Routledge Studies in Seventeenth-Century Philosophy

1. **The Soft Underbelly of Reason**
The passions in the seventeenth century
Edited by Stephen Gaukroger

2. **Descartes and Method**
A search for a method in meditations
Daniel E. Flage and Clarence A. Bonnen

3. **Descartes' Natural Philosophy**
Edited by Stephen Gaukroger, John Schuster and John Sutton

4. **Hobbes and History**
Edited by G.A.J. Rogers and Tom Sorell

5. **The Philosophy of Robert Boyle**
Peter R. Anstey

Descartes' Natural Philosophy

Edited by

Stephen Gaukroger, John Schuster and John Sutton

London and New York

First published 2000
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group

First issued in paperback 2011

Typeset in Baskerville by Wearset, Boldon, Tyne and Wear

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
Descartes' natural philosophy / [edited by] Stephen Gaukroger, John Schuster and John Sutton.
p. cm.
Includes bibliographical references and index.
1. Descartes, René, 1596–1650 – Contributions in philosophy of nature. 2. Philosophy of nature. I. Gaukroger, Stephen, 1950–. II. Schuster, John Andrew, 1947– III. Sutton, John, 1965–

B1878.N3 D47 2000
113'092–dc21 99–059525

ISBN13: 978-0-415-21993-8 (hbk)
ISBN13: 978-0-415-51070-7 (pbk)

Contents

Contributors

Peter Anstey is a Research Fellow, Department of Philosophy, University of Sydney.

Jean-Robert Armogathe is Professor of the History of Religious and Scientific Ideas in Modern Europe, École Pratique des Hautes Études, Sorbonne.

Gordon Baker is a Fellow of St. John's College, Oxford.

David Behan is Professor of Philosophy, Agnes Scott College, Decatur, Georgia.

Annie Bitbol-Hespériès is attached to the Continuing Education section, Sorbonne.

Desmond Clarke is Professor of Philosophy, University College, Cork.

Betsy Newell Decyk is Lecturer in Philosophy and Psychology, California State University, Long Beach.

Dennis Des Chene is Associate Professor of Philosophy, Emory University.

Véronique M. Fóti is Associate Professor of Philosophy, Pennsylvania State University.

Daniel Garber is Professor of Philosophy, University of Chicago.

Stephen Gaukroger is Professor of History of Philosophy and History of Science, University of Sydney.

Peter Harrison is Associate Professor of Philosophy, Bond University.

Gary Hatfield is Professor of Philosophy, University of Pennsylvania.

Trevor McClaughlin is Senior Lecturer in History, Macquarie University.

Peter McLaughlin is Lecturer in Philosophy, University of Konstanz.

Katherine Morris is a Fellow of Mansfield College, Oxford.

References to Descartes' works

References to Descartes' works are to the standard edition: Charles Adam and Paul Tannery (eds.), *Oeuvres de Descartes*, 2nd. edn (11 vols., Paris, 1974–86). The edition is abbreviated to AT throughout, and reference is made to volume number and page number by Roman and Arabic numerals respectively, e.g. AT iv. 123. In the case of the *Principia* and the *Passions*, however, references are to Part and Article number, since this is a more convenient way of locating the relevant passage. Descartes' works are referred to by their original titles, in the original language.

A number of Descartes' natural-philosophy works are missing from, or appear only in a truncated form in what is now the standard English translation of Descartes' works: John Cottingham et al, *The Philosophical Writings of Descartes* (3 vols., Cambridge, 1984–91). Full English translations of the major works missing from this edition can be found as follows:

La Dioptrique, Les Météores, La Géométrie in Paul J. Olschamp (trans.), *René Descartes: Discourse on Method, Optics, Geometry, and Meteorology* (Indianapolis, 1965).

Principia Philosophiae in V.R. and R.P. Miller (trans.), *René Descartes: Principles of Philosophy* (Dordrecht, 1991).

Le Monde, L'Homme, Description du Corps Humain in Stephen Gaukroger (trans.), *Descartes, The World and Other Writings* (Cambridge, 1998).

Introduction

This volume gathers together a number of new studies of Descartes' natural philosophy. We have not concerned ourselves with the textbook image of Descartes in philosophy or the history of ideas, as father of modern philosophy, or as the inventor of modern epistemology, mind/body dualism, or advocate of a universal method. Rather, we focus on Descartes in the context of his times as a pioneer of the mechanical philosophy and leading practitioner of mathematics and a number of the then existing specialised traditions of scientific endeavour, such as mechanics, optics, anatomy, and physiology (including psycho-physiology). We view Descartes, moreover, as a natural philosopher whose aims and agendas were not independent of the social and intellectual contexts within which he was working; and as someone who, over time, not only achieved numerous remarkable successes, but who also endured several deflections of aim, tactical retreats and outright failures.

The theme of our volume is not entirely new. In recent years a small but growing body of research has examined aspects of Descartes' natural philosophy as part of a reassessment of his role in the history of Western thought. Our aim here is to represent and consolidate some of the present concerns in the area of Descartes' natural philosophy and to bring to light a number of new possibilities for its study. How these aims are viewed will inevitably depend in large measure upon how the term 'natural philosophy' is understood, both in general, and in the particular case of Descartes.

The term 'natural philosophy' has often been used, particularly in the literature in the history of science, in two ways: either it is used in an anachronistic way as a synonym for 'science' – an anachronism, since 'science' as a term denoting the presumed unity, methodological and institutional, of all inquiry into nature, is a nineteenth-century coinage. Or, with more justification it is used as a synonym for 'the sciences', meaning the set of narrower traditions of intellectual practice that existed in the early modern period on the basis of classical models, such as astronomy, optics, mechanics, anatomy, music theory, and the like. Strictly speaking, however, in the early modern period the term 'natural

philosophy' denoted attempts to explain in a systematic way the nature of matter, the cosmological structuring of that matter, the principles of causation and the methodology for acquiring or justifying such natural knowledge. The dominant genus of natural philosophy – and the exemplar for its form, content, and the grammar of articulation – was, of course, Aristotelianism in various neo-scholastic guises, but the term similarly applied to challengers and alternatives of similar scope and aim; that is, to any particular species of the various competing genera: neo-Platonic, mechanistic (as in Descartes' work) or, later, Newtonian.

The construction of any particular natural philosophy in the early modern period was complicated by three further sets of considerations. First, each natural philosophy had to make out discursive linkages or articulations to matters of theological, political, and pedagogical interest, as well as, increasingly, to matters pertaining to the status and content of the practical arts. The patterning of these linkages went a long way to defining the character of a particular natural philosophy, and can reveal a great deal about the aims and interests of its author and the contextual forces to which he was responding.

Second, each natural philosopher had to consider the set of narrower traditions of science-like practice which existed at the time, such as astronomy and anatomy, setting priorities and possibly exclusions amongst them, and linking them conceptually to his natural philosophy. This too created a pattern of discursive linkages characteristic of a particular natural philosophy. Natural philosophers competed for status and precedence, and part of that competition involved attempts to co-opt and direct the practice of the already existing traditions of scientific endeavour. The practice of a subordinate science under the aegis of a particular natural philosophy was coloured by the nature of the conceptual linkage involved, as in Descartes' manner of mechanising physiology or optics. However, the macro-history of such sub-fields obviously eluded the control of any given natural philosophy and consisted in the interplay and concatenation, over time, of the ways it was linked to, and thus practised under, competing natural philosophies. The larger history of physiological or optical inquiry would show this character in the early modern period, with Descartes' interventions shaping moments in the process.

