Systematicity, the Life Sciences, and the Possibility of Laws Concerning Life.

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Introduction

According to Kant, different natural sciences should be related to each other in such a way that they constitute a systematic unity. However, the life sciences have often been taken to threaten Kant's ideal of the systematic unity of different natural sciences. Whereas in physics we can provide mechanical explanations of natural phenomena, organisms resist mechanical explanation. Moreover, organisms require a special kind of teleological judgment, which is not employed in the exact sciences. For reasons such as these, authors such as Zammito (2003) and Guyer (2000) argue that Kant's views on organisms and the life sciences, as articulated in the third *Critique*, are difficult to square with his ideal of the systematic unity of natural science.

In this article, I will argue that there is a sense in which sciences such as physics, chemistry, and the life sciences constitute a unity. On the basis of an analysis of Wolff's and Kant's views on the hierarchy of the sciences, I argue that one sense in which different sciences constitute a unity is when more fundamental sciences provide statements which are used in less fundamental sciences to prove statements. For example, metaphysics is a more fundamental science than physics, i.e., physics presupposes results from metaphysics, and statements from metaphysics are used to prove statements in physics. In the same way, I argue, the life sciences, according to Kant, borrow statements from physics and chemistry in order to prove statements in the life sciences. I will express this state of affairs by saying that physics and chemistry *ground* the life sciences. Insofar as physics and chemistry ground the life sciences, these different sciences constitute a unity. Hence, Kant allowed for the ideal of a systematic unity among physics, chemistry, and the life sciences, and in the case of some features of organisms, took physics and chemistry to explain phenomena in the life sciences. However, the unity of physics, chemistry, and the life sciences is limited since Kant takes the purposeful unity of organisms to be mechanically inexplicable. I further argue that although there is in some sense a unity between physics, chemistry, and the life sciences, the life sciences do not contain laws that are specific to these sciences. The reason that the life sciences of Kant's time do not, according to Kant, have laws is that biological regularities described in Kant's time (i) concern the purposeful unity of organisms which according to Kant is mechanically inexplicable, and (ii) these regularities could not be systematically related to the a priori foundations of natural science. Thus, whereas Kant allows for the idea that some features of organisms could be explained in terms of the laws of physics and regularities of chemistry, the scientific practice of his time did not allow him to fully articulate the ideal of a systematic unity of physics, chemistry, and the life sciences.

I proceed as follows. In the first section, I describe communalities between Wolff's and Kant's views on the hierarchy of the sciences. I show that Wolff and Kant both adopt the idea that some sciences borrow statements from preceding sciences in order to provide proofs. In the second section, I show that according to Kant we must reflect on organisms in mechanistic terms, which implies that we must provide mechanical explanations of organisms for so far this is possible. This entails, as I will show on the basis of two case studies, that statements from physics and chemistry are used in the life sciences in order to provide proofs. In this sense, physics, chemistry and the life sciences constitute a systematic unity. In the third and final section, I consider, in discussion with Breitenbach (2017), the question whether Kant allowed for the possibility of laws in the life sciences. I argue that although such laws may be in principle possible for Kant, he could not take the life sciences of his day to possess laws. The reason is that the regularities discussed in the life sciences of Kant's time concerned the mechanically inexplicable purposeful unity of organisms and could not be systematically related to the a priori principles of natural science.

Wolff and Kant on the Hierarchy of the Sciences

According to Kant, not only individual sciences should constitute systematic wholes. The relations among different sciences should also be constituted in such a way that these different sciences constitute a systematic unity. This is what Thomas Sturm calls "external systematicity": "Ideally, an 'architectonical mind' works towards reaching a complete system of special sciences, whereby we understand how metaphysics, mathematics, physics, chemistry, biology, medicine, geography, anthropology, history, law, and so on are different yet stand in well-ordered relations to one another" (Sturm 2020, 7). In the present section, I will not provide an exhaustive analysis of Kant's conception of external systematicity (see for one of the most extensive accounts Sturm 2009). Rather, I will focus on one specific aspect of this view: the idea that more fundamental sciences provide concepts and propositions that are used by less fundamental sciences. This aspect of Kant's thought comes into sharp focus if we compare Kant's views on the hierarchy of the sciences with Christian Wolff's views on the hierarchy of the sciences.

