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978-0-521-36394-5 - Immanuel Kant: Natural Science
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IMMANUEL KANT

Natural Science

The purpose of the Cambridge Edition is to offer translations of the best modern German editions of Kant's work in a uniform format suitable for Kant scholars. When complete the edition will include all of Kant's published works and a generous selection of his unpublished writings, such as the *Opus postumum*, *Handschriftlicher Nachlaß*, lectures, and correspondence.

Though Kant is best known for his strictly philosophical works in the 1780s, many of his early publications in particular were devoted to what we would call 'natural science'. Kant's *Universal Natural History and Theory of the Heavens* (1755) made a significant advance in cosmology, and he was also instrumental in establishing the newly emerging discipline of physical geography, lecturing on it for almost his entire career. In this volume Eric Watkins brings together new English translations of Kant's first publication, *Thoughts on the True Estimation of Living Forces* (1746–9), the entirety of *Physical Geography* (1802) and a series of shorter essays, along with many of Kant's most important publications in natural science. The volume is rich in material for the student and the scholar, with extensive linguistic and explanatory notes, editorial introductions, and a glossary of key terms.

Eric Watkins is Professor of Philosophy at the University of California, San Diego. He is author of *Kant and the Metaphysics of Causality* (Cambridge, 2005) and editor of *Kant and the Sciences* (2001), and he translated and edited *Kant's Critique of Pure Reason: Background Source Materials* (Cambridge, 2009).

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THE CAMBRIDGE EDITION OF THE
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Natural Science

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Contents

	<i>General editors' preface</i>	page vii
	<i>Editor's preface</i>	x
	<i>General introduction</i> by Eric Watkins	xiii
1		
1	<i>Thoughts on the true estimation of living forces and assessment of the demonstrations that Leibniz and other scholars of mechanics have made use of in this controversial subject, together with some prefatory considerations pertaining to the force of bodies in general</i> (1746–1749)	I
	Translated by Jeffrey B. Edwards and Martin Schönfeld	
2		
2	<i>Examination of the question whether the rotation of the Earth on its axis by which it brings about the alternation of day and night has undergone any change since its origin and how one can be certain of this, which [question] was set by the Royal Academy of Sciences in Berlin as the prize question for the current year</i> (1754)	156
	Translated by Olaf Reinhardt	
3		
3	<i>The question, whether the Earth is ageing, considered from a physical point of view</i> (1754)	165
	Translated by Olaf Reinhardt	
4		
4	<i>Universal natural history and theory of the heavens or essay on the constitution and the mechanical origin of the whole universe according to Newtonian principles</i> (1755)	182
	Translated by Olaf Reinhardt	
5		
5	<i>Succinct exposition of some meditations on fire</i> (1755)	309
	Translated by Lewis White Beck	
6		
6	<i>On the causes of earthquakes on the occasion of the calamity that befell the western countries of Europe towards the end of last year</i> (1756)	327
	Translated by Olaf Reinhardt	
7		
7	<i>History and natural description of the most noteworthy occurrences of the earthquake that struck a large part of the Earth at the end of the year 1755</i> (1756)	337
	Translated by Olaf Reinhardt	

Contents

8	<i>Continued observations on the earthquakes that have been experienced for some time</i> (1756) Translated by Olaf Reinhardt	365
9	<i>New notes to explain the theory of the winds, in which, at the same time, he invites attendance at his lectures</i> (1756) Translated by Olaf Reinhardt	374
10	<i>Plan and announcement of a series of lectures on physical geography with an appendix containing a brief consideration of the question: Whether the West winds in our regions are moist because they travel over a great sea</i> (1757) Translated by Olaf Reinhardt	386
11	<i>New doctrine of motion and rest and the conclusions associated with it in the fundamental principles of natural science while at the same time his lectures for this half-year are announced</i> (1758) Translated by Olaf Reinhardt	396
12	<i>Review of Silberschlag's work: Theory of the fireball that appeared on 23 July 1762</i> (1764) Translated by Eric Watkins	409
13	<i>Notice of Lambert's correspondence</i> (1782) Translated by Eric Watkins	414
14	<i>On the volcanoes on the Moon</i> (1785) Translated by Olaf Reinhardt	418
15	<i>Something concerning the influence of the Moon on the weather</i> (1794) Translated by Olaf Reinhardt	426
16	<i>Physical geography</i> (1802) Translated by Olaf Reinhardt	434
	<i>Appendices</i>	680
	<i>Notes</i>	683
	<i>Glossary German–English</i>	751
	<i>Glossary English–German</i>	762
	<i>Index of names</i>	772
	<i>Index of places</i>	777
	<i>Index of subjects</i>	786

