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van den Berg, H.

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Hein van den Berg

Wolff and Kant on Scientific Demonstration and Mechanical Explanation

Abstract: This paper analyzes Immanuel Kant's views on mechanical explanation on the basis of Christian Wolff's idea of scientific demonstration. Kant takes mechanical explanations to explain properties of wholes in terms of their parts. I reconstruct the nature of such explanations by showing how part-whole conceptualizations in Wolff's logic and metaphysics shape the ideal of a proper and explanatory scientific demonstration. This logico-philosophical background elucidates why Kant construes mechanical explanations as ideal explanations of nature.

Hein van den Berg: Faculty of Philosophy and Network Institute, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands, h2.vanden.berg@vu.nl

1 Introduction

In § 75 of the Dialectic of Teleological Judgment of the *Kritik der Urteilskraft* Kant famously remarks that it is absurd to hope that there may arise a Newton who can explain the generation of organisms purely mechanically. Kant's notion of mechanical explanation has been extensively examined in recent scholarship.[1] As a result, our understanding of this notion has significantly increased. However, Kant also construes mechanical explanations as *ideal* scientific explanations, noting that without the principle of mechanism there can be no proper cognition of nature.[2] As Eric Watkins has stressed, Kant does not fully explain why mechanical explanations constitute ideal explanations and the secondary literature is largely silent on this question.[3]

Kant provides little justification for treating mechanical explanations as ideal scientific explanations. In § 77 of the Dialectic of Teleological Judgment he sug-

1 Cf. Zumbach 1984; McLaughlin 1990; Allison 1991; Ginsborg 2001, 2004, 2006; Breitenbach 2006; Zuckert 2007. I discuss influential interpretations below.

2 AA 5, 387. Cf. AA 5, 418. Translations from the work of Kant are from *The Cambridge Edition of the Works of Immanuel Kant*.

3 Watkins 2009, 204.

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gests that it is in virtue of our *discursive understanding*, which proceeds from part to whole, that we aim to explain nature mechanically.[4] It is not clear how this remark and similar ones[5] support the claim that mechanical explanation provides proper cognition of nature.

In the present paper, I argue that Kant's views on mechanical explanation can be understood by taking into account Christian Wolff's notion of scientific demonstration. For Wolff, scientific demonstrations are explanatory, i.e., show *why* something is the case. In addition, scientific demonstrations are valid synthetic demonstrations proceeding from *part* to *whole*. Scientific demonstrations thus capture two ideals: they are deductively valid and they are explanatory.

For Kant, I argue, mechanical explanations constitute ideal explanations because they conform to traditional Wolffian views on proper demonstrations. Like Wolffian scientific demonstrations, mechanical explanations constitute *explanatory proofs* in natural science showing why something is the case. Moreover, they are *deductively valid* demonstrations that proceed synthetically from part to whole. The claim that our discursive understanding necessitates mechanical explanations of nature highlights that mechanical explanations capture these two logical ideals of demonstration.

Recent interpretations of Kant's notion of mechanical explanation focus on explaining the mechanical inexplicability of organisms. According to Peter McLaughlin, mechanical explanations explain properties of wholes in terms of the properties of their parts, properties the parts have *independently* of the whole.[6] Explanations of machines are paradigmatic instances of mechanical explanations. Mechanical explanations of organisms are impossible as the parts of organisms have properties that they do not have independently of the whole. Hannah Ginsborg rejects McLaughlin's interpretation, construing mechanical explanations as explanations of phenomena in terms of fundamental attractive and repulsive forces of matter. Such explanations, Ginsborg argues, are unable to account for the law-like regularities found within organic nature.[7]

Neither of these interpretations considers the logical and methodological views informing Kant's notion of mechanical explanation. If we interpret Kant from this perspective, we can explain why he construes mechanical explanations as ideal explanations of nature. In addition, we deepen our understanding of the notion of mechanical explanation. We will see that Kant's notion of mechanical

4 AA 5, 407f.

5 Kant also states that the determining power of judgment would "like to know everything to be traced back to a mechanical sort of explanation" (AA 20, 218).

6 McLaughlin 1990, 153.

7 Ginsborg 2004, 40f. Cf. Ginsborg 2001, 238–241.

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explanation integrates ideas highlighted by McLaughlin and Ginsborg.[8] Kant, in conformity with McLaughlin's reading, treats mechanical explanations as explaining properties of wholes in terms of their parts. Hence, part-whole conceptualizations are crucial to understanding mechanical explanation. However, they are employed to capture a logical ideal of demonstration from general principles. As such, the notion of mechanical explanation is not exclusively linked to the idea of explaining machines.

The construal of mechanical explanation as a demonstration from general principles is akin to Ginsborg's reading of mechanical explanation as an explanation in terms of fundamental forces. However, contrary to Ginsborg's views, such demonstrations are viewed as explaining wholes in terms of their parts. This is because the notions of 'part' and 'whole', as they figure in Wolff's and Kant's conception of explanation, are notions first introduced in *logic*. They allow us to describe demonstrations from general principles as explaining wholes in terms of their parts.

Wolff and Kant construe scientific and mechanical explanations on the basis of the *part-whole* scheme. This paper is organized around the question of how the part-whole scheme enables Wolff and Kant to capture the abovementioned ideals of scientific demonstration. First, I treat Wolff's metaphysics and logic, highlighting how scientific demonstrations can be said to explain wholes in terms of their parts (section 2). I then show how Wolff construes scientific demonstrations in natural science (section 3). Turning to Kant, I show how, similar to Wolff, part-whole conceptualizations introduced in logic are employed to construe mechanical explanations as scientific demonstrations proceeding from part to whole. This conception of scientific demonstration elucidates why mechanical explanations are ideal explanations of nature and why it is in virtue of our *discursive understanding* that we aim to provide mechanical explanations (section 4). In the final section, I show how the developed notion of mechanical explanation sheds light on Kant's claim that organisms are mechanically inexplicable and reconstruct the status of biology in Kant's philosophy (section 5). I argue, contrary to a dominant line of interpretation, that Kant's construal of mechanical explanation entails that biology is grounded in other physical disciplines.

8 Zuckert 2007, 101–108, takes Ginsborg's account of explanation in terms of fundamental forces of physics to entail explanation of wholes in terms of their parts. My account supports that of Zuckert. In contrast to Zuckert, I focus on the relationships between metaphysics, logic and physics in Wolff and Kant, showing that part-whole conceptualizations introduced in metaphysics and logic were fundamental to their views on explanation.

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2 Parts, Wholes, and Demonstration

The present section analyzes how the part-whole scheme figures in Wolff's account of scientific demonstration. For Wolff, scientific demonstrations are explanatory demonstrations (syllogisms) showing *why* something is the case. Such demonstrations, reasoning from ground to consequence, specify a reason for why something is the case.[9] I show that scientific demonstrations are conceptualized as synthetic demonstrations proceeding from parts to wholes. This conception is based on construing the concept 'part' in terms of the concept 'ground'.