An influential conception of the hierarchy of sciences was articulated by Christian Wolff, who dominated the philosophical landscape in the early eighteenth century. According to Wolff, sciences constitute a hierarchy, with more fundamental sciences providing concepts or propositions that are used in less fundamental sciences. As Wolff explains, for example, in the *Preliminary Discourse* (1728), the science of ontology provides concepts and propositions that are used in demonstrations in sciences such as physics. As Wolff puts the point:

> Such general notions are the notions of essence, existence, attributes, modes, necessity, contingency, place, time, perfection, order, simplicity, composition, etc. These things are not explained properly in either psychology or physics because both of these sciences, as well as the other parts of philosophy, use these general notions and the principles derived from them. Hence, it is quite necessary that a special part of philosophy be designated to explain these notions and general principles, which are continually used in every science and art, and even in life itself, if it is to be rightly organized. Indeed, without ontology, philosophy cannot be developed according to the demonstrative method. (Wolff 1963 [1728], 40)

In line with this view on the hierarchy of sciences, Wolff argues that metaphysics must provide the foundations of physics if we are to give proper demonstrations in physics. The reason for this is that metaphysics provides grounds or reasons that explain phenomena discussed in physics. Hence, principles from metaphysics must lie at the basis of demonstrations in physics:

> If everything is to be demonstrated accurately in physics, then principles must be borrowed from metaphysics. Physics explains those things which are possible through bodies (#59). If these things are to be treated demonstratively, then the notions of body, matter, nature, motion, the elements, and other such general notions must be known. For such notions contain the reason of many things. Now these notions are explained in general cosmology and ontology (##73, 78). Therefore, if all things are to be demonstrated accurately in

physics, principles must be borrowed from general cosmology and ontology. (Wolff 1963 [1728], 48)

We can illustrate Wolff's views by looking at his *German Physics*. In the first chapter of his German physics, Wolff explicates the essence and nature of bodies, which is a metaphysical topic. In the subsequent chapters, Wolff applies metaphysical propositions to results from experimental physics to provide demonstrations in physics. For example, Wolff proves in this way that bodies cannot be completely dense (*vollkommen dichte*), i.e, there are no bodies without any empty spaces (Wolff 2003 [1723], 67). Wolff starts by noting that observation and experiment teaches us that gold is the most dense body we know. However, gold has empty spaces between its parts. If the question is whether a completely dense body is possible, Wolff first cites the proposition of physics that a body is completely dense if it is continuously made up of matter, and the parts of the body are only different from each other qua location. From this it follows that all the parts of matter are similar to each other. Wolff then cites a proposition from metaphysics, according to which it is impossible that the smallest parts of a body are similar to each other. From this he concludes, within physics, that a matter cannot be completely dense (Wolff 2003 [1723], 70). This reductio shows how Wolff uses propositions from metaphysics and physics to demonstrate propositions in physics.

Although Kant's views on the hierarchy of sciences differ from those of Wolff (I will return to this point below), he shares the idea that sciences constitute a hierarchy and that concepts and propositions of more fundamental sciences can be used in less fundamental sciences. Evidence for such a reading of Kant comes, for example, from the *Critique of Judgment* and the *Jäsche Logic*. In the former, Kant argues that more fundamental sciences provide so-called auxiliary propositions (*lemmata*) that are used in less fundamental sciences:

> The principles of a science are either internal to it, and are then called indigenous (*principia domestica*), or they are based on principles that can find their place only outside of it, and are *foreign* principles (*peregrina*). Sciences that contain the latter base their doctrines on auxiliary propositions (*lemmata*), i.e., they borrow some concept, and along with it a basis for order, from another science (V:381. See for discussion of this quote in the context of Kant's views on teleology, van den Berg 2013).

How should we precisely understand this quote? A "principle" is a technical term that denotes an a priori judgment from which other judgments are derived and which is itself not derived from other judgments. In the *Jäsche Logik*, Kant defines principles as follows:

> Immediately certain judgments a priori can be called principles, insofar as other judgments are proved from them, but they themselves cannot be subordinated to any other. On this account they are also called *principles* (beginnings). (IX:110)

Such principles can thus be either internal to a science or in a science we use principles that are foreign to this science. Foreign principles are called *lemmata*. In the *Jäsche Logik*, Kant defines lemmata as follows: "Propositions that are not indigenous to the science in which they are presupposed as proved, but rather are borrowed from other sciences, are called *lemmas* (*lemmata*)" (IX:113). This conception of lemmata was standard in Kant's time. In his *Neues Organon* (1764), for example, Lambert defines lemmata as statements which are not proven at the place in which they are used, but are borrowed from a preceding science (*vorgehende Wissenschaft*) (Lambert 1764, 99). Hence, according to Lambert and Kant lemmata are (i) presupposed as proved in a science and (ii) borrowed from another science. This characterization perfectly fits Wolff's views on the hierarchy of sciences. As we have seen with respect to the relationship between metaphysics and physics: Wolff (a) presupposed statements from metaphysics as proved in physics and (b) borrowed these statements to prove other statements in physics.

