

G.W.F. Hegel's *Philosophy of Nature*, which forms the second part of his *Encyclopedia of the Philosophical Sciences* (1817, 1827, 1830), has long been the object of ridicule and disdain. Karl Popper famously mocked Hegel's account of sound and heat in *The Open Society and its Enemies* (first published in 1945); and one hundred years earlier (in 1844) the biologist, Matthias J. Schleiden, dismissed the entirety of the *Philosophy of Nature* as a "string of pearls of the crudest empirical ignorance" consisting of little more than "miserable criticism and excerpts put together without judgment."¹ As a result of such uncompromising condemnation, all that the name "Hegel" has signified to many during the last century and a half is an arrogant and ignorant German philosopher who denied evolution and who (in 1801) "proved" *a priori* that there could only be seven planets just as the asteroids were being discovered between the orbits of Mars and Jupiter. Jacob Bronowski, speaking to a television audience of millions in the 1970s in his series, *The Ascent of Man*, mentioned nothing at all about Hegel *except* the latter's "proof" that there can be no eighth planet, and felt moved to confess that he "specifically detest[s]" Hegel, in part no doubt because of the latter's infamous "proof."² It seems that for many the only redeeming feature of Hegel's philosophy of nature is that (unlike Schelling's) it failed to exercise any significant influence whatsoever over practicing natural scientists.³

Herbert Schnädelbach has pointed out that ever since the early to mid-nineteenth century Hegel's *Philosophy of Nature* has been regarded by scientists as precisely the kind of work from which serious students of nature should seek to distance themselves. After 1830, he notes, scientific consciousness in Germany was distinguished by regular attacks on Romantic and Idealist nature-philosophy as a whole. But Hegel's nature-philosophy in particular was generally regarded as a horrible example of the aberrations of philo-

sophical speculation, and was taken as a motive for affirming that it was now finally time to leave philosophy in general well alone and to pursue the advance of science.

For nineteenth-century scientists (and for historians), the rejection of Hegel thus had "paradigmatic significance."⁴ It is clear, then, that one of the reasons why Hegel's *Philosophy of Nature* has met with so much ridicule is that modern science has so often defined itself explicitly against Hegel.

The problem is that the rejection of Hegel's *Philosophy of Nature* as the product of a scientifically ignorant mind by so many scientists and philosophers has itself all-too often been based on a profound *ignorance* of Hegel's philosophy and its relation to nature and science. Too few have been willing to approach Hegel with the sympathy and understanding they (quite properly) accord to Kant, and too many have been prepared, without reading anything of Hegel's work, simply to follow the injunction of Popper and his nineteenth-century forebears not to take Hegel "too seriously."⁵ It is, however, now being recognized by a small but growing number of Hegel scholars and philosophers of science that Hegel was neither ignorant of, nor indifferent to, natural science, as is often claimed, but was in fact deeply knowledgeable about the science of his day.⁶ We have learned that Hegel drew intelligently on the work of, amongst others, Lagrange and Cauchy in mathematics, Cuvier and Hutton in geology, and Berthollet and Pohl in chemistry.⁷ Indeed, Michael Petry has shown that even the few definite scientific mistakes Hegel made invariably have a highly respectable source in the scientific literature of the time (according to Petry, Hegel's claim that "*ammonia* ... has a metallic base in *ammonium*," for instance, is almost certainly based on a paper by Sir Humphry Davy).⁸ Parts of Hegel's *Philosophy of Nature* may indeed be outdated or just plain wrong, and his philosophical language may well continue to create problems for those who are not trained in his philosophy. However, what is becoming more and more apparent, through the work of scholars like Petry, is that those who simply dismiss Hegel as ignorant about science or

as a charlatan are blinding themselves to one of the richest and most sophisticated philosophical accounts of the natural world ever produced. For, in fact, as Petry points out, “the ‘Philosophy of Nature’, far from being an arbitrary and irresponsible exposition of partially understood subject matter, is a sensitively structuralized, deeply informed and infinitely rewarding assessment of the whole range of early nineteenth-century science.”⁹

Hegel’s *Philosophy of Nature* is clearly not intended to be a work of straightforward natural science itself, but to be a work of *philosophy* in the manner of Aristotle’s *Physics* or Kant’s *Metaphysical Foundations of Natural Science*. It does not simply offer the results of empirical research and observation (or of mathematical analysis), but seeks to provide an account of the ultimate *conceptual* structure of nature. Hegel thus does not just provide a philosophy of science in the manner of a Popper, Kuhn or Lakatos (Gerd Buchdahl notes that “to the modern Anglo-Saxon scholar, there appears to be a curious lack of concern with epistemological issues [in Hegel]”).¹⁰ He offers a metaphysical account of the very structure of nature itself, of what nature itself ultimately *is*.

