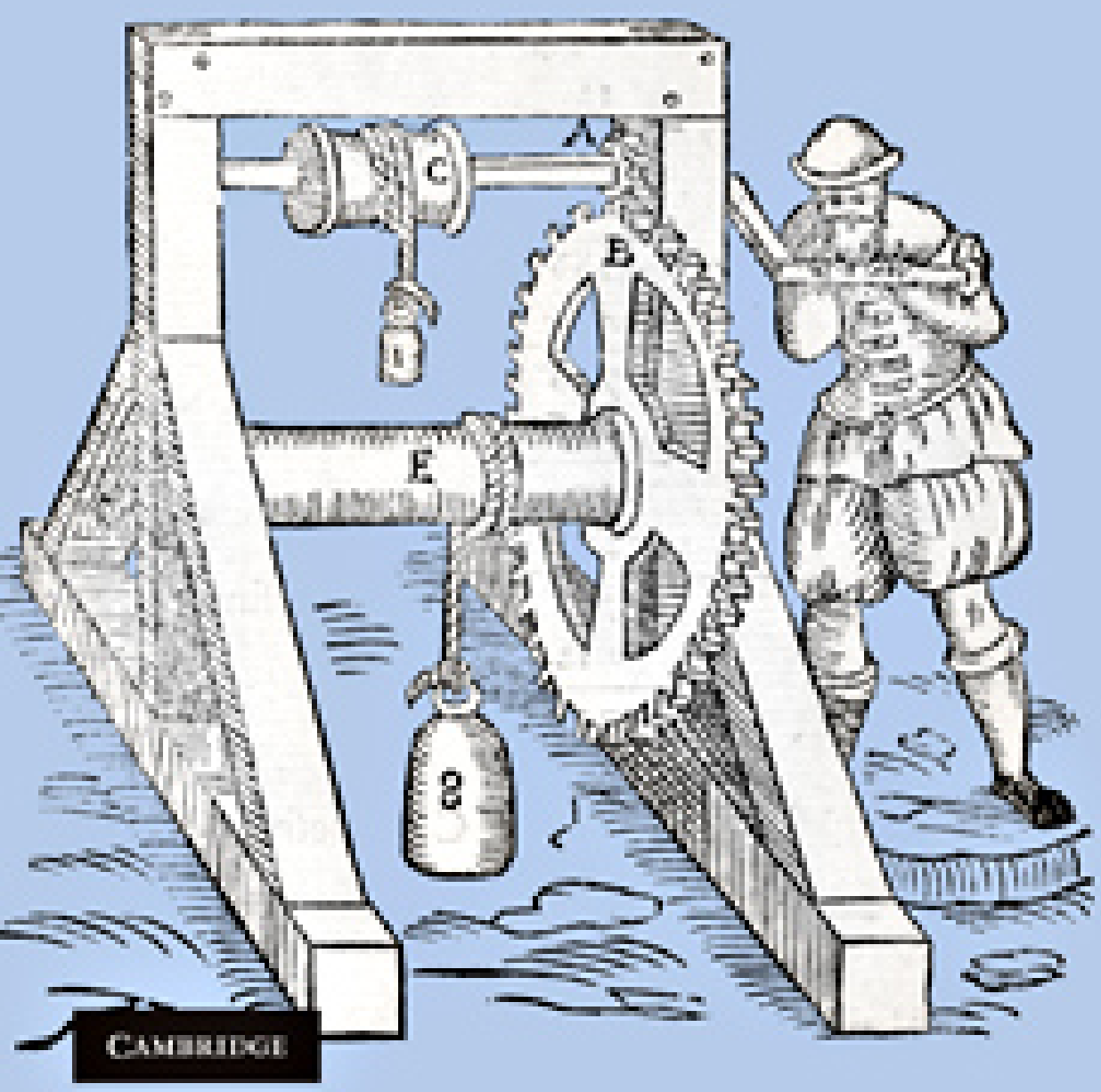
DESCARTES
on Forms and Mechanisms

HELEN HATTAB



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The modern view of causation can be traced back to the mechanistic science of Descartes, whose rejection of Aristotelian physics, with its concept of substantial forms, in favor of mechanical explanation was a turning point in the history of philosophy. However, the reasoning which led Descartes and other early moderns in this direction is not well understood. For the first time, this book traces Descartes' groundbreaking theory of scientific explanation back to the mathematical demonstrations of Aristotelian mechanics and interprets these advances in light of the available arguments for and against substantial forms. It also examines how Descartes' new theory led him to develop a metaphysical foundation for his science that could avoid skeptical objections. It will appeal to a wide range of readers interested in the philosophy and science of the early modern period.

HELEN HATTAB is Assistant Professor in the Department of Philosophy, University of Houston.

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To my father, Stephan Andel

Contents

Acknowledgments

I may be the proximate efficient cause of this work, but many other causes were involved in its generation. Prior studies of Descartes and his context provided me with exemplars of what I could only aspire to attain. In particular, over the years, I have benefited both from the scholarly examples and from the personal encouragement offered by Roger Ariew, Dennis Des Chene, and Dan Garber. A series of fellowships provided the material resources to translate my aspirations into actualities. A National Endowment for the Humanities summer seminar on "Descartes and His Contemporaries" directed by Dan and Roger first sparked my interest in the Aristotelian *Mechanica* tradition. My participation in an NEH Summer Institute in Washington DC, directed by Pam Long and Pam Smith the following summer, put me in the vicinity of rare book collections that could satisfy my curiosity. The two Pams, as we affectionately called them, were both excellent role models as I began my historical forays into Aristotelian *Mechanica* commentaries. My investigations advanced significantly thanks to a residential research grant from the Dibner Library of the History of Science and Technology at the Smithsonian Institution in the spring of 2004. Ron Brashear, then the director of the Dibner Library, and his assistants, Kirsten van der Veen and Daria Wingreen-Mason, provided invaluable assistance and support both during and after my residency. The remaining research for this book was completed thanks to residential fellowships at the Herzog August Bibliothek in Wolfenbüttel, Germany, in the summer of 2005; the Scaliger Institute in Leiden, the Netherlands, in the summer of 2007; and the Folger Shakespeare Library in Washington DC in fall 2007. I thank all the staff who assisted me, especially Dr. Gillian Bepler and Mr. Kaspar van Ommen, who oversaw the nuts and bolts of the fellowship programs at the Herzog August Bibliothek and Scaliger Institute, respectively.

The year in which this book was conceived was also the year when I was first confronted with a painful, long-term physical illness. There were

many times when I thought I would never have the strength to complete this project. At crucial stages, my load was significantly lightened by two excellent research assistants. Jessica Weiss assisted me in translating some of the *Mechanica* commentaries from Latin to English in 2004, most notably that of Ioannis de Guevara, cited in this work. Francesca Bruno, my student at the University of Houston, received a Summer Undergraduate Research Fellowship in 2006 to study Bernardino Telesio's *De rerum natura* and the secondary literature on Telesio's influence under my supervision. While most of this material had to be cut from the final version of this book, the conclusions I reached about Telesio draw on the work Francesca did for me. I could not have wished for two better assistants than Jessica and Francesca – both were far more dedicated than the remuneration I was able to give them warranted. I consider myself extremely fortunate to have colleagues and graduate students at the University of Houston who took an active interest in my research. Drafts of select chapters were presented to the Philosophy Department at the University of Houston and the Houston Circle for the Study of Early Modern Philosophy, as well as meetings of the International Society for Intellectual History, the Mid Atlantic Seminar in Early Modern Philosophy and the History of Science Society. I thank all those who participated for their feedback. I would like to add a special thanks to my fellow co-founders of the Houston Circle, Greg Brown and Mark Kulstad, for all our stimulating discussions of early modern philosophy, and to my Chair, Cynthia Freeland, who provided comments on the Aristotelian chapters. Finally, the detailed feedback from anonymous referees and the invaluable assistance of my editor, Hilary Gaskin, gave this work its final form. I thank them for their time and effort, and for this opportunity to publish the fruits of my research.

Last but not least, I will always be grateful to my family, and especially my husband, Jim Hattab, for being there to offer encouragement and support while I juggled the seemingly impossible demands of my career and illness. There ought to be a special medal for partners who remain unwavering in their devotion, while their loved one turns into a basketcase! In the absence of a medal, I can only offer my undying thanks.

Abbreviations

AT	*Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 12 vols. (Paris: Vrin, 1996).
CAM	St. Thomas Aquinas, *Commentary on Aristotle's Metaphysics*, trans. John P. Rowan (Notre Dame, IN: Dumb Ox Books, 1961).
CSM	René Descartes, *The Philosophical Writings of Descartes*, vols. I and II, trans. John Cottingham, Robert Stoothoff, and Dugald Murdoch (Cambridge: Cambridge University Press, 1985).
CSMK	René Descartes, *The Philosophical Writings of Descartes*, vol. III, trans. John Cottingham, Robert Stoothoff, Dugald Murdoch, and Anthony Kenny (Cambridge: Cambridge University Press, 1991).
MD7	Francisco Suarez, *Francisco Suarez on the Various Kinds of Distinctions*, trans. Cyril Vollert (Milwaukee, WI: Marquette University Press, 1947).
MD15	Francis Suarez, *On the Formal Cause of Substance: Metaphysical Disputation XV*, trans. John Kronen and Jeremiah Reedy (Milwaukee, WI: Marquette University Press, 2000).
PP	René Descartes, *Principles of Philosophy*, trans. V. R. Miller and R. P. Miller (Dordrecht: D. Reidel Publishing Co., 1983).
QNS	Francisco Sanches, *That Nothing Is Known*, ed. Elaine Limbrick and Douglas F. S. Thomson (Cambridge: Cambridge University Press, 1998).
SCG	St. Thomas Aquinas, *Summa Contra Gentiles*, trans. James F. Anderson, 4 vols. (Notre Dame: University of Notre Dame Press, 1975).
ST	St. Thomas Aquinas, *The Summa Theologica of St Thomas Aquinas*, trans. Fathers of the Dominican Province (London: R. & T. Washbourne, 1912)

Introduction

René Descartes gives few philosophical arguments to directly support his rejection of forms in favor of mechanisms. Moreover, the scattered reasons he offers in his corpus are cryptic and hard to unpack. Hence I will draw on Descartes' intellectual context to reconstruct his reasoning and shed light on his historic elimination of Scholastic Aristotelian substantial forms from the physical world. Given that Descartes continues to call the soul a substantial form, my focus will be on his rejection of material substantial forms employed in Aristotelian physics (for lack of a better term I will refer to all substantial forms that exist only in matter, i.e., all except the rational soul, as 'material substantial forms').[1] I will not, therefore, examine the viability of his claim that the soul is the substantial form of a human being and instead refer the reader to the body of literature that already exists on this subject.[2] Unlike the rational soul, which was thought to be directly created by God and to survive the body, material substantial forms were widely held to be educed from pre-existing matter, and to exist only in matter. It is only by familiarizing ourselves with contemporaneous arguments for and against such forms and the philosophical issues at stake in this debate that we can fully understand and appreciate Descartes' contribution to their ultimate elimination from physics. We are all familiar with the Cartesian rhetoric against substantial forms. It is my hope to penetrate beyond this rhetoric to the philosophical developments and arguments that underpin his vehement denunciations of this key Scholastic principle.

[1] For an in-depth discussion of the Cartesian soul as a substantial form and its relation to Scholastic substantial forms see Marleen Rozemond, *Descartes' Dualism* (Cambridge, MA: Harvard University Press, 1998).

[2] See, e.g., Paul Hoffman, "The Unity of Descartes' Man," *Philosophical Review* 95 (1986), pp. 339–370, and "Cartesian Composites," *Journal of the History of Philosophy* 37 (1999), pp. 251–270; and Rozemond's alternative view in *Descartes' Dualism*.