Finally, natural philosophising constituted an evolving sub-culture. Institutionalised Aristotelianism faced a host of challengers and the fate, as well as the meaning, of any particular natural philosophy was in the hands of its proponents and adversaries as the process of cultural bidding and competition unfolded over time. In this connection it should be noted that a natural philosophy did not have to exist in an explicit, frozen, systematised form. In any case the degree to which a natural philosophy had become consolidated, and the legitimacy of this consolidation were open to challenge, debate and negotiation. Nothing in fact prevented an individual natural philosopher from offering differently systematised

natural philosophies (or versions of the 'same' natural philosophy) in different circumstances. Descartes notoriously did this, there being considerable differences between the mechanism of *Le Monde* and that of the *Principia* in terms of attempted metaphysical grounding, pedagogical systematisation, and articulation of fundamental concepts. All this points to the shaping of particular natural philosophies by local circumstances and their character as continually renegotiated cultural entities. Indeed many scholars would now acknowledge that the struggles over natural philosophies, which entrained and coloured struggles within the narrower traditions of scientific practice as well, defined the rhythms and moments in that process usually termed the 'Scientific Revolution' of the seventeenth century.

It follows from our perspective, as well as from recent developments in the literature, that neither Descartes' natural philosophy, nor anyone else's, could be produced by applying a universal method, or 'deduced' from metaphysics. Many modern scholars now hold that, although Descartes himself may have believed in the efficacy of his method (at least until it met severe difficulties in the late 1620s), grand, set-piece doctrines of scientific method such as Descartes' cannot and do not control and guide the actual practice in any given field of research, let alone the entire gamut of disciplines. Descartes' technical achievements in mathematics and the sciences cannot therefore be explained as applications of his method, nor can use of his method explain the complex and shifting architecture of his natural philosophy.

Similarly, it is now virtually impossible to believe Descartes deduced his entire system of natural philosophy from metaphysical principles. This folklore arose from the deductivist tone of Descartes' abortive method and from some of his more offhand public and private statements about the issue. It is clear that in his mature work, after abandoning the *Regulae* in 1628, Descartes increasingly came to see that neither the details of particular explanatory models, nor the facts to be explained, could be deduced from metaphysics. In the *Principia* his position became very clear: we may know with certainty from metaphysical deduction that the essence of matter is extension, but we cannot deduce from this truth more detailed explanatory mechanistic models for such phenomena as gravity, light, magnetism, planetary motion, sensory perception and animal locomotion. The best one can say is that such models should not contradict metaphysically derived certainties and that relevant facts must also be considered in shaping explanatory models. Hence, such lower-level models are necessarily hypothetical and can achieve at best only 'moral certainty'.

Given all this, our approach to Descartes' natural philosophy may be termed dynamic rather than static, a perspective shared by most of the papers included in the collection. By this we mean that Descartes' natural philosophy, including his work in the subordinate domains of practice, was continually in process, contested and negotiated during his life and

after his death. This is not to say that Descartes lacked systematising aims or failed to pursue them; rather, it means that we do not believe he ever finally espoused one temporally frozen system, let alone a system deducible from metaphysics or method. To study Descartes' natural philosophy is thus to study his natural-philosophising: his various attempts at systematic explanation of matter, cosmos, causation and method in relation to his practice of those more narrow science-like traditions particularly favoured by him, such as optics, statics and hydrostatics, music theory, anatomy, and physiology. It also necessarily involves the study of his situationally shaped attempts, over time, to enrol followers, marginalise competitors, and defeat opponents, as well as the continuation of these processes by his supporters and detractors, even after he had vanished from the natural-philosophical scene.

Many of the contributions to the collection pay much greater attention to Descartes' immediate predecessors, contemporaries, and immediate successors than is usual. The first is important because we must understand the context in which Descartes' work began: what tradition bequeathed to his generation as problems, techniques, and solutions. The second is important because we need to know how Descartes' contemporaries understood and reacted to his natural philosophy if we are to reach a better sense of just what was at issue for Descartes. What exactly his immediate successors took up, and why they took up what they did, is also of critical importance because twentieth-century understandings of Descartes often bear little relation to how he was interpreted before the twentieth century. This is nowhere more striking than on questions of cognition and the nature of the mind, for Descartes was generally taken as a dangerous materialist from the mid-eighteenth to the end of the nineteenth century, and as the antithesis of a materialist from then on. Paramount among influential modern caricatures of Descartes are Gilbert Ryle's *Concept of Mind* (1949) – with its idea of the Cartesian mind as 'the ghost in the machine', a mysterious spiritual being somehow concealed within a robotic exterior, implicated in a bewildering bifurcation of inner and outer lives – and Richard Rorty's account in *Philosophy and the Mirror of Nature* (1980), whereby philosophy has since Descartes become divorced from questions of practical, moral, and political importance through its arid attempts to ward off epistemological scepticism.

Much of the misunderstanding that lies behind these kinds of account comes from a refusal to take the category of natural philosophy seriously, or even to take any notice of it at all. A distinction between philosophy and science, although it has often been recognised as problematic (especially in the last twenty years), has dominated twentieth-century thinking. This distinction has been applied to physical theory, separating out the properly metaphysical/epistemological/methodological bits from the properly scientific bits, and to cognition, where it has motivated a separation between those questions appropriate to empirical psychology and

neurophysiology, and those appropriate to epistemology. The result is the carving up of questions and domains which, for Descartes and other seventeenth-century thinkers, were part of an integrated project, so that something that made perfectly good sense and had a clear rationale now becomes at best problematic and at worst indefensible.

If one takes the category of natural philosophy seriously, however, we are forced to recognise a number of themes cutting across his project which ultimately must be brought together. These include: his technical work in the various sciences as a function of his natural-philosophical agenda, including especially his little-studied deep concern with anatomy and physiology; his insistence on the central place of medicine in his overall project; the connections between his detailed investigations of specific psychological capacities and his developing ethics of self-government and the management of the passions; the associated, previously almost unexamined issue of his strategies for the organisation and supervision of empirical and experimental evidence; the contrast between his formal doctrine of method, used rhetorically in the presentation of his work, and his actual working styles and techniques in natural philosophy and the subordinate sciences; the links between his theorising about the idiosyncratic dynamics at the basis of his mechanical philosophy and his work in optics and mechanics; his early aims and techniques in natural philosophising; the debates and controversies into which he and his later followers were drawn, and their effects in shaping Cartesian natural philosophy.

The overall thrust of the view of Descartes' natural philosophy presented in the essays in this volume is of something dynamic, something that changes both in response to internal developments and in response to external pressures which shape the milieu in which Descartes pursues his natural-philosophical programme. Although he perhaps failed in terms of his own vision of his mature projects and aims, Descartes' interventions shifted the ground of debate in several key areas of natural philosophy, mathematics and the narrower technical sciences. Our aim is to develop an assessment of Descartes as a central figure in the Scientific Revolution of the seventeenth century, and to go some way to changing the conceptual space within which discussions of Descartes have traditionally proceeded. The essays help to establish that we must recognise, in his work, the priority of natural-philosophical considerations over the kinds of epistemological considerations that came to dominate philosophy in the era of Malebranche, Locke, and Berkeley. Indeed, the detailed accounts of the explicitly natural-philosophical way in which Descartes pursues questions of perceptual cognition, in the later essays in the volume, stands in stark contrast to the idea that the *cogito* and dualism motivate and guide his treatment of cognition.

The volume is split up into relatively discrete areas or topics, and a guide to these areas follows, but the reader will have realised by now that

such divisions are not always sharp, that there are themes which underpin the whole Cartesian enterprise, and that these themes are manifested in different ways in different areas. The kinds of considerations that regulate the mechanist programme in cosmology are very different from those that regulate it in physiology, for example, although there may be unexpected and quite precise parallels, as in the very distinctive and key role of fluids in Descartes' cosmology and physiology.

