DESCARTES' SYSTEM OF NATURAL PHILOSOPHY

STEPHEN GAUKROGER

CAMBRIDGE
UNIVERSITY PRESS

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK
40 West 20th Street, New York, NY 10011-4211, USA
10 Stamford Road, Oakleigh, VIC 3166, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain
Dock House, The Waterfront, Cape Town 8001, South Africa

http://www.cambridge.org

First published 2002

Printed in the United Kingdom at the University Press, Cambridge

Typeface Baskerville Monotype 11/12.5 pt. *System* LaTeX 2ε [TB]

A catalogue record for this book is available from the British Library

Library of Congress Cataloguing in Publication data

Gaukroger, Stephen.
Descartes' system of natural philosophy / Stephen Gaukroger.
p. cm.
Includes bibliographical references and index.
ISBN 0 521 80897 9 (hardback) – ISBN 0 521 00525 6 (paperback)
1. Descartes, René, 1596–1650. I. Title.
B1873 .G38 2002
194 – dc21 2001043655

ISBN 0 521 80897 9 hardback
ISBN 0 521 00525 6 paperback

Contents

CHAPTER 1

Before the Principia

In each of the decades of his maturity, Descartes embarked upon an unfinished project: the *Regulae* in the 1620s, *Le Monde/L'Homme* in the 1630s, and the *Principia* in the 1640s. The first two of these projects inaugurate major changes of direction in Descartes' thinking, while the third attempts to consolidate a major development begun in *La Discours de la Méthode* and the *Meditationes*. There are some themes that persist, however, and this is particularly true of *Le Monde/L'Homme,* which provides much of the material for the final project. Indeed, in thinking through this final project, Descartes talks of teaching *Le Monde* 'to speak Latin' before bringing it into the world, and 'naming it *Summa Philosophiæ* to make it more welcome to the Scholastics, who are now persecuting it and trying to smother it before its birth'.[1]

Between the abandonment of *Le Monde* and the publication of the *Principia*, Descartes formulated some of his results in method, optics, meteorology, and geometry in the form of four essays, published in 1637, and then he turned away from explicit natural philosophy for a while. Developing a theme that had already been evident in the first of these essays, *La Discours*, he set out a sceptically driven epistemology as a way of indicating the tasks of a foundational metaphysics in the *Meditationes*. Then, 'when I thought that these earlier works had sufficiently prepared the minds of my readers to accept the *Principia Philosophiæ,* I published these too'.[2] The *Principia* is the work in which the foundational tasks are carried out, and it begins its account with a number of fundamental claims about the nature of knowledge, claims that had been worked out in detail in *La Discours* and in the *Meditationes*. In these texts, Descartes had provided a metaphysical foundation for knowledge, something wholly absent from *Le Monde*, and indeed from anything he wrote before the mid 1630s. The remaining three books, then, present a revised version of

[1] Descartes to Huygens, 31 January 1642; AT III. 523. [2] AT IXB. 16.

Le Monde, with some important additions (such as the rules of collision and the account of the formation of planets) and some important revisions (such as the doctrine of the reciprocity of motion). The *Principia* appears, in sum, as a revised version of the project of *Le Monde/L'Homme*, prefaced by a foundationalist metaphysics which reshapes some of the natural–philosophical doctrines of the earlier writings, and – taking *Les Passions de l'Ame* as providing a version of the final part of the exercise – culminating in an account of human psychology and the attainment of a moral life.

The *Principia*, in its projected complete form, offers us the mature Cartesian system, and, in order to come to terms with it, it is important that we understand what this system developed from, why it developed in the way it did, and just why Descartes chose to set out his system in the form of the *Principia*. To this end, my aim in this chapter is to explore the first and second of these questions by looking at Descartes' own earlier projects, particularly as they bear upon the *Principia* and its projected two final parts, and then, in the next chapter, to explore the third question by looking at possible models for the *Principia*.

'PHYSICO-MATHEMATICS'

'Physico-mathematicians are very rare', wrote Isaac Beeckman in a diary entry for December 1618, shortly after meeting Descartes for the first time, and he notes that Descartes 'says he has never met anyone other than me who pursues his studies in the way I do, combining physics and mathematics in an exact way. And for my part, I have never spoken with anyone apart from him who studies in this way.'[3] It was Beeckman who introduced Descartes to a quantitative micro-corpuscularian natural philosophy, one that he was to reshape and make into his own very distinctive system of natural philosophy.[4]

Descartes' earliest writings, which derive from late 1618/early 1619, deal with questions in practical mathematical disciplines. He composed a short treatise on the mathematical basis of consonance in music, exchanged letters with Beeckman on the problem of free fall, and worked

[3] *Journal tenu par Isaac Beeckman de 1604 à 1634*, ed. Cornelius de Waard, 4 vols. (The Hague, 1939–53), I. 244.

[4] On the details of Descartes' relationship with Beeckman, see Klaas van Berkel, 'Descartes' Debt to Beeckman: Inspiration, Cooperation, Conflict', in Stephen Gaukroger, John Schuster, and John Sutton, eds., *Descartes' Natural Philosophy* (London, 2000), 46–59. On how Descartes reshaped his early work with Beeckman see Stephen Gaukroger and John Schuster, 'The Hydrostatic Paradox and the Origins of Cartesian Dynamics', *Studies in History and Philosophy of Science*, forthcoming.

with him on a number of problems in hydrostatics.[5] The second, and particularly the third, of these exercises are of interest. In the correspondence on free fall,[6] Beeckman poses Descartes a mathematical question about the relation between spaces traversed and times elapsed in free fall, but Descartes seems keen to steer the question in the direction of dynamics, seeking the nature of the force responsible for the continued increase in motion. The move is not successful, and in fact it leads Descartes to misconstrue the original problem, but it is indicative of what will be an important and productive feature of his thinking about mechanical problems, and later about physical problems more generally.

The hydrostatics manuscripts[7] are of even greater interest in this respect. Here Descartes turns his attention to a paradoxical result that Simon Stevin had proved in hydrostatics, namely that the pressure exerted by a fluid on the base of its container is independent of the weight of the fluid and, depending on the shape of the vessel, can be many times greater than its weight. Here, Descartes takes a question which has been solved in rigorous mathematical terms and looks for the underlying physical causes of the phenomenon. He construes fluids as being made up from microscopic corpuscles whose physical behaviour causes the phenomenon in question, and he asks what kinds of behaviour in these corpuscles could produce the requisite effect. This is, in effect, an attempt to translate what Stevin had treated as a macroscopic geometrical question into a dynamically formulated micro-corpuscularian account of the behaviour of fluids. In the course of this, Descartes develops a number of rudimentary dynamical concepts, particularly his notion of *actio*, which he will use to think through questions in physical optics in the mid 1620s, and then questions in cosmology in 1629. This is of particular importance because his whole approach to cosmological problems, for example, is in terms of how fluids behave, and, as we shall see, it is fluids that carry celestial bodies around in their orbits.

