 161, 164, 360, 363, 367 (1798); AA 22: 279–280, 287–289 (1799–1800).

not be able to specify a systematic relation between rational and empirical physics.

Recall that Gehler, in his dictionary on physics, analyzed physics as a fragmentary doctrine, in which there exist gaps between various disciplines.[152] In particular: Gehler cited the existence of gaps between the doctrine of the universal properties of bodies (*physics generalis*) and the doctrines concerning simple materials of bodies (as treated in chemistry), electricity, magnetism and the phenomena of air (all pertaining to *physica specialis*). In analyzing physics as a fragmentary doctrine full of gaps, Kant was thus not original. In addition, Kant was not original in emphasizing that physics should constitute a system. Although scientists in the late eighteenth century became increasingly sceptical of the possibility of presenting physics as a systematic science, they did not, as we have seen, abandon the ideal of physics as a system. However, distinctively Kantian is the thought that if physics is to be a systematic science, this systematicity is to be grounded philosophically (a priori). Hence, the transition project is construed as an *a priori*, *philosophical* discipline, grounding physics as a systematic science. To conceive of something like a transition project is completely foreign to the views of many scientists in the late eighteenth century. Neither Eberhard, Erxleben, Karsten nor Gehler conceived of such an enterprise. However, given Kant's general views on systematicity, in particular his conviction that rational physics should ground empirical physics, the emergence of such a project in Kant's thought is understandable.

It is important to note that Kant conceives of his transition project as a transition between distinct *territories*.[153] For example, in a draft to an introduction for the *Transition*, contained in fascicle 4 (September-October 1798), Kant 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.[154]

Recall that Kant speaks of the territory of a concept in order to refer to the set of objects, contained in the extension of this concept, that we can have cognition of. To say that the territory of the metaphysical foundations is delimited by a priori principles is to say that the former have a particu-

[152] Cf. §4.3.3.
[153] On the notion 'territory', cf. §4.1.
[154] 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).

lar set of corporeal objects as their object of investigation, yet only provides cognition of these objects on the basis of a priori principles. In other words, the metaphysical foundations of natural science are concerned with a priori comprehensible properties of corporeal objects (here we determine the territory of the *Metaphysische Anfangsgründe* in terms of its a priori source of cognition). Analogously, physics has a particular set of corporeal objects as its object of investigation, yet provides cognition of these objects on the basis of empirical principles. In other words, physics is concerned with empirical cognizable properties of corporeal objects (here we determine the territory of physics in terms of its empirical source of cognition). Importantly, although the metaphysical foundations of natural science and physics have distinct territories, they are concerned with the same object, i.e., both are concerned with the same set of corporeal objects. As Kant puts it: both are concerned with (corporeal) nature. The distinction between the metaphysical foundations and physics is *merely* a distinction in terms of the status of their principles (a priori versus empirical).[155]

Because 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.[156] The necessity of a transition project thus arises (at least in part) from the fact that the metaphysical foundations and physics have the same object of investigation. The *Transition* is now assigned to bridge the gap (*Kluft*) existing between these different territories, which is precisely to say that this project provides a transition between the a priori and the empirical principles of natural science.

In conclusion: Kant's transition project is meant to ground the possibility of physics as a systematic science. Systematicity is a logical perfection of cognition, constituting a prerequisite for the scientific status of physics. If physics is based merely on empirical principles, it can only constitute a fragmentary aggregate. Hence, if physics is to constitute a systematic science, it must be based on a priori principles. These principles are provided by the *Transition*. The *Transition* is motivated by the fact that both the metaphysical foundations of natural science and physics are concerned with a common object. Hence, it is necessary to show not only that these disciplines are consistent with each other, but also how they are related to each other. We must show how rational physics grounds empirical physics.

Kant's transition project thus has the purpose of providing an a priori foundation of empirical physics. In a passage from the second fascicle

[155] AA 21: 178.
[156] *Ibid.*

(September-October 1798), 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 subject to the contest of mere opinions and hypotheses.[157] Here, we once again witness Kant's stress that scientific knowledge must constitute *certain* cognition, and, as such, should be properly (a priori) grounded. By showing how physics (considered as a science of nature comprising *physica rationalis* and *physica empirica*) can constitute a systematic whole, the *Transition* provides preliminary steps in grounding physics as a *proper science*, where the notion 'proper science' should be understood in the manner explicated in Chapter 1.

4.5.2 *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. Kant presents the *Transition* as an extension of the metaphysical foundations of natural science to physics. The question remains, of course, why Kant thought an intermediary a priori science such as the *Transition* is necessary. Did not the *Metaphysische Anfangsgründe*, providing the a priori principles of natural science in accordance with the system of the categories[158], already ground physics as a systematic science? A possible answer to this question presupposes an account of how Kant construes the nature of physics in the *Opus postumum*.

In the *Opus postumum* Kant characterizes physics as an *empirical* science. Physics is described as a system of cognition of experience, as a system of cognition based on (or from) experience, or as a doctrine of the laws of moving forces insofar as they can *only* be derived from experience.[159] 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, as well as the forces of corporeal nature, from experience (a posteriori).

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[157] AA 21: 177.

[158] In the Preface to the *Metaphysische Anfangsgründe* Kant remarks with respect to this metaphysical doctrine of corporeal nature: "In everything that is called metaphysics one can hope for the *absolute completeness* of the sciences […]. Therefore, just as in the metaphysics of nature in general, here also the completeness of the metaphysics of corporeal nature can confidently be expected. […] the schema for the completeness of a metaphysical system […] is the table of categories." AA 4: 437–474. Although these remarks concern special metaphysics (the *Metaphysische Anfangsgründe*), they suggest that the *Metaphysische Anfangsgründe* ground physics as a systematic science.

[159] Cf. for example, AA 21: 387, 402–403, 407, 310 (1796–1798); AA 22: 279, 281, 289, 448 (1799–1800).

As such, empirical physics, a science proceeding analytically from effects to causes, is distinguished from *physica rationalis* 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*). Given that Kant's description of physics in the *Opus postumum* conforms to a standard description of empirical physics in the eighteenth century, it is plausible to assume that Kant primarily associates physics with what Eberhard called *physica specialis*.[160]

There are other passages in the *Opus postumum* that support this interpretation. Kant often conceptualizes the transition project as enabling the *application* of the metaphysical foundations of natural science (*physica rationalis*) 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)[161]

Kant elucidates this claim by citing the doctrine of "attraction at a distance in general" as pertaining to the metaphysical foundations of natural science.[162] In the *Metaphysische Anfangsgründe*, Kant took the universality and immediacy of universal attraction to be established a priori. Kant now notes that the doctrine of gravity as "its laws are observed at different heights" pertains to physics.[163] This makes sense, for Newton's law of gravitation is an empirical law. To be sure, from Kant's point of view the law of gravitation is established on the basis of the application of a priori principles to phenomena. However, the law of gravitation is empirical in the sense that it is (in Newton's terms) deduced *from* the phenomena. As such it pertains to physics. Moreover, in the passage quoted above Kant stresses 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

[160] 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*.

[161] Cf. AA 21: 407, quoted above.

[162] AA 21: 311.

[163] AA 21: 311.

experimentally. For this reason, this topic pertains to physics. Once again: the distinction between the metaphysical foundations and physics is made in terms of the distinction between a priori and empirical cognition.

For our present purposes, it is important to note that the idea of *applying* rational physics to empirical physics is once again 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* within *physica specialis*, in order to explain particular properties pertaining to specific types of bodies (e.g., fluidity, solidity, etc.). Eberhard applied the notion of attractive, cohesive force (developed in *physica generalis*) in order to explain fluidity, the brittleness of solid bodies, elasticity, etc. Kant's transition project can thus be understood on the basis of a traditional view on the relationship between *physica generalis* and *physica specialis*. This circumstance again suggests that Kant associates what he calls physics in the *Opus postumum* with the notion of *physica specialis* as employed by Eberhard.

In some passages in the *Opus postumum*, Kant follows Eberhard's division of physics in *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)

The description of *physica specialis* conforms to Eberhard's conception of a special physics concerned with non-universal properties peculiar to specific classes of corporeal bodies. The distinction between organic and inorganic bodies which Kant mentions as being treated in *physica specialis* is a late eighteenth-century rendering of the idea that natural history is a part of special physics (recall that Eberhard treated the distinction between minerals, plants and animals within special physics). In a passage of later date (September-October 1798), Kant defines *physica generalis*, completely in line with Eberhard's terminology, as a 'universal doctrine of nature' (*allgemeine Naturlehre*) that is concerned with the moving forces of matter and its a priori specifiable universal properties.[164] Finally, in a passage of the third fascicle (August-September 1798) Kant defines *physica specialis* as a doctrine concerned with

[164] 21: 366.

a *specific class* of moving forces, while the study of organic nature is defined as *physica specialissima*.[165] Here, we thus have Eberhard's tripartite division between *physica generalis*, *physica specialis* and *physica specialissima*.

The importance of these conceptual divisions for Kant's transition project become apparent in a draft to an introduction contained in the fourth fascicle (September-October 1798).[166] Here, Kant introduces the *Transition* by distinguishing three parts of natural philosophy: (i) the metaphysical foundations of natural science, (ii) the universal doctrine of forces (*dynamica generalis*), and (iii) physics. The notion *dynamica generalis* is a novel one and does not, to the best of my knowledge, occur in Kant's critical writings. In the passage under consideration, Kant seems to interpret his *Transition* as providing a *dynamica generalis*. Kant notes that *dynamica generalis* is traditionally interpreted as *physica generalis*. Hence, the *Transition* adopts the place traditionally assigned to *physica generalis*, which is described as *physiologia propaedeutica*, i.e., a propaedeutic to a true doctrine of nature. Following metaphysics and the *Transition* is physics, defined as the *empirical* doctrine of nature as a system.[167] Once again, therefore, it is suggested that Kant's use of the term physics conforms to the notion of *physica specialis* as adopted by Eberhard.

In short: there is plenty of evidence suggesting that in the *Opus postumum*, the term 'physics' signifies *physica specialis*. Unfortunately, however, this reading is not entirely accurate. To be sure: Kant's transition project must be read in the context of a traditional interpretation of physics (explicated above), in which (a) it was common to believe that physics should constitute a systematic whole, (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. After all: the task of the transition project is to ground physics as a systematic whole by determining how rational physics is related to empirical physics. Moreover, as we shall see in the next paragraph, most of the scientific topics investigated within the *Opus postumum* were traditionally assigned to *physica specialis*. However, apart from believing that a philosophical (a priori) transition project is required to ground the systematicity of physics, Kant differed (albeit slightly) from late eighteenth-century scientists in his interpretation of physics.

Above, we discussed passages in which Kant explains his transition project employing the traditional terminology of *physica generalis* and *physica specialis*. However, in general Kant simply presents his transition project as a transition

[165] AA 21: 293.
[166] AA 21: 366.
[167] *Ibid.*

from the metaphysical foundations of natural science to physics. Why did Kant not simply describe his transition project as a transition from *physica generalis* to *physica specialis*? That Kant did not describe his transition project in this manner follows, I take it, from the status he assigns to his *Metaphysical Foundations* of 1786. Eberhard's *physica generalis* incorporated metaphysical explications (e.g., of the concept of body, impenetrability, etc.), kinematics, and the most famous parts of Newtonian physics as presented in the *Principia* (e.g., the laws of motion, the theory of gravitation). Recall, however, that Kant distinguished his metaphysical foundations from the traditional notion of *physica generalis*. The *Metaphysische Anfangsgründe* were taken to provide a rational physics in the strict Kantian science, i.e., a philosophical a priori foundation of natural science. In this science, mathematical and empirical principles did not have any place.

In developing his *Metaphysische Anfangsgründe*, Kant provided a metaphysical explication of the universal properties of matter (e.g., filling a space, impenetrability), as well as the parts of Newtonian physics that Kant took to allow of a priori justification (e.g., immediate and universal attraction and the laws of motion). Kant's *Metaphysische Anfangsgründe* thus absorbed many topics that were traditionally assigned to *physica generalis*. Alternatively, Kant reassigned what he took to be empirical topics discussed in *physica generalis* to empirical physics. This was the case for the discussion of cohesion, which Eberhard discussed within *physica generalis*. It follows that the notion of *physica generalis* does not have a well defined meaning within Kant's philosophy. The use of this term ultimately becomes redundant, and the division between *physica generalis* and *physica specialis* loses much of its significance. In line with his practice of distinguishing sciences in terms of their characteristic mode of justification (a priori versus a posteriori), Kant thus distinguished between the a priori part of natural science (rational physics as presented in the *Metaphysische Anfangsgründe*) and its empirical part, i.e., physics or empirical physics. The upshot of defining physics in this sense, i.e., as a body of cognition based on empirical grounds, is that the scope of physics is broader than that of *physica specialis*. Not only does physics (in Kant's sense) contain *physica specialis*, it also contains, e.g., those parts of Newtonian mathematical physics based on empirical grounds. As such, it is no surprise that Kant, as we have seen, assigns the doctrine of gravity to physics in the *Opus postumum*.

In conclusion, we may provide a first answer to the question why Kant thought a transition project was necessary within his philosophical system. 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 show (i) how empirical physics can constitute a system and (ii) how rational and empirical physics constitute a unified system. As such, Kant's transition project is analogous to (though not identical with) the project that we have located in the work of Eberhard. The project of showing how propositions of *physica specialis* are grounded by propositions of *physica generalis*. This project was, as we have seen, not fully articulated in Kant's *Metaphysische Anfangsgründe* of 1786 (§4.3.2). To be sure, in the General Remark to the 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".[168] This is to acknowledge the existence of a gap between rational and empirical physics. That propositions of empirical physics are grounded by propositions of rational physics had not been shown. However, this must be shown if physics is to constitute a true system. In short: that Kant thought that something like a transition project was necessary can be already understood from the *Metaphysische Anfangsgründe*, without presuming that Kant came to believe that the project of the *Metaphysische Anfangsgründe* was fundamentally flawed, as several commentators believe (§4.1).

4.5.3 Scientific topics in the *Transition*

In the previous sections, we have seen that 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 the question remains: why did Kant think that, apart from rational and empirical physics, a *mediating* a priori science is necessary (the *Transition*)? We have already remarked that neither Eberhard nor any other of Kant's contemporary physicists conceived of such a third science. In Eberhard's *Naturlehre*, the transition between *physica generalis* and *physica specialis* occurs directly through the application of the principles of general physics to the domain of special, empirical physics. As we have seen, the notion of an attractive force of cohesion (as developed in *physica generalis*) is crucial to Eberhard's enterprise, who stated that, e.g., fluidity and elasticity are to be explained in terms of the (short-range) attractive force of cohesion. In general terms: Eberhard adopted a consequent dynamist position. On this position, specific properties of specific types of material bodies, treated in

[168] AA 4: 525.

physica specialis, are to be explained in terms of microscopic attractive and repulsive forces.

In the fourth sheet of the fifth fascicle (July 1797-July1798), Kant explains why he thinks that a mediating science (a *Transition*) is necessary, contrary to the view that the principles of rational physics can be applied directly to empirical physics:

> 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 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)

Kant claims that in natural science the application of the metaphysical foundations (rational physics) to empirical physics is often problematic, resulting in the admixture of a priori and empirical principles. Although Kant does not specify a target of his criticism, we may note that his worries apply to Eberhard (and presumably other influential authors on physics in Kant's time). As said, Eberhard discussed the attractive force of cohesion in *physica generalis* and took this attractive force to be fundamental for *physica specialis*. In contrast, already in the *Metaphysische Anfangsgründe* Kant assigned cohesion to empirical physics, treating it as a derivative force, i.e., a force reducible to an (as yet unknown) ground. 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 consequently (iii) did not give a precise account of the relation between rational and empirical physics. For Kant, it follows that Eberhard could not properly account for the systematicity of physics. Insofar Eberhard did not show how the propositions of rational physics ground those of empirical physics, the propositions of empirical physics constitute a fragmentary aggregate lacking certainty.

Kant's assessment of the fragmentary, non-systematic treatment of (empirical) physics in his time 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, Eberhard 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 the parts of the whole.[169] In addition, the transition from solids to fluids is understood in terms of a decrease in cohesion among its parts.[170] 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 fluid ether (elementary fire) that penetrates solid bodies.[171] The ether is, however, not systematically discussed within *physica generalis*.

How does Kant's *Transition* provide a solution to the above mentioned problems? In order to provide an answer to this question, we may inquire into the scientific topics Kant discusses in the *Opus postumum*. In the *Oktaventwurf*, we find (among others) a discussion of the following scientific 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; (v) the different types of air (*Luftarten*); (vi) light; (vii) droplet-shaped fluidity; (ix) the behaviour of liquids in capillary tubes. This non-exhaustive list is typical for Kant's discussion of scientific topics in the *Opus postumum*. The largest part of the work is occupied with innumerable sketches of possible explanations of these various phenomena. Note that Kant's position regarding these scientific topics is often subject to change and is not always consistent. I will not detail changes in Kant's reflections. For our present purpose, it is important to note that almost all of the topics discussed in the *Oktaventwurf* were traditionally rubricated under *physica specialis*. The question now becomes: how do we arrive at a unified, non-fragmentary treatment of these topics?

In the early parts of the *Opus postumum*, i.e., the early leaves, *Oktaventwurf* and the subsequent drafts concerned with establishing what is eventually called an 'elementary system of moving forces'[172], Kant attempts to ground physics as a systematic science by discussing the concept of matter in accordance with the table of the categories. This methodology mirrors that

[169] Eberhard 1774, 164.
[170] Eberhard 1774, 165. Recall that Kant had argued that the distinction between fluid and solid bodies cannot be accounted for in terms of different degrees of cohesion.
[171] Eberhard 1774, 616–619.
[172] As Förster 2000, 18 notes, the concept of an elementary system of moving forces of matter first occurs at AA 21: 533.

of the *Metaphysische Anfangsgründe*.[173] As Kant puts it while introducing his transition project:

> I believe that I could not better reach the completeness of a system in the composition of this work, than if here, too, I were to follow the clue given by the categories and bring into play the *moving forces* of matter according to their *quantity*, *quality*, *relation* and *modality* in turn. (AA 21: 311)

Kant never arrived at a definite description of an elementary system of moving forces of matter.[174] However, his discussions of matter under the heading of the categories do provide insight into how Kant attempted to ground physics as a systematic science. In the following, I will briefly highlight some of the scientific topics Kant discusses in accordance with the categories of quantity, quality and relation.[175]

(i) 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".[176] This claim results from the fact that Kant takes universal gravitation, being proportional to mass, 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*.[177] In the *Opus postumum*, Kant 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.[178]

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[173] Cf. AA 4: 474–477.

[174] Cf. Förster 2000, 12–19.

[175] I abstract from 'modality' given that Kant's remarks on modality do not add to the scientific content discussed within the transition project. As Kant explains in the first *Critique*, "The categories of modality have this peculiarity: as a determination of the object they do not augment the concept to which they are ascribed in the least, but rather express only the relation to the faculty of cognition". *KrV*, A 219/B 266.

[176] AA 22: 208.

[177] Carrier 2001b.

[178] Cf. AA 22: 138–139, 260, 587. This argument is often discussed. Cf. Adickes 1920, 475–483; Mathieu 1989, 98–100; Friedman 1992a, 297–299; Förster 2000, 15–17. Friedman

(ii) When discussing the *quality* of matter, Kant provides an analysis of the states of aggregation.[179] In particular: if we consider matter in accordance with its quality, matter can be construed as *fluid* or *solid* (*rigid*). Fluids are in turn divided in attractive fluids (liquid state) and expansive or elastic fluids (gaseous state).[180] The cause of all fluidity is taken to be the matter of heat or caloric (ether). Caloric or heat is construed as the principle of all fluidity.[181] It is conceived of as distributed throughout space, endowed with repulsive and attractive forces conferring to the ether an oscillating or vibrating motion. Caloric can penetrate bodies, thus communicating its motion to the parts of bodies. These parts are set in a state of trembling 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 expensive (repulsive) forces bring matter into a greater state of expansion. In general: the three states of aggregation are dependent on the quantity of heat or caloric present in a material body.[182]

Recall that in the *Metaphysische Anfangsgründe* Kant had still proclaimed that "how rigid bodies are possible, is still an unsolved problem".[183] In the *Opus postumum*, Kant invokes the ether or caloric to account for the formation of solid bodies. Solid bodies are taken to be produced via the release of caloric. Kant takes the fluid state of matter to be its original state. Fluids are conceived of as mixtures of heterogeneous elements. These heterogeneous elements are (as we have seen) mixed due to the action of the matter of heat or caloric, a mixture which allows for the displacement of its parts (a characteristic of fluids). When a quantity of caloric is released from a fluid, the fluid is divided in its several heterogeneous elements (the fluid is de-mixed or *entmischt*).[184] These heterogeneous elements form a crystalline texture that resists internal displacement (a characteristic of solid bodies). In short: solidification is con-

succinctly 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."

179 Cf., for example, AA 22: 213, 141–142.

180 Cf. AA 21: 317, 296; AA 22: 218.

181 AA 22: 213,

182 For a more detailed account on this topic, cf. Adickes 1920, 483–489. Cf. also Friedman 1992a, 291–294; Carrier 2001a, 214.

183 AA 4: 529.

184 AA 21: 298. Cf. AA 21: 276–280.

strued as a process of crystallization occurring when a sufficient amount of caloric is released from fluids.

This account of the states of matter in terms of the action of caloric is novel with respect to the *Metaphysische Anfangsgründe*.[185] In the *Opus postumum*, Kant also accounts for distinctive properties of fluids in terms of caloric, in particular: the tendency of liquids to assume a spherical droplet shape and the rising of water in capillary tubes. I will not provide a detailed account of Kant's claim that these phenomena should be explained in terms of the action of an ether.[186] However, as a rough indication we may note that Kant's arguments are primarily based on the elimination of alternative physical explanations of these phenomena. For example, Kant argues that the tendency of liquids to assume a spherical, droplet shape cannot be explained by microscopic attractive forces. Neither can this phenomena be explained in terms of the pressure of (say) an ether. These considerations lead Kant to postulate that it is through the impact of a penetrating, vibrating (oscillating) ether, which unceasingly moves the parts of the body it penetrates in all directions, that liquids assume a spherical, droplet shape.[187] In a similar fashion, Kant argues that the rising of water in capillary tubes is an (at least partial) effect of the ether.

(iii) Kant usually discusses cohesion under the heading of the category of *relation*.[188] Recall that the property of cohesion was treated by Kant in the General Remark to the Dynamics of the *Metaphysische Anfangsgründe*. In the *Opus postumum*, Kant emphasizes that cohesion cannot be explained in terms of microscopic attractive forces. In the early leaves predating 1796, Kant rhetorically asks whether "cohesion be possible through inner forces of matter (like gravity)."[189] The answer emerging in Kant's subsequent reflections is negative. Kant's arguments are anything but perspicuous. He often simply

[185] Hence, I cannot follow Carrier 2001a, 214, who claims that in the *Opus postumum* Kant retains the account of the fluid state developed in the *Metaphysische Anfangsgründe*. That the fluid state is due to the action of the matter of heat (caloric) is not a view expounded in the latter work.

[186] For a more detailed account, cf. Adickes 1920, 489–500.

[187] These argumentative steps can be found, for example, at AA 21: 521–522. Here, Kant denies that attraction in contact (cohesion) can account for the formation of droplets, since attraction in contact produces no motion or change of shape. This leads (quite prematurely) to the conclusion that water, mercury, etc. would form no droplets by their own forces. Then Kant denies that pressure can account for the formation of droplets, since, given that pressure is uniformly applied to a whole body, pressure cannot account for a change of shape. Then, he arrives at his account of terms of the impact of the ether, which leads to the formation of droplets (a state characterized in terms of an equilibrium of forces).

[188] Cf. AA 22: 146

[189] AA 21: 417.

emphasizes differences between cohesion and attraction or gravitation. Thus, cohesion is said to be a contact force as opposed to a penetrating (long-range) force, it is not proportional to mass or density and it is not an inverse-square force. These considerations quickly lead to postulating the ether as a cause of the cohesion of physical bodies. However, 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.[190]

In arguing that the cohesion of physical bodies is not possible through microscopic attractive forces, Kant distanced himself from the views of Eberhard and Erxleben. Eberhard treated cohesion as a microscopic attractive force, while Erxleben, explicitly rejecting the view that cohesion results through the pressure of an ether, argued that bodies cohere in virtue of an 'actual inner force' efficacious within microscopic bodily parts.[191] As we have seen, Gehler was also sceptical with regard to such views. In his article on attraction, Gehler notes that, although we conceptualize cohesion as a form of attraction and typically conceive of various forces in nature as attractive, 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.[192]

According to Gehler, it is clear that the law of universal gravitation does not hold for all types of attraction. This, Gehler notes, was established by Newton himself.[193] Proposition 85 of Book I 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 1999 [1726], 610)

Gehler notes that that the antecedent of this implication is true of attraction in contact (cohesion). Hence, attraction in contact will not vary as the inverse-square of the distance (rather it will vary in accordance with higher powers) and the laws governing cohesion are quite different from those governing universal gravitation. In this respect, the problems that Kant, in the *Opus pos-*

[190] Cf. AA 22: 146–147. Cf. Förster 2000, 67.
[191] Erxleben 1772, 33–34.
[192] Gehler 1787–1796, Bd. 1, 171–172.
[193] *Ibid.*

tumum, associates with conceiving of cohesion as resulting from microscopic attractive forces can also be found in Gehler. However, in contrast to Kant, Gehler did not immediately 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 and cannot (as yet) determine its laws.[194]

Let us return to the question 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, i.e., provide a unified account of (e.g.) cohesion, the states of matter, droplet-forming fluidity, by invoking the *ether* as the fundamental principle of empirical physics. In the *Opus postumum*, Kant often construes the ether as the matter of heat (caloric).[195] As such, the ether functions as a principle of the theory of heat, allowing of application in various domains of empirical physics. Kant also construes the ether as a matter of light, i.e., as a light-ether.[196] Finally, magnetism is construed as a possible effect of aetherial matter.[197] In this manner, most phenomena traditionally discussed within *physica specialis* are taken to be (at least partly) explicable in terms of the action of the ether.

We have seen that according to Kant the systematicity of empirical physics must be grounded on a priori principles. The existence of the ether, as invoked in scientific explanations described above, is an empirical hypothesis. If the existence of the ether is merely hypothetically assumed, empirical physics would on Kant's account not be properly grounded. Rather, empirical physics would still constitute an aggregate and its propositions would lack certainty. In the early parts of the *Opus postumum*, Kant treats the assumption of the existence of an ether as a scientific hypothesis, adopted for the sake of explaining specific phenomena. For example, in the *Oktaventwurf* Kant remarks that the ether is a hypothesis invoked for explaining the possibility of cohesion.[198] However, in line with the idea that a systematic physics must be based on a priori principles, Kant comes to treat of the ether as an a priori principle of his transition project. 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 states:

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[194] Ironically, Gehler makes the same claim with respect to the cause of the formation of droplets, which, as we have seen, Kant also discussed in the *Opus postumum* and attributes to the ether. This underscores the fact that Kant's reflections on physics in the *Opus postumum* are highly speculative.

[195] AA 21: 378, 380, 383.

[196] Cf. AA 21: 381, 383. Cf. Friedman 1992a, 323-326.

[197] AA 21: 381.

[198] AA 21: 378.

> There exists a matter, distributed in the whole universe as a continuum, uniformly penetrating all bodies, and filling [all spaces] (thus not subject to displacement). Be it called ether, or caloric, or whatever, it is no *hypothetical material* (for the purpose of explaining certain phenomena, and more or less obviously conjuring up causes for given effects); rather, it can be recognized, and postulated *a priori*, as an element [*Stück*] necessarily belonging to the transition from the metaphysical foundations of natural science to physics. (AA 21: 218)

This a priori postulated ether provides a basis of a system of moving forces and thus grounds physics as a systematic science. Thus, Kant notes that the ether or caloric "is the basis for the unified whole of all moving forces of matter" and as such constitutes a "principle of the possibility of the unity of the whole of possible experience".[199]

I will not discuss Kant's ether proofs.[200] On the basis of the foregoing, I will summarize my views on why Kant, in contrast to his contemporary physicists (e.g., Eberhard, Erxleben), believed that a transitional science is necessary in order to connect rational and empirical physics:

(i) In the *Metaphysische Anfangsgründe*, Kant already noticed difficulties in systematically relating rational and empirical physics. (ii) In the *Opus postumum*, Kant distances himself from the project of explaining phenomena discussed within empirical physics in terms of microscopic attractive and repulsive forces. This direct application of principles pertaining to rational (general) physics to special physics, a project undertaken by for example Eberhard and Erxleben, is taken to be problematic because: (iia) the laws concerning such microscopic forces are unknown, and (iib) it involves the mixing up of rational and empirical physics (as witnessed by Kant's critique of Eberhards treatment of cohesion). (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. Hence, if the existence of the ether is only hypothetically assumed, empirical physics constitutes a mere empirical aggregate. (v) Therefore, Kant undertakes the project of providing an a priori proof for the existence of the ether. This is a *philosophical* task, which belongs to the province of the transition project.

In short: Kant believed a *Transition* was necessary because he did not believe that propositions of empirical physics can be derived from propositions

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[199] AA 21: 224. Cf. Förster 2000, 93-94.

