

Chapter 2: Kant's Normative Conception of Natural Science

Angela Breitenbach

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1. Introduction

Kant is well-known for spelling out a remarkably strict conception of natural science, or “proper natural science”, as he calls it in the Preface of the *Metaphysical Foundations of Natural Science* (MAN, 4:468). A proper natural science, he argues, is any body of cognition that is systematically unified, ordered by rational principles, and known with apodictic certainty.

Kant's interest in disciplines that have reached the rank of science is well-motivated by his desire to circumscribe the most venerable form of knowledge. It offers the standard against which Kant measures the progress of philosophy when, in the *Critique of Pure Reason*, he famously asks whether metaphysics can find “the secure course of a science” (KrV, Bxix). But Kant's account of proper natural science raises a problem. On Kant's strict conception, there turn out to be very few such sciences: one, to be precise, namely, physics. At the same time, it is clear that Kant is deeply interested in a large variety of disciplines including chemistry, biology, and psychology that, today, would be classified as genuine sciences and that Kant himself regards as genuine forms of the study of nature. For example, in the *Critique of Pure Reason*, Kant uses distinctively chemical examples to illustrate the way necessary ideas guide the classificatory efforts of “investigators of nature (*Naturforscher*)” (KrV, A646/B674). Similarly, in the *Critique of Judgment*, Kant argues that, although biology does not belong to “(properly so called) natural science” (KU, 5:416–17), its teleological heuristic contributes to the genuine study of nature.¹ Moreover, even as he spells out his strict conception of natural science in the Preface to the *Metaphysical Foundations*, he seems to

¹ For more on the status of biology in Kant, see my (2009b, 2017).

leave room for a more inclusive notion of science. In some passages he suggests that chemistry and empirical psychology are doctrines of nature that, while apparently missing the mark of science proper, nevertheless qualify as a kind of science (see MAN, 4:470–71). How should we make sense of these assertions against the background of Kant’s strict conception of science? Can such disciplines as chemistry, biology, and empirical psychology be awarded scientific status if they fail to qualify as proper natural sciences?

In the literature, Kant’s strict notion of proper natural science has been the focus of significant scrutiny.² But commentators have paid much less attention to whether Kant may be assuming a more inclusive notion of science, and what that notion might consist in.³ I believe that this narrow focus makes it difficult to properly understand and situate Kant’s views on science. I argue that, instead, we must understand Kant’s strict conception of proper natural science in context. More specifically, Kant’s account in the *Metaphysical Foundations* must be construed against the background of a broad notion of science Kant introduces in the *Critique of Pure Reason*. According to this broad notion, both ‘proper’ and ‘improper’ natural science are forms of genuine science. But my proposal is not simply that Kant develops a broad notion that subsumes his conception of proper natural science. I argue, more specifically, that according to Kant’s broad notion all improper natural science is a form of genuine natural science because it has an important *normative* relation to natural science proper: not all science *is* proper natural science, but all science *ought to be* proper natural science. On my Normative Reading, to qualify as a science in general, a discipline must seek systematicity, order under rational principles, and apodictic certainty.

My reading has an important advantage. It resolves the apparent tension between the strict conception Kant develops in the *Metaphysical Foundations* and his wider interests in those disciplines that do not meet this strict conception. It explains how Kant can hold that there is a broad domain of genuine

² E.g. Plaass (1965), Parsons (1984), Friedman (1992c, 2013), Watkins (1998a), Pollok (2001), Van den Berg (2011).

³ There are exceptions including Sturm (2009) and the contributors to Watkins (2001) who signal the existence of a plurality of sciences, not all of which are proper natural sciences, without however addressing the question of what they have in common. Gava (2014) discusses Kant’s conception of science in the Architectonic of Pure Reason without, however, explaining its relation to the account of the *Metaphysical Foundations*.

science, while reserving a central place for proper natural science. My interpretation thereby shows that Kant's conception of science is integral, and indeed central, to his investigation into the nature of human knowledge and cognition. Kant's discussion in the Preface to the *Metaphysical Foundations* presents science not simply as a set of systematically ordered knowledge claims, but as a human activity that is central to our cognitive endeavours.

The plan for this chapter is as follows. In the next section, I begin with a sketch of Kant's contrast between proper and improper natural science in the Preface to the *Metaphysical Foundations*. In Section 3, I carve out and discuss two interpretations of this contrast, which I call the Demarcation Reading and the Classification Reading. The first construes Kant's contrast as demarcating science from non-science. The second interprets the contrast as a distinction between two equally genuine kinds of natural science. I argue that neither is satisfactory. In Section 4, I present my proposed Normative Reading as an alternative. I argue that if we interpret the Preface in light of the conception of science Kant presents in the *Critique of Pure Reason*, we can overcome the difficulties that threaten the Demarcation and Classification accounts. I conclude in Section 5 by ascribing to Kant a broad notion of science as a central human cognitive activity.