THE *REGULAE*

Later in 1619, Descartes began work on the *Regulae*. His principal interest had shifted to mathematics by this time, and this interest was stimulated by reflection upon an instrument called a proportional compass, which had limbs that were attached by sliding braces so that, when the compass was opened up, the distances between the limbs were always in the same

[5] On these see my *Descartes, An Intellectual Biography* (Oxford, 1995), ch. 3.
[6] AT x. 58–61, 75–8, 219–22. [7] AT x. 67–74, 228.

proportion.[8] The proportional compass enabled one to perform geometrical operations, such as trisection of angles, and arithmetical ones, such as calculation of compound interest, and Descartes asked how it was possible for the same instrument to generate results in two such different disciplines as arithmetic, which dealt with discontinuous quantities (numbers), and geometry, which deals with continuous quantities (lines). Since the principle behind the proportional compass was continued proportions, he realised that there was a more fundamental discipline, which he initially identified with a theory of proportions, later with algebra. This more fundamental discipline had two features. First, it underlay arithmetic and geometry, in the sense that, along with various branches of practical mathematics such as astronomy and the theory of harmony, these were simply particular species of it, and for this reason he termed it *mathesis universalis*, 'universal mathematics'. Its second feature was that this universal mathematics was a problem-solving discipline: indeed, an exceptionally powerful problem-solving discipline whose resources went far beyond those of traditional geometry and arithmetic. Descartes was able to show this in a spectacular way in geometry, taking on problems, such as the Pappus *locus*-problem, which had baffled geometers since late antiquity, and he was able to show how his new problem-solving algebraic techniques could cut through these effortlessly. In investigating the problem-solving capacity of his universal mathematics, however, Descartes suspected that there might be an even more fundamental discipline of which universal mathematics itself was simply a species, a master problem-solving discipline which underlay every area of inquiry, physical and mathematical. This most fundamental discipline Descartes termed 'universal method', and it is such a method that the *Regulae* sought to set out and explore.

When Descartes began work on the *Regulae*, it was intended to be in three parts, each part to contain twelve 'Rules'. What was offered was a general treatise on method, covering the nature of simple propositions and how they can be known (first twelve Rules), how to deal with 'perfectly understood problems' (second set of Rules), and 'imperfectly understood problems' (projected third set). The composition proceeded in two stages, however, and the nature of the work shifted somewhat between stages.[9] In 1619–20, Descartes completed the first eleven Rules, and then apparently

[8] See my *Descartes, An Intellectual Biography*, ch. 4 for details.

[9] On dating see Jean-Paul Weber, *La Consitution du texte des Regulae* (Paris, 1964) and John Schuster, 'Descartes' *Mathesis Universalis*, 1619–28', in Stephen Gaukroger, ed., *Descartes, Philosophy, Mathematics and Physics* (New York, 1980), 41–96.

abandoned them. When he took up the *Regulae* again in 1626–8, he revised two of these (Rules 4 and 8) and added Rules 12 to 18, with titles only for Rules 19–21. The thrust of the work remains methodological, and mathematics is still taken very much as model – which is what we would expect, since the fact that the move to universal method comes through universal mathematics is what provides the former with its plausibility. But the complete Rules of the second Part, particularly Rules 12 to 14, focus on the question of how a mathematical understanding of the world is possible by investigating just what happens in quantitative perceptual cognition, that is, just what happens when we grasp the world in geometrical terms. The change in focus is interesting, but it is not thoroughgoing, and severe problems arise in reconciling universal method with universal mathematics, which has now become algebra.

Specifically, the problem that Descartes faced was that universal method was supposed to provide a general form of legitimation of knowledge, including mathematical knowledge, but algebra also provided its own specific kind of legitimation of mathematical knowledge, and the point at which the *Regulae* break off and are abandoned is exactly that at which it becomes clear that these two forms of legitimation come into conflict. The general form of legitimation provided by universal method is one in which problems are represented in the form of clear and distinct ideas, and Rule 14 spells out just what this means in the case of mathematics: it means representing the pure abstract entities that algebra deals with in terms of operations on line lengths, and in this way the truth or falsity of the proposition so represented is evident. To take a simple example, the truth of the proposition $2 + 3 = 5$ is not immediately evident in this form of representation, but it is evident if we represent the operation of addition as the joining together of two lines, as in Figure 1.1.

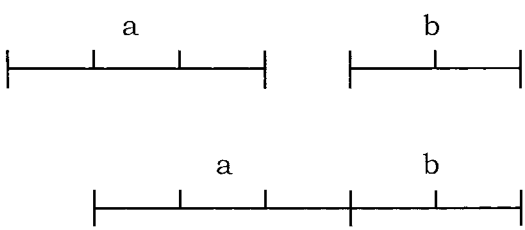

Figure 1.1

In this case we can see how the quantities combine to form their sum (and this is just as evident in the case of very large numbers the numerical value of whose sum we cannot immediately compute). This is a very insightful and profound move on Descartes' part. The problem he is concerned with is that of identifying those forms of mathematical demonstration not merely in which we can grasp that the solution or conclusion follows from the premises, but in which we can track how the solution or conclusion is generated. The difficulty that arose was that the range of operations for which this kind of basic legitimatory procedure held did not extend to the more sophisticated kinds of operation with which Descartes' algebra was able to work. And it is just such operations that begin to be envisaged in Rules 19–21, namely the extraction of higher-order roots, where no manipulation of line lengths is going to generate the result.

It is at this point that the *Regulae* are abandoned, and this also marks the end of the attempt to model knowledge on mathematics, at least in anything other than a merely rhetorical sense. When mathematics is invoked from now on, it will be invoked as a paradigm of certainty, but, in contrast to the work of the 1620s, it will cease to be accompanied by an attempt to capture at any level of mathematical detail just what this certainty derives from or consists in. Indeed, Descartes' interest in methodological questions in his later writings comes to be overdetermined by metaphysical, epistemological, and natural–philosophical issues.

LE MONDE AND *L'HOMME*

At the end of 1629, Descartes began work on a new project, which he later described to Mersenne in these terms:

> Since I tried to explain the principles in a Treatise which certain considerations prevented me from publishing, I know of no better way of making them known than to set out here briefly what it contained. I had as my aim to include in it everything that I thought I knew before I wrote it about the nature of material things. But just as painters, not being able to represent all the different sides of a body equally well on a flat canvas, choose one of the main ones and set it facing the light, and shade the others so as to make them stand out only when viewed from the perspective of the chosen side; so too, fearing that I could not put everything I had in mind in my discourse, I undertook to expound fully only what I knew about light. Then, as the opportunity arose, I added something about the Sun and the fixed stars, because almost all of it comes from them; the heavens, because they transmit it; the planets, comets, and the Earth, because they reflect light; and especially bodies on the Earth, because they are coloured,

or transparent, or luminous; and finally about man, because he observes these bodies.[10]

The work described here was again intended to be in three parts. The first part (*Le Monde*), which covers inanimate nature, and the second, which covers animal and human non-conscious functions (*L'Homme*), were to have been complemented by a third part, on the 'rational soul', but, just as with the *Regulae*, this third part never appeared. And, again as with the *Regulae*, the project was abandoned, but, whereas the *Regulae* was abandoned because problems internal to the project became evident, in the case of this second project the problems were wholly external: *Le Monde* had set out to derive the truth of a heliocentric system from first principles, and the 1633 condemnation of Galileo's defence of Copernicanism by the Roman Inquisition stopped Descartes in his tracks.

Le Monde sets out a theory of the physical world as something consisting exclusively of homogeneous matter, which can be considered as comprising three types of corpuscle, distinguished solely by size. On the basis of laws describing the motion of these corpuscles, a mechanistic cosmology is set out which includes both a celestial physics and an account of the nature and properties of light. Descartes begins with an argument to the effect that the world may be different from our perceptual image of it, and indeed that our perceptual image may not even be a reliable guide to how the world is. This is in no sense a sceptical argument, and, once Descartes has established the nature of the world, it is clear that it is in fact very different from our perceptual image of it. He begins with the nature of fire, partly because fire is the only terrestrial form of production of light and one of his main tasks is to offer a theory of light, and partly because it showcases his very economical theory of matter. The aim is to show how a macroscopic phenomenon can be accounted for plausibly in micro-corpuscularian terms, and fire is a good example for Descartes' purposes: all we need to postulate in order to account for the burning process, he argues, is the motion of parts of the wood resulting in the separation of the subtle parts (flame and smoke) from the gross parts (which remain as ashes).