We can, following van den Berg (2013, 731), also give an example from Newton's *Principia* to illustrate Kant's views on the role of statements in a science that are borrowed from another science. In Book III of the *Principia*, Newton borrows several mathematical or kinematical statements, demonstrated in the first books of the *Principia*, to prove statements within natural philosophy. For example, Newton starts Book III with listing phenomena, among which phenomenon 1, which states that the satellites of Jupiter "by radii drawn to the center of Jupiter, describe areas proportional to the times, and their periodic times - the fixed stars being at rest - are as the 3/2 powers of their distances from the center" (Newton 1999 [1726], 797). This is, as Newton explains, an *a posteriori* statement based on astronomical observation. Hence, from Kant's point of view, this is a statement that is *internal* to natural philosophy. In proposition 2 of Book I, Newton had demonstrated the mathematical or kinematical hypothetical proposition that "every body that moves in some curved line described in a plane and, by a radius drawn to a point, either unmoving or moving uniformly forward with a rectilinear motion, describes areas around that point proportional to the times, is urged by a centripetal force tending toward that same point" (Newton 1999 [1726], 446). This is a mathematical or kinematical *a priori* statement, and is thus from Kant's point of view *external* to natural philosophy. Newton applies this a priori statement to phenomenon 1 to derive proposition 1 of Book III, which states, among others, that the forces by which the satellites of Jupiter are drawn away from rectilinear motions are directed to the center of Jupiter (Newton 1999 [1726], 802) (note that I have only treated part of proposition 1 of Book III and only part of its proof. My account nevertheless accurately describes Newton's procedure). Hence, Newton applies mathematical or kinematical a priori statements, principles *external* to natural philosophy, to a posteriori statements or phenomena, statements *internal* to natural philosophy, in order to derive statements of natural philosophy. This Newtonian example shows that Kant's views on lemmata capture an important aspect of scientific practice.

Up to this point we have pointed out similarities between Wolff's and Kant's views on the hierarchy of the sciences. It is important to note that there are also important differences. One of the most important differences is that for Kant, as Watkins argues (2019, chapter 4), the principles of natural science are not derived from a more fundamental science but are established by *transcendental arguments* that show how experience of objects of outer sense is possible (see also Sturm (2022)). Hence, Kant and Wolff have different views on how to establish the principles of (natural) science: the transcendental perspective of Kant is, not surprising, completely absent in Wolff. Notwithstanding this difference, and other differences which I will not elaborate here, Wolff's, Lambert's and Kant's views on statements borrowed from preceding sciences are substantially the same.

Kant and Mechanical Explanations in the Life Sciences

As van den Berg (2014, chapter 3) has argued, Kant construes mechanistic explanations of nature as ideal explanations that provide proper cognition of nature. Thus, for example, when commenting on the mechanistic maxim in the third *Critique*, a maxim we must follow in science, Kant states that it "indicates that I *should* always reflect on them *in accordance with the principle* of the mere mechanism of nature, and hence research the latter, so far as I can, because if it is not made the basis for research then there can be no proper cognition of nature" (V:387). Moreover, as Breitenbach (2017, 246) has stressed, Kant always emphasizes that we must reflect on organized beings in terms of mechanisms. According to Kant, we must reflect on organisms mechanistically if they are to count as natural beings, which entails, since we also conceptualize organisms teleologically as natural purposes, that we judge mechanisms as means for certain ends:

> [T]he mere teleological ground of such a being is equally inadequate for considering and judging it as a product of nature unless the mechanism of the latter is associated with the former, as if it were the tool of an intentionally acting cause to whose ends nature is subordinated, even in its mechanical laws. (V:422. Also quoted in Breitenbach 2017, 246)

However, the idea that we must reflect on organisms mechanistically and that mechanical explanations are proper explanations of nature is threatened by Kant's infamous claim that organisms are mechanically inexplicable. There cannot be, as Kant famously put it, a Newton who makes comprehensible even the generation of a blade of grass (V:400). How can we reconcile the view that we must reflect on organisms mechanistically while also doing justice to Kant's idea that organisms are mechanically inexplicable?