[200] The ether proofs constitute the most discussed part of the *Opus postumum*. Cf. Adickes 1920, 363–397; Mathieu 1989, 111–127; Förster 2000, 75–101; Edwards 2000, 147–166; Emundts 2004, 156–201; Friedman 1992a, 290–316.

pertaining to rational physics without introducing mediating (a priori) principles (in concreto: the ether). However, if empirical physics is to be a system the mediating principles must allow of a priori proof. Hence, we require a *philosophical* transition project explicating the a priori principles that ground empirical physics as a systematic science.

4.5.4 On the a priori and the empirical in the *Transition*

Having analyzed some of the scientific topics Kant discusses in the *Opus postumum*, we may inquire into the relation between philosophical (a priori) and scientific, empirical theorizing in the *Transition*. Several of Kant's proposed accounts of (e.g.) cohesion, the states of matter, etc., pertain to (empirical) physics. They are proposed scientific explanations that can be related to eighteenth-century discussions in physics. What is the role of these accounts in the *Transition*, which is supposed to provide a *philosophical* (a priori) foundation of physics? In his commentary on the *Opus postumum*, Erich Adickes criticized Kant for conflating the domains of philosophy and natural science. According to Adickes, Kant passed of bad physics as philosophy.[201]

In my view, Adickes' critique is somewhat harsh. Kant always insists that the *Transition* is a transition to physics and should not be indentified with physics itself. Kant himself thought he could provide a clear distinction between philosophy and natural science. What creates confusion is the fact that the status of Kant's reflections in the *Opus postumum* (which remains an unfinished work) is not always clear. In particular, it is not always easy to distinguish between reflections that merely summarize Kant's thoughts on particular topics of empirical physics, and reflections explicating his philosophical interpretation on the foundations of physics. Kant's views on the ether are a case in point. The conception of the ether is clearly derived from the use of this concept in eighteenth-century physics, in which the ether functioned as a hypothesis for explaining particular phenomena. However, Kant also thinks that the ether requires a philosophical treatment. This raises the following question: why does Kant take the concept of the ether to be properly discussed within the transition project?

Kant often emphasizes the difference between a philosophical treatment of the ether and the use made of this concept within physics. In fascicle 9, he states that the notions of a 'light-material' and 'caloric' are nothing but different names for a material which permeates all bodies universally, i.e., the ether. In assigning one or the other name to the ether, we represent the

[201] See, for example, Adickes 1920, 514–528.

ether according to different qualities.[202] These remarks are significant, for the notion 'caloric' was a term of art in 18th century physics, mainly employed to refer to the matter of heat assumed within Lavoisier's new chemistry. Kant thus seems to distinguish between a scientific use made of the concept of the ether (in which some material substrate is conceptualized, for example, as caloric by the chemist or as light-material by the physicist) and a notion of the ether presupposed by scientist (dealt with philosophically within the transition project). This reading is confirmed by the fact that Kant insists that one should refrain from attributing properties to the ether (e.g., ponderability, fluidity) that the ether itself is supposed to explain:

> The causality of heat [the ether, v.d. Berg] is that it expands all bodies, weakens their cohesion, and renders them fluid; that it is the cause of all elasticity, which is thus fundamentally derived from it (although it cannot itself be called elastic, for, for that, another heat would, in turn, be required); and since it is incoercible, its material content cannot be estimated by weight. How one could call it a fluid is unintelligible. For, in order to be an elastic fluid, it would itself require heat […]. (AA 21: 521)

In line with the idea that one cannot ascribe properties to the ether that the ether is supposed to explain, Kant characterizes the ether, in contrast to physical bodies, as a formless matter in general that, once again in contrast to physical bodies, is incoercible, imponderable, etc.[203]

We can relate Kant's views on the ether to the manner in which the ether was invoked by Eberhard in his *Naturlehre*. Eberhard invoked the ether to account for the elasticity of solid bodies. The ether is construed as an elastic fluid penetrating solid bodies and rendering them elastic.[204] Eberhard notes that this explanation is somewhat peculiar: we explain the elasticity of solids in terms of an elastic fluid, without knowing the cause of the elasticity of the ether. However, he denies that his explanation is problematic, arguing that in physics we do not have insight in the first causes of nature.[205] Kant, as we have seen, does take such explanations to be problematic: they are circular and comprise pseudo-explanations. Kant's conclusion therefore seems to be that physicists presuppose an indeterminate concept of an ether. Insofar as this concept is presupposed, it constitutes a proper subject of philosophical discussion. This seems to be one of the reasons why Kant takes it to be permissible to treat of the concept of the ether within his *Transition*.

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[202] AA 22: 214.
[203] Cf., for example, AA 22: 141; AA 21: 215. Cf. Emundts 2004, 119-126.
[204] Eberhard 1774, 616–619.
[205] Eberhard 1774, 622.

Abstracting from the thorny problem of the ether, it is also important to note that Kant continuously treats physics as an empirical science in the *Opus postumum*. Knowledge of propositions in physics is always based on experience, i.e., "physics contains the natural moving forces and effects of matter, knowable through experience".[206] Moreover, the existence of moving forces in nature must be determined empirically.[207] The important point of Kant's transition project is that physics is *also* based on a priori principles. In particular, the systematic form of concepts of moving forces dealt with in physics must be a priori if physics is to be a system. It is the task of the *Transition* to determine this systematic form. For example, in fascicle 4, Kant, treating of the totality of moving forces comprising the object of physics, describes the transition project as follows:

> Insofar as the totality of these forces permits of classification *a priori*, founded on *a priori* concepts, there must exist a *topic* of the moving forces of matter in which each of these forces is assigned its location (*locus communis*) in the system; and a special science will both be possible and necessary, which is solely occupied with these locations in the investigation of nature. Empirical concepts (e.g., gravity), whose moving force can be thought according to *a priori* concepts (e.g., attraction and repulsion) although their existence must be given through experience, belong to this topic of the transition.[…]
>
> For the moving forces can be enumerated *a priori* according to their form; but they can be known according to their content [only] by the appearances of their effects.
>
> The investigation of nature, in the absence of any principles of classification, can result in no system of physics; for there would arise from it merely an aggregate (*farrago*) of particular observations, and how far these might extend cannot be anticipated […]. (AA 21: 483–484)

Thus, the formal relations between conceptions of moving forces can (and must) be specified a priori, while determinate knowledge of the moving forces of matter and cognition of their existence requires experience.

Kant describes the *Transition* as providing a topic of the moving forces of matter, i.e., as providing *a priori topoi* for empirically given moving forces of matter. Here, *topoi* refers to headings or characteristics enabling the classification of moving forces.[208] In the previous section, we have seen that in the *Transition* Kant treats of the moving forces of matter in accordance with the categories, e.g., ponderability under quantity, fluidity and solidity

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[206] AA 21: 525.

[207] Note that, although this view constantly reappears throughout the *Opus postumum*, Kant seems to take a different view with respect to the ether. After all, Kant thinks that the existence of the ether can be established a priori.

[208] For Kant's construal of the notion 'topic' (*Topik*), cf. *Logik Pölitz*, AA 24: 596–597. A topic enables determining the place of cognitions within a science.

under quality, etc. This procedure corresponds to Kant's characterization of the *Transition* as a *Topica*: we classify (a priori) the moving forces of matter in accordance with the categories, i.e., (in Kant's terms) assign moving forces their place in a system. Note also that empirical concepts (e.g., gravity) are dealt with within this *Topica*. What is a priori is the manner in which we classify moving forces (their *form*), not determinate knowledge concerning empirically given moving forces of matter.

The last point can be further explicated if we consider Kant's example of gravity. The concept of gravity is an empirical concept and the existence of gravity must be determined empirically. Moreover, in the *Opus postumum* Kant is quite explicit in taking scientific knowledge concerning gravity to be "drawn from experience", i.e., in Newton's terms, the law of gravitation is deduced from phenomena.[209] However, Kant notes that gravity can be thought of in accordance with a priori concepts, i.e., of *attraction*. In the *Metaphysische Anfangsgründe*, Kant had established that the universality and immediacy of attraction is a necessary, a priori condition if matter is to be an object of scientific cognition. This a priori concept of attraction was taken to ground Newton's law of gravitation. Hence, although the law of gravitation is derived from phenomena, it is also taken to be grounded by a priori principles. Kant stresses this fact in the quote above from the *Opus postumum*. The *Transition* can then be taken to provide a priori *topoi* under which empirically given moving forces of matter (e.g., gravity) can be subsumed. In this manner, empirical physics is given a philosophical foundation.

In conclusion: in §4.3.2 we noted that Kant distinguished between (i) a purely 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. There, we also noted that, in Kant's view, Newton's theory of universal gravitation can be classified under (iii). Via our analysis of the *Opus postumum*, we now see that Kant also takes a priori principles to ground empirical physics, i.e., what we call empirical physics is also an instance of (iii) (this is not surprising. After all: Newton's theory of universal gravitation belongs to empirical physics insofar as it is drawn from experience). Hence, what Kant calls physics in the *Opus postumum* is based on both a priori and empirical principles. In the second

[209] Cf.: "Physics in general has two kinds of objects: (I) Those whose assumed or inferred possibility can only be sustained by experience – and of this sort are organic bodies, as also gravitation. The latter is, indeed drawn from experience, but that it should be attraction – as Newton first maintained – was problematic. It required that a leap be made, namely, to assume something for the sake of the system […]." (AA 22: 245) The other type of object is the ether, the existence of which is proven a priori.

fascicle of the *Opus postumum* Kant makes this explicit, arguing that a system of moving forces of matter based *solely* on a priori concepts is called 'metaphysics of nature', while a system that is *also* based on principles of experience is called physics.[210] Scientific cognition is classified as pertaining to empirical physics if it is derived from experience. This characterization corresponds to the traditional characterization of *physica specialis*, which, as we have seen, employs the analytic method to derive causes from empirically given effects. However, in this derivation we use a priori principles (as, e.g., in the derivation of the law of universal gravitation). For Kant, there is no purely empirical science of nature.

4.5.5 The *Transition* and the *Metaphysische Anfangsgründe*: addressing conflicting interpretations

The interpretation developed so far takes Kant's transition project to be an extension, rather than a fundamental revision of his *Metaphysische Anfangsgründe* of 1786. To be sure, the *Transition* does contain significant revisions with respect to the *Metaphysische Anfangsgründe*. However, it is not the case that the transition project results from Kant's recognition that the *Metaphysische Anfangsgründe* is fundamentally flawed, as argued for by Tuschling (§4.1). In the present Chapter, I have argued that Kant's transition project is analogous to the traditional project of establishing the systematic unity of physics by grounding *physica specialis* in *physica generalis*. Such a project was not fully explicated by Kant in the *Metaphysische Anfangsgründe* (§4.3.2). Hence, in order to complete the project of providing a thorough philosophical grounding of physics a transition project was necessary (irrespective of problems confronting the *Metaphysische Anfangsgründe*).

It is important to assess the interpretation of Tuschling (and those in agreement with him) with care. Tuschling has correctly pointed to argumentative problems in the *Metaphysische Anfangsgründe* that have undoubtedly influenced Kant's work in the transition project. Note that it is evident that Kant's theory of matter expounded in the *Transition* differs from that of the *Metaphysische Anfangsgründe*. It is only in the *Transition* that the ether (caloric) functions as an a priori principle grounding physics. In addition, Kant's account of phenomena such as cohesion, the aggregate states of matter, etc., in terms of the ether differs from that given in the General Remark to the Dynamics of the *Metaphysische Anfangsgründe*.[211] Finally, Tuschling has

[210] AA 21: 176.
[211] These first two modifications are recognized by most commentators.

pointed to Kant's recognition of a circularity afflicting his account of density differences. In the *Opus postumum*, there are various passages that show that Kant provided a new account of density, once again invoking the ether for this purpose.[212] Hence, Kant's recognition of problems afflicting the *Metaphysische Anfangsgründe* certainly influences various aspects of Kant's transition project.

However, Tuschling's interpretation is more radical. Tuschling argues that in the 1790s Kant came to believe that the legitimate content of the *Metaphysische Anfangsgründe* reduces to phoronomy or kinematics. The *Metaphysische Anfangsgründe* did not succeed in introducing dynamics at all and hence a *Transition* was necessary. In contrast, I simply take Kant's transition project to complete a task not yet fully dealt with in the *Metaphysische Anfangsgründe*. I would suggest that Kant primarily viewed the *Transition* as a necessary extension of the *Metaphysische Anfangsgründe*, although in developing his transition project he modified several theories expounded in the *Metaphysische Anfangsgründe*.

That Kant himself also conceives of the *Transition* as an extension of the *Metaphysische Anfangsgründe* is suggested by the following:

(i) The *Transition* is meant to explicate how rational and empirical physics are systematically related to each other. Rational and empirical physics are taken to concern the same object, yet have different *territories* (§4.5.1). Given that rational and empirical physics have the same object, we must show how general laws concerning material nature are related to more determinate laws concerning (what Kant calls) the specific variety of matter. As such, the *Transition* is meant to demonstrate the consistency of rational physics (*Metaphysische Anfangsgründe*) and empirical physics, and to show how rational physics grounds empirical physics. This in no way suggests that Kant took the *Metaphysische Anfangsgründe* to be fundamentally flawed.

(ii) The transition project corresponds to the traditional project of showing how the principles of *physica generalis* can be applied to *physica specialis* (§4.5.2). This project was based on the assumption that the principles of *physica generalis* are valid and constitute grounds for explanations in *physica specialis*. Kant presents his *Transition* in a similar manner. Moreover, the project of grounding empirical physics was not fully developed in the *Metaphysische Anfangsgründe*. As we have seen, Kant treated of topics pertaining to empirical

[212] Cf. AA 21: 374, 425, 428, 446, 449 On this topic, cf. Förster 2000, 34–45; and especially Emundts 2004, 103–117. This circumstance suggests that Friedman 1992a, 223, is wrong in taking the circularity problem to be of no significance to Kant's transition project. However, contrary to Emundts, my analysis suggests that Kant was confronted with the task of providing a philosophical foundation of empirical physics even without knowledge of this circularity problem.

physics in the General Remark to the Dynamics. However, he acknowledged that his treatment was tentative and provisional (§4.3.2). Hence, Tuschling's claim that the *Metaphysische Anfangsgründe* does not allow of any transition to physics because it already grounds physics as a mathematical science is problematic. Note further that Tuschling's indentification of physics with mathematical physics is problematic. In the *Opus postumum*, physics denoted empirical physics, a terms associated with *physica specialis*. Many doctrines pertaining to *physica specialis*, in Kant's time, did not have a mathematical character.

Finally (iii), we may highlight the terminology Kant employs in characterizing the *Transition*. Kant construes the *Transition* as building a bridge between the territory of the metaphysical foundations and that of physics. This bridge is supposed to prevent a *Sprung* from one territory onto the other. The concept '*Sprung*' (*saltus*) was traditionally employed to denote a logical fallacy. For example, G.F. Meier, in his *Auszug aus der Vernunftlehre*, states that we commit a "*Sprung im Beweise*" if in a series of connected inferences one or more judgments are omitted.[213] Kant himself explicates the concept '*Sprung*' in his lectures on logic by noting that we commit a "*Sprung im Beweise*" if in an inference we omit a premise.[214] In a more general sense, a *Sprung* is defined as the immediate connection of a remote ground with a consequence without taking into account intermediate grounds.[215] Kant's *Transition* builds a bridge between rational and empirical physics by specifying intermediate principles relating the two types of physics. From this perspective, the *Transition* appears again as an extension of the *Metaphysische Anfangsgründe*, allowing for the presentation of physics as a systematic and deductively ordered whole.

Apart from these general considerations, we may note that in the *Opus postumum* there are several passages suggesting that Kant continues to treat the original forces of attraction and repulsion as essential to matter. These passages cannot be explained on the basis of the interpretation of Tuschling. For example, in the ninth fascicle Kant argues that the *possibility of matter* requires attractive and repulsive forces. If "*attraction* alone were to belong to the parts of the world-matter, then they would coalesce into one point and space would remain empty".[216] Conversely, were "*repulsion* the only mode of action of its parts on one another, it would dissolve and disperse its parts into

[213] AA 16: 773.
[214] Cf. AA 9: 135. See also AA 24: 596.
[215] AA 14: 288.
[216] AA 22: 211.

infinity, and cosmic space would remain equally empty."[217] This argument is a modified version of an argument already contained in the *Metaphysische Anfangsgründe*. The idea that attraction and repulsion are necessary for the possibility of matter constitutes the heart of Kant's Dynamics. In Proposition 6 of the Dynamics, Kant argued, in a fashion quite similar to the argument under consideration, that without construing attraction and repulsion as basic, fundamental forces "space would always remain empty, and no matter would be found therein".[218] There are several other passages in the *Opus postumum* in which Kant takes attraction and repulsion to be necessary for the possibility of matter.[219]

Note, however, that Kant's argument in the *Transition* is not identical to the argument given in support of Proposition 6 of the Dynamics. In the former argument, Kant introduces the notion of a world-matter, i.e., the *ether*, a notion absent in the latter argument. Given the fundamental importance Kant assigns to the ether in the *Transition*, this inclusion is no surprise. The introduction of the ether does not, however, imply that Kant rejected the entire dynamics chapter of the *Metaphysische Anfangsgründe*. In the *Opus postumum*, Kant conceptualizes the ether in terms of the original forces of attraction and repulsion, which account for its oscillating motion, and the ether is presented as a third force posited in addition to the original forces of attraction and repulsion.[220] This suggests that Kant retains the idea that attraction and repulsion are essential to matter, while adding the ether to effect a transition from the *Metaphysische Anfangsgründe* to physics.

Given that the ether is meant to provide an explanation of phenomena studied within empirical physics, it is natural to introduce the ether as a third posit within the *Transition*. The phenomena of cohesion, the states of matter, etc., traditionally assigned to *physica specialis*, were all discussed by Kant within the General Remark to the Dynamics. The same is true of Kant's account of density differences, and of the distinction between matter and bodies (topics central to the *Transition*).[221] Hence, it is natural to view the *Transition* as supplanting the General Remark of Dynamics, while leaving the main body of the Dynamics in tact. This is the interpretation of the *Transition*

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[217] *Ibid*.
[218] AA 4: 511–512.
[219] These passages are also highlighted by Friedman 1992a, 249. Cf. AA 21: 310–311, 362–363; AA 22: 282, 518.
[220] See, for example, AA 21: 378; AA 22: 211. Cf. Emundts 2004, 119-120.
[221] Cf. AA 4: 523–525.

given by Dina Emundts, with which I concur (§4.1).[222] However, I arrive at this conclusion on the basis of different grounds, namely: the fact that the transition project can be read in the context of contemporary textbooks on physics that aimed to establish the systematicity of physics by taking *physica generalis* to ground *physica specialis*.

There is one more aspect of Tuschling's interpretation of Kant's *Transition* that has to be discussed. According to Tuschling, Kant changes his conception of the role of mathematics in natural science, as articulated in the *Metaphysische Anfangsgründe*, in the *Transition*.[223] This interpretation is also adopted by Eckart Förster.[224] Förster notes that in the *Metaphysische Anfangsgründe* Kant argued that in every special doctrine of nature there is only so much proper science as there is mathematics in it. According to Förster, this shows that in the *Metaphysische Anfangsgründe* mathematics was one of the pure parts of what Kant called *physica rationalis*, i.e., of rational physics grounding physics. In the *Transition* however, the foundational role of mathematics is rejected. In order to substantiate this interpretation, Förster argues that in the *Transition* Kant comes to reject the idea that mathematics is a part of the philosophy of nature. For example, in the fourth fascicle of the *Opus postumum*, Kant notes:

> What are called the *mathematical* foundations of the science of nature (*philosophiae naturalis principia mathematica*), as expressed by Newton in his immortal work, are (as the expression itself indicates) no part of *philosophy of nature*. They are only an instrument (albeit a most necessary one) for the calculation of motions and moving forces (which must be given by observation of nature) and for the determination of their laws for physics (so that the quality of the motions and moving forces can be specified in regard to the central forces of bodies in circular motion, as well as the motion of light,

[222] Emundts 2004. To be more precise: according to Emundts, it was the circularity in Kant's matter theory, which invalidates Kant's position in the General Remark to the Dynamics (but not the main body of the Dynamics), that necessitated Kant to revise the contents of the General Remark to the Dynamics (Emundts 2004, 74–117). I have not discussed the ramifications of the circularity in Kant's matter theory in the present chapter. However, I concur with Emundts insofar as I take the *Transition* to take up and revise Kant's position articulated in the general Remark to the Dynamics in order to provide a foundation of empirical physics (and thus of the physics as a unified systematic whole). An important aspect of Emundts' interpretation is that the General Remark itself already provided a foundation of empirical physics (Emundts 2004, 48–54). Here I differ from Emundts. As said in §4.3.2, Kant acknowledged the existence of explanatory gaps between rational and empirical physics in the General Remark to the Dynamics. A proper grounding of physics as a systematic science is not given in the *Metaphysische Anfangsgründe*.

[223] Tuschling 1971, 111–122.

[224] Förster 1987, 548–551.

> sound and tone, according to their direction and degree). Consequently, this doctrine properly forms no part of the philosophical study of nature. (AA 21: 482)

The mere *instrumental* status assigned to mathematics in the *Transition* is taken to contradict the crucial foundational function ascribed to mathematics in the *Metaphysische Anfangsgründe*.[225] Only *philosophical* principles truly ground the science of nature. Note further that Kant describes Newton's *Principia* as containing mere mathematical principles of natural science, and thus seems to conceive this work as a mere exercise in mathematics or kinematics. This leads Tuschling to interpret the *Transition* as articulating a Newton polemics.[226] In this polemic, Kant often distinguishes between two ways of conceptualize (central) forces, a mathematical and a philosophical or dynamical treatment of forces. For example:

> If one […] speaks of mathematical foundations of natural science (as in Newton's *Philosophiae naturalis principia mathematica*), the moving forces are then presupposed as belonging to physics (e.g., gravitation, moving light, sound, and water); and it is not shown how motion results from the moving forces, but how certain forces result from motion (e.g., in the case of the central forces of bodies in circular motion). Hence, it is only a part of physics which may be treated mathematically […]. Consequently, the mathematical foundations of natural science do not form a part of the system of the moving forces of matter. (AA 21: 286)[227]

Tuschling and Förster again interpret these passages as involving a revision of Kant's view on the role of mathematics in natural science. Moreover, as we have seen, Tuschling argues that just as Kant characterizes Newton's *Principia* as merely providing a mathematical or kinematical theory of nature, Kant came to believe that the *Metaphysische Anfangsgründe* merely provided a theory of kinematics.

Michael Friedman has criticized this interpretation of Tuschling and Förster.[228] Friedman does not so much discuss Kant's views on the role of mathematics in natural science, but places Kant's distinction between mathematical and philosophical foundations of natural science in a different histori-

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[225] Cf. also Westphal 2004, 234, who notes in this context: "Kant now demotes mathematics from a model to be imitated in metaphysics to a mere auxiliary aid". There are numerous passages in the *Opus postumum* in which Kant distinguishes between mathematical and philosophical foundations of natural science, and appears to criticize the mathematical method adopted by Newton. For references, see Tuschling 1971, 91.

[226] Tuschling 1971, 91.

[227] Quoted from Förster 1987, 549.

[228] Friedman 1992a, 222–237.

cal context. According to Friedman, Kant's distinction between a mere mathematical and a dynamical treatment of moving forces must be understood "in the context of the eighteenth century struggle between the corpuscular or mechanical natural philosophy and the Newtonian natural philosophy".[229] The distinction between mathematical and philosophical foundations does not entail any revision of Kant's earlier thoughts (articulated in the *Metaphysische Anfangsgründe*) and Kant praises rather than rejects the Newtonian natural philosophy.

Friedman notes that Newton's *Principia* is not a work in mere kinematics. Rather, the *Principia* presents us with a progression from mathematical kinematics to a true physical dynamics, in which he introduces a dynamic conception of force as a *cause of motion*.[230] Importantly, Kant adopts this Newtonian conception of force, i.e., force as a cause of motion, in the *Transition*. This Newtonian conception of force is distinguished from a mere mechanical or *mathematical* conception of force, in which forces are mere *effects* of motion. Friedman therefore argues that Kant's distinction between (i) mere mathematical and (ii) philosophical foundations of natural science must be read as being directed against the mechanical natural philosophy. It is the mechanical natural philosophy that threats moving forces merely mathematically, i.e., as effects of motion. In contrast, Newton introduces a true dynamic conception of force. Newton thus "makes the decisive step from mechanical or mathematical moving forces to dynamical moving forces"[231], i.e., the step from (i) to (ii),[232] and Kant praises him for doing so in the *Opus postumum*.

I am in agreement with Friedman's claim that Kant's distinction between mathematical and philosophical foundations of natural science does not entail a serious revision of his earlier views. Moreover, Friedman correctly states

[229] Friedman 1992a, 226.

[230] We may add that Kant's *Metaphysische Anfangsgründe* also show a progression from a purely kinematical perspective to a truly physical perspective. Thus, in phoronomy (Chapter 1 of the *Metaphysical Foundations*) Kant deals with kinematics, treating physical bodies as points and abstracting from true physical forces and (more generally) causes. (cf. AA 4: 480, 487). In dynamics (Chapter 2), Kant introduces the notion of a force as a *cause* of (change of) motion (see for example AA 4: 496, 498). Here, Kant also treats of physical qualities such as (relative) impenetrability and density and (in the General Remark to the Dynamics) introduces the concept of a physical body. In Mechanics (Chapter 3), Kant officially introduces the concept of mass (AA 4: 537). To a certain extent, the progression of kinematics to physics is more clearly visible in Kant philosophical account of physics than in Newton.

[231] Friedman 1992a, 233.

[232] Friedman 1992a, 233–234, gives a list of references in which Kant takes Newton to introduce a dynamical conception of force. For example, at AA 22: 528–529, Kant notes that Newton "called the moving force *attraction* – whereby it was emphasized that this cause is effected from the body itself immediately, and not through communication of motion, to another body, and thus not mechanically but rather purely dynamically".

that Kant ascribes a dynamical conception of force, i.e., force as a *cause* of motion, to Newton. However, Friedman's reading does not fully explain the many passages in which Kant also describes Newton's *Principia* as providing merely mathematical principles of natural science.[233] How can Kant give such different characterizations of Newton's *Principia*?

A possible answer to this questions emerges if we allow for the possibility that in the eighteenth century the status of Newton's *Principia* was a source of confusion. In the present chapter, we have, I think, identified one such case of confusion. Recall that in his *Anleitung*, Karsten treated applied mathematics as a doctrine that does not provide insight into the nature or properties of material bodies and that does not investigate the *causes* of phenomena. I have argued that Newton's *Principia* may have been construed as a form of applied mathematics by Karsten, and that his critique of applied mathematics (i.e., of not being a truly physical doctrine) may have been directed against Newton (§4.4.2). If my interpretation is correct, there thus seems be a tendency in the eighteenth century to interpret Newton's *Principia* as a purely mathematical or kinematical work.

Although Friedman is correct in emphasizing that an interpretation of Newton's *Principia* as a purely mathematical work is incorrect, Newton himself can be taken to have given rise to such an interpretation, given that (as Friedman also notes) in the bulk of Book I of the *Principia* Newton emphasizes that his treatment of forces is mathematical and not physical. For example, in his comments to definition 8 of Book I Newton states:

> […] I use interchangeably and indiscriminately words signifying attraction, impulse, or any sort of propensity toward a center, considering these forces not from a physical but from a mathematical point of view. Therefore, let the reader beware of thinking that by words of this kind I am anywhere defining a species or mode of action or a physical cause or reason, or that I am attributing forces in a true and physical sense to centers (which are mathematical points) if I happen to say that centers attract or that centers have forces. (Newton 1999 [1726], 408)[234]

[233] Although, as Friedman correctly points out, there are various passages in which Kant attributes to Newton the introduction of a truly dynamic (not merely mathematical or mechanical) conception of force. Again, however, Kant also treats of Newton's *Principia* as containing mere mathematics or kinematics. This shows that Kant's position in the *Opus postumum* is often inconsistent.

[234] Note, however, that Friedman is correct in treating Newton's *Principia* as exhibiting a progression from kinematics to physical dynamics. For example, in the *Scholium* to Proposition 69 of Book I (a passage Friedman does not cite) Newton describes his own method as proceeding from a purely mathematical treatment of forces to a physical treatment, in which it will be possible to argue "concerning the physical species, physical causes, and physical proportions of these forces". Newton 1999 [1726], 588–589.

If we treat forces merely mathematically, we do not (also on Newton's own account) provide insight into the true physical causes of phenomena. As we have seen, this was precisely Karsten's critique of applied mathematics. Importantly, in the *Opus postumum* Kant levels the same critique against those scientists that merely treat moving forces mathematically, arguing that mathematical principles of natural science merely provide cognition of laws of motion or provide a *formal* treatment of motion, without considering the *material* original moving forces of matter.[235]

Now, as I understand Kant's position in the *Opus postumum*, he does not (as Karsten seems to do) criticize Newton for treating forces merely mathematically. He criticizes Newton for giving rise to a confusion of a merely mathematical (kinematical) treatment of forces and a truly physical treatment of forces, in which forces are treated as causes of motion (a confusion Kant sees reflected in the title of the *Principia*). Kant acknowledges that Newton treated forces (e.g., attraction) as a true physical cause, but he criticizes Newton for not providing sufficient justification for the intelligibility of such a conception of (attractive) force. This is precisely the task that Kant assigns to *metaphysics* in the *Metaphysische Anfangsgründe*. As we have seen in §4.3.3, this critique of Newton was already contained in the *Metaphysische Anfangsgründe*, in which Kant criticized mathematical physicists (i.e., Newton) for not strictly distinguishing between mathematical principles of natural philosophy and metaphysical principles of natural philosophy. This critique is repeated innumerable times in the *Opus postumum*.

