Ch. 45. Contemporary Kantian Philosophy of Science

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1. Introduction

Deeply fascinated by the scientific developments of his own time, Kant is famous for his appraisal of Newtonian physics, which for him serves as a paradigm case for all sciences *properly* so-called.[1] Newtonian science is the exemplar upon which Kant models his own natural philosophy.[2] Some commentators even claim that Newtonian physics must be thought of as necessarily complementing Kant's Critical philosophy in general.[3] Yet the progress of science, such as the development of non-Euclidean mathematics, relativity theory and quantum mechanics, has often been viewed as a challenge to some of Kant's core claims or even as a threat to the whole of his Critical philosophy. Despite these allegations, however, numerous philosophers have attempted to develop Kant's philosophy of science so as to reconcile it with the revolutionary findings of newly emerging research programmes in physics, biology, and psychology.[4]

This chapter explores the extent to which a Kantian approach to the philosophy of science enables philosophical insights that are still relevant today. It will not defend Kant's specific theories of physics or of proper science against attacks launched on the basis of certain results of modern research programmes. Rather, it focuses on certain cognitive constraints that a Kantian approach places on science *in general*: namely the demand of systematicity, according to which nature is regarded as systematically unified and from which emerge

regulative principles that guide our scientific endeavours. It will be suggested that a Kantian philosophy of science is a serious alternative to naturalistic theories of science, broadly construed as those theories that naturalize the relation between the cognizer and nature by fully reducing it to natural or scientific terms. As a result, the chapter outlines how a Kantian theory of science is able to acknowledge the diversity and autonomy of *particular* sciences.

Section 1 introduces Kant's account of systematicity, based on the Appendix to the Dialectic in the *Critique of Pure Reason* and on the two Introductions to the *Critique of the Power of Judgment*, and identifies the philosophical issue that it addresses, namely the underdetermination of our scientific view of the world. Section 2 reviews two main lines of interpretations. Against the prevailing methodological or heuristic reading, it is argued that the demand of systematicity – despite being merely *regulative* (as opposed to being constitutive) – is for Kant a *transcendental* condition of *empirical* cognition *in general*, since it is a necessary condition of the very intelligibility of nature. Section 3 then discusses – in light of this reconstruction of Kant's view – its philosophical significance for a contemporary Kantian approach to philosophy of science. This discussion suggests that a Kantian approach is not only compatible with the modern sciences, but that it advances the debate about the foundational principles of the sciences by refusing to construe those principles in a naturalistic way.

2. The principle of systematicity and the problem of scientific underdetermination

In his Critical philosophy, Kant draws a close connection between science and systematicity: science is a body of cognitions that are ordered in a systematic way. The clearest articulation of this view can be found in the following two passages – one from the Doctrine of Method in the *Critique of Pure Reason* and the other from the Preface of the *Metaphysical Foundations of Science*:

> [. . .] systematic unity is that which first makes ordinary cognition into science, i.e., makes a system out of a mere aggregate of it, [. . .] I understand by a system, however, the unity of the manifold cognitions under one idea. (A832/B861)
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> Every doctrine that is supposed to be a system, that is, a whole of cognition ordered according to principles, is called a science. (*MAN* 4:467)

A body of cognitions constitutes a system if it is ordered in accordance with principles. More precisely, for a body of cognitions to be a *rational* system, it is required that cognitions be ordered according to *rational* principles (see *MAN* 4:467). Such rational principles fall within the scope of reason (*Vernunft*) or, more generally, of those faculties that deal with the deliverances of the understanding (*Verstand*), viz. cognitions.[5] Reason, according to one of its definitions, is specified as "the faculty of the unity of the rules of understanding under principles." (A302/B359) That is, reason does not directly relate to (or even determine) objects of experience, but "applies to the understanding": Reason defines the rules by which the understanding works so that our cognition reaches or approaches systematic unity (A302/B359). Kant claims further that it must – in some sense – be "presupposed" that the systematic completeness of all cognitions prescribed by reason "conforms to nature itself" (A653/B681) and hence "we simply have to presuppose the systematic unity of nature as objectively valid and necessary." (A651/B679). Kant thus moves from an *epistemic* claim about the systematic relations among our cognitions to a *metaphysical* claim about the unity of nature itself.

Two questions arise. Why should science pursue systematicity at all? And why should nature as such be assumed to be systematically unified? We find two strands of replies in Kant's Critical writings. On the one hand, the demand of systematicity is understood to be an integral part of Kant's Critical conception of reason, which first makes possible his distinctive

conceptions of science and nature. On the other hand, the demand of systematicity is understood to be a useful or perhaps even necessary tool for the actual pursuit of the sciences to *get things right* with regard to nature itself. As will become clear in Section 3, much of the understanding of the principle of systematicity depends on which of the two strands is emphasised.