Matter theory is developed in a more systematic way from the beginning of chapter 3, Descartes drawing attention to the prevalence of change in nature by arguing that the total amount of motion in the

[10] AT VI. 41–2.

universe is conserved, although this motion may be redistributed among bodies. The general principle from which he works is that, given that all bodies can be divided into very small parts, a force is required to separate these parts if they are stationary with respect to one another, for they will not move apart of their own accord. If the very small parts of which the body is constituted are all at rest with respect to one another, then it will require significant force to separate them, but, if they are moving with respect to one another, then they will separate from one another, at a rate which may even be greater than that which one could achieve by applying a force oneself. The former bodies are what we call solids, the latter what we call fluids, and in the extreme cases they form the ends of a spectrum on which all bodies can be ranked, with rigid solids at one terminus and extremely fluid bodies at the other. This ranking on a spectrum of fluidity provides the basis for Descartes' theory of matter, for it enables him to reduce the properties of matter to the rate at which its parts move with respect to one another. At the extreme fluid end of the spectrum comes, not air as one might expect, but fire, whose parts are the most obviously agitated, and whose degree of corpuscular agitation is such that it renders other bodies fluid.

On Descartes' account, all bodies, whether fluid or solid, are made from the one kind of matter. He argues that the degree of fluidity of a body cannot be proportional to the amount of vacuum that exists between its constituent parts, trying to establish that, if voids did exist, there must be more space between the parts of a solid than between those of a liquid, because the moving parts of a liquid 'can much more easily press and arrange themselves against one another' than can the parts of a solid. His main conclusion is that if there is a vacuum anywhere it cannot be in fluids but must be in solid bodies, and he is more concerned to make sure that we accept that there are no interstitial vacua in fluids than to show the absence of such vacua in solids. This is because his account of the basic structure of the universe effectively subsumes it under fluid mechanics, and hence his interest is really in fluids. This begins to become evident in the subsequent discussion of how motion is possible, and in his interconnected accounts of the nature of light and the differentiation of matter into 'elements'. In the former case, the question arises of how bodies can move at all if there are no empty spaces for them to occupy, and the answer Descartes gives is that 'all the motions that occur in the world are in some way circular'. Among the images Descartes uses to fill out this idea is that of a fish swimming through a relatively dense medium by making the water circulate around it. On the second question, Descartes' model of light is one drawn from fluid mechanics: it is something that acts by means of mechanical pressure, and what needs to be explained is how this mechanical pressure is generated in the first place, how it is propagated, and why light so construed behaves in particular geometrically defined ways when it encounters opaque and transparent bodies. Light is generated by fiery bodies, transmitted through the air, and is refracted and reflected by terrestrious bodies. The traditional elements of fire, air, and earth have, then, a cosmological analogue. These three elements are, for Descartes, simply three different sizes of corpuscle: very fine, fine, and gross respectively.

Chapter 6 of *Le Monde* begins with Descartes' construction of a hypothetical world on the basis of the theory of matter set out in the first five chapters. The ultimate aim is to show that a world constructed in this manner, one without forms or qualities, is indistinguishable from the actual world. The traditional Aristotelian forms and qualities are excluded because they could not form part of a properly mechanist explanation. Indeed, if we strip the world of the traditional forms and qualities, what we would be left with would, in Descartes' view, be its genuine properties. His new world is to be conceived as 'a real, perfectly solid body which uniformly fills the entire length, breadth, and depth of the great space at the centre of which we have halted our thought'. This perfectly solid body is 'solid' in the sense of being full and voidless, and it is divided into parts distinguished simply by their different motions. At the first instant of creation, God provides the parts with different motions, and after that He does not intervene supernaturally to regulate their motions. Rather, these motions are regulated by laws of nature which Descartes now sets out.

The three laws of nature that Descartes provides are designed to describe the behaviour of bodies in collision. They deal quite separately with the power of moving and the determination of a body. The first law tells us that a body conserves its motion except in collision, when, the second law tells us, the total motion of the colliding bodies is conserved but may be redistributed amongst them. It is left to the third law to tell us about direction, and according to this law, because a body's tendency to move is instantaneous, this tendency to move can only be rectilinear, because only rectilinear motion can be determined in an instant: 'only motion in a straight line is entirely simple and has a nature which may be grasped wholly in an instant'. Motion in a circle or some other path would require us to consider 'at least two of its instants, or rather two of its parts, and the relation between them'. What path the body will actually take, however, will be a function of the collisions to which it is subject.

The first law states that certain states of bodies are conserved: they will remain unchanged unless something acts to change them. Among these are a body's size, shape, its position if it is at rest, and also its motion, for once a body has begun to move, 'it will always continue in its motion with an equal force until others stop or retard it'. This rule of conservation of state has always been considered to hold for the first three items, and many others, Descartes tells us, but not for the last, 'which is, however, the thing I most expressly wish to include in it'. In defence of the first law, Descartes spells out the conception of motion that it employs and contrasts this with the Aristotelian conception. His suggestion is that motion is simply to be equated with change of place or translation. The second law of motion is a law of the conservation of motion (or perhaps a law of conservation of the total 'force of motion') in collisions. In its defence, Descartes points to its advantages over the traditional accounts of continued projectile motion. Aristotelians were in disagreement amongst themselves about how to account for the continued motion of projectiles, and their accounts were premised upon a distinction between terrestrial and celestial motions. Descartes changes the question, so that it now becomes that of explaining why the motion of the projectile decays rather than why it continues to move, and the answer he provides is the air's 'resistance'.

Whereas the first two laws deal with the power of motion, the third deals with what Descartes regards as a separate issue: the direction of motion. It asserts that, whatever the path of a moving body, its tendency to motion, or *action*, is always rectilinear. The evidence presented for this is, first, that a stone released from a sling will not continue to move in a circle but will fly off along the tangent to the circle, and, second, while in the sling the stone will exert a force away from the centre causing the string to stretch, showing 'that it goes around only under constraint'. But there is a notorious discrepancy in Descartes' account here. The trouble is that, while the third law as stated in chapter 7 would seem to establish the uniqueness of rectilinear motion as an inertial motion, when he elaborates further on the law in chapter 13, he apparently counts a circular component in the motion of the stone as inertial as well. Why, after giving a clear statement of rectilinear inertia and providing an explanation of why rectilinear motion is the only inertial motion in terms of its 'simplicity', does he appear to blatantly contradict this? There are two complementary answers to this question, I believe, and both derive from Descartes' attempt to use hydrostatic model in his physical theory. The first is that a statement of a principle of inertia does not seem to be the point of the exercise. In one sense Descartes was not, and could not have been, concerned with inertia. He is not concerned to specify how a body behaves in the absence of forces, for example, because the bodies he deals with always move within a system of constraints, just as in statics: the aim is to understand the instantaneous collisions of inelastic bodies. One does not ask what would happen if the forces were removed, because the understanding of the action of these forces is the point of the exercise. The second is that what Descartes is concerned with in chapter 13 is not so much circular inertia as circular equilibrium, namely, the idea that a body moves in a continuous circular orbit because the forces acting upon it are exactly balanced, so that the net force is zero. The confusion arises because Descartes slides between this static notion of equilibrium (which involves the extremely problematic assumption that some motions are dynamically unbalanced) and the dynamic notion of inertia.