Nevertheless, Hegel makes it clear, not only that the insights of philosophy must coincide with those of natural science, but also that the philosophy of nature must actually draw on the discoveries of natural science in presenting its philosophical conceptions of space, time, matter, and so on. In this sense, for Hegel, “philosophic science presupposes and is conditioned by empirical physics” (and the other sciences).¹¹

It should be noted, however, that there is by no means universal agreement amongst Hegel scholars on the precise nature of the relation between philosophy and natural science in Hegel’s *Philosophy of Nature*. Some argue that the structure or skeleton of the *Philosophy of Nature* is developed purely conceptually, but that the flesh, as it were, is derived from empirical observation and scientific experimentation and analysis. On this view, Hegel is led to the very idea of nature by the *Science of Logic*, develops the

conceptual structure of nature *a priori* from the initial determination of nature as abstract externality, and then “maps” natural phenomena as described by science on to the various conceptual determinations that arise. Discoveries in science are thus understood and evaluated in the light of a conceptual account of nature which is developed *a priori*. Others argue, however, that scientific discoveries themselves condition, and perhaps even determine, the development of Hegel’s conceptual account of nature. On this view, the procedure of Hegel’s philosophy is not to map natural phenomena on to an *a priori* conceptual structure, but to provide a flexible conceptual framework which organizes in an intelligible way, and is wholly *relative* to, the scientific knowledge of a given time, and which changes with future scientific discoveries. Passages can be cited from Hegel’s *Philosophy of Nature* in favor of each of these interpretations, but, as yet, it has not been definitively determined which, if either, is more correct.¹² One of the major tasks facing those who concern themselves with Hegel’s *Philosophy of Nature* continues, indeed, to be to work to resolve this central issue.

The essays in this collection, written by internationally recognized Hegel scholars from the USA, Britain, Italy, Germany, and Belgium, deal with a wide array of topics: Hegel’s alleged idealism, his account of space and time, his conception of geometry, his critique of Kant’s *Metaphysical Foundations of Natural Science* and indebtedness to Kant’s *Critique of Judgment*, his critique of Newtonian science, his concept of evolution, his notion of *Aufhebung*, and his theory regarding the orbits of the planets around the sun. Some essays concentrate on Hegel’s writings on the philosophy of nature from the early Jena period (1801) rather than on the text of the *Encyclopedia Philosophy of Nature* itself. Each of these essays, however, makes a distinctive contribution towards furthering our understanding of the relation between philosophical concepts and natural science in Hegel’s philosophy of nature as a whole. The essays do so by falling broadly into two groups. On the one hand, several of the essays focus specifically on the

conceptual structure of nature as Hegel understands it and seek to clarify its relation to the structure of pure thought set out in the *Science of Logic*. On the other hand, several of the essays examine in detail Hegel's relation to the sciences, in particular Newtonian physics, modern geometry, and neo-Darwinian biology. No single interpretation of Hegel's philosophy of nature emerges from the essays; nor, indeed, do all the contributors agree on whether the structure of the philosophy of nature is determined *a priori* by self-determining reason or *a posteriori* by the findings of the sciences of Hegel's day. What does emerge clearly from this collection, however, is that the philosophy of nature cannot be understood in isolation from Hegel's speculative logic and that anyone seeking to establish the precise role played by the sciences in the philosophy of nature can only do so by simultaneously establishing the precise role played by speculative logic. Similarly, it becomes clear that, whether the insights of Hegel's philosophy of nature are to be understood as founded on, or as merely coincident with, the findings of natural science, Hegel was scientifically literate and made penetrating and insightful criticisms of specific sciences, in particular of Newtonian physics and Enlightenment biology. Indeed, two contributors suggest that Hegel's philosophy of nature also contains important criticisms of modern neo-Darwinism. The essays in this collection thus all confirm that, far from being irrelevant to, or having been simply surpassed by, nineteenth- and twentieth-century scientific developments, Hegel's philosophy of nature has always had, and continues to have, great significance for the natural sciences and our understanding of the natural world.