With regard to Kant's Critical philosophy in general, it can be seen from the very definition of nature why certain epistemic claims about cognition are closely – indeed conceptually and in this sense necessarily – related to metaphysical claims about nature. Nature is defined as the "sum total" of all possible objects of *our* experience, and the transcendental conditions of experience are shown to be at the same time the transcendental conditions of possible objects of experience (see, e.g., B161-163). The understanding provides the "source of the laws of nature", insofar as it defines the rules according to which our sensible representations are to be combined in order to yield cognition of objects (A127). These rules are given through the categories, the pure concepts of the understanding, which define the conceptual forms of all experience through which we grasp objects in nature. In particular, the category of causality prescribes *a priori* to nature the principle that every change in nature must have a cause upon which it follows in accordance with a necessary rule or law (see A189/B232ff.). In order for us to be able to cognize an objective sequence of states in nature we must assume *a priori* that every (state of an) empirical object observable in time and space must have a lawful, causal connection to *some* other (state of an) empirical object. This transcendental principle of causality gives "formal unity" to nature; it serves as the "original ground of [nature's] necessary conformity to law." (B165) In other words, in cognizing nature we must think of it as containing lawfully connected objects, giving rise to objective sequences of their states; for, otherwise, no experience of these objects and sequences would be possible.

Kant's transcendental conception of nature thus implies the *formal* or *transcendental lawlikeness* of nature itself.[6]

Although this formal lawlikeness is a necessary condition of any causal experience and thus of any particular empirical law that we may find operative in nature, it is a rather weak kind of lawlikeness. It tells us neither (i) the *actual cause* of a particular effect we observe, nor (ii) which *particular empirical laws* may govern this observed cause-effect relationship.[7] Moreover, it does not tell us whether (iii) nature – in its material sense as the sum total of empirically-real phenomena – can *in fact* be represented through a complete system of empirical laws.[8] The formal lawlikeness determines only *that* there are lawful connections in nature, if the experience of causal relations in nature is to be possible. Yet, in turn, this means that there is a *conceptual underdetermination* (at least at the level of the categories) with respect to (i) the *actual cause* that determines a particular effect, (ii) the *particular empirical law of nature* (or *necessary* rule) according to which all similar effects must have similar causes, and (iii) the *complete system* of laws of nature. In the third *Critique*, Kant explicitly alerts us to the problem of underdetermination for (ii) empirical laws as follows:

> [. . .] many modifications of the universal transcendental concepts of nature [. . .] are left undetermined by those laws that the pure understanding gives *a priori*, since these pertain only to the possibility of a nature (as object of the senses) in general, [. . .] [T]here must nevertheless also be laws for [nature], which, as empirical, may seem to be contingent, in accordance with the insight of *our* understanding, but which, if they are to be called laws [. . .] must be regarded as necessary on a principle of the unity of the manifold, even if that principle is unknown to us. (*KU* 5:179-180)[9]

The understanding's transcendental-formal principle of causality alone cannot guarantee that a particular natural law obtains or – a fortiori – that nature in its material meaning is really a

unity that can be represented through a complete system of empirical laws. Even if Kant provides an argument for a formal principle of causality in the Second Analogy, the problem of *actual inductive* inferences remains unsettled by this argument. Rather, for a complete account of empirical laws, he requires an argument for the *empirical lawlikeness* of nature.[10] Neither the understanding nor the senses nor the combination of both, it seems, can deliver a complete account of nature and its laws.[11]

Kant is aware of the problem of underdetermination also in the context of scientific practice. First, scientists simply do not have a full description of nature through empirical laws at their disposal. Rather, every scientific field that deals with empirical reality lacks some knowledge of causes, laws, and full explanatory grounds.[12] Therefore, scientists require some guidance in how to derive further laws of nature. Secondly, every empirical law that scientists postulate remains under scrutiny and may be refuted by future empirical research.[13] The observed regularities may not be instances of the presumed necessary, lawful connection, but require some revision of the scientific concepts or of the laws assumed to be involved. Thirdly, the relationship between different scientific disciplines or between the domains governed by different, at times even opposing, empirical laws often remains unclear or even disputable.[14] It is often controversial whether a set of empirical laws (or even an entire discipline) can be reduced to a more general set of laws (or a more foundational discipline). For example, it is still a matter of debate today to what extent human psychology can be explained by appealing only to the physical-chemical processes observed in the human brain, rather than to laws of ethology or to genuine laws of psychology.

Kant acknowledges that in the worst case our observations of nature would not display the kind of uniformity that we need to grasp nature according to a well-defined set of laws. Rather, nature could remain "a raw chaotic aggregate" (*EEKU* 20:209) such that we would have to discover infinitely many special empirical laws:

> one need only consider the magnitude of the task of making an interconnected experience out of given perceptions of a nature that in the worst case contains an infinite multiplicity of empirical laws (*KU* 5:184).