Chapters 8 to 12, using the theory of matter and laws of nature which have now been elaborated, set out the details of a heliocentric cosmology in the form of an account of a hypothetical 'new world', from the formation of the Sun and the stars (ch. 8), the planets and comets (ch. 9), the Earth and the Moon (ch. 10), and, finally, weight or gravity (ch. 11) and the tides (ch. 12). The key to this whole cosmology is Descartes' account of vortices. Because the universe is a plenum, for any part of it to move it is necessary that other parts of it move, and the simplest form of motion which takes the form of displacement is going to be a closed curve, although we have no reason to think that the universe turns around a single centre: rather, we may imagine different centres of motion. The matter revolving furthest away will be the largest or most agitated because it will describe the greatest circles, owing to its greater capacity to realise its inclination to continue motion in a straight line. Whatever differences in size and agitation we may imagine there to have been in the early stages of the universe, however, except for the large clumps of third element we can imagine that the constant motion and collision caused the difference in sizes of matter to be reduced as 'the larger pieces had to break and divide in order to pass through the same places as those that preceded them'. Similarly, differences in shape gradually disappear as repeated collisions smooth off the edges and all matter (of the second element) becomes rounded. Some pieces of matter are sufficiently large to avoid being broken down and rounded off in this way: these are what

Descartes refers to as the third element, and such pieces of matter form the planets and the comets. Finally, the collisions yield very small parts of matter, which accommodate themselves to the space available so that a void is not formed but this first element is formed in a greater quantity than is needed simply to fill in the spaces between pieces of second and third element, and the excess naturally moves towards the centre because the second element has a greater centrifugal tendency to move to the periphery, leaving the centre the only place for the first element to settle. There it forms perfectly fluid bodies which rotate at a greater rate than surrounding bodies and exude fine matter from their surfaces. These concentrations of first element in the form of fluid, round bodies at the centre of each system are suns, and the pushing action at their surfaces is 'what we shall take to be light'.

The universe, as Descartes represents it (Fig. 1.2), consists of an indefinite number of contiguous vortices, each with a sun or star at the centre, and planets revolving around this centre carried along by the second element. Occasionally, however, planets may be moving so quickly as to be carried outside the solar system altogether: then they become comets. Descartes describes the difference between the paths of planets and comets in terms of an analogy with bodies being carried along by rivers, the latter being like bodies that will have enough mass and speed to be carried from one river to another when rivers meet, whereas the former will just be carried along by the flow of their own river. Planets eventually enter into stable orbits, the less massive they are the closer to the centre, and once in this orbit they are simply carried along by the celestial fluid in which they are embedded. The stability of their orbits arises because, once a planet has attained a stable orbit, if it were to move inward it would immediately meet smaller and faster corpuscles of second element which would push it outward, and if it were to move outward, it would immediately meet larger corpuscles which would slow it down and make it move inward again.

This accounts for the motions of comets, and the motion of planets proper around the Sun, and Descartes now moves on to explain the motions of planetary satellites and the diurnal rotation of a planet like the Earth. The celestial matter in which the Earth is embedded moves faster at one side of the planet than at the other, and this gives the Earth a 'spin' or rotation, which in turn sets up a centrifugal effect, creating a small vortex around itself, in which the Moon is carried. Turning next to consider what the weight (*pesanteur*) of the Earth consists in, Descartes rejects the idea of weight as an intrinsic property. In earlier writings he

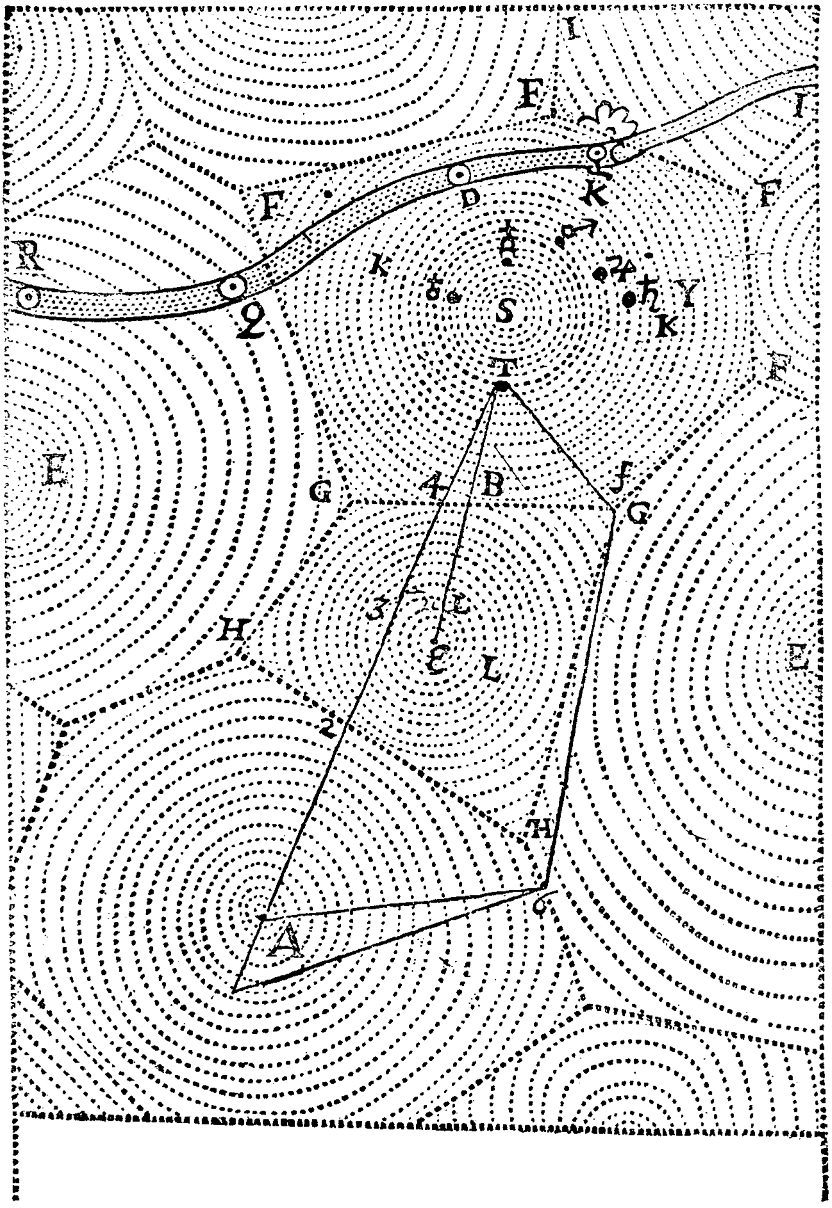

Figure 1.2

had defined weight in functional terms as 'the force of motion by which a body is impelled in the first instant of its motion'.[11] In a homogeneous plenum, where there is not only one kind of matter but one density of matter, this functional approach to weight is clearly crucial and he continues to think in functional terms in *Le Monde*.

