MECHANICS AND NATURAL PHILOSOPHY BEFORE THE SCIENTIFIC REVOLUTION

BOSTON STUDIES IN THE PHILOSOPHY OF SCIENCE

VOLUME 254

MECHANICS AND NATURAL PHILOSOPHY BEFORE THE SCIENTIFIC REVOLUTION

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Springer

EUROPEAN SCIENCE FOUNDATION

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-1-4020-5966-7 (HB)
ISBN 978-1-4020-5967-4 (e-book)

Published by Springer,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

www.springer.com

Printed on acid-free paper

PREFACE

This book is the result of a workshop entitled “Mechanics and Natural Philosophy: Accommodation and Conflict” that was held in La Orotava, Tenerife, on January 30–February 1, 2004. The workshop was part of a program on the general theme “From Natural Philosophy to Science” generously sponsored by the European Science Foundation. With the exception of the essay by Edith Sylla, who kindly agreed to the labour of contributing to the volume without the compensatory pleasure of having been in Tenerife, all the papers here were read at the workshop in preliminary form and then thoroughly revised for publication.

In addition to the scholars whose essays follow in this volume, participants at the workshop also included Romano Gatto, Elzbieta Jung, Cees Leijenhorst, Ian Maclean, Antoni Malet, Peter McLaughlin, Pier Daniele Napolitani, Jürgen Renn, and Hans Thijssen. Their contributions to the workshop in Tenerife, whether mentioned in the footnotes or not, have left their mark throughout the arguments of this book. We hope that this volume will continue in another form those stimulating and productive discussions. For we think that the result demonstrates the challenges that the history of ancient, medieval, and pre-Galilean mechanics now presents—challenges to philologists with the skills necessary for editing, commenting on, and translating texts, challenges to historians tracing the interactions both between texts and between texts and practices that resulted in new ways of thinking about mechanics and natural philosophy, and challenges to scholars engaged in delineating the structures of scientific knowledge.

For their efficiency in organizing the workshop and especially for their warm hospitality in Tenerife, we thank Carlos Martín and José Montesinos, Director of the Fondación Canaria Orotava de Historia de la Ciencia. And for their patient and constant support, we thank Hans Thijssen, Chairman of the European Science Foundation program “From Natural Philosophy to Science”, and Cees Leijenhorst, the coordinator of the program.

Finally, this book would not have been possible without the help of Mark Naimark, who translated papers originally written in French and checked the language of papers written by non-native English speakers; and of Marije van Houten-Hettinga, who, through the generosity of the Région Rhône-Alpes (contrat de plan État-Région, Sciences Humaines et Sociales, appel d’offres 2003), assisted in the last phase of a long editing process.

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INTRODUCTION

By the end of the 17th century, modern mechanics – the general science of bodies in motion – had replaced natural philosophy to become the paradigm of the physical sciences, a place it held at least through the 19th century. Modern mechanics was forged in the 17th century from materials that were inherited from Antiquity and the Middle Ages through various and sometimes divergent conceptual traditions that had been transformed in the course of the 16th century partly under the influence of technological innovations and an interest in practical applications. The purpose of the workshop "Mechanics and Natural Philosophy: Accommodation and Conflict" from which this book arose was to articulate the conceptual background to the historical emergence of modern mechanics in relation to natural philosophy. In the workshop we did not pretend to offer a comprehensive account either of natural philosophy or mechanics from Antiquity to the 17th century – or even of the relation between them. Rather, our purpose was much more modest: to present a variety of moments when conflicts arose within one textual tradition, between different traditions, or between textual traditions and the wider world of practice, and to show how the accommodations sometimes made ultimately contributed to the emergence of modern mechanics. More specifically, before the workshop participants were encouraged to consider the following general questions:

1. Problems that are now referred to as mechanical were once treated within a variety of different disciplines, including logic and theology. Did these theoretical contexts have any effect on the formation of mechanical concepts? How did the various types of problems come eventually to be identified as belonging to a single discipline? Was mechanics considered an art or a science? Where and how was it taught? How did mechanics, once considered an Aristotelian mixed science, become identified with the science of nature as such? And in general, what was the status of mechanics in relation to other disciplines?