In order to understand Wolff's account of demonstration we must first treat his views on concepts. The application of the part-whole scheme to demonstrations is predicated on taking *concepts* to be the fundamental objects of study in logic.[10] This view is common in the modern period. For example, in the Logic of Port-Royal, Arnauld and Nicole remark that we can form a *complex concept* by adding an explication or a determination to a concept.[11] An addition is an *explication* if it develops what is contained in the intension of the concept and applies throughout its extension (as in 'a human being is an animal'). An addition is a *determination* if its addition to a concept restricts its signification, i.e., if it *specifies* a concept (as in 'a rational animal'). Importantly, complex concepts and judgments are not distinguished. Likewise, Wolff takes judgments to express complex concepts.[12]

In addition to judgments, in the 18th century, *syllogisms* were often understood as a manner to connect concepts.[13] For example, Reimarus argued that, in syllogisms, the conclusion follows from the premises *because* the connection between concepts expressed in the conclusion is made clear in the premises through a middle term. Through the middle term, providing a *ground* for predicating some concept of a subject-concept, syllogisms allow for connecting concepts.[14]

The part-whole scheme is applied to demonstrations because relations among concepts are interpreted on the basis of this scheme. Wolff conceptualizes relations between concepts as containment relations. He takes the intension of a

9 Cf. Wolff [1728] 1963, 17, and Wolff [1751] 2003, 36f.

10 In treating Wolff's logic, I build on Longuenesse 1998 and Anderson 2004 and 2005, who stress the importance of Wolff's logic for 18th century logic, metaphysics and mathematics. I show how Wolff's logical views influence his views on demonstration in *natural science*.

11 Arnauld/Nicole [1683] 1996, 44f.

12 Cf. Wolff [1754] 1978, 156f.

13 This point is stressed by Anderson 2005, 30–32.

14 Reimarus [1766] 1979, 172–174.

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concept to be the set of marks contained in it, whereas the extension of a concept is the set of concepts contained under it.[15] In the 18th century, marks (higher and more universal concepts) are generally construed as *parts* of composite concepts (lower concepts).[16] Hence, the relation of marks to concepts contained under these marks is a relation of *parts to whole*.

Given this account of the order of concepts, Wolff construes definitions as explicating wholes in terms of their parts. A definition of a concept supplies *marks*, allowing us to identify and distinguish the objects constituting its extension.[17] In defining a concept we thus specify a relation between a whole and its parts: if we define 'man' in terms of the genus 'animal' and the difference 'rational', we represent the concept 'man' in terms of marks or parts *contained in* a composite concept (whole).

It is important to note that the order of concepts (parts) figuring in the *definiens* is essential. This idea, as it figures in 18th-century logic, is explained by Lanier Anderson, who stresses that, e.g., the concepts 'long pieces of clothing with stripes' and 'pieces of clothing with long stripes' need not be identical with respect to some domain (e.g., pieces of clothing in my closet), i.e., they can differ qua extension.[18] Hence, in defining a concept, which must enable the identification of things to which the defined concept applies, the order of concepts contained in the *definiens* matters. Wolff expresses this idea ontologically by noting that definitions provide knowledge of the essence of a thing, whereas the concept 'essence' is construed as the *mode of composition* of its parts.[19] In a definition, we thus explicate a whole (composite concept) by specifying its parts and the mode of composition (order) of these parts.

The part-whole scheme is further applied to the methods by which we form concepts and definitions. Wolff distinguishes three such methods: (1) reflection, (2) abstraction, and (3) arbitrary determination.[20] Through reflection we identify and distinguish things contained in a perceived object (e.g., perceiving a table, we can distinguish top and base as its parts). As such, we may distinguish marks that, if they identify essential characteristics of an object, figure in a definition

15 Wolff [1754] 1978, 138. For a detailed discussion, cf. Anderson 2005, 27–29.

16 This point is made by De Jong 1995, 627, who notes that Leibniz, Reimarus and Crusius apply the part-whole scheme to relations of concepts. Cf. Anderson 2005. For the importance of the part-whole relation in Leibniz, cf. Engfer 1982, 172–174.

17 Wolff [1754] 1978, 128–130 and 141.

18 Anderson 2004, 529.

19 Wolff [1754] 1978, 146f.

20 Wolff [1754] 1978, 132–134, 136f., 139f. The examples in the following are taken from Wolff. See Engfer 1982, 249–255, for discussion of (1)–(3) in the *Philosophia rationalis*.

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of the concept of this object. In abstraction, through which we form *general* concepts, we compare concepts of different things (e.g. 'rectilinear triangle' and 'rectilinear quadrangle') and abstract common marks ('rectilinear figure') contained in the former concepts.

Finally, we can form definitions through the arbitrary determination of concepts. For example, given the concept of a rectilinear triangle, we can add the determination that the three lines must be equal and obtain the concept of an equilateral triangle. Whereas reflection and abstraction are *analytic* (regressive) methods, the method of determination is a *synthetic* (progressive) method. In analytically defining a concept we resolve a given whole (composite concept) in its parts (marks), whereas in synthetically defining a concept, we compose a whole from given parts.

Having treated the application of the part-whole scheme to concepts, we may now focus on the application of this scheme to demonstrations. In the *Deutsche Metaphysik*, Wolff provides an ontological account of how the notions 'essence', 'ground', 'part' and 'whole' are related. This account illustrates why demonstrations of wholes in terms of their parts are construed as explanatory demonstrations.

As said, a ground allows us to know why something is the case.[21] Wolff connects the notion 'ground' with the metaphysical notion 'essence'. The *essence* of a thing contains the ground of its attributes, i.e., (necessary) properties of a thing grounded solely in its essence.[22] Wolff explicates the concept of essence in terms of the concepts of 'part' and 'whole': we know the essence of a thing (for example a clock) if we know its parts and the necessary mode of composition of its parts (springs, gears, etc.).

The above analysis provides the following picture: we must explain the attributes of an object (whole) in terms of its parts and the mode of composition of these parts. The reason is that we know the *essence* of objects by knowing the mode of composition of their parts. Thus, we might explain why eyes provide sight by analyzing their parts and the manner in which they are combined. Such an explanation, proceeding from cognition of the *essence* of an object, provides a ground that allows us to understand *why* an object possesses certain attributes.

The application of the part-whole scheme to demonstrations of attributes is based on the conception of marks (e.g., *genera* and *differentiae*) as parts contained in composite concepts (e.g., *species*). Attributes are understood as being derivable from marks. Marks such as *genus* and *differentia* are *essential* marks

21 Wolff [1751] 2003, 15 f.
22 Wolff [1751] 2003, 18 f. and 23.

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(parts): they specify (parts of) the essence of a species. Attributes are grounded in essential parts.[23] Hence, a syllogism in which essential parts of a thing are taken to ground the predication of an attribute provides a proper explanatory demonstration.

Take the following syllogism: bodies have extension, whatever has extension is divisible, hence bodies are divisible.[24] 'Extension' is a specific difference and essential part of the concept 'body'. 'Divisibility' is an attribute of 'body'. The partial concept and middle term 'extension', denoting an *essential* characteristic of bodies, provides us with the *ground* for predicating the attribute 'divisibility' of 'body'. Hence, *marks* (partial concepts) of a concept constitute *grounds*.

The above syllogism proceeds from a (partial) definition of 'body' to the conclusion that bodies are divisible. For Wolff, definitions explicate the *essence* of a thing falling under a concept.[25] Hence, syllogisms in which (some of) the concepts constituting the *definiens* of the subject-concept or minor term function as a middle term and ground, proceed from parts to whole and from ground to consequence. Insofar as the synthetic method is characterized as proceeding from parts to whole and from ground to consequence, the above inference may be construed as synthetic.