In 1970 M.J. Petry produced his ground-breaking English edition of Hegel's *Philosophy of Nature* and demonstrated just how subtle and well-informed that work is. Since then there have appeared at least four major collections of essays designed to promote the serious study of Hegel's nature-philosophy: *Hegel and the Sciences*, edited by R.S. Cohen and M.W. Wartofsky (Dordrecht: Reidel, 1984); *Hegels Philosophie der Natur: Beziehungen zwischen empirischer und*

spekulativer Naturerkenntnis, edited by R.-P. Horstmann and M.J. Petry (Stuttgart: Klett-Cotta, 1986); *Hegel und die Naturwissenschaften*, edited by M.J. Petry (Stuttgart: Frommann-Holzboog, 1987); and *Hegel and Newtonianism*, edited by M.J. Petry (Dordrecht: Kluwer, 1993). The essays collected together in the present volume reflect the wide variety of work that continues to be done by scholars from North America and Europe in the 1990s to deepen our understanding of the historical importance and enduring scientific relevance of Hegel's philosophy of nature.

In the opening essay of the collection, "The Very Idea of the Idea of Nature, or Why Hegel Is not an Idealist," William Maker offers a vigorous defense of Hegel's *Encyclopedia Philosophy of Nature* against the familiar charge that it is metaphysically idealistic. Maker argues that, contrary to popular belief, Hegel does not deny the existence of an independently given nature or conceive of nature as a mere product of thought, but proceeds rather from the conviction that thought and nature are radically *non-identical*. Furthermore, Maker contends that Hegel is led to this conviction by the philosophical requirement of systematicity. Hegel's *Logic* sets out the process of thought's systematic and autonomous self-determination; and, according to Maker, if such self-determining thought is to become fully determinate, it must *limit* itself. But it can only limit itself, we are told, by conceiving of itself as bounded by what is radically other than itself—that is, by the realm of sheer givenness, externality and non-self-determination that constitutes *nature*. Systematic philosophy must conceive of nature as other than thought, therefore, in order to conceive of thought itself as a distinctive and complete domain of logical self-determination. Maker goes on to show that, precisely because it recognizes nature to be genuinely other than systematic thought, Hegel's *Philosophy of Nature* has to acknowledge that specific contingent features of nature lie beyond the reach of *a priori* philosophy and can only be discovered by empirical observation. Far from seeking to supplant empirical science, therefore, Hegel's systematic

philosophy of nature *necessarily* accords an indispensable and independent role to such science.

In his essay, "The Logic of Hegel's *Philosophy of Nature*," Edward Halper offers an alternative account of the relation between the *Science of Logic* and the *Philosophy of Nature*. In his view, the transition from pure logic to nature is effected not by conceiving of logical thought as limited by its other, but rather by conceiving of the logical "Idea" *itself* as immediate and external to itself. The realm of nature, for Halper, is thus simply the absolute Idea together with a further logical determination, namely, immediate being. In the latter part of his essay, Halper then argues that the transitions in the *Philosophy of Nature* result from the complex interplay between the absolute Idea and its further determination (unlike the transitions in the *Logic* which are the result of the simple self-determination of the individual logical categories). By showing in this way that nature is constituted by a new and distinctive "totality" of logical determinations that is not found in the *Logic* itself, Halper aims to demonstrate that nature is systematically derived from logical determinations by Hegel, but is not reducible to the determinations of logic as such. Despite clear differences between his approach to the *Philosophy of Nature* and that of William Maker, it is thus evident that he, too, like Maker, is endeavoring to explain how nature can be both different from, and intelligible to, thought.

In "Space, Time and Matter: Conceiving Nature Without Foundations," Richard Dien Winfield also considers the relation between Hegel's speculative logic and philosophy of nature. If Hegel's philosophy of nature is not simply to take for granted what it must prove, Winfield argues, it must articulate the structure of nature without appealing to anything assumed to be given in reality. This means that the idea of natural determinacy from which the philosophy of nature begins must emerge from an account of logical determinacy in general which is itself presuppositionless and self-determining. However, the philosophy of nature must at the same time provide categories of nature that go beyond purely logical categories. Like Halper, therefore, Winfield

maintains that Hegel can make use of nothing but self-determining logical categories in his derivation of the minimal determination of nature, and yet must employ those logical categories in such a way that they comprise a new determination that remains clearly distinct from each one of them. Furthermore, Winfield maintains, the philosophy of nature must itself proceed by passing from its starting point—the self-externality of logical determinacy, or space—to further structures of nature which incorporate nothing other than what has already been determined, but which at the same time comprise something irreducible to their antecedents. Space must thus be determined independently of time; time must require nothing but space for its determination; place and motion must require nothing but space and time for their determination; and the sheer formality of space, time, place and formal motion must alone serve to account for matter.