Let us now return to the interpretation of Tuschling and Förster. According to Förster, Kant treated mathematics as a part of *physica rationalis*, grounding natural science, in the *Metaphysische Anfangsgründe*. This conception of mathematics is, Förster argues, rejected in the *Transition*. I think this interpretation is incorrect. Already in the *Metaphysische Anfangsgründe*, Kant treats *physica rationalis* as a purely *metaphysical* discipline, and explicitly distinguishes it from the mathematical principles, pertaining to *physica generalis* grounding natural science (§4.3.3). The strict distinction between mathematical and philosophical principles of natural science can thus already be located in the *Metaphysische Anfangsgründe*, and is no novelty of the *Opus postumum*. Moreover, as said, already in the *Metaphysische Anfangsgründe* Kant criticizes mathematical natural philosophers (i.e., Newton) for confusing mathematical and metaphysical principles, and for rejecting metaphysics while implicitly making use of metaphysical principles in natural science. Hence, the critical

[235] AA 21: 292, 166–167.

distance towards Newton's *Principia* that we find in the *Opus postumum* can already be found in the *Metaphysische Anfangsgründe* of 1786.

It is also incorrect to argue that Kant, in contrast to his views of the *Metaphysische Anfangsgründe*, *demotes* mathematics to a mere *instrument* or *auxiliary aid* in the *Opus postumum*, as Tuschling, Förster and Westphal claim. In Chapter 1, I discussed Kant's views on the role of mathematics in natural science. I argued that Kant takes mathematics to ground proper natural science because mathematics provides a priori principles that can be applied to individual physical objects, in order to derive or deduce with apodictic certainty propositions concerning natural objects. In a nutshell: mathematics allows for certain, deductive reasoning concerning natural objects. This circumstance is expressed by the fact that in the logic lectures mathematics is described as an *organon* of the sciences, i.e, mathematics is an *instrument* for bringing about certain cognition (knowledge). The characterization of mathematics as an organon can already be found in the *Logik Pölitz* of the 1780s.[236] Hence, in treating mathematics as an instrument in the *Opus postumum*, Kant is not adopting a novel view. Moreover, it is precisely in virtue of the fact that mathematics functions as an instrument for certain, deductive reasoning in natural science, that mathematics is taken to be necessary for proper natural science.

In conclusion, Kant's distinction between mathematical and philosophical principles of natural science in the *Opus postumum* corresponds to his views articulated in the *Metaphysische Anfangsgründe*. Mathematics allows us to strictly deduce propositions concerning natural objects, propositions that can thus be assigned apodictic certainty. As we have further seen in Chapter 1, Kant argued in the *Metaphysische Anfangsgründe* that a proper natural science requires, apart from mathematics, a philosophical or metaphysical foundation. It is only on the basis of metaphysical principles, and not on the basis of mathematical principles, that we can infer to objective grounds of phenomena. For example, the inference to the existence of universal gravitation as an objective ground of natural phenomena requires, according to Kant, *metaphysical* principles. Thus, when Kant, in the *Opus postumum*, notes that mere mathematical principles do not provide insight in true physical causes of phenomena, he is repeating one of the central claims of the *Metaphysische Anfangsgründe*: the claim that proper natural science requires philosophical grounding. That Kant rehearses this claim in the context of his transition project is not surprising. After all, the *Transition* is to provide a *philosophical* foundation of empirical physics. In addition, given that Kant, already

[236] AA 24: 505. cf. also AA 21: 695.

the *Metaphysische Anfangsgründe*, criticizes Newton for not investigating the metaphysical principles of natural science, it is no surprise that Kant levels the same critique against Newton in his transition project.

Let us turn to the general interpretation of the *Transition* given by Michael Friedman. Recall that Friedman characterized the *Transition* as providing a grounding of what he calls experimental physics. The *Transition* concerns a general foundational problem facing eighteenth-century natural science, i.e., the problem of how to extend the Newtonian paradigm to experimental sciences (such as chemistry). This characterization of the *Transition* seems to be fully correct. I have related the *Transition* to the traditional enterprise of showing how propositions of *physica specialis* are grounded in those of *physica generalis*. This supports Friedman's interpretation, while explaining more specifically how Kant and his contemporaries conceived of the relationship between various branches of physics.

Friedman further construes the *Transition* as providing a foundation of Lavoisier's chemistry, arguing that Kant adopted Lavoisier's system by 1795 at the latest. According to Friedman, it were developments within the experimental science, most importantly those associated with the so-called chemical revolution, that explain why Kant undertook his transition project. Friedman provides convincing evidence that Kant adopted various physico-chemical theories developed in the late eighteenth century (e.g., the discovery of factitious airs, the caloric theory of the states of aggregation, etc.).[237] Nevertheless, the claim that the *Transition* constitutes a foundation of Lavoisier's chemistry must be qualified. As said, the idea of exhibiting physics as a systematic unity by explicating the relationship between *physica generalis* and *physica specialis*, a project to which the *Transition* can be related, was common in the eighteenth century. Eberhard already undertook such a project in the 1750s. Hence, Kant's *Transition* can be understood against the background of a traditional conception of physics, one that predates the chemical developments that Friedman describes. To be sure: the developments within chemistry surely motivated Kant in constructing his transition project. However, the aims of the *Transition* cannot be interpreted solely from this perspective.

In this context, we may further note that the purpose of the *Transition* is to ground physics as a systematic science. Although in the latter half of the eighteenth century chemistry was taken to be a part of physics, physics is of course not identical to chemistry. As we have seen, most of the scientific topics that Kant discusses within the *Transition* were traditionally taken to pertain to

[237] Friedman 1992a, 264–295.

physica specialis. Chemistry was taken to be indispensable to physics precisely because it illuminated topics discussed within *physica specialis*. To give one example, the discovery that atmospheric air is not an element but a mixture of various gases is indispensable for physics because air was on of the fluids discussed within *physica specialis*. In short: Friedman is correct in emphasizing the importance of chemistry for understanding Kant's *Transition*, but the latter work is not simply a foundation of chemistry. Rather, the *Transition* is meant to explain how a priori principles of natural science (developed within the *Metaphysische Anfangsgründe*) can be applied within empirical physics so as to ground physics as a systematic science.

4.5.6 The *Transition* and biology

In conclusion of this chapter, we may again return our attention to biology. Note that none of the interpretations discussed in the previous section takes into account the status of biology within Kant's transition project. 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 himself apparently excluded the study of organic nature from his transition project in the early parts of the *Opus postumum*. In the *Oktaventwurf* (1796), Kant states that:

> "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."[238] 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)

[238] AA 21: 402.

The precise interpretation of these and like passages present formidable difficulties. The sudden introduction of these passages has further 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*.[239] In contrast, Eckart Förster argues that the introduction of these topics can be explained without reference to a third edition of the third *Critique*,[240] treating Kant's reflections on organic nature as preliminaries to the *Selbstsetzungslehre* developed in fascicles 10, 11 and 7 of the *Opus postumum*.

The interpretation of Kant's *Transition* that I have 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. In §4.3.1, we have seen that Kant does not, as is sometimes thought, 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, Eberhard, Karsten and Gehler all took the study of plants and animals, i.e., of *organic nature*, to be included in physics. More specifically: the study of organic nature was treated within *physica specialis*, and was sometime termed *physica specialissima*. In the *Transition*, Kant himself describes the study of organic nature as *physica specialissima*.[241] 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.

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*? Although I cannot fully answer this question, it must be emphasized that reflections on organic nature are already contained in the *Oktaventwurf* of 1796 (despite the fact that Kant seems to officially excludes this topic from the *Transition*). Already in the *Oktaventwurf*, Kant introduces the concept of a vital force (*Lebenskraft*) and lists the paradigmatic organic processes of nutrition, growth and generation.[242] Hence, reflections on organic nature were from the beginning con-

[239] Lehmann 1968, 371; Mathieu 1989, 240.
[240] Förster 2000, 21–23. Cf. also Tuschling 1971, 164–168.
[241] Cf. AA 21: 510, 512.
[242] AA 21: 376.

tained within Kant's transition project, even if the study of organic nature was only officially introduced within the *Transition* in 1799. In the next chapter, we will investigate more precisely how Kant conceives of biology within the *Transition*.

4.6 Conclusion

Kant's transition project can be best understood as an extension of the project of the *Metaphysische Anfangsgründe* of 1786. In particular: the *Transition* provides an a priori foundation of physics as a systematic science. Through an analysis of the concept of physics, as employed by Kant and his contemporaries, we have shed more light of Kant's transition project.

Kant construes physics in terms of its (i) object (corporeal nature), (ii) its sources of cognition, and (iii) the type of cognition (method of cognizing its object). Given Kant's insistence that we cannot sufficiently distinguish sciences from each other in terms of their object, he argues that we understand a science in terms of the *differentiae* (i)–(iii), which determine the *territory* of a science.

If we consider the object of physics (i), we learn that Kant adopts a rather broad conception of physics including doctrines such as chemistry and biology, but excluding empirical psychology. Hence, Kant does not equate physics with mathematical physics. On the basis of (ii), Kant distinguishes between *physica rationalis* and *physica empirica*, while (iii) leads to a distinction between *physica rationalis* and *physica generalis*.

In light of the *Opus postumum*, the distinction between *physica rationalis* and *physica empirica* is of crucial importance. In the *Metaphysische Anfangsgründe*, Kant construes this distinction in terms of a distinction between a priori comprehensible properties of matter and properties that require physical (empirical) treatment. Already in the *Metaphysische Anfangsgründe*, however, Kant acknowledged the existence of explanatory gaps between rational and empirical physics. If physics is to constitute a system, i.e., if propositions pertaining to rational physics must ground those pertaining to empirical physics, these gaps must be bridged, a project undertaken in the *Opus postumum*.

In our analysis of the use of the concept of physics in eighteenth-century textbooks on physics, we are confronted with similar considerations. In these textbooks, the importance of establishing physics as a systematic science is, even in light of an increased scepticism concerning the feasibility of such a project, continuously stressed. Also in line with Kant's views, we find a strict distinction between a mere mathematical treatment of nature and a truly

physical treatment of nature, in which we are concerned with establishing the true causes of natural phenomena. Most importantly, is, however, the distinction 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 with respect to particular classes of objects. Propositions pertaining to *physica specialis* are taken to be grounded by propositions pertaining to *physica generalis*. Moreover, the study of organic nature is a part of *physica specialis*.

Kant's transition project 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. It is because these sciences have the same object that a mediating science, such as the *Transition*, is necessary.

Kant's transition project is analogous to (though not identical with) the traditional project of grounding *physica specialis* in *physica generalis*. According to Kant, in contrast to the views of his contemporary physicists, this requires philosophical (a priori) principles. The systematicity of physics cannot be established empirically. Rather: the systematicity of physics must be grounded by specifying a priori *topoi* of empirically given moving forces of matter. Through this procedure, we can conceive of a continuous transition between the *Metaphysische Anfangsgründe* and physics.

In developing his philosophical foundation of empirical physics, Kant introduces the ether as a fundamental principle grounding the unity of physics. Kant's conception of the ether derives from the use made of this concept in eighteenth-century physics. Kant seems to be attracted to the idea of an ether because he does not believe (not always on the basis of intelligible or persuasive grounds) that microscopic attractive and repulsive forces can explain properties such as cohesion, the states of matter, etc. In addition, however, Kant takes the concept of the ether to be necessarily presupposed by physicists and thus interprets the ether as a topic allowing of a priori (philosophical) treatment. Finally, Kant's transition project also has ramifications for the study of organic nature. The latter is an integral part of physics. Hence Kant argues that an a priori concept of final causes, whose logical place is within Kant's *Transition*, must precede physics. This topic will be treated in the next and final chapter.

5 | Kant's reflections on organic nature in the *Opus postumum*

In the previous chapter we have analyzed Kant's project of providing a transition from the metaphysical foundations of natural science to physics. The *Transition* aims to provide a foundation of physics as a systematic science, where the study of organic nature is taken to be a part of physics. Hence, considerations concerning what we now call biology are pertinent to Kant's transition project. The *Transition* is supposed, as I argue in more detail in the present chapter, to ground biology so as to establish physics as a systematic science.

The present chapter will provide an analysis of Kant's various reflections concerning organic nature contained in the *Opus postumum*. I will analyze Kant's late views on organic nature in the context of several late eighteenth-century biological theories, most importantly theories invoking the fundamental concept of 'vital force' (*Lebenskraft*). In my opinion, one can only fully understand Kant's reflections on organic nature in the *Opus postumum* if one interprets them in light of eighteenth-century biological theories. The scientific context in which Kant formulated his theories concerning organic nature has received much attention in recent interpretations of Kant's third *Critique* (and earlier writings). However, this is not the case with respect to the *Opus postumum*. By relating Kant's views on organic nature as articulated in his last projected work to late eighteenth-century biological theories, we can increase our understanding of both the *Opus postumum* and of Kant's position with respect to the biological science of his day.

In the present chapter I intend to show that Kant's reflections concerning organic nature, as contained in the *Opus postumum*, are consistent with and

build on Kant's position developed in the *Kritik der Urteilskraft*. In the *Opus postumum*, Kant does not significantly revise his earlier views. Most importantly, Kant remains convinced that the idea of an organism (natural purpose) is a regulative concept, as opposed to a constitutive concept.

I further argue that in the *Opus postumum* Kant analyzed late eighteenth-century developments within the biological sciences on the basis of his regulative doctrine of teleology articulated in the third *Critique*. A central feature of my analysis is 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 concepts and theories that he took to have materialist and/or hylozoist implications, with physiological theories that conflated the domain of science and metaphysics, and with dogmatic metaphysical interpretations of biological theories that again conflated the domain of science and metaphysics. For Kant, the view that the concept of an organism is a regulative concept provided a natural antidote to these transgressions.

The amount of topics treated in the present chapter is rather large. In order to provide the reader with a guideline, I will give a rather elaborate account of the topics treated within each section. In §5.1, I discuss some existing interpretations of Kant's philosophy of organic nature in the *Opus postumum* and I position myself with respect to these interpretations. In addition, I explain how an analysis of the *Opus postumum* can help us in determining Kant's position with respect to the biological science of his day.

§5.2 provides a discussion of some dominant views on the concept 'vital force', views entertained by different biologists in the late eighteenth century. In §5.2.1, I discuss the theory of vital force developed by Johann Friedrich Blumenbach. Blumenbach is shown to construe vital forces, most importantly his famous *Bildungstrieb*, as teleological causes operative in nature. Vital forces are forces invoked to explain various organic phenomena such as (e.g.) generation, nutrition and growth and regeneration. Importantly, Blumenbach takes vital forces to be *irreducible* to so-called physical forces (e.g., forces treated within physics or chemistry).

In §5.2.2, I discuss the views on vital force of Joachim Dietrich Brandis and Johann Christian Reil. Like Blumenbach, these biologists construed vital forces as causes of organic phenomena. However, in *contrast* to Blumenbach, they allowed for the possibility that vital forces are reducible to so-called physical forces. Reil provides a strong reductionist account of vital force, arguing

that organic phenomena should all be explained in terms of *chemical* forces and regularities.

On the basis of the discussion of Blumenbach, Brandis and Reil, we can give a rather precise account of the relationship between Kant's views on biological method and those of his contemporary biologists. This relationship will be discussed throughout the present chapter. At this point, before turning to the other topics treated in the present chapter, I will summarize my position.

The relationship between Kant's views on biological method and the views of his contemporary biologists is complex. Kant's views on biological method cannot be identified with the views of any of the mentioned biologists (Blumenbach, Brandis and Reil). Rather, he entertained some views that are very akin to those of Blumenbach, while he entertained other views that are very akin to those of Reil. Moreover, in contrast to many of his contemporary biologists, Kant strictly distinguished methodological presuppositions guiding biological inquiry from ontological claims. This perspective strongly influenced Kant's reception of the biological theories of his day.

In particular: Kant was attracted to Blumenbach's theory of vital force (most importantly his account of *Bildungstrieb*) 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 Chapter 3 (§§3.8–3.9), 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. As we shall see, Blumenbach precisely highlighted the self-maintaining character of organisms while developing his theory of *Bildungstrieb*. In this respect, Kant's views are very similar to Blumenbach.

However, as we have also seen in Chapter 3, Kant, in contrast to Blumenbach, 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 highly akin to that of Reil for example.

Finally, Kant differed from both Blumenbach and Reil (and various other contemporary biologists) by strictly distinguishing *methodological* presuppositions grounding biological research from *ontological* presuppositions (§3.10). According to Kant, we necessarily 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. Similarly, that we should always explain organic phenomena or processes mechanically is a necessary methodological maxim that does not imply that teleological causation in nature does not exist. In eighteenth-century biological theories, the distinction between methodological and ontological presuppositions was vague. As we shall see, various biological theories proceeded from ontological assumptions, while various biologists and philosophers took biological theories to have ontological implications. Kant, as we shall see throughout this chapter, strongly insisted on the demarcation of biology and metaphysics or ontology, and he strongly criticized anyone who attempted to derive metaphysical conclusions from biological theories.

In §5.3, Kant's views on vital forces in his critical writings and his use of the concept 'vital force' in the *Opus postumum* are discussed. In §5.3.1, I analyze Kant's critique of Herder's notions of 'organic force' and 'genetic force', a critique contained in his 1785 reviews of Herder's *Ideen zur Philosophie der Geschichte der Menschheit*. Herder's views on organic forces and genetic force are developed on the basis of eighteenth-century biological theories of vital force. However, Herder employs these notions to derive various *metaphysical* conclusions, arguing for the formation of organic bodies from inorganic matter (hylozoism), affirming the reality of the transformation or transmutation of species, and arguing for the immortality of the human soul.

Kant strongly criticized Herder's speculative use of biological concepts. Here, we have a clear example of how Kant insisted on strictly demarcating biology from metaphysics. This point of view is also strongly present in the critique of hylozoism contained in the *Kritik der Urteilskraft* (a critique often taken to be directed against Herder), which is discussed in §5.3.2. Hylozoism affirms the objective reality of purposiveness in nature. Kant rejects hylozoism as a dogmatic form of metaphysics. The fact that we necessarily conceive of organisms as purposive does not imply the objective reality of purposiveness in nature.

In §5.3.3, I discuss Kant's views on vital force as contained in the *Opus postumum*. I argue that Kant reinterpreted Blumenbach's theory of vital force on the basis of his regulative doctrine of teleology developed in the third *Critique*. For Kant, vital forces give expression to the methodological idea that organisms have a purposive structure and are capable of purposive action, i.e., action in accordance with representations. However, we can only problematically ascribe vital forces to organisms (plants and animals) and we cannot

affirm the objective reality of vital forces in nature. To affirm the objective reality of vital forces in nature is to conflate a methodological presupposition of biological inquiry with a dogmatic ontological thesis.

Kant thus partly distanced himself from the views of Blumenbach, who affirmed the objective reality of vital forces and explicated the distinction between organic and inorganic nature in terms of an *ontological* distinction between physical forces (operative throughout the whole of nature) and vital forces (operative solely within organic nature). For Kant, the notion of vital force expresses how we *view* organisms, i.e., we view organisms by analogy with ourselves as purposively structured objects capable of purposeful or intentional action. It does not express how organisms objectively are.

§5.4 contains an analysis of how Kant construes the distinction between organic and inorganic nature in the *Opus postumum*. Kant did not conceive of the distinction between organic and inorganic nature in ontological terms as Blumenbach and other late eighteenth-century biologists did. In Chapter 3 (§3.10), we saw that in the third *Critique* Kant argues that the object or domain of biology is determined by conceptualizing organisms as natural purposes, i.e., the object of biology is determined by its method.

This idea is developed even more forcefully in the *Opus postumum*. There, Kant argues that the concept of an organisms, understood in the technical sense as a teleological whole in which everything is both end and means, is presupposed if organic bodies are to constitute an object of investigation for physics. The distinction between the organic and inorganic is a principle for the investigation of nature, *preceding* empirical investigation. As such, this principle is *a priori*. In the *Opus postumum*, Kant develops these ideas in a general context, arguing that the object of physics is constructed by the investigating subject.

In §5.5, Kant's anti-materialism in the *Opus postumum* is discussed. In the third *Critique*, Kant dismisses the metaphysics of materialism, arguing that it is absurd that inorganic matter could by itself give rise to organisms. This position is reaffirmed in the *Opus postumum*. I argue that Kant reaffirms his anti-materialism in the *Opus postumum* due to his encounter with biological theories in the 1790s that he took to have materialist implications. For example, he construed Johann Christian Reil as a materialist natural philosopher. In addition, in 1795 Kant wrote a short piece that was annexed to Samuel Thomas Sömmering's *Über das Organ der Seele* (published in 1796). This piece is discussed in §5.5.1.

In his *Über das Organ der Seele*, Sömmering argued that the organ of the soul or the *sensorium commune*, the organ through which perceptions obtained by different organs are combined, could be identified with the fluid contained in the ventricles of the brain. Kant criticized Sömmering for conflating physiological with metaphysical questions, a conflation that could give rise to materialism. However, Kant also, in order to further Sömmering's physiological research, articulated a chemical explanation of how fluids can be organized, and can thus be capable of performing organic functions (such as correctly combining various perceptions). This chemical explanation of the organization of fluids leads Kant to reaffirm his anti-materialism in the *Opus postumum*, for he needs to exclude the possibility that a chemical account of organization implies materialism.

Finally, in §5.5.2, I discuss various passages in the *Opus postumum* in which Kant claims that organisms have an immaterial ground such as a soul. These passages have been interpreted as evidence for the fact that in the *Opus postumum* Kant adopted a form of dogmatic metaphysics (cf. §5.1). In contrast, I argue that there is sufficient evidence to conclude that Kant's position in the *Opus postumum* is conform his position in the third *Critique*. We regulative assume that an immaterial substance endowed with understanding is the ground of organisms, although we have no sufficient theoretical grounds to affirm that this is objectively the case.

In §5.6, Kant's anti-hylozoism in the *Opus postumum* is discussed. As in the case of his anti-materialism, I argue that Kant reaffirmed his anti-hylozoism in the *Opus postumum* due to his encounter with particular biological theories in the 1780s and 1790s and with problematic philosophical interpretations of these theories.

In §5.6.1, I argue that in the 1790s Kant became acquainted with the hylozoist doctrine of the world-soul articulated by Salomon Maimon. This doctrine is rejected in the *Opus postumum*. Maimon arrived at his hylozoist theory, according to which a world-soul guides the formation of both inorganic and organic objects in nature, by providing a somewhat loose philosophical analysis of Blumenbach's doctrine of the *Bildungstrieb*. Hence, after his encounter with Herder in the 1780s, Kant was once again confronted with a philosopher who attempted to derive metaphysical conclusions from biological theories in the 1790s.

In §5.6.2, I discuss Kant's conception of 'life' in the *Opus postumum* and relate this conception to the use of concept 'life' by some eighteenth-century biologists. These 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 interpreting the concept of life in a manner that does not imply hylozoism.

§5.7 provides an analysis of how Kant attempts to incorporate biology within physics in the *Opus postumum*, so as to ground physics as a truly systematic science. In other words, the question is how Kant can conceive of biology as a part of a unified physics. In the *Opus postumum*, Kant comes to treat the ether as a principle for explaining certain organic phenomena. Given that, as we have seen in Chapter 4, the ether functions as a unifying principle of empirical physics, biology can be construed as a part of a unified physics. More specifically: the ether, functioning as a principle of chemistry and the theory of electricity, allows us to connect biology with physical disciplines such as chemistry and electricity. In this manner, various disciplines pertaining to physics are related to each other and physics can be constructed as a systematic science.

It must be emphasized that Kant merely provides some very loose speculations on how to ground biology in other physical disciplines. These speculations are, however, conform his conception of proper biological method and his idea that physics (which includes biology) should be construed as a systematic science. In the 1790s, Schelling truly undertook the project of grounding biology in terms of chemical, electrical and magnetic forces. Kant's intentions in the *Opus postumum* are thus in certain respects akin to those of Schelling. However, in contrast to Schelling, Kant never developed the project of grounding biology as a science.

Finally, in §5.8 Kant's views on natural history in the *Opus postumum* are discussed. I argue that Kant position with respect to natural history in the *Opus postumum* is conform his earlier views on natural history. In §5.8.1, I discuss Kant's views on natural history articulated from the 1770s up to the third *Critique*. Kant construed natural history as a historical discipline, concerned with specifying the historical causes of present properties of organisms. However, he also severely restricted the scope of natural history, arguing that one cannot allow for the generations of organisms from unorganized matter (*generatio equivoca*), nor for the possibility of a transformation or transmutation of species (*generatio heteronyma*). These restrictions are, in spite of the fact that several philosophers and biologists in the eighteenth century did not adhere to them, maintained in the *Opus postumum*, as I argue in §5.8.2.

5.1 The *Opus postumum* and Kant's philosophy of organic nature

In his influential commentary on the *Opus postumum*, Erich Adickes provided a rather marginal discussion of Kant's ideas on organic nature. Adickes analyzed the many seemingly contradictory statements concerning organisms in the *Opus postumum*, and took Kant as developing a dogmatic metaphysical account of organic nature.[1] To substantiate this claim, Adickes identified various passages in which Kant states that organisms have an immaterial principle as their ground (for instance: a soul), that they are created, etc. These passages indeed occur frequently in the *Opus postumum*, as, however, do passages which are fully in line with Kant's critical position articulated in the third *Critique*.

In response to Adickes, it must be emphasized that in his lectures, Kant often adopted a traditional metaphysics of substances in discussing the idea of the organic. One should therefore simply be advised to note that in the Kantian corpus we can distinguish between a traditional metaphysics of organisms and a critical, transcendental philosophy of organic nature. Given that the *Opus postumum* remains an unpublished work, it is no surprise to find both such 'dogmatic' and 'critical' passages. This interpretative stance was already adopted by Heinz Heimsoeth in 1940, who, in an instructive discussion of the idea of the organic in the *Opus postumum*, distanced himself from Adickes' interpretation. Although Kant's metaphysics of organisms does not play a major role in this chapter, I agree fully with the position of Heimsoeth.[2] In §5.5.2, I show that several passages in the *Opus postumum* are fully in line with Kant's position articulated in the third *Critique*. Hence, it is problematic to interpret the *Opus postumum* as articulating a dogmatic philosophy of organic nature.

More recently, Vittorio Mathieu has, although distancing himself from Adickes, 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, according to Mathieu is assigned a constitutive function.[3] Thus, Kant rejects the interpretation of the third *Critique* according to which

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1 Adickes1920, 216–235.

2 Heimsoeth 1940, 81–108. For a similar view, cf. Ingensiep 2009. Emundts 2001 stresses the continuity between the third *Critique* and the *Opus postumum* with respect to the concept organism, but hardly discusses the passages in which we can discern Kant's traditional metaphysical views on organisms.

3 Mathieu 1989, 209–213.

the concept of a natural purpose is a regulative concept of reflective judgment. This interpretation fits Mathieu's general interpretation of Kant's transition project as being predicated on a rejection of (what is sometimes called) the 'as-if' philosophy of the third *Critique*.[4]

In the present chapter, I develop a different interpretation. In the *Opus postumum*, Kant indeed assigns a fundamental significance to the concept of an organism, treating it as a concept that is a priori presupposed within physics. However, Kant continues to argue that this concept is regulative. Part of this argument is developed by focusing on the biological theories to which Kant was exposed in the 1780s and 1790s. The various problematic metaphysical implications of biological theories or metaphysical interpretations thereof provide a number of reasons why Kant continued to think of the idea of an organism as regulative. In addition, the fact that the idea of an organism is a necessary condition for scientific knowledge does not, according to Kant, imply that it is constitutive.

This leads us to our discussion of the biological theories influencing Kant. As said, the biological theories determining Kant's philosophy of organic nature in the third *Critique* have been intensively investigated. I have referred to the main personae in Chapter 3. Timothy Lenoir has argued that Kant's philosophy of organic nature, articulated in the third *Critique*, provided a theoretic foundation for the what he calls the Göttingen School of Biology, including prominent biologists as Johann Friedrich Blumenbach (1752–1840), Johann Christian Reil (1759–1813), and others.[5] More recently, several authors have endorse a radically different view. For example, Robert Richards argues that Kant's philosophy and Blumenbach's work on epigenesis are radically at odds with each other, claiming that the praise that both authors exchanged to each other was based on a grand misunderstanding.[6]

If we take into account Kant's reflections in the *Opus postumum*, a nuanced position concerning the relationship between Kant philosophy and the biology of his time arises (cf. the Introduction to this chapter). It becomes clear that the relationship between Kant's views on biological method and the views espoused by his contemporary biologists is highly complex. It is

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4 Mathieu 1989, 43.

5 Lenoir 1989.

6 Cf. Richards 2000, which has as title: "Kant and Blumenbach on the *Bildungstrieb*: A Historical Misunderstanding". Cf. Zammito 2006. For an overview of the views of these authors, see the Introduction to Chapter 3. I have distanced myself from this line of interpretation in Chapter 3. My view on the relationship between Kant's philosophy of biology and the biology of his time is, building on the account given in Chapter 3, further developed in the present chapter.

not the case, as Lenoir argues that there are fundamental continuities and similarities between, for example, Kant and Blumenbach. For Kant certainly rejects some tenets of Blumenbach's theories. It is also not the case, as Richards argues, that Kant's views and those of Blumenbach are fundamentally at odds with each other. Kant simply accepted certain views of Blumenbach while rejecting others. The same is true if we consider, for example, the differences and similarities between the views of Kant on biology and those entertained by Johann Christian Reil (whose views on biology differ greatly from those of Blumenbach). Kant would have accepted some tenets of the work of Reil while rejecting others.