2. Proper and Improper Natural Science

Kant presents his distinction between proper and improper natural science in the Preface to the *Metaphysical Foundations*. There, the conception of proper natural science, and its contrast with improper natural science, emerges as the third of three increasingly demanding characterisations of science. In this section, I offer a sketch of this progressive characterisation before highlighting tensions in the text, which any satisfactory interpretation needs to address.

First, Kant begins by characterising systematicity as the fundamental mark of science: "every doctrine, if it is supposed to be a system, that is, a whole of cognition ordered according to principles, is called a science" (MAN, 4:467). It is striking that, in this passage, Kant does not characterise as science those doctrines, or bodies of cognition, that actually *are* systematic. He argues, instead, that the title 'science' applies to any doctrine that is *supposed to be* a system ["eine jede Lehre, wenn sie ein System...

sein soll”, my italics]. Why Kant uses this apparently normative formulation is left unexplained at this point. It is a thread I pick up in Section 4. What is immediately clear, by contrast, is that Kant regards the tight link with systematicity as central to his conception of science. It is this link that distinguishes science from non-science or, as Kant had put it earlier, “scientific” from “common cognition” (KrV, A832/B860).

The connection of science with systematicity is familiar from the *Critique of Pure Reason*. In the Doctrine of Method, Kant puts it succinctly: “systematic unity is that which first makes common cognition into science” (ibid.). And, as he explains in the Appendix to the Transcendental Dialectic, seeking the systematicity of cognition necessary for science is the task of reason:

“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.” (KrV, A645/B673)

By ‘reason’ Kant means the “faculty of principles” (KrV, A300/B357). Just like the understanding it contributes to cognition. But while the understanding confers unity on the manifold of sensory intuitions by subsuming them under concepts, reason seeks unity, in turn, among the cognitions of the understanding. The unity reason seeks is a unity under principles. As the faculty of principles, reason works to bring systematic unity into the cognitions provided by the understanding by ordering them under higher-level principles (see A299/B356). For instance, reason aims to systematise cognitions of the various different kinds of matter by postulating pure kinds, “pure earth, pure water, pure air, etc.” (KrV, A646/B674). According to the Preface to the *Metaphysical Foundations*, it is this systematic unity, or “interconnection based on one principle” (A645/B673), that constitutes the first distinguishing mark of science.

Second, in the Preface, Kant goes on to suggest that we can distinguish different kinds of science, depending on the kinds of ordering principle the science employs in its systematising endeavours. In the case of the cognitions of nature, Kant argues, we can distinguish between “historical” principles, which *classify* natural phenomena according to observed similarities, and “rational” principles, which *explain* these phenomena according to “an interconnection of grounds and consequences” (MAN, 4:468). Correspondingly, it would seem that we could distinguish between two kinds of natural science, “*historical*

or *rational* natural sciences” (ibid.), depending on which principles they employ. In one, the historical natural sciences, we would be concerned with systems ordered according to purely classificatory principles. For example, on Kant’s account in the *Metaphysical Foundations*, both natural description and natural history employ principles of the first kind. The principles of natural description classify “natural things in accordance with their similarities”;⁴ the principles of natural history order “natural things at various times and places” (ibid.).⁵ Both generate an order in accordance with principles that emerge from contingent events, which occurred at particular moments in time (“*Facta*”, ibid.).⁶ By contrast, in the other, the rational natural sciences, we would be concerned with principles whose function is not simply to classify but to explain natural phenomena. For example, Newtonian physics explains the movement of matter by means of universal laws of motion. These laws are necessary principles, governing timeless characteristics that are not reducible to particular contingent occurrences. Cognitions ordered by the laws of Newtonian physics thus constitute “an interconnection of grounds and consequences” and, hence, a rational natural science (ibid.).

Third, having introduced the distinction between historical and rational natural science, Kant comes to his final distinction, that between proper and improper natural science. As he points out, only sciences that are ordered exclusively according to a priori principles can be known with apodictic certainty, that is, with the “consciousness of their necessity” (ibid.). Only these natural sciences are natural sciences in the proper sense. By contrast, natural sciences that also contain empirical principles can only ever be known with empirical certainty. They are only natural sciences improperly so-called:

⁴ In a smaller essay, Kant mentions Linnaean taxonomy as an example of this type of classification (see ÜGTP, 8:161). Linnaeus’ classifications are based on structural similarities, for instance, the number of stamens and pistils of the flowers of plants.