In Lawrence Stepelevich's essay, "Hegel's Geometric Theory," attention is turned from the method employed in the *Philosophy of Nature* to the relation between Hegel's philosophy and modern geometry. According to Stepelevich, the opening of Hegel's *Philosophy of Nature* presents a "geometry of reason" which not only recognizes the modern distinction between "pure" and "physical" geometry, but presents speculative grounds for their mediation. From a Hegelian perspective, Stepelevich maintains, the difference between the "logical" or "pure" point of Hilbert's geometry and the "physical" point of Max Born's empirical geometry is that the latter is the dialectically or speculatively articulated conclusion of the former. Moreover, in so far as Hegel's "geometry of reason" is not tied to a spatial metric expressed exclusively as *either* a "pure" or "physical" geometry, it can provide speculative support for both non-Euclidean and Euclidean geometry. Stepelevich further emphasizes the importance of Hegel's contribution to geometric theory by pointing out that he anticipated not only Carnap's critique of Kant's theory of geometry, but also Minkowski's claim that space and time are united, Einstein's view that space and its geometry is logically prior to physical mass and gravitational

force, and Riemann's geometry of "constant positive curvature."

In her essay, "How to Save the Phenomena," Brigitte Falkenburg considers the relation between Hegel's *Philosophy of Nature* and empirical science, focusing in this case on Newtonian physics. Her main concern is to clarify how empirical science relates to natural phenomena and how Hegel's philosophy of nature relates both to these phenomena and to the concepts of empirical science itself. Falkenburg argues that Hegel shifts from the extensional view of scientific concepts espoused by Newton (in which concepts refer to classes of individual entities) to a non-extensional view of scientific concepts (in which concepts refer to law-like structures in nature or to natural kinds). Furthermore, she contends that the concepts of Hegel's own philosophy of nature do not refer directly to entities in nature, but correspond rather to the concepts of empirical science. In other words, Hegel's philosophy of nature begins, not with nature itself, but with concepts supplied by science (in particular physics) and organizes the contents of such concepts into an adequate system of natural kinds in accordance with the categories of the *Science of Logic*. But, if the philosophy of nature presupposes the concepts of physics in this way, then it obviously cannot be a wholly *a priori* theory of nature as some have claimed. Falkenburg's study of Hegel's understanding of the meaning and reference of scientific and philosophical concepts thus leads her to the conclusion that Hegel's philosophy of nature is far more dependent on empirical science than is often recognized.

Hegel's criticisms of Kant's philosophy are often regarded as failing to hit their intended target. However, in his essay, "On Hegel's Early Critique of Kant's *Metaphysical Foundations of Natural Science*," Kenneth Westphal sets out to show that one specific criticism made by Hegel in 1801 of Kant's theory of nature is in fact far more significant than has hitherto been recognized. In his *Differenzschrift* Hegel claimed that, for Kant, forces are either purely ideal or transcendent and that "the only construction of phenomena that he [Kant] can allow is mathematical, not dynamical."

Westphal contends that Hegel is right, and he undertakes a close and detailed analysis of Kant's *Metaphysical Foundations of Natural Science* (1786) to show why. Westphal's main argument is that Kant's "phoronomic" analysis of the mathematics of motion does not justify the "dynamical" claim it is intended to justify that "matter fills a space ... by a special moving force." In his view, this clearly establishes Hegel's point that the only *valid* construction of phenomena Kant can offer remains a merely *mathematical* one. Westphal points out that by 1800 Kant had himself come to acknowledge that dynamical principles and the concept of force they employ cannot be constructed on a purely mathematical basis. Indeed, Kant saw that the mathematical expression of forces itself presupposes dynamical forces, because those forces are necessary for the means of measurement through which alone their mathematical relations can be determined. According to Westphal, this problem profoundly undermines Kant's claim to be able to provide a proper rational *foundation* for a physics of the real world, based purely on principles drawn from the *Critique of Pure Reason* together with the concept of motion. It thus paves the way for Hegel's alternative conception of philosophy as itself rooted in, and in dialectical relation with, the empirical sciences.