In May of 1643, responding to charges by Gijsbert Voetius, Dutch theologian and rector of the University of Utrecht, Descartes writes of Scholastic philosophy that it is

> merely a collection of opinions that are for the most part doubtful, as is shown by the continual debates in which they are thrown back and forth. They are quite useless, moreover, as long experience has shown to us; for no one has ever succeeded in deriving any practical benefit from 'prime matter,' 'substantial forms,' 'occult qualities,' and the like.[3]

As indicated by this quote, when early modern philosophers railed against Scholasticism one of their prime targets was the material substantial forms of Aristotelian physics. Diehard Scholastics like Voetius strove in turn to defend and preserve them. Despite the fact that the substantial form is never explicitly mentioned by Aristotle, it remained a cornerstone of Scholasticism from the moment that St. Thomas Aquinas injected it into medieval Latin philosophy. In the late sixteenth and early seventeenth centuries, it stood at the center of the battlefield where warring philosophical factions collided.[4]

The substantial form is the essential act constituting the 'whatness' (*quidditas*) or individual being of a composite substance, e.g., the particular animal soul that makes Fido not just a dog, but this dog, Fido, and the material form holding together the mixture that is this chrystal. It fulfills several important functions within Scholastic Aristotelian philosophy. First since the substantial form is the stable bearer and uniter of the multitude of accidental properties a created substance acquires and loses over time, it supplies the crucial link between a substance's essence (the unchanging realm of metaphysics) and its accidental properties (the changing realm of physics). At the metaphysical level the substantial form

[3] René Descartes, *The Philosophical Writings of Descartes,* vol III, trans. John Cottingham, Robert Stoothoff, Dugald Murdoch, and Anthony Kenny (Cambridge: Cambridge University Press, 1985–91), (henceforth CSMK), "Letter to Voetius, May 1643," p. 221. When my own translations differ in a non-trivial manner, I will cite the Adam and Tannery edition (*Oeuvres de Descartes*, ed. Charles Adam and Paul Tannery, 12 vols. [Paris: Vrin, 1996]); otherwise I will cite the standard English translations of Descartes' works by Cottingham *et al*. and cross-refer to the Adam and Tannery edition as follows: AT VIIIB, p. 26.

[4] See, e.g., J. A. van Ruler's excellent discussion of the controversies between Voetius and Dutch Cartesians in *The Crisis of Causality: Voetius and Descartes on God, Nature and Change* (Leiden: Brill, 1995). This indicates that Bob Pasnau, while correct in saying that "it begins to look as if formal explanation was already undergoing a shift in focus during the Middle Ages, and by the Renaissance had reverted to something much more like a material mode of explanation," is mistaken in his judgment that the substantial form was "scorned and ignored by anti-Aristotelians" and "at the same time ineptly defended by late Scholastics." Robert Pasnau, "Form, Substance and Mechanism," *Philosophical Review* 113/1 (2004), pp. 46, 72.

accounts for the individuation of substances, and their identity over time. At the physical level, it explains the actions of a substance and the fact that certain accidental properties with no other apparent connection are inextricably linked in particular substances. For example, milk always possesses both the accidental forms of whiteness and sweetness when fresh, and darkens and turns sour when the underlying substantial form supporting both accidental forms of the fresh milk is gradually destroyed by an external cause. Second, the substantial form constitutes the bridge between the physical nature that is the source of all natural causality and the logical essence that links the premises to the conclusion in an Aristotelian syllogism. St. Thomas Aquinas makes this clear in Book VII, lesson 8, of his *Commentary on Aristotle's* Metaphysics, where he explains Aristotle's words as follows:

> Hence it is evident that, just as in syllogisms the basis of all demonstrations "is substance," i.e., the whatness (for demonstrative syllogisms proceed from the whatness of a thing, since the middle term in demonstrations is a definition), "so too in this case," namely, in matters of operation, processes of generation proceed from the quiddity.[5]

Not surprisingly then, when Aristotle's logic came under violent attack by Renaissance humanists, it had serious implications for the doctrine of substantial forms, and, via this portal, for the whole structure of Aristotelian physics.

When Descartes and other proponents of the new science eventually eliminated material substantial forms from physics, the metaphysical grounding these forms had provided for both the existence and scientific demonstration of real natural causes proved difficult to replace. Over time, accounts of real, extra-mental causal interactions gave way to Leibniz's pre-established harmonies, Hume's constant conjunctions and Kant's *a priori* concepts. Hence Descartes' replacement of the hylomorphic model with the mechanistic model stands at the crossroads of an historic transition that forever changed our conceptions of causality and scientific explanation. Over the last few centuries, this has had serious ramifications for both science and theories of human agency and moral responsibility. The wide-ranging effects of this conceptual revolution are well studied. The underlying philosophical concerns and arguments that prompted it remain, for the most part, as hidden and mysterious as the alleged 'occult qualities' of the Scholastics.

[5] St. Thomas Aquinas, *Commentary on Aristotle's* Metaphysics, trans. John P. Rowan (Notre Dame, IN: Dumb Ox Books, 1961), p. 484, sec. 1450. (Henceforth *CAM*).

The philosophical, scientific, and historical factors driving the shift from hylomorphism to mechanism are exceedingly complex, and a study of this length could certainly not do them justice. Instead I propose to bring this complex, blurry landscape into focus by employing two lenses. The first lens, intended to narrow our focus and bring into relief a part of the larger landscape, limits my discussion of the Scholastic background to Descartes' mechanism to philosophical arguments pertaining to material substantial forms. My choice of this lens is motivated by the central place the substantial form occupies both within late Scholastic natural philosophy and attacks launched against it by Descartes and other critics. While studying such a fundamental concept has the advantage of illuminating the larger philosophical picture, the fact that it lies at the center of the Scholastic web also has the potential to blur the line between matters bearing directly on the substantial form and interconnected concerns about causation, scientific demonstration, matter, form, and substance in general. Therefore, I will address such related concerns only to the extent necessary to clarify the arguments for and against material substantial forms, rather than giving them full coverage.

While the first lens narrows our focus, the addition of a second lens is meant to lengthen our view. As Descartes states in the letter quoted above, the ultimate rejection of substantial forms was the product of "long experience." It is, therefore, not possible to understand the philosophical reasoning at play by restricting ourselves to the few derisive comments scattered around Descartes' corpus, or even by juxtaposing them with what Descartes was taught about substantial forms by his staunchly Aristotelian Jesuit teachers. These are excellent starting points, but they cannot convey the arduous philosophical process by which substantial forms were gradually undermined, to the point where Descartes could confidently pronounce them of "no practical benefit" to Voetius. While scholarship on the particular brand of Scholastic Aristotelianism that Descartes was taught by the Jesuits has increased in recent times, along with the number of historically informed treatments of Descartes' philosophical doctrines, we are still confronted with large gaps in trying to get from one to the other.[6] In particular, with the exceptions of Isaac Beeckman and Marin Mersenne, there has been little study of anti-Aristotelian philosophers that

[6] The most recent study of late medieval and early modern thinking about the substantial form is the above-cited article by Pasnau (see n. 4). While it identifies the central issues and lays out the views of canonical figures such as St. Thomas Aquinas, Descartes, Boyle, and Locke, as well as mentioning some of the more frequently discussed later Scholastics, it does not address the arguments of any of the minor figures who are likely to have influenced Descartes.

form part of Descartes' intellectual context.[7] Descartes' silence regarding his sources, and his disavowal of any philosophical influences, make it difficult to trace a path from Descartes the schoolboy, imbued with Scholastic Aristotelianism by his Jesuit teachers, to Descartes the virulently anti-Aristotelian father of mechanism.

In actual fact, Descartes was neither the first nor the most virulent opponent of Scholastic Aristotelian substantial forms, nor was he the first to replace them with alternative principles. Some of the philosophers he mentions in a letter of 1630 to his Dutch mentor, Isaac Beeckman (cited below), had already proposed influential alternatives to Scholastic material substantial forms. By 1570 the Italian naturalist philosopher Bernardino Telesio, whose followers included Tommaso Campanella, had replaced them with the principles of hot and cold, characterizing heat, in particular, as both "substance and form."[8] By 1585 Giordano Bruno, the controversial proponent of Copernicanism, infinite worlds, and monism, had published his dialogue on *Cause, Principle and Unity,* in which he argued:

> Now take away that material common to iron, to wood, to stone, and ask, "What substantial form of iron remains?" They will never point out anything but accidents. And these are among the principles of individuation, and provide particularity, because the material cannot be contained within the particular except through some form, and because this form is the constituent principle of some substance they hold that it is substantial, but then they cannot show it physically except as something accidental. When they have finally done all they can, they are left with a substantial form which exists only logically and not in nature. Thus a logical construction comes to be posited as the principle of natural things.[9]

In 1621 the eclectic physician turned philosopher Sebastian Basso renewed the attack against material substantial forms in his *Philosophiae Naturalis Adversus Aristotelem* (Natural Philosophies Against Aristotle), writing:

> And what is in fact mostly deduced from the doctrine of Plato and the Ancients we showed fully by the most certain and clear reasons, that the divine mind, diffused through all things, standing near, gives the proper motion towards the end

[7] E.g., Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca: Cornell University Press, 1988) and the studies of Beeckman by Klaas Van Berkel and Stephen Gaukroger cited below (see n. 17).

[8] I cite from the Latin edition of 1570, included by Bondi alongside his Italian translation. Bernardino Telesio, *La natura secondo i suoi principi* (1570), trans. Roberto Bondi (Florence: La Nuova Italia Editrice, 1999), p. 118. We know that Descartes at least read Campanella, since he mentioned a work by him that he had borrowed from Huygens in a letter dated March 9, 1638.

[9] Giordano Bruno, *Cause, Principle and Unity and Essays on Magic*, trans. Richard J. Blackwell and Robert de Lucca (Cambridge: Cambridge University Press, 1998), p. 60.

to individual things and gives its power to a certain thing and conserves it. Why do they seek individual substantial forms in individual things when one universal cause extending through all things suffices for individual things?[10]

Nevertheless, in the long run, these earlier attempts to displace Aristotelian natural philosophy failed, and by the early seventeenth century many universities were turning back to more conservative Scholastic Aristotelian teachings.[11] The University of Leiden in the Netherlands, the *alma mater* of Beeckman, and one of the Dutch universities where Descartes pursued his medical investigations, is a case in point.[12]

Regardless of the prevailing trend of seventeenth-century universities, the extent of the influence of earlier anti-Aristotelian philosophers on individual early modern proponents of the new science is unclear. Whereas the influence of Telesio on Thomas Hobbes has been documented, Descartes disavows any such influences in his 1630 letter to Beeckman:[13]

As for mere opinions and received doctrines, such as those of the philosophers, simply to repeat them is not to teach them. Plato says one thing, Aristotle another, Epicurus another, Telesio, Campanella, Bruno, Basson, Vanini, and the innovators (*novatores*) all say something different. Of all these people, I ask you, who is it who has anything to teach me, or indeed anyone who loves wisdom?[14]

Of course, we must take Descartes' disavowal with a healthy pinch of salt, since the overall purpose of the letter is to defend himself against mounting suspicions that he stole much of his natural philosophy from Beeckman. Descartes cites these earlier philosophers to support his final claim that no one, not even Beeckman, has anything to teach him. Given the well-established importance of Beeckman's *physico-mathematics* to Descartes' early physics, the fact that Descartes draws a parallel between his relationship to the teachings of the above-cited philosophers and those

[10] Sebastian Basso, *Philosophiae naturalis adversus Aristotelem* (Geneva, 1621), Bk. III on Form, Int. 1, a. 5, 267. Again, there is evidence that Descartes had read Basso.

[11] Edward G. Ruestow, *Physics at Seventeenth- and Eighteenth-Century Leiden: Philosophy and the New Science in the University* (The Hague: Martinus Nijhoff, 1973), p. 12.

[12] Theo Verbeek notes that what passed for 'Aristotelianism' in the early years of the university was rather a mix of Ramism and works in natural philosophy by Romans like Lucretius, Pliny, Seneca, and Virgil. However, in 1582 six students, backed by theology professors, made a plea to the Senate for a return to Aristotle's texts and the teaching of metaphysics. Hence during the first three decades of the seventeenth century there was a return to Scholastic Aristotelianism at Leiden. Theo Verbeek, *Descartes and the Dutch Early Reactions to Cartesian Philosophy, 1637–1650* (Carbondale and Edwardsville: Southern Illinois University Press, 1992), p. 6.

[13] Karl Schuhmann, "Telesio's Concept of Matter," *Atti del Convegno Internazionale di Studi su Bernardino Telesio*, 13 March 1989 (Cosenza: Academia Cosentina, 1989), pp. 115–134; Cees Leijenhorst: *The Mechanisation of Aristotelianism: The Late Aristotelian Setting of Thomas Hobbes' Natural Philosophy* (Leiden: Brill, 2002).