2. What are the criteria by which we say that a given text belongs to a given conceptual tradition? Not every writer who cited or even commented on the pseudo-Aristotelian *Mechanica*, for example, can be placed within the conceptual tradition of that work; and beyond this simple criterion lie even more complications. Certain words or complexes of words (e.g., "natural" versus "violent motions", *gravitas secundum situm*, *impetus*) are often

W.R. Laird and S. Roux (eds.), Mechanics and Natural Philosophy before the Scientific Revolution, 1–11.

associated with a certain physical theory, as though the words themselves contain the theory in a nutshell. Further, concepts have histories of their own, which may be different from the histories of the words representing them, and the same word can have various meanings in various contexts. Similarly, since the limitations of the mathematical tools at hand imposed certain constraints, we might be tempted to define a conceptual tradition by its mathematical tools. But in the period considered it would seem that the Euclidean theory of proportion was the main, if not the only mathematical tool applied to the analysis of motion and to the science of weights. Lastly, a conceptual tradition might be characterized by the concrete models it appeals to in its explanations (such as the lever, the inclined plane, a thrown ball, a sling, a pendulum, etc.). But the expression "concrete models" is ambiguous: it refers to common experiences as well as to the learned knowledge of practitioners, to figures in books as well as to general physical principles.

3. What were the material routes that these traditions followed and how are the relationships between these traditions to be understood? How were mechanical texts circulated, both before and after the introduction of printing? What were the active and interacting traditions at a given time and at a given place? Were they perceived as conflicting? If they were, why was an accommodation looked for and according to what principles was it eventually found? Do we as historians now see these traditions as conflicting and what criteria do we now apply to determine whether they were?

The chapters in this book all focus on at least one of these questions. But, as often happens in historical studies, the particular materials here are so rich and complex that they cannot be compassed by any preliminary set of questions. We hope that this collection of essays at least begins to answer some of the questions above, while giving rise to new ones that we had not anticipated before we undertook it.

Until about the 17th century, natural philosophy (*physica* or *philosophia naturalis*) was the general science of motion and change – motion being understood as any sort of gradual change, whether change of quality, change of quantity, or change of place. As the name suggests, natural philosophy was concerned mainly with those motions and changes that occur naturally, such as generation, growth, and spontaneous motions such as heartbeat and digestion, the fall of heavy bodies and the rise of light, and the circular motions of the celestial spheres. Throughout Antiquity and the Middle Ages, natural philosophy was dominated by the works of Aristotle, though even his most loyal followers introduced significant novelties into the Aristotelian system. In the *Physica,* Aristotle had established the general principles of motion and change that govern all natural bodies; in his more specific natural works – such as *De caelo*, *De generatione et corruptione*, and the various works *De animalibus* – Aristotle applied these principles to natural changes of all kinds occurring in animate and inanimate bodies: generation, growth, the fall of heavy bodies, and the motions of the stars. But inevitably, within the context of natural philosophy, there also arose questions concerning unnatural or forced motions, such as the motion of projectiles and in general the changes effected by men through the various arts. Partly this was because Aristotle used forced motions and in general the changes produced by art as analogies in order to discover the less obvious causes of natural motions; and partly it was because natural and forced motions are often inextricably combined in daily experience.

In contrast to natural philosophy, the ancient art or science of mechanics was notable for working against or at least outside of nature to effect motion for the use and benefit of mankind. This, at least, was the view taken in the pseudo-Aristotelian *Mechanica* ("Questions of Mechanics" or "Mechanical Problems") (4th century BC), the earliest known theoretical treatment of machines and the earliest attempt to reduce their operations to a single principle. In its introduction, the *Mechanica* suggested that machines of all sorts work against or outside of nature in order to effect changes that are of benefit to men. A machine that moves a large weight with a small power, for example, produces an effect for human benefit, and this effect is not natural, for it violates the Aristotelian physical assumption that a moving power must be greater than the weight it moves. Mechanics and physics thus seem to be in conflict. But the introduction of the *Mechanica* went on to suggest that in mechanical problems, nature provides the subject matter and mathematics the explanation, which is similar to the account Aristotle gave elsewhere of the so-called subalternate sciences – astronomy, optics, music, and of course mechanics itself. In this earliest mechanical work, then, we find the origins of the ambiguous – even paradoxical – relation between mechanics and natural philosophy. On the one hand, mechanics concerns effects that are produced against or outside nature; on the other, mechanics consists in applying mathematics to natural things. In the *Mechanica*, this application takes the form of reducing all mechanical effects to the motions of the balance, which in turn are explained through the marvellous properties of the circle.