The need for addressing this problem of underdetermination can be seen as one of the reasons for Kant to supplement the cognition-constitutive principles of the understanding by introducing regulative principles of reason based on the idea of systematicity, according to which nature is merely regarded as a systematic whole such that our experience of nature can form a systematic unity of cognitions.[15] This idea is supposed to provide rules for finding particular empirical laws that are left undetermined by the understanding.

This demand for systematicity seems *prima facie* imposed upon nature "for the sake of *our* faculty of cognition, in order to make possible a system of experience in accordance with particular laws of nature" (*KU* 5:184), yet without necessarily having an objective realization in nature itself. Kant also calls it a subjective "interest of reason." (A648/B676) In its most general articulation, the idea of systematicity is specified as the "idea of the *maximum* of division and unification of the understanding's cognition in one principle" (A665/B693).[16] This idea is then explicated in terms of the principles of homogeneity, specification, and continuity, which are required to find relations among concepts (and hence among cognitions that correspond to certain objects in nature) in terms of genera and species and by assuming continuity between them. These principles guide us in looking for higher, ever more general levels of description (e.g., unifying the description of electric and magnetic effects in a common theory of electromagnetism) and in distinguishing particulars in smaller degrees at ever more specific levels of description (e.g., finding more subspecies of plants).[17]

Central for the current discussion is the epistemic and the metaphysical status of these regulative principles of systematicity. On the one hand, Kant construes them as merely

subjectively valid *maxims* of reason that guide the employment of the understanding without directly determining objects in nature. They only instruct our epistemic enquiries in searching for further pieces of experience and acquiring a more comprehensive insight into nature and may thus be understood as *principles of discovery*. On the other hand, Kant attributes "objective, but indeterminate validity" (A663/B691) to the idea of systematicity: only if systematicity is assumed to "pertain to nature itself" can the regulative principles of reason be used to supply a "mark of empirical truth" (A651/B679) or the "touchstone of truth" (A647/B675) for our cognitions and thus serve as *principles of justification*. These two characterizations produce an interpretative conflict: If systematicity is viewed as a merely subjective maxim that is heuristically conducive, but not strictly necessary for cognition, then reason could not be an arbiter of "empirical truth". But if systematicity is viewed as an objectively valid principle to which, however, nothing in nature corresponds, then reason might introduce an idealistic moment into our cognition of nature that contradicts Kant's empirical realism (and which may lead precisely to the rationalist conception of nature that Kant criticizes in the Antinomies).[18] In what follows, I explore how each of the two major lines of interpretation attempts to resolve this interpretive difficulty.

3. Systematicity: Regulative principle *and* transcendental condition?

With his seminal contribution (Buchdahl 1969) to the study of Kant's philosophy of science, Gerd Buchdahl highlighted the central role of systematicity for acquiring scientific insight. Since then, two major lines of interpretation have developed: a *methodological interpretation* that stresses the heuristic, hypothetical and subjective character of systematicity, and a *transcendental interpretation* that emphasizes its (indeterminately) objective, necessary and truth-relevant character.

According to the methodological interpretation, the demand of systematicity is considered as a "heuristic" tool guiding us in looking for further cognition.[19] Considering all cognitions as systematically connected aids us in discovering and articulating further cognitions and empirical laws within a systematic taxonomy of concepts and cognitions (e.g., Kepler's laws of celestial motions can be subsumed under Newton's laws of motion). For Grier, reason must avail itself of the idea of systematicity, in order to "consider a disparate set of phenomena as ideally unified", rather than really unified (Grier 2001: 298). This interpretation sees the primary role of systematicity in the context of scientific "discovery and articulation of empirical laws." (Grier 1997: 22) The unity of nature is "projected" by reason to fulfil its subjective "demand for the systematic unity of thought" (Grier 1997: 20). The unity itself is only "hypothetical in character" and remains a subjective *illusion* or *fiction* without corresponding to anything real (Grier 1997: 22; see also Grier 2001: 300). In this sense, the principle of systematicity provides a subjectively useful method for ordering cognitions, but does not have any objective bearing upon their contents.

Kitcher also pursues a methodological reading. For him, systematicity is a methodological principle that defines the "ideal limit of inquiry", which is conducive to achieve scientific progress (Kitcher 1986: 214). What counts as a causal law can be understood only against the background of a system that would emerge from an ideally extended inquiry, the outcome of which finally defines truth.[20] The demand of systematicity thus provides only a framing condition for our minds to recognize explanatory patterns and dependencies between different real phenomena.[21] Similarly, Sturm (2009: 153-162) argues that in order for scientists to be able to find and corroborate empirical laws, these laws must be understood within a structured order of concepts and cognitions, even though such an order is only projected and subject to further revisions.

The methodological reading is supported by passages in which Kant characterizes reason as supplying

> only a heuristic [. . .] concept, as it shows not how a concept is constituted but how, under the guidance of that concept, we ought to seek after the constitution and connection of objects of experience (A671/B699, also A663/B691).