In his treatment of propositions, Wolff also construes the ground for predicating a concept of a subject as a part (mark) of the subject-concept. Every proposition can be analyzed into two components: the ground under which something pertains (or does not pertain) to a thing and the assertion.[26] In the proposition 'the warm stone makes warm' the act of making warm is *asserted* of the stone in virtue of the stone being warm (ground). In categorical propositions where we predicate a concept of a subject in virtue of its essence (e.g., 'divisibility' of 'bodies'), the ground of predication is not apparent. We can explicate this ground by analyzing the subject-concept and transposing the proposition in hypothetical form. For example, the categorical proposition 'every triangle has three angles' can, using

23 This conforms to Wolff's view that the attributes of a thing are grounded in its essence. We also find this conception of attributes and essential marks (parts) in Meier's *Vernunftlehre* (1752), 178–180. See also Baumgarten's *Metaphysica* (1757), at AA 17, 35–36.

24 The example is cited by Kant in his *Über eine Entdeckung* (AA 8, 229). It illustrates Wolff's views on the demonstration of attributes. Kant treats divisibility as an analytic attribute derived from the essence of the concept 'body'. For an account of how this example highlights Kant's conception of analysis, see Zinkstok (forthcoming).

25 Wolff [1754] 1978, 147.

26 Wolff [1754] 1978, 159. The examples in the following are taken from Wolff. On the transformation of categorical into hypothetical judgments (and vice versa) in Wolff, see Longuenesse 1998, 99–101.

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the definition of a triangle as a space enclosed in three lines, be transformed in the hypothetical 'if a space is enclosed in three lines it has three angles'. In this proposition we explicate the ground for attributing three angles of triangles (namely: being enclosed in three lines), and it becomes clear that this ground is part of the complex subject-concept 'triangle'.[27]

Up to this point we have focused on judgments and demonstrations of judgments in which we predicate attributes of a subject-concept in virtue of its essence. In the terminology of Port-Royal: we have focused on judgments in which we *explicate* the intension of a subject-concept. We may now focus on Wolff's conception of *determination* in order to show how judgments in which we predicate modes (accidents) or relations of a thing are demonstrated.[28]

In the *Philosophia rationalis sive logica*, Wolff construes a *determination* as a concept added to a subject, determining the state of this subject in virtue of which certain predicates can be attributed to it.[29] At issue are predicates that do not always belong to a subject and cannot be attributed to a subject in virtue of its definition or essence (as 'extension' can be attributed to bodies in virtue of the definition of the latter).[30] We are thus concerned with predicates attributed to a thing in virtue of a ground pertaining to a thing at certain times or that lies outside of the thing, i.e., with modes and relations.

As an example, Wolff cites the predicate expressing the relation of making warm that is attributed to a stone.[31] The definition of a stone is not sufficient for attributing the act of making warm to a stone. A stone does not make anything warm in virtue of being a stone. Rather, the fact that a stone is warm is the ground in virtue of which a stone can be attributed the predicate of making warm. If we wish to specify the sufficient ground for attributing the act of making warm to a stone, we need to *determine* the subject 'stone' by means of the determination of being warm, as in the compound proposition 'the warm stone makes warm' (*lapis calidus calefit*). The determination of being warm provides a ground for the truth of the judgment 'the stone makes warm'. This ground can be expressed by the middle term of a categorical syllogism in which the minor premise determines the

27 Wolff [1754] 1978, 158–160.

28 Wolff's views on determination and his views on modes and relations have received little attention. Anderson 2005, 47–50, argues, without treating Wolff, that synthetic propria and modes cannot be represented in analytic hierarchies (relations are not discussed). Longuenesse 1998, likewise, does not discuss Wolff's views on modes and relations. How Wolff views demonstrations of modes and relations thus remains unclear.

29 Wolff [1740] 1983, II 231.

30 Wolff's notion of determination is thus similar to that of Arnauld and Nicole treated above.

31 Wolff [1740] 1983, II 231.

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subject, such as: what is warm makes warm, the stone is warm, hence the stone makes warm.

Syllogisms through which we justify the predication of modes or relations of a subject-concept are distinguished from syllogisms through which we justify the predication of attributes. In the latter case, the essence of a thing provides a sufficient ground of predication, whereas this is not true in the former case. Nevertheless, just as *essentialia* are construed as parts of a subject-concept, Wolff construes modes and relations as parts of a subject-concept. In his treatment of propositions, he interprets propositions containing multiple concepts within their subject as having a single subject-concept *composed of* multiple concepts taken together.[32] As such, the proposition 'warm stones make warm' can be taken to have a complex subject containing the *ground* of predication as its part.[33] This idea was influential in the 18th century. It led Reimarus to argue that the ground of predicating a concept of a subject is *always* contained in its subject. The ground for predicating modes or relations of a thing is given by external or internal conditions contained in the (determined) *whole* concept of a thing *as its parts*.[34]

On the above view, syllogisms through which we justify the predication of modes or relations of a thing can be treated as explaining a whole in terms of its parts: we justify the attribution of the *relation* of 'making warm' of a stone, i.e., show that 'making warm' is a part of the *whole* concept of some stone, by determining the concept of a stone via the mode of 'being warm', i.e., by taking this mode to be a part of the whole concept of some stone. Similarly, syllogisms through which we ground the attribution of *modes* to things can be said to explain a (determined) whole concept in terms of its parts.

According to Wolff, demonstrations of modes or relations must proceed *from a determination*.[35] Here, we can think of the following types of demonstration, in which the determination (italicized in the following) functions as ground: whatever is warm makes warm, *stones that are warm* are warm, hence: stones that are warm make warm. Or: if *a stone is warm* it makes warm, x is a warm stone, hence: x makes warm. These demonstrations can be construed as synthetic, i.e., as proceeding from parts to wholes. Let us focus on the first example. Here, the middle term denoting the mode of being warm can be construed as *part* of the complex concept (*whole*) denoting warm stones. As such, it functions as a ground for predicating the relation of 'making warm' to this complex concept.

32 Wolff [1754] 1978, 157.
33 Cf. Wolff [1754] 1978, 159.
34 Reimarus [1756] 1979, 149f.
35 Wolff [1728] 1963, 63f.

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In conclusion to this section, we may provide an example of a non-explanatory inference that, in contrast to our previous examples, proceeds analytically from whole to part. Inductive inferences, which Wolff construes as inferences in which what is affirmed or negated of the *lower* is ascribed to the *higher*, provide a nice example.[36] For example, given the premise that the eyes represent external objects, the premise that the sense of smell represents external objects (and so forth for all senses), we may infer that *all senses* represent external objects.[37] Here, we infer from premises predicating some property of fully determined concepts denoting individuals (wholes) to a conclusion predicating this property of a concept (genus) that is contained in or *part* of these fully determined concepts.

3 Explanatory Demonstrations in Natural Science

In the previous section, we saw how Wolff applies the part-whole scheme to definitions and demonstrations. Analytic definitions and demonstrations proceed from whole to parts, while synthetic definitions proceed from parts to whole. Synthetic demonstrations, in which partial concepts function as *grounds*, provide explanatory demonstrations showing *why* something is the case. In this section, we will see how Wolff applies the part-whole scheme within natural science and sketch his account of proper demonstrations in natural science.

In natural science, Wolff argues, knowledge of the characteristics of wholes (corporeal objects) must be based on knowledge of their parts and the mode of composition of these parts. This is because natural science must be based on knowledge of the *essence* of corporeal objects or bodies.[38] The essence of a body, i.e., the mode of composition of its parts, provides the ground for the *attributes* it possesses, such as figure, quantity, divisibility and the filling of a space.[39] These characteristics pertain generally to *composite objects*, e.g., to physical objects studied in physics and to mere extended objects studied in geometry. In order to delineate the class of physical bodies we need to specify distinguishing characteristics of these bodies. I will specify these features below.