In the centuries after Aristotle, mechanics was developed in two general streams, the one more mathematical and theoretical, represented by Archimedes (3rd century BC), and the other more practical and technical, represented by Heron of Alexandria (1st century AD). Although Archimedes was known in Antiquity and the Middle Ages mainly as a designer and builder of instruments and machines, his extant writings on mechanics are entirely theoretical and mathematical. Most notable of these for our purposes is *On Plane Equilibrium*, in which he gave an entirely static proof of the law of the lever that relied on the notion of centre of gravity. Heron of Alexandria, in contrast, while mentioning Archimedes and being obviously inspired by the pseudo-Aristotelian *Mechanica*, wrote extensively on the design and construction of machines. Perhaps his main contribution to the science of mechanics was to reduce all complex machines to what he established as the canonical five simple machines (lever, wheel and axle, pulley, wedge, and screw), each of which in turn he reduced ultimately to the balance. Mark Schiefsky shows in his contribution to this volume that Heron's reduction of complex machines to the five simple machines, and their reduction to the balance, both relied on and attempted to explain the knowledge of machines acquired by mechanical practitioners through experience. Like the pseudo-Aristotelian *Mechanica*, Heron's purpose in general was to explain how with machines one could move great weights with small forces, seemingly in violation of the Aristotelian physical assumption that moving powers must be greater than weights. By offering such an explanation, according to Schiefsky, Heron was in effect explaining away the apparent opposition between machines and nature by modifying natural principles to accommodate machines. Heron also challenged the Aristotelian physical assumption that all forced motion requires a constant mover, using the balance and the inclined plane as cases in point. For a balance in equilibrium, he argued, can be moved by a force as small as one pleases, and a weight on a perfectly smooth horizontal surface likewise. But despite these challenges to its central principles, Heron did not propose to replace Aristotelian natural philosophy with another, new kind of physics.

Although Heron's *Mechanics* was unknown in the medieval Latin West and survives today only in a medieval Arabic translation, an extract from it, which included his account of the five simple machines, was later incorporated by Pappus of Alexandria into Book VIII of his *Mathematical Syntaxis* (3rd century AD), the fourth main source of ancient mechanics. In general, Pappus' purpose was to collect and systematize previous works, although he also tried to fill in the gaps left by his predecessors. In the case of mechanics, he provided a definition of centres of gravity missing from Archimedes, and he attempted to reduce the inclined plane to the balance.

In the Latin Middle Ages, there was, strictly speaking, no science of mechanics. Although there were references to a science of mechanics in the works of Aristotle and other ancient authors, there were no extant treatises on mechanics. Neither the pseudo-Aristotelian *Mechanica* nor Pappus' *Mathematical Syntaxis* were recovered and translated into Latin before the 16th century, and Heron's *Mechanics* remained unknown in the West until very recently. The fate of Archimedes was more complex. His mechanical works exerted considerable influence in the Arabic-speaking world of the early Middle Ages, but although almost all of Archimedes' works were translated from the Greek into Latin in the late 13th century, they had very little influence in the West until the beginning of the 16th century. In the absence of any texts on the ancient science of mechanics, the word *mechanica* was applied solely to the mechanical arts (*artes mechanicae*), which included variously agriculture, metalworking, building, clothmaking, and the like – those arts that provide the necessities of life and are linked with manual labours and dirty hands. As such, they were also characterized as *sellularian* (the Latin translation of the Greek *banausia*, handicrafts) or "adulterine" (because they were adulterated with practice and physical needs) and were explicitly contrasted with the liberal arts and with philosophy in general. And finally, the art of designing and building machines, when it was distinguished at all from the other arts, was called the *scientia de ingeniis*, although this was largely an empty name rather than a coherent body of theory and practice.

The science of weights (*scientia de ponderibus*) is the best candidate for a medieval science of mechanics, although it was never identified with the *scientia de ingeniis* or included with the *artes mechanicae*, since it was considered a theoretical and mathematical science like astronomy and music. From Greek and Arabic works on the unequal-armed balance (the *statera* or Roman balance), it developed in the course of the 13th century, especially in the works of Jordanus de Nemore, into a sophisticated, mathematical treatment of the main problems of statics and a few problems of dynamics, and it held a minor place alongside the other mathematical sciences at the medieval university. The science of weights survived through the 14th and into the 15th century, though little was added to the achievements of the 13th century; only in the 16th century did the science of weights converge with the recovered mechanical traditions of Antiquity to contribute to the development of a new science of mechanics.