In the *third* Critique, the principle of systematicity is characterized as "a subjectively necessary transcendental *presupposition*" (*EEKU* 20:209, see also *KU* 5:181) and associated with the reflective power of judgment. It is, therefore, often understood as defining the way in which subjects like us must reflect upon nature, without asserting that nature is *in fact* a unity.[22]

Hence, the methodological reading can elegantly make sense of systematicity as a merely regulative principle, rather than a constitutive claim about nature itself. It resolves the interpretive difficulty mentioned above by downplaying the role of reason as the objectively valid arbiter of empirical truth for cognition in general. The truth-promoting function of reason is understood only in terms of a meta-principle that facilitates higher-order scientific theorizing and progress towards a more comprehensive scientific picture of the world.

Yet the methodological reading struggles with accommodating those passages in which Kant emphasises the principle's "indispensably necessary" use (A644/B672) and its "objective, but indeterminate validity" (A663/B691), as well as those passages in which he even rejects viewing it "merely as a methodological device." (A661/B689) Although this reading is the prevailing interpretation, there is an alternative line of interpretation available, paying particular attention to the principle's being a "transcendental presupposition" (A651/B679, A678/B706; *EEKU* 20:209) or a "transcendental principle." (A650/B678, A663/B691; *KU* 5:181)

The main idea of a transcendental reading is that the demand of systematicity is a *necessary condition* of *empirical* cognition *in general*, namely insofar as the objects of our experience only become *intelligible* to us if we can make sense of them as parts of a systematizable whole, viz. nature. Only then can these objects be conceptualizable (and hence cognizable) according to a system of concepts (and, respectively, of cognitions). So understood, the principle of systematicity not only implies that, at the higher-order level of science, empirical laws and scientific theories ought to be put into a systematic order, but also implies that, at the more basic levels, nature as such must be assumed to fit our efforts for empirical conceptualization and hence cognition. Systematicity is thus a transcendental, though regulative, condition of empirical cognition in general: it must be presupposed, if we are to be able to find adequate empirical concepts for *all* objects we encounter in nature (see *KU* 5:211).[23]

Although Buchdahl is often viewed as a proponent of the methodological reading, having first highlighted the central role of regulative principles for Kant's philosophy of science, this classification might be a bit short-sighted.[24] Buchdahl (1969) does put most of his emphasis on the methodological import of systematicity for the discovery of scientific theories, but he also develops a substantial interpretation of the interaction between reason and the understanding, which shows marks of a transcendental reading. He argues that reason's idea of systematicity must supplement the understanding's principle of causality in order to account for the "empirical lawlikeness" of nature (Buchdahl 1967: 214). He conceives of reason as contributing to the procedural realization of the *a priori* principles of the understanding, thereby providing rules for specifying those aspects of cognition that are left contingent or undetermined from the perspective of the understanding (Buchdahl 1992). A full employment of the understanding, and thus a full exploration of empirical reality, can only be accomplished

through the involvement of reason.[25] Reason's regulative principles are thus necessary ingredients for Kant's empirical realism (esp. Buchdahl 1992: 245-287).

Further versions of the transcendental interpretation have been advocated more recently. Geiger (2003; 2009) frames it in terms of a meaning-enabling function of reason in the acquisition of empirical concepts: the idea of systematicity is a "necessary condition of the very meaningfulness of empirical concepts." (Geiger 2003: 285) Only by finding its place within a systematic network of concepts can a newly acquired empirical concept be used to refer to an object given in experience. The idea is transcendental because it first enables the formation of empirical concepts whose contents are determined through their "conceptual relations within a systematic whole of concepts." (Geiger 2003: 290) Nonetheless, it is also only regulative, since such a system can never be completed, but must be assumed as a guideline for all empirical enquiries.[26]

Abela (2006) emphasises the justificatory role that the demand of systematicity plays in the acquisition of empirical knowledge, insofar as it "suppl[ies] an empirical criterion for truth-conditional judgments" (Abela 2006: 409). While the understanding provides formal conditions that any truth-apt judgment must fulfil, reason offers "discriminating-conditions" according to which empirical criteria of truth can be found on the basis of considerations of coherence and systematicity (Abela 2006: 421-2).[27] Sturm's account shows signs of the transcendental reading insofar as, for him, the demand of systematicity also provides *criteria* or *standards* for the acceptability of scientific explanations (Sturm 2009: 156, 160-1, 176-179).

More recently, perspectivalist and contextualist readings have been proposed that combine the meaning-enabling and justificatory roles of reason. According to Massimi's (2017) perspectivalist reading, reason "makes possible a perspectival systematic space of reason for the correct use of the understanding" (Massimi 2017: 76). Such a space is necessary to confer "universality and unanimity" to *our* scientific knowledge claims, which nonetheless

remain confined to the distinctive human perspective (Massimi 2017: 78-79).[28] Kraus (2020) has developed a reading of reason as "generating contexts of intelligibility" (Kraus 2020: 194ff.), within which the understanding can properly operate, generate truth-apt judgments of objects, and approximate the goal of scientific inquiry, which for Kant still is the pursuit of truth as the "agreement with the object" (A821/B849). The details of this view will become relevant in the last section.