⁵ It is not obvious that all natural history must be purely classificatory. Thus, in other places, Kant seems to think that Buffon’s natural history is more than classificatory. On Buffon’s theory, different races are ordered according to the principle of whether they developed from one another. And this principle of historical descent may well constitute a principle of ‘grounds and consequences’ (see VvRM, 2:429).

⁶ As Plaass points out (1965, 36), Kant here follows Baumgarten and Meier in understanding *Facta* as past occurrences of which we can have empirical knowledge.

“Natural science would... be either *properly* or *improperly* so-called natural science, where the first treats its object wholly according to a priori principles, the second according to laws of experience.

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.” (ibid.)

The a priori laws of mechanics furnish the theoretical basis for explaining the movements of the planets. And they do so in keeping with the requirements of apodictic certainty. This is why Newtonian physics is a proper natural science according to Kant. But the empirical laws of chemistry deliver explanations that may always be revised upon discovery of further evidence. Chemistry contains empirical principles and, for this reason, counts as an improper natural science (see MAN, 4:470–71).

Kant’s conception of proper natural science further delimits his account of rational natural science. While the historical natural sciences must rely on empirical, and hence contingent, principles, the rational natural sciences may be grounded in either empirical or a priori principles of grounds and consequences. And only those rational principles that are known a priori can be the basis for proper science. All other principles—empirical rational or historical—result in ‘knowledge improperly so-called.’ In the Preface, Kant has thus laid out his characterisation of proper natural science by gradually delineating a more and more restrictive notion of science and the criteria necessary for realising it: *systematicity*, ordering according to *rational principles*, and *apodictic certainty*.

Having presented his third and most restrictive conception of science as natural science ‘properly so-called,’ in the rest of the Preface Kant is then concerned to outline how, and to what extent, such proper natural science can be achieved. He argues that we can formulate a proper natural science, and know natural phenomena with apodictic certainty, only by investigating what we can know from reason alone. Proper natural science must contain a *pure* part. And since such a pure part is what Kant calls metaphysics, proper natural science requires metaphysics. But it requires a metaphysics of a particular sort. For natural science is concerned not with nature *in general*, but with the *special* characteristics of specific kinds of natural objects. The metaphysics required for proper natural science must therefore be a “special metaphysics”

(MAN, 4:470), an a priori investigation into the features of a particular kind of natural phenomenon. In physics, for instance, it consists in an a priori investigation into the nature of matter.

This requirement is a complex one. For how can we have *a priori* knowledge of the particular nature of *empirical* phenomena? Kant's answer is that we cannot achieve such a priori knowledge analytically, from mere concepts, but must proceed synthetically, by constructing the object of enquiry in a priori intuition. This answer is deeply rooted in his account of human cognition. Only by examining objects given in intuition can we learn anything beyond the concepts we already possess; but only by examining objects given in *a priori* intuition can what we learn qualify as a priori knowledge. Kant argues that this process consists in mathematical construction. In mathematical construction the imagination produces a representation of a concept in a priori intuition. While the result is an "individual object," the construction nevertheless provides a "universal" representation of all those objects that fall under the concept (KrV, A713/B741). It does so by representing the rule-governed "act of construction" (KrV, A714/B742), or "universal procedure," of producing the object (KrV, A140/B179). In this way, the construction grounds the apodictic certainty, or 'consciousness of [the] necessity' of the laws that govern material phenomena. On Kant's account, special metaphysics, and with it proper science, thus requires mathematics.⁷ It is this insight that leads Kant to his famous claim that "in any special doctrine of nature there can be only as much proper science as there is mathematics therein" (MAN, 4:470).

These details about the requirement of science for mathematics become relevant in Section 4 below. In the Preface, Kant argues, moreover, that in order to apply mathematics to material objects we need to introduce the "principles for the *construction* of the concepts that belong to the possibility of matter in general" (MAN, 4:472). The special metaphysical investigation into these principles that are required for proper natural science is the aim of the body of the *Metaphysical Foundations of Natural Science*. Whether the book does indeed succeed in laying the foundations for what Kant regards as a proper natural science,

⁷ Why, exactly, Kant regards mathematics as necessary for special metaphysics is a question that is discussed controversially in the literature. I cannot go into the details here. See, e.g., Plaass (1965, 79ff.), McNulty (2014), van den Berg (2011).

namely physics, is a question I shall not pursue here. Instead, I highlight two important complications for Kant's progressively more demanding characterisations of science outlined thus far.