Meanwhile, natural philosophy was almost entirely separate from both the mechanical arts and from the science of weights. Topics that we now identify as mechanical, inasmuch as they arose within the Aristotelian corpus of natural philosophy, were discussed using natural philosophical principles and usually with only the most rudimentary mathematics. Several passages on such topics in Aristotle's *Physics* gave rise to an extensive tradition of commentary and criticism in Late Antiquity and the Middle Ages, notably on the motion of projectiles and the relation between movers and things moved. In Book VII of the *Physics*, as part of his introduction to the argument for the Prime Mover, Aristotle gave a set of rules for the relation between movers and things moved and the speeds and times of their motions. By the early

14th century, these rules had been extensively discussed and interpreted in various ways in the Greek, Arabic, and Latin commentary traditions. But in 1328, Thomas Bradwardine, drawing on the medieval theory of proportion, offered in his *Treatise on the Ratios of Speeds of Motions* (*Tractatus de proportionibus velocitatum in motibus*) a strikingly novel and later widely accepted mathematical interpretation now known as Bradwardine's rule. In his contribution to this volume, Jean Celeyrette argues that Bradwardine's intention was not to replace Aristotle's rules of motion with his own, but only to act as a commentator and to offer an interpretation that made these rules clearer and more consistent. Among Bradwardine's successors who accepted and developed further this interpretation in the 14th century, Celeyrette continues, only Richard Swineshead and Nicole Oresme offered significant new insights: Swineshead applied Bradwardine's result to new physical problems, and Oresme tackled the conceptual difficulties implied by stating a proportionality between the speeds on the one hand, and the ratios between forces and resistances on the other. According to Celeyrette, only Swineshead and Oresme offered Bradwardine's rule as a mathematical law of local motion, although neither of them enjoyed a lasting influence. And finally, contrary to the common modern opinion, Celeyrette concludes, Bradwardine's rule was not properly a mathematical function.

Bradwardine's rule was founded on the medieval theory of proportion, and in particular on the idea that ratios could be compounded from other ratios. At the time that Bradwardine wrote, Edith Sylla argues in her contribution to this volume, there were in fact two different ways of understanding the composition of ratios, and Bradwardine chose the one that made his dynamical rule simple and elegant. By the 16th century, however, Bradwardine's way of compounding ratios had been superseded by the simple multiplication of denominations. As a result of this purely mathematical change, then, Bradwardine's rule had disappeared from discussions of motion by the time Galileo took up the subject. Thus, the fate of Bradwardine's rule was tied not to its failure to correspond to the actual behaviour of bodies in motion, Sylla concludes, but to the falling out of favour of a mathematical idea.

The other topic that aroused considerable controversy in the commentary tradition of natural philosophy – a topic that we would now consider proper to mechanics – was the continued motion of projectiles. Since he held that all forced motions needed the continual action of a cause, Aristotle had suggested that projectiles continued to move after they were thrown because of the continual action of the medium through which they move. But even the earliest Greek and Arabic commentators found fault with this explanation and suggested various alternatives, including some sort of moving power impressed on the projectile itself. In the 14th century, Jean Buridan, a master at the University of Paris, gave the most thorough and coherent account of this alternative under the name of *impetus*. Although *impetus* theory directly challenged Aristotle's explanation of projectile motion, Jürgen Sarnowsky argues in his contribution to this volume that there was no distinct *impetus* physics as a stage intermediate between ancient physics and the classical theory of inertia, as some historians of science have suggested. This is because the nature and properties of the impressed force or *impetus* varied greatly from the earlier commentators to Buridan and his successors, so that there never formed around it a distinct and coherent alternative to Aristotelian physics. But although *impetus* was just an ad-hoc solution to particular problems in Aristotelian dynamics, Sarnowsky concludes, it called into question other key Aristotelian principles and thus contributed to the demise of Aristotelian natural philosophy.