Mechanics and cosmology

The essays begin with an account of the natural-philosophical tradition in which Descartes was reared and which he saw his own system as replacing. Descartes mentions Aristotelian authors by name only a few times, and the commentaries of the Coimbrans and of Franciscus Toletus are mentioned but once. Yet, as Dennis Des Chene argues, for Descartes, as for other innovators of the seventeenth century, the commentaries and the *cursus*, or textbooks, that gradually took their place in Aristotelian teaching were inescapable. The *Summa quadripartita* of Eustachius a Sancto Paulo, which draws heavily on the Coimbrans, comes up several times when Descartes contemplates using the work as an exemplar against which to set the comprehensive presentation of his natural philosophy that eventually became the *Principia*. Des Chene focuses on the immense project of the Jesuit teachers at the University of Coimbra in Portugal. He surveys the background to the writing and publication of the commentaries, examines the literary character of the texts, and explicates their natural philosophical content. He shows that the commentators, charged as they were with the defence of the faith, strove to clarify Aristotle, to reconcile Aristotelianism with the tenets of the Church, and to shear off the extravagances of their Medieval predecessors, while incorporating some of the achievements of contemporaries, often presenting what was in fact new thought under the guise of commentary, or in the *quaestiones* that accompanied the explication of Aristotle. The commentaries and *cursus* were, by and large, the historically effective Aristotle, the basis of university instruction: whether philosophers rejected, as Descartes did, the philosophy of the Schools, or, like Leibniz, mollified their leave-taking with gestures of reconciliation, or, like Honoré Fabri, continued to adhere to Aristotelian principles while contributing to the new science, for most of them the Aristotelianism of the textbooks provided a vocabulary, especially in logic and metaphysics, that was only gradually superseded. Aristotelianism, moreover, defined to some extent the problems to which philosophers addressed themselves: as is clear from the chapters in the second half of the volume, for example, the range of biological and psychological topics that Descartes took as targets for revisionary mechanistic explanation matches that of the scholastic tradition. Des Chene's essay documents the living culture of systematic natural philosophising, under dominant forms of neo-

scholasticism, into which Descartes and his contemporaries were inducted as adolescents.

Descartes' induction into natural philosophy had a second source, however. It is well known that when Descartes met Isaac Beeckman in Breda in 1618, they became intimate friends, with Descartes serving a sort of second natural-philosophical apprenticeship under Beeckman. They discussed several problems in mathematics and natural philosophy, approaching them with a loose amalgam of mathematics and corpuscular-mechanical theorising, which they termed 'physico-mathematics'. Ten years later, when Descartes went to Holland once again, he and Beeckman renewed their friendship and Beeckman showed Descartes his private *Journal*, in which he had noted several new ideas concerning his mechanical philosophy. Soon, however, their friendship deteriorated into open animosity. Klaas van Berkel looks at this relationship and throws new light on the reasons for its breakdown, thus explicating the first documented instance of conflict over Descartes' natural-philosophical projects. Descartes' letters to Mersenne testify to his fear that Beeckman might claim to have instructed Descartes in his mechanical philosophy. Van Berkel suggests that Descartes was alarmed by Beeckman's intention to publish his mechanical philosophy just at a time when Descartes was considering this as well. Descartes knew all too well that Beeckman and he shared some important conceptions regarding natural philosophy. Hence Beeckman's publication might destroy his claims to being the first to have discovered the right way of doing natural philosophy. Descartes' behaviour towards Beeckman and Mersenne therefore was aimed at discouraging Beeckman from publishing his booklet. In this, van Berkel shows, Descartes succeeded.

It was noted above that Descartes' particular version of the mechanical philosophy embodied his own idiosyncratic style of dynamics. In his chapter, Stephen Gaukroger explores this issue, arguing that what underlay Descartes' physical theory was not kinematics, as is generally thought, but statics and hydrostatics. He notes that Galileo, too, had used a hydrostatic model in his early account of free fall, in *De Motu*, later switching to a kinematic account of free fall in the *Two New Sciences*, where free fall in a void is taken as the core case. Descartes' strategy, according to Gaukroger, was quite different, but no less reasonable at the time, for he continued to use a statically based model. Gaukroger shows that in applying this model to cosmology, Descartes was able to explain the stability of planetary orbits, the transmission of light, and the lunar orbits in terms of the nature of the fluid separating the Sun, the planets, and their satellites. Similarly, he argues that the problematic nature of Rule 4 of Descartes' Rules of Collision can be explained if we assume that there is a static model lying behind Descartes' kinematics. He concludes that while Descartes' static and hydrostatic models produced undeniably problematic results, the success of the kinematic route to dynamics – followed by

Newton on the basis of Galileo's work – should not blind us to the strengths of the Cartesian project, as assessed in the context of his natural-philosophical agenda and the tools at hand for pursuing it.

The core of Descartes' physical theory, as he sets it out in *Le Monde* and the *Principia*, lies in the principle of the conservation of motion (or force of motion), and the three laws of nature that describe how the behaviour of bodies is governed. Peter McLaughlin explores the basic ideas behind the laws of nature, focusing on the case of collision and Descartes' problematical and much disputed conception of 'determination'. He thereby extends Gaukroger's theme of a coherent, but conceptually specific dynamics residing at the heart of Descartes' mechanical philosophy. There are two traditional interpretations of 'determination' – as actual motions or as directions of the motions – and McLaughlin shows that neither of these traditional interpretations can be correct. Rather, it is a hybrid of directionality and the absolute value of a motion. McLaughlin also deals with the nature of the force involved in impact in Cartesian physics, concluding that this somewhat obscure force needs to be clarified in terms of the two relatively better understood forces discussed by Descartes – the forces invoked in the principle of conservation of motion, and in the law of the lever. He shows that a good deal depends on what one takes the surface of collision of a body to be: once this has been clarified, the rest of Descartes' account falls into a coherent pattern.

Descartes' physics, grounded in his dynamics, may have been coherent and defendable in context, but it was almost entirely qualitative. Daniel Garber asks why this was so, and whether, as some have suggested, Descartes was fundamentally unable to see how to apply mathematics to the physical world, unlike his contemporary Galileo. Garber argues, however, that Descartes' correspondence, particularly his correspondence with Mersenne, presents a very different picture. In the 1630s, Mersenne was attempting to build upon the Galilean physics of heavy bodies, seeking to extend Galileo's treatment of machines, bodies in free fall and projectile motion to the understanding of a wide variety of phenomena. Descartes was drawn into this enterprise and his responses are very much in the spirit of Mersenne's Galilean investigations, with Descartes showing himself thoroughly adept at the Galilean programme for a physics of heavy bodies. Garber focuses on Descartes' participation in the geostatics debate and his virtual co-authorship with Mersenne of the *Cogitata Physico Mathematica* (1644). Descartes insisted, however, that his name was not to be given in print, and this raises for Garber the question why Descartes should have wanted to hide his work in mathematical physics. The explanation, Garber argues, resides in the fact that in order to do the kind of mathematical physics practised by Galileo, one had to make certain assumptions about the natural tendency bodies have to fall toward the centre of the earth with a uniform acceleration. Descartes considered these assumptions to be simply unfounded. Using these assumptions,

Descartes was capable of doing physics in the Galilean style with great elegance, but for him this was only a mathematical game, not serious natural philosophy. Hence his reluctance to have his name publicly associated with it. Why, then, did Descartes not publish his own mathematical physics? Part of the reason was the complexity of the behaviour of ordinary bodies in Descartes' physics of vortices. But, Garber argues, Descartes also believed that the full mathematical account of ordinary bodies required empirical evidence that he simply did not possess. To understand the true laws that bodies obey in free fall, for example, we must know how they behave over longer periods of time as they fall through greater distances than he or anyone else had observed. Thus, on Garber's account, Descartes' response to Galileo, as well as his own explanatory agenda, arguably had more to do with matters of empirical adequacy than they did with the demands of systematisation. Indeed, as mentioned above, Descartes' concern with evidence and its management is a feature of a number of other contributions to this volume.