A study of the *Opus postumum* further shows that Kant interpreted developments within biology from his own philosophical perspective, being quite aware of fundamental differences existing between his philosophical views and assumptions made by biologists of the time. Importantly, these differences were often *metaphysical* differences. The lesson to draw from the *Opus postumum* is that Kant mainly distanced himself from metaphysical implications and presuppositions of biologists, rather then distancing himself from their scientific work. From Kant's perspective, biology in the late eighteenth century often intruded in the domain of metaphysics and vice versa.

5.2 Theories of vital force

In reflections concerning organic nature in the *Opus postumum*, Kant introduces the term vital force (*Lebenskraft*) and employs apparently analogous terms such as organic formative force (§5.3.3). Moreover, Kant takes such forces to be fundamental to biological inquiry. The introduction of these terms is novel with respect to the third *Critique*. In the latter work, apart from a brief (and rather cryptic) reference to Blumenbach's *Bildungstrieb*,[7] terms such as vital or organic force do not play any significant role. The introduction of these terms, and the importance assigned to them, must be understood in light of biological theories developed in the late eighteenth century. In several of these theories, the notion of a vital (or organic) 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

[7] AA 5: 424.

biologists in the late eighteenth century. This is the subject of the present section.

In §5.2.1, I discuss the theory of vital force developed by Johann Friedrich Blumenbach. I have treated some of Blumenbach's works and theories in §3.8. However, a full understanding of his theory of vital force requires further discussion. 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). The *Bildungstrieb* was construed as a vital force or drive responsible for the generation and preservation of organic form. More generally, it directed all forms of organic generation (including, e.g., nutrition and growth). As such, it constituted the most important and fundamental vital force and was distinguished from other vital forces such as irritability and sensibility. However, all vital forces are placed by Blumenbach in a distinct order or hierarchy enabling the account of distinct vital properties. Finally, a crucial characteristic of Blumenbach's theory of vital force consists in adopting a strict distinction between vital and physical forces of bodies: the former only exist within organic nature while the latter act universally on all corporeal bodies. Vital forces are taken to be irreducible to physical forces.

In §5.2.2, I discuss two theories of vital force that differ from that of Blumenbach. First, I briefly 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 matter or parts. In addition, he questions the universal applicability of teleology in biological research, explicitly attacking Kant's claim that we must always reflect on organisms in teleological terms.

5.2.1 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.[8] 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 simply speak of vital force (*Lebenskraft*).

In the present section, I focus on the account of vital forces developed by Johann Friedrich 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.[9] Hence, Blumenbach's conception of vital forces was dominant, although, to be sure, 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[10], 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 Haller, who understood embryological development as the unfolding of preformed embryonic parts contained in preexisting germs.[11] Blumenbach, by contrast, endorsed an epigenetic theory, according to which the organization of the embryo developed from a not yet organized mass.[12] In order to explain the possibility of epigenesis, Blumenbach postulated the existence of a formative

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8 This, at least, is what Reil 1795, 48, claims.

9 Blumenbach's students included (to name only a few): 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.

10 It is important to note that Kant was familiar with the first and second edition of *Über den Bildungstrieb*, published in 1781 and 1789. I will refer to the second edition in the following, occasionally also referring to the first edition. At the end of this section, I will note some minor differences between the first and second edition. Blumenbach first published his ideas on *Bildungstrieb* in the *Göttingisches Magazin der Wissenschaften und Litteratur* 1780.

11 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.

12 Blumenbach 1789, 5–6.

force, the *Bildungstrieb* (*nisus formativus*), which directed the formation of the embryo out of homogeneous seminal 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) [13]

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

[13] My translation, with help from Richards translation of the first edition. Cf. Richards 2000, 18.

of this particular force.[14] However, the hypothesis of the *Bildungstrieb* was mainly 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.[15] 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 upon his observation 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.[16] 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.[17] The regenerative processes characteristic of organisms, could, according to Blumenbach, 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 *Bildungstrieb* to guide phenomena such as nutrition and growth. I will briefly return to this last topic at the end of our discussion of Blumenbach.

In discussing generation, Blumenbach referred, to give one 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.[18] This, according to Blumenbach, is

[14] 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. Cf. Richards 2000, 18–19.

[15] Blumenbach 1789, 85–87.

[16] Blumenbach 1789, 85–87

[17] Blumenbach 1789, 89.

[18] 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). To give some background information: the larvae of many gall wasps develop in plant galls that they themselves induce. Blumenbach is focusing on this phenomenon, giving explicit attention to the generation of plant galls (specifically: sleep apples) themselves.

a particular mode of generation, a mode distinguished from the generation of like organisms by like organisms (the mode of generation or reproduction typical of humans for example). The sleep apples are purposive structures, which, however, have little in common with the roses on which they grow.[19] 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 (in reserve so to speak) and waiting for the very unlikely occurrence that they are somehow activated.[20] If this hypothesis were true, nature would do a lot in vain. In contrast, Blumenbach thought it was very plausible that plants 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.[21]

At this point, I will not discuss any further examples Blumenbach cites for taking the *Bildungstrieb* to be responsible for generation. It must be emphasized that Blumenbach's positive empirical 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 formation of embryo's, or more generally: 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, for example, 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).

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[19] Blumenbach 1781, 21–24.

[20] Blumenbach 1781, 25.

[21] Blumenbach 1781, 25–26. I must confess, the supposed superiority of the hypothesis of the *Bildungstrieb* is not very clear to me in this particular case.

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, Blumenbach, employing the assumption that generation, nutrition and growth, and regeneration are similar processes, offered different (mutually supporting) arguments from *analogy* in order to conclude to the *Bildunsgtrieb* (e.g., regeneration and generation are similar processes, the *Bildungstrieb* guides regeneration, hence: the *Bildungstrieb* guides generation; regeneration and growth are similar processes, etc.).

(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*, first published in 1787,[22] Blumenbach argued that all bodies are subject to physical or chemical forces. However, according to Blumenbach organic bodies also possess properties, i.e., vital properties, that are completely different from the properties of inorganic bodies, and which cannot be accounted for in terms of chemical and physical laws alone.[23] 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".[24] 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. In general terms: 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

[22] I have consulted an English translation by John Elliotson of the third edition of 1810, published in 1817. Blumenbach's *Institutiones physiologicae* is instructively discussed by Larson 1979, 236–241.

[23] Blumenbach 1817, 16–17.

[24] *Ibid.*

within the domain of organic bodies. Blumenbach emphasizes this point by stating that the *Bildungstrieb* cannot even be thought to 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 can not 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".[25]

(iii) Finally, we must consider Blumenbach's views on different kinds of vital forces. We have seen that Blumenbach distinguished the *Bildunsgtrieb* 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 discernable vital properties of organisms must be accounted for by establishing distinct orders of vital forces.[26] He specified three classes of vital properties: (i) organic *formation*, (ii) *motion* of the parts of organisms, (iii) *sensation*.[27] 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 stimuli by means of contraction.[28] 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.[29]

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[25] Blumenbach 1817, 79–80.
[26] *Ibid.* 18. See also Larson 1979, 237–238.
[27] Blumenbach 1817, 18.
[28] *Ibid.* 18–19.
[29] *Ibid.* 20.

The order in which these vital forces were enumerated was, according to Blumenbach, identical to the order in which these forces arise during embryogenesis. Thus, before we can determine the existence of a new embryo, 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.[30] 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 (self-maintenance seems to be the overarching purpose of organisms). Blumenbach did not, however, specify any physical basis for the operation of vital forces and insisted on a strict distinction between vital and physical forces. This ultimately suggests that 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) (cf. §3.8).

As indicated in Chapter 3 (§§3.8–3.10), Kant could not (or should not) have accepted this tenet of Blumenbach's thought. Although he took biology inquiry to be necessarily based on a teleological interpretation of organisms,

[30] *Ibid.*

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 (§§3.8–3.9). 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, from Kant's perspective, a step to far.

Given these differences between the views of Kant and Blumenbach, it is surprising that in the third *Critique* Kant praised Blumenbach so lavishly. Indeed, we might be inclined to argue along the lines of Robert Richards, who claims that Kant and Blumenbach simply misunderstood each other.[31] In the present chapter I argue that in the *Opus postumum*, Kant, without discussing Blumenbach's work directly, distances himself from the ontological implications of theories of vital force espoused (e.g.) by Blumenbach, reinterpreting vital forces as regulative assumptions ascribed to nature by analogy with human purposive action. In the 1790s, Kant thus apparently become aware of differences between his own views and those entertained by (for example) Blumenbach. The question then becomes: why did Kant not already distance himself from Blumenbach in the third *Critique*?

Although I cannot answer the above question in detail, it is important to emphasize that the ontological implications of Blumenbach's views are more clearly articulated in later editions of his works. For example, in the foregoing I have discussed Blumenbach's theory of the *Bildungstrieb* on the basis of the second edition of *Über den Bildungstrieb* (1789). In this edition, as we have seen, the *Bildungstrieb* is explicitly treated as a vital *force*. Yet, in introducing the notion of a *Bildungstrieb* in the first edition (1781), the *Bildungstrieb* is not described as a force, but merely as a *drive* that must be distinguished from all other forces of nature.[32] The status of this drive is left rather obscure. Moreover, Blumenbach's methodology of basing biological research on teleology is also more clearly articulated in the first edition. In discussing nutrition and growth, Blumenbach notes that what is characteristic of organisms is their continual change, loss and renewal of parts (cf. §3.9). Organisms are conceptualized as purposive bodies adapted to maintaining themselves. Blumenbach sometimes seems to invoke the *Bildungstrieb* merely to emphasize that nutrition and growth have the function or purpose of

[31] Richards 2000.
[32] Blumenbach 1781, 12–13.

maintaining organisms (preserving organic form).[33] Organisms are (in Kant's terms) self-organizing wholes. If this is all that the term *Bildungstrieb* is meant to indicate Kant would not have objected (of course, in the present section we have seen that this is not the case in Blumenbach).

We may now construct Kant's interpretation of Blumenbach's theories as follows. In the third *Critique*, Kant, basing himself on the first edition of *Über den Bildungstrieb*, did not explicate the ontological implications of Blumenbach's theory of vital force, given that these implications were not clearly articulated by Blumenbach himself. Moreover, Kant focused on Blumenbach's methodology and found great similarities between Blumenbach's conception of biological method and his own conception of biological method. However, in the 1790s, Kant became more aware of the difficulties pertaining to theories of vital force espoused by Blumenbach, and he reinterpreted vital forces as regulative posits in the *Opus postumum*. That Kant became aware of such problems may have been partly caused by vigorous debates among biologists in the 1790s concerning the notion of vital force. Part of this debate is dealt with in the next section, where I will discuss two views on vital force differing from the views of Blumenbach.

5.2.2 Brandis and Reil on vital force: some different perspectives

In the previous section, I 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.

(i) In the preface to his *Versuch*, Brandis describes the aim of his work as providing an account of the concept 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, in contrast to Blumenbach, ultimately allows for the reduction of

[33] Blumenbach 1781, 69–73.
[34] Brandis 1795, xi.

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. The form of these parts is purposive with respect to the whole, i.e., the 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 he calls 'organization'.

The human body can only function as an instrument of communication when it is alive. When 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 this 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

[35] Brandis 1795, 1–2.
[36] Brandis 1795, 2–3.
[37] Brandis 1795, 15–17.
[38] Brandis 1795, 3–4.

and consequently applied (by analogy) 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 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, in contrast to (e.g.) Blumenbach, 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.

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[39] Here, I adopt the translation by Förster 1990, 258.
[40] Brandis 1795, 15–16.
[41] Brandis 1795, 29.
[42] Brandis 1795, 30–31.
[43] Brandis 1795, 81.

(ii) Johann Christian Reil provides a strong critique of the notion vital force as employed, e.g., 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 (*Mischung*) 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 inorganic bodies is simply a consequence of the different type of matter of which it is 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 while arguing 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

[44] Reil's work is instructively discussed by Lenoir 1989 and Richards 1998. 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, and that Reil distances himself from the position of Blumenbach. This is quite obvious if one reads *Von der Lebenskraft*. However, as I will argue throughout this chapter, in certain respects the views of Kant and Reil are quite similar.

[45] Reil 1795, 11.

[46] Reil 1795, 12.

[47] Reil 1795, 13–14.

[48] Reil 1795, 15–19.

of bodies of specifically different types. In particular, all elements combine with each other in accordance with their 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, Reil promotes the explanation of organic bodies in terms of the chemical elements found in organic bodies and their mode of composition.[51]

How did Reil conceive of the notion of a vital force? Reil construes a force, here we are dealing with the *general* concept of 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.[52] 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, we do not require to posit a third element effecting this combination.[53] According to Reil, the concept force is most precisely explained if one understands it as a *property of matter*.

In line with this account of the concept 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.[54] The concept 'vital force' signifies the relation of particular phenomena (peculiar to organic

[49] Reil 1795, 19.
[50] Reil 1795, 24–25.
[51] Note that the methodology Reil proposes for conducting biological and physiological research is akin to the methodology of providing mechanical explanations that I have attributed to Wolff, who argued that we must explain properties of corporeal bodies in terms of their parts, mode of composition of these parts, and forces acting upon the parts (§§2.3–2.6). What is distinctive of Reil's views, is his emphasis on the importance of chemical affinities.
[52] Reil 1795, 45–46.
[53] Reil 1795, 47.
[54] Reil 1795, 47–48.

bodies) to a particular type of matter (i.e., organic matter).[55] This is Reil's version of the distinction between physical and vital forces. In contrast to Blumenbach, this distinction is not taken to have ontological import. 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.[56] However, any phenomenon of any body is grounded in its basic materials and their elective affinities. Hence, Reil concludes that we will only fully understand what vital forces are, defined in the above manner, if by chemical research we become acquainted with the particular type of mixture or chemical composition of organic matter.[57] In contrast to Blumenbach, Reil thus allowed for a complete mechanical and 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.[58] This assumption is contrary to proper scientific methodology, which requires that we conceive of nature as governed by unchangeable laws (e.g., parts of organic bodies have a particular weight irrespective of having vital properties). Proper methodology further requires that we explain different phenomena of a body, e.g., the weight, cohesion, chemical properties and irritability of muscle fibres, 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, which (according to Reil) shows that differences in the composition of matter can explain variable

[55] Reil 1795, 48–49.
[56] Reil 1795, 50.
[57] *Ibid.*
[58] Reil 1795, 52–53.

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? In this manner, Reil critiqued the notion vital force from biology as employed by Blumenbach.

It is worth noting that Reil also criticized Kant's construal of organisms as natural purposes.[59] 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".[60] In organisms, nothing is judged to be in vain or purposeless. Referring to Kant, Reil argues that Kant's construal of organisms as natural purposes is incorrect. In particular, 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., particular or 'arbitrary' muscle groups, sense organs, the higher operations of the brain) can fail without hindering the maintenance of the whole.[61] 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.

In conclusion: 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, in particular the theory of the *Bildungstrieb*, because of its overtly teleological character. While discussing the nutrition and growth of organisms, Reil notes (clearly referring to Blumenbach) that the capacity to assimilate and transform external substances is sometimes described by means of the term *Bildungstrieb*.[62] However, he notes 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, according to Reil, 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[63], criticized the

[59] Reil 1795, 54–56. Cf. Richards 1998, 710.
[60] AA 5: 376.
[61] Reil 1795, 55.
[62] Reil 1795, 66–67.
[63] Hildebrandt 1799, 43.

assumption of a vital force (*Lebenskraft*) existing *independently* of matter and effecting life.[64] 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.[65] Note, however, that in contrast to the views of Reil, Hildebrandt does not take his denial of the existence of vital forces independently of matter to imply that teleology plays a limited role in the study of organisms. Rather, citing Kant, he construes organic bodies as products of nature in which everything is an end and reciprocally a means.[66] Hence, the insistence on mechanical explanation in biology does not make the use of teleology superfluous (a rather Kantian insight).

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.

5.3 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*?

In a series of influential writings on Kant and late eighteenth-century German biology, Timothy Lenoir has argued that there exists considerable similarities between Kant's philosophy of organic nature and the conception

[64] 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.

[65] Hildebrandt 1799, 41–44.

[66] Hildebrandt 1799, 110–111.

on biological method adopted by Blumenbach (as well as other biologists, including among others Karl Friedrich Kielmeyer and Johann Christian Reil).[67] According to Lenoir, Kant embraced Blumenbach's theory of vital force and both shared the same view on proper biological method, which is described (among others) as a form of *teleomechanism* (cf. the Introduction to Chapter 3)

In contrast to Lenoir, many modern commentators think that Kant could not have consistently adopted the notion of vital force. This thesis has been forcefully articulated by Robert Richards in a series of writings on the biologists of Kant's time.[68] The problem, in a nutshell, is that assuming the existence of vital forces is inconsistent with Kant's regulative doctrine of teleology. 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 a existent teleological force (cause) directing the formation of organisms (cf. the Introduction to Chapter 3).

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. As I have frequently emphasized, Kant accepted the view of Blumenbach that in biology we presuppose that organisms and their parts are purposive wholes adapted to performing certain functions. Kant added the claim that proper explanations in biology are mechanical explanations. Finally (and importantly), Kant argues that the (what we may call) teleological and mechanical maxim lying at the basis of biological research are regulative, methodological principles having no ontological import. That we conceptualize organisms teleologically does not imply the objective reality of teleological causation in nature. Hence, Kant accepted some tenets of Blumenbachs thought. He could not, however, consistently adopt the ontological position of Blumenbach, who affirmed the

[67] Lenoir 1980, 1981, 1989. Cf. Chapter 3 for my discussion of Kant's views on proper biological method. 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.

[68] Richards 1998, 2000, 2002. Richard's thesis is generally accepted. Cf. Beiser 2006, 13–14; Zammito 2006, 765.

objective reality of vital forces in nature. For this reason, I argue in the following, Kant reinterprets vital forces as regulative posits in the *Opus postumum*.

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, who rejects the theory of vital force expounded by Blumenbach. 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.[69] As we have seen, Richards is correct in emphasizing that Reil criticizes Kant's construal of organisms in teleological terms (and Kant would no doubt resist such a criticism). However, Kant would have no problem in accepting the view that organic phenomena should (as far as possible) be explained mechanically. In Chapters 2 and 3, we have seen that Kant construed mechanical explanation as a form of proper scientific explanation that functions as an ideal of explanation in biology. What Kant does object to is an ontological reduction of organisms to their material parts and forces.

In my opinion, a shortcoming of various interpretations of the relationship between Kant's philosophy and late eighteenth-century biology, consists in the limited recognition of the fact that Kant adopted different levels of analysis when interpreting the works of his contemporary biologists. On the one hand, Kant 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). As I have already emphasized in Chapters 2 and 3, these two levels must be distinguished. Let us recapitulate Kant's main views

In the Dialectic of Teleological Judgment of the third *Critique*, Kant described the (what we may call) mechanist maxim, according to which we must judge material things and their forms in accordance with merely mechanical laws, and the (what we may call) teleological maxim, according to which we must judge some products of material nature as possible in accordance with final causes, as maxims of the reflecting power of judgment.[70] These maxims are subjective regulative principles employed in reflecting on organisms. They provide methodological prescriptions: the teleological maxim directs us to conceive of organisms in teleological terms, i.e., as purposive wholes in which

[69] Richards 1998, 709–711.
[70] AA 5: 387.

everything is an end and reciprocally a means. However, this does not mean that we should abandon the mechanist maxim. On the contrary, we should always try to specify the mechanical processes operative in organisms or (put differently) the mechanical means through which some end is brought about.

Kant argues that as regulative principles, the mechanist and teleological maxim are complementary and consistent with each other, leading him to characterize the proper method of biology as consisting in the subordination of mechanism to teleology. However, if these regulative principles (maxims) are transformed into constitutive principles, i.e., as *objective* principles for the determining power of judgment, the mechanical and teleological maxim do contradict each other. To take the mechanist maxim as a constitutive principle is to deny the *objective reality* of final causation in nature, whereas to take the teleological maxim as constitutive is to affirm the *objective reality* of final causation in nature. In short: to transform these regulative maxims into constitutive principles is to confuse subjective methodological prescriptions with objective ontological claims (claims which Kant took to be central to traditional dogmatic metaphysical systems).

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 (or any other biologists of the time) emphasizes the necessity of conceptualizing organisms in teleological terms, Kant would have agreed. Conversely, when for example Reil (or any other biologists) emphasizes the necessity of explaining organic phenomena mechanically, Kant again would have agreed. These different biologists can simply be taken to emphasize the importance of either the teleological or the mechanist maxim. At worst, Kant could have criticized biologists for overtly privileging one maxim for judging organisms over the other, i.e., for not recognizing that the teleological and mechanical maxim are complementary. However, when for example Blumenbach affirms the objective reality of vital forces, Kant would 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 to 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.[71]

[71] In this context, we may speculate on a Kantian response to Reil's argument, treated in the previous section, that the organs of organisms are not always means to an end. Recall that Reil rejects Kant's teleological interpretation of organisms and their parts by citing organs that are irrelevant for the maintenance of the individual organisms. The male testicles are

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. In §5.3.3, I argue that in the *Opus postumum* Kant treats vital forces as regulative posits, thus modifying Blumenbach's theory of vital force in terms of his regulative teleology as developed in the third *Critique*. For Kant, the introduction of the term vital force points to the methodological claim that organisms must be interpreted teleologically. In this respect, Kant position builds on that of Blumenbach. However, in contrast to Blumenbach Kant 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* (as in the third *Critique*) Kant argues that in 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.

Before turning to the *Opus postumum*, I will discuss two passages from Kant's critical period that are related to the topic of vital force. In §5.3.1, 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 §5.3.2, I discuss Kant's critique of hylozoism, contained in the Dialectic of Teleological Judgment of the third *Critique* (1790).[72] An analysis of these texts points to a particular continuity in Kant's thought, one that can be traced

a case in point (Reil 1795, 55). The traditional objection to Reil's claim would be that the male testicles simply do serve a function (although we may not yet know which). Kant could retort that Reil does not understand that parts (organs) are conceptualized as means to an end relative to a subjectively specified end or purpose. Thus, the male testicles, although seemingly irrelevant to the maintenance of an individual (male) organisms, can be judged as a means to reproduction and the maintenance of the species. It is because we judge something to be a purpose, that certain things are judged to be means relative to this purpose. Nowhere does Kant argue that the maintenance of individual organisms is the sole (objective) purpose of organisms. For Kant, I think, this is not a futile way of evading the issue. When judging something as an end or purpose, we open new domains of investigation and inquire how some end is brought about (e.g., if we focus on the means for the preservation of species we focus on different things than if we were to focus on the means for the preservation of individual organisms). That we can subjectively ascribe different purposes to organisms and their parts is thus central to the advent of biological knowledge.

[72] 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.

to the *Opus postumum*. 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 who employ notions such as vital or organic force, was that they invoke such notions, which have a legitimate place in biology, to arrive at unsupportable metaphysical positions. For Kant, vital forces have a legitimate place in biology if interpreted as regulative posits. However, they cannot be employed to support metaphysical theories. This view, as I argue in §5.3.3, is also expounded in the *Opus postumum*.

5.3.1 Kant's critique of Herder

Kant's reviews of the two volumes of Herder's *Ideen*, which appeared in the *Allgemeine Literatur-Zeitung* in January and November 1785, are famous for their attack on the latter's conception of living or organic forces.[73] 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".[74] In addition, Kant sharply criticized Herder's notion of a genetic force (*genetische Kraft*), a single force construed as the principle of all organic formation in nature, claiming that "the unity of organic force [...] is an idea which is entirely outside the field of empirical natural science and belongs merely to speculative philosophy".[75] In this manner, Herder's conception of organic forces was dismissed as the fruit of dogmatic metaphysical speculation.

Herder's use of the term organic force is quite similar to Blumenbach's use of the term vital force. In particular, Herder's use of the term organic force is akin to Blumenbach's use of *Bildunsgtrieb*. This is not always evident. To my knowledge, Herder does not cite Blumenbach as a source. However, the functions Herder ascribes to organic forces are similar to the functions Blumenbach ascribes to the *Bildungstrieb*.

For example, in the third book of the first part of the *Ideen*, Herder

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[73] I have greatly benefited from John Zammito's insightful analysis of the Kant-Herder controversy. Zammito 1992, 189–213. However, I do not share his view that Kant's stance towards the (biological) sciences is profoundly reactionary. The present chapter aims to show that in the *Opus postumum*, Kant was quite sensitive to the developments within the biological sciences of his time, even if he interpreted them from his own philosophical perspective. For Zammito's views on the relationship between Kant's philosophy of biology and the views entertained by his contemporary biologists, see also Zammito 2003, 73–109; Zammito 2006, 754–764.

[74] AA 8: 53.

[75] AA 8: 54.

attributes an organic force to plants that is supposed to account for their generation or reproduction and the processes of nutrition and growth.[76] 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 be postulating preformed germs distributed throughout the organism, but require the posit of mighty organic forces. Finally, Herder posits organic forces as being responsible for epigenetic embryological development. Herder's acceptance of epigenesis thus lead him to accept the notion of organic force. This treatment of organic forces strongly resembles Blumenbach's discussion of the *Bildungstrieb* (§5.2.1), who, as we have seen, argued for the *Bildunsgtrieb* as a cause of the epigenetic development of embryos while highlighting its function in the generation, nutrition and growth, and the regeneration of organisms and organic structures.

Herder's notion of a genetic force is somewhat 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.[77] He discusses the notion of genetic force in the seventh book of the second part of the *Ideen*.[78] 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 which produces organic parts out of the chaos of a homogeneous matter.[79] The notion of a genetic force is then introduced as a general formative principle, it is (in Herder's terms) 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).[80] As we shall see in the following, Kant was especially critical of this idea of genetic force. Let us turn to Kant's criticism of Herder.

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 im-

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[76] Herder 1785, 135–137.

[77] This is no surprise. As we have seen, the notion 'organic force' functioned as a general term applicable to distinct forces such as irritability, sensibility, the *Bildungstrieb* etc. The notion of a genetic force is, as we will see, invoked specifically to explain the adaptation of organisms to different environmental conditions.

[78] Herder 1786, 122–140.

[79] Herder 1786, 122–124.

[80] Herder 1786, 128–133. Cf. Sloan 2002, 242–244.

plications 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;[81] (ii) it is the cause of the transformation of species; and (iii) it is aimed at the realization of human nature.[82] As such, this force is conceived to be the cause of a continuous progression of species, a progression which cannot end with the death of man and thus provides evidence for the immortality of the human soul. Herder thus infers the immortality of the soul on the basis of an analogy with the continuous gradation of organisms.

Kant reject's Herder's analogy.[83] 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, Kant criticizes Herder's method of invoking presumed empirical facts in order to decide metaphysical questions.[84] 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. Kant was fully aware of the biological context in which Herder developed his notion of organic force. In his first review, Kant noted that Herder rejected the assumption of preformed germs (*Keime*),[85] i.e., the theoretical entities assumed within Haller's preformationism. In contrast to Herder, however, Kant at-

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[81] AA 8: 46–47.
[82] AA 8: 49.
[83] AA 8: 53.
[84] Ibid. Cf. Zammito 1992, 185.
[85] AA 8: 50.

tempted to mediate between epigenesis and preformationism. It was precisely his adoption of the notion of pre-existent germs (*Keime*), in conjunction with the notion of predispositions (*Anlagen*), which allowed Kant to articulate an intermediate position.[86]

Germs were construed as species-specific entities, accounting for a set of physical properties displayed by the members of the species. In addition, germs were taken to determine the range of possibilities within which organisms can develop their structure. Predispositions were construed as variable adaptive mechanisms manifesting themselves under environmental conditions, thus accounting for the variety of traits among members of a species.[87] Postulating predispositions implied a rejection of a strong form of preformationism, since the organization of individual organisms is not taken to be completely preformed. Nevertheless, since germs determine the limits within which organisms can attain a specific structure, the structure of organisms is preformed to a certain extent. Thus, in contrast to Herder, Kant did not advocate an outright rejection of preformationism. This becomes clear in his review of the second volume of the *Ideen*:

> The division of the human species into *races* is not favored by our author [i.e., Herder], primarily not that grounded on inherited colors, presumably because the concept of a race is for him not distinctly enough determined. In the seventh book, third number, he calls the cause of the climactic difference of human beings a *genetic* force. The reviewer has the following concept of the meaning of this expression, in the author's mind. He wants to dismiss on the one side the system of evolution and yet also on the other side the mere mechanical influences of external causes as providing unworkable grounds of elucidation, and he assumes as its cause a principle a principle of life, which appropriately modifies itself *internally* in accordance with differences of the external circumstances; with this the reviewer fully concurs, only with this reservation, that if the cause organizing itself *from within* were limited by its nature only perhaps to a certain number and degree of differences in the formation of a creature (so that after the institution of which it were not further free to form yet another type under altered circumstances), then once could call this natural vocation of the forming nature also "germs" or "original predispositions", without thereby regarding the former as primordially implanted machines and buds that unfold themselves only when occasioned (as in the system of evolution), but merely as limitations, not further explicable, of a self-forming faculty, which latter we can just as little explain or make comprehensible. (AA 8: 62–63)

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[86] Cf. Zammito 1992, 203–206; Grene & Depew 2004, 96–97.

[87] This account of *Keime* and *Anlagen* is contained in Kant's *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. Sloan 2002 provides a thorough historical analysis of these notions. See also Grene & Depew 2004, 96–97.