In his essay "Hegel's Appropriation of Kant's Account of Teleology in Nature" Daniel Dahlstrom continues to focus on the relation between Hegel and Kant, in this case pointing to the central importance of Hegel's reading of the *Critique of Judgment* for the development of his speculative metaphysics. Dahlstrom notes that, in Hegel's eyes, Kant's account of inner purposiveness in nature is nothing short of a disclosure of what Hegel understands by the "Idea." However, for Hegel the concept of purposeful organization is not merely a regulative one, but is an ontological category characterizing the status of organic entities themselves quite apart from their relation to a potential observer. Dahlstrom goes on to stress that, despite this difference, Kant and Hegel both agree that organic behavior can only be rendered intelligible by means of the concept of *purpose*. Both thus

endorse the thesis that organic processes are irreducible to physico-chemical processes. Dahlstrom points out that this commitment to the teleological explanation of organic behavior conflicts with the more recent, neo-Darwinian commitment to the idea of random mutation generated by chance and mechanistic necessity alone. Yet, Dahlstrom also notes that recent research into a strain of the *E. coli* bacterium suggests that in certain circumstances this bacterium can in fact adapt its DNA "purposefully" to its environment, and that genetic mutation is thus not always random. For Dahlstrom, this opens the possibility that contemporary biology might have more to learn from Kant and Hegel than is often assumed.

The possibility of a Hegelian challenge to modern neo-Darwinism is also envisaged by Errol Harris in his essay, "How Final Is Hegel's Rejection of Evolution?" Hegel is well-known for his rejection of evolution. However, Harris argues that what Hegel sought to reject were primarily the inadequate theories of biological development known to him at the time: preformation (the belief that a miniature version of the mature creature was encapsulated in the original germ and in the course of time grew in size to become the mature organism) and epigenesis (the idea that the germ-plasm was simple protoplasm which gradually differentiated itself into the embryo and then grew larger to attain adult form). Furthermore, in so far as Hegel rejected the idea that *species* were transformed one into another, he was simply following other noted scientists of his day, such as Linnaeus, Haller, Bonnet and Cuvier. In spite of its apparently anti-evolutionary bias, however, Harris argues that Hegel's dialectical philosophy is in fact profoundly *evolutionary* in character and indeed anticipates certain modern biological concepts, such as the recent Gaia hypothesis that the earth is an organic whole. Harris acknowledges that Hegel would have rejected the modern, Darwinian assumption that species originate solely as a result of an accumulation of chance variations giving selective advantage. However, like Dahlstrom, Harris points out that there is now evidence to suggest that not all genetic mutation is in fact random, but

that some may well be induced by pressures within the organism to maintain its integrity in its specific surroundings. This change of outlook promises a theory of evolution based on the nature of, and nisus towards, the whole; and, according to Harris, if such a theory, with sound scientific credentials, had been available to Hegel in the early nineteenth century, there is little doubt that he would have embraced it with alacrity.

In his presidential address, "Hegel's Nature," Donald Phillip Verene returns to the problem of the transition from the *Science of Logic* to the *Philosophy of Nature* and asks what it means for Hegel to claim that the Idea freely goes forth as nature. Verene prefaces his discussion of the move from the *Logic* to the *Philosophy of Nature* by looking back to the *Phenomenology* remarking that there consciousness lives in the ambiguity of two objects: what is "for it" and what is "in itself." Each stage of the *Phenomenology* is predicated on the belief that this ambiguity can be resolved, but this belief is an illusion and in the attempt to resolve the ambiguity consciousness simply passes over into more complex ambiguity. In Verene's view, the moves from the *Phenomenology* to the *Logic* and from the *Logic* to the *Philosophy of Nature* are also marked by an "unresolved twoness": there is no real *transition* in either case, but rather free acts of "doubling up." The key to the free release of the Idea into nature thus lies not in any mysterious movement of *Aufhebung*, but rather in the constant doubling of one-to-one relationships—one self freely going forth into another and another. Taking his cue from Schiller's poem, *Die Freundschaft*, (mis)quoted by Hegel at the end of the *Phenomenology*, Verene refers to such doubling as *friendship*. In Verene's view, therefore, there is not so much a smooth transition of the Idea into nature at the end of the *Logic*; rather the Idea *befriends* nature.