One of the most pressing problems concerning the metaphysical underpinnings of Descartes' natural philosophy was the nature of causation, which preoccupied many of his successors, not least Spinoza, Malebranche, and Leibniz. On the physical level, the issue structured Descartes' notion of force, while at the metaphysical level it inscribed the relation between God and his creation. Approaching the question metaphysically, the most obvious way to explicate Descartes' account was through occasionalism. Desmond Clarke looks at the treatment of causation by La Forge, one of the first Cartesians to write systematically about occasionalism in this context. For La Forge, bodies have the power to move other bodies, but he qualifies this by maintaining that they do not have a power 'from within themselves': the power is an acquired one, supplied and regulated by God. This raises the question: to what extent are bodies genuinely causally active? Clarke shows that the degree to which the Cartesian account of causation was occasionalist was a delicate and finely tuned matter, and that La Forge's attempt to reconcile the reality of the 'finite', causal powers of bodies, and their dependence on God's infinite causality was designed to maintain this delicate balance. In this way Clarke offers a particularly instructive illustration of the renegotiation of a key dimension of Cartesian natural philosophy by a later supporter, the matter having no essentially 'correct' and timeless remedy.

Compared to the metaphysically grounded presentation of his natural philosophy in the *Principia*, Descartes' *Le Monde* had treated 'nature' simply as a theoretical model built up from various elements that we can conceive of clearly. As noted above, this illustrates the variety of natural-philosophical utterance available even to an individual author pursuing the 'same' genre of natural philosophy, in this case mechanism. In his chapter, Theo Verbeek looks at the way in which Descartes' disciple Regius, who was sent *Le Monde* in 1641, develops this way of thinking

about physical theory in his *Fundamenta physices* (1646). Verbeek explains the gulf between Regius' presentation of his natural philosophy and that of Descartes by the facts that Regius was writing in a largely medical context; that his highly problem-oriented method of argument owed more to Ramism than it did to Descartes; and finally, that Regius cleaved to the programme of *Le Monde*, seeing no need for the kind of metaphysical legitimation of natural philosophy that Descartes provides in the *Principia*. This illustrates the ways in which natural philosophical systematisation responded to local epistemic and institutional pressures, and how disputes could arise even amongst members of the same natural-philosophical 'school'. Regius was, as Verbeek shows, a faithful follower of Descartes, but his work led to some quite unCartesian conclusions, causing Descartes to disown both him and his theories. These issues are taken up again by Catherine Wilson in ch. 26, in the context of the mind/body question.

The idea that the ways in which Cartesianism, or any natural philosophy, was received depended to a large extent on local circumstances is further explored by Peter Harrison. He examines how English natural philosophers took up Descartes' cosmology and cosmogony, showing how it was intimately tied in with the question of sacred history, that is, the sequence of, and significance of, historical events as set out in the Bible. Harrison shows that these English controversies were not as alien to the tactics and tenor of Cartesian cosmology as might at first appear, and that Descartes' own account had already harboured an in-built sensitivity to such issues. He also demonstrates that the central issue was not whether Cartesian natural philosophy provided a parallel creation narrative. It was, rather, whether Cartesian or Aristotelian natural philosophy would shed more light on the biblical account of creation. That is, the issue was not Cartesianism versus religion, but rather which system within the field of natural-philosophical options fits better with the English reading of Genesis as history. This chapter, together with that of Peter Anstey on the development of and diversity of English responses to Descartes' cardiology (ch. 18), offers a clear, sustained picture of the response to Cartesian natural philosophy in England.

Method, optics and the role of experiment

It was suggested above that, although grand doctrines of method, such as Descartes', do not actually control the practice of the technical sciences (problem solving in traditions of scientific practice requiring field-specific tools, techniques and standards), such grand method discourses do play rhetorical roles in the presentation and negotiation of knowledge claims. It follows that both grand method theories and actual working techniques must be studied. The first two papers in this Part offer such a balanced approach.

Timothy Reiss explores Descartes' concerns with method in the context

of sixteenth-century neo-Aristotelian thinking about method. He argues for a continuity, in particular, between Zabarella's attempt to reformulate the Aristotelian treatment of discovery in natural philosophy and Descartes' attempts to think through questions of method. Reconstructing the content of debates over method in the sixteenth century, Reiss shows that Descartes was aware of these disputes; that he transformed these debates and that the outcome of this transformation was his treatment of method in the *Discours*, as well as in his answers to the second set of objections to the *Meditationes*.

In contrast, Dennis Sepper uncovers what one might term the central working technique involved in Descartes' early mathematical and physico-mathematical work. In his mature mathematical work Descartes' played down the intuitive and visual aspects of geometry in favour of the 'transparency' of algebraic procedures. Sepper shows, however, that Descartes' early theory of proportions (of which his algebra is really a formalisation) was intended as a shorthand representation of the concrete, visualisable relations of geometric figures. Descartes' use of figures extended to the solution of mathematical and physical problems in early writings like the *Compendium Musicae*, the manuscripts on the proportional compasses and free fall, and in later work on the solution to quadratic equations, topics also pursued by Decyk (ch. 19) and Schouls (ch. 20). A more formal methodological rationale for this technique of 'figuration', as it might be called, was presented in the *Regulae*, where the notion that sensation proceeds by means of a kind of natural geometry is first set out, a theory which was later to be developed in the *Dioptrique*. Sepper shows that the key concept involved in Descartes' trying to capture the essential ingredients of problems in a 'figurate' way was his idea of the imagination as something that naturally operates with lines and line lengths. Ultimately the need for figuration arose for Descartes because there was for him a sense in which algebra is only potential knowledge, whilst geometry is real knowledge, its figures sharing the character of what they are about.

Sepper's analysis casts light on Gaukroger's theme of the hydrodynamic origins of Descartes' dynamics, as well as the reconstruction of Descartes' early optical work offered in John Schuster's chapter. In his *Dioptrique* of 1637 Descartes presented the law of refraction by 'deducing' it within the terms of a model in which light was represented by the motion of some curious tennis balls. Many of Descartes' contemporaries doubted the cogency of this model, and failed to grasp the theory of dynamics upon which it is based. Questions were also raised about how Descartes had obtained the 'law', if not through this dubious deduction. Schuster cuts a path of reconstruction through these controversies. Beginning with the *Dioptrique* he shows that the tennis-ball model was an adequate model for what Descartes took light to be, an instantaneously transmitted mechanical impulse, provided one understands Descartes' underlying dynamical concepts, elucidated by Gaukroger and McLaughlin in earlier chapters.

This then permits a reconstruction of how the law was discovered, or constructed, in 1626/7 by Descartes and his friend Claude Mydorge, using techniques from traditional geometrical optics. Their work involved nothing about the dynamics of light or tennis balls, raising the question of the relation between the law and Descartes' dynamical and methodological rationalisations of it. Schuster examines Descartes' earliest 'physico-mathematical' musings about light and refraction, showing that they could not have directed Descartes to the law. He argues it was only after the initial construction of the law in 1627 that Descartes literally read revised principles of the dynamics of light out of the very geometry of his key discovery diagram, forging the concepts he later used to 'deduce' the law from the dynamics of light or tennis balls. Schuster then shows how Descartes moved towards a dynamic rationale for the law, first with an ingenious balance beam analogy, followed by the tennis ball model itself. All this shows affinities to Sepper's analysis of Descartes' early figurate technique of working, while Descartes' methodological account in Rule 8 of the *Regulae* of his optical discoveries is interpreted as a cover story, obscuring the pitfalls, hesitations and incongruities involved in his long course of optical research. The final step in the reconstruction is a return to the text of the *Dioptrique* and *Météors* to show why Descartes bothered with the cumbersome tennis-ball model of light at all. The answer, Schuster argues, resided in the demands of his theory of colour, although here again there was compromise and rhetorical slight of hand, for Descartes' colour theory and his theory of light transmission did not cohere – the former required the actual translation of the light causing particles, whilst the latter denied precisely that point.