Some commentators have taken Kant's claim that organisms are mechanically inexplicable, coupled with his regulative conception of teleology, to imply that Kant could not view life sciences as genuine sciences. Thus, Zammito (2006, 755) states that "The third *Critique* essentially proposed the reduction of life science to a kind of pre-scientific descriptivism, doomed *never* to attain authentic scientificity, never to have its 'Newton of the blade of grass'." Similarly, Richards argues that "the *Kritik der Urteilskraft* delivered up a profound indictment of any biological discipline attempting to become a science" (Richards 2000, 26). Moreover, several authors have argued that the life sciences threaten Kant's ideal of the systematic unity of different (natural) sciences. Guyer (2001, 260), for example argues that organisms threaten Kant's ideal of the unity of science insofar as "we have good reason to suppose that we can never succeed in bringing all of nature under a single principle attributing a single fundamental power to a single kind of substance." Similarly, Zammito argues that the life sciences are irreconcilable with Newtonian science, and thus threaten Kant's ideal of the unity of science: "*any* science involving 'internal purposiveness' becomes irreconcilable with 'Newtonian science'. Indeed, this is the point toward which my whole exposition has been aiming, for it brings into glaring salience the problem of reconciling biology *at all* with Kant's prescriptions for science. Organisms rupture the 'top down'/'bottom up' integration of Kant's scientific system" (Zammito 2003, 102). In contrast to authors such as Richards and Zammito, Breitenbach (2017) argues that Kant allows for naturalistic explanations in the life sciences and allows for the possibility of biological laws, thus opening up the possibility that biology can become a science. Finally, van den Berg (2014) argues that although Richards and Zammito are correct that the life sciences do not constitute proper sciences for Kant, mechanical explanations of many features of organism are possible, since Kant's claim that organisms are mechanically inexplicable must be read as denying the possibility of mechanical explanations of specifically (i) the purposive complex unity of organisms and (ii) the fact that traits of organisms are adaptative, but not of any feature of organisms *tout court* (see for an instructive account of biological method in Kant also Geiger 2022). In the following, I argue, drawing on van den Berg and Breitenbach, that Kant indeed allows for the mechanical explanation of many features of organisms, and that this implies that physics, chemistry and the life sciences constitute a systematic unity insofar as judgments from physics and chemistry are used in the life science to provide explanations, in line with Kant's views on the hierarchy of the sciences described in the previous section. However, as we shall see, the unity of physics, chemistry, and the life sciences is limited in scope, insofar as Kant argues that the purposive unity of organisms is mechanically inexplicable.

We have already seen that Kant takes mechanisms to be proper explanations of nature and that we must reflect on organisms in mechanistic terms if they are to be regarded as products of nature. Indeed, Kant prescribes to the life sciences the method of subordinating mechanism to teleology, investigating mechanisms in organisms but viewing these mechanisms as means towards certain ends. This already strongly suggests that Kant thinks that at least some features of organisms can be explained mechanically. Why would Kant insist that we investigate mechanisms in the life sciences if nothing can be mechanically explained? That mechanistic investigation plays a role in the life sciences is also strongly suggested by the scientific context in which Kant operated, in which organisms were in fact investigated mechanically. In the following, I analyze this scientific context.

Let us start by giving a physiological example: the investigation of the human eye. The human eye provides a prototypical example of a complex and purposeful organized organ. According to Kant, we cannot mechanically explain the purposeful unity of the human eye, i.e., we cannot mechanically explain how the different parts of the human eye (the cornea, iris, lens, etc.) came to be purposefully organized in the order and structure which they have, where every part is adapted to the other parts. However, this does not mean that mechanical explanations play no role in explaining the functioning of the human eye. In fact, mechanical explanations of the functioning of the human eye were accepted in Kant's time, which becomes clear if we consider Karsten's *Anleitung zur gemeinnützlichen Kenntniß der Natur, besonders für angehende Aerzte, Cameralisten und Oeconomen* (1983), a textbook on physics that Kant used for his lectures. Karten's treatment of the human eye is guided by the conviction that the eye functions like lens glasses and that therefore the laws of optics can be used to explain the process of vision. He first provides an anatomical description of the eye, describing the different layers of skin of the eye, the lens, the retina, and so forth (1983, 133-136). Then he argues that the light, which falls on the eye is refracted just as in the case of a glass lens. Through this process of refraction, which Karsten explains in great detail, we can explain that an image is formed on the retina, which accompanies the sensation of seeing (1983, 137).

Karsten's explanation of the functioning of the human eye is a prototypical example of a mechanical explanation: we explain the functioning of the eye in terms of the functioning of its parts (see for this account of mechanical explanation McLaughlin 1990; van den Berg 2014). In addition, and important for our present purposes, Karsten makes clear that we can use the laws of optics, a part of natural philosophy, to explain the functioning of the human eye. Hence, we can say that statements from optics are borrowed and applied to the physiological investigation of the human eye. In other words, optics grounds physiology, and the two sciences constitute a unity in this specific sense.

Let us secondly look at contemporary scientific accounts of growth via nutrition (here I draw on van den Berg 2014, 133-137). Kant describes the growth via nutrition of a tree as follows:

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

This quote makes a lot of sense when compared with the contemporary late eighteenth-century *chemical* investigation of the nutrition of plants. As described in Gehler's *Physikalisches Wörterbuch* (1798-1801), the scientist Senebier published his *Recherches sur l'influence de la lumière solaire pour métamorphoser l'air fixe en air pur par la vegetation* in 1783. In this work, as Gehler describes, Senebier argued that the growth of plants occurs in part by the decomposition of carbon dioxide gas into carbon. The carbon is retained in the plant and is used for the generation of parts of plants. Through this chemical process, oxygen is made, which is exuded as oxygen gas (Gehler 1798-1801, vol V, 683-684).