[14] To [Beeckman], October 17, 1630, CSMK, pp. 26–27; AT I, p. 158.

of Beeckman tends to confirm their influence on him, rather than deny it. However, as Descartes points out, even though he may have reached similar results to prior philosophers, that does not mean that his philosophical ideas are directly borrowed from them, for he claims to have reached these conclusions through the application of his own philosophical method. While earlier philosophers, most notably Telesio and Francis Bacon, had also appealed to a new method to support the introduction of new principles of natural philosophy, Descartes' method is sufficiently distinct from these earlier ones to make the resulting principles of his physics significantly different.[15]

Setting aside the thorny question of the extent to which Descartes' actual physics conforms to and is the product of his philosophical method, one substantive difference between Descartes and these earlier opponents of Scholastic substantial forms is that none of their attacks implies the complete elimination of the matter/form ontology, and the associated substance/accident distinction, whereas Descartes' later works do. Telesio goes the furthest, denying that hot and cold are accidents, and turning the material substratum into a *quasi* substance, which unlike the prime matter of the Scholastics has bulk and mass. However, for Telesio, heat becomes the active, physical instantiation of form which gives rise to the qualities matter can take on, whereas cold, as the passive principle that can resist the action of heat, becomes the stand-in for Aristotle's privation. As the above extract implies, Basso replaces individual forms with one universal form which he equates with the divine Mind, the Neoplatonic World Soul, and in its physical manifestation, with the Stoic ether. This ethereal universal form insinuates itself in between Basso's Democritean atoms, setting them in motion and determining the structure of macroscopic objects; hence, it simultaneously fulfills the roles of both the formal and the efficient causes. Basso may have, in part, been inspired by Bruno's Neoplatonism, which embraces the World Soul, a universal form of matter:

> We now know how to distinguish matter from form, as much from the accidental form (whatever it may be) as from the substantial form. We must still look into its nature and its reality. But first, I would like to know whether, in view of the great union that this world soul and universal form has with matter, one could not admit the other mode of philosophizing, belonging to those who do not separate the act from the essence of matter, and who understand matter as a divine thing, and not as something so pure and formless that it cannot form and clothe itself.[16]

[15] Unlike Descartes, both Bacon and Telesio base their methods on sensory observation.

[16] *Bruno, Cause, Principle and Unity*, p. 62.

In short, whereas this first generation of anti-Aristotelians embraces alternative theories of matter, and is thereby forced to redefine the matter/form relationship, in doing so, it does not eliminate the substantial form altogether, but rather reifies it, turning it into a universal form of matter, whether it be Telesio's heat, Bruno's World Soul, or Basso's universal Mind/Soul/Ether. I will show that Descartes initially also presents his new theory in terms of the matter/form distinction, treating the configurations of material particles as the forms of different types of material substances. However, he eventually eliminates the traditional matter/form and substance/accident distinctions altogether, replacing them with a substance/mode ontology. This makes Descartes' rejection of material substantial forms more firmly grounded and thoroughgoing than previous attempts, which could account for its success. And yet, the substance/mode ontology Descartes adopts is not entirely original, for I will show that it has strong affinities with the metaphysics of the Dutch atomist, David Gorlaeus.

In what follows, I examine probable sources for Descartes' arguments against substantial forms so as to elucidate the steps by which he gradually came to eliminate them from the physical world. In so doing, I also show that Descartes' mechanistic alternative to substantial forms represents neither a complete break from the past nor an outgrowth from one particular philosophical movement of his day. To assume that Descartes must have either reinvented philosophy *de novo* or been influenced by one particular school of thought is a false dichotomy that oversimplifies the complex philosophical landscape of early seventeenth-century Europe and the range of philosophical traditions with which Descartes came into contact. Instead I show that Descartes' mechanistic alternative to hylomorphism, like most original theories, is best understood as a creative response to a variety of pre-existing problems and solutions he encountered in his immediate intellectual circles. Textual evidence internal to Descartes' *corpus* and historical evidence drawn from his intellectual environment indicate that developments in both Aristotelian and anti-Aristotelian philosophy played vital roles in shaping his philosophical enterprise. In particular, I will show, on both textual and contextual grounds, that Descartes' reasons for rejecting hylomorphism in favor of mechanism are illuminated by the interplay among the following four philosophical developments:

1. Francisco Suarez's influential defense of the substantial form which, unlike that of St. Thomas Aquinas, emphasizes empirical over metaphysical arguments;

2. skeptical humanist arguments against the very possibility of scientific knowledge in the Aristotelian sense;
3. the rise of the mixed mathematical Aristotelian science of mechanics and its implications for scientific objects and demonstrations; and
4. the revival of atomist physics and Gorlaeus' replacement of an Aristotelian substance/accident/mode ontology with a substance/mode ontology.

By highlighting these four factors as important to our understanding of Descartes' eventual elimination of substantial forms I do not intend to rule out other factors that played a significant role in the development of his mechanistic philosophy. In particular, Descartes' indebtedness to Beeckman's mathematical approach to physical problems, his theory of matter, and his formulation of the principle of inertia, along with their early discussions on certain problems in hydrostatics, has been documented.[17] However, rather than duplicate the extensive research already accomplished in this domain, I focus more narrowly on the philosophical problems and resources that explain Descartes' replacement of substantial forms with mechanical principles at the metaphysical level.

I organize my examination of these four philosophical developments and the role they played in the demise of the substantial form chronologically according to three distinct periods in Descartes' life. In Part I, I determine the extent to which Descartes is attacking the accounts of the substantial form developed by two Scholastic philosophers whose works shaped the Jesuit curriculum of the time: St. Thomas Aquinas and Francisco Suarez. In Part II, I examine the mechanical explanations of Descartes' early scientific works in light of challenges to Scholastic Aristotelian scientific explanations posed by skepticism and Aristotelian mechanics – both were central to Descartes' Parisian intellectual environment in the 1620s. Finally, in Part III, I study Descartes' elimination of material substantial forms in his later works against the background of a Dutch atomist philosophy that he would have encountered during his years in the Netherlands.

[17] See, e.g., Klaas Van Berkel, "Descartes' Debt to Beeckman: Inspiration, Cooperation, Conflict," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton (London and New York: Routledge, 2000), pp. 46–59; and Stephen Gaukroger, "The Foundational Role of Hydrostatics and Statics in Descartes' Natural Philosophy," in *ibid.*, pp. 60–80. Henk Kubbinga, "Le Concept d''individu substantiel' chez Beeckman et Descartes," in *Descartes et Regius Autour de l'Explication de l'Esprit Humain*, ed. Theo Verbeek (Amsterdam and Atlanta: Rodopi, 1993), pp. 93–103.

I begin, in Part I, by placing Descartes' arguments against the substantial form within the context of Scholastic Aristotelian philosophy, which dominated his intellectual environment during his early education at the Jesuit Collège La Flèche. However, great caution must be used in drawing inferences regarding the influence of Jesuit textbooks in philosophy on Descartes' own philosophical doctrines. First, it is unclear how much Descartes remembered from his schooldays at La Flèche for, in September 1640, he asks Marin Mersenne to recommend some reading so he can refresh his memory of Scholastic philosophy in preparation for objections to the *Meditations.* In the same letter Descartes recalls the commentaries by the Jesuit philosophers Toletus, the Coimbrans, and Ruvius.[18] This has led to a veritable cottage industry of articles and books seeking to relate elements of Descartes' philosophy to textbooks by these authors.[19] But Descartes makes it clear to Mersenne that he has no interest in pouring over "their huge tomes," and instead solicits Mersenne's help in finding a current abstract of all Scholastic philosophy.[20] Hence there is no evidence that Descartes refreshed his fading memory regarding the teachings of Toletus, the Coimbrans, and Ruvius at this stage. He did consult the *Summa Philosophiae Quadripartita* of Eustachius à Sancto Paulo, presumably the abstract that Mersenne recommended, and praises it as "the best book of its kind ever made," something it is most decidedly not.[21] One recent scholar aptly characterized it as "the Cliff's notes of Scholastic philosophy" and indeed, it does not give sufficient detail to fulfill the aims of this study.[22] However, it served Descartes' purposes in 1640 since, at that stage, he was not interested in the subtleties of Scholastic philosophy, proclaiming instead that "It is easy to overturn the foundations on which they all agree, and once that has been done, all their disagreements over detail will seem foolish."[23] In light of this, a second cautionary note is in order. Even if Descartes did remember and

[18] To Mersenne, September 30, 1640, CSMK, pp. 153–154; AT III, p. 185.

[19] See David Clemenson, *Descartes' Theory of Ideas* (London: Continuum, 2007). He argues that commentaries such as those of Toletus, Rubio, and the Coimbrans are more directly relevant to Descartes' philosophy than is Suarez's *Metaphysical Disputations*, for, even though we do not know which texts were used at La Flèche at that time, we know they had to follow Aristotle's texts, and Suarez's text does not. However, this presupposes that Descartes remembered the textbooks of his youth clearly enough to retain the subtle distinctions between their teachings and those of Suarez and others. As we shall see, this is highly unlikely.

[20] CSMK, pp. 153–154; AT III, p. 185.

[21] To Mersenne, November 11, 1640, CSMK, p. 156; AT III, p. 232. Descartes was so enthralled with this work that he initially planned to publish his *Principles of Philosophy* alongside it.

[22] Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca: Cornell University Press, 1996), p. 11.

[23] November 11, 1640, CSMK, p. 156; AT III, p. 232.

draw on the concepts and arguments found in the Jesuit textbooks of his youth, he was more interested in what they shared with other Scholastics than in what was unique to them. Absent a comprehensive study comparing the writings of a large number of Scholastic authors from this period, we are not in a position to separate uniquely Jesuit positions from common Scholastic views on the substantial form.

For the above reasons, an in-depth investigation of the Jesuit commentaries Descartes is likely to have studied in school would not serve our current purpose of shedding light on his eventual elimination of material substantial forms.[24] To the extent that Jesuit teachings about the substantial form continued to exercise any influence on him, we must look to Jesuit texts he consulted after leaving La Flèche.[25] Francisco Suarez's *Metaphysical Disputations* is the only Scholastic text granted the honor of a citation in Descartes' published works, and so I will focus on this work, while acknowledging that many of the views and arguments it contains could well turn out to be common to other Scholastics of this period.[26] In addition to Descartes' preference for quoting Suarez, there are good reasons to focus on his work. He was by far the best-known and most influential philosopher and theologian of the Jesuit order, and his *Metaphysical Disputations* contain what is arguably the most detailed and sophisticated philosophical account of the substantial form.[27] Therefore,

[24] However, as I demonstrate elsewhere, they can be very useful for getting at "the foundations on which they [the Scholastics] all agree" provided they are studied in conjunction with other Scholastic commentaries. Helen Hattab, "Concurrence or Divergence? Reconciling Descartes' Physics with his Metaphysics," *Journal of the History of Philosophy* 45/1 (2007), pp. 49–78.

[25] The textbooks by Eustachius à Sancto Paulo and Charles François d'Abra de Raconis, which Descartes does appear to have consulted, are very different from the Jesuit ones in that they rely on Scotist teachings. Roger Ariew, *Descartes and the Last Scholastics* (Ithaca: Cornell University Press, 2000). As I show in "Concurrence or Divergence," some of Descartes' claims about concurrence resemble de Raconis' view more than that of the Jesuits; however, absent a thorough investigation of all well-known Scholastic treatises, it is impossible to rule out other sources. Given his lack of interest in subtle differences between Scholastics, it is more likely that Descartes' grasp of key Scholastic concepts was an amalgam of various views he encountered.

[26] Descartes gives a specific reference to Suarez's text in his reply to Arnauld. René Descartes, *The Philosophical Writings of Descartes*, vols. I and II, trans. John cottingham, Robert Stoothoff, and Dugald Murdoch (Cambridge: Cambridge University Press, 1985) (henceforth CSM), II, p. 164; AT VII, p. 235. While this does not prove that Descartes had firsthand knowledge of Suarez's text, it does show that he knew of Suarez's theories and expected them to carry significant weight with his readers.

[27] The influence of Suarez's philosophy during the first half of the seventeenth century cannot be overstated. The *Metaphysical Disputations* established themselves as the premier text on metaphysics, not just in Catholic countries, but in Protestant ones as well. There were at least seventeen editions of it outside the Iberian peninsula in the forty years following its initial publication – almost double the total number of editions of Descartes' *Meditations on First Philosophy* that appeared in the first sixty years following its publication. Jorge J. E. Gracia, "Francisco Suárez: The Man in History," *American Catholic Philosophical Quarterly* 65/3 (1991), p. 265.

whether at first hand or second hand, via other Scholastics, Descartes is likely to have come into contact with the arguments Suarez had collected in his *Disputations*. Even though the Jesuits were instructed to follow St. Thomas Aquinas on all non-controversial issues and Descartes owned a copy of the *Summa Theologica*, I show that Descartes' metaphysical arguments against substantial forms are best understood in light of Suarez's rather than Aquinas' defense of the substantial form. Chapter 1 offers an interpretation of Descartes' most detailed arguments against the substantial form. After a brief overview of St. Thomas Aquinas' doctrine of the substantial form in chapter 2, chapter 3 examines Suarez's definition of the substantial form and his supporting arguments so as to reveal their importance to Descartes' understanding of the substantial form. Suarez's defense of the substantial form also appears to be the target of other anti-Aristotelian attacks on the substantial form, such as that of Gorlaeus. Hence, to understand the growing dissatisfaction with Aristotelian substantial forms during this period, one must understand the ways in which Suarez argued for them.