Finally, the phenomenon of the tides is explained using the same materials. Direct evidence for the orbital and rotational motion of the Earth was not available in the seventeenth century, but the tides, which are difficult to explain on the assumption of a non-rotating Earth, do offer indirect evidence. Tides are a very complicated phenomenon, however, involving daily, half-monthly, monthly, and half-yearly cycles. Descartes was especially pleased with his account and wrote to Mersenne at the time that accounting for the tides had given him a great deal of trouble, and that, while he was not happy with all the details, he did not doubt the success of his account.[12] Although he will revise it over the next ten years, he will not alter its fundamentals. Indeed, the theory of the tides is really the first genuinely quantitative ingredient in *Le Monde*, but the fact that the earlier material is not quantitative should not blind us to the significance of Descartes' success in presenting a thoroughly mechanist cosmology which takes as its foundations a strictly mechanist conception of matter and the three laws of motion. *Le Monde* presents a fully mechanist alternative to Aristotelian systems, one which effectively derives heliocentrism from first principles, which offers a novel and apparently viable conception of matter, and which formulates fundamental laws of motion – laws that are clearly open to quantitative elaboration. But the jewel in the crown of *Le Monde* is the theory of light set out in the last three chapters, for, especially if we read these together with Descartes' other work in optics at this time, later set out in *La Dioptrique* and *Les Meteores*, we have an empirical, quantitative account of a physical question whose explanation derives directly from his mechanist cosmology.

Descartes' purpose in the last three chapters is to show how the behaviour of light rays can ultimately be explained in terms of his theory of the nature of matter and the three laws of motion. Indeed, the theory of matter turns out to be motivated directly by the requirements of Descartes' physical optics, for the first element makes up those bodies that produce light, namely suns and stars; the second element makes up the medium in which light is propagated, namely the celestial fluid; and those bodies that refract and reflect light, such as the planets, are

[11] AT x. 68. [12] AT i. 261.

made up from the third element. Moreover, it is the laws of motion that underpin and explain the laws of refraction and reflection of light, and the accounts of phenomena such as the rainbow and parhelia that are based on these.

The laws of motion show us that, given the rotation of the Sun and the matter around it, there is a radial pressure which spreads outwards from the Sun along straight lines from its centre. This pressure is manifested as 'a trembling movement', a property which is 'very suitable for light'. Indeed, the inhabitants of Descartes' proposed new world 'have a nature such that, when their eyes are pushed in this way, they will have a sensation which is just like the one we have of light'. The question that Descartes now poses is whether this model accounts for the known properties of light. Setting out twelve 'principal' properties of light which a theory of light must account for, he proceeds to show that his account is not only compatible with all of these, but can actually explain them.

Descartes' achievement in *Le Monde* is twofold. In the first place, his vortex theory explains the stability of planetary orbits in a way that presents an intuitively plausible picture of orbital motion which requires no mysterious forces acting at a distance: the rapid rotation of the Sun at the centre of our solar system, through its resultant centrifugal force, causes the 'pool' of second matter to swirl around it, holding planets in orbits as a whirlpool holds bodies in a circular motion around it. Moreover, it explains this motion in terms of fundamental quantifiable physical notions, namely centrifugal force and the rectilinear tendencies of moving matter. In other words, the heliocentric theory is derived from a very simple theory of matter, three laws of motion, and the notion of a centrifugal force. Secondly, this account also enables Descartes to account for all the known principal properties of light, thereby providing a physical basis for the geometrical optics that he had pursued so fruitfully in the 1620s.

Le Monde was not to appear in Descartes' lifetime, however. At the end of November 1633, he wrote to Mersenne:

> I had intended to send you my *Le Monde* as a New Year gift . . . but in the meantime I tried to find out in Leiden and Amsterdam whether Galileo's *Sisteme du Monde* was available, as I thought I had heard that it was published in Italy last year. I was told that it had indeed been published, but that all copies had been burned at Rome, and that Galileo had been convicted and fined. I was so surprised by this that I nearly decided to burn all my papers, or at least let no one see them. For I couldn't imagine that he – an Italian and, I believe, in favour with the Pope – could have been made a criminal, just because he tried,

as he certainly did, to establish that the Earth moves. . . . I must admit that if this view is false, then so too are the entire foundations of my philosophy, for it can be demonstrated from them quite clearly. And it is such an integral part of my treatise that I couldn't remove it without making the whole work defective. But for all that, I wouldn't want to publish a discourse which had a single word that the Church disapproved of; so I prefer to suppress it rather than publish it in a mutilated form.[13]

Galileo's *Dialogo . . . sopra i due Massimi Sistemi del Mondo* had in fact been withdrawn shortly after its publication in Florence in March 1632, and it was condemned by the Roman Inquisition on 23 July 1633. The condemnation had clear implications for *Le Monde*. Galileo's *Dialogo* provided physical evidence both for the Earth's diurnal rotation, in the tides, and for its annual orbital motion, in cyclical change in sunspot paths. It also provided a detailed and ingenious account of why our perceptual experience apparently does not accord with the Earth's motion, in the principle of the relativity of motion (albeit a very different principle from the one that Descartes will propose in *Principia*). The Inquisition's condemnation focused on the question of the physical reality of the Copernican hypothesis. A core issue in dispute in both the 1616 and 1633 condemnations of Copernicanism was whether the heliocentric theory was 'a matter of faith and morals' which the second decree of the Council of Trent had given the Church the sole power to decide.[14] Galileo and his defenders denied that it was, maintaining that the motion of the Earth and the stability of the Sun were covered by the first criterion in Melchior Cano's handbook of post-Tridentine orthodoxy, *Locorum Theologicorum Libri Duodecim*, namely that when the authority of the Church Fathers 'pertains to the faculties contained within the natural light of reason, it does not provide certain arguments but only arguments as strong as reason itself when in agreement with nature'. Opponents of Galileo treated Scripture as a source of scientific knowledge, and argued that the case was covered by different criteria, such as the sixth, which states that the Church Fathers, if they agree on something, 'cannot err on dogmas of the faith'. In the 1633 condemnation, the latter interpretation was effectively established, and this meant that the physical motion of the Earth could not be established by natural–philosophical means. In other words, the kind of arguments that Galileo offered in the *Dialogo* had no power to decide the issue, and this in effect meant that the kind of arguments that Descartes had offered in *Le Monde* had no power to decide the issue either.

[13] AT I. 270–1.

[14] For details see Richard J. Blackwell, *Galileo, Bellarmine, and the Bible* (Notre Dame, 1991).

Descartes was clearly devastated by the condemnation of Galileo, and he abandoned any attempt to publish *Le Monde* as a result.[15] Because *L'Homme* is a continuation of *Le Monde* – it is part of the same project in natural philosophy, extending the mechanist programme into physiology, and relying on the matter theory and mechanics established in *Le Monde* – it, too, had to be abandoned. In some ways, *L'Homme* was even more radical than *Le Monde*. The idea that mechanism might allow one to account for everything from physical processes to the behaviour of celestial bodies was certainly contentious, not least in the Copernican consequences that Descartes draws from this. But the project was common ground among quite a few natural philosophers in the 1630s: Beeckman, Mersenne, and Gassendi for example. A mechanistic physiology was a different matter: this was both far more ambitious and far more threatening. In *Le Monde*, Descartes postulated a single kind of matter in the universe and this matter is inert, homogeneous, and qualitatively undifferentiated. The boundaries of bodies are determined by motion relative to surrounding matter, and any variation in properties is a function of the size, speed, and direction of the matter. It is with this notion of matter that Descartes attempts to account for all functions and behaviour of animals.