General editors' preface

Within a few years of the publication of his *Critique of Pure Reason* in 1781, Immanuel Kant (1724–1804) was recognized by his contemporaries as one of the seminal philosophers of modern times – indeed as one of the great philosophers of all time. This renown soon spread beyond German-speaking lands, and translations of Kant's work into English were published even before 1800. Since then, interpretations of Kant's views have come and gone and loyalty to his positions has waxed and waned, but his importance has not diminished. Generations of scholars have devoted their efforts to producing reliable translations of Kant into English as well as into other languages.

There are four main reasons for the present edition of Kant's writings:

1. *Completeness.* Although most of the works published in Kant's lifetime have been translated before, the most important ones more than once, only fragments of Kant's many important unpublished works have ever been translated. These include the *Opus postumum*, Kant's unfinished magnum opus on the transition from philosophy to physics; transcriptions of his classroom lectures; his correspondence; and his marginalia and other notes. One aim of this edition is to make a comprehensive sampling of these materials available in English for the first time.
2. *Availability.* Many English translations of Kant's works, especially those that have not individually played a large role in the subsequent development of philosophy, have long been inaccessible or out of print. Many of them, however, are crucial for the understanding of Kant's philosophical development, and the absence of some from English-language bibliographies may be responsible for erroneous or blinkered traditional interpretations of his doctrines by English-speaking philosophers.
3. *Organization.* Another aim of the present edition is to make all Kant's published work, both major and minor, available in comprehensive volumes organized both chronologically and topically, so as to facilitate the serious study of his philosophy by English-speaking readers.
4. *Consistency of translation.* Although many of Kant's major works have been translated by the most distinguished scholars of their day, some of these translations are now dated, and there is considerable terminological disparity among them. Our aim has been to enlist some

General editors' preface

of the most accomplished Kant scholars and translators to produce new translations, freeing readers from both the philosophical and literary preconceptions of previous generations and allowing them to approach texts, as far as possible, with the same directness as present-day readers of the German or Latin originals.

In pursuit of these goals, our editors and translators attempt to follow several fundamental principles:

1. As far as seems advisable, the edition employs a single general glossary, especially for Kant's technical terms. Although we have not attempted to restrict the prerogative of editors and translators in choice of terminology, we have maximized consistency by putting a single editor or editorial team in charge of each of the main groupings of Kant's writings, such as his work in practical philosophy, philosophy of religion, or natural science, so that there will be a high degree of terminological consistency, at least in dealing with the same subject matter.
2. Our translators try to avoid sacrificing literalness to readability. We hope to produce translations that approximate the originals in the sense that they leave as much of the interpretive work as possible to the reader.
3. The paragraph, and even more the sentence, is often Kant's unit of argument, and one can easily transform what Kant intends as a continuous argument into a mere series of assertions by breaking up a sentence so as to make it more readable. Therefore, we try to preserve Kant's own divisions of sentences and paragraphs wherever possible.
4. Earlier editions often attempted to improve Kant's texts on the basis of controversial conceptions about their proper interpretation. In our translations, emendation or improvement of the original edition is kept to the minimum necessary to correct obvious typographical errors.
5. Our editors and translators try to minimize interpretation in other ways as well, for example by rigorously segregating Kant's own footnotes, the editors' pure linguistic notes, and their more explanatory or informational notes; notes in this last category are treated as endnotes rather than footnotes.