After completing his education, Descartes served in Prince Mauritz's army in the Netherlands and in 1618 he had his famous first encounter with the Dutch physicist Isaac Beeckman. As mentioned, the influence of Beeckman's *physico-mathematics* on Descartes' engagement with mixed mathematics and mathematical physics has been well studied, so I skip over this brief episode of his life and limit myself to some scattered observations about Beeckman's philosophical orientation in relation to that of Descartes. After his first brief stint in the Netherlands, Descartes traveled with various armies in what is now Germany and Austria and then returned to France. The second part of this book deals with novel theories Descartes would have encountered in Paris as an active member of Marin Mersenne's intellectual circle in the 1620s. I focus on two crucial streams of thought that occupied the Mersenne Circle: skepticism and the revival of Aristotelian mechanics. In chapter 4, I focus on Francisco Sanchez's attack on Aristotelian forms as found in his skeptical treatise, *That Nothing Is Known.* This treatise both represents the kind of full-scale skeptical humanist attack on Aristotelian philosophy that preoccupied Mersenne at the time and anticipates Descartes' later use of skeptical argumentation to clear the ground for a new philosophical method. In chapter 5, I show that commentators of the Aristotelian *Quaestiones Mechanicae*, who formed part of Descartes' mixed mathematical studies at this time, introduced three important conceptual shifts which help us understand his application of mechanical demonstrations to physics and

eventual replacement of scientific explanations in terms of substantial forms with mechanical explanations. Finally, in light of this background, chapter 6 advances a new interpretation of Descartes' use of mechanical principles in his early scientific treatises.

Part III of my study follows Descartes to the United Provinces of the Netherlands, to which he returned in 1629. He was to spend most of his adult life there, so this period is crucial for Descartes' burgeoning interest in metaphysics and the development of his mature philosophy. In chapter 7, I examine the new substance/mode ontology advanced by Gorlaeus, a highly controversial proponent of atomism whose works circulated among Descartes' Dutch colleagues and friends. In chapter 8, I study the elements of Descartes' mature metaphysics that necessitate the elimination of substantial forms in light of both Sanchez's skeptical arguments and Gorlaeus' rejection of Aristotelian principles in favor of aggregates of atoms and their modes.

PART I

Resurrecting the substantial form

Despite earlier attacks by naturalists like Telesio, humanists like Bruno, and eclectic proto-atomists like Basso, Aristotelian physics and its cornerstone doctrine of the substantial form underwent something of a revival in the early seventeenth century and managed to survive late into the century. Its ultimate demise had to await a second wave of attacks by figures we now hail as the great philosophers and scientists of the early modern era: Francis Bacon, René Descartes, Pierre Gassendi, Thomas Hobbes, Robert Boyle, and John Locke, to name just a few. But what frequently gets neglected in the story they tell, and which we continue to regurgitate, is the role that innovations within Scholastic Aristotelianism played in the shift from hylomorphism to mechanism.[1] While the larger story yet to be told lies beyond the scope of this book, I will begin, in Part I, to make up for this neglect by showing that Descartes' metaphysical arguments against the substantial form are best understood against the background of Suarez's definition of the substantial form as an incomplete substance. Indeed, Descartes' arguments would fail against Aquinas' account of the substantial form. I will demonstrate that the post-Suarezian Scholastic doctrine of the substantial form, targeted by anti-Aristotelians like Gorlaeus and Descartes, had key features that facilitated its ultimate replacement, whether by atomism or mechanism. But first I examine Descartes' arguments against the substantial form in order to then make sense of them in light of the relevant arguments in its favor advanced by the premier authorities of the Jesuit educational system: St. Thomas Aquinas and Francisco Suarez.

[1] The vitality and sheer variety of Aristotelian doctrines during this period were first recognized by Charles Schmitt. See, e.g., Charles B. Schmitt, "Renaissance Aristotelianisms," in his *Aristotle and the Renaissance* (Cambridge, MA: Harvard University Press, 1983). While he laid the groundwork, much work still needs to be done to uncover the contributions of various Scholastic Aristotelian philosophies.

CHAPTER 1

Descartes' arguments against the substantial form

Descartes' most sustained arguments against substantial forms occur in the correspondence of January 1642 with Henricus Regius, where Descartes instructs his Dutch disciple how to defend himself against Voetius' attacks on the Cartesian natural philosophy Regius taught at the University of Utrecht. For Regius' benefit, Descartes collects several objections against substantial forms one finds throughout his writings and adds a few more. He organizes his discussion around seven theses, following the structure and order of Voetius' objections, and urges Regius to employ and elaborate on his suggested replies in answering Voetius. In the course of countering some of Voetius' specific points, Descartes offers several arguments to defend the superiority of Cartesian principles over the Scholastic notions of substantial forms and real qualities. These can be divided into two broad classes: scientific arguments and metaphysical arguments. The scientific arguments can be further subdivided into three distinct ones. (1) In the first and fourth theses, Descartes argues from the use of substantial forms in physics, claiming they are unnecessary and pointing to the explanatory success of his scientific principles. (2) In the second and third theses he employs an analogy between natural objects and machines to show that substantial forms are no more necessary to explain the actions of the former than the latter. (3) In the fifth thesis he charges that scientific explanations in terms of substantial forms explain the obscure by the more obscure.

Descartes likewise offers three distinct metaphysical arguments. (4) In the second thesis, he addresses Voetius' concern that denying substantial forms in purely material things makes it more difficult to refute those who affirm the existence of a universal world soul and those who claim that the human soul is corporeal and mortal. Indeed, as we saw in the Introduction, Basso, having refuted the Peripatetic view, posits a universal World Soul to do the work of their individual substantial forms. While it need not, such a view could also put personal immortality into question.

Against Voetius, Descartes claims that embracing substantial forms in material things lends itself to the view that the human soul, as a substantial form, is likewise corporeal.[1] Therefore, it is better to reject them. (5) Descartes argues that if there are substantial forms, they can have no greater being than modes. (6) Finally, in the third thesis, Descartes constructs an *a priori* (which in the seventeenth century refers to reasoning from cause to effect) metaphysical and theological argument, based on the natures of substance and substantial form. Since Regius was familiar with Descartes' scientific writings, Descartes offers no clarification with respect to his first and second scientific arguments. Therefore, I will address the origins and meaning of the machine analogy and the sense in which Descartes took his scientific demonstrations to have superior explanatory success when I turn to his early scientific writings in Part II. In this chapter, I unpack Descartes' scientific argument based on the obscurity of substantial forms and provide an interpretation of his second and third metaphysical arguments. In short, I will give an in-depth reconstruction of Descartes' arguments against material substantial forms in the following order:

Part I – (3) obscurity of substantial forms and (6) *a priori* argument
Part II – (2) nature/machine analogy and (1) superiority of mechanical explanations
Part III – (5) substance/mode ontology

I will not address argument (4) in further detail since it is sufficiently explained, and is driven by concerns about the immortality of the soul.

1.1 THE OBSCURITY OF SUBSTANTIAL FORMS

Since this type of argument does not appear to presuppose the metaphysics Descartes developed after advancing his mechanistic science, and hence could well pre-date his metaphysical arguments, I begin with an overview of Descartes' scientific objections to substantial forms. First Descartes tells Regius that this kind of argument "is drawn from the purpose or use of substantial forms."[2] He explains that philosophers introduced substantial forms to account for the proper actions of natural things. As we shall see in chapter 3, this is precisely the function of material substantial forms that Suarez emphasizes in his account, whereas it is not central to Aquinas'

[1] AT III, p. 503. [2] CSMK, p. 208; AT III, p. 506.

account. But, Descartes points out, substantial forms cannot fulfill this goal because they are occult and even the philosophers who embrace them do not understand them. Therefore, to explain an action by stating that it proceeds from a substantial form elucidates nothing, for it is equivalent to stating that the action proceeds from something we do not understand. Descartes concludes from this that substantial forms should not be introduced to explain natural actions. We should rather adopt Descartes' theory, for "Essential forms explained in our fashion, on the other hand, give manifest and mathematical reasons for natural actions, as can be seen with regard to the form of common salt in my *Meteorology*."[3] I will explore the meaning of this claim in Part II. For now it suffices to highlight that, like other critics of Scholastic Aristotelian science (including skeptics like Francisco Sanchez, whose objections will be examined in chapter 4), Descartes recognizes that proper scientific explanations must be based on knowable foundations. However, unlike many other critics, Descartes proposes an alternative to Aristotelian foundations which, as I will show in Part II, is based on the principles of mathematics and mechanics.

To unpack what Descartes means when he labels substantial forms as "occult" and his own theory as one that gives "manifest and mathematical reasons for natural actions," it is instructive to examine other passages where Descartes makes the same argument and offers examples. For example, he offers a parallel argument against real qualities in his letter to Mersenne dated April 26, 1643.[4] Real qualities include accidental properties that inhere in a substance, like an object's color or its heaviness, but are nevertheless *res* (things) that God could conserve apart from the substance. Descartes starts off by describing real qualities in much the same way that he characterizes substantial forms, namely, as separate substances attached to matter, like a soul attached to a body, and separable from the body by God.

> My view on your questions depends on two principles of physics, which I must establish before I can explain it.
>
> The first is that I do not suppose there are in nature any *real qualities*, which are attached to substances, like so many little souls to their bodies, and which are separable from them by divine power.[5]

[3] CSMK, pp. 208–209; AT III, p. 506. In Part II, I will examine what 'essential forms' and 'mathematical reasons' Descartes proposes in his scientific writings.

[4] Rozemond cautions against assuming that Descartes conflated substantial forms with real qualities. *Descartes' Dualism*, p. 102. However, he does frequently dismiss them together on the same grounds, and, as discussed below in connection with his second metaphysical argument, he takes the Scholastic view that distinguishes them to result in absurdity.

[5] CSMK, p. 216; AT III, p. 648.

Then adding the metaphysical distinction between substances and modes that is central to Cartesian philosophy from the *Meditations* onwards, Descartes concludes that he considers qualities to be modes, not substances in their own right. However, it must be noted that his initial characterization of real qualities as little souls attached to bodies need not, as is often thought, presuppose Cartesian dualism, or the substance/mode ontology.[6] Descartes rather could be read to understand the nature of material substantial forms (those which unlike the rational soul are educed from and exist only in matter) and the real qualities they give rise to in terms of Suarez's paradigmatic case of the substantial form: i.e., the separable rational soul. I will show in chapter 3 that Suarez's main argument for the existence of substantial forms lends credence to the idea that material substantial forms, as manifested by the real qualities of an object, must be just like the rational soul.

Descartes goes on to give two reasons for rejecting real qualities; the first can help clarify his claim to Regius that substantial forms explain nothing because of their obscurity. According to Descartes, when we speak of real qualities and attribute existence to them we have no particular idea by which to conceive them. Therefore, we are speaking of something of which we have no notion and which we consequently do not understand.[7] While Scholastic Aristotelians would deny this with respect to real qualities, Suarez and other Scholastics admit that we cannot know the substantial form directly by experience. Hence Descartes' complaint that substantial forms and real qualities are 'occult' because we do not have a particular idea to conceive them by has considerable credibility with respect to substantial forms. However, the Scholastic could still respond that he has a particular idea of greenness from his perception of it, of heaviness from the downward motion of the body, and of the substantial form from its effects. So when Descartes charges the Scholastics with lacking a particular idea by which they can conceive of real qualities, he really means that they lack a particular non-obscure or clear idea. But what does he mean by a clear idea? He cannot mean by it a direct perception of the body's hidden structure, for Descartes is no more able to perceive the particles in motion that he takes to give rise to certain

[6] For example, Rozemond attributes to Descartes the view that substantial forms and real qualities are "the products of confusions of the mental and physical," and also claims that his dismissal of real accidents "is part and parcel of his development of the mode-attribute conception of substance." *Descartes' Dualism*, p. 102. While Descartes does sometimes explicitly reject substantial forms and real qualities on these grounds, I will show that he employs other arguments as well.

[7] CSMK, p. 216; AT III, p. 649.

sensible properties of a body than the Scholastic is able to perceive the real quality of heaviness or the substantial form of a body. All that either camp perceives is the body as a whole, along with its properties and alterations; they come into conflict because each side posits different entities to account for them. Since Scholastic Aristotelianism is the entrenched philosophy, Descartes must show that his theory is preferable on grounds that do not presuppose it (i.e., to be convincing, he cannot presuppose dualism and a substance/mode ontology). He does this by arguing that we need 'clear' ideas to do science and that his natural philosophy has the advantage of being based on such ideas.