As I have shown, Kant develops three increasingly restrictive characterisations of science: proper natural science emerges as a specification of rational natural science, which in turn qualifies science in general. But the Preface contains problematic texts that shed doubt on the stability of Kant's distinctions. Two are of specific relevance for my purposes. First, the taxonomy set out so far allows both historical, i.e. classificatory, and rational, i.e., explanatory, disciplines to count as genuine sciences. But Kant also claims that only rational disciplines count as genuine sciences of nature while historical ones constitute mere doctrines of nature. His proclaimed reason for not calling historical doctrines of nature 'natural sciences' is that a science of nature ought to be concerned with the cognition of natural phenomena "from their inner principle" (MAN, 4:468), that is, from principles of the 'interconnection of grounds and consequences', or necessary laws. Kant demands such a conception of natural science because he does not allow for a conception of nature that is independent of determination by inner principles. As he argues throughout his work, nature is the sum total of the possible objects of experience under laws. And if nature is necessarily determined by laws, then natural science must consist in the study of such laws. It would follow that such historical doctrines as Linnean taxonomy do not constitute genuine sciences of nature because they are not grounded in laws, or inner principles, that govern their objects of study. The science of nature, it would therefore follow, reduces to rational natural science.⁸

Second, in some passages, Kant even refuses to give the title 'natural science' to any doctrine of nature, even a rational one, if it is not grounded in a priori principles, and thus is not a natural science proper. For instance, Kant claims that chemistry "should...be called a systematic art rather than a science," since it is grounded in empirical laws and therefore fails to meet the definition of science proper (ibid.).

⁸ A science of nature in the material sense, concerned with "the sum total of all things, insofar as they can be objects of our senses", must therefore also be a science of nature in the formal sense, concerned with the inner laws of those objects, or "the first inner principle of all that belongs to [their] existence" (MAN, 4:467). On Kant's complicated and fraught distinction between nature (and natural science) in the material and formal sense, see Plaass (1965, 39–40), Pollok (2001, 56–58), McNulty and Stan (2017, 494–99).

Furthermore, he maintains that empirical psychology “must remain even further from the rank of a properly so-called natural science than chemistry,” since we cannot provide a priori constructions of the phenomena of inner sense (MAN, 4:471). More generally, Kant states that “natural science must derive the legitimacy of this title only from its pure part—namely, that which contains the a priori principles of all other natural explanations” (MAN, 4:468–69). Kant’s reason appears to be that for something to be a natural science at all it must be grounded in principles that we can know a priori and with apodictic certainty. The science of nature, we must conclude, is co-extensive with proper natural science.

These complications introduce a serious tension into the Preface that any reading of Kant’s conception of science should address. What, exactly, does Kant intend to achieve with his distinction between proper and improper science? Does he seek to set up a contrast between *real* science and a form of cognition that is *not really* science? Or is he aiming at a contrast between distinct *types* of science, ‘proper’ and ‘improper,’ where the first qualifies as science in a stricter sense, the second only in a looser sense?⁹ In the next section, I argue that two existing interpretations along these lines fail to give satisfactory answers.

3. Two Problematic Interpretations

I identify two broad interpretive trends among philosophers who have commented on Kant’s distinction between proper and improper natural science. The first trend emerges from those readings that construe Kant’s definition of proper natural science as his conception of the science of nature in general. For example, in his discussion of Kant’s complex and changing views about chemistry, Michael Friedman reads Kant as identifying “proper” with “true” science (1992b, 267).¹⁰ Similarly, John Zammito spells out what he regards as the immediate implications of Kant’s “highly restrictive characterisation of

⁹ Kant does not explain the terminology of his ‘proper’/‘improper’ distinction, and 18th-century German has both meanings: ‘proper’ as ‘true’ (“*genau, der Sache völlig gemäß*”; “*der Wahrheit nach*”) and as ‘primarily’ or ‘strictly’ belonging to the meaning of a word (“*einer Sache allein eigen, oder derselben doch vor vielen andern zukommend*”). See Adelung (1811, 1676–77).

¹⁰ See also Friedman (1992a, 189–90 and 1992b, 213–42).

Naturwissenschaft” in the *Metaphysical Foundations* (2017, 488). According to Zammito, disciplines that fail to meet the three-fold definition of proper science such as biology cannot be reconciled “at all with Kant’s prescriptions for science” (2017, 486).¹¹ Kant is engaged in “boundary maintenance,” as Jennifer Mensch puts it (2013, 215–16n). He—strictly speaking—*misspeaks* when he attributes scientific status to disciplines that are based on empirical principles and have merely empirical certainty. On this reading, which I call the ‘Demarcation Reading’ because it demarcates scientific from common cognition, proper natural science is the only possible natural science.

The Demarcation Reading has the great advantage that it ascribes to Kant a single conception of natural science, coherently and definitively characterised by the three criteria I outlined in the previous section. But the Demarcation Reading does not explain how to resolve the obvious tension between this single notion of natural science and Kant’s more inclusive conception that emerged from my discussion in Section 2. For example, Kant claims that “any whole of cognition that is systematic can, for this reason, already be called *science*” (MAN, 4:468). And he goes on to maintain that in some of these wholes of cognition “as in chemistry, for example, [...] the laws from which the given facts are explained through reason are mere laws of experience” (ibid). In these passages, Kant is clear that there are genuine sciences, and even genuine natural sciences, that do not fit the strict definition of proper natural science.