Without being able to settle this debate within the limited space of this chapter, I would like to point out what I take to be the crucial advantage of the transcendental reading over the methodological one. And this brings us back to the issue of underdetermination discussed earlier. On the methodological reading, reason offers a helpful heuristic maxim to deal with the underdetermination of empirical laws and empirical concepts that the employment of the understanding leaves us with. Nonetheless, on this reading, it is possible to acquire single instances of empirical cognition without employing the principle of systematicity. In consequence, we could have experience of a single object subsumed under an empirical concept, without being able to infer other empirical cognitions from it or to further analyse it in conceptual terms. Suppose we have the experience of a tree, without being able to relate it to any other concepts, such as "leaves", "branches", "stem", or "roots". The determination of this experience would then have to be sufficiently accomplished by sensibility (in combination with the formal principles of the understanding). Yet this account of experience involves an empiricist bias, since it implies that it is possible to read off the defining marks of an empirical concept directly from the representations yielded by our senses. Similarly, suppose that in a single cognition we discovered the cause C of some particular effect E that we have observed, which, however, bears no systematic relation to any other cause we have observed so far. In order for the discovery of a single cause C to be possible, it must be possible for us to read off the empirical fact that C is the actual cause of E directly from our sensation. The gap between

transcendental concepts and empirical concepts or cognitions left by the understanding would have to be filled by sensibility.[29]

The methodological reading could accept this empiricist leaning, but then would have to assume – in order to avoid scepticism about empirical lawlikeness – that sensibility yields direct insight into particular empirical causes and hence into particular governing empirical laws of nature. This, however, implies that nature, as it exists out there and independently of the mind, must be assumed – in a strong, constitutive sense – to display the systematic connections that are graspable by our cognitive faculties. But this would turn Kant's account of nature into a sort of transcendental realism. Hence, the methodological reading of systematicity does not find an adequate answer to the problem of underdetermination.

By contrast, the transcendental reading reflects Kant's basic insight that *our* concept of nature crucially depends on *our* cognitive faculties (regardless of nature's mind-independent features). The principle that we must view nature as a unified system is a demand of our reason, but at the same time it necessarily completes the account of empirical cognition and answers a need that is left unanswered by the understanding.[30] The principle defines an additional *transcendental* condition of cognition in general, namely a necessary condition of the *intelligibility* of experience. The principle of systematicity imposes a condition on nature as a whole, rather on single objects: only if we live in such a nature that conforms to this condition can it be intelligible for our faculties of cognition at all; only then can all the objects that we possibly experience be conceptualizable and cogniziable in truth-apt judgments. Only then can we develop "marks" or "touchstones" for *empirical* truth in an ongoing process of scientific research: we accept as true only those empirical cognitions or laws of nature that can be made sense of within a system of cognitions or laws, whose *empirical* aspects remain under scrutiny. Hence, even though the principle of systematicity is *subjectively* demanded by *our* reason, it can now also be seen as *objectively* but indeterminately valid with regard to nature itself. Due

to the progressive-processual character of both nature and our scientific investigations of it, the principle remains theoretically unprovable and by itself without determining force. In the final section, I outline a Kantian philosophy of science based on this transcendental conception of nature that could serve as an important alternative to naturalistic philosophies of science.

4. A Kantian philosophy of science: The diversity and autonomy of the sciences

Much of today's philosophy of science is underwritten by a naturalistic presumption according to which the relationship between the cognizer and the cognized object can be explained in purely scientific (or, more broadly, natural) terms. Depending on the scientific discipline one takes to be most fundamental with respect to this relationship, one adopts different views.[31] For example, evolutionary theory takes the epistemic relationship to be the outcome of a historical process of natural selection vis-à-vis our cognitive capacities, while neuroscience accounts for it in terms of the physiological processes of the brain and the peripheral nervous system in interaction with the environment. It is common to all these naturalistic approaches that they must presuppose the explanatory priority of a specific scientific theory over the representational capacities of the mind. That is, they must view a specific scientific theory as more fundamental than our basic capacity for thought and cognition.[32] Yet these naturalistic explanatory frameworks cannot justify our fundamental entitlement to think of nature as being intelligible at all, since none of their explanations can do without the presupposition of nature's intelligibility.

Unlike naturalistic philosophies of science, a Kantian approach does not presuppose the primacy of a specific scientific theory, such as evolutionary theory or neuroscience, but rather takes our basic capacity for representation to be fundamental.[33] It carves out the basic conditions that must obtain between nature and our cognitive faculties in order for us to be able to examine nature at all, one condition being that nature is assumed to be lawful and systematic.