Despite the innovations of Bradwardine, Buridan, and Oresme, when the science of mechanics emerged in the course of the 16th century, it did not emerge from within natural philosophy. Rather, it arose largely out of the newly recovered mechanical sources from Antiquity and the Middle Ages – the pseudo-Aristotelian *Mechanica*, the almost complete works of Archimedes, the *Pneumatica* of Heron, the *Mathematical Syntaxis* of Pappus, and the Jordanus tradition of the science of weights. The first of these to be edited, translated, paraphrased, and commented on was the *Mechanica*, and historians of science have recently shown that its influence was to be felt through the whole of the 16th century. Although now it is usually attributed to Strato, a successor of Aristotle, it relied sufficiently on Aristotelian natural principles that in this period it was commonly, though sometimes doubtfully, attributed to Aristotle himself. The attribution to Aristotle challenged commentators to compare its mechanical principles to the principles of Aristotle's natural philosophy found in his other works, and it came to be the main locus for discussions about the general relation between mechanics and natural philosophy.

Christiane Vilain, in her contribution to this volume, examines how commentators on the *Mechanica* treated the opposition of circular and rectilinear motion, which Aristotle had said were incommensurable, and their relation to natural and violent motion, which was a fundamental dichotomy in Aristotle's natural philosophy. In the *Mechanica*, the circular motion of the balance is resolved into two rectilinear motions, one of which is identified as natural while the other as violent or against nature, though it is not at all clear that the natural motion here must be downwards. Vilain shows that 16th-century commentators were divided on this question, Benedetti being the first to consider explicitly the motion of a sling – where the "natural" motion is no longer the downward motion of a heavy body, but the rectilinear and tangential motion of the stone as it is flung from the sling. In this way, she shows how commentators on the *Mechanica* both drew upon and modified the principles of Aristotelian natural philosophy.

One of those who commented on the pseudo-Aristotelian *Mechanica* was Giuseppe Moletti, professor of mathematics at the University of Padua in the 1580s, to whom it gave particular occasion to reflect on the relation between nature and art. In his contribution to this volume, Roy Laird shows how Moletti, in his lectures on the *Mechanica*, took up the suggestion that art both imitates and overcomes nature for human benefit. Drawing on another Aristotelian text, the *De motu animalium*, Moletti went on to suggest that nature itself uses mechanical means in its own works. This implies, according to Laird, that – for Moletti at least – to understand mechanics was also to understand the workings of natural things. With the benefit of hindsight, it seems that from there it would be only a small step to thinking of mechanics itself as the science of nature.

In the 1580s, at the same time that Moletti was lecturing on the *Mechanica* at Padua, the leading natural philosophers at the University of Pisa were discussing several topics that would later come to be of special interest within the emerging science of mechanics, including the fall of heavy bodies, motion in a void, and *impetus*. Mario Otto Helbing, in his contribution to this volume, shows that, contrary to the common opinion, Andrea Cesalpino and Francesco Buonamici were not old-fashioned scholastics treating these topics entirely within the tradition of the medieval commentators on Aristotle, but humanists making extensive use of the newly recovered ancient texts. In his *De motu*, Buonamici drew from the *Mechanica* when he asserted that since the same principles hold for natural motions and for motions that are against nature, mechanics is especially close to natural philosophy. Buonamici also drew on Archimedes: in the *On Plane Equilibrium* he found the concept of centre of gravity, and he devoted one book of his *De motu* to an exposition and criticism of Archimedes' hydrostatical treatise *On Floating Bodies*. Buonamici's most famous student – Galileo – would later take up these same topics in his earliest works on mechanics and motion.

Since there was no single canonical text in the 16th century to define the scope and contents of mechanics, the body of problems and questions that came under mechanical scrutiny was in flux. For all its influence in the 16th century, the *Mechanica* was not a systematic treatise, but rather a collection of miscellaneous questions on a number of applications of mechanical principles, including the balance and lever, pulleys, wheels, and the like. The *Mechanica* did not contain, notably, any account of the inclined plane. For this one has to look to the traditions of Heron, Pappus, and Jordanus. Egidio Festa and Sophie Roux, in their contribution, present a history of the attempts to discover the law of the inclined plane from Heron to Galileo. They show how Heron and Pappus tried to reduce the inclined plane to the balance, and how Pappus was misled by trying to determine the force needed to move a weight on an inclined plane in relation to the force needed to move it on a horizontal plane. Jordanus, in contrast, arrived at the correct solution by appealing to the notion of positional weight; and Galileo also arrived at the correct solution, not through reading Jordanus, however, but by reducing the inclined plane to the bent lever and thus to the balance. Galileo's solution to the inclined plane had implications far beyond the theory of simple machines, since it provided him with a key principle for his new science of motion. Festa and Roux conclude that this solution was arrived at not by new mathematical techniques but rather by the clarification of concepts such as gravity and moment, and that, in general, similarities in method and approach may be the result of a common paradigm rather than direct influence.