L'Homme follows much the same course as *Le Monde*. It does not purport to describe the physiology of real human beings, but of 'a statue or machine made of earth' that God could have created,[16] just as *Le Monde* purports to describe an imaginary world and not the real one. At the end of each work the aim is to establish that, if we compare the imaginary constructs with the real thing, we will find in both cases that they are indistinguishable, and, although the text breaks off before this point in *L'Homme*, Descartes writes to Mersenne that he has discovered nothing in his extensive dissections that he cannot explain, that is, that he cannot explain in micro-mechanical terms.[17] The only difference is that a full account of human beings would also include their souls, whereas Descartes is concerned here only with their bodies.

Animal physiology is introduced right from the beginning of *L'Homme* as the workings of a machine.[18] The digestion of food is described in a mixture of mechanical and chemical terms. The food is first broken

[15] That it was indeed the condemnation of Galileo that prevented publication is clear not just from the letter to Mersenne just quoted, but also from his request to Mersenne to tell Naudé that the only thing stopping him publishing his physics was the prohibition on advocating the physical reality of the Earth's motion: Descartes to Mersenne, December 1649; AT III. 258.

[16] AT XI. 120. [17] Descartes to Mersenne 20 February 1639; AT II. 525. [18] AT XI. 120.

down into small parts and then, through the action of heat from the blood and that of various humours which squeeze between the particles of blood, the food is gradually divided into excrementary and nutritive parts. The heat generated by the heart and carried in the blood is the key ingredient here, and Descartes devotes much more attention to the heart and the circulation of the blood than to functions such as digestion and respiration. He accepts that blood circulates throughout the body, but, like most of his contemporaries, rejects Harvey's explanation of circulation in terms of the heart being a pump, preferring to construe the motion as being due to the production of heat in the heart. The heart is like a furnace, or rather like the sun, for it contains in its pores 'one of those fires without light',[19] which are comprised of the first element that also makes up the sun. In fact, Descartes really had little option but to reject Harvey's account. To accept that the motion of the blood was due to the contractive and expansive action of the heart would have required providing some source of power for its pumping action, and it was hard to conceive how he could do this without recourse to non-mechanical powers, whereas at least he can point to phenomena such as natural fermentation in defending his own account of thermogenetic processes creating pressure in the arteries. The most important feature of the circulation of the blood from the point of view of Cartesian psycho-physiology is the fact that it carries the 'animal spirits', which it bears up through the carotid arteries into the brain. These are separated out from the blood and enter the brain through the pineal gland, at the centre of the cerebral cavities. This is a mechanical procedure in that the animal spirits are the subtlest parts of the blood and hence can be filtered into the pineal gland through pores too fine to admit anything larger.[20]

Having dealt with the heart – the heat of which is the 'principle of life' – and the circulation of the blood, Descartes turns to the nervous system. The nervous system works by means of the animal spirits, which enter the nerves and change the shape of the muscles, which in turn results in the movement of the limbs, an analogy being drawn with the force of water in fountains. He sets out his programme as follows:

> I wish to speak to you first of the fabric of the nerves and the muscles, and to show you how – from the sole fact that the spirits in the brain are ready to enter into certain of the nerves – they have the ability to move certain members at that instant. Then, having touched briefly on respiration and other such simple and ordinary movements, I shall say how external objects act upon the sense

[19] AT XI. 123. [20] AT XI. 128.

organs. After that I shall explain in detail all that happens in the cavities and pores of the brain, what route the animal spirits follow there, and which of our functions this machine can imitate by means of them. For, were I to begin with the brain and merely follow in order the course of the spirits, as I did for the blood, I believe what I have to say would be much less clear.[21]

The pineal gland is also responsible for the discharge of the animal spirits to the muscles via the nerves, which are hollow tubes with a double membrane continuous with the brain's pia mater and dura mater.[22] In general terms, what happens is that external stimuli displace the peripheral ends of the nerve fibres, and a structural isomorph of the impression made on the sense organ is transmitted to the brain. This results in changes in the patterns formed by the animal spirits in the brain, which can produce changes in the outflow of spirits to the nerves. At the muscle, a small influx of spirit from the nerve causes the spirits already there to open a valve into its antagonist. Spirits then flow from the antagonist which causes it to relax, as well as causing the first muscle to contract.

Descartes deals in turn briefly with the control of breathing, swallowing, sneezing, yawning, coughing, and excretion, before turning to 'automatic motions', which we shall be looking at in chapter 7. He then deals with the external senses, concentrating on vision, before turning to an account of the internal senses, where he not only attempts to explain traditional areas such as imagination and memory in corporeal terms, but also provides a sketch of various temperaments in terms of animal spirits. The treatment of the latter simply translates various temperaments and humours into their supposed microscopic correlates in an intuitive but simplistic way. Generosity, liberality, and love, for example, are attributed to abundance of animal spirits; confidence and courage are attributed to strong or coarse animal spirits; promptness, diligence, and desire are attributed to unusually agitated animal spirits; tranquillity is attributed to the exceptionally uniform action of animal spirits; on the other hand, malice is attributed to lack of animal spirits, timidity to weak animal spirits, tardiness to lax spirits, and so on.[23] Various conditions such as sneezing and vertigo are explained in a similarly primitive way, as is the difference between the sleeping and the waking state: the brain in a waking state is characterised as having all its fibres tense and

[21] AT XI. 132.

[22] AT XI. 133. In reflex action, as we shall see, the pineal gland is bypassed, so that the discharge of animal spirits will be independent of the action of the pineal, and it will be the cerebral ventricles that direct the animal spirits.

[23] AT XI. 166–7.

its animal spirits strong, whereas the sleeping brain is characterised as having lax fibres.[24]

Some parts of Descartes' account do go beyond this simplistic picturing of micro-corpuscularian mechanisms, however, and memory and perceptual cognition, for example, are given particularly sophisticated treatment. We shall be looking at these in chapter 7.

LA DISCOURS AND *LES ESSAIS*

As we have seen, Descartes abandoned *Le Monde*, and with it *L'Homme*, in 1633. As far as *L'Homme* is concerned, it is evident that Descartes continued his research in this area, as there are manuscript notes on anatomy, physiology, and embryology dating from the 1630s and early 1640s.[25] This work culminates in the incomplete *La Description du Corps Humain*, dating from the winter of 1647/8. In his published writings, however, the only mentions of his work in physiology are in Part V of *La Discours*, which summarises *L'Homme*, focusing on the circulation of the blood, and in the opening sections of *Les Passions de l'Ame*.

The situation with regard to *Le Monde* is different. In 1637, in his first published work, Descartes offered a 'discourse on method' and three 'essays', on geometrical optics, meteorology, and analytic geometry respectively. The first two of these essays bear on the project of *Le Monde*. As regards the first, optics had been a key concern of *Le Monde*, but within the context of cosmology, where it had been tightly tied in with his heliocentrism. So, for example, the fact that the sun was the source of light had been premised on its being composed of the finest type of matter – that responsible for heat and light on Descartes' scheme – which was pushed into the centre as larger bodies exercised their inertial and centrifugal tendencies more freely, revolving closer to the periphery, where their orbits approximated more closely to a straight line. And the uniform radiation of light from the sun had been explained in terms of its rotation around the centre of the system, the centrifugal tendencies at its surface causing light matter to be projected radially outwards. The cosmological setting for Descartes' theory of light is ignored in *La Dioptrique*, where the concern is with geometrical optics, rather than physical optics, and the contentious cosmological consequences of his physical optics are avoided.

[24] AT XI. 174–5, 197–9. [25] See the collections of texts in AT XI. 505–638.