The unity of nature is not a fact that can be discovered from empirical observations or derived from the laws of logic. Rather, it is a necessary and regulative principle that scientists must assume in order to be able to make sense of the diversity of empirical reality in a lawful way. The basic question as to why we are entitled to make the assumption that nature fits our cognitive faculties is primarily a question about the *very concept* of nature and as such defies naturalization. This question cannot be sufficiently answered in scientific terms or by empirical inquiry, but this very concept must already be presupposed in the acquisition of any specific scientific terms and theories.

A Kantian approach to philosophy of science, I finally propose, offers an attractive account of the diversity of the sciences and their relative but irreducible autonomy. Following the transcendental interpretation, my considerations above suggest that the demand for systematicity is by no means confined to the so-called "improper" sciences, such as biology and psychology, i.e., those sciences that are less amenable to a strictly scientific methodology including mathematization, nomological description, and experimental reproducibility. Even the "proper" sciences, such as physics, require principles of systematicity in order for their empirical concepts and laws to have sense and meaning.[34] By defining a science in general as "a system, [i.e., . . .] the unity of the manifold cognitions *under one idea*" (A832/B861, emphasis added), Kant provides a goal-directed account of science, according to which each science is based on a distinctive guiding idea of reason.

According to Kraus's (2020) contextualist reading of reason, the guiding idea of a science can be understood to "generate[] a context of intelligibility" within which we can first make sense of an experience as a "certain *kind of cognition*" and determine through it objects that are available in the corresponding "domain of nature" and that hence belong to the subject matter of the corresponding science (Kraus 2020: 206).[35] By generating such a context of intelligibility, we acquire not only an outline of the whole domain, but also a specific set of

procedural rules that normatively guide us in achieving, or at least approximating, the goal of scientific inquiry: that is, *getting things right* within that particular domain. For each specific science, reason's general demand for systematicity is thus exemplified through discipline-specific rules that guide the more basic conceptualizing and cognizing activities in empirical research within the discipline-specific domain of nature.

If this account is correct, then even the mathematical and physical sciences are based on domain-defining ideas that normatively guide research in these sciences. Newtonian physics is, for example, based on the idea of absolute physical space (see *MAN* 4:558), which outlines the domain within which the laws of Newtonian mechanics can be applied to determine physico-material objects. In biology the idea of natural purposiveness (see CJ, §§73-74) delineates the domain of organic-living nature and is, moreover, needed to make sense of a "heap" of matter as a living being, the parts of which can then be described in terms of physico-chemical processes.[36] In psychology the idea of the soul delineates the domain of psychological reality and is, moreover, needed to make sense of a "bundle" of mental states (and corresponding behavioural states) as belonging to a trans-temporally unified person.[37]

Hence, each science requires a specific idea that outlines its distinctive domain of nature as an *irreducible whole* that must be assumed to be *intelligible* in order for scientists to determine discipline-specific objects within that domain at all (e.g., physico-material objects, organisms, persons). In those sciences in which mathematization and nomological description have further progressed, the domain and its objects can be exclusively described by domain-specific causal laws (e.g., Newtonian physics). In less developed sciences the discipline-specific principles of systematicity are particularly important in first making out the proper objects of scientific inquiry (e.g., biology, psychology).[38] While scientists still aim to find mechanical, efficient-causal explanations for all natural phenomena, they can first begin with this task once they have contextualized the phenomenon to be explained within an adequate

context of intelligibility, as generated by a discipline-specific idea (e.g., by adopting the corresponding system of scientific concepts).[39]

One important merit of the Kantian approach to philosophy of science reconstructed in this chapter is the way that it allows for acknowledging the continuity between the "proper" sciences, such as physics, and the "improper" sciences, such as biology and psychology, without succumbing to the route of mechanistic reduction. Both require principles of systematicity in order to confer meaning to a conceptual description of nature. In addition to the ubiquitous principle of efficient causality, the Kantian approach justifies the use of goal-directed (or teleological) descriptions, which today is often called top-down (or downward) causation, as a legitimate method that is necessary to proceed further towards an objective grasp of nature – a grasp that is both increasingly unified and increasingly specified, despite always remaining confined to our distinctive human perspective.[40] Understanding the demand of systematicity as a necessary condition of the intelligibility of nature *within the human perspective*, as sketched here, highlights the foundational relationship between the *human* scientists and their distinctive objects of scientific inquiry.[41] The Kantian approach thus presents a serious alternative to naturalistic and reductionist theories of science.

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[1] See *MAN* (4:469).

[2] Falkenburg (2020).

[3] Friedman (1992; 2013).

[4] The Neo-Kantian philosophers further developed Kant's philosophy of science, trying to reconcile it with the scientific findings in mathematics (Cohen 1883), physics (Cassirer 1923) and experimental psychology (Natorp 1912). For a survey on Kant's relevance for science in the nineteenth century, see Friedman & Nordman (2006).