In this passage, Kant agrees with Herder in rejecting two influential accounts of the existence of varieties within a species, i.e., of the 'climatic differences' among human beings which constitutes the topic in the passage above (e.g., different races). According to the theory of individual preformationism (evolution), embryological development is understood as the *evolution* of an embryo contained in germs originally created by God. This embryo, in turn, contained the germs of all of its descendents. Such a theory seemed to imply that the traits exhibited by offspring cannot significantly differ from those possessed by their ancestors. The problem was resolved by positing, as Kant's puts the point above, the existence of implanted machines or buds (germs) that unfold when stimulated by certain external triggers (e.g., environmental conditions). In our discussion of Blumenbach (§5.2.1), we have already witnessed that the strategy of the preformationist to posit implanted buds or encased germs in order to account for various organic phenomena was treated as problematic. Thus, for example, Blumenbach rejected the attempt to explain the regeneration of the parts of a polyp by postulating the existence of a variety of encased germs distributed throughout its parts. Such a postulate is not supported by empirical evidence and is made *ad hoc*. The same type of criticism seems to leveled against the preformationist account of climactic differences among human beings in the passage above. In this respect, Kant and Herder agree.

Kant and Herder also agree in denying that varieties within a species (e.g., races) are *merely* the result of mechanical influences, e.g., variations in climate and nutrition. Kant argues that a mere appeal to environmental factors does not sufficiently explain the existence of varieties, since it does not allow us to understand how different traits within a species are *hereditable*.[88] It is, however, only on the basis of hereditary traits that we can determinately distinguish various classes within a species.[89] For this reason, Kant agrees with Herder's in rejecting the purely 'environmentalist' account of varieties.[90]

The main difference between Kant and Herder is, as Zammito has shown, contained in Kant's commitment to the existence of germs (*Keime*)[91], an assumption which, as already noted, Herder rejected. In reaction to Herder's account of variation within a species, Kant emphasized that the formative capacity of a genetic force should be limited, so that it would not be free to "work from another type under altered circumstances". In other words, Kant

[88] AA 2: 435.
[89] AA 8: 99.
[90] Cf. Zammitto 1992, 205.
[91] Zammito 2003, 86.

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. Herder, by contrast, explained the existence of varieties in terms of the modified action of the genetic force caused by changing environmental conditions. Since the action of the genetic force is not 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.[92] Kant invoked his specific version of preformationism against Herder precisely to exclude this possibility and to guarantee the constancy of species.

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. As such, Kant's critique of Herder does not have any significant bearing on the question whether hypotheses concerning vital forces can be legitimately entertained within biological inquiry. Kant's critique of Herder is directed against the untenable implications which result from Herder's employment of the notion of a genetic force, and not to the notion of a vital force as such. Blumenbach's *Bildungstrieb*, for example, was not taken by Kant to have such transformationist implications as Herder's genetic force and was treated as unproblematic in the third *Critique*.

5.3.2 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*.[93] As John Zammito has emphasized, Kant's critique of hylozoism must be understood in the context of his controversy (treated in the previous section) with

[92] AA 8: 54.

[93] Frederick Beiser 2006, 9, 13–14, has, in an otherwise 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. I disagree, as will become clear from the following.

Herder.[94] According to Kant, Herder adopted the untenable hylozoist position that unorganized matter can form itself into a purposive whole. Kant's official argument against hylozoism (in which he does not mention Herder by name) will be treated below. At this point, we may already note that Kant explicitly refrains from attributing hylozoism to the likes of Blumenbach. According to Kant, Blumenbach, in explicit contrast to the position of hylozoism, rightly rejected the idea that "life should have arisen from the lifeless".[95] Hence, Kant's critique against hylozoism cannot be taken as a critique directed at the biological work and theory of vital force espoused by Blumenbach.

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".[96] 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, and contrary to this position, we have what Kant calls (2) the "realism of the purposiveness of nature".[97] 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 existence of final causation within nature.

Note that both (1) idealism and (2) realism are presented by Kant as dogmatic metaphysical theories: whereas (1) categorically denies the existence of final causation in nature, (2) affirms the existence of final causation in nature. Hence, Kant presents both (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 of judgment.[98] Hylozoism, the doctrine which explains the appearance of purposiveness by hypothesizing the "life of matter", belongs, together with theism which derives ends of nature from an intentionally productive intelligent being (original ground), to the category of realism.

Kant distinguishes between two versions of hylozoism.[99] According to the first version *life* is an essential (internal) property of matter as such. This implies that there is no distinction between the domains of the inorganic

[94] Zammito 1992, 189–213.
[95] AA 5: 424.
[96] AA 5: 391.
[97] AA 5: 392.
[98] AA 5: 398–391.
[99] AA 5: 394. This is also pointed out by Beiser 2006, 13–14.

and organic. According to the second version, matter is *animated* by some (external) principle, e.g. a world-soul or vital force. Kant provides specific arguments against both versions of hylozoism. His main objection, however, boils down to the claim that hypothesizing the existence of a living or animated matter in order to explain the existence of purposiveness in nature is illegitimate.

Kant rejects the first version of hylozoism by arguing that the assumption of living matter contradicts the law of inertia, according to which every change of matter has an *external* cause.[100] 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.[101] As such, the hylozoistic assumption of the existence of living matter, cutting across the distinction between the organic and the inorganic, contradicts a fundamental principle of physics and must be rejected.

With respect to 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".[102] Thus, we can only legitimately 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. 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.[103]

We can now ask the question whether Kant's critique of hylozoism implies that he denied the legitimacy of assuming vital forces within the domain of biological inquiry. This does not seem to be the case. First, we may note that hypothesizing 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's conception of vital forces is based on the idea that one must sharply distinguish between the domains of the inorganic and organic. Vital forces are taken to be efficacious only within the domain of organic bodies, and can only be employed to explain vital functions. This is a position which harmonizes quite well with Kant's rejection of the first version of hylozoism.

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[100] *Ibid.*

[101] This explication of the law of inertia is given in the *Metaphysische Anfangsgründe*, AA 4: 544.

[102] AA 5: 394.

[103] *Ibid.*

Kant's critique of the second version of hylozoism also has little bearing on the question 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 which, according to Kant, is circular. To assume the existence of a teleological agent in order to explain the reality of purposiveness in nature is simply 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 were explained, e.g., to account for embryogenesis, irritability, etc.).

In conclusion, the analysis of Kant's critique of Herder (§5.3.1) and his critique of hylozoism (§5.3.2) shows 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, biological investigation (as, e.g., Blumenbach employs them). Nevertheless, it is clear that the notion of vital force is intimately related to metaphysical discussions.

As we shall see (§5.6.1), in the *Opus postumum* Kant similarly criticizes Salomon Maimon's idea of a world-soul, who (quite similar to Herder) employs Blumenbach's notion of *Bildungstrieb* to argue for a form of hylozoism. Kant thus remained critical of people who invoked biological theories to argue for metaphysical positions. In the *Opus postumum*, Kant also assigns a positive function to the notion of a vital force, treating it to be essential to biological inquiry. This, however, 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.

5.3.3 Vital forces in the *Opus postumum*

In the *Opus postumum*, Kant discusses the concept 'vital force' (*Lebenskraft*) and several cognate 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 have seen in the previous chapter, it is the task of the *Transition* to specify the elementary 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 thus 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 treated are already treated in the *Oktaventwurf*).[104] However, early 1799, in the draft "A Element. Syst: I", Kant explicitly begins to argue that a systematic physics must be taken to include the study of organic nature. In addition, Kant 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)[105]

How are we to understand these difficult passages? In my view, Kant's introduction of notions such as an 'organic formative force' can be best understood in the scientific context of his time, where, as we have seen, the notion of a vital force was a fundamental biological concept. We may note that, although Kant does not employ the concept vital force (*Lebenskraft*) in this context, the notion of an organic formative force is similar to notions employed by biologists of Kant's time. For example, as said, Johann Christian Reil, in his

[104] Cf. §4.5.6.

[105] 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".

Von der Lebenskraft, 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.[106] Moreover, in other passages of the *Opus postumum* Kant does employ the more common term vital force.[107]

To which theory of vital force can we relate the cited passages? It is important to note that there is insufficient textual evidence enabling us to precisely determine any concrete historical influence on Kant's thoughts in this context. Nevertheless, I think the passages above can be best understood as introducing a conception of vital forces quite similar to that of Blumenbach. In the last passage cited, Kant defines an organic formative force as a force which 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, and it is precisely because of this organization that we take bodies to be organic. This construal of organic formative forces is 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 researches were taken to govern physiological processes so that certain parts of (human) organisms were capable of performing specific functions (e.g., sensibility, pertaining to the nerves, was taken to be the cause of the capacity of sensation) within the whole organism. Both Kant and Blumenbach, therefore, emphasize the importance of introducing a specific type of force in order to understand the purposeful organization of organisms. In contrast, as we have also seen, biologists such as Reil rejected the Kantian claim (also endorsed in the *Opus postumum*) that organisms must be construed as objects in which everything is both end and means. Such a view is anathema to Kant.

In the *Opus postumum*, Kant thus seemingly adopted a conception of vital force that is akin to that developed by Blumenbach.[108] Moreover, Kant's insis-

[106] Reil 1795, 48.

[107] 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*.

[108] Again, 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,

tence that the concept of vital or organic force must be necessarily employed in the investigation of nature shows that he took this concept to be fundamental to biological inquiry. The most pertinent question confronting us now is whether Kant, in the *Opus postumum*, was committed to a view entailing 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 last question must, in my opinion, be negative.

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., 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.[109] 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 concerning inner organic formative forces:

> 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)[110]

[109] Cf. *KrV*, B 310.

[110] 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".

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 more understandable 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 a causality in accordance with purposes. Already in the essay *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant specified the human will as a *force* which, if determined by an idea of the understanding, i.e., a *purpose*, produces something in accordance with a purpose.[111] Hence, we might attribute organically moving forces to organic bodies by analogy with forces that we, as beings capable of intentional action, are aware of exerting. In short: teleology is modelled on intentionality and vital forces are modelled on intentional action. Vital forces are conceptualized as efficacious in accordance with *ideas* or *purposes*.

In the third *Critique*, the view that the purposiveness of organisms is thought of by analogy with human purposive (intentional) action, is a reason for taking the concept of purpose (when ascribed to nature) to be a *regulative* concept of reflective judgment. Kant's insistence on the problematic status of the concept of organisation and of organically 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 integrates one of the fundamental biological notions of his time in his philosophy on the basis of his regulative doctrine of teleology developed in the third *Critique*.

In this context, it is further worth noting that in the second fascicle of the *Opus postumum*, Kant describes the *desires* of bodily substances as true vital forces (*Lebenskräfte*).[112] 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

[111] AA 8: 181.
[112] AA 21: 213.

objects[113], and desire is the self-determination of the force of a subject through *representations*.[114] Thus, when Kant construes desires as true vital forces, he again emphasizes that human purposive or intentional action (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. Thus, for example, we may treat of plants *as if* they are sensitive beings without claiming that this is objectively the case.[115] 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 attribute true vital forces to cognitive and volitional subjects, while vital forces are only problematically ascribed to other organisms. This view may come as a surprise given the manner in which the concept of vital force was employed in late eighteenth-century biological theories (cf. §5.2). However, in Chapter 3 we have already established that Kant only attributes purposes to cognitive and volitional subjects capable of acting in accordance with representations. It is on the basis of this background that Kant interprets the notion of vital force.

In conclusion of this section, we should emphasize that 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. Here, again, we witness the difficulties in determining the relationship between Kant's philosophical views and late eighteenth-century biological theories. The prominence of the concept vital force within late eighteenth-century biology no doubt influenced Kant to introduce this concept within his transition project (as we have seen above). Moreover, the manner in which

[113] AA 5: 9.

[114] AA 7: 251.

[115] 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 construes this concept is, as we have also seen above, akin to the manner in which Blumenbach construed this concept. However, Blumenbach can be interpreted as postulating the existence of vital forces (e.g., the *Bildungstrieb*), which are taken to constitute objective grounds of certain phenomena (e.g., the process of embryogenesis). Vital forces (most notably the *Bildungstrieb*) are genuine forces of nature allowing for objective explanations in biology

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 (ascribed to organisms, as we have seen, by analogy with human intentional actions). He does not assigns them any properly explanatory role. This is no surprise, for as we have seen in Chapters 2 and 3, Kant 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 assed according to their mechanical relationships […]; their appearances must be explained in this way […]".[116] Moreover, as we have also seen in Chapter 3, in explaining organic phenomena (e.g., nutrition) we must specify the physical forces and mechanisms underlying such phenomena (e.g., the chemical processes involved in nourishment). In this specific respect, Kant's position does not profoundly differ from that of (e.g.) Reil. However, distinctive of biology is that these mechanisms are treated as *serving a purpose*. As Kant puts it aptly in the third *Critique*: "the connection of efficient causes could at the same time be judged as an effect through final causes".[117] It is this teleological perspective that Kant takes to be expressed by the concept of a vital force.

5.4 The concept 'organism' in Kant's *Transition*

In the previous section, we have seen that Kant, influenced by late eighteenth-century biology theories, introduced the concept 'vital force' (interpreted as a regulative posit) within his transition project. This is a novelty with respect to the third *Critique*. At this point, the following question arises: what is the systematic significance of the concept of a vital force in Kant's transition project? In addition: how is Kant's general concept of an organism related to the concept of vital force?

[116] AA 21: 186.
[117] AA 5: 373.

In the *Opus postumum*, Kant defines organisms (now also called natural machines) in a manner similar to the third *Critique*, i.e., *teleologically*, as a whole in which every part is an end and reciprocally a means.[118] This characterization is frequently explicated in terms of the notion vital force (or analogous terms).[119] Thus, organized bodies are assigned a vital force (*Lebenskraft*)[120] or organic bodies are ascribed a productive force of life.[121] This shows that the concepts organism and vital force (as well as life) are intimately related.

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 notes:

> The division into organic and inorganic cannot be lacking from the division of the moving forces of matter which belongs to the transition from the metaphysical foundations of natural science to physics; and, indeed it must be thought *a priori* in it, without previously being instructed, by experience, of the existence of such bodies. (AA 21: 211)

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 explicate the possibility of physics as a systematic science. The distinction between organic and inorganic bodies (respectively: between vital or organic and physical forces) is necessary in order to secure that this classification is complete,[122] even if, as Kant argues, the division between the organic and inorganic is

[118] Cf. AA 21: 189, 194. AA 5: 376.
[119] Cf. Kant's multiple characterizations of organisms at AA 21: 184–189, 193, 197–199, 211–213.
[120] Cf. AA 21: 612. AA 22: 100
[121] AA 21: 211.
[122] Cf. also AA 21: 188.

problematic, i.e., we do not affirm anything concerning the existence or nonexistence of organic bodies and their forces.[123]

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 suggests that he took the study of organic nature (biology) to belong to physics. This conforms to our analysis of the notion of physics, as employed by Kant and scientists of his time, given in Chapter 4, in which we saw that the study of organic nature was taken to be a part of physics. In the *Opus postumum*, Kant seems to argue 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).

In the *Opus postumum*, Kant thus claims that the concept of an organism (understood in the technical sense as a teleological whole in which everything is both end and means) is presupposed if organic bodies are to constitute an object of investigation for physics. Hence, Kant states in the passage quoted above that the distinction between the organic and inorganic is a principle for the investigation of nature, *preceding* 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*).[124] We have encountered a similar idea in Chapter 3 (§3.10). There, we saw that in the third *Critique* Kant argues that the object of biology is determined by conceptualizing organisms as natural purpose, i.e., the object of biology is determined by its method. Moreover, as we saw in the same chapter, Blumenbach employed the notion of vital force to demarcate the domain of the organic from that of the inorganic (§3.8). Hence, vital forces were taken to play a role in determining the domain of biology. Considering the scientific context of the 1790s, the inclusion of the notion of a vital or organic force within Kant's transition project is thus fully understandable. In the third *Critique*, Kant argued that the concept of a natural purpose determines the object of biology. In the *Opus postumum*, concerned with the specific presuppositions of physics, this idea is supplemented with the concept vital force, one of the fundamental notions of biological inquiry in the 1790s.

[123] The same idea is expressed, once again, at AA 21: 188.
[124] AA 22: 466.

It is worth emphasizing that in the *Opus postumum*, Kant places heavy emphasis on the idea 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*, in Kant's terms: understand them as *organized*, because we conceptualize them as organized bodies. Insofar as the concept of an organism is presupposed in identifying objects as organized bodies, i.e., in Kant's terms 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: (1) 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: 340–341)

This complex passage expresses the view that the object of physics is construed by the subject. Let us give an example to illustrate Kant's point. In a passage from the third fascicle, Kant states, in line with the above remarks, that we cannot intuit a body *as such*, rather we form a body through composition (*Zusammensetzen*).[125] Hence, a body would, in line with the above quotation, be 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)".[126] In the lecture notes on physics, the *Berliner Physik*, the concept body is construed as a matter that *coheres* and that has a figure.[127] 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.[128] 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"[129], while in the *Metaphysische Anfangsgründe* Kant specifies the grounds of these properties (the fundamental forces of attraction and repulsion and the law of inertia). Hence, the concept 'body' is taken to occupy a determinate place within a hierarchical system of concepts. In the *Opus postumum*, Kant argues that the form of this system is a priori and is presupposed within physics (in Kant's terms: this form is given for the sake of experience). It is for this reason, that Kant argues that we cannot intuit a body as such, i.e., bodies (in the technical sense of a matter that coheres and has a figure) are not empirically given. Rather, when we identify an object as a body, we presuppose a specific hierarchical system of concepts in terms of which we understand something

[125] AA 21: 275. I owe the reference to Mathieu 1989, 139.
[126] AA 4: 525.
[127] AA 29: 79.
[128] 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
[129] *KrV*, B 876.

as a body. In the *Opus postumum*, Kant expresses this line of thought with a brief formula: *Forma dat esse rei*.[130]

As in the case of body, an organism (in the technical sense of a teleological whole) is thus our cognitive product. In Kant's terms: an organism is an appearance of appearance. In the passage quoted above, Kant explains that the object of an appearance of appearance is one which we extract from intuition only insofar as we have inserted it ourselves. Once again: that, e.g., 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. However, as Kant also explains in the *Opus postumum*, the physicist does often take (or confuse) the object of an appearance of appearance (our construction) for the thing itself. As he puts it: "for physics […] these objects are things [*Sachen*] in themselves, which affect sense."[131] Thus, the physicist may take means-end relationships among the parts of plants to be empirically given, and take these relationships as objective properties of plants. However, as Kant argues, we identify specific means-ends relationships among the parts of, e.g., plants and animals, *only because* we have conceptualized them in teleological terms.

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 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, as noted in §5.1, is 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, in my opinion, incorrect. The idea that the concept of a natural purpose determines the object of biology was, as we have seen in Chapter 3, already contained in the third *Critique*. Nevertheless, there Kant remained committed to the idea that the concept of a natural purpose was a *regulative* concept of reflecting judgment. Thus, in the Dialectic of Teleological Judgment Kant claimed that the maxims of reflective judgment

[130] Cf., 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

[131] AA 22: 320.

(i.e., the teleological and mechanical maxim) are *necessary* "for the sake of the cognition of natural laws in experience".[132] However, he remained committed to the idea that it is impossible to justify the objective reality of the concept of a natural end a priori[133], and that "the objective reality of the concept of a natural end is not demonstrable by means of reason at all (i.e., it is not constitutive for the determining, but is merely regulative for the reflecting power of judgment)."[134]

The latter idea is maintained in the *Opus postumum*. Thus, as we have already 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. Moreover, Kant continues to argue with respect to an organic body that "it is easily seen that this is a mere idea, which is not assured of reality *a priori* (i.e., that such a thing could exist).[135] Hence, the idea of an organism remains regulative. The fact that principles are necessary condition for scientific cognition thus does not imply that they are constitutive. Regulative principles can be necessary conditions for scientific cognition as well. This is, in fact, a common train of thought in Kant's philosophy. To give one example: in the published introduction to the third *Critique* Kant argues that the principle of the formal purposiveness of nature is a transcendental principle, i.e., one "through which the universal *a priori* condition under which alone things can become objects of our cognition at all is represented", even though this principle is also regulative.[136] Another example might be Kant's concept of a *system*, which is a regulative ideal, while, as we have seen in Chapter 1, also functioning as a necessary condition of scientific knowledge.

In conclusion of this section, we may note that the *Opus postumum* also retains the idea, central to the third *Critique*, that we conceptualize organisms as purposive *by analogy* with human purposive action (cf. §5.3.3). Thus, Kant argues:

> How can we include such bodies [i.e., organic bodies; vd Berg] with such moving forces in the general classification, according to *a priori* principles? Because man is conscious of himself as a self-moving machine, without being able to further understand such a possibility, he can, and is entitled to, introduce *a priori* organic-moving forces of bodies into the classification of bodies in general – although only indirectly, according to the analogy with the moving force a body as a machine. (AA 21: 213)

[132] AA 5: 385–386.
[133] AA 5: 399.
[134] AA 5: 396.
[135] AA 21: 210.
[136] AA 5: 181.

In the *Opus postumum*, the concept of a self-moving machine is employed interchangeably with that of an organism.[137] Hence, Kant argues that because we are conscious of ourselves as an organism, we are justified in introducing the concept of organic-moving forces. In other passages, Kant remarks that we experience organic forces in our own body. The concept of such organic forces is then generalized and attributed to natural objects by analogy with these forces.[138] This argument is sometimes construed as a novelty of the *Opus postumum*.[139] However, the novelty is marginal. Already in his *Über den Gebrauch teleologischer Principien in der Philosophie* of 1788, Kant argued that the cognition of our own will, construed as a *force* acting in accordance with purposes, provides a model of purposiveness attributed to natural objects (i.e., organisms). This idea provided the basis for Kant's central thought in the third *Critique* that pruposiveness is attributed to organism by analogy with human purposive action, an idea restated in the *Opus postumum*. What is novel, however, is Kant's continued employment of the notion of an organic moving force. The use of this notion can, as we have seen, be related to late eighteenth-century biology. Kant can therefore be taken to recast familiar arguments in terms of novel terminology.

5.5 Anti-materialism in the *Opus postumum*

In the previous sections, we have seen that Kant took the concept of vital force to have problematic metaphysical implications and reinterpreted this concept as a regulative posit. It cannot be denied however (somewhat ironically) that Kant was partly attracted to Blumenbach's theory of vital force because of his own metaphysical convictions. After all, according to Kant Blumenbach rightly denied that life has arisen from the lifeless. Kant was thus partly attracted to Blumenbach's theories because of their supposedly anti-materialism.

The rejection of materialist accounts of organic phenomena is a recurring theme in the *Opus postumum*. Another important theme in the *Opus postumum* is the rejection of hylozoism, i.e., the view that matter can organize itself into purposive objects. Kant's critique of materialism and hylozoism are related. Although materialist and hylozoists may differ in the properties they ascribe to matter, i.e., respectively conceptualize matter as inert (lifeless) or

[137] Cf. AA 21: 194.
[138] AA 22: 373
[139] Cf. Förster 2000, 26.

attribute life to matter, both take matter to be sufficient for explaining organic phenomena.[140] Many reflections on organic nature in the *Opus postumum* are concerned with a rejection of this view, i.e., with a rejection of materialism and/or hylozoism. These reflections are treated in the current and next section. The present section focuses on Kant's anti-materialism.

Kant's reiteration of his anti-materialist position in the *Opus postumum* may have been influenced by what he took to be materialist convictions implicit in biological theories in the 1790s. In §5.2.2, we have considered the views of Brandis and Reil who adopted a reductionistic view on the explanation of biological phenomena (note: this, of course, need not imply materialism). Although the evidence is sparse, we can say that Kant was aware of the work of Brandis and Reil. In a letter to Kant from the physiologist Samuel Thomas Sömmering of August 1795, Sömmering points to his excerpt of Brandis *Versuch* published in the *Göttinger Gelehrten Anzeigen*.[141] In *Der Streit der Facultäten* (1798), a manuscript Kant already finished in 1796, Kant himself mentions Reil's physiological writings as contributing to a new doctrine of nature concerning humans, according to which the understanding is merely dependent on the human body and is a product of the working of the brain. This doctrine is associated with the traditional metaphysical doctrine affirming the *materiality of the soul*.[142] Kant thus construed Reil as a materialistic natural philosopher.

Kant's position towards the likes of Reil is not wholly unambiguous, for (as I have argued throughout this work) he adopted the ideal (similar to Reil) of providing mechanical explanations in biology. The problem is: how much can we explain mechanically in biology? In the following, I argue that in the 1790s and in the *Transition*, Kant, in line with his conception of biological method, developed very specific ideas on nature and organisms, in particular the idea that unorganized fluids can be chemically organized (a mechanical account of organization!), that forced him to reassert his anti-materialism.

In §5.5.1, I treat Kant's encounter with the previously mentioned Samuel Thomas Sömmering in 1795, a physiologist who according to Kant conflated metaphysical with physiological questions. I argue that the debate with Sömmering provides a context on the basis of which we can understand some of Kant's anti-materialist arguments in the *Opus postumum*. In §5.5.2, I discuss Kant's anti-materialist claim (frequently made in the *Opus postumum*) that organisms have an immaterial ground (e.g., a soul). Claims such as these have

[140] Cf. Zammito 1992, 216.
[141] AA 12: 40.
[142] AA 7: 73.

led Erich Adickes to argue that Kant, in the *Opus postumum*, reverts to a form of dogmatic metaphysics (§5.1). Although it cannot be denied that the *Opus postumum* expounds views on organic nature that we would (in light of Kant's critical philosophy) classify as dogmatic metaphysics, I argue that there is considerable continuity between Kant's views on organic nature in the third *Critique* and the *Opus postumum*. Kant's position in the *Opus postumum* certainly does not amount to a adoption of dogmatic metaphysical theories.

5.5.1 Kant on Sömmering's *Über das Organ der Seele*

In his *Über das Organ der Seele* (1796), Sömmering formulated a theory concerning the so-called organ of the soul or *sensorium commune*.[143] Sömmering argued that the organ of the soul, 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 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 all nerve endings. Moreover, this fluid could be interpreted as being animated and Sömmering concluded that this fluid constituted the *sensorium commune*.[144]

Before publishing his work, Sömmering sent the manuscript to Kant, noting that he wanted to dedicate the work to Kant and asking 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, finally 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.[145] 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 Söm-

[143] Sömmering's work is instructively discussed by Peter Hans Reil 2005, 152–153. Reil relates Sömmering's work to late eighteenth-century biology theories on sensibility, nervous force, and Schiller's and Herz' theories on the relation between mind and body. Kant's views are, however, hardly discussed.

[144] Sömmering 1796, 31.

[145] 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.

mering as arguing that the soul itself is located in the fluid filling the ventricles of the brain.[146] However, this leads to an untenable materialistic conception of the soul, which must be understood as a substance distinct from matter. In virtue of the unity of consciousness, the soul must be conceptualized as *simple* and hence cannot constitute an object of outer sense, i.e., cannot be located in space.[147] As such, the question concerning the local presence of the soul is rejected as meaningless. In his published essay, Kant writes that the soul can only perceive itself through inner sense and hence cannot be assigned any (spatial) location. Any solution to the problem of the seat of the soul leads to the affirmation of an "impossible quantity ($\sqrt{-2}$)".[148] We simply cannot spatially localize the soul (e.g.) in the human brain. In short: in 1795 (just priori to Kant starting to substantially work on the *Opus postumum*) Kant was confronted with a physiological theory that, because it conflates metaphysical and physiological questions leads to a materialistic conception of soul (a critique that, as we have seen, Kant also levelled against Reil).

Despite his criticism, Kant argued that we can interpret Sömmering's work purely physiologically, thus preventing a transgression into the domain of metaphysics. The proper physiological question concerns the matter which makes the combination of all sense-perceptions in the mind (*Gemüth*) possible. Kant emphasizes that the term 'mind' must be understood as the *faculty* that effects the combination of representations and the unity of empirical apperception, it does not refer to any *substance* with a nature different from matter (e.g., the soul of metaphysics).[149] As Kant explains in his drafts, if we interpret Sömmering's question physiologically, we are not investigating any relation between the material and immaterial, but are inquiring into the *material conditions* for the influence of the nerves on the faculty of representation.[150] How does Kant conceive of Sömmering's work?

Kant praised Sömmering's anatomical research and argues that, since the nerves that lead to the ventricles of the brain are separated from each other, one could maintain the hypothesis that the fluid contained in the ventricles of the brain enables the combination of sense-representations propagated through the nerves.[151] According to Kant, this fluid is water. However, here a problem arises. It is not clear whether a fluid can be regarded as organized whereas only organized bodies can be regarded as candidates for being the

[146] AA: 13: 399, 401, 405–406.
[147] AA: 13: 399, 401–402.
[148] AA: 12: 31–32, 35.
[149] AA: 12: 32, 35n.
[150] AA: 13: 402.
[151] AA: 12: 32–33.

sensorium commune. Kant explicates 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, rigid bodies can properly be called 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).[152]

Kant does not explicate why only organized bodies can be candidates for being the *sensorium commune*, but 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. *Rigid* bodies, in virtue of their persistent form, are bodies that are typically capable of consistently performing a function, which explains 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 or change of relation among the materials comprising the fluid might result in insanity.[153] 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 (under normal circumstances). This leaves Sömmering's theory with the problem of how a fluid can be regarded as organized, i.e., consistently perform 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".[154] The dynamical organization of fluids is taken to rest on chemical principles. In explaining his hypothesis, Kant alludes to the anti-phlogistic chemistry of his day. He argues that chemical division can (as far is known) proceed *in indefinitum*. To elucidate this claim, he states that pure common water, which until recently was regarded as an element, can be separated through pneumatic experiments into two types of air.[155] Here, Kant is referring to the traditional Stahlian chemistry of principles, where water was regarded as a chemical element or principle, its subsequent overthrow by (Lavoisier's) anti-phlogistic chemistry and the finding of anti-phlogistic chemists that water can be separated into

[152] AA: 12: 33.
[153] AA 13: 399.
[154] AA 12: 33.
[155] *Ibid.*

hydrogen gas and oxygen gas.[156] 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 while oxygen gas is a composite of oxygen base and caloric. Finally, Kant suggests that the matter of heat may in turn be decomposed by nature into a light material (i.e., light-ether) and other matter, just as light can be decomposed into colours, and so forth.