Most of the material in the essay on meteorology is very traditional (we shall look at the *Principia* version of this material, which includes Descartes' contentious theory of the formation of the Earth, in chapter 6), but one section, that on the rainbow, is novel, and indeed Descartes identifies it as the example of his 'method'. It is of interest in countering those views of Descartes that construe him as deducing his results in natural philosophy from first principles. In *La Discours*, he describes the procedure by which he has proceeded in *La Dioptrique* and *Les Meteores* in the following terms:

> The order which I have followed in this regard is as follows. First, I have attempted generally to discover the principles or first causes of everything which is or could be in the world, without in this connection considering anything but God alone, who has created the world, and without drawing them from any source except certain seeds of truth which are naturally in our minds. Next I considered what were the first and most common effects that could be deduced from these causes, and it seems to me that in this way I found the heavens, the stars, an Earth, and even on the Earth, water, air, fire, the minerals and a few other such things which are the most common and simple of all that exist, and consequently the easiest to understand. Then, when I wished to descend to those that were more particular, there were so many objects of various kinds that I did not believe it possible for the human mind to distinguish the forms or species of body which are on the earth from the infinity of others which might have been, had it been God's will to put them there, or consequently to make them of use to us, if it were not that one arrives at the causes through the effects and avails oneself of many specific experiments. In subsequently passing over in my mind all the objects which have been presented to my senses, I dare to say that I have not noticed anything that I could not easily explain in terms of the principles that I have discovered. But I must also admit that the power of nature is so great and so extensive, and these principles so simple and general, that I hardly observed any effect that I did not immediately realise could be deduced from the principles in many different ways. The greatest difficulty is usually to discover in which of these ways the effect depends on them. In this situation, so far as I know the only thing that can be done is to try and find experiments which are such that their result varies depending upon which of them provides the correct explanation.[26]

In a letter to Antoine Vatier of 22 February 1638, Descartes elaborates:

> I must say first that my purpose was not to teach the whole of my method in *La Discours*, where I set it out, but only to say enough to show that the new views in *La Dioptrique* and *Les Meteores* were not random notions, and were perhaps worth the trouble of examining. I could not demonstrate the use of this method

[26] AT vi. 63–5.

in the three treatises which I gave, because it prescribes an order of research which is quite different from the one I thought proper for exposition. I have however given a brief sample of it in my account of the rainbow, and if you take the trouble to re-read it, I hope it will satisfy you more than it did the first time; the matter is, after all, quite difficult in itself. I attached these three treatises to *La Discours* which precedes them because I am convinced that if people examine them carefully and compare them with what has previously been written on the same topics, they will have grounds for judging that the method I adopt is no ordinary one and is perhaps better than some others.[27]

The point is reiterated in *Les Meteores* itself, where Descartes tells us that his account of the rainbow is the most appropriate example 'to show how, by means of the method which I use, one can attain knowledge which was not available to those whose writings we possess'.[28]

One of the central problems in *Les Meteores*, to which Book 8 is devoted, is that of explaining the angle at which the bows of the rainbow appear in the sky. He begins by noting that rainbows are not only formed in the sky, but also in fountains and showers in the presence of sunlight. This leads him to formulate the hypothesis that the phenomenon is caused by light reacting on drops of water. To test this hypothesis, he constructs a glass model of the raindrop, comprising a large glass sphere filled with water, and, standing with his back to the sun, he holds up the sphere in the sun's light, moving it up and down so that colours are produced (Fig. 1.3). Then, if we let the light from the sun come

from the part of the sky marked AFZ, and my eye be at point E, then when I put this globe at the place BCD, the part of it at D seems to me wholly red and incomparably more brilliant than the rest. And whether I move towards it or step back from it, or move it to the right or to the left, or even turn it in a circle around my head, then provided the line DE always marks an angle of around 42° with the line EM, which one must imagine to extend from the centre of the eye to the centre of the sun, D always appears equally red. But as soon as I made this angle DEM the slightest bit smaller it did not disappear completely in the one stroke but first divided as into two less brilliant parts in which could be seen yellow, blue, and other colours. Then, looking towards the place marked K on the globe, I perceived that, making the angle KEM around 52°, K also seemed to be coloured red, but not so brilliant.[29]

Descartes then describes how he covered the globe at all points except B and D. The ray still emerged, showing that the primary and secondary bows are caused by two refractions and one or two internal reflections of the incident ray. He next describes how the same effect can be produced

[27] AT I. 559–60. [28] AT VI. 325. [29] AT VI. 326–7.

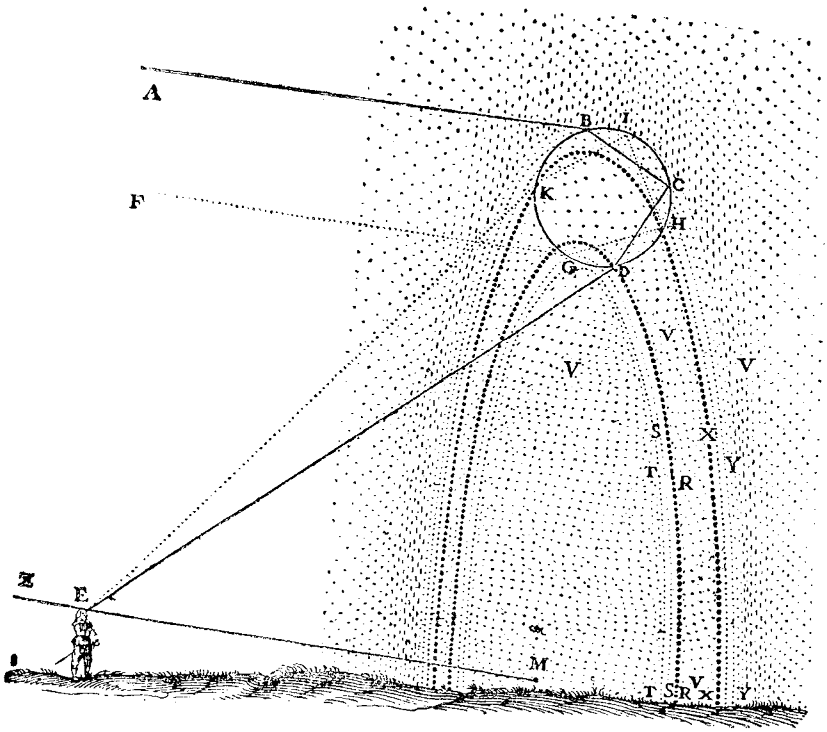

Figure 1.3

with a prism, and this indicates that neither a curved surface nor reflection are necessary for colour dispersion. Moreover, the prism experiment shows that the effect does not depend on the angle of incidence and that one refraction is sufficient for its production. Finally, Descartes calculates from the refractive index of rainwater what an observer would see when light strikes a drop of water at varying angles of incidence, and finds that the optimum difference for visibility between incident and refracted rays is for the former to be viewed at an angle of 41° to 42° and the latter at an angle of 51° to 52°,[30] which is exactly what the hypothesis predicts.

In so far as there is a method of discovery in Descartes, this is it. But the later writings, most notably the *Meditationes* and the *Principia*, are even less concerned with discovery than *La Discours*: their concern is with the legitimation of Descartes' natural philosophy.

[30] AT VI. 336.