If Descartes' most important result in geometrical optics is his construction of a law of refraction, his crucial work in physical optics was in the area of the formation of colours. In his chapter, Jean-Robert Armogathe looks at Descartes' account of the formation of the rainbow, reinforcing the theme of the importance to Descartes of empirical evidence and its management, which is taken up in the final two chapters of this Part.

Guillermo Ranea shows that Descartes treated experience and experiment as something problematic that had to be regulated, thus demonstrating the existence of an earlier and continental variant of the English controversy over how one defines the 'experimental life', studied by Shapin and Schaffer. Ranea focuses on Descartes' dialogue, *La recherche de la vérité par la lumière naturelle*, in which one of the interlocutors, Poliandre, is cast as the *honnête homme*, relying on his natural faculties and not on scholastic training. In addressing himself to the *honnête homme*, Descartes is identifying an audience of practical men whom he believes he can educate to adjudicate (in his favour) in scientific controversies. Ranea therefore argues that Descartes intended his natural philosophy as something that might close controversies stirred by the endemic variability and unreliability of factual reports.

Trevor McClaughlin looks at the role of experiment in Descartes' immediate successors, focusing on the case of Jacques Rohault, one of the most distinguished Cartesian experimental natural philosophers of the second half of the seventeenth century. Given the themes of several earlier chapters, one should not be surprised that experimentalism was a legitimate development of Descartes' own project. McClaughlin outlines a number of factors that motivated and shaped Rohault's experimental programme (thereby illustrating the situational patterning of a particular variant of Cartesian natural philosophy): Rohault's close ties with craftsmen and resulting access to high quality instruments; the ever-growing threat of censorship of more metaphysically and theologically oriented approaches to Cartesianism; and the utilitarian and Baconian rhetoric of the early years of the Parisian Académie des Sciences, to which Rohault aspired, in vain, to be elected. McClaughlin succeeds in demonstrating the care taken over the management of experiment in Rohault's version of a Cartesian experimental natural philosophy, thus illustrating how 'the experimental life' was lived on the Continent, amongst committed natural-philosophical systematisers, providing a striking contrast with what Steven Shapin and Simon Schaffer have depicted – in their influential *Leviathan and the Air-Pump* (1985) – as the resolutely atheoretical and amathematical approach taken by Robert Boyle and others in England.

The natural philosophy of body and mind

The chapters in the final three Parts broadly deal with what may be termed Descartes' natural philosophy of body and mind. There is, of course, no grand metaphysical system or set of methodological prescriptions driving Descartes' work across the range of natural-philosophical domains in which he was interested. His writings on medicine, physiology, and psychology respond to a diversity of contexts and problems. To some extent his views across these areas do share a commitment to a bare 'mechanical' form of explanation, showing how natural phenomena can arise from the motions of material particles. But the range of topics and explanations canvassed in the second half of the volume demonstrate that this commitment to mechanism does not inevitably render Descartes' theories insensitive to the diversity of the phenomena in question.

Descartes' concern with what later came to be known as the life sciences focuses on cognition and physiology, and these are as integrated into a natural-philosophical programme as his work in the physical sciences. Not just that, but it is the same natural-philosophical programme: one guided by mechanism and particular conceptions of the roles of mathematics and experiment, but which is also responsive to theological, pedagogical and other considerations, and which is located in an often fierce combat among competing natural philosophies in which particular issues come to occupy centre-stage for reasons which may be quite

independent of the trajectory of Descartes' own research or that of his followers; he (or his followers) has however to take them on to establish the credentials of his own programme. This is true of his work in mathematical and physical enquiry, and it is no less true of his work in the life sciences, which were in many respects an even more contentious area.

Under the rubric 'life sciences' are included some areas which are to us straightforwardly biological, such as general physiology, cardiology, and embryology. But they also include a number of domains which blur our own disciplinary boundaries, such as imagination, perception and the senses, memory, the passions, psychosomatic medicine, and the psychology of meditation. As the essays show, Descartes employed a variety of methods for addressing these topics. Two common misconceptions are clearly rejected: on the one hand, Descartes was no less concerned with empirical evidence in physiology than in optics, and he undertook sequences of anatomical and physiological experiments, for example in embryology and on the circulation of the blood. On the other hand, his own claims to be devising entirely new theoretical frameworks should not blind us to his reliance on a range of (often unnamed) sources in Renaissance medical writings.

Physiology

It has long seemed obvious that Descartes' defence of an incorporeal and immortal soul or mind was coupled with a set of unfortunate concomitant views about nature, the body, and the physical world. Even the most complex natural operations are to be reduced to mere clockwork; second, the messy, pulsing, decaying and regenerating processes of the biological realm are, in the infamous 'beast-machine' doctrine, to be reduced to unconscious and unfeeling automatism; and, finally, the human body is either to be loathed as a hindrance to our true and distant goal, or at best to be mechanically maintained as the soul's temporary vehicle. Along with the division of mind from body, the realm of meaning is, according to this mythical Cartesianism, to be divorced entirely from the science and the realm of causality.

The genuine force of Descartes' mechanisation of physiology lies in his rejection, examined in many of these papers, of vital and animal souls. In Christian-Aristotelian orthodoxy, these intrinsically organic souls, distinct from the rational soul, were meant to explain the animation of biological matter and the various physiological processes. Descartes was concerned, like his friend Marin Mersenne, with eliminating the possibility, implicit in certain naturalistic Renaissance medical writers, that the self-organising powers of specific biological matter might extend to reason, since this would threaten beliefs in immortality. Attacking the indiscriminate attribution of intention and intrinsic purpose to organic parts, Descartes insisted that organic corpuscles have no more powers of deliberation or

reasoning than do any other parts of the realm of extended matter. Thus far is the mainstream account vindicated. There is no doubt that Descartes was committed to the ultimate inertness of matter, and to the idea that ultimately order and complexity must derive from the external activity of the Creator. But there is considerable doubt that this basic commitment to inert matter entails that there is no genuine development and self-organisation in nature at all, or that natural philosophy should not be a legitimate path of investigation into its changing processes.

So while it is true that even the most complex natural processes are to be reduced to mechanical operations, this does not mean that they are all simple clockwork. As several of these studies stress, we can be easily misled by our images of clinically regular wheels and cogs into thinking that Descartes is simply eliminating the biological in advance. In fact, many seventeenth-century conceptions of the machine did not render complexity incompatible with mechanism, and the idea that organic bodies are machines did not entail that they are hard, rigid, or preprogrammed, as opposed to fleshy, flexible, and adaptive. As with Descartes' fluid-based physics and cosmology, there is a sense in which complexity is built into the physiological system once it has been set in motion.

Although he never took a degree in medicine, Descartes had an extensive grasp of anatomy and physiology. William Harvey and other physiologists discussed his ideas on the nature of blood and the movement of the heart and he was consulted by physicians on medical problems. Annie Bitbol-Hespériès looks at Descartes' work on physiology. She takes as a test case his differences with Harvey over cardiology, and his account of the union of mind and body, showing how Descartes eliminates both the devotional wonder at the body that characterised teleological traditions, and also a series of old 'cosmobiological' links between body and cosmos, such as the idea that the action of the heart can be modelled on the sun.

Stephen Gaukroger's chapter begins by looking at more general questions about the aims of a mechanist physiology. Stressing the importance of Descartes' theory of matter in his account of physiology, he shows how this account is in stark opposition to more traditional attempts to explain differences in physiological function, either in terms of different kinds of matter (the four elements) or in terms of the Aristotelian vital, animal, and rational souls that animate matter at different levels. The bulk of the chapter is then devoted to discovering what resources are available within the framework within which Descartes chooses to work, and it focuses on two such resources. The first is his elimination of a goal-directedness from physiological processes, the clearest case of this being in his embryology. The second is his attempt to deal mechanistically with processes that involve receptive capacities, something manifest in his treatment of perceptual cognition.