In this manner, the decomposition of fluids *in indefinitum* is illustrated. The nerves that lead to the water contained in the ventricles in the brain thus find within this water a manifold of instruments (*Werkzeuge*), in accordance with which they may be receptive to the world of the senses. If we think that the capacity of the mind to analyse 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 (e.g., caloric, light) in different ways. As such, the nerves 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.).[157] In this manner, Kant explains, we might understand the water contained in the ventricles of the brain as being continually subject to organization, i.e., water is continually organized in accordance with chemical principles, and thus capable (in virtue of the regularity of chemical decomposition) of performing a function in a regular manner.

In elaborating this speculative hypothesis, Kant emphasizes that it is only by means of this interpretation that Sömmering's anatomical results 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. However, he regards the hypothesis that he develops to have no bearing on metaphysical questions concerning the soul and the unity of consciousness, questions which inform Sömmering's inquiry.[158]

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. However, in performing this type of biological inquiry one must always presuppose a purposeful organization of the object of investigation (the organism). At first sight, the idea of a dynamical organization, explicated in terms of chemical principles, seems to contradict this methodology. However, Kant states that the hypothesis of

[156] Cf. Friedman 1992a, 288–289.
[157] AA 12: 33–34.
[158] *Ibid.*

the decomposition of water effected by the nerves, giving rise to sensations, requires that the separated materials (e.g., light, caloric, hydrogen gas, etc.) must recombine immediately when the nerves stop being stimulated.[159] This makes sense, for how (e.g.) should we otherwise understand, on the proposed hypothesis, the short period in which we have sensations? In his drafts Kant develops this point in more detail, arguing 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*.[160] 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 conformity with the idea that in biology we must subordinate mechanism to teleology. However, there are elements of Kant's hypothesis that seem difficult to reconcile with his conception of biological method, most importantly: the idea that a fluid can be organized. In a nutshell: if unorganized matters such as fluids can be organized dynamically, the strict distinction between organic and inorganic nature that Kant upheld in the third *Critique* becomes blurred. If fluids can be dynamically organized, why would we not, for example, explain the ultimate origin and subsequent formations of organisms as a process of crystallization from fluids.

In Kant's time, the above line of thought was (to some extent) accepted.[161] Johann Christian Reil, for example, argued in his *Von der Lebenskraft* that the nutrition and growth of organisms, i.e., the process of assimilation and transformation of external substances allowing for the 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.[162] In a similar vein, the development of a foetus was conceived of as a process of crystallization.[163] Kant's views on biological method do not

[159] AA 12: 34.

[160] AA 13: 399–400.

[161] I say 'to some extent' because virtually nobody, including Reil, allowed for the view that organisms ultimately arise from mere inert matter.

[162] Reil 1796, 66–69. Cf. Richards 1998, 709, who stresses the importance of the idea of crystallization in the work of Reil.

[163] Reil 1796, 80.

entail a rejection of this type of procedure. Reil is simply trying to provide a mechanical explanation of processes such as nourishment, growth and reproduction (which is a correct procedure according to Kant, whether Reil is correct is another issue).[164] However, if we apply Reil's methodology to other domains of research, we might also allow for the spontaneous generation of organisms from unorganized matter, i.e. (in Kant's terms), allow for the generation of life from the lifeless?[165] This is a view that Kant explicitly rejected in the third *Critique*. The hypothesis that unorganized fluids can be dynamically (chemically) organized, does however seem to allow for such a possibility. With these problems in mind, we can turn to the *Opus postumum*.

Some passages in the *Opus postumum* seem to be related to his encounter with the work of Sömmering. In his reflections on natural machines (organisms), Kant remarks, sometimes with emphasis, that objects conceptualized as machines must be thought of as consisting of *solid or rigid parts*.[166] This seems to refer to Sömmering's 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 in accordance with chemical principles. 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 precisely when treating the problem of how we should distinguish between organic and inorganic bodies, and while 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 lead Kant to think again on the problem of materialism (as one would expect given the problems I identified above). Moreover (as I argue for below), 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".[167] Immediately preceding these remarks, which seem to be related to the problems discussed in the encounter with Sömmering, Kant introduces a distinction between organic and inorganic natural bodies:

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[164] 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.

[165] Richards 1998, 710 notes that even Reil did not allow for such a possibility. This view was extremely contentious in Kant's time, and was hardly endorsed by any scientist.

[166] AA 21: 193; AA 22: 283; 22: 547

[167] 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, since in applying these predicates we do attribute form to bodies. We only apply these predicates to *bodies*. Yet, what is the aim of these remarks?

As indicated in §4.5.3, the distinction between matter and (physical) body, i.e. (as Kant puts it) a matter between determinate boundaries which therefore has a figure[168], 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. In particular, fluid bodies are homogeneous 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*.[169] In this manner, the ether or caloric serves as a 'formative means' (*Bildungsmittel*) for the formation of bodies in nature. Kant even states that the formations "in the three realms (*Reichen*) of nature all begin from the fluid state, hence from heat".[170] Here, the three realms or kingdoms seem to refer to the traditional distinction between minerals, plants and animals.

Hence, the fluid state is fundamental and through the action of the ether solid bodies having a crystalline structure are formed. All rigid bodies have a crystalline structure due to the ether and this is also true of the rigid parts of organisms. In a nutshell: Kant's *Transition* 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 (as for example Reil did) for a purely mechanical account of organic phenomena such as nutrition, growth etc. Once again,

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168 AA 4: 526.
169 See for example AA 22: 213.
170 *Ibid.*

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 (rather it encourages it). Ultimately, however, such a strong stress on mechanical explanation may lead to a form of materialism, in which the origin of organisms is ultimately traced to a transition from unorganized fluids to more and more organized bodies. Here, we are once again confronted with the problem identified in Kant's discussion with Sömmering. How do we exclude the idea that life has arisen from the lifeless?

In the *Opus postumum*, Kant is thus forced to exclude materialism (a position he could never endorse) and 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)

This argument rehearses one of the central claims of Kant's philosophy of organic nature (dealt with in Chapters 2 and 3). Although organic bodies may ultimately be generated by physical grounds, and we must always search for such physical grounds (as Kant partly does in the *Opus postumum*), organisms are bodies that are *purposive* wholes, i.e., they have a structure in which the parts are perfectly adapted to performing certain functions. We cannot explain why organism have such a purposive structure merely mechanically, i.e., in terms of the moving forces of matter *alone*. Rather, that organisms have such a purposive structure is a *presupposition* of biological inquiry (guiding our search into the mechanisms that are involved in performing certain functions or the mechanisms that give rise to certain structures). In this manner, materialism, according to which mere inert matter can give rise to purposive structures (organisms) is rejected.[171] That Kant repeated his critique of materialism is, as I have argued, due to the fact that in his encounter with Sommering

[171] Let me rehearse the quote of Réamur: "how will attractions be able to give such and such a mass the form and structure of a heart, to another that of a stomach, to a third one that of an eye, and to another that of an ear? [A]ll their tendency will amount barely to the reunion of the similar parts into solid masses. What law of attraction shall one imagine for the making of that small bone of the ear, whose figure makes it to be called the stirrup? How shall so many different organs be placed and assembled in their proper order?" Quoted in Roe 1981, 14.

and in the *Transition*, he developed mechanistic hypothesis on the (ultimate) nature of organic bodies and organization that forced him to reassert his anti-materialism.

The above argument also adds another claim (one that is not easily read in line with Kant's critical philosophy), namely: that the ground of the purposive unity of organisms must be *immaterial*. These type of claims have led Adickes to argue that in the *Opus postumum* Kant revert back to a dogmatic metaphysical position. I will deal with these passages in the following section.

5.5.2 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 be concerned with discussing various reflections on organic nature in the *Opus postumum* that may suggest that Kant himself adopted a dogmatic metaphysical position on the nature of organisms. In particular, I am concerned with the claim that organisms have an *immaterial ground*.

Kant clearly makes such apparently metaphysical claims in the *Opus postumum*. However, I think that he did not revert to a form of dogmatic metaphysics in the *Opus postumum*. Many of Kant's metaphysical claims concerning organisms in the *Opus postumum* correspond to views articulated in lectures on metaphysics in the 1770s. The arguments contained in these lectures can also be found in Kant's critical philosophy, although in the latter they are presented in a (what we may call) metaphysically neutral fashion. Given the fact that the *Opus postumum* is an unfinished work, the appearance of several seemingly metaphysical statements need not by itself indicate the Kant endorsed a form of dogmatic metaphysics. Moreover (and more importantly) the argument that organisms have an immaterial ground can, I argue, be understood on the basis of the third *Critique*. There Kant argues that an immaterial ground or substance of organisms is a necessary *regulative* assumption. In the *Opus postumum*, the same position is expressed. Hence, there is a great continuity between Kant's views of organic nature as expressed in the third *Critique* and the *Opus postumum*.

In many passages in the *Opus postumum*, Kant argues that organisms (natural machines) 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 concludes from the fact that organic bodies are purposively arranged composites of parts to the fact that organic bodies must have a single unitary efficient cause, which in turn leads to the conclusion that an immaterial substance is the ground of the possibility of organic bodies. In other passages, Kant identifies the immaterial principle of (animal) organisms with the *soul*.[172] For example, in fascicle 10 Kant states:

> Bodies whose inner form can be thought as intentional (that is to say, as possible only according to a principle of purpose) are organic; and hence, must also be thought as rigid. They are machines – either *lifeless* (merely vegetative) or living, *animal* – for which indivisible unity of the moving principle (soul) is required; for an aggregate of substance cannot by itself found a purposive unity. (AA 22: 373)

The idea that animals have a soul (here contrasted with soulless, non-living plants) was already expressed by Kant in his metaphysics lectures of the 1770s (*Metaphysik L1*), where Kant argued against the Cartesian conception that "animals are not mere machines or matter, rather they have souls".[173] Animals are contrasted with matter. The latter is defined as an extended, impenetrable and inert thing, which has no inner principle of self-activity or spontaneity. Animals are taken to be animated because they can determine themselves according to the power of choice (are capable of voluntary motion), and the Cartesian conception of (non-human) animals as lifeless machines is rejected.

It is useful to contrast the above view, resulting in the claim that animals have souls, with Kant's official (published) argument against the Cartesian conception of (non-human) animals. In §90 of the Methodology of Teleological Judgment of the third *Critique*, Kant argues by means of (what he calls) an inference in accordance with an analogy that animals "act in accordance with representations (and are not, as Descartes would have it, machines)."[174] This inference is as follows: in comparing the artistic action (*Kunsthandlungen*) of animals with that of humans (e.g., the *construction* by beavers with that by humans), two similar effects, we conceive of the ground of the former (which we do not know) by means of the ground of the latter (*human reason*,

[172] AA 22: 97, 373, 418, 469.
[173] AA 28: 275. The importance of this passage has been emphasized by Heimsoeth 1940, 96–97. Guyer 2001, 268 also treats the passage.
[174] AA 5: 464–465.

which we do know). Hence, we conceive of the unknown ground of, e.g., the construction of beavers as an *analogue of human reason*.

This inference in accordance with analogy, in which we compare humans with animals on the basis of their similar mode of operation, is, according to Kant, sufficient to conclude that animals act in accordance with representations (and are thus, in contrast to what Descartes claims, living beings), although it does not establish that animals have reason. Here, then, we have what we may call a more metaphysically neutral argument than that contained in Kant's lectures on metaphysics and the *Opus postumum*.

The foregoing shows that in his lectures, Kant had no qualms in voicing his metaphysical views. Moreover, these metaphysical views clearly influence his argumentation in the critical philosophy (here: the third *Critique*). Given that the *Opus postumum* is an unfinished work, it is, I suggest, understandable to find Kant expressing similar views. It may simply be the case that his reflections on the immaterial ground or soul of organisms require editing (e.g., by adding the usual restrictions and qualifications, such as 'merely regulative', 'we necessarily think but cannot know', etc.).

However this may be, it is worth noting that Kant's metaphysical views also influence his reception of biological theories in the *Opus postumum*. In one of the passages in which Kant argues that an immaterial principle is a ground for the possibility of organisms, he again seems to refer to Sömmering noting that nerves (the seat of sensations) are called soul.[175] However, he denies that the soul is material, stating that "the school of experience" is wholly inadequate for the science of medicine. Recall that Kant was afraid that Sömmering, because he conflated metaphysical with physiological questions, adopted a materialistic theory of the soul. Kant rejected such a theory because the soul must be treated as a *simple* substance and hence cannot be material (matter being composite and infinitely divisible). Here, again, we find evidence that Kant's encounter with physiological theories in the 1790s influenced his anti-materialistic remarks in the *Opus postumum*.

In addition, as I have briefly noted, Kant was attracted to anti-reductionistic theories of vital force (e.g., that of Blumenbach) because they were compatible with belief in the existence of a soul. In his proclamation of the near completion of *Zum ewigen Frieden* (1796), he quotes Chrysippus' phrase that nature has given the swine a soul so that it does not decay. Noting the similarity with modern arguments for the existence of vital forces, which prevent living bodies from chemical putrefaction, Kant takes the concept of vital force as a substitute for that of soul. This substitution is for the better, since

[175] AA 22: 418.

one can properly infer from an effect to a force producing this effect, while the inference from an effect to a substance fit for producing such an effect is problematic.[176] Kant's description alludes to Blumenbach's methodology in developing the theory of the *Bildungstrieb*. According to Blumenbach, we infer to the existence of the *Bildungstrieb* on the basis of perceptible effects, while (similar to Newton) acknowledging that we lack cognition of the cause of the *Bildungstrieb*.[177] For Kant and Blumenbach, inferences to vital forces, in contrast to inferences to a soul (a hidden substance), conform to the strictures of scientific methodology. Nevertheless, insofar as vital forces are efficacious in accordance with purposes, we can rationally believe (though not know!) that the cause of vital forces is a substance endowed with intellect (e.g., a soul). For Kant, this fact provided an important incentive for adopting Blumenbach's theories.

Although Kant sometimes identifies the immaterial ground of organisms with a soul, other passages in the *Opus postumum* are more in line with his critical philosophy. For example, he repeatedly claims that we necessarily *conceive* of organisms as having an immaterial ground yet cannot have knowledge of it.[178] How should we understand the claim that because organic bodies are only possible through purposes, they 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).[179] Spinoza is criticized for failing to explain why we make teleological judgments concerning natural objects. According to Kant, Spinoza denies the reality of natural purpose by treating organisms not as *products* of an original being, but as *accidents* inhering in this being, which 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).[180]

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[176] AA 8: 413.
[177] Blumenbach 1789, 25–26. Blumenbach quotes Ovid's: *causa latet, vis est notissima*. Cf. Richards 2000, 24.
[178] Cf. AA 22: 56, 59, 100.
[179] AA 5: 390–391.
[180] AA 5: 393.

According to Kant, Spinoza partially captures one condition for understanding organisms (objective purposiveness), for Spinoza "secures for the natural forms the unity of the ground".[181] How should we understand this claim? In the second chapter, we saw that Kant argued that the necessary unity of (the parts of) organisms defies mechanical explanation and can only be understood in teleological terms. In particular: from the perspective of mechanical science the parts of organisms constitute a contingent unity since we cannot relate them to a common (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, i.e., as the effect of a (rational) cause determined by a representation of this effect. This allows us to take the parts of organisms as constituting 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 be relating them to a single ground (although, in biology, we specify a subjective as opposed to an objective ground). Spinoza's theory of a single ground in which natural things inhere captures the idea that the unity of natural things (including organisms or natural purposes) is based on a single ground.

Kant criticizes Spinoza's theory of an original being because it cannot explain why we take certain objects of nature to exhibit a 'unity of purpose'[182], i.e., construe natural objects as purposively arranged wholes. The 'unity of purpose', when ascribed to objects, implies that we conceive of these objects as (a) effects of a substance functioning as a *cause*, while the latter is conceived (b) as a cause operating through its *understanding*.[183] These two conditions relate to Kant's conception of purposiveness. Kant defined a purpose as the object of a concept insofar as the latter is regarded as the cause of the former, i.e., we take the *representation* of an effect (the object) to be the determining ground of its cause.[184] This conception of purpose 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 should not be a cause and

[181] *Ibid.* Cf. AA 5: 421.
[182] AA 5: 393.
[183] *Ibid.*
[184] AA 5: 220.

is denied understanding or intelligence.[185] Hence, Spinoza's conception of purposiveness is faulty. Moreover, Spinoza's metaphysics was essentially fatalist, taking all unity of objects as the effect of a blind necessity.[186] Hence, he could not explain why objects appear as purposive and why we judge them teleologically. Rather, he merely explains this judgment as an expression of ignorance.

For Kant, interpreting natural objects as purposes implies interpreting these objects as the product of intentional agency. In §80 of the third *Critique*, Kant, discussing possible objections to his view, refers to an argument of Hume in Part IV of his *Dialogues Concerning Natural Religion*.[187] There, the argument from design is taken to imply the likeness of the Divine Mind with the mind of the human artificer. The skeptic Philo objects, as Kant points out[188], that this 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, 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.[189]

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* (i.e., are spatially separated).[190] If this ground "is posited in the understanding of a productive cause as a simple substance"[191], this question is adequately answered. Kant's point is that the order of ideas need not resemble the order of material objects.[192] The parts of the latter exist external to one another and we invoke teleology to comprehend the order of these parts. However, there is no reason

[185] 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.

[186] AA 5: 391–394.

[187] AA 5: 420–421.

[188] AA 5: 420.

[189] Hume 1998 [1779], 28–33.

[190] AA 5: 420.

[191] AA 5: 421.

[192] In the *Dialogues*, Philo explicitly argues that experience does not find any material difference between the world of ideas and the material world and finds these worlds "to be governed by similar principles". Hume 1998 [1779], 30. By denying this claim, Kant blocks Hume's regress.

to think of ideas as being similar to the parts of material objects, for we can doubt whether ideas are spatially separated.

In addition, Kant blocks Hume's regress by conceptualizing the productive cause of organisms, the existence of which is regulatively assumed, as a simple or *non-composite* substance.[193] If we take a simple substance (efficacious through its understanding) to be the cause of organisms, we conceive of a single ground of organisms that allows us to understand the unity of the composition of their parts. In contrast, if this cause is "sought merely in matter", the "unity of the principle for the intrinsically purposive formation" of organisms is entirely lacking.[194] In other words, matter does not provide us with a single (mechanical) ground for cognizing organisms. We comprehend the order of the parts of organisms by interpreting them teleologically, an interpretation which involves the regulative claim that organisms are produced by a single and simple cause.

To summarize: in the *Kritik der Urteilskraft*, Kant (in discussion with Spinoza and Hume) argues that if we conceive of natural objects as purposes we make the regulative assumption that these objects are produced by (i) a single unitary 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 argues in the *Opus postumum* that "only an immaterial substance can contain the ground of the possibility of organic bodies".[195] The arguments in the *Opus postumum* concerning an immaterial ground of organisms can thus 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. It is a subjective assumption we make in order to comprehend the structure of organisms, implied by the necessity of conceptualizing organisms as purposes. We cannot claim any objective validity for this assumption nor do we have any determinate knowledge of such an immaterial substance. Although, as we have seen, Kant does not always express himself in this manner, this position is maintained in the *Opus postumum*. Immediately after arguing that organic bodies are possible through an immaterial substance, Kant continues with respect to this substance (construed as an efficient cause):

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[193] Hence, on this level there is no order of composite parts that requires explanation by teleological principles or an appeal to design (as Hume argued).

[194] AA 5: 421.

[195] AA 22: 507.

> 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)

We subjectively represent an immaterial substance that is an efficient cause of organic bodies as an intelligent cause by means of an *analogy* with the human intellect, without claiming to have any determinate knowledge of this substance. In other words: the assumption of the existence of such an immaterial substance is a regulative posit and we do not claim objective validity for this assumption.

5.6 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, as we have seen in §5.3, related to the topic of vital forces. To affirm the objective reality of vital forces (e.g., of a *Bildungstrieb* guiding embryogenesis) is dangerously close to accepting hylozoism, i.e., the view that matter can organize itself. In §5.3.1, we saw that Herder employed the biological concept of vital force in a manner implying hylozoism (the self-organization of matter). In the third *Critique*, Kant simply did not connect Blumenbach to hylozoism. Nevertheless, in the *Opus postumum* he reinterpreted vital forces as regulative posits, denying any metaphysical position that affirms the objective reality of teleological causation in nature. Kant was thus aware of particular illegitimate *metaphysical* interpretations and implications of the concept of vital force. In general, the dividing line between metaphysics and specific biological theories is not always strict.

In the present section, I argue that in the 1790s Kant was again confronted, as was the case in his encounter with Herder, with a philosophical, hylozoistic interpretation of then contemporary biological theories. A clear example of the manner how, according to Kant, biological theories can lead to hylozoism is contained in fascicle 11 of the *Opus postumum* (1800). There, Kant asks himself whether according to Hildebrandt life is a property of matter. Kant continues by stating that the concept of a living matter is a *contradictio in*

adjecto, and that life is only possible through an immaterial principle.[196] In §5.2.2, we have seen that Hildebrandt in his *Lehrbuch der Physiologie* (1799), criticized the assumption of a vital force (*Lebenskraft*) existing *independently* of matter and effecting life. Apparently, Kant, although he was uncertain about the position of Hildebrandt, thought of Hildebrandt as hinting at hylozoism.

In the 1790s Kant also became acquainted with the hylozoist doctrine of the world-soul articulated by Salomon Maimon, a doctrine rejected in the *Opus postumum*. I will argue that Maimon's theory of the world-soul and Kant's critique can (once again) be understood in light of eighteenth-century developments in biology. In particular: Blumenbach's doctrine of the *Bildungstrieb* informed Maimon's metaphysical doctrine of the world-soul (§5.6.1).[197] Consequently, I discuss Kant's conception of 'life', as articulated both in his critical works and the *Opus postumum*, and relate this conception to the use of the concept 'life' by some eighteenth-century biologists. This will highlight 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 interpreting this concept (and the associated concept of vital force) in a manner that does not imply hylozoism (§5.6.2).

5.6.1 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 metaphysics lectures Kant discusses the 'system of a world-soul' of stoic philosophy.[198] In these passages, Kant construes this doctrine as implying the heterodox idea (which he rejects) that God and the world are reciprocally dependent on each other. In the third *Critique*, Kant describes the world-soul as a posit of hylozoism, which argues for the objective

[196] AA 22: 481.

[197] Klaus Düsing 1968, esp. 172–197, has discussed Kant's conception of the world-soul in the *Opus postumum*. Though Düsing discusses passages in which Kant rejects this notion, he argues that Kant ultimately accepted the theory of the world-soul while dissociating it from hylozoism. I cannot follow Düsing because in almost all passages on the theory of the world-soul in the *Opus postumum*, Kant expresses scepticism towards this theory (including several passages cited by Düsing as evidence for Kant's change of position). In contrast to Düsing, I will further consider the biological background to Maimon's views on the world-soul.

[198] Düsing 1968, 173–175, provides an overview.

reality of purposiveness in nature.[199] According to Kant, as we have seen, hylozoism aims to explain the objective reality of purposiveness by ascribing life to matter. Hylozoists can either take matter itself to be alive (which contradicts the law of inertia) 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.[200] This is not, however, the opinion of some modern commentators. Thus, Eckart Förster, in the factual notes to the Cambridge Translation of the *Opus postumum*, argues that the frequent 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 Organismus*, published in 1798".[201] However, it is doubtful whether Kant had a thorough knowledge of Schelling's work.[202] More importantly, as I argue below, Kant was familiar with the ideas of Maimon, and the manner in which the idea of a world-soul is discussed in the *Opus postumum* is reminiscent of the manner in which Maimon construes the notion of a word-soul. Of course, the manner in which Schelling construes the world-soul is probably quite similar to the manner in which Maimon construes this notion. Hence, we cannot exclude the possibility that in the *Opus postumum* Kant thinks of Schelling. The world-soul was simply a hot philosophical topic in the 1790s.

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.[203] 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.[204] Finally, Maimon (afraid of being called a Spinozist) argues that the world-soul should not be identified with God.

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[199] AA 5: 392, 394–395.

[200] 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.

[201] Förster 1993. 274.

[202] Cf. Onnasch 2009. Onnasch concludes that Kant was probably familiar with some of Schelling's ideas through discussion of these ideas in his circle of philosophical friends.

[203] AA 9: 174–176.

[204] Maimon 1790, 48–49. Cf. AA 9: 174.

Rather, it is an understanding or intelligence (*Intelligenz*), which is related to the world of corporeal bodies.[205]

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*. Recall that Kant rejected Herder's concept of a genetic force interpreted as the ground of all organization and of the transition from inorganic to organic nature. Maimom's world-soul, interpreted as providing matter its form enabling it to assume higher forms of organization, is strongly reminiscent of Herder's genetic force. In addition, it is clear that Maimon, by asserting the existence of the world-soul, asserts the objective reality of teleological causality in nature, something which according to Kant we can only regulatively assume.

The notion of a world-soul as employed in the *Opus postumum* strongly resembles Maimon's construal of a world-soul. For example, in the fifth fascicle, Kant describes the world-soul as an immaterial being in space, that is the ground of organization in nature and acts in accordance with different modifications of matter.[206] This suggests that Kant's remarks on the world-soul in the *Opus postumum* are related to his encounter with Maimon's doctrine of world-soul. If Maimon's doctrine is a form of hylozoism, we would expect Kant to reject this doctrine. This is indeed the case in the *Opus postumum*.

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.[207] In this manner, the posit of a world-soul is treated as a posit of dogmatic metaphysics. As we have seen (§5.5.2), Kant had no problem with the *regulative* assumption that we view an immaterial, simple substance endowed with understanding as constituting the ground of organization in nature. Insofar as Maimon treated the world-soul as an immaterial substance with understanding, Kant did not have a problem with this theory (whether the world-soul can actually be attributed understanding is, however, debatable. I return to this problem below). However, Maimon simply posited the objective reality of a world-soul, which, according to Kant, is a form of dogmatic metaphysics.

According to Kant, the posit of a soul or world-soul does not advance natural science one bit, for it is difficult to square with our conviction that

[205] AA 11: 175.
[206] AA 21: 569.
[207] AA 21: 569–570; 22: 548.

organisms are *products of nature*, and that nature itself is the ground of its organized products. As it is put in the third *Critique* with respect to the idea of introducing a soul as the ground of organisms:

> Perhaps one comes closer to this inscrutable property if one calls it an *analogue of life*: but then one must either endow matter as mere matter with a property (hylozoism) that contradicts its essence, or else associate with it an alien principle *standing in communion* with it (a soul), in which case, however, if such a product is to be a product of nature, organized matter as an instrument of that soul is already presupposed, and thus makes that product not the least more comprehensible, or else the soul is made into an artificer of this structure, and the product must be withdrawn from (corporeal) nature. (AA 5: 374–375).

Transposed in the present context: Maimon's theory of the world-soul treats an immaterial substance with understanding as the *real cause* of organization in nature, and thus organisms must be withdrawn from corporeal nature. The world-soul is not an object of natural science (what is its nature, what is its mode of operation?) and natural science is not advanced by introducing such an idea. At best, according to Kant, we can regulatively assume that an immaterial substance with understanding is the ground of organization in nature. Natural science then has the task of specifying how organization *in nature* is brought about (abstracting from the question of the ultimate immaterial ground of organization in nature).

Now, Maimon also treats of the world-soul as 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 also seems to be a physical and material force. Then, the question arises, however, whether we can consistently hold the view that the world-soul is an immaterial substance endowed with understanding (properties normally not assigned to physical and material entities). In the *Opus postumum*, Kant thus denies that the immaterial substance with understanding, that we regulatively view 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 (*pace* hylozoism) organize itself. He acknowledges that we (regulatively) take an immaterial

substance with understanding to be the ground of organization in nature (§5.5.2). 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 whether understanding can be attributed to the world-soul.[208] The problem thus seems to be that it is difficult to attribute intellect to a physical and material substance. In conclusion: either the world-soul is treated as an immaterial substance with understanding, and Maimon cannot legitimately affirm the objective reality of such a concept (which he does), or the world-soul is treated as a physical and material substance and Maimon cannot assign immateriality and understanding to the world-soul (which he does). For Kant, the world-soul is an inherently contradictory concept.

How does Maimon's doctrine of the world-soul relate to contemporary biological theories? Not surprisingly, 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 (prefomationist) theories of generation.[209] Following Blumenbach quite literally, Maimon discusses several historical versions of the theory of evolution (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 preformationsit theories of generation.