We have not attempted to standardize completely the format of individual volumes. Each, however, includes information about the context in which Kant wrote the translated works, a German–English glossary, an English–German glossary, an index, and other aids to comprehension. The general introduction to each volume includes an explanation of specific principles of translation and, where necessary, principles of selection of works included in that volume. The pagination of the standard edition

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978-0-521-36394-5 - Immanuel Kant: Natural Science
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Frontmatter
[More information](#)

General editors' preface

of Kant's works, *Kant's gesammelte Schriften*, edited by the Royal Prussian (later German) Academy of Sciences (Berlin: Georg Reimer, later Walter de Gruyter & Co., 1900–), is indicated throughout by means of marginal numbers.

Our aim is to produce a comprehensive edition of Kant's writings, embodying and displaying the high standards attained by Kant scholarship in the English-speaking world during the second half of the twentieth century, and serving as both an instrument and a stimulus for the further development of Kant studies by English-speaking readers in the century to come. Because of our emphasis on literalness of translation and on information rather than interpretation in editorial practices, we hope our edition will continue to be usable despite the inevitable evolution and occasional revolutions in Kant scholarship.

PAUL GUYER
ALLEN W. WOOD

Editor's preface

The present volume in the Cambridge Edition of the Works of Immanuel Kant in Translation contains sixteen works that Kant published in natural science, broadly construed, over a fifty-six-year period that span his entire career, from his first publication in 1746 to one of the last works published under his name while he was still alive in 1802. All of the works, except one, Kant's Latin dissertation on fire, were translated especially for this volume. They vary considerably in their character and length, ranging from the brief notice on Lambert's correspondence, which was essentially a short advertisement for one of Lambert's volumes that had just been published, to the two-volume *Physical Geography*, which contains a comprehensive and at times extremely detailed description of many of the physical features of the Earth, and its animals, as these were understood in East Prussia in the second half of the eighteenth century.

Two works in particular, beyond the *Physical Geography*, deserve special mention here. Kant's *Thoughts on the True Estimation of Living Forces*, his first publication, and his *Universal Natural History and Theory of the Heavens*, published in 1755, are both major books that tackle central issues of the day and are meant to be important contributions to natural science. The former attempts to develop a novel solution to the *vis viva* controversy, which raged in Europe for several decades and engaged many of the leading thinkers, while the latter attempts to articulate a broadly Newtonian cosmogony in original ways. While neither work was especially influential during Kant's own lifetime (for different reasons), both are significant works that form central components of Kant's early thought. For this reason alone they both deserve more attention than they have received so far; for if one is to have any hope of understanding Kant's later philosophical project and contributions, one must come to terms with the intellectual interests and projects that he pursued in his earliest years, if only to understand the points on which he changes his mind and to appreciate his reasons for doing so.

In addition to English translations of Kant's own works, and in line with the guidelines of the Cambridge Edition of the Works of Immanuel Kant, this volume contains editorial material designed to aid the reader with basic information about the linguistic, historical, and philosophical features of Kant's publications. We have not attempted to provide an exhaustive critical apparatus.

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 Frontmatter
[More information](#)

Editor's preface

The *general introduction* addresses in outline form the scope and nature of those of Kant's publications in natural science that are included in this volume. It does so by giving a brief characterization of Kant's conception first of science in general and then of natural science, emphasizing how he articulated a conception that is in certain respects somewhat narrower than what we call natural science today, but without thereby either discrediting or demoting those systematic cognitions of the world that he referred to as a doctrine of nature (such as natural description and natural history).

The *introductions* to each of the works by Kant in the present volume detail the circumstances of their publication and briefly introduce the subject matter and overall argument of each work. If an introduction does not specify that it was written by the general editor, then it has been a joint effort of the editor and particular translator.