In pursuing his mechanistic physiological programme, Descartes invokes his doctrine of *'bêtes-machines'* (animal machines). Katherine Morris examines

just what is involved in this notoriously problematic and contentious doctrine. She argues, first, against the idea that animals are unconscious, that they can neither think nor feel: on the contrary, she points out that it follows from Descartes' doctrine that they can feel. Against the neo-Aristotelians, who ascribed sensitive souls to animals, Descartes' view is that sentience can be explained mechanically. The post-Montaignean argument, which held that animals could think, and hence must have a rational soul, was something that Descartes could not refute in such a clear-cut way. Possession or non-possession of a rational soul was an essential matter, so he could not demonstrate empirically that animals lacked rational souls. Nevertheless, he did argue that it was 'morally certain' that they lacked rational souls. Morris manages to tease out the intrinsically moral force of the human soul in Descartes' natural philosophy, as the bearer of responsibility and free agency. This nuanced understanding of the role of the soul in Descartes' system makes it difficult to separate Descartes' account of mind from his metaphysics, theology, physiology, and ethics.

Peter Anstey, arguing that the details of Descartes' account of the circulation of the blood have not always been properly understood, examines the case of Cartesian cardiology. The issue is not merely one of physiology, however, for basic questions of natural philosophy were tied in with Cartesian physiology, and its reception was closely bound up with natural-philosophical issues. Anstey shows this by using the reaction in England to Descartes' cardiology as a test case to throw light on the connections between questions of physiology and questions of natural philosophy. Some responses, like that of Digby, were purely natural-philosophical whereas others, like that of Lower, were purely physiological, yet the response in England, unlike that in continental Europe, was uniformly negative. As Anstey shows, despite the fact that there was no comprehensive evidence against Descartes' idea that the movement of the heart is caused by the ebullition of the blood until Lower's work on the colouration of the blood in the late 1660s, and despite deep divergences in natural philosophies in England, ranging from Harvey's vitalism to Boyle's mechanism, rejection of Cartesian cardiology transcended all party disputes.

Imagination and representation

In a number of the chapters on imagination and thought, Descartes' accounts of perception, imagination, and memory are described in terms of the coding, transmission, and reconstruction of information. The history of cognitive science, often seen as the unmasking of one or other of Descartes' errors, may in fact provide some resources for subtler readings of his views. It is not by any means that all the contributors are sympathetic to the general project of cognitive science: indeed, some explicitly

deny the utility of the information-processing interpretation. But even when they look back to quite different alternatives, describing Descartes' reliance on earlier traditions of faculty psychology, or perspectival art, they are seeking more naturalistic readings of his project than the traditional focus on dualism alone would allow.

While we see perception, dreaming, memory, and imagination as specifically cognitive functions, for Descartes they were, in one legitimate sense, life functions, on a par with respiration and nutrition. In this sense, beasts do have genuine memory and perception, and many such functions in humans operate for the most part without the intervention of the soul. Pursuit of Descartes' extensive accounts of the nature of these capacities sanctions attention to the details of psycho-physiological processes, and locates his work in a longer history from Aristotelian theories of the internal senses to the nineteenth-century psycho-physics described by Gary Hatfield, and beyond. Obviously it is not enough simply to announce that computational neuroscience, for instance, is now modernising Descartes' vision of reflex action in neural nets: but the hope is that sensitivity to obstacles and problems in our own attempts to naturalise cognitive capacities may help to refresh contextual historical readings of the philosophy of mind.

As a result, the place of imagination in Descartes is thoroughly re-evaluated. Rather than an unfortunately particularising capacity which distracts us from the true business of abstract thought, imagining in its various forms appears (especially in the chapters by Sepper, Decyk, and Schouls) as an essential bridge between theory and practice. In turn, the role of memory is reconceived: instead of being the general and untrustworthy means by which the results of intellectual intuitions have to be stored in the mind, remembering appears (especially in the papers by Fóti and Sutton) as the focus of Descartes' attempts to make us more aware of the effects of our own specific and embodied history. Closer attention to the detailed operations of the nervous system, and in particular to its ties with the circulatory and digestive systems, reveals surprising complexity, activity, and interconnectivity in the human body according to Descartes. Finally, contexts appear for the pineal gland and the 'animal spirits' beyond the notorious absurdity of linking natural and supernatural realms: even within the animal economy, organic automata (and humans when their minds are elsewhere) can form genuine representations of the world, patterns or traces, which retain the effects of experience and which ground adaptive responses over time.

These representations are neither ontologically ambiguous sense-data, nor simple reflections or copies of objects. Many of the contributors quote passages in which Descartes rejects the idea that representation operates by resemblance. The patterns traced by neural fluids on the surface of the pineal gland are not pictures of things, to be viewed or interpreted by the separate soul. At least this is clearly the shape of the theory for which

Descartes hoped, and it is only after acknowledging the scope of this ambitious programme for the mechanistic explanation of various specific perceptual capacities that Celia Wolf-Devine, for instance, is able to convict him of failing successfully to discharge the 'homunculus'. In the symposium on perceptual cognition, the differing views taken by Peter Slezak and John Yolton, for example, on whether or not Descartes was seeking a primarily causal/mechanistic theory, directly reflect their respective positions on current issues in philosophy of mind.

According to these reinterpretations of Descartes, the mind is not seeking simply to reflect or mirror a static world. This is to question a persuasive narrative synthesised and entrenched by Richard Rorty, who attributes the divorce of questions of practical, moral, and political importance from philosophy in part to the seventeenth-century invention of a 'veil of ideas', which seems to cut us off from the natural and cultural environment. A number of the essays in this volume reject the idea that Descartes removed perceptual processes so decisively from nature. He did indeed deny that we are unproblematically aware of the true nature of our world, and did insist on the gap between appearance and reality to which his corpuscular mechanism committed him. But the fact that processes of selection, distortion, reconstruction, and enrichment operate on perceptual data is precisely a spur to understand both the general 'natural geometry' of perceptual cognition, and the specific idiosyncrasies of experience which drive different individual responses. We can recover information about real objects without it simply being impressed or copied, just as we can retain and reconstruct past episodes and events without the past events having to be permanently stored at single inner locations.

In her chapter, Betsy Decyk looks at the connections between perspectival painting and Descartes' natural philosophy. The perspectival tradition had, not surprisingly, elevated the standing of geometry, although Alberti had argued that a knowledge of geometry is even more important than a thorough grounding in the liberal arts for the painter. Both the writers on perspective and Descartes thought of our understanding of nature in terms of an ability to geometrise it. Moreover, both thought in terms of a two-dimensional grid imposed on a three-dimensional scene: in Descartes' case this grid is psycho-physiological, and it is a distinctive operation of the imagination, whereas in the perspectivists' case it is a physico-geometrical device that defines mathematical relations between objects in the picture. Decyk stresses the idea of the grid as an overlay in both cases, and draws attention to Descartes' descriptions of the imagination as providing a mathematical overlay on corporeal objects. Moreover, both the perspectivists and Descartes are intrigued by the flexibility or transformability of the optical/perceptual image.

Peter Schouls' chapter continues the investigation of Descartes' account of the imagination as a crucial source of hypotheses. He argues that just as there is a corporeal and an intellectual memory in Descartes, so too is there a corporeal and an intellectual imagination, and it is the latter that plays the more important role. Indeed, it ultimately underpins the relations between poetry, philosophy, art, and science. Schouls concentrates on the case of intellectual imagination in algebra and in geometry, where the diagrams it helps us to produce can mediate between pure thought and its practical applications. In turn, the neurophysiology by which the corporeal imagination is to be understood explains how what is first merely imaginatively possible can be linked with the actual in the physical world.