In the final three essays of the collection, we turn to Hegel's 1801 *Dissertation on the Orbits of the Planets*. This dissertation is a sorely neglected text, but, according to Mauro Nasti De Vincentis, it contains a highly significant criticism of Newton's generalized areal law which deserves to

be taken seriously. Newton's areal law states that, when one body is in orbit around another (fixed central) body, the line drawn from the orbiting body to the central body—the "radius vector"—describes equal areas in equal times, hence these areas are proportional to the times. However, according to Hegel, what is actually *proven* by Newton in the *Principia* is that the orbital *arcs*, as well as the areas, are proportional to the times. But, of course, if this is this case, then Newton in fact proves—absurdly—that all orbits must be circular, since a circular orbit is precisely one in which equal orbital arcs are described in equal times. Guided by Hegel, Nasti De Vincentis examines Newton's original proof closely and ascertains that, although certain qualifications need to be added, Hegel's criticism is highly astute. Nasti De Vincentis points out that, as it stands, Newton's proof proves the areal law for *polygonal* arcs, but does not soundly prove that what holds for polygonal arcs also holds for the corresponding *finite curvilinear orbital* arcs. Since the differences between polygonal arcs and curvilinear orbital arcs can be ignored when the orbital arcs are *infinitesimally small* (i.e. non-finite), Newton's proof *can* be considered valid in the case of such infinitesimal orbital arcs. Furthermore, if certain other conditions are also specified, Newton's proof does successfully establish in this case that the areas only and *not* the arcs are proportional to the times. However, Newton's proof cannot be considered to be sound in the case of *finite* curvilinear orbital arcs of a determinate magnitude, even though it is clear that Newton intends his proof to be valid of such finite orbital arcs. According to Nasti De Vincentis, it is when Newton's proof is taken—incorrectly, but in accordance with Newton's intentions—to be valid of *finite* orbital arcs, that not only the areas swept through by the radius vector, but also the orbital *arcs* described by the moving mass point, are proven to be proportional to the times of describing them. It is in this case, therefore, that, just as Hegel contended, Newton's proof has the absurd conclusion that all the arcs must be equal in equal times and the orbit must be circular. Nasti De Vincentis notes that modern proofs of Newton's areal law have been developed

which avoid this problem, but that Hegel's criticism (which is derived from one made by the French Jesuit, Louis-Bertrand Castel) remains an important criticism of Newton's original proof.

Hegel's *Dissertation on the Orbits of the Planets* has long been ridiculed and scorned (by writers such as Jacob Bronowski) because it is there that Hegel offered what he took to be a rational explanation for the supposed absence of any planet between Mars and Jupiter just at the time the asteroid Ceres was being discovered. In his essay, "The Ontological Foundations of Hegel's Dissertation of 1801," Olivier Depré sets out to understand what led Hegel to commit his error and argues that Hegel is not by any means as guilty of mindless "apriorism" as has often been claimed. Towards the end of the eighteenth century a group of scientists, guided by an arithmetical series of numbers known as the "Titius-Bode Law," committed themselves to looking for a planet between the orbits of Mars and Jupiter. Hegel regarded this law as nonrational and inexact, and suggested that an alternative *exponential* series, inspired by Plato's *Timaeus*, would be much more rational and would account for the gap between Mars and Jupiter. Depré notes that, although Hegel would probably have heard reports that a minor planet had been discovered precisely where he thought there should be a gap, he would not have had any reason at the time he was writing to regard the existence of this minor planet as anything more than conjecture. His motivation for preferring the exponential series was thus not only that it was more rational, but also that it corresponded more closely to what he took to be the currently *known* empirical facts. Indeed, from Hegel's point of view, it was actually the scientists looking for a planet between Mars and Jupiter on the basis of a merely arithmetical series who were guilty of apriorism. Moreover, Depré points out that, although Hegel was wrong not to take the reports of the discovery of Ceres more seriously, he was actually right not to trust the Titius-Bode law, as the discovery of Neptune in 1846 would later demonstrate. Depré concludes by arguing that Hegel's critique of Newton in his dissertation is

motivated by precisely the same desire to provide a rational, rather than merely quantitative, account of nature and its laws.