A natural way to resolve the tension might consist in distinguishing between two senses of the term ‘natural science’: one broad, ranging over both proper and improper natural science (MAN, 4:468), the other strict, limiting science to natural science proper. On this second reading, natural science in the broad sense includes, but is more than, proper natural science. The contrast between proper and improper science turns out, not to *demarcate* the science of nature from non-science, but to *classify* natural science in the broad sense into distinct but equally genuine kinds, proper and improper. I refer to this second proposal as the ‘Classification Reading’. It is often assumed, even if not always explicitly, by commentators who find in Kant a philosophy of the special sciences. For example, Bennett McNulty maintains that “in the preface

¹¹ For a similar conclusion concerning the relationship between biology and science, see Richards (2000) and Beiser (2006).

to MAN, Kant claims that chemistry is a science but not a proper science, like physics” (2014, 393). Similarly, Thomas Sturm contends that Kant’s criterion of aprioricity is not a “universal criterion of scientificity” but rather a criterion of natural science in a very specific sense—one which, presumably, can stand alongside sciences in other senses (2009, 229). More broadly, Eric Watkins argues that Kant “does not let the special status of physics blind him to the fact that other sciences, such as chemistry, anthropology, and biology, can be scientific in different senses” (2001a, 4).

The Classification Reading has the advantage that it avoids charging Kant with a contradiction. Kant can, for example, exclude chemistry from the domain of natural science in the strict sense while also ascribing to chemistry scientific status in the broad sense. Indeed, Kant implies this dual conception when he claims that “the whole of [chemical] cognition does not deserve the name of science in the *strict* sense” (MAN, 4:468; my italic emphasis), thereby suggesting that it may deserve the name of science in a *broader* and more inclusive sense. The Classification Reading thus helpfully accounts for a number of different ways Kant uses the term ‘science.’

Despite these advantages, I argue that the Classification Reading faces a considerable difficulty of its own. For, without further amendments, it is unclear how the Classification Reading can explain what makes improper natural science *genuine* natural science. The difficulty arises because, on the Demarcation Reading, improper natural science differs from proper natural science in not fulfilling the demands of natural science proper. A science is therefore improper either because it is not grounded in any laws at all or, more specifically, because it is not grounded in a priori laws. But, according to the first complication spelt out in the previous section, Kant does not allow for a conception of genuine natural science that is independent of the study of laws. Kant does not allow for such a conception of natural science because, on his conception, nature is necessarily determined by inner principles, or principles of ground and consequence. And if nature is necessarily lawful, then the science of nature must consist in the study of those laws. Moreover, according to the second complication I mentioned in the previous section, Kant does not even allow for a conception of science that is independent of the study of laws that are known a priori and with apodictic certainty. There thus seems to be no room, in Kant, for a conception of natural science

that is satisfied with purely empirical classifications, or even with empirical regularities, and the merely empirical certainty they provide. The science of nature, therefore, cannot be independent from the demand for a priori knowledge of the necessary laws of nature.

But, unless it is developed further, the Classification Reading implies precisely such independence. To be fair, I do not take this shortcoming to threaten the readings of those proponents of the Classification Reading I have mentioned above. Insofar as they hold the Classification Reading as a background assumption, and not as a developed theory, they do not positively assert the independence of improper natural science from the study of necessary laws known with apodictic certainty.¹² And, indeed, they might disagree over the nature of such independence. For example, they might argue over whether improper natural science is only contingently or necessarily lacking in a priori laws and, hence, only contingently or necessarily unlike proper natural science. They might thus disagree over whether the improper natural sciences can at least in principle achieve proper scientific status at some point in the future, or whether the metaphysical nature of their objects of study is such that they cannot even in principle be given an a priori grounding in necessary laws.¹³ But either way of resolving the ambiguity would put pressure on the Classification Reading. Whether a natural science is improper because it *has not yet achieved* a priori knowledge, or because it *can never in principle achieve* it, the science would be sufficiently disconnected from the demand for a priori knowledge of necessary laws to count as a genuine natural science. On my reading, any attempt to classify the natural sciences into two distinct but equally genuine kinds must therefore give an account of the tight link between Kant's conception of science and the demand for a priori knowledge of necessary laws.

Both the Demarcation Reading and the Classification Reading must address serious concerns. The Demarcation Reading cannot explain why Kant ascribes scientific status to disciplines that lie outside the strict limits of proper science. It cannot account for the progressive picture of Kant's increasingly

¹² See Watkins, Sturm, and McNulty above. Because the Classification Reading is not argued for explicitly, I do not intend to attribute to these authors any particular views on this issue.