[5] In the third *Critique*, Kant introduces the reflective power of judgment to complete the task of systematization, initially attributed to reason in the first *Critique*. On the relationship between reason (in its regulative use) and reflective judgment, see Guyer 1990a. While the chapter focuses mainly on the first *Critique*, it indicates further developments of Kant's view in the third *Critique*.

[6] Buchdahl (1967: 214; 1971: 24-25) shapes the notion of "transcendental lawlikeness" [*Gesetzmäßigkeit*] to denote the sort of "lawlikeness" that is already conceptually contained in Kant's notion of nature.

[7] E.g.: "empirical laws as such, can by no means derive their origin from the pure understanding" (A127); "Particular laws, because they concern empirically determined appearances, cannot be completely derived from the categories" (B165).

[8] Kant distinguishes between "*natura formaliter spectata*" – nature viewed with respect to the formal principles that make nature and our experience thereof possible – and "*natura materialiter spectata*" – nature viewed as "the sum total of all appearances, insofar as those are in thoroughgoing connection through an inner principle of causality", i.e., the real "things of nature." (B163, A418-419/B446; also *MAN* 4:467)

[9] See also "The actions of the understanding, however, apart from the schemata of sensibility, are *undetermined*" (A664-5/B692-3), as well as O'Shea (1997) and Abela (2006). On the problem of underdetermination in the third *Critique*, see Zuckert (2007: 31-61).

[10] Buchdahl (1967, 214, 1971, 25) distinguishes between "transcendental lawlikeness", which determines the formal notion of nature ("*natura formaliter spectata*") based on the principles of the understanding, and "empirical lawlikeness" of nature, which determines the material notion of nature ("*natura materialiter spectata*") based on additional principles of systematicity demanded by reason (see fn. 8).

[11] There is an on-going debate regarding Kant's account of empirical laws (see Massimi & Breitenbach 2017, Watkins 2019). The main positions are: (1) the *Derivation account*, according to which necessity can only be "injected" into or conferred by the transcendental principles of the understanding (Friedman 1992: 2013); on this account, the laws of physics, in particular mechanics, are the only laws that can be deductively derived; (2) the *Best-system account*, according to which the necessity of empirical laws is the result of an ideal unlimited process of inquiry (Kitcher 1986); (3) the *Necessitarian account*, according to which necessity is "built into the nature of things" in terms of their natural causal powers (Messina 2017); and (4) the *Reason-based account*,

according to which reason provides – with its principles of systematicity – an additional *transcendental* conditions of "empirical lawlikeness." (Buchdahl 1969: 651ff., 1971; O'Shea 1997).

[12] See Kant's discussion of incomplete theories held by scientists and philosophers in *Thoughts on the true estimation of living forces* (*GSK*), and *Progress* (*FM* 20:326-7).

[13] See Kant's discussion of various errors committed by scientists and philosophers in *GSK*, and *FM* (20:326-7).

[14] See Kant's discussion of the development of a science (A832/B860-A835/B863) and of the proper "place" of empirical psychology within the system of the sciences (A848/B876).

[15] *A priori* concepts of reason are called "ideas" (see A310/B366ff.). On the distinction between constitutive and regulative principles, see A647/B675. In the third *Critique*, Kant focuses on the principle of purposiveness, see Ch. 37 (Biology), Ginsborg (2006; 2017), Zuckert (2007), and Breitenbach (2014, 2017).

[16] Like a category of the understanding, an idea of reason is explicated by a corresponding "schema of reason" (A665/B693), which "contains the outline (*monogramma*) and the division of the whole into members in conformity with the idea, i.e. *a priori*." (A833/B861) See Kraus (2020, 202-206).

[17] See A652/B680-A668/B696; *KU* (5:185-186). See Watkins (2019, 212-223).

[18] On the antonomies, see Falkenburg (2020).

[19] E.g., Vaihinger (1935); Kitcher (1986; 1994); Guyer (1990b); Grier (1997; 2001).

[20] Kitcher assumes that Kant holds a coherence, rather than a correspondence, theory of (scientific) truth. But note that for Kant truth is the "correspondence of cognition with its object." (A58/B82)

[21] Kitcher's interpretation of Kant here reminds us of his own view of scientific progress (cf. Kitcher 1994).

[22] E.g., Gyuer (1990a), Zuckert (2007: esp. 41-52) takes the principle to be subjectively necessary for empirical concept formation.

[23] Ginsborg (2006, 466) and Zuckert (2007: esp. 41-61) articulate this idea most clearly with regard to the principle of purposiveness.

[24] Abela (2006) sees Buchdahl as a major proponent of the methodological reading; see also O'Shea (1997).