The purpose of this 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.[210] 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 natural laws.[211] 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 interpreted as being in conformity with the metaphysical (Aristotelian) view 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, communicating to particular bodies their particular orga-

[208] AA 21: 570; AA 22: 548.
[209] Maimon 1790, 52–63.
[210] Maimon 1790, 52–53, 63–64.
[211] Maimon 1790, 64–65

nization.[212] 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* can not be thought without a formative force (*bildende Kraft*). He then argues that it is in conformity with reason to assume the existence of only one such force in nature, while explaining the variety of different types of natural formations in terms of their different material composition.[213] Hence, the 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*, where Blumenbach distinguishes between formative forces (*bildenden Kräften*) operative in inorganic and organic nature and the *Bildungstrieb* (belonging to the class of vital forces peculiar to organic nature).[214] Blumenbach argues that one can utilize phenomena of inorganic nature to elucidate phenomena of organic nature. Various types of crystallizations, whose regular form bears a remarkable similarity to organic bodies, provided evidence for the existence of formative forces in the realm of inorganic nature. This fact, in turn, supports the assumption of the existence of the *Bildunsgtrieb* in the realm of organic nature.

Blumenbach emphasizes, however, that the *Bildungstrieb* should not be identified with a formative force of inorganic nature (e.g., a force of crystallization), for the former is a *vital force* and does not exist in inorganic nature. Hence, the appeal to inorganic formative forces is not interpreted as providing objective evidence for the existence of the *Bildungstrieb*. Rather, this appeal is merely meant to *elucidate* (*Erläuteren*) the hypothesis of the *Bildungstrieb* by analogy. Only empirical 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, in contrast to Blumenbach, does not distinguish between inorganic (physical) and vital forces, construing the world-soul as the single formative forces of nature. In short: Maimon reinterpreted Blumenbach's theory of the *Bildungstrieb* in order to arrive at his hylozoist doctrine of a world-soul.

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[212] Maimon 1790, 65.
[213] Maimon 1790, 89–90.
[214] Blumenbach 1789, 71–74.

Kant was certainly aware of the use to which Maimon put Blumenbach's theory. In his letter to Kant, Maimon explicitly said that it was by reading Blumenbach that he came to his theory of the world-soul (moreover, he read Blumenbach because of Kant's praise of Blumenbach in the third *Critique*).[215] 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. More specifically: he was confronted with the attempt to derive illegitimate metaphysical conclusions from biological theories. This may have also influenced Kant to treat the concept of a vital force more systematically in the *Opus postumum* and to treat this concept as regulative. For if it is clear that if vital forces are regulative posits within natural science, i.e., posits for which we cannot claim that they objectively exist, the inference from the objective reality of vital forces to hylozoism (e.g., to affirming the objective reality of a world-soul) is blocked. By arguing in this manner, Kant of course also deviated from the position of Blumenbach (as I have argued in §5.3).

5.6.2 The concept of life in the *Opus postumum*

The debate on hylozoism concerns the proper scope of the concept 'life'. In order to deepen our understanding of this debate, it is useful to consider again the manner in which biologists in the late eighteenth century employed this concept. In the present section, I aim to show that these biologists often assigned the concept 'life' a much wider scope than Kant allowed for. Kant's reflections on life (and vital force) in the *Opus postumum* can be understood in this context. First, we may briefly discuss Kant's critical views on life.[216]

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.[217] Hence, in natural science (concerned

[215] AA 9: 174.

[216] Reinhard Löw 1980, 153–168, has extensively discussed the various senses of Kant's concept of life. More recently, the problem of life has been instructively analyzed by Ingensiep. Ingensiep 2004, 107–136; 2006, 59–84; 2009, 99–105. 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. My account is indebted to these authors.

[217] AA 4: 544.

with finite material substances) 'life' is applied to substances that can determine themselves to motion, i.e., are capable of *self-motion*. The law of inertia denies that matter can move itself. Thus, matter is lifeless and hylozoism is false.

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", while the faculty of desire is "the faculty for being through one's representations the cause of the reality of the objects of these representations".[218] Hence, only beings that have desire, that can act in accordance with representations, are alive. Kant allowed for the attribution of desire to animals.[219] Animals have (in Kant's terms) a lower faculty of desire, in which desires, the grounds for 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 determined by the moral law.[220] Importantly however, Kant does not ascribe desire to plants.[221] Hence, Kant does not attribute life to plants although plants are organic bodies.

This conception of life was more restricted compared to that entertained by many of Kant's contemporary biologists. Let us treat a few illustrative examples. In his *Über das Kantische Prinzip für die Naturgeschichte* (1796), Christoph Girtanner assigns the concept '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.[222] This distinction is meant to show that in organic bodies matter is subject to different laws than in inorganic bodies, i.e., in living bodies physical, chemical and mechanical laws are *subordinated* to 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.[223] It is in virtue of *life* that the parts of a body are teleologically related to one another, constituting a structure that is adapted to performing the organic functions of generation, growth and nutrition and regeneration. Since these organic functions are characteristic and differentiating features of organic bodies, the concept 'life' can be taken to determine the object of biology. Finally, vital forces are responsible for the

[218] AA 5: 9.
[219] Ingensiep 2009, 102.
[220] AA 5: 177–179.
[221] Ingensiep 2009, 103.
[222] Girtanner 1796, 13–14. Note that dead matters (e.g., hairs, nails) are also parts of organized bodies.
[223] Girtanner 1796, 13–14, 17.

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 his critical writings. 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, as Girtanner clearly believed, we should conceive of both animals and plants as being alive.

Girtanner stresses that he employs the concept 'life' in a *physical* (i.e., non-metaphysical) sense.[224] Here, we see his sensitivity toward the fact the 'life' also has a traditional metaphysical meaning. Girtanner's views conform to a dominant view on life articulated by the Scottish physiologist John Brown (1735–1788). In his *Elementa medicinae* (1780),[225] Brown, basing himself on Haller's concept of irritability, defined the state of life through which living beings are differentiated from dead matter, as the property to be determined by external actions (e.g., heat, different types of nutrition) in a manner resulting in the characteristic phenomena of life (e.g., contraction, sensation, etc.).[226] In short, living bodies are characterized by excitability. This property is the basis for the characteristic phenomena of life, which result from external stimulation. Importantly, 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 positively 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

[224] 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.

[225] A German translation of Brown's work appeared in 1795. I have consulted the German translation by Röschlaub of 1806.

[226] Brown 1806, 5–7. On Brown, cf. Löw 1980, 96–97.

are irritable are assigned a vital force and plants are assigned life (although no sensation (*Empfindung*) or volitional movement).

Kant was most likely aware of these developments. He was certainly aware of Brown's work.[227] In his reflections on medicine (1798), Kant praised Brown's theoretical presentation of the moving forces of human life, while criticizing practical elements of Brown's medical theory.[228] In his proclamation to *Zum ewigen Frieden* (1796), Kant, basing himself on Brown, defined life as consisting in the action of stimulating forces and the capacity to react on such forces.[229] Finally, as Ingensiep points out, Kant was aware of discussions concerning the irritability and (even) sensibility of plants.[230] In the *Physische Geographie* (1802), Kant speaks of *planta sensitiva*, which, when touched, drops its twigs and leaves *as if* having sensations (*Empfindungen*).[231]

In the *Opus postumum*, the concept of life is also discussed. In the fifth fascicle (leaves of Mai-Aug 1799) Kant states "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".[232] This definition conforms to the critical view that only beings that have desire are alive. It occurs in a passage in which Kant, discussing the subject matter of physics, 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.[233] Hence, in various passages of the *Opus postumum*, 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.[234] Fascicle eleven contains the remark that organic bodies (which include plants!) contain a principle of life.[235] In fascicle 7 (leaves of April-December 1800) Kant states that organic bodies (again: including plants) have life, the term life being explicated as an inner purposive cause.[236] In addition, Kant attributes vital forces to both vegetative and animal bodies. In fascicle 2, for example, after defining organisms as bodies in which each part is functionally related

[227] Löw 1980, 156–161, has shown the influence of Brown on Kant in the late 1790s.
[228] AA 15: 963–964.
[229] AA 8: 413. Cf. Löw 1980, 157.
[230] Ingensiep 2009, 103.
[231] AA 9: 364.
[232] AA 21: 566.
[233] AA 21: 558, 22: 547.
[234] AA 22: 283. Cf. 22: 499, 23: 483.
[235] AA 22: 481.
[236] AA 22: 99.

to the other parts and to the whole, Kant claims that the productive force of the unity of organic bodies is 'life'.[237] In short: in the *Opus postumum* Kant struggled with the concept of 'life'. This struggle can best be understood against the background of contemporary biological conceptions of life. At some times Kant denies life to plants, at other times he attributes life to plants.

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 'life' and 'vital force' in biology? It is important to recognize that Kant does not want to sever the intimate relationship between his critical view on life and the concept of life and vital force as employed in biology. Life, defined as the capacity to act in accordance with representations, points to action in accordance with purposes. Vital forces are similarly conceived as forces acting in accordance with purposes. The term *Lebenskraft* was, 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 have seen (§5.3), 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, without affirming that this is objectively the case.

5.7 Revisiting mechanical explanation in the *Opus postumum*: construing biology as a part of a unified physics

In the second chapter we have considered Kant's views on mechanical explanation. Mechanical explanations provide cognition of the objective grounds of properties of natural objects. For this reason they constitute ideal scientific explanations. In biology, as we have seen in the third chapter, we should also try to provide mechanical explanations of the functioning of organisms, although we always conceptualize organisms as natural purposes. This position is maintained in the *Opus postumum*. Thus, in fascicle 2, Kant argues that

[237] AA 21: 210–211.

organic bodies must be assessed according to their mechanical relationships and must be explained mechanically.[238]

Paul Guyer has recently argued that in the *Opus postumum* Kant allowed for the unlimited mechanical explanation of organisms and (as a result) gave up the strict distinction between organic and inorganic nature.[239] 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 (e.g., as the basis of light, heat and chemical phenomena). 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".[240] This situation, Guyer argues, leads Kant to reconsider his argument contra hylozoism as presented in the third *Critique*.

Guyer's interpretation is, in my view, partly correct and partly incorrect. He is correct in arguing that according to Kant we must always explain organisms and their features mechanically (a view, contrary to what Guyer claims, Kant consistently espoused in the third *Critique*). He is also correct insofar as Kant (in the *Opus postumum*) indeed 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*. Hence it is incorrect to argue that Kant reconsidered his position with respect to hylozoism in the *Opus postumum* and gives up the strict distinction between organic and inorganic nature.

Guyer argues that Kant drops the strict distinction between the organic and the inorganic because Kant came to recognize that even the motion of inorganic matter cannot be fully explained by mere mechanical impact forces.[241] Rather, the motion of inorganic matter requires some self-moving, non-inertial (thus, in a sense, living) principle, i.e., the ether (one can think of a first mover to better understand Guyer's point). 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

[238] AA 21: 186.
[239] Guyer 2001, 272–276.
[240] Guyer 2001, 263.
[241] Guyer 2001, 272–274.

> 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 matter that, since it is characterized by both repulsion and attraction, is a continually vibrating or oscillating matter, filling the entire universe and communicating its motion to 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 (a first motion), which undermines Kant's claim that the motion of matter is governed by inertia alone. I do not think, however, that Kant's argument has such a wide scope. Note that in this context Kant does not speak of the problem of a first motion. As Martin Carrier has already shown, Kant's remarks must be understood against the background of views entertained by Newton.[242] 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 the various heavenly bodies, due to the influence of gravitational attraction, would ultimately collapse unto the centre 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, arguing 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. Kant does not question the validity of the law of inertia in natural science. 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.

[242] Carrier 1989, 223–227.

As said, 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 (the second argument is also cited by Guyer)[243]:

> 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)

It must be admitted: 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).[244] Kant does seem to refer to these persons, however, Förster does not provide any further evidence linking Kant's remarks to the works of the former (which could explain Kant's intentions). The only thing we can say with relative certainty is that Kant seems to invoke the ether, i.e., the all-penetrating, all-moving material, as a principle that governs vital forces such as sensibility and irritability. What might be the significance of this speculation? Let us try to unravel its significance step by step.

In Chapters 2 and 3 we saw that Kant took proper scientific explanations in biology to be mechanical explanations. Moreover, in Chapter 3 we saw that Kant took chemistry to provide partial grounds for providing objective explanations of organic phenomena (e.g., 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 (matter

[243] Guyer 2001, 278.
[244] Förster 2000, 108.

of heat) 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 sciences such as chemistry, where higher sciences ground lower sciences.[245] Note also that in the 1790s Kant emphasized the close relationship between chemistry and the study of organic phenomena. As we have seen in §5.5.1, 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.

The above interpretation is also conform the interpretation of the status of biology given in Chapter 4. As I have argued, biology was always conceptualized as being a part of physics, even though the relation between biology and other parts of physics (e.g., chemistry) was obscure. Nevertheless, biology was conceptualized by Kant as being grounded in other (higher) sciences of physics, such as chemistry. Kant's intention in the *Opus postumum* is to establish physics (including biology!) 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 also take the ether as a ground of organic phenomena.

The above remarks provide a certain rationale for introducing the ether as 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 §5.2.2 for example, Brandis did not think the contraction or irritability of organic matter (e.g., the contraction of the muscles) can be explained in terms of chemical forces, e.g., by the release of caloric (matter of heat). For the speed of the contraction of 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 that 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), who 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

[245] What exactly constituted lower and higher science in the late 18th century is by no means clear. I will say a bit more on this problem in the following.

that animals contained an innate electrical fluid contained in the muscle fibers. The normal contraction of muscles was explained in terms of electrical currents, ensuing from the brain though nerves to muscles.[246] In the first fascicle of the *Opus postumum,* Kant sometimes refers to the doctrine of galvanism, associating this theory as providing an explanation of the sensibility of nerves.[247] 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 (i.e., caloric) is itself a part of an electric matter.[248] At other passages Kant describes the matter of heat (caloric), the matter of electricity and the matter of magnetism as penetrating fluids, which suggests that Kant relates the concept of the ether (an imponderable fluid) to these various types of matters, perhaps even somehow identifying caloric with a matter of electricity (just as Kant identifies caloric with a light-ether).[249] 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 Chapter 4 (§4.5.3), we have seen that Kant argues that the ether, more specifically: caloric (the matter of heat), grounds physics as a systematic science. Thus, Kant argues, for example, that the aggregate states of matter are to explained in terms of the actions of the ether. In his reflections of organic nature, Kant extends his speculations

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[246] 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.

[247] 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. Dietsch 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.

[248] AA 21: 515. Cf. Adickes 1920, 468–469.

[249] AA 23: 468. On Kant's identification of caloric with a light-ether, cf. Friedman 1992a, 323.

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 (unfortunately) by providing many speculations of our own.

Although we cannot make complete sense of Kant's construal of the ether as a principle for explaining organic phenomena, it must be emphasized that taking the ether as a principle for explaining organic phenomena is conform Kant's methodology that in biology we should always strive to find mechanical explanations. It is also conform the idea that biology is a part of physics grounded in other (higher) physical disciplines. We may note that at the very 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.[250] Schelling took biology to be a proper rational science and, extending Kant's project of the *Metaphysische Anfangsgründe*, 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. Roughly: 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, as we have seen, 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.

Finally, it is noteworthy, as Ernst-Otto Onnasch has shown, that Schelling

[250] The following brief account of Schelling's views is based on Friedman 2006, 51–79; Beiser 2002, 506–550; Beiser 2006, 7–26.

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 the materials now collected under the title *Opus postumum*.[251] Schelling thought, quite remarkably, that Kant's *Transition* must have 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, in my view, is entirely 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, who no doubt, even if he might have appreciated Kant's intentions, would have been mightily disappointed had he read the *Opus postumum*.

5.8 Natural history in the *Opus postumum*

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, also called 'archaeology of nature'[252], in a similar manner. There are several reflections in the *Opus postumum* related to natural history. These reflections have not received much attention. One of the few commentators who has discussed these reflections is Klaus Düsing.[253]

Düsing interprets the passages relating to natural history in the *Opus postumum* as developing Kant's account of natural history of the third *Critique*. In particular, he takes Kant as providing a developmental account of the origin of varieties in species and of species themselves, thus anticipating the Darwinian theory of evolution.[254] Historically, Düsing relates Kant's position in the *Opus postumum* to that of Herder in his *Ideen zur Philosophie der Geschichte der Menscheit*, who, as we have seen, allowed for the transmutation of species.

[251] Onnasch 2009, 310.
[252] AA 5: 428.
[253] Düsing 1968,133–142, 154–169.
[254] 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 rather implausible (to put it mildly). Kant seemed to be committed to the fixity of species, and did not allow for (what we would now call) speciation. In the following, I will, however, refrain from comparing any of Kant's views to those of Darwin. Not only is this anachronistic, it is also highly problematic to speak in general and vague terms of 'the theory of evolution' or 'the teaching of evolution' (as Düsing and Zammito do).

Although Kant rejected Herder's views in the 1780s, Düsing claims that in the third *Critique* Kant adopted a position closer to that of Herder, a position further developed in the *Opus postumum*. In short: according to Düsing, from the 1780s onwards Kant's views on natural history came to resemble those of Herder more and more.

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 (not only in the 1780s but also in the third *Critique*)[255], and the encounter with Herder led Kant to become skeptical of the discipline of natural history. John Zammito, basing himself on an analysis of the third *Critique*, 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.[256] Philip Sloan, building on the work of Zammito, has recently argued that the encounter with Herder in the late 1780s led Kant to weaken the epistemic status of natural history, giving preference to natural description.[257] Although I deviate from Sloan in certain respects, I agree that Kant adopted a somewhat skeptical stance with regard to natural history. There is, as I will argue in the following, no reason to suppose that Kant changed his views in the *Opus postumum*.

In the following, I will, building on the work of Zammito and Sloan, first describe Kant's systematic views on natural history preceding the *Opus postumum* (§5.8.1). 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 (in contrast to natural description). 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 (hylozoism or materialism), 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).[258]

Second (§5.8.2), 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*, i.e., Kant continued to take natural history as a legitimate discipline as long as the reality of *generatio equivoca*

[255] The *Opus postumum* is not taken into account in this interpretation.
[256] Zammito 1992, 199–213, 215.
[257] Sloan 2006, 627–648.
[258] Cf. AA 5: 419–420.

and *generatio heteronyma* was not affirmed. Kant's remarks on 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.

5.8.1 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[259], 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.[260] As such, Kant employed the latter notion in a sense that became *en vogue* in then contemporary biology (see the example of Blumenbach below). Kant first distinguished natural history from natural description in his *Von den verschiedenen Racen der Menschen* (1775)[261]:

> 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)[262]

Natural description provides cognition of natural things as they are at present. In particular, it provides a scholastic, classificatory system of natural things. A scholastic division (*Schuleinteilung*) of natural things is "based upon classes and divides things up according to similarities".[263] Hence, classifications of

[259] Sloan 2006.
[260] Cf. AA 5: 428.
[261] Cf. Sloan 2006, 629–635, on the influence of Buffon on this distinction.
[262] I have, with debts to Philip Sloan 2006, 635, slightly modified the Cambridge Translation, which renders *Abartungen* as 'subspecies' and *Stammgattung* as 'phyletic species'.
[263] AA 2: 429. Cf. Zammito 1992, 199–201.

natural things in accordance with similar morphological characteristics, as provided by Linneaus' artificial natural system, pertain to natural description. In contrast, natural history bases itself on hypotheses concerning 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, e.g., the current form of organisms. 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[264], which, in Kant's terms, takes individuals to 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",[265] 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.[266] Races must, on the basis of Buffon's species concept, be taken to pertain to the same species. However, we can explain the existence of different races, the existence of variations (*Abartungen*)[267] from the original form of the stem genus, through (among others) the effects of natural migrations of organisms.

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[264] Sloan 2006, 633- 634.

[265] AA 2:429.

[266] Cf. Zammito 1992, 199–202.

[267] 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, individuals that 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 prduce half-breeds in reproduction as in the case of races (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. Cf. 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.

In his *Über den Gebrauch teleologischer Principien in der Philosophie* (1788), Kant, reacting to the criticism of Georg Forster concerning the legitimacy of his notion of natural history, describes natural history as follows:

> Now as far as the doubted, even outright rejected difference between description of nature and natural history is concerned: if one were to understand by the latter a *narrative* of events in nature not to be reached by any human reason, e.g., the first origin of plants and animals, then indeed that would be, as Hr. F. puts it, a science for gods, who were present then or were even the authors, and not one for human beings. Yet *natural history* would only consist 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 laws of efficient causality, which we do not make up but derive from the powers of nature as it presents itself to us now. Such would be a natural history that is not only possible but that also has been attempted enough […]. (AA 8: 162–163)

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).[268] 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 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).[269] In his *Beyträge*, Blumenbach argued against physico-theologians and (in particular) Albrecht von Haller, who claimed that species cannot become extinct and that nature does not allow for the coming into existence of new species.[270] Blumenbach does

[268] Cf. Sloan 2006, 638–640.

[269] 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.

[270] Blumenbach 1806, 1–5. I have consulted the second edition of Blumenbach's *Beyträge*.

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.[271] 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.[272] 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.[273] 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.[274] 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 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

[271] Blumenbach 1806, 6–12.
[272] Blumenbach 1806, 13–18.
[273] Blumenbach 1806, 19–20.
[274] Blumenbach 1806, 21–23.

species were "originally developmental states and only later achieved the rank of independent species".[275]

Blumenbach's theory provides a good example of the nature of natural history. Natural history is fundamentally a historical science, aiming, in Kant's terms, to provide cognition of relations between present properties of natural objects and their historical causes. We may note that Blumenbach heavily employs inferences from analogy in constructing his arguments, e.g., in arguing that the *Bildungstrieb* was responsible for the production of organisms in ancient times. As we have seen above, Kant took inferences from analogy to be central to the enterprise of natural history. Finally, we may 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 (i.e., explains the origin of organisms from unorganized matter) and does not advocate 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 his conditions of proper natural science (expounded in Chapter 1).[276] 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 (objective grounds). As such, natural history aims to specify the order of nature, providing reasons for *why* something is the case. In contrast, natural description merely provides subjective grounds of cognition for present effects (e.g., properties of organisms), providing reasons for *that* something is the case. However, natural history is problematic insofar as it does not satisfy the epistemic condition Kant poses on proper science, according to which a proper science must provide apodictically certain cognition.

[275] Quoted in Lenoir 1981, 163.

[276] 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.

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.[277] 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 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 […]".[278]

We can apply Kant's notion of analogy to the reasoning underlying Blumenbach's arguments in his *Beyträge*. For example: we observe that currently existing organism exhibit a specific organization and take the *Bildungstrieb* to be the causal agent responsible for this organization. We 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 though exhibit a specific difference. Hence, we infer that the *Bildungstrieb* was also responsible for the generation of organisms in ancient times. After this inference from 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, employing Kant's terms, infer to some existence though we cannot cognize it determinately. Hence, we cannot conclude, e.g., that the *Bildungstrieb* efficacious in ancient times has the same intensity as the *Bildungstrieb* now operative in nature.[279] Indeed, even the inference to the existence of the *Bildungstrieb* in ancient times remains problem-

[277] *KrV*, A 178–180/B 221–222.

[278] *KrV*, A 178/B 221.

[279] Although Sloan does not discuss Kant's notion of analogy, this is also specified 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.

atic. This claim, like any existence claim, requires observational support which is hard to come by in natural history. For example, although Blumenbach did cite fossil findings as evidence for his hypotheses, it is doubtful whether this evidence alone supports his claim that the *Bildungstrieb* was operative in ancient times while acting on modified materials, thus giving rise to organisms that are specifically different from currently existing ones.

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".[280] Kant's view that natural history cannot constitute a science of origins may also be interpreted on the basis of his conception of analogy. We must base our arguments within natural history on our observation of present properties of natural objects that we understand as effects of certain forces of nature. We can take these forces to be efficacious in the past if we observe natural objects, or more precisely petrifactions of natural objects, of a similar type. This means that sciences of origins that aim to explain the first origin of organisms from unorganized matter cannot draw support from analogies, for unorganized matter is simply not similar to any (currently) observable organism.

As Sloan points out, Kant's claim that natural history should not be a science of origins can be regarded as a condemnation of many eighteenth-century research within natural history.[281] 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 and ultimately to the generation of human beings and human society. This certainly was a science of origins and Kant could not accept it. To a certain extent, Kant could also not adopt the views espoused by Blumenbach in his *Beyträge zur Naturgeschichte*.[282] For, as we have seen, 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. In general, we may note that both Buffon and Blumenbach, in articulating their history of nature, seemed to endorse the possibility of spontaneous generation and *generatio equivoca*, ideas which Kant vehemently

[280] AA 5: 428. A view already contained in Kant's discussion of proper science in the *Metaphysische Anfangsgründe*.
[281] Sloan 2006, 636–640.
[282] Cf. Richards 2000, 20–22.

rejected. Once again: 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*.[283] In this paragraph, Kant acknowledges that in natural science the search for a mere mechanical explanation of natural objects is unrestricted, associating this search with research conducted in natural history. This association is understandable, given that Kant takes mechanical explanations to provide insight in the objective order of grounds and consequence. Kant's views on natural history as expounding this order thus fit his views on mechanical explanation. However, we also know that Kant argues that in judging organisms one must always base these judgments on "some original organization" which uses mechanism "in order to produce other organized forms or to develop its own into new configurations […]".[284] As Kant also puts it, in the scientific investigation of organisms one must subordinate the principle of mechanism to a teleological principle.

Kant associates the search for a fully mechanical account of the structure of organism with the research of comparative anatomists and archeologists of nature. Thus, through comparative anatomy we might establish the following:

> 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 protomother, through the gradual approach of one animal genus to the other […]. (AA 5: 419)

Through comparative anatomy we establish structural similarities between the skeletal structure and arrangement of non-skeletal parts of animals pertaining to different species. This *analogy of forms* leads to the idea of a real kinship

[283] This passage has been stressed by commentators eager to interpret Kant as anticipating Darwinism. Cf. Bauch 1917, 453–457. 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.

[284] AA 5: 418.

among these forms, i.e., we take different species to be related through 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.[285] 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 to the explanation of the origin of organisms from the forces governing raw matter, thus incorporating *generatio equivoca*, i.e., the generation of organisms from unorganized matter. However, Kant criticizes such an undertaking. Although the archeologist is free in order 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 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.[286] 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.[287] 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 to be a law of nature and he rejected any hypothesis contradicting this law.[288] Hence, by excluding the possibility of *generatio equivoca* and by rendering highly problematic the idea of the transmutation of species, Kant restricted the scope of natural history.

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[285] This characterization once again fits our description of mechanical explanation of Chapter 2. Observable differences between members (wholes) of different species are explained in terms of variations among their parts.

[286] AA 5: 419–420.

[287] *Ibid.*

[288] AA 8: 164.

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 (what he takes to be) 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.[289] 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*), i.e., hereditable characteristics or variations that do not concur with their origin, i.e., that can not be related to the properties of the original stem.[290] In other words, different races do not constitute different species. In order to explain the generation of different races, Kant postulated germs (*Keime*) and natural predispositions (*Natürliche Anlage*).[291] 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*. In particular, permanently hereditable variations (e.g., races), although they are the result of mechanical causes,[292] must be judged as an "incidental development of a purposive predisposition to the self-preservation of the kind that was originally present in the species".[293] 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* (is good for) the preservation of a species. In this manner, we base our investigation of the mechanism of hereditability on the teleological 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 self-preservation.[294] 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 origin of organized beings (are not committed to *generatio equivoca*), we refrain from affirming the reality of *generatio heteronyma*, and we merely investigate, in

[289] On these earlier theories, cf. Zammito 1992, 199–213.
[290] AA 8: 163–165. On the term *Ausartung*, cf. Sloan 1973, 293–321.
[291] On the precise meanings of these terms, cf. Sloan 2001, 627–648; Zammito 2003, 80–98.
[292] Cf. Zumbach 1984, 102; Zammito 2003, 84.
[293] AA 5: 420.
[294] AA 5: 420.

accordance with Kant's views that mechanism must be subordinated to teleology, 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 (in Kant's view) to all kinds of speculative fancy.

5.8.2 Natural history and external teleology

In the previous section we have discussed Kant's views on natural history up to the *Kritik der Urteilskraft* (1790). As we have seen, these views do not always harmonize with those of his contemporary biologists and philosophers, who allowed for the possibility of *generatio equivoca* (Buffon, Blumenbach, Herder) and sometimes of *generatio heteronyma* (Herder). 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, in order to explain the extinction of certain natural species, 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.[295] 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)".[296] In *Der Streit der Facultäten* (1798), Kant attributed to both Blumenbach and Camper the view that a revolution of nature had, before man had come into existence, extinguished the plant- and animal kingdom. Finally, in the *Opus postumum* (Juli 1797- August 1799) Kant cites Camper's claim that the revolutions of nature took place before humans existed, since we cannot find any fossil findings concerning humans.[297]

[295] Cf. Adickes, AA 14:619n and Förster 1999, 265, who refer to Camper's writing.
[296] AA 5: 428.
[297] AA 21: 213.

In the *Opus postumum*, as in the writings rubricated above, Kant is quite positive concerning the archeological research of nature conducted by Camper and Blumenbach. In particular, he took (a) fossil findings to provide evidence for the earlier existence and extinction of organisms that are not similar to currently existing and observable organisms[298], and (b) he allowed for the coming to be of new species in the course of nature's history.[299] This raises the question whether Kant also modified his views on *generatio equivoca* and *generatio heteronyma*, adopting (as Düsing argues) 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)[300]

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 relating to the transition from an artificial division of natural species to a *physical* division of natural species, not ordered on the basis of similar morphological similarities but on the basis of relations of *generation* (note: I do not endorse this interpretation, as I will argue more fully below).[301] 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, also referring to the archaeological research of his contemporaries, states that the earth, underlying

[298] AA 21: 215, 566; 22: 549.