In a letter to Morin of July 13, 1638, Descartes implies that, unlike Scholastic substantial forms, the mechanisms he posits are based on observable things. Inviting Morin to compare "the suppositions of others with mine, that is to say, all their *real qualities,* their *substantial forms*, their *elements* and like things, the number of which is almost infinite, with this alone: that all bodies are composed of parts," he points out that his assumption "is something one sees with the naked eye in many cases, and which one can prove by an infinity of reasons in others (since all I add to this is that the parts of this or that body are of such a shape rather than another, it is easy to demonstrate it to those who admit that they are composed of parts)".[8] One sense in which his ideas are 'clearer', then, is that we can all see that bodies are made of parts whereas we cannot see substantial forms. But in what sense is the attribution of certain shapes to parts not visible to the naked eye 'clearer' than positing a substantial form? We find clues in Descartes' first treatise on natural philosophy, *The World*, which he began to write in 1629, well before the letters cited above. There Descartes claims that his idea of motion is clearer because it is easier to understand than that of the Aristotelians, complaining that their definition "Motion is the actuality of a potential being in so far as it is potential" is utterly obscure. He then emphasizes the advantages of his conception of motion:

> By contrast, the nature of the movement of which I mean to speak here is so easy to know that even the Geometers, who among all men are the most concerned to conceive very distinctly the things they have examined, have judged it simpler and more intelligible than that of their surfaces and lines – as appears from the fact that they have explained 'line' by the movement of a point and 'surface' by that of a line.[9]

[8] AT II, p. 200. [9] AT XI, p. 39.

Descartes argues that his idea of motion is so easy to understand because, like the geometer's definitions, it includes only local motion, or simple displacement. "For my part, I am not acquainted with any motion except that which is easier to conceive than the lines of the geometers – the motion which makes bodies pass from one place to another and successively occupy all the spaces which exist in between."[10] We find references to the ease with which we understand geometrical ideas and mathematical demonstrations throughout Descartes' later writings as well. Hence Descartes' notion of 'clarity' remains closely related to its mathematical roots.

In short, the fact that geometers use it to explain notions such as 'line' and 'surface' is supposed to convince his contemporaries that Descartes' idea of motion is simple and easy to understand. Like the mathematicians of his time, whose views will be discussed in chapter 5, Descartes appeals to the intuitive intelligibility and certainty of mathematical definitions. But in Descartes' case this notion of intelligibility is also tied to our ability to picture something to ourselves. An idea is clear and easily understood when, like the ideas of geometry, we can imagine it in our mind. For example, we can represent local motion to ourselves by imagining something like a dot in one place and then in another. Similarly, we get the idea of a surface or a line by letting the dot move and occupy several places successively. On the other hand, according to Descartes, the Aristotelian has no way of picturing to himself what a real quality is. For example, what is the quality of heaviness that causes the downward motion of the body? On the Aristotelian view, we have no way of picturing it other than in terms of its effect, i.e., the downward motion. On Descartes' view, we can at least break the motion of a body down into the local motions of the particles of terrestrial matter that go to make up the body and then picture these in geometrical terms in our imagination.[11] However, Descartes' claim that the Scholastic cannot picture real qualities fails if we take the example of color. The Scholastic believes that a color, like greenness, literally inheres in the object as an accidental form or real quality, and on one influential Scholastic theory of perception, the same form of green is imprinted on the matter of the eye when we perceive it. Clearly, in the case of real qualities like color, Descartes' charge that the Scholastic cannot picture them is less successful than in the case

[10] CSM I, p. 94; AT XI, p. 40.

[11] See René Descartes, *Principles of Philosophy* (henceforth *pp*), trans. V. R. Miller and R. P. Miller (Dordrecht: D. Reidel publishing Co., 1983), Part IV, a. 20–23, pp. 190–191, CSM I, p. 268–269; AT VIIIA, p. 212.

of heaviness, since the Scholastic can picture the form of greenness by imagining green. Descartes would have to presuppose his own ontology and the distinction between primary and secondary qualities in order to argue that the quality that the Scholastic clearly perceives is clear only as a mental entity, and is not identical to the form which exists in the body itself. Therefore, his third scientific argument rests on the very metaphysical principles it is meant to establish. To avoid this circularity Descartes needs a separate reason for his claim that we have a clearer explanation, and therefore a better understanding, when we can picture something to ourselves in geometrical terms rather than in terms of sensory qualities.

In a letter to Morin dated September 12, 1638, Descartes appears to give additional reasons for regarding his own notions as clearer and easier to grasp than Scholastic ones. There he complains that the analogies used by the Scholastics explain "intellectual things by means of physical ones, substances by means of accidents, or at least one quality by means of a quality of a different kind."[12] Descartes finds these analogies uninstructive. The reason seems to be that they explain one thing by something that belongs to a different category; for example they explain intellectual things by means of physical ones and substances by means of accidents. Both these count as confusions of ontological categories for Descartes, although the Scholastic who holds that ideas in the intellect are derived from imprints of real physical forms would not consider the first to be so. The last type of confusion, whereby one property is explained by another kind of property, could include cases where one of Aristotle's logical categories is confused with another; for example, the property of shape belongs to the category of quantity whereas color is a non-quantitative property. However, Descartes seems to be advancing a criterion for clear analogies that is even stricter than avoiding this kind of category mistake. His explanations do not even mix things that belong to the same logical category: for example, size and shape are both quantitative, and yet Descartes seems to think we can explain shapes only by shapes.[13]

Descartes believes that mixing properties in our explanations confuses matters and makes it harder for us to achieve clear explanations.

[12] AT II, p. 367.

[13] In a letter to Morin dated September 12, 1638, he writes: "But in the analogies which I employ, I compare movements only with other movements, or shapes with other shapes; that is, I compare things that are too small to be perceived by the senses with other things that can be so perceived, the latter differing from the former simply as a large circle differs from small one." CSMK, p. 122; AT II, p. 367–368. Using 'analogy' in a sense consistent with the Aristotelian meaning, Descartes appears to mean 'proportion,' not what we mean by 'analogy.'

He even goes so far as to say that any claim which cannot be explained by the analogies that he recommends must be false.[14] The analogies or proportions Descartes claims to employ stay not only within the same ontological category but even within the same kind; for example, movements are compared only to movements, and shapes to shapes. But, on this account, what is the problem with the view of the Aristotelians? If we examine their explanation of color it seems that it conforms perfectly to this criterion. The quality of green we perceive in the body is explained by the inherence in that body of the real quality of green. Both the thing being explained (the perception of greenness) and the explanation (the real quality of greenness in the object) are properties of the same type in that they both belong to the category of quality. Thus, by Descartes' criterion, the Scholastics provide an unconfused, clear explanation. Once again, only if we accept Descartes' dualistic ontology can we state that the Scholastic Aristotelians are illegitimately attempting to explain something that belongs to the category of body (the properties of the body that makes it appear green) by something that belongs to the separate category of mind (i.e., the green quality as perceived by us). Hence, despite appearing to offer a theory-neutral criterion for preferring his scientific explanations, Descartes' insistence that the ideas of his scientific explanations are unmixed and clear turns out to be metaphysically laden.

It should also be noted that by the time he writes the *Principles* Descartes is cheating on his own criterion. In article 200 of Part IV, he writes:

> I have considered the shapes, motions and sizes of bodies and according to the laws of mechanics, confirmed by certain and everyday observations, examined what in fact must follow from the mutual concourse of those bodies. But who has ever doubted that bodies are moved and have various sizes and shapes, in proportion to which their motion is also changed, and that from mutual collision, the larger are divided into smaller ones and alter their shape?[15]

In other words, in his actual scientific writings, Descartes is quite happy to explain changes in motion in terms of shapes and sizes, and changes in size and shape in terms of collisions. I will argue in Part III that what really drives Descartes' conception of clarity is his underlying conception of mathematical principles as direct internal apprehensions of the intellect that are immune to skeptical doubts of the kind raised by Sanchez. As long as we infer observable mathematical properties from more basic intuitable mathematical properties, we can bypass the senses and prevent our intellects from being led astray by deceptive sensory images.

[14] CSMK, p. 122; AT II, p. 368. [15] AT VIIIA, p. 323.

Substantial forms, by contrast, are obscure precisely because they can be inferred only from such sensory ideas.

In short, the scientific argument based on the obscurity of Aristotelian notions and clarity of Cartesian ideas is insufficient, on its own, to fully convince someone educated in Scholastic Aristotelian metaphysics and natural philosophy that one should abandon substantial forms. Nor does it reflect the actual scientific explanations Descartes gives in his scientific writings. As Descartes eventually came to realize, what he needed was a metaphysical argument for dualism to support his mechanistic physics. However, this does not mean that Descartes lacked justification for his rejection of substantial forms until he composed the argument for dualism found in Meditation 6. To the contrary, in his response to Regius, Descartes draws on *a priori* metaphysical reasons that may pre-date, or at least are logically independent of, the dualistic metaphysics found in his mature philosophy.

1.2 METAPHYSICAL ARGUMENTS AGAINST THE SUBSTANTIAL FORM

Before we turn to Descartes' *a priori* argument against substantial forms, let me briefly address his argument that substantial forms, if they exist, cannot have greater being than modes. Descartes first claims that it would be absurd if those who posited substantial forms to account for the actions of a substance made them the immediate principles of such actions. Descartes here merely acknowledges the standard Scholastic view that accidental forms are the instruments by which substances act and produce effects. That is, wind does not cool things down directly by means of its substantial form of windiness, but by means of its accidental quality of coldness. Only those who equate substantial forms with these active qualities can claim without absurdity that substantial forms are immediate principles of action. Descartes thus implies that if material substantial forms exist, they must be active qualities (presumably he would treat the case of the soul differently). As we shall see when we turn to Suarez's arguments in chapter 3, one Scholastic view accounted for specific actions of physical substances by means of a substance's qualities, like coldness, or the higher quality that virtually contains coldness, rather than attributing all actions to its substantial form. Descartes next adds that he does not deny the existence of such qualities but rather denies that "a greater Being than Modal being is to be attributed to

them."[16] This conclusion follows directly from Descartes' substance/mode ontology, which eliminates Scholastic accidents. If substantial forms cannot be substances, and they cannot be substances if they are merely active qualities, then they must be modes.

Descartes clarifies the distinction between substances and modes in a letter to Mesland of Febuary 9, 1645, in which he explains to him what he means by 'surface,' which is a mode of body.

> By 'surface' I do not mean any substance or real nature which could be destroyed by the omnipotence of God, but only a mode or a manner of being, which cannot be changed without a change in that in which or through which it exists; just as it involves a contradiction for the square shape of the wax to be taken away from it without any of the parts of the wax changing their place.[17]

Unlike a substance, a mode, like the surface of a body, is not a self-subsistent thing that can exist independently of other created things. Rather, it exists only as a result of the arrangement of the parts that make up the substance. Consequently, it could not be removed (not even by God) without a change in the substance, for that would involve a contradiction. A Scholastic accident, by contrast, can remain when the substantial form is replaced, as when Christ's substantial form enters the Host. It can also be removed by God even though the substantial form is present, as in the case of the miracle of the fiery furnace, which, having lost its action of burning, spared the men in it. Cartesian modes, however, are completely dependent on the nature of the substance. Hence there is no need for the substantial form as an intermediate form uniting a substance's accidental properties with the subject in which they inhere. Modes cannot but inhere in the subject which they modify. In Part III I will delve more deeply into Descartes' rejection of the Scholastic distinction between substances and accidents in favor of a substance/mode ontology in relation to Suarez's and Gorlaeus' accounts of modes. For now it suffices to highlight that Descartes does rely on his new substance/mode ontology to eliminate real qualities, and, with them, material substantial forms. He does not of course eliminate the rational soul as the substantial form of the human body, but this apparent inconsistency lies outside the scope of this study.

Brief statements of the conclusion and premises of Descartes' *a priori* argument can be found in the *Principles* and in other parts of the *Correspondence*, but the argument is laid out in its entirety only in

[16] AT III, p. 503. [17] CSMK, p. 241; AT IV, p. 163–164.