[25] Allison (2004: 423-448), too, reads the idea of systematicity as a "transcendental condition" of experience insofar as it is "indispensable for the proper functioning of the understanding." (Allison 2004: 432)

[26] Ginsborg offers a weaker version, construing the principle of systematicity as a "thin" normative constraint of the "activity of empirical conceptualization *überhaupt*" (Ginsborg 2017: 72). Based on her account of reflective judgment, she argues that conceptualization must be guided by the presupposition of a "normative fit between nature and our judging of it." (Ginsborg 2017: 77).

[27] Similarly, O'Shea (1997).

[28] See also Zuckert (2020).

[29] In a similar vein, Geiger (2003: 287-291) and Abela (2006: 416-417) detect an empiricist bias with the methodological reading.

[30] See O'Shea (1997) on the harmonic relation between reason's interests and the understanding's needs.

[31] See also current attempts to naturalize epistemology and our mental capacities, e.g., Dretske (1995), Kornblith (2014).

[32] Ginsborg (2006: 467) points out this prioritization in her discussion of teleosemantic accounts of cognition.

[33] For a comparison of Kantian approaches with contemporary naturalistic approaches to the principle of teleology, see Ginsborg (2006), Breitenbach (2009; 2017) and Ch. 23.

[34] On "proper" science, see Van den Berg (2014).

[35] Sturm (2009: 127–82) offers a detailed account of how ideas delineate scientific domains. See also Zuckert (2017).

[36] Breitenbach (2009; 2014) has pioneered a transcendental reading of Kant's conception of living nature and of biology based on the idea of purposiveness. See also Ch. 37 in this volume.

[37] See Kraus (2018); on the conceptualization of psychological phenomena, see also Kraus (2020: 231-240).

[38] On the use of regulative ideas in chemistry, see McNulty (2015).

[39] On the plurality of the sciences see Breitenbach & Choi (2017). For Breitenbach (2017: 250-254), the principle of purposiveness first makes possible a conception of scientific research as a goal-directed activity. On Kant's anti-naturalism and the importance of teleology for science in general see Falkenburg (2020: 231-242).

[40] The epistemic status of top-down causation is a recurring issue in contemporary philosophy of science, which is also central to discussions about the possibility of reduction and emergence within and across scientific disciplines. For a contemporary discussion see Ellis, Noble, & O'Connor (2012). For a contemporary argument against intertheoretic reductionism in neuroscience see Craver (2005). Craver & Bechtel (2007) offer an argument for the assumption of top-down (or final) causation in neuroscience, without accepting top-down (or final) causes as explanatory causes. Scientific explanations must still appeal to mechanic or efficient causes.

[41] Massimi (2018) develops a Kantian perspectival account of science, highlighting its potential to explain (and ultimately resolve) cases of scientific disagreement.

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Abstract:

The chapter explores a Kantian approach to the philosophy of science, focussing on the principle of systematicity, according to which nature is regarded as systematically unified. By introducing Kant’s account of systematicity in the *Critique of Pure Reason* and the *Critique of the Power of Judgment*, the chapter identifies the philosophical issue that it addresses, namely the underdetermination of our scientific view of the world. Against the prevailing methodological reading, it is argued that the demand of systematicity is for Kant a *transcendental* principle of *empirical* cognition in general, which concerns the very intelligibility of nature. A discussion of its philosophical significance for contemporary philosophy of science suggests that a Kantian approach is a serious alternative to naturalistic theories of science. A Kantian philosophy of science not only demonstrates the indispensable role of principles of systematicity for our scientific practice, but also offers an attractive explanation for the diversity of the sciences and their relative but irreducible autonomy.

Annotated titles:

Buchdahl, G. (1969) *Metaphysics and the Philosophy of Science. The classical origins – Descartes to Kant*, Oxford: Basil Blackwell. is a classic introduction to philosophy of science in the early modern period, offering on a detailed interpretation of Kant.

Falkenburg, B. (2020) *Kant's Cosmology. From the Pre-Critical System to the Antinomy of Pure Reason*. Berlin: Springer. provides a comprehensive account of Kant's metaphysics of nature, as it develops from the 1750's to the Critical turn in 1781.

Friedman, M. (2013) *Kant's Construction of Nature: A Reading of the Metaphysical Foundations of Natural Science*, Cambridge: Cambridge University Press. offers a detailed interpretation of Kant's *Metaphysical Foundations of Nature Science*.

M. Massimi & A. Breitenbach (Eds.) (2017) *Kant and the laws of nature*. Cambridge: Cambridge University Press. assembles a set of articles on Kant's account of laws of nature in different scientific disciplines.

Van den Berg, H. (2014). *Kant on Proper Science*. Springer, Dordrecht. provides an illuminating account of Kant's conception of proper science.

Watkins, E. (Ed.). (2001). *Kant and the Sciences*. Oxford: Oxford University Press. assembles a set of articles on Kant's accounts of various scientific disciplines.

Watkins, Eric (2019) *Kant on Laws.* Cambridge: Cambridge University Press. offers a comprehensive study of the notion of law as it is employed in Kant's theoretical and practical philosophy, concerning both science and morality.