¹³ In Breitenbach (2017) I have argued that, even though Kant does not think we know any biological laws, such laws are in principle possible on his account.

demanding conceptions of science that emerges from the Preface to the *Metaphysical Foundations* as I have presented it in Section 2. The Classification Reading fares better on this score and offers a way around the tension between some of Kant's apparently contradictory views. But the Classification Reading fails to illuminate Kant's professed claim that a science of nature must be concerned with necessary laws that can be known with apodictic certainty. Do these failings show that Kant's own views about natural science are ultimately self-contradictory? Must we disregard part of Kant's commitments if we want to extract a coherent account of natural science? In the following section, I argue for a third interpretation that avoids these conclusions.

4. An Alternative Interpretation

On my proposed Normative Reading, Kant construes both proper and improper natural science as genuine kinds of natural science. In this regard, my interpretation sides with the Classification Reading against the Demarcation Reading. However, by contrast with the Classification Reading, I argue that improper natural science is essentially linked to the criteria of proper natural science: systematicity, grounding in rational principles of 'grounds and consequences,' and apodictic certainty. I thus agree with the Demarcation Reading that these criteria are the hallmarks of genuine science. Importantly, on my reading, Kant's apparent ambiguity in the Preface to the *Metaphysical Foundations* can be resolved if we see that, while Kant allows for two kinds of genuine natural science, proper and improper, these kinds are connected in an important way. Moreover, I argue that this connection is normative: while the improper natural sciences do not *actually* fulfil the criteria of proper natural science, they *ought* to fulfil them. Improper natural science is legitimately called 'science' because it is normatively guided by the criteria of proper natural science. I call this the 'Normative Reading.'

My reading takes its cue from Kant's surprising normative claim, which I flagged at the beginning of Section 2. Kant maintains that "every doctrine, *if it is supposed to be a system*, that is, a whole of cognition ordered according to principles, is called a science" (MAN, 4:467: my italic emphasis). In the Preface to the *Metaphysical Foundations*, Kant does not make it explicit why he regards this normative

relation to systematicity as a criterion for scientificity. But this is to be expected once we see that Kant has already provided an explanation in the *Critique of Pure Reason*. There, as I argue in this section, Kant shows that the normative relation to systematicity implies a normative demand to fulfil the criteria of proper natural science. It is this first *Critique* conception, I argue furthermore, that Kant takes for granted in the *Metaphysical Foundations*. There is thus good reason why Kant begins his characterisation of science in the Preface with a general account of science, as I have shown in Section 2: he deliberately frames his argument in the *Metaphysical Foundations* within the first *Critique* conception of science.

In the *Critique of Pure Reason*, Kant argues that science requires systematicity. It is the systematic unity of cognition, its ordering under principles, that “makes common cognition into science” (KrV, A832/B860). Three aspects of this conception are important for my interpretation.¹⁴ The first is the insight that the systematicity required for science is brought about by reason and guided by reason’s idea of the systematic unity of all possible cognitions of the understanding under a highest principle. This is the idea of the “*complete* unity of the understanding’s cognition” (KrV, A645/B673; my italic emphasis). According to Kant, it is a “mere idea,” since it does not apply to anything in experience, and thus cannot in principle be realised in cognition (KrV, A647/B675). But it is also a “regulative” idea, since it sets a “goal” and guides the activities of reason (KrV, A644/B672). Even when reason has systematised a set of cognitions under a principle, it is thus guided by the demand to search for yet higher principles that subsume yet further cognitions. This demand is not satisfied by anything other than complete systematic unity. Thus, according to Kant’s first *Critique* account, while cognitions must have achieved *some* systematicity in order to count as scientific, any actual system of cognitions stands under the continued demand of reason for *complete* systematicity.

Second, the idea of the complete systematic unity of cognition, applied to cognitions of nature, is the idea of unity under rational, or explanatory, principles. Although reason is also involved in classifying natural objects, it ultimately aims at uncovering the conditions of things; it is after explanation. For instance,

¹⁴ I can only give a sketch of these three points here. For a more detailed account see my (forthcoming).

reason is involved in classifying materials into earths, salts, combustibles, water and air (see KrV, A646/B674). However, Kant also argues that, in classifying, reason is ultimately after systematicity under explanatory principles. It is involved in classifying materials into earths, salts, combustibles, water and air “*in order to explain* the chemical effects of [these] materials” (KrV, A646/B674; my italic emphasis). The activities that constitute the historical sciences are aimed at those that constitute the rational sciences. In systematising cognitions, reason is thus guided by an idea of the complete unity of cognitions ordered according to *rational* principles, or laws. As Kant puts it, “this idea [of reason] 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, A645/B673).