Senebier's theory explains Kant's claim that plants develop by means of material that qua compositions is its product. Senebier recognized that materials providing nutrients for plants are drawn from inorganic nature. These materials are given from without, and are thus, in Kant's term, an educt. However, plants decompose inorganic compounds and thus generate (new) parts of plants. The chemical composition of these products is newly created. Similarly, Kant claimed that the composition of materials in plants is newly produced. In this sense, the plant is a product and not an educt. For our present purposes, it is important to note that Senebier borrowed statements from chemistry in order to prove statements concerning the nutrition of plants. Hence, chemistry grounds the scientific study of plants, and in this sense these sciences constitute a systematic unity.

To conclude this section, note that Kant's view that physics and chemistry ground the life sciences is limited in scope. The reason is that not all properties of organisms allow of mechanical explanation. As we have already seen in our discussion of the human eye, Kant argues that the purposeful unity of organisms defies mechanical explanation. Hence, physics and chemistry cannot explain the purposeful unity of organisms or organs. However, if we presuppose this purposeful unity as a given, we can mechanically investigate the causal processes that play a role in a purposefully organized organism or organ. Thus, for example, we can take the organization of the human eye as given, and consequently investigate how the different parts of the eye mechanically function in securing the possibility of vision. In the next section, we will see that Kant's claim that we cannot properly explain the purposeful unity of organisms implies that he denied that the life sciences of his time possess genuine laws.

Kant and Laws Concerning Life.

On the basis of two case studies we have seen that the life sciences borrow statements from optics, a branch of natural philosophy, and chemistry. Kant, I propose, recognized that sciences such as physics and chemistry ground the life sciences. The practice of providing mechanical explanations whenever possible can be understood as the practice of using statements from physics and chemistry to provide proofs in the life sciences.

Does this mean the life sciences constitute proper sciences or that there are laws regarding life according to Kant? Breitenbach (2017) argues that according to Kant the life sciences can become genuine sciences and that Kant allows for the possibility of what she calls biological laws. Breitenbach, stressing that Kant leaves room for naturalistic or (in my terms) mechanistic explanations of organisms, describes these biological laws as follows:

> Such laws would have to fulfill two desiderata. First, in order to be a genuine law of nature, they would have to be thoroughly naturalistic; that is, they would have to make use exclusively of concepts that determinately apply to natural phenomena. They would have to employ causal, nonteleological concepts. Second, in order to qualify as specifically biological laws they would have to employ some specifically biological concepts. Such concepts would have to be suitable naturalistic, too. (Breitenbach 2017, 247-248)

Breitenbach notes that Kant did not have knowledge of such biological laws, but that his philosophy allows for the possibility of such laws. I agree with the conclusion that Kant leaves room for the possibility of such laws. However, I think it is interesting to adopt a more historical perspective and to inquire why Kant did not think that the life sciences of his time could have genuine laws, a topic Breitenbach does not discuss. This will be my focus in what follows. I argue that Kant did not think that the life sciences of his time have genuine laws because (i) these sciences were often concerned with explaining the purposeful organization of organisms, a feature of organisms that is mechanically inexplicable according to Kant, and (ii) because the regularities that contemporary life scientists proposed only had inductive support and could not be systematically related to the a priori principles of natural science. In order to make this argument, we will first have to discuss Kant's conception of empirical laws.

There are different competing accounts of Kant's views on empirical laws, which have been aptly summarized by Kreines (2009), Messina (2017), Breitenbach (2018) - who follows Messina - and McNulty (2015). In the following, I will follow Messina's and Breitenbach's systematization of different accounts of Kant's views on empirical laws.

According to the Best System interpretation, developed by Kitcher among others, the "particular laws of nature are those empirical generalizations that would figure in the best systematization of the empirical data at the ideal end of inquiry" (Breitenbach 2018, 111). Being part of a system of laws also confers necessity to a law, according to this account (ibid.). According to a competing interpretation, called the Derivation Account and developed by Michael Friedman, generalizations are empirical laws if they can be derived from the a priori laws of nature (ibid.). It is important to add that, according to the Derivation Account, empirical laws of nature are of course not derived *solely* from a priori principles. Additional empirical principles are required to. Thus, for example, according to Friedman's (1992) analysis of Kant's views on the Newtonian deduction of the law of gravitation (which is an *empirical* law), the law of gravitation is deduced on the basis of mathematical principles (a priori principles), metaphysical principles (a priori principles), and empirical generalizations captured by Newton's phenomena (see for Newton's procedure of applying mathematical a priori principles to empirical phenomena section I of this paper). Finally, according to the Necessitation

Account, “the necessity of particular laws is grounded in the essential natures of things” (Breitenbach 2018, 112).