Wolff's claim that in natural science we must investigate the mode of composition (essence) of the parts of objects captures the idea that such objects must

36 Wolff [1740] 1983, II 369.
37 The example is taken from Meier 1752, 594.
38 Wolff [1723] 2003, 1f.
39 Wolff specifies this list of attributes in Wolff [1751] 2003, 35. They are predicated of bodies in Wolff [1751] 2003, 374f.

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be treated *mathematically*. In the *Deutsche Metaphysik*, the notions 'part' and 'whole' are employed to argue that composite things have a determinate *quantity*. The quantity of a composite thing is construed as its *set of parts*. In virtue of having a determinate quantity, all composite things are *measurable*: we determine the quantity of composite things by taking them to consist of a set of homogeneous parts and by specifying how many times a unit of measurement is contained in the whole.[40] Insofar as composite things are composed of actual parts that are external to one another and occupy a *place*, they *fill a space* and are *extended*.[41] Finally, insofar as extended things have limits they have a particular *figure*, resulting from the mode of composition of its parts.[42] Hence, the essence of composite things grounds properties that allow of mathematical treatment.

Wolff's views on scientific demonstration entail that explanations in natural science should incorporate mathematical knowledge. In his *Preliminary Discourse*, he states that the ground of some things is "seen only from what is demonstrated mathematically because they depend on some determinate figure or quantity".[43] As an example, he cites the attempt to explain why bees construct honeycombs with hexangular cells.[44] This demonstration requires historical (empirical) knowledge, philosophical knowledge of the ground, and mathematical knowledge of quantity. Mathematics shows that of all possible figures the hexagonal figure is "the most convenient of all".[45]

Wolff does not know the physical ground for why bees construct honeycombs with hexangular cells. From a modern perspective, following Mancosu and Lyon and Colyvan, we may locate this ground in the evolutionary fact that bees that use less wax and energy have a better chance at being selected. The point is that this explanation must be supplemented with a mathematical demonstration that shows that a hexagonal grid is the most optimal way to divide a surface in equal regions with the least total perimeter. A complete explanation of why bees construct honeycombs with hexangular cells must thus be based on mathematics: the natural scientist must proceed from a study of the geometry of honeycomb

40 Wolff [1751] 2003, 29–31.
41 Wolff [1751] 2003, 26f.
42 *Ibid*.
43 Wolff [1728] 1963, 20.
44 This example has a long history. The idea that the hexagonal grid provides (in Wolff's terms) the most *convenient* partitioning of the plane is known as to the *honeycomb-conjecture*. Paolo Mancosu (2008) discusses this conjecture, though not in reference to Wolff, to argue for the explanatory role of mathematics in natural science. The proof of the conjecture was given by Hales 2001. Cf. Lyon/Colyvan 2008, 228f.
45 Wolff [1728] 1963, 20.

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cells. In Wolff's terminology, this is to say that we must proceed from a study of the mode of composition (essence) of the parts of honeycombs. Explanatory demonstrations in natural science proceed from mathematical propositions concerning the mode of composition of natural objects.

The attributes of bodies considered so far (extension, divisibility, etc.) pertain to composite objects in general. According to Wolff, a distinguishing feature of corporeal (physical) objects is that they are composed of material parts. This fact grounds the *inertia* of bodies.[46] In addition, bodies are characterized by having a force. We explain the features of corporeal bodies in term of their material parts, the mode of composition of parts (comprising the essence of a body) and by ascribing forces to bodies and their parts.[47]

The introduction of the notion 'force' is crucial for Wolff's account of explanation in natural science. To see this, we may refer to the distinction between attributes, modes (accidents) and relations introduced earlier. Recall that Wolff took the attributes of a thing to be grounded solely in its essence. This is not the case for modes and relations. The essence of a thing is an *insufficient ground* for explaining its modes and relations. In natural science, however, we are fundamentally concerned with relations. For example: the *motion* of a body can be construed as a change of *relation*. Hence, the essence of a body is not a sufficient ground of its motion.[48] In order to account for motion, we need to introduce the notion of a moving force that constitutes an *objective ground* of motion.

In the previous section, we have seen that the *ground* for predicating some concept of a subject-concept was taken to be provided by the middle term of a syllogistic demonstration. Insofar as motive forces are objective grounds of (change of) motion, demonstration in natural science will often have some concept of force as a middle term.

To elucidate Wolff's views, we may refer to Newton's synthetic deduction of celestial motions from principles of motion given in Proposition 13 of Book 3 of the *Principia*.[49] Within this deduction, Newton refers to the principles: (a) if a body P departs from a place along a straight line with any velocity and is acted upon by an inverse-square force, P will move along a conic section with a focus in the center of forces (part of Corollary 1 to Proposition 13 of Book 1)[50], and (b) that "the weights of the planets are inversely as the squares of the distances from the center of the

46 Wolff [1751] 2003, 374–377.
47 Cf. Wolff [1751] 2003, 382f.
48 Wolff [1751] 2003, 381f.
49 Newton [1726] 1999, 817f.
50 Newton [1726] 1999, 467.

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sun".[51] From (a) and (b) we may infer that the planets orbit in a conic section having a focus at the sun. This demonstration proceeds from mathematically demonstrated principles. In addition, the fact that planets are subject to an inverse-square force of gravity is an objective ground of the orbit of planets. This example provides a proper explanatory demonstration in natural science, proceeding from objective grounds (forces) to their consequences (celestial motions).[52]

In conclusion, Wolff construes proper (chains of) demonstrations in natural science as proceeding from mathematical propositions concerning the mode of composition (essence) of wholes, and as proceeding from the specification of forces as objective grounds of motion (consequences). In this manner, we aim to provide complete explanatory demonstrations of the characteristics of wholes. These characteristics include not only attributes, but also modes and relations.

4 Mechanical Explanation in Kant

Wolff's ideal of scientific demonstration provides us with a background for understanding Kant's idea of mechanical explanation in natural science. In the present section, I argue that that Kant construed mechanical explanations in a manner akin to Wolff's ideal of scientific and *explanatory* demonstrations. The justification for this interpretation lies in Kant's use of the part-whole scheme, which resembles Wolff's employment of this scheme.

In the following, we will see that, similar to Wolff, Kant (i) conceptualized relations between concepts in terms of part-whole relations. This view provides the basis for his views on mechanical explanation expounded in the Dialectic of Teleological Judgment. In addition (ii), Kant takes mechanical explanation to constitute an ideal of scientific explanation because it provides cognition of objective grounds for natural phenomena. Mechanical explanations constitute *explanatory demonstrations*. Finally (iii), Kant takes mechanical explanations to be based on mathematical principles.

51 Newton [1726] 1999, 817. I have simplified Newton's demonstration, which shows that planets move in *ellipses* in accordance with the law of areas. To accomplish this end, Newton refers to several principles not treated above. For a full account, cf. Cohen 1999, 232.

52 Georgio Tonelli has emphasized that the advent of Newtonianism in the 18th century broadened the notion of mechanism (relative to the traditional Cartesian conception of mechanism). Wolff's construal of scientific demonstration confirms this view. See Tonelli 1974, 245; cf. Ferrini 2000, 307. In the following I will employ Newtonian demonstrations to illustrate the nature of mechanical explanations.