Descartes' letter to Regius of January 1642.[18] It appears to depend on the definition of substance that Descartes gives in other places, notably in the *Principles*, Part I, article 51, and also, in part, on his replacement of the Aristotelian substance/accident ontology with a substance/mode ontology. I will show that, unlike the argument from the obscurity of substantial forms and real qualities, Descartes' metaphysical rejection of substantial forms does not logically follow from his dualism, but rather rests heavily on something akin to Suarez's conception of the substantial form. Thus his rejection of substantial forms does not, as is often thought, stand or fall with his dualism. If anything, Descartes' dualism necessitates that he treat the human mind as the substantial form of the human body so as to account for the *per se* unity of human beings.[19]

In the *Principles* Descartes employs one of Aristotle's criteria for substancehood, defining a substance as a self-subsistent thing, with the added qualification that it depends on nothing other than God for its existence. "By substance we can understand nothing other than a thing which exists in such a way that it needs no other thing to exist."[20] The epistemological corollary to this is that we can conceive of a substance apart from other substances, and therefore there is a *real distinction* between different substances.[21] Substances are then contrasted to mere modes. Unlike substances, modes, like a body's size and shape, are not self-subsistent and depend on substances for their existence: "When we consider a substance affected or changed by them [qualities or attributes] we call them modes."[22] Based on this new ontology, substantial forms must be substances, since the only alternative is to be a mode, and this precludes any degree of separability. In this regard, Cartesian modes differ significantly from Scholastic Aristotelian accidents, which are separable from substances (most notably in the case of transubstantiation), and so Descartes' introduction of the substance/mode ontology is what ultimately enables him to eliminate substantial forms at the metaphysical level.

While Descartes' substance/mode dichotomy serves to directly eliminate all substantial forms except the immortal human soul, he also offers Regius an argument against substantial forms that does not rely on this controversial new ontology. Descartes often refers to substantial forms as

[18] CSMK, p. 208; AT III, p. 505.

[19] Descartes instructs Regius to say that he must state that a human being is an *ens per se*, such that the mind and body are united in a real substantial manner, not accidentally, and adds: "You must say that they are united not by position or disposition, as you assert in your last paper – for this too is open to objection and, in my opinion, quite untrue – but by a true mode of union, as everyone agrees." CSMK, p. 206; AT III, p. 493.

[20] AT VIIIA, p. 24. [21] *PP* I, a. 60, CSM I, p. 213; AT VIIIA, p. 28. [22] AT VIIIA, p. 26.

substances joined to matter and he explicitly states this in the letter to Regius several pages before his presentation of the *a priori* argument:

> For lest there be any ambiguity in the term, it must be noted here that by the name of the substantial form, when we deny it, is understood a certain substance joined to a certain matter, and with it composing a certain merely corporeal whole. And this [form] no less than matter or even more than matter is a true substance, or self-subsisting thing, since it is certainly called Act, the latter in fact only Potency.[23]

In the next two chapters, I will show that even though this characterization of substantial forms is at odds with the account of Aquinas, whose doctrines Jesuits were supposed to follow on all non-controversial matters, Descartes is not attacking a straw man here. Rather, his argument appears to rely on Suarez's doctrine of the substantial form. Since Suarez treats the substantial form as a self-subsisting thing joined to matter, by Descartes' definition of substance, Suarezian substantial forms must therefore be substances. Even on a Scholastic ontology, a substantial form must be either a substance or an accident, and since Scholastics are adamant that it is not an accident, it must therefore be a substance. But then why would substantial forms, as self-subsisting entities, need matter to exist? Descartes' answer is that they do not – the only substantial form is the rational soul, which does not need the body to exist.

Based on his definition of substance, and the definition of a substantial form as a substance joined to matter, Descartes constructs his main metaphysical argument against substantial forms. His first premise is that it is inconceivable (literally, it opposes the intelligible or the plain and clear) that a substance should exist *de novo* without being created *de novo* by God. Descartes then states a fact, namely, that every day we see the forms called substantial forms begin to exist *de novo* (e.g., when a chrystal is formed or a plant germinates from a seed).[24] Here he grants the Scholastic premise that when a new substance is generated, a new substantial form comes into being. Next Descartes reminds us that, by their definition, his Scholastic opponents consider substantial forms to be substances. Finally, he claims that these same opponents deny that substantial forms are created

[23] AT IV, p. 502.

[24] The Latin text states: "Quod Plane repugnet ut substantia aliqua de nouo existat, nisi de nouo a Deo creetur; videmus autem quotidie multas ex illis formis, quae substantiales dicuntur, de nouo incipere esse, quamuis a Deo creari non putentur ad ijs qui putant esse substantias; ergo male hoc putant" (AT III, p. 505). The English translation by Cottingham *et al.* neglects to repeat the phrase *de novo* in the 1st and 2nd premises because it seems redundant (all things that begin to exist, begin to exist newly). However, as I argue below, I believe that the phrase *de novo* must be equated with creation *ex nihilo* for the argument to work, and so I have included it.

by God (this is true of material substantial forms which were said to be educed from the matter). Descartes concludes from this that since (by the first premise) it is inconceivable that a substance should come into being *de novo* without being created *de novo* by God, his opponents must be mistaken about the fact that substantial forms are substances. Of course, then the only possibility that remains is that they are accidents or modes, something every Aristotelian would deny.

To show that he is on firm ground when he claims that substantial forms, defined as substances, must be created *de novo* by God, Descartes cites the example of the soul, which is the "true substantial form of man."[25] We shall see in chapter 3 that this is also Suarez's prime example of a substantial form. Descartes argues that the soul is thought to be *immediately* (emphasis mine) created by God just because it is a substance. By 'immediate creation' Descartes means that the soul is created directly by God, without the mediation of another thing. For example, one would not say that the body of a person is immediately created by God, for it arises from the union of the sperm and egg of the parents, which existed prior to the embryo. However, the soul of the person was not thought to arise out of the pre-existing matter; rather it was supposed to be created out of nothing by God and to enter the embryo at the time of quickening. Descartes' reasoning appears to be that souls, as substances, cannot be created mediately, for this would turn them into accidents that inhere in the matter out of which they are created. He concludes that if there are substantial forms attached to matter, and if they are substances, not accidents (as his opponents think they are), they must, like the rational soul, be immediately created by God. But his Scholastic opponents deny that substantial forms are immediately created by God, for on their view material substantial forms emerge from the potentiality of matter. This entails that the creation of substantial forms is not immediate, and that, therefore, they are accidents rather than substances. Descartes has reduced the Scholastic doctrine of substantial forms to absurdity: either substantial forms are accidents, in which case the soul must inhere in matter and hence cannot exist separately from it, or they are substances, in which case material substantial forms cannot come to be from matter.

Since Descartes presents this argument from the creation of the rational soul not as a separate argument but as an example to illustrate his main argument, it is fair to conclude that he introduces the creation of the soul, which is an immediate creation *ex nihilo*, as representative of the creation

[25] CSMK, p. 208; AT III, p. 505.

de novo true of all substantial forms. Descartes equates creation *de novo* with creation *ex nihilo*, which requires the immediate efficient causation of God.[26] Indeed, it will become clear in chapter 3 that Descartes merely draws out the problems latent in Suarez's view of the substantial form. If the paradigm of a substantial form is the rational soul, which is a substance created *ex nihilo* by God, then must not material substantial forms also be created *ex nihilo* by God? But this is precisely what Suarez denies, for he upholds Aquinas's doctrine that material substantial forms are educed from pre-existing matter. Descartes focuses on this fundamental inconsistency in Suarez's view and concludes that the existence of material substantial forms is inconsistent with the premise that the soul is a substantial form, i.e., an incomplete substance created *ex nihilo* by God.[27]

The arguments Descartes presents to Regius are, of course, intended as ammunition to counter the attacks launched against Cartesianism by his Scholastic Aristotelian critics. This raises the question whether they accurately reflect Descartes' own reasons for rejecting substantial forms or whether he merely suggests these arguments to Regius because of their effectiveness against his Scholastic opponents. The tone of the letter indicates that Descartes considers the arguments to be instruments of persuasion and means to appeasing his critics, rather than crucial components of his own reasoning. For example, he reprimands Regius for openly rejecting substantial forms and active qualities as they have made him (Regius) so unpopular with his colleagues.[28] He also advises Regius to abandon

[26] Among medieval proponents of the eternity of the world, there is a distinction – God creates the world *ex nihilo* but not *de novo* since there is no time when the world did not exist. Similarly, one can conceive of something being created *de novo* but not *ex nihilo*, like the form of an oak tree, which did not previously exist, and which comes to be, not out of nothing, but out of the matter of the acorn. Suarez, like Descartes, does not consider the latter case a creation.

[27] Rozemond calls this argument the theological argument and reads it as resting heavily on Descartes' view that separability is sufficient for substancehood. Since substantial forms are separable, they must all, like the immortal soul, be substances that are created *de novo* by God. But the Scholastics deny that material substances and their substantial forms are created *de novo*, so the immortal soul turns out to be the only true substantial form. This reconstruction of the argument begs the question against the Scholastics, since, as Rozemond acknowledges, they do not regard separability as sufficient for substancehood. *Descartes' Dualism*, pp. 130–131. It also presupposes that all substances must be created *de novo* in Descartes' sense of an immediate creation. This too is controversial, since material substances were thought to come to be from pre-existing materials. On my reading, Descartes need not assume these controversial premises – instead, the argument rests on his conflation of creation *de novo* with creation *ex nihilo* and his treatment of the soul as representative of all substantial forms. As we shall see in chapter 3, given Suarez's treatment of the substantial form, both premises would have been reasonable to Scholastic contemporaries even if they denied that separability was sufficient for substancehood.

[28] CSMK, p. 205; AT III, p. 492.

some arguments because they are more open to attack by his opponents. It is clear that Descartes is, in this context, more concerned with polemics than with the accurate representation of his own thought process. As I will show in Part II, outside his polemics with Voetius, Descartes does not invoke metaphysical arguments but rather characterizes substantial forms as redundant in light of the superiority of mechanical forms of demonstration in physics. However, as I will argue next, Descartes' metaphysical arguments reveal not only a good grasp of the weaknesses in Suarez's logical defense of the substantial form, but also an underlying assumption that his Scholastic opponents based their arguments for substantial forms on Suarez's, not Aquinas's, definition of the substantial form. Hence Descartes' arguments against the substantial form bear testimony to the widespread nature of Suarez's influence, and the role that Suarez's arguments for the substantial form played in its demise. To appreciate the philosophical significance of Suarez's re-conceptualization of the substantial form and its relevance to Descartes' argument, we must first familiarize ourselves with Aquinas' view.

CHAPTER 2

Aquinas' introduction of the substantial form

The doctrine of the substantial form is itself a Scholastic innovation. Nowhere does Aristotle employ this term, and though Aquinas and others take him to imply the existence of such a form in certain passages of the *Physics* and *Metaphysics*, it is not clear that Aristotle was committed to such a form in the Scholastic sense.[1] Even if one agrees with Scholastics that Aristotle was committed to substantial forms, the Christian doctrine of the immortality of the soul required significant revisions to the sense in which Aristotle took the soul to be the form of the body. In this chapter, I will first examine the main argument Aquinas presents for the distinction between substantial and accidental forms in his commentaries on Aristotle's *Physics* and *Metaphysics*. Then, as background to Suarez's alternative argument for the substantial form, I will highlight certain tensions created by Aquinas' attempt to account for the immortality of the soul in these terms in the *Summa Theologica*. I will conclude that, despite Aquinas' status as the theologian all Jesuits were to follow on non-controversial issues, and the fact that Descartes owned a copy of the *Summa Theologica*, Aquinas' view is not the target of Descartes' *a priori* metaphysical argument.[2]

Since my goal is to provide background to Suarez's view of the substantial form and make sense of Descartes' arguments against material

[1] For instance, Ellen Stone Haring argues that in *Metaphysics Zeta*, chs. 7–9, Aristotle "establishes that substantial form is a simple and primary ousia, and identical with its essence." "Substantial Form in *Metaphysics* Z,1," *Review of Metaphysics*, 10/2/38 (1956), p. 324. By contrast, Aquinas reads these chapters as a continuation of Aristotle's discussion of the essences of sensible things from the point of view of logic. Having refuted the Platonist view that the universals appealed to in logic are separate forms, Aquinas then takes Aristotle to switch gears from logic to metaphysics in *Zeta* 17, where he introduces the view that substance in the sense of essence is a principle or a cause. Consistent with his distinction between the essences employed in logic and essence/form as a principle and cause, Aquinas does not employ the term 'substantial form' in the chapters preceding *Zeta* 17. *CAM*, p. 610.