As we have already mentioned, some of the topics that we now consider mechanical arose within natural philosophy; others arose from practical experience with actual machines. One of these latter was the pendulum, which Jochen Büttner in his contribution to this volume characterizes as a "challenging object". Because challenging objects by definition do not lend themselves easily to treatment by the means available within existing frameworks of knowledge, they offer the opportunity for conceptual transformations of those frameworks. Büttner shows that the pendulum emerged as a challenging object only at the beginning of the 16th century and largely from its technological applications, in the regulation of clocks, for example, and in machines for the accumulation of power. Galileo took up the pendulum and tried (unsuccessfully) to establish a relation between its isochronism and his newly discovered law of chords; Isaac Beeckman saw planetary motion as analogous to the pendulum; and Baliani used the pendulum as the principle of the laws of motion. These instances show, Büttner concludes, that the pendulum was not only a challenging object, but also an object of shared knowledge, and that the challenge that it offered led to transformations in early-modern mechanics.

If Büttner examines a case of the interaction between the world of texts and the world of practice, the final papers in this volume examine the emergence of mechanics within different institutional and national contexts. In the early 16th century, writing on mechanics was mostly an Italian affair, but by the end of the century, it had developed outside of Italy as well. In his paper, Victor Navarro argues that Spanish authors drew on the same classical and renaissance sources in mechanics as the rest of Europe, and that Spain was not so much the bastion of conservative natural philosophy as is often thought. In the first half of the 16th century, Diego Hurtado de Mendoza, Imperial Ambassador to Venice, not only encouraged the early mechanical work of Alessandro Piccolomini and Niccolò Tartaglia but also translated into Spanish the pseudo-Aristotelian *Mechanica*. Later in the century, the architect Juan de Herrara founded the Academy of Mathematics in Madrid to provide training in theoretical and practical mathematics, especially navigation and artillery. His successors included Juan Bautista Villalpando, whose main interest was static equilibrium as applied to architecture and who drew on the pseudo-Aristotelian *Mechanica*, Pappus, Federico Commandino, and Guidobaldo dal Monte; and Diego de Alava, whose work on artillery was based largely on Niccolò Tartaglia. Although *impetus* theory and the correct law of free fall were taught as part of natural philosophy at Spanish universities by such notables as Juan de Celaya, Domingo de Soto, Francisco Valles, Diego de Zuñigo, and Diego Mas, Navarro concludes that because mechanics was taught only at the Academy and not at the university, there was little opportunity for the sort of contact between mechanics and natural philosophy that elsewhere would give rise to Galileo's new science of motion.

In the final paper in this volume, Geert Vanpaemel describes how the Jesuits, barred from teaching at the universities in the Spanish Netherlands, established themselves at Antwerp and Leuven by teaching mathematics, a subject neglected by the universities. The first of these Jesuit mathematics teachers was Gregorius a Sancto Vincento, who had been a student of Christopher Clavius's at the Collegio Romano. While Gregorius and then Jean Charles de la Faille were concerned mainly with pure mathematics, later Hugo Sempilius and Joannes Ciermans were concerned also with its practical applications, especially in mechanics. Vanpaemel argues that Ciermans considered the action of fluids to be a machine effected by nature without the use of levers or pulleys, and that he implied that to understand the laws of statics as applied to hydrostatics was to understand nature. Nevertheless, Vanpaemel concludes that Ciermans did not espouse a full-blown corpuscular philosophy of nature, because he still allowed room for hidden causes in natural philosophy.

The modern science of mechanics, then, emerged from conflicts between the different textual traditions of ancient and medieval mechanics, between an inchoate mechanics, natural philosophy, and mathematics, and between theoretical considerations and practical experience. To a large extent, modern mechanics is the result of the accommodations that were effected in order to resolve these conflicts and establish it as an independent, mathematical science with a practical bent. The history of mechanics – unlike the history of astronomy or optics – is the history of a variety of disparate topics and problems that were treated in different ways within very different disciplines and conceptual traditions. For this reason it is not enough for the historian of mechanics to trace these various problems and their solutions from one era to another until the right answer was hit upon. Rather, the history of mechanics is to a large extent the history of the relations between different textual and conceptual traditions, between different disciplines, and between theory and practice. We hope that the essays in this volume illustrate some of the ways that this history may be written.