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(i) First, we may show how part-whole conceptualizations determine Kant's views on mechanical explanation in the third *Critique*. Discussing Wolff (section 2), we noted that the relation between marks, such as *genus* and *differentia*, and composite concepts contained under them (*species*), is construed as a relation between parts and whole. Kant likewise conceived of universal concepts (marks) *contained in* a (more determinate) concept as parts of a composite concept.[53] Thus, for example, the genus 'metal' is part of the species gold, copper, etc.

This view on the order of concepts informs Kant's conception on mechanical explanation. In § 77 of the Dialectic of Teleological Judgment, 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".[54] This claim is the conclusion of a famous argument in which he discusses a special characteristic of our *discursive understanding*.[55]

In § 77, Kant states that our discursive understanding progresses from "the parts, as universally conceived grounds, to the different possible forms, as consequences, that can be subsumed under it".[56] He similarly notes that our understanding proceeds from the "analytic universal (of concepts) to the particular (of the given empirical intuition)" by means of the *subsumption* of an empirical intuition under the concept.[57] Kant uses the term *determination* to characterize this progression. Finally, Kant claims that in accordance with the constitution of our understanding, a "real whole of nature is to be regarded only as the effect of the concurrent moving forces of its parts".[58] Mechanical explanations are thus partly construed as ideal explanations because our discursive understanding directs us to explain nature mechanically.

The above account suggests that when Kant characterizes the human understanding as proceeding from the analytic universal to the particular, he thinks of a process of *determination* in which we proceed from partial concepts to composite concepts (from the universal to the particular). Kant employs the notion of determination similar to Wolff (section 2): we determine a concept if we specify its

53 This view is explicated throughout Kant's lectures on logic. Cf. AA 24, 910. For further discussion, cf. De Jong 1995, 623–627. Anderson 2005, 27–34.

54 AA 5, 408.

55 One of the best accounts of this argument is contained in Düsing 1968, who interprets (as I will) Kant's views on the discursive understanding in light of containment relations among concepts. Good treatments are found in Guyer 2001, 269 f., and Förster 2002. I focus on this argument to elucidate the notion of mechanical explanation.

56 AA 5, 407.

57 *Ibid*.

58 *Ibid*.

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extension. Determination occurs through *subsumption* under a concept. Hence, we can say that we determine the concept 'metal' by subsuming the concept of 'gold' under it, or that we determine the concept 'animal' by subsuming the *intuition* of a particular (say Socrates) under it. On this reading, it is no surprise that Kant characterizes the discursive understanding as proceeding from parts to whole. For, as we have seen, determination was traditionally understood as a method of composing wholes (composite concepts) out of parts (partial concepts).

(ii) Some commentators have emphasized that Kant's views on the order of concepts influence his treatment of mechanical explanation in § 77 of the Dialectic of Teleological Judgment.[59] However, this is insufficient to explain why mechanical explanation constitutes an ideal of scientific explanation. In discussing Wolff, we noted that ideal scientific demonstrations (a) constitute deductively valid inferences and (b) are *explanatory*, i.e., provide cognition of all the *grounds* of properties of composite things. Does Kant construe mechanical explanations in a similar manner? The answer is yes. To see this, we must consider Kant's use of the part-whole scheme in more detail.

As mentioned previously, in § 77 of the *Kritik der Urteilskraft* Kant relates explanations proceeding from parts to wholes to explanations proceeding from *grounds* to *consequences*. Referring to relations among concepts, he notes that our understanding progresses from the parts "as universally conceived grounds" to forms or consequences that can be subsumed under it.[60] Here, we find an association of the notions of 'part' and 'ground' encountered in Wolff. In the *Jäsche Logik*, concepts (parts) are taken as grounds of cognition with respect to the totality of representations making up their extension.[61] The idea is that concepts that are part of the intension of a concept subsumed under it can function as a middle term in a syllogism, providing a ground for predicating the major of the minor in the conclusion. To elucidate this idea, we can cite our standard example: bodies have extension, whatever has extension is divisible, hence, bodies are divisible. Here, 'extension' is part of the intension of 'body', providing the ground for predicating 'divisible' of 'bodies'. Kant thus treats the progression of our understanding from part to whole as a *demonstration* proceeding from ground to consequence.

Kant further relates the activity of our understanding of progressing from parts to whole with *determining judgment*. The idea of mechanical explanation is,

59 Düsing 1968, 90–92. Cf. Quarfood 2011, 146–148.
60 AA 5, 407.
61 AA 9, 96.

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in turn, associated with the activity of determining judgment. Kant states that the determining power of judgment would "like to know everything to be traced back to a mechanical sort of explanation".[62] This circumstance provides evidence for the idea that mechanical explanation is conceived as a *demonstration* in which we proceed from parts (grounds) to wholes. For Kant takes the faculty of determining judgment to enable demonstrations:

> If the universal (the rule, principle, the law) is given, then the power of judgment, which subsumes the particular under it [...] is *determining*. (AA 5, 180)

As Longuenesse has shown, Kant construes the term 'rule' as the major premise of a syllogism whose minor term is the object.[63] Hence, he understands determining judgment as allowing, by means of *subsumption* under a rule (take, e.g., the subsumption of 'bodies' under 'extension' in our standard example), for a syllogistic inference in which we proceed from the universal (part) to the particular (whole). This subsumption is conceived by Kant as a *determination* (specification) of a concept. In the First Introduction to the third *Critique*, Kant further writes that the power of judgment can be regarded as a faculty for "*determining* an underlying concept through a given *empirical* representation".[64] Let us give another Newtonian example to elucidate how demonstration through subsumption (determination) works in natural science.

In Proposition 1 of Book III of the *Principia*, Newton argues from the mathematically demonstrated proposition 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 (call this antecedent [A]), then that body is subject to a centripetal force tending toward that point (Proposition 2 of Book I).[65] Then, by means of phenomenon 1, according to which the satellites of Jupiter describe areas proportional to the times, he infers that the satellites of Jupiter are subject to centripetal forces directed toward Jupiter.[66] From Kant's point of view, we can interpret this inference as proceeding via the *determination* of a rule ([A]) by subsuming empirical representations of the satellites under this rule. This rule provides a *ground* for the fact that the satellites of Jupiter are subject to centripetal forces.

I have argued that in the Wolffian tradition inferences such as the abovementioned one would be interpreted as explaining a whole (a composite concept) in

62 AA 20, 218.
63 Longuenesse 1998, 92.
64 AA 20, 211.
65 Newton [1726] 1999, 446.
66 Newton [1726] 1999, 802.

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terms of its parts. This view was based on construing *all* the marks (grounds of cognition) of a thing, whether *essentialia* or modes and relations, as *parts* of our whole concept of this thing. Hence, we may interpret the property (call it [C]) of 'describing areas proportional to the times' (contained in [A] and predicated of the satellites of Jupiter) as a mark that is part of our individual representation of some satellite of Jupiter. That Kant construes determining judgment as a process allowing for the syllogistic inference from universal to particular and as a process proceeding from part to whole suggests he adopted a similar view.