The *linguistic footnotes* are lettered alphabetically to distinguish them from Kant's own footnotes, which are marked by asterisks. The linguistic footnotes typically either specify the German original of key words and phrases or provide English translations of the Latin phrases that Kant uses in his texts.

The *numbered editorial endnotes* provide factual information and explanation, especially on the historical figures and authors referred to in the main body of the text.

The *German–English* and *English–German glossaries* help the reader to track the most important words that occur in the original texts as well as the words that the translators have used to render them in English.

Finally, there is an *index* of names, places, and subjects.

All the translations and a significant amount of the editorial material found in the present volume are based on the Academy edition of Kant's Collected Works: *Kants gesammelte Schriften*, edited by the Prussian Academy of Sciences (vols. 1–29), primarily volumes 1, 2, and 9. Throughout this volume, this work is referred to as the Academy edition. References to the Academy edition make use of the volume number, followed by a colon, and then the page number (e.g., 2:13 would refer to Volume 2, page 13, of the Academy edition). The pagination of the Academy edition is indicated in the margins of the translations contained in this volume.

Over the course of the years during which this volume took shape, countless people and institutions contributed in essential ways; without their help, this volume would have been much the worse and, quite possibly, never come into existence. In light of this, I hope to thank the most important individuals and institutions for their contributions. On the institutional side, I thank the University of California, San Diego, the Max Planck Institute for the History of Science, and the John F. Templeton Foundation for generous financial support of the

Cambridge University Press
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Edited by Eric Watkins
Frontmatter
[More information](#)

Editor's preface

project (in the guise of research assistance and money for both research assistance and the preparation of the final manuscript). Given the length of time it has taken to complete the project, I fear that I can no longer recall the help of all those individuals who have in fact contributed to the volume in important ways. First and foremost, however, I am extremely grateful to the translators of the works contained in the volume for their invaluable skill and expertise in tackling an incredibly daunting task. H. B. Nisbet, the first general editor of the volume, also did significant and much-appreciated work on the volume before I took over. I thank Paul Guyer and Allen Wood, the editors of the entire series, and Hilary Gaskin, philosophy editor at Cambridge University Press, for their encouragement and sage advice. I am also thankful for the research help I received from Wolfgang Lefevre, Peter McLaughlin, Steve Naragon, Werner Stark, Marius Stan, James Messina, Destanie McCalister, Tim Jankowiak, and Peter Yong. Special acknowledgement must also be given to David Oldroyd, whose extensive knowledge of the history of science was indispensable on many occasions. He provided the bulk of the endnotes for the translation of the *Physical Geography* and several other items.

ERIC WATKINS

General introduction

This volume will come as something of a surprise to someone accustomed to thinking of Kant as a prime example of an armchair philosopher. For although it is true that he never travelled far beyond Königsberg and is famous for having emphasized (synthetic) *a priori* cognition, that is, (substantive) cognition of the world that can be obtained independently of any particular sensory experiences, Kant wrote extensively throughout his career on a broad range of topics that we today would consider part of natural science. It is not uncommon to recognize that Kant produced important publications that bear on natural science in some way, publications that find a home in other volumes in the Cambridge Edition of the Works of Immanuel Kant. For example, Kant's relatively brief *Physical Monadology* (1756) appears as part of *Theoretical Philosophy, 1755–1770*. The more substantial *Metaphysical Foundations of Natural Science* (1786), which attempts to show how the abstract principles argued for in the *Critique of Pure Reason* can be realized in more specific principles by having an empirical concept of matter applied to them, can be found in *Theoretical Philosophy after 1781*. And the remarks Kant composed late in his career (in the 1790s and beyond) on the transition from the principles established in the *Metaphysical Foundations of Natural Science* to empirical natural science are available in the *Opus postumum*. However, even an awareness of these important works still falls short of an acknowledgment of the breadth and depth of Kant's interests in natural science. For one, Kant writes on an even wider range of specific topics in the domain of natural science, such as the causes of earthquakes, the nature of fire, the rotation and ageing of the Earth, theories concerning moisture in winds, and the appearance and nature of comets and other meteorological phenomena. For another, he is not content to provide brief interventions on narrowly defined scientific questions, but also undertakes foundational and comprehensive projects in natural science, such as determining the conservation of force in nature, formulating the proper laws of motion, developing a full-scale Newtonian cosmogony, and offering an expansive physical geography. The comprehensiveness and depth of Kant's publications on these disparate topics make it necessary to dedicate a separate volume to his works in natural science and also to reconsider our assessment of the character of Kant's intellectual contributions so as to include not only philosophy, regardless of how broadly construed, but also natural science.