Third, the idea of reason is also the idea of the complete unity of cognitions under laws that can be known a priori and with apodictic certainty. This is because, on Kant’s account, in seeking systematicity under rational principles, we are searching for a unity of cognitions, a unity whose parts, the individual cognitions, and their ordering principles can be inferred a priori and, thus, with apodictic certainty. Reason is after *certainty*, and after the a priori insight that gives us this certainty.¹⁵ In the Architectonic of Pure Reason, Kant characterises this unity as

“the unity of the manifold cognitions under one idea. This [idea] is the concept of reason of the form of a whole, insofar as through it the domain of the manifold as well as the position of the parts with respect to each other is determined a priori.” (KrV, A832/B860)

In order to understand the significance of Kant’s third point, it is important to see that Kant construes the idea of the whole in teleological terms. The whole, or complete system, is construed as the end-directed realisation of the idea of the whole. As Kant continues the passage from the Architectonic, “the scientific concept of reason,” that is, reason’s idea of a complete system under rational principles, “contains the end and the form of the whole” (KrV, A832/B860).¹⁶ As an end of reason, the idea guides the realisation of the

¹⁵ Willaschek highlights this point (2018, 53–55).

¹⁶ Kant’s use of ‘end’ can here be understood according to the characterisation Kant puts forward in the *Critique of Judgment*: an “end” is “the concept of an object insofar as it at the same time contains the ground of the reality of this

system. And it is because the idea of the whole contains an end in this teleological sense that, in a complete system, it “precedes the determinate cognition of the parts” (KrV, A645/B673), as Kant puts it in the Appendix to the Transcendental Dialectic. The idea determines the realisation of the system and thus precedes our cognition of its parts. It follows that, if we had fully determinate knowledge of the idea, we would be able to infer a priori not only the “domain of the manifold,” that is, all those cognitions that form part of the whole, but also “the position of the parts with respect to each other” and, hence, the rational principles that govern their relation (KrV, A645/B673). We would know the system and its ordering principles a priori and, therefore, with apodictic certainty. In seeking to uncover systematic unity under rational principles, reason is thus guided by an idea of systematic unity that can be known a priori and with *apodictic certainty*.¹⁷

My analysis highlights that, according to the *Critique of Pure Reason*, a manifold of cognition is scientific if it is systematised under principles, even if it is incompletely systematic. For to be incompletely systematic is to stand under reason’s demand for complete systematicity. And this, in turn, implies the demand for ordering under rational principles and for apodictic certainty. For cognition to be scientific, in other words, is for it to stand under the demand to fulfil the criteria of proper natural science: not only systematicity, but also grounding in rational principles, and apodictic certainty. All incompletely systematised cognition, even the ‘improper’ sciences such as the merely classificatory historical sciences and the merely empirical explanatory science, stand under this demand of reason.

My analysis also shows that, according to the first *Critique*, the demand for proper scientific status is a normative one. It is a necessary end of the “regulative employment of reason” (KrV, A644/B672) to search for complete systematicity, and thereby for grounding in rational principles and apodictic certainty.

object” (KU, 5:180). See my (2009a, chapter 4) for a related account of Kant’s teleological conception of the systematic unity of reason.

¹⁷ My reading crucially differs from well-known best systems accounts of laws and science associated with Kitcher (e.g. 1994) and others such as Buchdahl (1969b and 1992), Brittan (1978), and Allison (1994). See my (2017) for a criticism of the best systems account. On my account, our best scientific systems can count as science, but not by virtue of their actually grounding the necessity of laws. They can count as science by virtue of their aiming for complete systematicity and, thereby, for necessary laws.

It is an end reason “prescribes and seeks to bring about” (KrV, A645/B673), by regulating or “directing the understanding to a certain goal” (KrV, A644/B672), the complete systematicity of its cognitions. Kant’s conception of science in the first *Critique* thus implies my proposed Normative Reading. It shows why improper natural science is a genuine form of natural science: improper natural science is cognition that is incompletely systematic and normatively guided by the criteria for proper science.