A problem confronting the above reading is that it may be taken to imply that all judgments, whether we predicate *essentiala*, attributes, modes or relations, are *analytic*. If this is the case, Kant, who took all significant judgments in science to be *synthetic*, could not subscribe to the view that all predicates are *part* of a complex subject-concept. However, in the *Jäsche Logik*, Kant upholds the analytic-synthetic distinction, while allowing for the idea that all predicates (marks) are *part* of a complex subject-concept. A mark is defined as follows:

> A *mark is that in a thing which constitutes a part of the cognition of it*, or – what is the same – a *partial representation*, *insofar as it is considered as ground of cognition of the whole representation*. All our *concepts* are marks [...]. (AA 9, 58)

Marks are thus *parts* or *partial representations*, functioning as grounds of cognition of a *whole representation*.[67] As we have seen, concepts function as marks insofar as they can be employed as a middle term in a syllogism. Note that *all* concepts are marks. Kant distinguishes between analytic and synthetic marks:

> *Analytic* or *synthetic* marks. *The former* are partial concepts of my *actual* concept (marks that I already think therein), while the latter are partial concepts of the *merely possible* complete concept (which is supposed to *come to be* through a synthesis of several parts). (AA 9, 59f.)

Analytic and synthetic marks are *parts* of a complete concept. In the case of analytic marks (a notion comprising the traditional categories of *essentialia* and (analytic) attributes), the marks are already thought in the concept and can be made explicit through analysis. Synthetic marks are parts of a *merely possible* complete concept, arising through the *synthesis* of these marks. The idea of a merely possible complete concept arising through synthesis can be understood in terms of the traditional idea of *determination*, as encountered in Wolff. Wolff ar-

67 Kant's notion of a mark has been nicely analyzed by Smith 2000, especially 247–253. In contrast to Smith, who focuses on intuitive marks, I discuss Kant's views on marks to show how demonstrations from synthetic principles can be construed as proceeding from part to whole.

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gued that we can form definitions through the arbitrary determination (combination) of concepts (section 2). Definitions obtained in this manner require that we show the *possibility* of concepts formed through determination (e.g., by empirically identifying objects corresponding to the concept in question).[68]

For Kant, the synthesis of synthetic marks, and the justification that the so-obtained complex concept is really possible, is based on intuition. Returning to our example, it is on the basis of *experience* that we take the satellites of Jupiter to describe areas proportional to the times. Hence, on the basis of experience we take the rule that bodies describe areas proportional to the times to apply to the satellites of Jupiter, i.e., synthesize the (synthetic) mark [C] with our individual representations of the satellites of Jupiter [B]. On this reading, [C] is a synthetic part of our individual (whole) representations of the satellites of Jupiter [B].

The distinction between analytic and synthetic marks allows Kant to treat demonstrations in general as proceeding from part to whole, as he does in the third *Critique*. In the case of demonstrations in which we merely employ analytic premises (as in our standard derivation of 'bodies are divisible'), we *subsume* a more particular concept (whole) under an *analytic mark*. In demonstrations in which we employ synthetic premises (as found in mathematics and natural science), we can subsume some particular (whole) under *synthetic marks*. In both cases, we reason from part to whole. Mechanical explanations can now be construed as demonstrations in which we proceed from *synthetic* principles of natural science and determine particulars in terms of these principles. In the next section, we will look more closely into the nature of these principles.

The given analysis explains the idea that it is in virtue of our discursive understanding that we must explain nature mechanically. Kant maintains that our understanding is discursive because it cognizes through marks. In the *Jäsche Logik*, he notes that it is through universal marks (grounds of cognition) that we are able to cognize things through *derivations*.[69] In addition, we cognize things through marks insofar as marks enable us to *compare* and *distinguish* things from one another (consider, e.g., marks functioning as *differentiae* in giving definitions). Finally, through the analysis and synthesis of marks we obtain clear and distinct cognition.[70]

Kant thus relates the discursivity of our understanding with various logical ideals of cognition: it is because our understanding is discursive that we are able to define concepts, provide derivations and demonstrations, etc. Hence, it is not

68 Wolff [1754] 1978, 139–141.
69 AA 9, 58.
70 AA 9, 58–60.

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psychological factors that determine that we should explain nature mechanically. In arguing that it is in virtue of our discursive understanding that we aim at providing mechanical explanations of nature, Kant, I take it, has in mind the above mentioned logical ideals of cognition. Mechanical explanations are treated as ideal explanations of nature because they are construed as deductively valid demonstrations that explain why something is the case.

(iii) Finally, we may consider the role of mathematics in mechanical explanations. In the third *Critique*, Kant does not explicitly associate mechanism with mathematics. Perhaps for this reason, commentators have not focused on the relationship between mechanical explanation and mathematics.[71] Nevertheless, Kant does, similar to Wolff, emphasize the importance of mathematical propositions for mechanical explanations in his early *Träume eines Geistersehers* (1766). Here, Kant construes a mechanical explanation as a "*physical* explanation which is also mathematical", i.e., mechanical explanations *combine* "the physical and the mathematical".[72] This is to say that mechanical explanations proceed from both mathematical and physical premises. The Newtonian inferences mentioned above are mechanical in this sense.

Several passages in the third *Critique* suggest a similar viewpoint. In the First Introduction, Kant claims that *a priori* and *empirical* principles can function as grounds for explanations in natural science. In *physical-mechanical* explanations, we *combine* these principles, i.e., such explanations "find their principles in part in the general (rational) science of nature, and partly in those sciences which contain the empirical laws of motion".[73] When employing the term 'general rational science', Kant is primarily thinking of the special *metaphysical* a priori principles of natural science expounded in the *Metaphysische Anfangsgründe*. Hence, mechanical explanations are based on metaphysical principles.[74] However, in Kant's time it was also customary to treat *mathematical* principles as pertaining to general physics. Hence, it is probable that Kant retains the idea of mechanical explanation as an explanation from mathematical principles in the third *Critique*.[75]

71 This is the case for most recent interpretations that consider Kant's idea of mechanical explanation (see the authors mentioned in footnote 1). Breitenbach 2006, 702, cites a passage from Kant's *Träume* relating mathematics to mechanical explanation, given below, but does not discuss the role of mathematics in mechanical explanation.

72 AA 2, 329.

73 AA 20, 237.

74 I return to this important point in the next paragraph.

75 For example, in his *Erste Gründe der Naturlehre* (1774), J. P. Eberhard defines general physics as treating universal properties of bodies that are partly cognizable from first grounds (a priori).

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5 Biology, Contingency, and Mechanical Inexplicability

In the previous section, we showed how demonstrations proceeding from universal synthetic principles can be construed as proceeding from parts to whole. This conception of demonstration underlies Kant's account of mechanical explanation as a demonstration proceeding from principles of natural science.

In this final section, I argue that the ideal of mechanical explanation leads Kant to adopt the view that knowledge of organisms should be assigned a place within a systematic and hierarchically ordered natural science in which organic phenomena are (partly) explained in terms of physical principles or grounds. In other words, biology is part of a systematic natural science ultimately grounded by a priori principles of natural science.[76] These principles provide fundamental grounds on the basis of which we can provide explanatory demonstrations in science. However, such a thorough systematic natural science (including biology) remains an ideal because (a) the relationship between biology and other physical disciplines was unclear in the 18th century, and (b) Kant principally denies that some features of organisms can be mechanically explained.