General introduction

To evaluate Kant's contributions to natural science properly, however, it is useful to be aware of his conception of science in general and of natural science in particular, especially since he does not distinguish, in the way we usually do today, between philosophy and natural science. The single most distinctive criterion of demarcation for science, according to Kant, is *systematicity* (A832/B860). That is, for a set of cognitions to qualify as scientific they must form a system or be systematically connected, as opposed to forming a mere aggregate. For cognitions to be systematically connected, they must be related as grounds and consequents (such that the one can be derived from the other) according to some single unifying idea or principle. The idea, or principle, helps to determine the (logical or rational) ordering of propositions such that a *plurality* of cognitions forms a *single* system, unified by rational relations.

In fact, Kant goes further by suggesting that reason should search not simply for systematic connections between cognitions within a science, but also for this kind of connection between the sciences, in the hope of creating a single science that would encompass all human cognition. Kant proposes that metaphysics (or transcendental philosophy) should play an important role here insofar as it is itself a science, consisting of a metaphysics of nature and of morals, with the former consisting, in turn, of physics (the science of corporeal nature, or of objects of outer sense) and psychology (the science of thinking nature, or of objects of inner sense), with additional divisions into other more specific sciences beyond that. In this way, Kant ends up being an advocate of the unity of science, even though he also argues explicitly and at length in the *Critique of Pure Reason* that this ideal is necessarily unattainable for us because of our cognitive limitations.

In some passages (e.g., at 4:468) Kant also states that cognition must be known with *apodictic certainty* to qualify as science. Yet care must be taken not to attribute to Kant an overly restrictive account of science such that only logic, mathematics, and perhaps a pure part of physics would qualify as science. For what Kant means by "apodictic certainty" is not the existence of a Cartesian standard of indubitability (or absolute epistemic incorrigibility), but that the cognition is universal (valid for all) and objective (one's assent being based on the presence and quality of appropriate intuitions or evidence rather than on, say, pragmatic grounds). In other instances, Kant explains apodictic certainty in terms of an awareness of a certain kind of necessity (4:468). For if cognitions are related systematically – that is as ground and consequent – then it is clear that an element of necessity is present insofar as a consequent follows necessarily from its ground and an awareness of the necessary element is required in drawing an inference from the one to the other.

Further, like some of his immediate predecessors (such as Christian Wolff), Kant distinguishes both between rational and empirical sciences

General introduction

and between the rational (and ‘pure’) versus the empirical (‘impure’) parts of a science. An example of the former distinction would be the distinction between logic and anthropology (which is, for Kant, closely related to empirical psychology). An example of the latter can be found in the Preface to the *Metaphysical Foundations of Natural Science* (4:469), where he distinguishes between the pure and the empirical part of natural science – he seems to have had physics in mind – before claiming that the empirical part depends on the pure part and thus on a metaphysics of nature. Obviously, despite its dependence on *a priori* principles, the empirical part would involve principles that are not known with the same kind and degree of epistemic certainty as the purely rational principles they depend on; but they would still nonetheless count as part of science (A846/B874). So, despite some of the very strict-sounding assertions that Kant makes about science, if understood properly, they can accommodate a much broader range of sciences than one might at first have thought possible.