Let us now turn back to the *Metaphysical Foundations of Natural Science*. There is clear evidence that there, too, Kant assumes the first *Critique* conception of science. After introducing the distinction between proper and improper science, Kant adds that one can easily see “that, in accordance with demands of reason, every doctrine of nature must finally lead to natural science and conclude there” (MAN, 4:469). Kant makes this claim after arguing that natural science derives the legitimacy of this title from its pure part. In this context, Kant refers by ‘natural science’ to proper natural science. He suggests that any doctrine of nature, in accordance with demands of reason, must strive to become a proper science. Any study of nature must aim to achieve complete systematic unity under rational principles and apodictic certainty. The ‘must’ Kant refers to is the ‘must’ of the necessary demands of reason. In the *Metaphysical Foundations*, just as in the first *Critique*, he maintains that for something to count as science in the broad sense it must seek to realise what reason demands. When Kant states that “every doctrine, if it is supposed to be a system, that is, a whole of cognition ordered according to principles, is called a science” (MAN, 4:467), he claims that something is a science if it stands under reason’s demands for complete systematicity and, hence, is normatively guided by the criteria of proper science. Improper science ‘must finally lead to’ proper science ‘in accordance with the demands of reason’, because the practice of improper science is directed at the norm of the complete systematicity of cognitions, an ideal in which we would have apodictically certain a priori knowledge of the laws of nature. My Normative Reading thus receives explicit support from the Preface to the *Metaphysical Foundations*.

My Normative Reading also solves the problems that beset the two prevalent alternative interpretations, the Demarcation and Classification Readings. The Normative Reading can account for a broad notion of science, which includes disciplines that do not satisfy the three criteria of proper science.

And it makes sense of the tight link between natural science and the demand for a priori knowledge of necessary laws. Kant can thus consistently hold that there is a wide class of cognition that may legitimately be called ‘natural science’ even if it does not qualify as natural science proper, while also maintaining that these improper natural sciences are supposed to have proper scientific status. He can without contradiction claim that not all natural sciences do in fact explain the phenomena within their domain in terms of necessary laws, while also arguing that all natural sciences aim for such explanation. Kant’s broad notion of natural science has inherently normative character.

But one might wonder where my reading leaves physics, the one discipline that, on Kant’s account in the *Metaphysical Foundations*, is established as a proper science. How, if at all, can my reading account for the exceptional status of this discipline? As I have argued, Kant offers a broad account of natural science. According to this account, all natural science aims for proper scientific status by virtue of its aiming for complete systematicity of cognitions. On my reading, this general account does not conflict with Kant’s view that there are some sciences whose laws are *actually* known with apodictic certainty. Thus, according to Kant, we can know the fundamental laws of physics a priori. And, similarly, there may be other disciplines that may be grounded in a priori laws. However, on my Normative Reading, physics lacks the foundational role ascribed to it by some commentators.¹⁸ Striving for proper scientific status does not amount to striving for derivation from the laws of physics. On my reading, science is guided by the norm of a complete systematic unity of all cognitions. Integration in the complete system can secure a normative relation to a priori grounding and apodictic certainty. But it can do so, not by aiming for derivation from a set of a priori laws of physics, but by aiming for derivation from the idea of the whole. Physics may serve as a model of a discipline that fulfils the criteria of proper natural science. But even as a model, its status is limited. Even physics, just as any other science, has a further task to complete: ‘in accordance with demands of reason,’ it must be unified with other sciences in the complete systematicity of cognition.

¹⁸ For Friedman, for example, the laws of matter provide the “brilliantly successful Newtonian paradigm” of proper natural science (1992b, 240). For related views, see Kreines (2009) and Stang (2016, ch. 8).

This construal of the place of physics in science also implies that we must read Kant's famous statement about the need for mathematics with care. On my reading, when Kant suggests that science proper "is only possible by means of mathematics" (MAN, 4:470), he is making a claim about the requirements for proper natural science insofar as such science is actually achievable by us. Kant is specifically concerned with proper science insofar as it "can be met with [*angetroffen werden könne*]" in the study of nature (ibid.). Proper natural science construed in this sense is proportional to the mathematics that, too, "is to be met with [*anzutreffen ist*]" in science (ibid.). But none of this rules out that, where mathematization is not achievable, we must aim for the apodictic certainty that comes with the idea of the whole.¹⁹ It is because of this normative demand that all natural sciences, whether proper or improper, are genuine sciences.

5. Conclusion

I have argued that Kant presents a well-defined broad conception of science that ranges over natural science 'properly' and 'improperly so-called.' A body of cognition qualifies as a natural science in this broad sense if it stands in a normative relation to science proper. And since aiming at proper natural science is construed, by Kant, in terms of the intellectual activities involved in systematising cognitions, we can see now that science in the broad sense concerns the scientific enterprise broadly construed. It encompasses not only scientific claims such as theories and explanations but also scientific practices such as calculating and experimenting, modelling, representing and visualizing of data and, more broadly, theorizing. Even in the text that is known for its strict, and even restrictive, notion of science, Kant is deeply committed to this broad, normative conception of science as a central human activity.²⁰

¹⁹ For this reason I disagree with van den Berg (2011) and McNulty (2014) that the mathematization requirement is equivalent to the aprioricity and apodictic certainty requirement. On my reading, apodictic certainty is the third requirement of proper science, and this requirement can but need not be met in the form of mathematization.

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