Kant's construal of mechanical explanation as an ideal of explanation proceeding from parts to whole gives rise to the following view on biology. In natural science, explanation proceeds from part to whole, i.e., by deriving phenomena and specific principles from more general principles grounding the former. If we wish to provide mechanical explanations in biology, biology must occupy a place in a systematic natural science grounded by higher physical sciences (e.g., mathematical physics, chemistry, and others). This is necessary for knowledge of organic phenomena, given that Kant construes mechanical explanations as explanations that we *must* pursue in biology. This interpretation fits the fact, stressed by Ginsborg, that Kant adopted a broad conception of mechanical law, construing principles concerning chemical, magnetic and electric phenomena as mechan-

General physics includes mathematics and kinematics (Eberhard 1774, 6 and 47–112). In the *Metaphysische Anfangsgründe*, Kant objects that in traditional treatments of general physics, mathematical and metaphysical principles are conflated (AA 4, 472–473). For the influence of Eberhard's textbook on Kant, cf. Pollok 2001.

76 Many interpretations of Kant's philosophy of biology strictly distinguish physics and biology. Friedman 2006, 56, states that biology cannot be a proper science grounded in fundamental forces of matter. Zammito 2006, 763, and Guyer 2001, 259–264, argue that organisms threaten Kant's views on the unity of science. Watkins 2009 states that biology is not a part of science proper or physics. I argue that biology *is* grounded in physics.

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ical.[77] Proper explanations of organic phenomena will be partly based on such principles, themselves grounded in higher physical principles.

Kant provided a priori grounds of mathematical physics in the *Metaphysische Anfangsgründe*. In the *Opus postumum* he extended this grounding program to *chemistry*.[78] Kant never explicated the relation between the biological sciences and other physical sciences. Nevertheless, his construal of mechanical explanation suggests that biology must be grounded in such higher disciplines. If proper mechanical explanation proceeds from part (universal) to whole (particular), all explanations in natural science must ultimately be based on the a priori principles of natural science (specifically, principles of kinematics, dynamics and mechanics) established in the *Metaphysische Anfangsgründe*. These principles specify *objective grounds* for explaining natural phenomena. As we know from the Introduction to this work, a priori grounding ensures that we objectively explain phenomena in natural science and that judgments in natural science are apodictically certain.[79] Given that Kant associates providing demonstrations in natural science from a priori principles with providing mechanical explanation, it is no surprise that he construed mechanical explanation as an ideal of explanation.[80]

The above interpretation is problematic with respect to a dominant interpretation of Kant's views on biology, according to which biology is strictly separated from other physical disciplines. For example, Eric Watkins states that Kant cannot argue for the necessity of mechanical explanation by referring to the necessity of the laws of mechanics as established in the *Metaphysische Anfangsgründe*. According to Watkins, these mechanical principles are necessary for explanations in proper science (physics) but not for biology, which is *not a part of physics*.[81]

It is, however, doubtful whether Kant accepted a strict distinction between physics and biology. Such a distinction was not common in the 18th century. Wolff treated topics relevant to biology as part of physics, allowing for the application of mechanical laws in any domain of natural science. Moreover, biologi-

77 Ginsborg 2001, 241f. Cf. AA 2, 113. As Ginsborg notes, Kant maintains this view in the third *Critique*, taking crystal formations to allow of mechanical explanation. Cf. AA 5, 348f.

78 Cf. Friedman 1992, Chapter 5.

79 AA 4, 468f.

80 See Kant's account of 'physical-mechanical' explanation treated in the previous paragraph. Note that on the present interpretation, Ginsborg's account of mechanical explanation in terms of fundamental forces of attraction and repulsion *follows* from interpreting mechanical explanations in terms of the part-whole scheme: attraction and repulsion are universal (simple) principles of dynamics.

81 Watkins 2009, 205.

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cal topics were treated in many influential handbooks on physics in the 18th century.[82] In the *Prolegomena*, Kant himself adopts a broad conception of (universal) physics as a science of *corporeal nature* in general.[83] Finally, in Kant's lectures on physics, the *Danziger Physik* (1785), physics is construed as a universal doctrine of nature providing grounds of chemical and *organic* phenomena.[84] Although Kant restricts himself to discussing pure natural science in the *Metaphysische Anfangsgründe*, this does not imply that biology is not a part of natural science.

Of course, Kant only explicitly grounded mechanics and dynamics, parts of natural science conforming roughly to Newtonian mathematical physics. Armed with merely the Newtonian laws of mechanics we can hardly explain any significant feature of organisms. However, this fact does not imply that biological sciences were not taken to be part of physics. In the 18th century, many people acknowledged the existence of a *gap* between established mechanical sciences and (what we call) biology, while arguing that this gap should somehow be bridged. For example, Wolff, in his discussion of plants, acknowledged that a proper understanding of the generation, nutrition and growth of plants requires the development of *chemistry*.[85] Crusius remarked that the movement of animals is irregular and cannot be explained by mechanical laws *alone*.[86] Finally, several handbooks of physics distinguished between *universal physics*, containing discussion of kinematics, the Newtonian laws of motion, and the theory of gravitation, and *special physics*, containing discussion of specific types of bodies (fluid, solid, magnetic, etc.), chemistry and biological topics. The latter include discussions of the classification, structure, origin and growth of plants and animals. It was believed that universal physics should *ground* special physics, although there was no consensus on how this should be done.[87]

In short, biological topics were part of natural science and biology was taken to be grounded in other physical disciplines, even though the relationship between biology and such disciplines was obscure in the 18th century. In my view, Kant's insistence that we should always continue the search for mechanical explanations in biology, coupled with the fact that he never fully explicated the relation between biology and other physical sciences, reflects this historical cir-

82 For example, Eberhard 1774, 762–781, discusses plants and animals in a manner similar to Wolff.

83 AA 4, 295.

84 AA 29, 97–99.

85 Cf. Wolff [1723] 2003, 630 f.

86 Crusius [1745] 1964, 789 f.

87 Cf. the introduction to Eberhard 1774, 2–12, and references above. For an overview of this work, see Pollok 2001, 516–518.

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cumstance. Nevertheless, his account of mechanical explanation strongly suggests that biology should be integrated with other physical sciences. Kant thus adopted an ideal of a unified science including the biological sciences.

This analysis does not imply attributing to Kant a reductionist conception of the biological sciences, whether a form of ontological reductionism (e.g., organisms are solely composed of material particles) or methodological reductionism (e.g., biological principles and terms can be deduced or defined solely in terms of propositions and terms of other sciences). To say that biology is grounded in other physical sciences is merely to say that propositions of the latter are used in biology to provide mechanical explanations. Kant famously holds that teleological concepts and principles are fundamental to the biological sciences.[88] These concepts and principles are irreducible and fundamental to biology. It is the use of teleology that strictly distinguishes biology from other physical sciences. Nevertheless, given certain teleological assumptions, the biologist should aim to provide mechanical explanations of organic phenomena.[89] For example, we may assume that reproduction is a purpose of species, while explaining that reproduction requires a specification of physical grounds involved in the process of reproduction.

The problem of teleology points to a further salient aspect of Kant's philosophy of biology, namely the mechanical inexplicability of certain features of organisms. In the third *Critique*, Kant states that some features of organisms are *contingent*.[90] The notion of contingency can be traced to Wolff. In the *Deutsche Metaphysik*, Wolff distinguishes *contingent* from *necessary* things. With respect to necessary things we can (after developing a series of grounds) specify the fundamental grounds of its existence (the chain of grounds stops). This is not possible in the case of *contingent* things, in which we cannot specify a limited number of fundamental grounds for its existence.[91] We may thus understand Kant's claim that organisms are contingent with respect to physical laws to mean that certain features of organisms cannot be demonstrated on the basis of such fundamental laws.