The problem of visual spatial perception presents serious difficulties for Descartes' project of finding a wholly mechanistic account of vision. Celia Wolf-Devine argues that the core mechanism of vision comes close to providing what he wants, a kind of mechanised Aristotelianism that conveys the figure of an object (rather than its 'form') to the soul at the pineal gland. But it does not account for how the defects of that image (such as two-dimensionality, inversion, perspective distortions) are corrected for, and Descartes does not succeed in providing any mechanistic explanation that he finds completely satisfactory, especially for size and shape perception. He is therefore driven to hypothesise an increasing role for judgements by the mind. But this leads to problems. If the mind is to correct for defects in the retinal image, it must have some access to that image – something very hard to explain on Descartes' premisses. Furthermore, the problem of animals' visual spatial perception becomes insoluble if judgement or reasoning is necessary to account for the perception of distance, size, and shape by sight. And if their perceptual abilities can be explained without reference to either conscious sensations or judgements, why not do the same for human visual spatial perception?

One of the most important stimuli for rethinking Descartes' account of perceptual cognition in recent years has been the work of John Yolton, who has suggested that Descartes' theory of perception is not a form of indirect or representative realism, but a form of direct realism. Yolton's influential reading drew attention to Descartes' discussion of perceptual cognition as the grasp of natural signs in the first chapter of *Le Monde*, and argued that, like his follower Arnauld, Descartes saw the relation between brain traces and the mind as significatory or cognitive, rather than simply causal. In ch. 22, four commentators address Descartes' view of perceptual cognition, and Yolton's interpretations of it. David Behan puts the issue in the context of sophisticated late scholastic discussions of signs. While supporting the view that, for Descartes, brain motions are signs to the mind which lead it to produce a sensation, he queries Yolton's direct realist interpretation of Descartes, and seeks to clarify Yolton's distinction between representation and signification. Peter Slezak agrees with Yolton that historical debates may be relevant to foundational issues in modern philosophy of mind, such as the nature of representation, but argues that the passages cited by Yolton in support of a non-mechanistic account of

perception are in fact compatible with a purely causal view. The centrality of implicitly causal language for describing the relation between brain motions and sensations is also defended by Celia Wolf-Devine. She goes on to reject a key claim of Yolton's 'reverse-sign' doctrine, the notion that physical motions in the brain signify not objects in the world, but sensations. Finally, Yasuhiko Tomida examines the relation between the perceptual and the corpuscularian theory of matter shared by Descartes, Locke and others, questioning Yolton's claim that Descartes and other early modern philosophers were concerned to set out a form of direct realism, and not a view of perception in which ideas stood proxy for the objects perceived. In his response, John Yolton replies to the various views with concessions on some points of his interpretation, accepting for example that the brain motions signify objects rather than ideas, but with a vigorous defence of others, such as Descartes' realism.

Mind and body, thought and sensation

The various approaches to Descartes' dualism in this volume offer quite different perspectives on the vexed questions of the relation between mind and body, and the nature of thought and sensation, going beyond the usual uncomprehending complaints about Descartes' unlikely solutions to the problem of causal interaction between thinking substance and the pineal gland. The re-evaluations do not swing to the opposing pole by following La Mettrie's claim that Descartes was a closet materialist. Instead, in one way or another exploring Descartes' insistence on the theoretical and practical importance of the union of mind and body, they agree in stressing his rejection of the Platonic or angelist version of dualism in which the soul is merely lodged in the body as a pilot in a ship. On the other hand, as we have seen, the revisionary perspectives on the natural philosophy of the body in this volume challenge the claims about Descartes' evisceration and disenchantment of nature in a number of ways.

Hence, while it is true that animals are automata and have, for Descartes, no rational souls (they are, in Katherine Morris' term, 'conscienceless'), this does not mean that they lack sentience and all awareness: although as John Wright points out, the Cartesian natural philosopher Claude Perrault did question Descartes on this doctrine and tried to reintroduce the soul to explain vital functions and sentience. In Descartes' view, as several contributions stress, these automata specifically are organic, in some sense self-moving machines. Descartes did rule out the possibility of a science of (rational) mind, but he allowed and encouraged the investigation, within natural philosophy, of many capacities shared by humans and beasts. There can, then, be sciences of motor control, vision, sentience, imagination, memory, and dreaming.

Similarly, while it is true that the operations of the human body, including the brain, are no longer (since the Fall) within the voluntary control of the soul, and thus that the moral life demands some vigilance against the unanalysed effects of bodily habits, this does not mean that the soul is inevitably and irretrievably hostile to the body with which it is united. In medicine as in morality, Descartes hints at theoretical and practical programmes for the careful mapping, exploration, and only ultimately exploitation of a range of truly psychosomatic phenomena. Although there are some differences of emphasis among the chapters that touch upon this issue, nowhere here is there much support for the picture of Descartes as evil metaphysical magus, seeking to make us masters and possessors even of our own bodies, anticipating the technologising impulse of later relentless modernisers. Cartesian physiology and psychology are thus here revealed not as symptomatic of the 'death of nature', part of the objectification of a barren cosmos, but rather, in Karl Rothschuh's words, as 'representative of the baroque', with Descartes exemplifying 'a dynamic interpretation of nature'.

Véronique Fóti looks at Descartes' distinction between two kinds of memory. The first, which is discussed extensively in the *Regulae*, is corporeal, and is discussed in psychophysiological terms. The second kind of memory, intellectual memory, is more elusive, and discussion of it is confined to Descartes' correspondence from 1640 to 1648. Fóti argues that some light can be thrown on the nature of intellectual memory by considering the *Meditationes*, where Descartes argues that, in the course of a proof, although he may remember having proved something, if he has 'turned his mind elsewhere', that is, if there is a break in continuity in memory, he cannot remain assured of its proof. It is not immediately clear just what the problem is here – misremembering and difficulties with the faculty of memory as such seem to be ruled out – and Fóti uses the problem to try to tease out just how Descartes may have conceived of intellectual memory.

In his chapter, Gordon Baker discusses the relation between sensation and thought by focusing on Descartes' claim that the senses are unreliable witnesses. When Descartes makes this claim, Baker suggests, he is presupposing that sense perceptions can only be contradicted by other sense perceptions, and each sense report can be treated as a separate piece of testimony, that is, as the report of a fresh witness, whose degree of reliability is not known. It is in this context that Descartes' warning that we have been misled by sense-perception in the past should be read: in particular, he is not, *per impossibile*, suggesting that we can do without sense perception. However, on the face of it this interpretation conflicts with the way in which Descartes leads up to the point, with some of the things he apparently concludes from it, and with the fact that he occasionally seems to suggest that the senses and the pure intellect can conflict. To yield a consistent interpretation, Baker argues, we need to go back and discover the purpose behind Descartes' analogy between sensation and witnesses. Two

considerations are important here. First, when Descartes says that what he has accepted as most true up to now has been acquired 'through the senses', the relevant contrast classes are the two other cognitive faculties – the imagination and the intellect. Second, 'most true' means something like 'having the highest degree of certainty'. And when he tells us that the senses have occasionally deceived him, and that therefore we should not trust them completely, he is saying that, in cases of perceived conflict, although he has shown a preference for the testimony of the senses, we should not automatically resolve any conflict between the senses and the intellect in favour of the senses. Whereas modern readers have found this line of reasoning opaque or speculative, educated seventeenth-century readers would have found it perfectly familiar, and the difference arises, Baker argues, because of a very different understanding of the provenance of logic in the seventeenth century, which includes what Baker calls a 'logic of testimony'. Descartes' overall aim is to establish the narrow jurisdiction of the senses, and the comprehensive scope of the intellect, whose principal power is *conscientia*.