These different interpretations all have some level of textual support. In the following, I argue for the validity of the Derivation Account . Let us first consider the textual evidence for the Derivation Account. In the *Metaphysical Foundations*, Kant claims that proper natural science treats its object according to a priori principles (IV:468). A rational doctrine of nature is a proper science if it is based on a priori natural laws, which secures the apodictic certainty of our cognition, i.e., the a priori laws secure that we are in the possession of knowledge in the strict sense (*Wissen*) (ibid.). Moreover, Kant argues that laws involve necessity: laws involve the necessity of determinations of an object, and this requires that natural science is based on an a priori part (IV:468-469. See for a thorough account of the necessity involved in laws Watkins 2019, chapter 1). More specifically, laws are principles of the necessity of that which pertains to the existence of an object, and this requires, according to Kant, that laws are based on metaphysical principles (IV:468-470). All these remarks suggest that natural laws must be grounded by a priori principles, and thus support the Derivation Account.

In the first *Critique*, Kant also provides arguments that explicitly support the Derivation Account. As McNulty stresses (2013, 3), Kant argues in the first *Critique* that the necessity of laws requires a priori grounds. As such, Kant’s argument in the first *Critique* is similar to his argument in the *Metaphysical Foundations*. Kant says:

> Even laws of nature, if they are considered as principles of the empirical use of the understanding, at the same time carry with them an expression of necessity, thus at least the presumption of determination by grounds that are a priori and valid prior to all experience. But without exception all laws of nature stand under higher principles of the understanding, as they only apply the latter to particular cases of appearance. Thus these

> higher principles alone provide the concept, which contains the condition and as it were the exponents for a rule in general, while experience provides the case which stands under the rule. (A159)

Thus, the necessity of laws requires that they are subsumed under a priori grounds, or principles of the understanding. According to the Derivation Account, it is the fact that laws of nature are derived from a priori principles, which are necessary statements, which secures the necessity of the laws of nature. This interpretation makes sense of Kant's claim that the necessity of laws requires them to have a priori grounds. The Best System interpretation, by contrast, has difficulty explaining why laws of nature can be necessary (Breitenbach 2018, 112; McNulty 2015, 3). As McNulty explains: "it is unclear how the mechanisms of the systematizers - the approximation of final science, increasing inferential density of a doctrine - could necessitate the judgments of a science. Verification by lower, entailed judgments could only inductively justify a judgment, and its entailment by higher principles would only necessitate the judgment in the case that these higher principles, themselves, carry necessity" (McNulty 2015, 3). Insofar as the Derivation Account is better able to explain the necessity of laws, it is to be preferred to the best system interpretation. Finally, proponents of the Necessitation Account such as Watkins (2005; 2019; 2021, who was one of the first to articulate this account) and Kreines (2009) claim that the Necessitation Account provides us with a *metaphysical* account of what laws are and how they are ontologically grounded by natures, whereas, for example, Friedman's Derivation Account provides us with an *epistemological* account of how we can have knowledge of laws. As two different perspectives on laws, the Necessitation Account and the Derivation Account, are fully compatible (see for a clear explanation of the Necessitation account also Stang 2016). However, some adherents of the Necessitation Account, such as Kreines (2009), claim that we often cannot achieve knowledge of particular laws. As

Breitenbach remarks on this point (2018, 113) "given Kant's extensive discussion of empirical laws in the context of his account of cognition, it would be somewhat surprising if our principled ignorance of particular laws were his last word on the matter." I fully agree: Kant's discussion of a priori laws of natural science in the *Metaphysical Foundations*, coupled with his views, described by Friedman (1992), of how the a priori laws ground empirical laws such as the law of gravitation, strongly suggest that we have cognitive access to laws (not just the a priori laws discussed in the *Metaphysical Foundations*).

My exposition so far seems to leave the Derivation Account as a correct epistemological account of Kant's views on how we can have knowledge of empirical laws. However, authors such as McNulty (2015) and Breitenbach (2017) object to the Derivation Account because very few laws can be derived from a priori principles together with appropriate empirical principles. Hence, the implication of the Derivation Account is that according to Kant there are very few laws. In sciences such as physics there seem to be laws, such as the law of gravitation, but in sciences such as chemistry and the life sciences, the sciences treated by McNulty and Breitenbach, there seem to be no laws. I do not think this objection against the Derivation account is decisive, because I think Kant had good reasons not to attribute empirical laws in the strict sense to sciences such as chemistry and the life sciences. In my opinion, denying the status of laws to chemistry and the life sciences in Kant's time is simply a reflection of the scientific practice of these sciences in the late eighteenth century. In what follows, I will thus provide a historical argument for why chemical laws and biological laws are not properly laws according to Kant, explaining Kant's views on chemical and biological laws on the basis of the scientific context of his time.