[2] On December 25, 1639, Descartes writes to Mersenne, telling him he has brought a copy of the *Summa* with him to the Netherlands. AT II, p. 630.

substantial forms, I will limit myself to Aquinas' account of the forms found in Aristotelian natural philosophy. However, it should also be noted that Aquinas considers such physical/natural forms to be closely related to the metaphysical essences that are picked out by definitions. In particular, he claims that there is a proportionality between the genus and species that define a substance, and its matter and form: "From this it is clear why genus, species, and difference are related proportionately to matter, form and composite, though they are not identical to them."[3] The close connection between the specific difference in a definition (what Suarez will label the logical form), and the natural form of a substance is of course what allows scientific demonstrations, which employ definitions as their middle terms, to reach true conclusions about the properties of substances. While an investigation of Aquinas' theory of essences and definitions would take us too far afield, their connection to the natural substantial forms of physics should be kept in mind, since I will later contrast it with the sharp distinctions Suarez draws between the natural form, and what he calls the metaphysical form (the essence) and the logical form (the differentia in a definition).

In his overview of the principles of Aristotelian philosophy, *On the Principles of Nature*, Aquinas defines form as anything from which (*a quo*) something has being. He further distinguishes between accidental being, which he characterizes as being *secundum quid* (e.g., being white or tall) and the essential or substantial being of a thing, which he characterizes as being *simpliciter* (e.g., being a man or an oak tree). It follows then that, corresponding to these two kinds of being, there must be two kinds of form. One is the accidental form, through (*per*) which something has accidental being, e.g., the form of whiteness through which a man who is potentially white becomes actually white. The other is the substantial form, through which something has substantial being, e.g. the form of an oak through which the acorn, which is potentially an oak, becomes an actual oak. Corresponding to these two kinds of being, and the two related kinds of form, Aquinas next identifies two kinds of generation. Since generation is the movement to form, it can likewise be either *secundum quid* or *simpliciter*. The first consists in a qualified movement to an accidental form. In this case, something that already exists becomes 'this' – e.g., when a man turns pale he acquires the accidental form of whiteness. The second consists in an unqualified movement towards a

[3] St. Thomas Aquinas, *On Being and Essence*, trans. Armand Maurer (Toronto, Ont.: Pontifical Institute of Mediaeval Studies, 1968), p. 41.

substantial form, e.g., when an individual man, Socrates, who did not previously exist, comes into existence. Aquinas clarifies the difference with the example of a statue borrowed from Aristotle. When a bronze statue is made, the shape it acquires is not a substantial form, for the bronze had an act of existing before it acquired the shape of the statue, and its act of existing does not depend on that shape. By contrast, the bronze did not exist until its matter acquired the form of bronzeness, and will cease to be when this essential form is lost.[4] For Aquinas then, the distinction between substantial and accidental forms is grounded in the fact that there are two different kinds of coming to be. Thus, in contrast to Descartes, who makes no mention of Aristotle's arguments in his objections to material substantial forms, Aquinas bases his distinction on the analysis of natural change found in Aristotle's *Physics*.

In his *Physics*, Aristotle clearly distinguishes between coming to be something, and coming to be *simpliciter*, and limits the latter to the generation of a substance (*οὐσία*).[5] However, it is exceedingly difficult to determine whether he took the generation of substances to occur out of informed matter (in which case even primary matter would always have at least an elemental form) or out of matter lacking any form (in which case primary matter would consist in a pure potentiality).[6] Contemporary commentators continue to propose arguments on both sides. For our purposes, it suffices to highlight that Aquinas advanced the line of interpretation that attributes prime matter as a pure potentiality to Aristotle. On this reading, since Aristotle holds that the four elements, earth, air, fire, and water, can transmute into one another, there must be a common underlying matter devoid of all form that can take on any of the elemental forms. This matter, Aquinas concludes, must then be nothing but pure potentiality – in other words, it is the sheer capacity for acquiring any form whatsoever. Since for Aristotle and Aquinas nothing can actually exist without form, we encounter only informed matter in the world – never prime matter. Given that Aquinas posits a formless prime matter, for him there must be a more basic, more stable form that gives being to matter

[4] St. Thomas Aquinas, *De principiis naturae*, ed. John J. Pauson (Fribourg: Société Philosophique, 1950), pp. 80–82. Translations from the Latin text are my own.

[5] Aristotle, *Physics*, trans. R. P. Hardie and R. K. Gaye, in *The Complete Works of Aristotle,* ed. Jonathan Barnes, 2 vols. (Princeton: Princeton University Press, 1984), Bk. I, ch. 7, 190a31–33; vol. 1, p. 325.

[6] At 190a34–190b3 and 191a7–11 Aristotle claims that, even in substantial generation, there is an underlying thing or nature out of which the substance comes to be, but he does not make clear what it is. Ibid., p. 326.

before it can take on sensible, unstable forms like whiteness. This more basic form which supports the other forms is the substantial form.

Aquinas distinguishes between artifacts and natural substances to justify positing these more basic, imperceptible forms in his *Commentary on Aristotle's* Metaphysics, Book VII, lesson 2. While he repeats the analogies Aristotle draws between the bronze of the statue and matter on the one hand, and the figure of the statue and "the specifying form" on the other, he claims that Aristotle does not intend this as an exact analogy. Aquinas reasons that "figure and other forms produced by art are not substances but accidents. But since figure is related to bronze in the realm of artifacts as substantial form is to matter in the realm of natural bodies, he uses this example insofar as it explains what is unknown by means of what is evident."[7] Further down, while responding to the arguments Aristotle gives in favor of the ancient view that matter, as the subject of all qualities, and of quantitative properties, is substance, Aquinas reveals the sense in which the case of the statue and that of natural bodies are disanalogous. Digressing from Aristotle's text, Aquinas volunteers a diagnosis of the source of the ancient error that accidental forms inhere directly in matter without the mediation of a substantial form. He explains that these ancients were not advanced enough to recognize the substantial form, but rather focused only on sensible accidental forms of bodies, such as white, black, great, small, etc. Considering these as the forms or specifying principles of bodies, they mistook composites of matter and form, such as air and water, for first matter. But unlike the accidental forms inhering in composite substances, "a substantial form is perceptible only indirectly, and therefore they did not acquire a knowledge of it so that they might know how to distinguish it from matter."[8]

The substantial form and prime matter stand or fall together for Aquinas. As he puts it in *On the Principles of Nature*:

> that which is in potency to substantial being is called prime matter; however, that which is in potency to accidental being is called a subject. For the subject gives being to the accident, namely of existing, since the accident does not have being except through the subject. For this reason it is said that accidents are in subjects, however, it is not said that the substantial form is in a subject.[9]

While Aristotle remains silent on this, Aquinas specifies that the substantial form of each individual substance directly actualizes the formless prime matter, giving being to it, whereas accidental forms inhere in an

[7] *CAM*, Bk. VII, les. 2, 1277, p. 433.
[8] *CAM,* Bk. VII, les. 2, 1284, p. 435.
[9] Aquinas, *De principiis naturae*, p. 80.

already existing subject, namely, the composite of prime matter and the substantial form. By interpreting Aristotle to have posited a first matter, devoid of all form, Aquinas can tease the distinction between substantial and accidental forms out of the analysis of coming to be that Aristotle develops in *Physics,* Book I.

The case of the human soul as the form of the body proves more difficult to reconcile with Aristotle's texts, for, if it were just like the material substantial forms that are educed from matter in physical generation, then its dependence on matter to exist would preclude immortality: "Forms dependent in being upon matter do not themselves have being properly, but being properly belongs to the composites through their forms."[10] Hence, for Aquinas, the human soul does not, like animal souls, emerge from the materials that combine to form the skeleton, muscles, and organs of the human body. Rather the human soul is created separately by God and joined to the appropriate body. Since it is not dependent on this body for its existence, it also survives it. Aquinas justifies the distinction between the immortal human soul and the mortal souls of other animals by identifying the intellectual soul as the substantial form of a human being. This allows him to treat the human soul as a special kind of substantial form that differs from material substantial forms in key respects. First he argues that, as the principle of life, the human soul cannot be corporeal for then all corporeal things would be alive. Instead the soul is the act of a body.[11] So far, Aquinas follows Aristotle's definition of the soul as the first act of a body with the potential for life found in *De Anima,* Book I, chapter 1. Next he argues that the soul is the principle of intellectual operation, and the intellect cannot have a corporeal nature, for this would prevent it from knowing all bodies; therefore, the soul must be incorporeal. Furthermore, it must be subsistent, for only self-subsisting things can have their own proper operations.[12] In response to the objection that only something that is said to be 'this particular thing' can subsist, Aquinas distinguishes between two different senses of 'this particular thing.' First, anything subsistent, even a separable part of a substance, like a hand, can be called 'this particular thing.'[13] In the

[10] St. Thomas Aquinas, *Summa Contra Gentiles* (henceforth *SCG*), trans. James F. Anderson, 4 vols. (Notre Dame: University of Notre Dame Press, 1975), vol. 1, Bk. II, p. 151.

[11] St. Thomas Aquinas, *The* Summa Theologica *of St Thomas Aquinas* (henceforth *ST*), trans. Fathers of the Dominican Province (London: R. and T. Washbourne, 1912), First Part, 75, a. 1, p. 3.

[12] *ST*, First Part, 75, a. 2, p. 5.

[13] Aristotle, by contrast, denies that parts of animals count as self-subsisting things or substances. "Evidently even of the things that are thought to be substances, most are only potentialities, – e.g.,

second sense only things which are 'complete in a specific nature' like the composition of soul and body count. The second sense thus excludes parts, accidents, and material forms of composite substances. However, the first sense allows the soul, as a part of the human nature, to count as a particular thing, or substance-like entity.[14] As we saw in the previous chapter, this is not the sense in which Descartes takes substantial forms to be self-subsistent.

This move enables Aquinas to establish that the intellectual soul, even though it is the substantial form of the body, and a part of the human being, can exist without the body. As he explains: "But for a thing to exist of itself, it suffices sometimes that it be not inherent, as an accident or material form; even though it be part of something. Nevertheless, that is rightly said to subsist of itself, which is neither inherent in the above sense, nor part of anything else."[15] In other words, while the soul, as a part of the composite human, falls short of being a substance in the proper sense, it subsists in a weaker sense sufficient to allow it to exist without being part of the body, or inhering in it as an accident or material form. Hence Aquinas draws a fundamental distinction between material forms, which are educed from matter, and can only exist by inhering in matter, and intellectual souls which, though joined to matter as parts of composite substances, can also subsist in the first, weaker sense. Perhaps Aquinas envisions a hierarchy of substantial forms, along the lines of his hierarchy among accidental forms.

> In view of the fact that all accidents are forms of a sort superadded to the substance and caused by the principles of the substance, it must be that their being is superadded to the being of the substance and dependent on that being. And by as much as the being of each and every one of them is prior or posterior, by that much the accidental form in its proper essence will be more like a substance or more perfect.[16]

The claim that some accidental forms are substance-like could provide a precedent for Descartes' later claim that all real qualities are like substances or souls attached to matter. It is unclear, however, whether Aquinas hereby implies a similar hierarchy from most unlike to most

the parts of animals (for none of them exists separately; and when they *are* separated, then they too exist, all of them, merely as matter)." He also explicitly denies that something like a severed body part subsists: "For they cannot even exist if severed from the whole; for it is not a finger in *any* state that is the finger of a living thing, but the dead finger is a finger only homonymously." *Metaphysics*, trans. W. D. Ross, in *The Complete Works of Aristotle*, ed. Jonathan Barnes, 2 vols. (Princeton: Princeton University Press, 1984), vol. II, Bk. VII, ch. 16, 1040b5–7, p. 1642, and ch. 10, 1035b22–25, p. 1635.

[14] *ST*, First Part, 75, a. 3, p. 6. [15] Ibid. [16] *SCG*, Bk. IV, p. 102.

like substance when it comes to substantial forms.[17] Absent further justification for Aquinas' rather arbitrary divide between subsisting substantial forms and inhering material substantial forms, it is not surprising that the gulf between these forms becomes more acute in Suarez's defense of the substantial form.

One last feature of Aquinas' account of the substantial form is worth highlighting before we turn to Suarez's arguments. As we have seen, since prime matter cannot exist on its own, being a pure potentiality, it must be actualized by a substantial form in order to exist. Thus matter depends on form to be; i.e., for Aquinas and his followers, the substantial form is the formal cause of the being of matter. This logical inference provides Aquinas with another argument for the immortality of the soul. He reasons:

> Now it was shown above that the souls of brutes are not subsistent, whereas the human soul is; so that the souls of brutes are corrupted, when their bodies are corrupted; while the human soul could not be corrupted unless it were corrupted of itself. This, indeed, is impossible, not only as regards the human soul, but also as regards anything subsistent that is a form alone. For it is clear that what belongs to a thing by virtue of itself is inseparable from it; but existence belongs to a form, which is an act, by virtue of itself. Wherefore matter acquires actual existence as it acquires the form; while it is corrupted so far as the form is separated from it. But it is impossible for a form to be separated from itself; and therefore it is impossible for a subsistent form to cease to exist.[18]

In contrast to matter, which owes its being to the substantial form, and is corrupted as soon as the form leaves it, the human soul, as pure form, cannot be separated from the act of existence and so by its very nature it cannot cease to exist (except by divine intervention of course). Consequently, unlike the non-intellectual forms that require the body to exist and operate, it cannot be corrupted by the decay of the body.