METAPHYSICS AND THE LEGITIMATION OF NATURAL PHILOSOPHY

The outcome of the crisis provoked by the condemnation of Galileo's heliocentrism was a new direction in Descartes' work. He does not abandon interest in natural philosophy, and to the end of his life continues to think it has been his most important contribution. In a letter to Elizabeth of 28 June 1643, he tells her that the principles of metaphysics must be understood, but once understood one need spend no more time upon them: rather one should then proceed to devoting one's time 'to thoughts in which the intellect co-operates with the imagination and the senses',[31] that is, natural philosophy. The same point is made to Burman in 1649, Descartes insisting that one should not waste too much time on metaphysical questions, especially his *Meditationes*, as these are just preparation for the main questions, which 'concern physical and observable things'.[32]

But Descartes' interest in natural–philosophical areas such as optics, mechanics, and cosmology after 1633 is confined largely, if not exclusively, to polemics and systematisation, and above all to the legitimation of a mechanist natural philosophy by metaphysical and epistemological means, a completely different enterprise from that pursued in the pre-1633 works, of which *Le Monde* and *L'Homme* are the culmination. Setting out the kind of metaphysics that gives just the right fit with his natural philosophy, indeed grounds the kind of natural philosophy he wants, is the preoccupation of the *Meditationes* and the first Part of the *Principia*, which reworks the *Meditationes*.

The *Meditationes* uses a sceptically driven epistemology to systematically strip down the world – the world of common sense and the world of Aristotelian natural philosophy – so that the assumptions that lie behind this picture are laid bare, and found wanting. Descartes then proceeds to build up the world metaphysically from first principles, using a notion of clear and distinct ideas, backed up by a divine guarantee. What this yields is a sharp distinction between the mind and the corporeal realm, and an account of the corporeal realm radically different from that with which the *Meditationes* began. Because our new starting point is clear and distinct ideas (the paradigm for which is the *cogito*), we cannot ask about the existence of the corporeal world without having a clear and distinct idea of what it is that we are asking for the existence of. The question of existence only becomes determinate, and thereby answerable on Descartes' account, when we ask whether something with

31 AT III. 695. 32 AT V. 165.

particular characteristics exists, where the characteristics in question are not only fully specified, but also securely grasped. Unless we start from things which we clearly and distinctly grasp, we can never be sure we are actually getting anywhere. The question is whether there are any conceptions of the corporeal world available to us which offer a grasp of this kind. Descartes' answer is that he knows of only one, namely a mathematical grasp of the world. Corporeal things, he tells us at the end of the *Meditationes*,

> may not all exist in a way that exactly corresponds with my sensory grasp of them, since sensory understanding is often very obscure and confused. But at least they possess all things that I perceive in them clearly and distinctly, that is to say, all those things which, generally speaking, come under the purview of pure mathematics.[33]

If the arguments of the *Meditationes* go through, what Descartes has established is that our starting point in natural philosophy must be a world stripped of all Aristotelian forms and qualities, and consisting in nothing but geometrically quantifiable extension. The only natural philosophy compatible with such a picture is mechanism, in particular, mechanism of the kind set out by Descartes in the matter theory and mechanics of *Le Monde*. If we grant him his matter theory, and the two basic principles of his mechanics, the principle of rectilinear inertia and that of centrifugal force, then, if the argument of *Le Monde* is correct, we have heliocentrism, for this is all he needs. In this way, the *Meditationes* connect up directly with *Le Monde*, providing a metaphysical route to the natural philosophy of the latter and providing a legitimation of the whole enterprise.

But the *Principia*, which begins with what is, despite a reordering of some arguments, in effect a summary of the *Meditationes*, does not simply lead into *Le Monde*. Much the same ground is covered, but the material is reworked in terms of a metaphysical vocabulary wholly absent from *Le Monde*, not required for the natural–philosophical (as opposed to the legitimatory) thrust of the *Principia*, and it is occasionally unhelpful in illuminating the natural–philosophical questions it raises.[34]

33 AT VII. 80.

34 This is particularly so on the vexed question of force. As Alan Gabbey points out, Descartes clearly has a realist view of forces (something determined by natural–philosophical considerations), but his metaphysics of substance and modes seems to leave no place for it, so its ontological status is very unclear: 'New Doctrines of Motion', in Daniel Garber and Michael Ayers, eds., *The Cambridge History of Seventeenth-Century Philosophy* (Cambridge, 1998), 649–79: 656.

LA RECHERCHE DE LA VÉRITÉ VERSUS THE *PRINCIPIA*

Descartes did not decide immediately on the textbook format for the development of his ideas in natural philosophy after the *Meditationes*, and there exists what is probably a first experiment in setting out his post-*Meditationes* natural philosophy, *La Recherche de la vérité*. Interestingly, this unfinished dialogo pulls us in a very different direction from that evident in the *Principia*.

La Recherche de la vérité par la lumiere naturelle – 'the search for truth through the natural light [of reason]' – begins by telling us that 'this light alone, without any help from philosophy or religion, determines what opinion *un honnête homme* [literally, a good or honest man] should hold on any matter that may occupy his thought, and penetrates into the secrets of the most difficult sciences'.[35] The dialogue contrasts the fitness for natural philosophy of three characters: Epistemon, someone well versed in Scholasticism; Eudoxe, a man of moderate intelligence who has not been corrupted by false beliefs; and Poliandre, who has never studied but is a man of action, a courtier, and a soldier (as Descartes himself had been). Epistemon and Poliandre are taken over the territory of sceptical doubt and foundational questions by Eudoxe, but in a way that shows Poliandre's preparedness for, or capacity for, natural philosophy, and Epistemon's lack of preparedness. Preparedness here is in effect preparedness for receiving instruction in Cartesian natural philosophy. The *honnête homme*, Descartes tells us,

> came ignorant into the world, and since the knowledge of his early years rested solely on the weak foundation of the senses and the authority of his teachers, it was close to inevitable that his imagination should have been filled with innumerable false thoughts before his reason could guide his conduct. So later on, he needs to have either very great natural talent or the instruction of a very wise teacher, to lay the foundations for a solid science.[36]

The thrust of Descartes' discussion is that Poliandre has not had his mind corrupted, because, in his role as an *honnête homme*, he has not spent too much time on book-learning, which 'would be a kind of defect in his education'.[37] The implication is that Epistemon has been corrupted in this way, and so is not trainable as the kind of natural philosopher Descartes seeks. It is only the *honnête homme* who can be trained, and it is Poliandre whom Eudoxe sets out to coax into the fold of Cartesian natural philosophy, not Epistemon.

[35] AT x. 495. [36] AT x. 496. [37] AT x. 495.

This is in stark contrast with the *Principia*, where the aim is to engage Scholastic philosophy, to some extent on its own terms, and in effect to reform and transform Scholasticism into Cartesian natural philosophy. Descartes sets out to convince his readers (the text is primarily aimed at students who would otherwise be reading the late Scholastic textbooks that Descartes himself was raised on) that they too should be Cartesians in natural philosophy. It is true that we might think of the procedure of radical doubt, and the purging that results, as a way of transforming everyone into an *honnête homme*, and to some extent it is, although, as we shall see, in his account of the passions Descartes makes it clear that, once we leave the programmatic level, ridding ourselves of prejudices and preconceived ideas is not so simple, and it requires the cultivation of a particular mentality, which is really what we witness in *La Recherche*. *La Recherche* does not so much contradict the trajectory of the *Principia* – as we shall see, the questions it raises are appropriate to the projected Part VI of the *Principia* – as provide a radically different route to thinking about how one achieves the ends of establishing a Cartesian natural philosophy. *La Recherche* raises such questions right at the beginning of the exercise, whereas the *Principia* (on my reconstruction) defers them until the end.

Descartes decided in favour of the *Principia*, abandoning *La Recherche* unfinished. To understand this choice, and to grasp what is going on in the *Principia*, we need to understand the Scholastic textbook tradition that it engages.