Let us first focus on the laws of chemistry, which have been discussed by McNulty. McNulty claims that Kant regularly refers to chemical laws, and notes that this is a problem for the Derivation Account (2015, 2). Indeed, Kant refers to chemical laws in the *Metaphysical*

Foundations. A close look at these passages suggests, however, that Kant does not regard these laws as laws in a proper sense. Thus, after arguing that proper natural science must be based on a pure a priori part, Kant states:

> Hence, the most complete explanation of given appearances from chemical principles still always leaves behind a certain dissatisfaction, because one can adduce no *a priori* grounds for such principles, which, as contingent laws, have been learned merely from experience (IV:469).

Hence, Kant explicitly states that chemical principles are, because they are based solely on experience, merely contingent. We have already seen that natural laws in the proper sense are necessary according to Kant. Hence, we can read the above passage as denying that chemistry has laws in the proper sense. Kant himself makes this inference fully explicit, when he argues:

> If, however, the grounds or principles themselves are still in the end merely empirical, as in chemistry, for example, and the laws from which the given facts are explained through reason are mere laws of experience, then they carry with them no consciousness of their *necessity* (they are not apodictically certain), and thus the whole of cognition does not deserve the name of a science in the strict sense; chemistry should therefore be called a systematic art rather than a science. (IV:468)

That chemistry does not have proper laws make sense if we consider the scientific practice of chemistry in Kant's time. In the *Metaphysical Foundations* (1786), Kant developed a dynamic theory of matter in which he explained fundamental properties of matter (such as the filling of a space or relative impenetrability) in terms of the interactions between the fundamental forces of matter (attraction and repulsion). However, Kant makes it clear that he cannot explain the specific variety of matter, including chemical phenomena, in terms of these fundamental forces. Thus, Kant claims: “But one should guard against going beyond that which makes possible the general concept of matter as such, and wishing to explain *a priori* its particular, or even specific, determination and variety” (IV:524). Hence, Kant strictly distinguishes between the a priori investigation of the *Metaphysical Foundations* and the specific empirical investigation into the specific variety of matter (which includes chemistry). As Michael Friedman (1992) has argued, there is according to Kant a gap between the a priori investigation of the *Metaphysical Foundations* and the empirical research into the specific variety of matter, belonging to what we may call experimental physics. We cannot explain specific phenomena such as cohesion and chemical phenomena in terms of the actions of attraction and repulsion. As Friedman explains this gap:

> Whereas the *Metaphysical Foundations* deals with the universal forces of matter in general (the original forces of attraction and repulsion), it says nothing at all about any additional, more specific forces of matter-which, therefore, as far as the *Metaphysical Foundations* is concerned, are left solely to empirical physics. As far as the Metaphysical Foundations is concerned, any additional, more specific forces are thus left entirely without an a priori foundation. (Friedman 1992, 238)

This gap, which Kant remarks on in the *Metaphysical Foundations* and which Kant tried to remedy at the end of his life in his *Opus postumum*, was recognized in the scientific literature of Kant’s time. This becomes clear if we focus on the phenomenon of cohesion. As van den Berg (2014, 182) notes: when writing on attraction, Gehler, in his *Physikalisches Wörterbuch*, states that although we conceive of cohesion as a form of attraction, we only have proper knowledge of Newton's law of universal attraction or gravitation. Laws concerning other types of attraction, such as attraction in contact (cohesion), have not been established with certainty. We only know that cohesion operates according to different laws than Newtonian attraction. According to Gehler, then, we do not have knowledge of the cause of cohesion and we are unable to properly explain it (Gehler 1787-1796, I, 171-172). Accordingly, we do not have knowledge of proper laws governing cohesion. Kant identified similar problems as Gehler with respect to cohesion, and can thus also be attributed the view that we do not have knowledge of proper laws governing cohesion. The situation is the same, I submit, with respect to chemistry: since there is a gap between the *Metaphysical Foundations* and chemistry we cannot (yet) properly explain chemical phenomena in accordance with the principles of physics, and accordingly we do not have knowledge of proper chemical laws.