In the first edition of his *Encyclopedia* (1817), Hegel acknowledged that the attempt made in his 1801 dissertation to find a law governing the distance of the planets from the sun was unsatisfactory. However, in the second and third editions of the *Encyclopedia* (1827, 1830), Hegel omitted any such criticism—indeed omitted all mention—of his dissertation. In her essay, “Framing Hypotheses,” Cinzia Ferrini considers the significance of this later omission and concludes that it reflects an important change, occurring between 1817 and 1827, in Hegel’s philosophical understanding of the relation between reason and empirical numbers in nature. Ferrini argues that in the 1817 *Encyclopedia* (and in the first edition of the *Science of Logic* on which it is based) Hegel understood the actual empirical numbers in nature to fall outside the scope of physical law and thus not to be determinable by reason. On this basis, Hegel had to regard as fundamentally misguided his earlier efforts in his dissertation to find a rational law governing the empirical distances of the planets from the sun. However, in the 1827 and 1830 editions of the *Encyclopedia* (and in the second edition of the *Science of Logic* with which they are closely connected), Hegel held the view that empirical numbers in nature can be captured *an sich* by reason. From this perspective, he would still have to acknowledge the specific error he made in 1801, but he would no longer have to reject out of hand the very attempt to find a rational law governing the empirical distances of the planets from the sun. By paying subtle attention to an apparently insignificant omission made by Hegel in the second and third editions of the *Encyclopedia*, Ferrini thus uncovers a radical shift that occurred between 1817 and 1827 in Hegel’s fundamental understanding of the relation between reason and mathematics and between reason and the empirical world.

Hegel’s philosophy of nature has for too long been dismissed as “mystifying cant” by those who should—but unfortunately do not—know better. The essays in this

collection serve to remind us just how powerful and perceptive that philosophy actually is. The essays were first presented under the title "Hegel and the Philosophy of Nature" at the Thirteenth Biennial Meeting of the Hegel Society of America, which was held at The Catholic University of America in Washington, D.C. from September 30 to October 2, 1994. I would like to thank Michael Baur for helping with the organization of that conference, and DePaul University, Chicago and the University of Warwick for supporting the preparation of this volume. Special thanks go to Pauline Wilson for completing the task of putting the manuscript into camera-ready copy with such grace and ease.

Notes

1. K.R. Popper, *The Open Society and its Enemies* (1945), 2 Vols (London: Routledge, 1966), 2: 28; M.J. Schleiden, *Schelling's und Hegel's Verhältnis zur Naturwissenschaft* (1844), edited by O. Breidbach (Weinheim: VCH, Acta Humaniora, 1988), Schleiden Nachdruck, p. 60.
2. J. Bronowski, *The Ascent of Man* (London: BBC, 1973), p. 360.
3. Schleiden Nachdruck, p. 61.
4. H. Schnädelbach, *Philosophy in Germany, 1831-1933*, translated by Eric Matthews (Cambridge: Cambridge University Press, 1984), pp. 76-7.
5. Popper, 2: 28.
6. Gerd Buchdahl, for example, speaks of Hegel's "formidable breadth of knowledge." See G. Buchdahl, "Hegel's Philosophy of Nature and the Structure of Science," in *Hegel*, edited by M. Inwood (Oxford: Oxford University Press, 1985), p. 110.
7. See, for example, the essays by M. Wolff, T.H. Levere, M.J. Petry and H.A.M. Snelders in *Hegels Philosophie der Natur. Beziehungen zwischen empirischer und spekulativer Naturerkenntnis*, edited by R.-P. Horstmann and M.J. Petry (Stuttgart: Klett-Cotta, 1986).
8. *Hegel's Philosophy of Nature*, edited by M.J. Petry, 3 Vols (London: George Allen and Unwin, 1970), 1: 51 and 2: 204. (Hereafter Petry, *PN*, 1: 51.)

9. Petry, *PN*, 1: 60.

10. Buchdahl, p. 111.

11. Petry, *PN*, 1: 197.

12. See Petry, *PN*, 1: 224 [ll. 8-13] and 2: 12 [ll. 8-11], which could be taken as supporting the first—*a priori*—interpretation, and Petry, *PN*, 1: 197 [ll. 11-13] and 1: 201 [ll. 33-6], which could be taken as supporting the second—*a posteriori*—interpretation.