If organic phenomena in general cannot be explained on the basis of certain fundamental laws, the interpretation of mechanical explanation provided in the present paper (and the importance assigned to it) would be problematic. In the following, I argue that Kant, in affirming the mechanical inexplicability of organ-

88 Cf. AA 5, 367f.
89 AA 5, 418f.
90 Cf. AA 5, 360.
91 Wolff [1751] 2003, 357f.

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isms, has in mind one specific feature: the harmonious unity or purposeful organization of organisms. This view is first fully developed in his *Der einzig mögliche Beweisgrund zu einer Demonstration des Daseins Gottes* (1763) and maintained in the third *Critique*.[92] Hence, Kant's claim that organisms are mechanically inexplicable is restricted, although, of course, modern biologists deem the explanation of the purposeful unity of the parts of organisms to be fundamental to biology (and unproblematic).[93]

In the second section of *Der einzig mögliche Beweisgrund*, Kant contrasts the manner in which the 'unity', 'order' or 'harmony' of things is demonstrated in mathematics and physics with the *indemonstrable* unity of the parts of organisms. When discussing geometry, Kant remarks that geometers often come to notice that the properties of geometric (spatial) objects have a certain *order* and *harmony*.[94]

These remarks are illustrated by focusing on the figure of a circle. Kant cites Propositions 35 and 36 of Book III of Euclid's *Elements* as theorems providing insight into the order and unity to which circles are subject.[95] For example, Proposition 35 states that if two straight lines, AC and BD, intersect one another in a circle at point E, and intersect the circle at A, C and B, D, it holds that the length of AE × the length of EC = the length of BE × the length of ED. This proposition holds for *any* two straight lines intersecting in a circle and points out a particular *order* and *unity* existing between segments of straight lines intersecting within a circle.

Kant argues that the order and unity to which circles are subject is a result of the construction of the circle. He takes Propositions 35 and 36 of Book III, two examples of a potentially infinite number of propositions, to be *grounded* in the constructive procedure of generating a circle by moving a straight line around a fixed point (the definition of a circle). The idea is that a multiplicity of theorems concerning circles, β, β', β'' ..., are ultimately grounded in a single ground α, on

92 The importance of *Der einzig mögliche Beweisgrund* is stressed by Ginsborg 2001, 241, who argues that the 'composite character' of organisms is mechanically inexplicable. Zuckert 2007, 108–111, argues that the unity of heterogeneous and contingent effects of the parts of organisms defies mechanical explanation. The following account of Kant's views on the mechanical inexplicability agrees with these interpretations, while also relating the latter to the notion of mechanical explanation developed in the previous paragraphs.

93 Ernst Mayr 1982, 67–71, famously distinguishes between biological explanations in terms of proximate (usually physico-chemical) causes, and *ultimate* biological explanations in terms of historical evolutionary causes. We can interpret Kant as stressing the importance of biological explanations in terms of mechanical proximate causes, while denying the possibility of ultimate explanations.

94 AA 2, 93.

95 AA 2, 94. Kant provides many examples showing that determinations of space exhibit "unity alongside the highest degree of complexity". Cf. AA 2, 94–96.

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the basis of which this multiplicity of theorems can be demonstrated. This fact shows that various things that seem to have "their own separate necessity" (e.g., the multiplicity β, β', β'' ...) are harmoniously connected.[96]

When discussing physics, Kant develops a similar line of thought with respect to natural objects that allow of mechanical explanation. To give only one example, he argues that gravity is the single universal ground that gives the earth its spherical form, prevents bodies from flying off the earth, and keeps the moon in orbit.[97] In natural science, we can thus often (as in geometry) demonstrate that a multiplicity of consequences β, β', β'' ..., follow from a single ground α. Because these consequences have a single ground, in contrast to multiple distinct grounds, they constitute a *necessary unity*.[98]

For organisms the case is different. Organisms constitute a *contingent* unity: they are characterized by a variety of characteristics or laws that do not have a *common ground*.[99] For example, Kant argues that human beings have faculties for seeing, hearing, tasting, etc., whereas the grounds of seeing are not the grounds of tasting: very different organs governed by different laws are required for seeing, tasting, etc. Likewise, the multiple parts of the eye are very different from each other and function differently, thus constituting a contingent unity. In short, the *contingent unity* of the parts of organisms, as well as the contingent unity of the different laws to which (parts of) organisms are subject, is contrasted with the *necessary unity* of effects of the single cause gravity.

In the *Kritik der Urteilskraft*, Kant claims that the necessary unity of the parts of organisms defies mechanical explanation or that the structure of organisms is *contingent* with respect to the *nexus effectivus* in nature.[100] We can now indicate what this means: we lack universal grounds on the basis of which we can demonstrate (i) the necessary unity of parts of organisms and (ii) the unity of laws governing the *functioning* of these parts. In Newtonian physics, by contrast, we can specify objective grounds (e.g., gravity) that explain the necessary unity existing between parts of complex systems and laws governing these systems (e.g., regularities concerning the orbits of heavenly bodies).

The preceding analysis provides us with the following account of the importance and scope of mechanical explanation in biology. According to Kant, in explaining organic phenomena we must take into account physical laws including (presumably) the laws of mechanics, chemistry and others. By applying these

96 AA 2, 95.
97 AA 2, 106.
98 *Ibid*.
99 AA 2, 106.
100 AA 5, 360.

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laws, we hope to properly explain organic phenomena and (sub-)processes. However, we cannot explain why the great multiplicity of physical laws to which organisms are subject are harmoniously coordinated, i.e., why they co-operate so as to give rise to specific (purposeful) effects. This necessary unity will always remain mechanically inexplicable, no matter how well biology is integrated within a system of natural science.

6 Conclusion

The above analyses have shown how part-whole conceptualizations in logic and philosophy determine the idea of mechanical explanation as an explanation of properties of wholes in terms of their parts. In discussing Wolff, we have seen that the application of the part-whole scheme to the order of concepts underlies the construal of *demonstrations* as explaining wholes in terms of their parts. Ideal demonstrations in natural science, proceeding from physical and mathematical principles, are construed as synthetically proceeding from parts to whole. These demonstrations are properly explanatory.

Kant's construal of mechanical explanation as an ideal explanation in natural science in which we explain wholes in terms of their parts is similar to Wolffian ideals of demonstrative science. His characterization of the discursive understanding as proceeding from parts to whole, used to argue for the necessity of mechanical explanation, is based on applying the part-whole scheme to concepts. Moreover, Kant, similar to Wolff, treats demonstrations in which we proceed from universal principles and infer more specific rules as demonstrations proceeding from parts to the whole. These principles can be analytic or synthetic. Explanatory demonstrations in natural science proceeding from synthetic (a priori) principles, providing grounds *why* something is the case, are construed by Kant as mechanical explanations.

This construal of mechanical explanation conveys the ideal of a unified science including biology. Biology is partly grounded in other physical disciplines (e.g., mechanics, chemistry, etc.) insofar as propositions of the latter are employed to provide mechanical explanations in biology. Nevertheless, Kant denies that we can explain the unity of physical laws to which organisms are subject.[101]

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AA *Kant's gesammelte Schriften*. Eds. Royal Prussian Academy of Sciences *et al*. Berlin 1902ff. [Translations are from *The Cambridge Edition of the Works of Immanuel Kant*. Eds. P. Guyer/A. Wood. Cambridge 1995ff.]

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