Let us now turn our attention to the life sciences. The question we are confronted with is whether we have knowledge of laws concerning organic phenomena. In my view, Kant denies we have knowledge of laws in the life sciences in the late eighteenth-century. The reason is that the life sciences in Kant's time were fundamentally concerned with the purposive unity and functioning of organisms, phenomena which are mechanically inexplicable according to Kant. This becomes clear if we consider Blumenbach's famous *Über den Bildungstrieb und das Zeugungsgeschäfte* (1781), a famous work in which Blumenbach argued for epigenesis. In this work, Blumenbach postulated the teleological vital force of the *Bildungstrieb* to account for the generation of organisms, the maintenance of organisms and regeneration of organic parts, and the nutrition and growth of organisms (1781, 12). Importantly, the features of organisms that Blumenbach wished to explain with the *Bildungstrieb* all concerned the purposive organization and maintenance of organisms. For example, the process of embryogenesis, guided by the *Bildungstrieb*, concerned the coming to be of organic and purposive structures. According to Kant, the coming to be of organic structures is mechanically inexplicable, and hence we do not have knowledge of laws concerning this phenomenon. In his account of nutrition, Blumenbach mentions that nutrition serves the self-maintenance of organisms. Organic bodies are continually subject to decay, and would, Blumenbach writes citing Bernoulli, be completely destroyed after three years if the process of nutrition did not serve to balance the organic body (Blumenbach 1781, 70-71). Nutrition serves to balance the decay of parts and thus enables the continued maintenance of the organic body. To account for this self-maintenance, Blumenbach postulated the *Bildungstrieb*. Hence, what Blumenbach stresses in his account of nutrition is not the chemical processes involved in the taking up of nutrition, as for example discussed by Senebier, but the purposive harmony and self-organization of organic bodies. To account for this harmony and self-organization Blumenbach invoked the teleological posit of the *Bildungstrieb*. According to Kant, such purposive harmony and self-organization is mechanically inexplicable, and hence we cannot properly explain such phenomena nor do we have knowledge of laws governing such phenomena. Finally, the process of regeneration again concerned the purposive self-maintenance of organisms, and is again a phenomenon that according to Kant is mechanically inexplicable. To conclude: the study of Blumenbach's seminal work shows that the life sciences in Kant's time were fundamentally concerned with the purposive features of organisms, features which are mechanically inexplicable according to Kant and for which we cannot articulate genuine laws.

Finally, we may inquire into the relation between the a priori principles of natural science and the regularities discussed in the life sciences. It follows from the fact that there is a gap between the *Metaphysical Foundations* and chemistry, as discussed above, that there is also a gap between the *Metaphysical Foundations* and the life sciences. The reason for this is that the life sciences, as we have seen, often borrow statements from chemistry in order to explain organic phenomena. For this reason, the regularities of the life sciences will not be systematically related to the a priori principles of natural science and accordingly there are no proper laws in the life sciences. This is the case even for these phenomena, such as nutrition, where chemical statements allow us to provide partial explanations in the life sciences.

We arrive at the same conclusion if we look at some of the regularities discussed in the life sciences of Kant's time. In the second edition of *Über den Bildungstrieb* (1789), at the end of the book, Blumenbach listed some of what he calls laws (*Gesetze*) concerning the *Bildungstrieb*. These include laws such as (i) the strength of the *Bildungstrieb* is inversely proportional to the age of the organism, and (ii) when the *Bildungstrieb* takes a counternatural course, there arise *Misgeburten* (1989, 93-107). For these laws, Blumenbach listed only empirical and inductive evidence. There is no attempt to relate these regularities to regularities in chemistry or physics, or, in Kant's terms, to achieve a systematic unity of physics, chemistry, and the life sciences. Accordingly, these laws also lack a priori grounding and are not laws in the proper sense. This is not a reason to fault *Blumenbach*. Blumenbach simply did not have at his disposal regularities from physics or chemistry with which the mainly embryological phenomena with which he was concerned could be explained. Hence, although we have seen examples from physiology (the human eye) and nutrition where physics and chemistry could aid with giving explanations, the situation is completely different for embryology, where there is a disunity of the sciences. With respect to several disciplines in the life sciences, Zammito and Guyer are thus correct that organisms pose a threat to the systematic unity of science. For this reason, we again cannot speak of the existence of proper laws in the life sciences of Kant's time.

Conclusion

On the basis of an analysis of Wolff's and Kant's views on the hierarchy of sciences, we have shown that some sciences, such as metaphysics, provide statements that are used to provide proofs in other sciences, such as physics. I have argued that, according to Kant, this situation also exists between physics, chemistry and the life sciences: statements from physics and chemistry are used to provide explanations in the life sciences. In this sense, physics, chemistry, and the life sciences constitute a systematic unity. Hence, Kant recognized the ideal of a systematic unity between physics, chemistry and the life sciences, and for some features of organisms, the ideal could be worked out. However, I have also argued that the scientific practice in the life sciences of Kant prevented him from fully working out the systematic unity between physics, chemistry and the life sciences. Many important features of organisms, in particular the purposive structure and self-maintenance of organisms, which were studied for example in the embryological works of Blumenbach, resisted mechanical explanation, and accordingly statements from physics and chemistry could not be used to provide explanations of these features. Moreover, there existed a gap between the *Metaphysical Foundations*, articulating the a priori principles of natural science, and chemistry and the life sciences. Accordingly, the regularities studied in the life sciences could not be systematically related to the a priori principles of natural science, and the life sciences of Kant's time did not contain proper natural laws. Hence, Kant's philosophy of the life sciences reflected the scientific practice of his day. He articulated an ideal of the systematic unity of different natural sciences, but could not fully work out this ideal due to the fact that several phenomena in the life sciences were treated in isolation from physics and chemistry. It was the task taken up by Kant's successors, such as Schelling, to fully articulate and give content to the ideal of a true system of the natural sciences.

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