Also relevant to Kant’s conception of science is the way in which he demarcates one science from another. Early on in the *Prolegomena*, he suggests that two sciences can be distinguished due to a difference “of the *object*, or the *source of the cognition*, or even of the *type of cognition*, or several if not all of these things together” (4:265). Accordingly, the difference between, for example, arithmetic and geometry can be characterized in terms of a difference in the object of each science (numbers versus shapes); the difference between, say, mathematics and physics could be accounted for by different sources of cognition (*a priori* versus empirical intuition); while logic and mathematics can be distinguished by the different types of cognition that are involved in each (analytic versus synthetic). Again, even with the core requirements of systematicity and apodictic certainty, Kant’s description of the various ways of distinguishing one science from another makes it possible for him to account for a surprisingly wide range of different sciences.

In light of this sketch of Kant’s conception of what science is and of how one science can be distinguished from another, we can now turn to his understanding of *natural* science in particular. In one sense, Kant’s conception of natural science is straightforward. Natural science is simply the science of nature: that is, the set of systematically connected, apodictically certain cognitions that has nature as its object. But what is nature? In both the *Critique of Pure Reason* and the *Metaphysical Foundations of Natural Science*, Kant distinguishes between material and formal senses of nature. Nature, understood materially, refers to “the sum total of appearances insofar as these are in thoroughgoing connection through an inner principle of causality” (A418/B446). That is, it refers to nature as a whole (as a set of existing objects). Nature, understood formally, by contrast, refers to “the connection of determinations

General introduction

of a thing in accordance with an inner principle of causality” (A419/B446) – that is, to the specific nature that this or that particular thing might have, such as water, air, chemical elements, different kinds of animals, etc. Nature in this second sense is clearly similar to an Aristotelian conception of a nature as that which has a principle of causality within itself and allows for qualitative distinctions. Kant clearly has the formal sense of nature in mind in his discussions of the different natural sciences. As Kant makes clear in the opening sentence of the *Metaphysical Foundations of Natural Science*: “If the word nature is taken simply in its formal meaning, where it means the first inner principle of all that belongs to the existence of a thing, then there can be as many different natural sciences as there are specifically different things, each of which must contain its own peculiar inner principle of determinations belonging to its existence” (4:467).¹

As a result, Kant is able to accommodate a wide range of cognitions under the umbrella of natural science. For example, arithmetic is the science of numbers; geometry is the science of shapes; anthropology is the science of one particular kind of animal, namely, man; logic is the science of the formal laws of rational thought in man; theology is the science of God (or of the highest ground of all nature); ontology is the science of the properties of all things in general, etc. Cosmology is the science of the world as such – that is, anything that is a whole of mutually interacting material substances (28:195–6, 28:657, 28:849). Physics is the science of bodies, more specifically, of matter whose inner principle is to be “the movable in space” (4:480) and where the nature of the body is unchanged through its interactions.² Interestingly, chemistry is also the science of bodies or matter, but, unlike physics, it concerns changes that occur in the inner constitution of the bodies (e.g., in the specific natures of the different bodies) due to their interaction with other bodies. And within physics, there are hard bodies, soft bodies, elastic bodies, inelastic bodies, etc. The distinctions between the different kinds of natures that are under investigation in the different natural sciences (and sub-branches thereof) can thus be subtle and complex.³

It is against the context of this conception of natural science that we must interpret further remarks that Kant makes in the Preface to the *Metaphysical Foundations of Natural Science* about what does and, more significantly, what does not count as science proper. Specifically, Kant asserts: “in any special doctrine of nature there can be only as much *proper* science as there is *mathematics* therein” (4:470). After clarifying how mathematical principles require metaphysical principles (in line with his view that metaphysics is required for natural science), he then infers that both chemistry and psychology cannot be sciences, given the requirement that science must contain mathematics (4:471).⁴ Indeed, judged by

General introduction

such a strict criterion, it is clear that very little would count as a science and Kant acknowledges at one point that only the pure part of physics would qualify.