[299] AA 22: 241.

[300] 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)

[301] This is how Düsing interprets these passages, cf. Düsing 1968, 158–163.

a principle that is both mechanically and organically formative, can itself be seen as an organic body which brings forth purposeful productions.[302] 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".[303] In other passages of the *Opus postumum*, Kant similarly speaks of our celestial body as organic and organically formative.[304] These passages may be taken to suggest (as Dusing claims) that Kant, in contrast to this position in the third *Critique*, allowed for the possibility of *generatio equivoca* and *generatio heteronyma*.

In another passage, Kant, alluding to the research of his contemporary natural historians (e.g., Camper and Blumenbach), 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, i.e., to specifying the real characters of species. 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 (as in the third *Critique*) the possibility of *generatio equivoca*, i.e., the generation of organized beings from unorganized matter (i.e., hylozoism). This is already implied by the fact that Kant consistently rejects materialism and hylozoism in the *Opus postumum* (§§5.5–5.6). In addition, in the passages in the *Opus postumum* in which Kant

[302] AA 21: 567–568.
[303] AA 5: 419.
[304] AA 21: 215.

speaks of the earth as an organic body bringing forth purposeful productions, he attributes to our earth (universal mother), as he did in the third *Critique*, an "organization purposively aimed" at the production of organic creatures.[305] 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. Importantly, I do not think that the above passages imply that Kant took different species to be connected by relations of *generation*. In §80 of the third *Critique*, as we have seen, Kant argued that the *analogy of forms* observed between different natural species may lead us to conjecture (note: it remains a 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 passages cited from the *Opus postumum* (and indeed in the *Opus postumum* in general) 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 obtain between different species of kingdoms: the domain of plants can be interpreted as a means relative to the domain of animals (plants are there *for the sake of* animals), which in turn can be interpreted as a means for mankind (animals are there *for the sake of* mankind). In short: in the *Opus postumum* Kant reintroduces external teleology. 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 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

[305] Cf. AA 21: 566.

morality and thus also the realization of human happiness.[306] In §82, Kant reintroduces the concept of external or relative purposiveness. *If* a natural object is judged as a purpose, other natural objects (e.g., air, water) can be judged as means relative to that purpose or end.[307] The latter are thus judged as *existing for the sake of* the former. The fact that we necessarily judge of some natural objects as purposes (organisms), allows us to conceive of the whole of nature as ordered according to relative means-end relationships.[308] Since teleological wholes (whether individual organisms or nature as a whole) 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*).[309] The term 'ultimate end' refers to the last object (the last node, so to speak) of means-end relations within the world. Thus, for example, the vegetable kingdom can be taken to exists 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.[310]

According to Kant, we have sufficient cause to take the human species (mankind) as 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".[311] 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".[312] 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

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[306] For a detailed account of this argument, to which I am indebted, cf. Guyer 2005, 314–342. I only treat those passages relevant to our understanding of Kant's view of natural history.

[307] AA 5: 425.

[308] 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. Cf. Guyer 2005, 328–329.

[309] AA 5: 426.

[310] AA 5: 434. Cf. Guyer 2005, 366.

[311] AA 5: 426–427.

[312] AA 5: 431–432.

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 ultimate and final end) as promoting the highest good and as promoting human happiness.[313] 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".[314]

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.[315] 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.[316] 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 (once again) the claim that organisms can have no other origin than in the mechanism of nature, claiming that, given the limits of our understanding, we necessarily conceive of organisms as purposes.[317]

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, after noting that classes of organic bodies can taken as existing 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

[313] AA 5: 433–436.
[314] AA 5: 435.
[315] AA 5: 427. It is precisely in this context that Kant mentions the research of Camper.
[316] AA 5: 427–428.
[317] AA 5: 428–429.

of the human species.[318] 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.

In conclusion, we can thus say that Kant took natural history to be a legitimate doctrine (though not a proper science) on the conditions that (i) it did 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, for example, 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 for a transmutation of species (*generatio heteronyma*), which Kant, who upholds the stability of organic forms, rejects.[319] 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 conceiving of mankind as the ultimate end of nature, and thus with the view that nature

[318] AA 21: 212.
[319] On this background, cf. Sloan 2006, 638–639.

is conducive to the ends of morality and to human happiness. In my view, this thought (foreign to any purely scientific reasons given in natural science) 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 his sceptical distance to natural history, rejecting the possibility of *generatio equivoca* and denying the reality of *generatio heteronyma*.

5.9 Conclusion

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, discussed in Chapters 2 and 3 of the current work, remains unaltered. The *Opus postumum* does show that, right up to his death, Kant tried to take account of biological developments in the late eighteenth century. Moreover, Kant interpreted these developments on the basis of his regulative doctrine of teleology espoused 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). As Kant puts it in the *Opus postumum*, the distinction between organic and inorganic bodies is a priori presupposed in physics.

Fundamental to Kant's philosophy is the idea that the teleological maxim that provides the foundation of biological research is a methodological maxims 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 or 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. According to Kant, one cannot affirm the objective reality of vital forces. Rather, 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.

Concluding remarks

In the present dissertation, I have analyzed Kant's views on biology and biological method from the perspective of his conception of proper science and methodology. I have argued that Kant's conception of biological science and methodology is strongly influenced by his conception of proper science and method. Hence, contrary to a dominant line of interpretation of Kant's philosophy of biology, there is no fundamental discrepancy between Kant's views on proper science and his views on biology. In the present section, I will present an overview of the main arguments contained in this dissertation while also providing some general considerations on the status of biology in Kant's philosophy of science.

Kant has a differentiated conception 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 demonstrative relations. In addition, 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 a consequence. Such a demonstration constitutes an explanative demonstration, i.e., a demonstration specifying the reasons *why* such and such is the case. Finally, the judgments of a proper science must be apodictically certain, which implies that the non-fundamental judgments of a science must allow of proof from *a priori* principles.

On the basis of the above mentioned conditions Kant argues that proper natural sciences must be based on mathematics and metaphysics. Both mathematics and metaphysics (*a priori* sciences) secure the apodictic certainty of judgments of natural science and aid in providing explanative (objective) demonstrations in natural science.

The specified conditions of proper science can be related to Kant's views on biological science. Let us treat these conditions one by one in relation to biology.

First, we may note that Kant did not seem to doubt the possibility of establishing biology as a systematic science. To be sure, Kant never explicitly considered the question whether biology as such can constitute a systematic science, for the simple reason that he (as almost all of his late eighteenth-century contemporaries) did not conceive of biology as a single unitary science. However, according to Kant any (natural) science must be capable of being established as a systematic whole. In addition, as we have seen in the first chapter, Kant took doctrines such as zoology and botany, doctrines that in the eighteenth century were taken to pertain to natural history (what Kant would call natural description) but are now often classified as branches of biology, to be paradigmatic types of systematic doctrines.

Second, we may note that Kant's conception of objective grounding and explanation in natural science strongly influence his conception of biological method. As we have seen in the second chapter, Kant construed mechanical explanation as an ideal of explanation in biology because mechanical explanations are understood as providing *objective* scientific explanations (demonstrations *propter quid*). Through mechanical explanations, i.e., explanations of features of wholes in terms of their parts, the mode of composition of these parts and forces acting on the parts, we specify the objective ground (reason why) of organic processes such as growth, nutrition and propagation. Moreover, we gain insight into how such processes work. In biology, proper explanations are thus mechanical explanations.

Kant's conception of objective scientific explanation also influences, as we have seen in the first and fifth chapter, his characterization of natural history and natural description. Natural history, in contrast to natural description, tries to provide causal explanations of present effects (e.g., traits of organisms) in terms of historical causes (objective grounds). Hence, natural history can in principle be an explanatory science. This is not the case for natural description, which Kant considered to be a mere descriptive and non-explanatory doctrine simply because in natural description we do not specify objective grounds of traits of organisms.

As we have seen in the third chapter, Kant's conception of proper scien-

tific explanation also determines his view that teleology is not explanatory in biology. Proper scientific explanations or demonstrations, which proceed from objective grounds (in natural science: causes) to consequences (in natural science: effects), represent the order of nature. However, in appealing to purposes or final causes we are lead beyond the order of nature. Purposes do not specify objective grounds that explain why something is the case. Moreover, the appeal to purposes does not explain the working of organic processes such as (e.g.) growth, nutrition, regeneration, etc. Purposes are merely subjectively ascribed to objects of nature (organisms) and by doing so we subjectively represent nature by analogy with ourselves.

That teleology is not explanatory in biology does not imply that teleology plays no significant role in biology. In the third chapter, we have seen that teleology determines the object or domain of biology. How we understand the object of biological investigation, i.e., organic nature, is dependent on our teleological conceptualization of this object. Through conceptualizing organisms in teleological terms we ascribe properties to organisms that we do not ascribe to inorganic objects. The distinction between organic and inorganic nature, as we have also seen in the fifth chapter, is not an ontological distinction. Rather it is, in Kant's terms, an *a priori* presupposition in terms of which we investigate nature. Finally, Kant takes the proper method of biology to consist in the subordination of mechanism to teleology. Through teleology we determine the object and *explanandum* of biological research, while proper explanations in biology are mechanical explanations. Kant always stresses, however, that the claims that one should comprehend organisms teleologically and explain them mechanically are regulative, methodological maxims and *not* ontological theses.

The problematic status of biology in Kant's philosophy of science emerges rather clearly if we consider the third condition of proper science, i.e., the condition that the judgments of a science must be apodictically certain. As said, it is on the basis of this condition that Kant argues that the non-fundamental judgments of a science must allow of proof from *a priori* principles, which in turn leads him to claim that natural sciences must be based on mathematics and metaphysics.

In Kant's time, biology was anything but a mathematical science. In the first chapter, we have seen that mathematics fulfills an important epistemic function in natural science. Mathematics provides a priori principles that can be applied to natural phenomena (or: judgments or propositions expressing phenomena). Through this application, as exemplified (e.g.) by the use of mathematics in Newton's *Principia*, mathematics enables deductive demonstrations from a priori principles in natural science. Judgments in natural

science that are deduced on the basis of mathematical (*a priori*) principles can thus be assigned apodictic certainty. For the biologists in the eighteenth century this ideal of epistemic justification was unavailable given that biology was a non-mathematical science.

I have also argued that mathematics aids in providing explanative demonstrations in natural science. In the first chapter, I gave the example of providing an objective explanation of why hive-bee honeycombs have a hexagonal structure (an example with a long history and of great interest for the biologist). In order to provide this explanation, we refer to (employing modern terminology) evolutionary facts, i.e., that bees that use less wax and spend less energy have a better chance at being selected, while showing mathematically that the hexagonal structure is optimal or most convenient. In this example, it is only through the use of mathematics that we can fully understand *why* hive-bee honeycombs have a hexagonal structure. Of course, objective demonstrations in biology in which we employ mathematical results were hard to come by in the eighteenth century, given that biology was fundamentally a non-mathematical science. In this respect, the non-mathematical status of biology also proves to be problematic.

Similar problems emerge if we take into account the relationship between biology and the metaphysical principles of natural science, presented by Kant in his *Metaphysische Anfangsgründe*. In the latter work, Kant specified the metaphysical (a priori) principles of phoronomy, dynamics and mechanics. This work provided the fundamental metaphysical principles grounding a mathematical science of nature (e.g., by specifying the fundamental dynamical forces of nature). In the critical period, the relationship between the *Metaphysische Anfangsgründe* and biological doctrines was never specified, despite Kant's continuous insistence that physics should be a systematic science. Thus, the relationship between the fundamental a priori principles of natural science and biology was obscure.

The above problem brings us to Kant's endeavors in the *Opus postumum*. In the fifth chapter, we have seen that Kant's reflections on organic nature, as presented in the *Opus postumum*, are continuous with his position endorsed in the *Kritik der Urteilskraft*. In particular: in Kant's last project work we find clear expressions of the ideas that teleology determines the object or domain of teleology and that the proper method of biology consists in the subordination of mechanism to teleology. In addition, Kant, on the basis of his position developed in the third *Critique*, interpreted developments within biology and philosophy in the 1780s and 1790s, treating vital forces as regulative posits and rejecting the dogmatic metaphysical positions of materialism and hylozoism

(positions that were often intimately associated with biological theories in the late eighteenth century).

For our present purposes, it is important to note that the *Opus postumum* is concerned with the (above mentioned) problem of specifying the relation between the metaphysical principles of natural science and the physical doctrines subordinated to the general, mathematical doctrine of nature. In the fourth chapter, I have argued that the project of providing a transition from the metaphysical foundation of natural science to physics 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 (among others) kinematics, mechanics and Newton's law of gravitation. Through this grounding project, the true systematicity and unity of physics was supposed to be established and this is precisely the goal Kant sets himself in the *Opus postumum*.

However, although Kant presented an account of scientific topics pertaining to *physica specialis* such as the aggregate states of matter and the cohesion of matter, he never succeeded in precisely specifying the relationship between biological sciences and other disciplines pertaining to physics. If we take into account the historical context in which Kant was operative, this is no surprise, for, as we have seen, the precise relationship between *physica generalis* and *physica specialis* was already highly obscure in eighteenth-century physics. Moreover, in textbooks on physics biological topics were loosely treated within *physica specialis*, usually in complete isolation from other physical topics. Despite these problems, the *Opus postumum* does however show Kant's commitment to the ideal of grounding biology in other (higher) disciplines pertaining to physics.

In conclusion, the *Opus postumum* is of interest in determining Kant's general views on the relationship between biology and physics, which is supposed to constitute a unified and systematic science. Kant clearly treated biology as a part of physics, and was convinced that biology should be grounded in other physical disciplines, such as chemistry and perhaps electricity. This view is in line with Kant's conception of proper biological method, which directs us to always explain organic phenomena and processes mechanically. However, it is also clear that Kant did not have the capacity to fully develop this project. A precise account of the relation between biology and other disciplines pertaining to natural science, and thus an account of how to ground biology as a science, is never articulated by Kant. In order to obtain such an account, we have to turn to the immediate successors of Kant, i.e., we have to turn to the *Naturphilosophie* of Schelling.

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Samenvatting

Kant over eigenlijke wetenschap: Biologie in de kritische filosofie en het *Opus postumum*

De status van biologie binnen Kants wetenschapsfilosofie wordt veelvuldig als problematisch ervaren. In zijn *Metaphysische Anfangsgründe der Naturwissenschaft* (1786) specificeert Kant condities waar een eigenlijke wetenschap aan moet voldoen. Op het eerste gezicht voldoet alleen de Newtoniaanse fysica aan deze condities. Het is dan ook gebruikelijk om te beargumenteren dat Kant biologie als onwetenschappelijk beschouwt. De biologie voldoet niet aan de eisen waar een eigenlijke wetenschap aan moet voldoen. De specifieke relatie tussen Kants visie op eigenlijke wetenschap en zijn visie op biologie is echter nauwelijks onderzocht.

Het doel van dit proefschrift is om Kants opvattingen betreffende biologie te analyseren op basis van zijn conceptie van eigenlijke wetenschap. Ik beargumenteer dat Kants opvattingen betreffende eigenlijke wetenschap, gearticuleerd in zijn *Metaphysische Anfangsgründe*, zijn visie op biologie en biologische methode, gearticuleerd in de *Kritik der Urteilskraft* (1790) en het *Opus postumum* (1796–1803), fundamenteel bepalen. Kants visie op eigenlijke wetenschap en zijn visie op biologie staan dus niet los van elkaar. Integendeel: Kants visie op eigenlijke wetenschap bepaalt in sterke mate zijn opvattingen over biologie en biologische methode.

Het resultaat van mijn analyse is dat biologie aan verschillende eisen van eigenlijke wetenschap voldoet. In de eerste plaats specificeert Kant een specifieke methode om het domein van de biologie te bepalen en af te zonderen

van het domein van overige natuurwetenschappen. Kants opvattingen over verklaringen in de biologie zijn tevens gebaseerd op een algemeen ideaal van wetenschappelijk verklaren. Tenslotte construeert Kant biologie als een deel van de fysica, gefundeerd in meer fundamentele natuurwetenschappen. Als zodanig is Kants opvatting van de biologie conform een algemeen ideaal dat stelt dat de fysica als geheel een systematische wetenschap moet zijn. De status van biologie is problematisch in zoverre de biologie in Kants tijd een niet-wiskundige wetenschap is en in zoverre de specifieke relatie tussen biologie en andere natuurwetenschappen niet volledig geëxpliciteerd wordt. Kant gaf dus in meerdere opzichten een aanzet om de biologie als wetenschap filosofisch te funderen. De volledige uitvoering van dit funderingsproject geschiedt echter pas na Kant in de negentiende eeuw.

Hieronder zet ik de voornaamste bevindingen van de afzonderlijke hoofdstukken van dit proefschrift uiteen.

Hoofdstuk 1

In hoofdstuk 1 analyseer ik Kants conceptie van eigenlijke wetenschap. Een eigenlijke wetenschap moet (i) een *systeem* zijn, (ii) de cognities van een wetenschap moeten als *gronden* en *gevolgen* geordend zijn, (iii) de cognities van een wetenschap moeten apodictisch zeker zijn. Deze condities worden geanalyseerd op basis van het *klassieke wetenschapsmodel*.

De begrippen en oordelen van een wetenschap vormen een hiërarchisch geordend *systeem* (i) met een duidelijk onderscheid tussen fundamentele en niet-fundamentele begrippen en oordelen. Systemen van begrippen worden geordend op basis van definities, logische analyse en logische divisie. Systemen van oordelen zijn geordend op basis van demonstratieve relaties tussen oordelen. De meer fundamentele oordelen van een wetenschap moeten *objectieve gronden* leveren voor minder fundamentele oordelen (ii). Wetenschappelijke bewijzen zijn deductieve demonstraties waar de premissen objectieve gronden specificeren voor datgene wat in de conclusie beweerd wordt. Een dusdanige demonstratie is een *verklarende demonstratie*: een demonstratie die gronden specificeert *waarom* iets het geval is. Tenslotte moeten de oordelen van een wetenschap *apodictisch zeker* zijn (iii). We moeten gerechtvaardigd zijn om wetenschappelijke oordelen als noodzakelijk waar te beschouwen. Dit impliceert dat wetenschappelijke oordelen bewezen moeten worden op basis van *a priori* principes. Op basis van deze condities wordt duidelijk waarom volgens Kant eigenlijke natuurwetenschappen gebaseerd moeten zijn op wiskunde en metafysica. Het is op basis van wiskundige en metafysische (*a priori*) principes

dat verklarende demonstraties gegeven kunnen worden in de natuurwetenschap (ii) en dat natuurwetenschappelijke oordelen apodictisch zeker zijn (iii).

Hoofdstuk 2

In hoofdstuk 2 worden enkele van Kants opvattingen over eigenlijke natuurwetenschap vergeleken met zijn opvattingen over biologie. In de *Kritik der Urteilskraft* beargumenteert Kant dat organismen niet mechanisch verklaard kunnen worden en worden mechanische verklaring als ideale natuurwetenschappelijke verklaringen geconstrueerd. Het doel van dit hoofdstuk is om de notie 'mechanische verklaring' te verhelderen en om te laten zien waarom mechanische verklaringen een natuurwetenschappelijk ideaal van verklaring leveren.

Kant construeert mechanische verklaringen als verklaringen van de eigenschappen van een geheel in termen van zijn delen. Ik laat zien dat deze conceptie van mechanische verklaring overeenkomt met opvattingen van Christian Wolff over wetenschappelijk verklaren. Wolffs visie op wetenschappelijk verklaren is gebaseerd op deel/geheel-redeneringen zoals deze voorkomen in zijn logica en metafysica. In de logica worden definities opgevat als verklaringen van een geheel in termen van zijn delen. In de metafysica worden verklaringen van de attributen van objecten geconstrueerd als verklaringen van een geheel in termen van zijn delen en de compositie van deze delen. In de natuurwetenschap verklaren wij volgens Wolff eigenschappen van natuurlichamen in termen van (a) hun delen, (b) de compositie van deze delen en (c) krachten tussen de delen. Verklaringen in termen van (a)–(c) zijn *mechanische verklaringen* die laten zien *waarom* iets het geval is en vormen zodoende een natuurwetenschappelijk ideaal van verklaren.

Kants opvattingen over mechanische verklaringen komen overeen met Wolffs opvattingen over mechanische verklaringen. In tegenstelling tot Wolff beschouwt Kant echter het natuurwetenschappelijk ideaal van mechanisch verklaren als een *regulatief maxime*. De claim dat wij alles in de natuur mechanisch moeten verklaren is een methodologisch voorschrift. Deze claim impliceert niets betreffende de ontologische aard van natuurlichamen. Tenslotte laat ik zien dat Kants these dat organismen niet mechanisch verklaarbaar zijn één specifieke eigenschap betreft: de ordening van de delen van een organisme. Natuurwetenschappers kunnen niet mechanisch verklaren *waarom* de delen van een organisme geordend zijn zoals ze zijn.

Hoofdstuk 3

Hoofdstuk drie analyseert Kants opvattingen over de rol van teleologie in de biologie. Ik beargumenteer dat Kant binnen de natuurwetenschap geen verklarende functie toekent aan teleologie. Echter, teleologie stelt ons in staat het domein van de biologie te bepalen.

In het eerste deel worden Kants opvattingen over teleologie besproken op basis van een analyse van Alexander Gottlieb Baumgartens *Metaphysica*. Baumgarten onderscheidt de relatie tussen werkoorzaken en gevolgen (*nexus effectivus*) van de relatie tussen middelen en doelen (*nexus finalis*). De *nexus effectivus* bestaat tussen objecten onafhankelijk van de wijze waarop deze objecten worden gerepresenteerd door een cognitief subject. Dit geldt niet voor de *nexus finalis*. Middelen en doelen bestaan slechts relatief aan subjecten die op basis van voorstellingen handelen.

Kants conceptie van 'doel' is vergelijkbaar met die van Baumgarten. Dit verklaart waarom teleologie geen verklarende rol vervult in de natuurwetenschap. Natuurwetenschappelijke verklaringen zijn *verklarende demonstraties*: demonstraties die objectieve gronden specificeren *waarom* iets het geval is. Doelen zijn echter geen objectieve gronden: het zijn ideële oorzaken die subjectief aan de natuur worden toegeschreven. In de biologie zijn verklaringen mechanische verklaringen waarin men zich beroept op de *nexus effectivus*.

In het tweede deel wordt beargumenteerd dat teleologie volgens Kant het object of domein van de biologie bepaalt. Door organische lichamen (planten en dieren) als *natuurdoel* te conceptualiseren, kennen wij eigenschappen en relaties toe aan organische lichamen die wij niet toekennen aan niet-organische lichamen. Als zodanig bepaalt de *methode* die wij hanteren in de biologie hoe wij het object van de biologie begrijpen.

Ik laat zien hoe volgens Kant de *mechanische* methode van onderzoek naar organismen bepaalt hoe wij de aard van organismen begrijpen. De eis dat wij natuurlichamen mechanisch moeten verklaren, leidt er toe dat wij organismen conceptualiseren als bestaande uit relatief enkelvoudige delen. Kants opvattingen over de wijze waarop *teleologie* het object of domein van de biologie bepaalt worden onderzocht in het licht van het werk van de achttiende-eeuwse bioloog Johann Friedrich Blumenbach. Blumenbach onderscheidt organische van niet-organische lichamen door de eerste te karakteriseren in termen van (i) reproductie, (ii) voeding en groei, (iii) een specifieke (doelmatige) structuur. (i)–(iii) leveren criteria op basis waarvan organische van niet-organische lichamen worden onderscheiden en moeten in teleologische termen begrepen worden. Bij Blumenbach vervult teleologie zodoende een cruciale rol in de demarcatie van organische van niet-organische lichamen.

Kant kent een soortgelijke rol toe aan de teleologie. Volgens Kant bestaat de biologische methode in de *subordinatie* van mechanisme aan teleologie. Door organismen teleologisch te bepalen conceptualiseren we organismen als zijnde in het bezit van een doelmatige structuur die aangepast is aan het uitvoeren van organische processen. Gegeven deze teleologische karakterisering van het object van biologisch onderzoek moeten wij echter trachten een mechanische verklaring te geven van deze processen.

Hoofdstuk 4

Hoofdstuk 4 bevat een analyse van Kants *Opus postumum*, waarin hij het project onderneemt een "transitie van de metafysische funderingen van de natuurwetenschap naar de fysica" te bewerkstelligen. Ik beargumenteer dat Kants transitieproject begrepen moet worden in het verlengde van diens *Metaphysische Anfangsgründe der Naturwissenschaft* van 1786 en dat dit project aansluit bij een traditioneel natuurwetenschappelijk ideaal van fysica als een systematische wetenschap.

In het eerste deel worden Kants opvattingen over fysica zoals gearticuleerd in de kritische periode geanalyseerd. Kant hanteert een breed begrip van fysica en construeert biologie als deel van de fysica. Hij onderscheidt tussen rationele (*a priori*) en empirische fysica. Op basis van een analyse van de *Metaphysische Anfangsgründe* laat ik zien dat Kant zich bewust is van het bestaan van een kloof tussen de rationele en empirische fysica. De noodzakelijkheid van Kants transitieproject, dat deze kloof moet overbruggen om fysica als *systeem* te funderen, ligt in de *Metaphysische Anfangsgründe* besloten.

In het tweede deel wordt de betekenis van de term fysica zoals gehanteerd in enkele toonaangevende achttiende-eeuwse fysicahandboeken geanalyseerd. In deze handboeken wordt fysica als een systeem gepresenteerd door de zogenaamde bijzondere fysica te funderen in de algemene fysica. Het onderscheid tussen algemene en bijzondere fysica wordt gepresenteerd als een onderscheid tussen rationele (*a priori*) en empirische fysica.

In het derde deel toon ik aan dat Kants transitieproject het doel heeft om fysica als een systematische wetenschap te funderen. Dit project kan begrepen worden in termen van de pogingen van achttiende-eeuwse fysici om fysica als een systeem te funderen door de bijzondere fysica in de algemene fysica te funderen. Door het transitieproject tracht Kant de kloof tussen rationele en empirische fysica te dichten. Het transitieproject heeft implicaties voor de status van biologie. Biologie is een deel van de (bijzondere) fysica en Kants transitieproject behelst de poging om biologie binnen de fysica te funderen.

Hoofdstuk 5

Dit hoofdstuk betreft Kants reflecties over biologie in het *Opus postumum*. Ik laat zien dat deze reflecties begrepen moeten worden in termen van biologische theorieën geformuleerd aan het einde van de achttiende eeuw. Tevens toon ik aan dat Kants positie in het *Opus postumum* overeenkomt met zijn positie gearticuleerd in de *Kritik der Urteilskraft*. In het *Opus postumum* herbevestigt Kant zijn opvattingen over biologie in het licht van biologische theorieën en interpretaties van deze theorieën die hij als problematisch beschouwt.

Ik beargumenteer dat Kant in het *Opus postumum* de theorie van levenskracht van de bioloog Johann Friedrich Blumenbach herinterpreteert. Kant accepteert Blumenbachs theorie voor zover deze uitdrukking geeft aan het idee dat we organische processen teleologisch moeten begrijpen. Kant argumenteert echter niet voor het bestaan van levenskrachten. De claim dat levenskrachten bestaan is een dogmatische metafysische claim. Levenskrachten kunnen alleen op basis van een analogie met menselijk doelmatig handelen aan organismen worden toegeschreven.

In het *Opus postumum* ontwikkelt Kant opnieuw het idee dat teleologie het object of domein van de biologie bepaalt. Het onderscheid tussen de organische en niet-organische natuur is geen ontologisch onderscheid. Dit onderscheid wordt a priori verondersteld binnen de fysica. Tevens handhaaft Kant het idee dat verklaringen in de biologie mechanische verklaringen zijn. Biologie is een deel van de fysica en verklaringen van organische processen vereisen de specificatie van de fysische en chemische oorzaken van deze processen.

Vervolgens behandel ik Kants verwerping van materialisme en hylozoïsme in het *Opus postumum*. Kants kritiek van materialisme kan begrepen worden in termen van zijn kennismaking met het werk van de fysioloog Samuel Thomas Sömmering, die een materialistische fysiologie ontwikkelde op basis waarvan metafysische vragen beantwoord kunnen worden. Kants kritiek op het hylozoïsme in het *Opus postumum* kan begrepen worden op basis van zijn kennismaking met het werk van Salomom Maimon, die Blumenbachs theorie van levenskracht hanteerde om een hylozoïstische metafysica te formuleren. Kant bekritiseert deze posities omdat zij het domein van de natuurwetenschap verwarren met het domein van de metafysica.

Tenslotte behandel ik Kants opvattingen betreffende natuurlijke historie in het *Opus postumum*. Zijn visie op natuurlijke historie wordt bepaald door zijn opvattingen over eigenlijke wetenschap. Natuurlijke historie tracht objectieve verklaringen te geven van waarneembare gevolgen in termen van historische oorzaken. Kants opvattingen over wetenschappelijke verklaringen leiden

hem ertoe natuurlijke historie positief te karakteriseren. Hij ontkent echter dat natuurlijke historie zekere kennis oplevert. Tevens verwerpt Kant het idee dat organismen uit niet-georganiseerde materie kunnen ontstaan, is hij sceptisch over de mogelijkheid van een transmutatie van soorten, en vindt hij dat de resultaten van natuurlijke historie in overeenstemming moeten zijn met het idee dat de mens het einddoel van de natuur is. Kant beperkt zodoende het bereik van de natuurlijke historie.