The radical dualism of the *Meditationes* has generally been characterised in terms of its putting all accessible mental states on a par and its treatment of sensory qualities as being mental. Gary Hatfield draws attention to two other aspects of Descartes' account of the mind. The first is his stress on the pure intellect. A fundamental aim of the *Meditationes*, an aim on which its metaphysical arguments depend, is to make one aware, perhaps for the first time, of one's own faculty of pure intellect. Descartes' project is to alter the reader's Aristotelian beliefs about the faculties of the mind while at the same time drawing one into using the newly recognised faculty to perceive the first truths of metaphysics. By his own lights at least, Descartes' achievements in the *Meditationes* must stand or fall with the correctness of his anti-Aristotelian understanding of the power of pure intellect. The second theme concerns Descartes' naturalism about the mind. It has been common to see Descartes, in virtue of his substance dualism, as having placed the mind 'outside nature'. He made the world safe for mechanistic physics by deanimating the 'physical' world, that is, the world of particles in motion, and collecting all mental phenomena in the soul as a separate substance. But, as Hatfield argues, Descartes included the mind as part of nature, and despite his dualism he continued an established line of thought according to which the operation of the senses is open to empirical investigation; indeed, in virtue of his dualism, he indicated a new line of thought leading to the search for specifically psycho-physical laws, that is, laws linking non-mental bodily states to states of mind. The question is whether the combination of these two themes, the idea that the pure intellect provides the normative foundation of his metaphysics, and his view that the intellect is in some sense natural, is effectively an appeal to psychologism. Hatfield argues that the question is not so straightforward, and in particular that the relations between the terms

'mind', 'nature', and 'psychology' in early modern thought is more complex than it has generally appeared.

Catherine Wilson explores the hermeneutics of Descartes' account of the mind and the body. Experience and cognition are sometimes described as if they were purely corporeal functions, and at other times experience and thinking are described as if they were independent of the body altogether. Wilson argues that we get ourselves into unnecessary difficulties if we treat this as an either/or situation; rather, there are degrees of belief and Descartes' claims have to be located within a continuum of degrees of beliefs. This raises the question of the hermeneutics of belief, and several hermeneutical devices can be identified in seventeenth-century writing: raising theses as possibilities, even if one goes through the motions of refuting them, means that theses that would otherwise not be taken seriously have to be considered on their merits; and giving intentionally unconvincing arguments for a conclusion while omitting more plausible arguments for it are a way of undermining the conclusion. Descartes' critic Voetius accuses him on these counts, and specifically charges that he gives poor arguments for the mind/body distinction so as to undermine it while appearing to support it. And to complicate matters of interpretation, there is a shift in Descartes' thinking away from stressing the similarity between human and animal faculties in *L'Homme* to stressing their differences in the *Meditationes*. Following through the disputes with Regius, Wilson highlights the highly contextual nature of a number of the claims about the mind/body relation, and points to a fundamental ambiguity in Descartes' position.

In his chapter, John Wright explores the response to Descartes' theory of soul in the work of the late seventeenth-century natural philosopher Claude Perrault. Wright describes Perrault as taking issue with a number of specific themes in Descartes and Malebranche, seeing the union of soul and body as fundamentally voluntary and under the rational control of the individual soul. Complaining that Descartes gives corporeal explanations for many functions of the soul (an interpretation which, however unusual among twentieth-century historians, was common in the early modern period), Perrault refers life functions as well as cognitive functions to the individual will of the organism, rather than to nature or to God.

John Sutton argues that Cartesian physiology is modelled on fluid dynamics: bodily processes, including the whirl of animal spirits across the brain's folds, are context-dependent and causally holistic. The innards are reciprocally joined to the cosmos and culture: bodies are but temporary pockets of stability. Corporeal memory and imagination mark brain pores with specific histories; the permeable bodies of animal automata bear traces of particular experience. Because long-term memory involves this plasticity, compound creatures like humans, who think as well as dream, can use the mechanisms of association for moral purposes. The extended

autopersuasion that Descartes recommends to Elizabeth and in the *Passions* is the deliberate alteration of the physiology of passion and association by effort and habit. Virtue is the application of intellect and will to extend control over bodily and associative responses normally beyond conscious reach. So expertise on the self involves a slow immersion in embodiment, and psychological work on one's own history and body. Analysis of Descartes' notions of disposition, habit, and temperament shows Cartesian ethics to be a set of provisional maxims, applicable differently in each individual, for applying intelligence to the reflexes, and recolonising the body.

Dennis Des Chene begins by noting that, although Descartes' natural philosophy has as one of its chief aims the preservation of health, he seems to have no normative conception of well-being. Such normative conceptions are difficult to capture in a natural philosophy which does not allow notions of ends, but Descartes did have two ways of approaching the question. The first was via a biomechanics, which treats the body in isolation from anything else, as a piece of material extension, so that any ends it has are external to it. Although this is the way in which most commentators have conceived of Descartes' approach to medicine, Des Chene argues that it is in fact via the completely different route of psychosomatics that Descartes approaches these questions. The difference is that, on the psychosomatic conception, the object of medicine is the union of mind and body, something which has ends that are internal to this union. Nevertheless, there are both biomechanical and psychosomatic trajectories in Descartes' thought and Des Chene brings these out by looking at the views of the next generation of Cartesians on the question of health, showing how Andreae adopts a psychosomatic model, Barbeck a biomechanical one, with Clauberg somewhere in the middle. As to the evolution of Descartes' agendas in this area, there is a clear difference of emphasis between Des Chene and Wilson: Des Chene sees a far-reaching transition, partly under the influence of Princess Elizabeth, from the pure early 'biomechanical' medicine to the more contextual and individualised psychosomatic medicine by the time of *Les Passions de l'Âme*; while Catherine Wilson rejects the idea that any crisis turned Descartes from an austere metaphysics to a richer sense of embodied and passionate life. As we have seen, she argues instead that the defence of dualism was a temporary and context-dependent interruption to a continuous and consistent interest in the psychophysiology of the mind/body union.

Descartes' account of cognition is in some respects more alien than it first appears, and in other respects more familiar than it first appears. His account of knowledge, as set out in the *Meditationes*, seems unproblematically familiar, however archaic the reliance on God might seem. But this reading is possible only on condition that we minimise the element of 'meditation' in the *Meditationes*, that we treat the meditative element as something we can abstract from the text. Dennis Sepper argues that, in doing this, we may be missing something very crucial in the *Meditationes*. The term 'meditation', although traditionally associated with a religious form of reflection (in Augustine and Ignatius, for example) had also traditionally had a specific philosophical significance, a significance it continued to have in Descartes' time. It was basically a kind of thought (*cogitatio*) standing somewhere between cogitation and contemplation: cogitation begins with sensory and memorative images of things which touch the mind; consideration of these cogitations with the aim of discovery constitutes meditation; and the recognition of something unifying or pervading the manifold is contemplation. Descartes' early biographer Baillet tells us that he called the operations of the imagination 'meditation' and those of the understanding 'contemplation'. As Sepper points out, there is nothing specifically devotional in this use of the term 'meditation': its orientation is psychological and indeed the tripartite cogitation/meditation/contemplation structure is part of a larger network evident in the traditional psycho-physiological theory of the internal senses in which Descartes was steeped. The early *Regulae* exhibit this meditational quality, the cognitive value of the imagination playing a key role, but Sepper argues that, despite a restriction of the direct cognitive value of the imagination in the later works, it is also to be found in the *Meditationes*, where the distinctive meditational process of going back over material, resuming previous considerations, taking up earlier considerations that have been put aside or left incomplete, is followed. What is involved is a distinctive – 'meditational' – way of thinking through problems that has disappeared from our culture but which informs Descartes' approach.