How should such remarks be understood? It is difficult to take them at face value or literally. After the developments of Lavoisier, Kant comes to recognize chemistry as a science.⁵ He also does not repeat, or explain further, the meaning of these very restrictive claims in any consistent way, either earlier or later in his corpus. Finally, he repeatedly refers to several other disciplines, such as logic and philosophy (which both clearly do not contain mathematics in any straightforward sense), as sciences. One can pursue a number of interpretive options here. One could: (1) draw attention to the distinction implicitly in play here between science and science ‘proper’ (however that distinction is ultimately to be understood); (2) note that these remarks, made in 1786, post-date a significant amount of Kant’s work in natural science, where he seems to refer indiscriminately to both natural science and research or enquiry into nature (“*Naturforschung*”); or (3) one could simply downplay his claim here not as fully representative of his view but just a temporary aberration (perhaps an exaggeration that slipped out in the heat of the moment while trying to emphasize the importance of physics for the principles established in the *Critique of Pure Reason*). As a result, whatever interpretive option one adopts, it is clear that Kant’s considered view is not as narrow as these statements might make it seem.

There is, however, an important distinction that Kant does explicitly and consistently draw concerning our cognition of nature. Near the beginning of the Preface to the *Metaphysical Foundations of Natural Science*, Kant distinguishes between the historical doctrine of nature and natural science, with the doctrine of nature (“*Naturlehre*”) serving as the genus for these two species of cognition. That is, any cognition of nature that does not satisfy the requirements for natural science (whether proper or otherwise) is still a cognition; and if it contains systematically ordered facts about natural things then it deserves the name of a historical doctrine of nature. In fact, Kant further divides such a historical doctrine of nature into natural description and natural history. Natural description is a system of classification for natural things in accordance with their similarities. One might, for example, think of Linnaeus’s elaborate taxonomies of the animal, vegetable, and mineral kingdoms as paradigmatic cases of natural description, since frogs, bears, beetles, and trees are all classified according to their shared traits (even if Linnaeus’s criteria for classification were artificial and did not yield ‘natural kinds’). Natural history, by contrast, is a systematic presentation of natural things at various times and places. Physical geography is a clear example of natural history, since it describes the Earth’s most important features at different times and places.

General introduction

Taking this important distinction between the different kinds of doctrine of nature into account puts us in a position to recognize two points, one relatively superficial and the other more fundamental. First, even if Kant's conception of natural science is not as narrow as is sometimes thought, it is restrictive enough to exclude much of what we today think of as natural science. As a result, many of the writings contained in this volume do not, technically, count as natural science for Kant. Second, and more importantly, Kant nonetheless recognizes the importance of these other kinds of cognition of nature. For not only does he provide a theoretical structure and nomenclature for them, he also attempts to make extensive contributions to the doctrine of nature. Some of these contributions are relatively minor, such as his writings in this volume on earthquakes, winds, fire, and comets. However, others are incredibly (perhaps even overly) ambitious – in particular two of the major publications contained in this volume. The *Universal Natural History and Theory of the Heavens* and the *Physical Geography* (and especially the former) are really substantial contributions to natural history.

Moreover, if we step back even further from the details of the exact status of Kant's writings in the present volume, we can also see that Kant's dedication through the course of his career to what we call natural science provides a somewhat different picture of the character and significance of his intellectual contributions from what appears in philosophers' accounts or analyses of his work. Without in any way calling into question the profundity of the strictly philosophical reflection that must have been required for his 'purely' philosophical achievements in the three great *Critiques* – whether it be the adoption of a transcendental standpoint, the argument of the Transcendental Deduction of the Pure Concepts of the Understanding, or even the development of transcendental idealism – we can simply add that this reflection was preceded and accompanied by considerable devotion, whether measured in terms of time, effort, or activity, to understanding the actual world we live in, both in its details and in its basic structure. Whatever Kant's own statements about philosophical method might be, his serious engagement with a broad range of natural sciences, or rather doctrines of nature, proved to be a particularly important element in the overall body of his work and in his philosophical accomplishments.