Aquinas elaborates on the sense in which the human soul is the formal cause of the being of matter in the following mysterious passage:

> The soul communicates that existence in which it subsists to the corporeal matter, out of which and the intellectual soul there results a unity of existence; so that the existence of the whole composite is also the existence of the soul. This is not the case with other non-subsistent forms. For this reason the human soul retains its own existence after the dissolution of the body; but it is not so with other forms.[19]

[17] While Aquinas does establish a hierarchy among substantial forms, this is based on their operations, not their resemblance to substances. *SCG* II, pp. 205–206.

[18] *ST*, First Part, 75, a. 6, p. 15. [19] *ST*, First Part, 76, a. 1, p. 26.

In trying to explain the mysterious way in which the intellectual soul can form an essential unity with the body while also existing apart from the body, Aquinas is reduced to analogy:

> To be united to the body belongs to the soul by reason of itself, as it belongs to a light body by reason of itself to be raised up. And as a light body remains light, when removed from its own proper place, retaining meanwhile an aptitude and an inclination for its proper place; so the human soul retains its own proper existence when separated from the body, having an aptitude and a natural inclination to be united to the body.[20]

It is not my task here to resolve Aquinas' paradoxical commitment to both the formal unity of soul and body and their natural inclination to one another, on the one hand, and the soul's independent existence, on the other. Nor is it my task to offer an interpretation that will reconcile the two very different types of substantial forms Aquinas argues for: the inhering material substantial forms justified by Aristotle's analysis of coming to be, and the subsisting intellectual substantial forms motivated by the need to preserve the soul's immortality. For my purposes it suffices to highlight these latent tensions in Aquinas' view so that the ways in which Suarez both develops and revises this account of the substantial form can come to the fore.

It should now also be clear why, despite his equally paradoxical claim that mind and body are distinct substances which nevertheless form an essential unity, Descartes is not arguing with Aquinas' doctrine of the substantial form in mind. Indeed, his *a priori* argument against substantial forms fails miserably if we take him to be targeting Aquinas' account. Recall Descartes' definition of a substantial form as "a certain substance joined to matter, making up with it a merely corporeal whole, and which, no less than matter and even more than matter – since it is called an actuality and matter only a potentiality – is a true substance, or self-subsistent thing."[21] This definition excludes the non-subsistent material forms which fit the root meaning of 'substantial form' Aquinas constructs from Aristotle's texts, and makes the subsistent intellectual soul, an exceptional kind of substantial form, the only kind. Hence it begs the question against Aquinas by presupposing that only subsisting substantial forms (human souls) count as substantial forms. Descartes also implies that such substantial forms are true substances, which is at odds with Aquinas' characterization of human souls as 'subsisting' in the weaker

[20] Ibid., pp. 26–27. [21] CSMK, p. 207; AT III, p. 502.

sense that separable body parts do, not as proper substances. As I will argue next, Suarez's account of the substantial form gets us closer to Descartes' definition, thus taking the post-Suarezian view of the substantial form as Descartes' main target provides allows us to read his argument more charitably and make better sense of it.

CHAPTER 3

Suarez's defense of the substantial form

Suarez places key elements of Aquinas' account of the substantial form, most notably his view that the immortal soul is both the form of the human body and a subsisting thing, on center stage and develops them. However, he also diverges significantly from Aquinas' arguments when he pries apart several concepts that, for Aquinas, are closely bound together. Suarez explicitly develops these distinctions in response to refinements and criticisms introduced by later Scholastic discussions of the substantial form. However, as I will argue in the next chapter, Suarez's explicit replies to criticisms that arose within the Scholastic tradition itself can also be seen as an implicit response to the devastating attack that had just been leveled against Scholastic philosophy by Renaissance humanists. Faced with the intellectual and political turmoil of a modern world, to many European universities, Protestant and Catholic alike, Suarez's innovative works provided a major resource for a revamped Aristotelianism that could meet the threat of skeptical humanism and other destabilizing intellectual movements. I will say more about the relationship between intellectual controversies in the Netherlands and Descartes' intellectual trajectory in Part III. For now, I limit myself to a discussion of Suarez's key arguments regarding material substantial forms and their relevance to Descartes' *a priori* argument against them.

As already highlighted, Aquinas refers to the form of a substance in at least three different, but closely related senses: (1) the form that actualizes the matter of a matter/form composite and causes it to be, e.g., my individual soul; (2) the non-accidental form constituting the essence of a substance – in my case, my human form versus accidents like tallness; and (3) the definition that enables us to know a substance's essence and advance our scientific knowledge by means of demonstrative syllogisms, e.g., 'rational animal'.[1] Suarez clearly separates these into (1) the physical

[1] As discussed in chapter 1, while not identical, the form, essence, and definition of a substance are closely related concepts for Aquinas.

form, (2) the metaphysical form, and (3) the logical form. In addition, he treats the physical form as the only true substantial form, characterizing the others as forms in a metaphorical sense. In what follows, I will trace the arguments by which Suarez limits the substantial form to the physical (in the sense of natural) form of a substance, clearly distinguishes the substantial form from the metaphysical form or essence of an individual substance, and sharply distinguishes it from the logical forms/definitions employed in scientific demonstrations. Furthermore, Suarez separates the substantial form from the matter it informs, defining each as a partial or incomplete substance that God could create and sustain without the other. Correspondingly, he denies that the substantial form causes matter to exist – instead, formal causality consists in the union of matter and form. While Suarez's redefinition of formal causality is fascinating in its own right, and has important implications for the union of soul and body, since I am primarily concerned here with the implications of his arguments for material substantial forms, I set this issue aside in favor of an in-depth examination of the parts of his account that bear on the appeal to material substantial forms in science.

In section 3.1, I will examine Suarez's defense of the substantial form and highlight both its differences from Aquinas' argumentative strategy and its affinities to the view Descartes targets in his *a priori* argument. Section 3.2 will be devoted to a detailed discussion of the distinctions Suarez draws between physical, metaphysical, and logical forms. While not directly relevant to Descartes' arguments against substantial forms, a familiarity with Suarez's account of each type of form is needed to make sense of the skeptical and atomist arguments against Aristotelian scientific demonstrations and substantial forms dealt with in Parts II and III. In this chapter, I will argue that, in the short run, Suarez succeeded in saving the substantial form by severely reducing its dependence on the most hotly contested elements of Scholastic philosophy: Aristotelian logic and metaphysical doctrines pertaining to essence and substance. He thus managed to temporarily insulate the doctrine of the substantial form, which was crucial to the theological doctrine of transubstantiation, from the greatest threats Renaissance philosophy posed to the coherence of Catholic Aristotelianism. However, as we will see in Parts II and III, the substantial form could not survive on its own for long and, in the long run, Suarez's loosening of the ties that bound the substantial form to other elements of the Scholastic edifice may have done more to undermine it than save it. Thus Suarez, one of the last and arguably the greatest of the Scholastics, could also be said to be the first, albeit unintentional, modern.

3.1 THE SUBSTANTIAL FORM AS PARTIAL SUBSTANCE

Since my goal is to shed light on the rejection of material substantial forms by Descartes and provide background to his ultimate replacement of Aristotelian scientific explanations with mechanistic ones, I will not offer a comprehensive treatment of Suarez's account of the substantial form. Rather, I limit my examination to Suarez's most detailed arguments for the existence of substantial forms, which are found in *Metaphysical Disputation* 15. There he begins his discussion of the substantial form with the claim that the physical form must be treated most extensively since it alone exerts real and true formal causality. Hence he appears to regard the physical form, which primarily constitutes the nature of a thing and is the object of physical investigation, as the primary sense of 'substantial form.'[2] Nevertheless, Suarez considers this form to belong to the domain of metaphysics, in part due to the abstractness of the notion of 'form,' and the fact that it is one of the principal causes. Correspondingly, the arguments he offers for the existence of such a form do not, like those of Aquinas, derive from the analysis of coming to be found in *Physics,* Book I. From the beginning, Suarez acknowledges the difficulty of knowing the substantial form. Echoing Aquinas, he points out that substantial forms are not known by experience for we directly observe only the accidents of things.[3] Writing for an audience that has been exposed to numerous doubts about the existence of substantial forms (which will be examined shortly) as well as the alternative natural philosophies mentioned in the Introduction, Suarez provides a philosophical justification for the substantial form that is quite different from that of Aquinas.

Suarez's argument for the existence of the substantial form

First, Suarez does not begin by drawing a distinction between the generation *simpliciter* of corporeal entities, and accidental changes, such as a body becoming white or cold. Nor does he establish the existence of prime matter at the same time that he argues for the substantial form. Suarez, surprisingly, starts from the immortality of the rational soul. He

[2] Note that 'physical form' means 'natural form' and includes souls, whereas I use the term 'material substantial form' to designate the forms of substances that lack a rational soul.

[3] Francis Suarez, *On the Formal Cause of Substance: Metaphysical Disputation XV*, trans. John Kronen and Jeremiah Reedy (Milwaukee, WI: Marquette University Press, 2000), (henceforth *MD* 15), p. 17.

then infers that the rational soul is a substance, not an accident, for how else could it survive without the subject in which it inheres? At the same time, it must be the true form of the body, for if it were not, it could not cause the body to live, nor would the life functions of the person cease once its union with the body was dissolved. Therefore, he concludes, the rational soul must be both a type of substance and the form of the matter which is the human body. He resolves the apparent conflict involved in the soul's being both a substance and a form by claiming:

> Hence, this soul is a substantial form because, as we will show below, the term 'substantial form' signifies nothing other than a certain partial substance which can be united to matter in such a way that it composes with it a substance that is whole and essentially (*per se*) one, such as a human being.[4]

Later on, Suarez clarifies what he has in mind with the phrase 'partial substance,' stating that "Form is a certain simple and incomplete substance which, as the act of matter, constitutes with it the essence of a composite substance."[5] Suarez is clear that, since it is an incomplete substance, God can conserve the substantial form without the matter of which it is the act. First it must be remarked that Suarez's definition of the substantial form as an incomplete substance is very different from Aquinas' account of it as the essential act of existing whereby the purely potential prime matter is caused to be.[6] Indeed, it appears to give all substantial forms the independent status that Aquinas granted only to the immortal soul. Moreover, since the substantial form is no longer defined as the formal act causing matter to be, this implies an accompanying change to the concept of 'prime matter,' which Suarez likewise redefines as an incomplete substance that God can conserve apart from form.

To a contemporary reader, Suarez's main argument looks suspect from the beginning. Why base the existence of the substantial form not only on a religious premise, but one as difficult to prove as the soul's immortality? Initially, Aquinas' strategy of beginning with Aristotle's analysis of natural change seems more promising. But, for Suarez's audience, the soul's immortality may well have been the best premise to start from since, with Aristotle's natural philosophy coming under increasing attack, it was the one thing that rival philosophical and theological factions could agree on. That the commitment to personal immortality ran very deep can be

[4] *MD* 15, p. 20. [5] *MD* 15, V. 1, p. 77.

[6] While it was not uncommon for late Scholastics to conceive of the substantial form as a substance-like entity, Suarez's argumentative strategy of beginning with the case of the immortal soul seems to emphasize the extent to which substantial forms are substances.

seen by the fact that even Descartes, the arch-mechanist who banishes all other substantial forms, still maintains the existence of one type of substantial form: the rational soul. Furthermore, as Suarez fully realizes (and Descartes, contrary to his mechanism, concedes), the doctrine of the substantial form does the tricky job of balancing the need for a close mind/body union during life, and a clean separation of the rational soul from the body, after death. In fact, Suarez's definition of the substantial form as a partial substance united to matter loosens the dependence of the substantial form on its matter, making it easier to explain how the rational soul survives the death of the body intact.

Whereas Aquinas simply leaves us with two different types of substantial form (subsisting incorporeal versus inhering material ones), by basing his main argument for substantial forms on the immortality of the rational soul, Suarez treats this particular kind of substantial form as the model for all substantial forms and redefines them accordingly. This fits Descartes' characterization of all substantial forms, including the material ones, as little soul-like substances attached to matter and explains why he takes the creation *ex nihilo* of the soul to be representative of the creation of all substantial forms. Moreover, Suarez appears to take Aquinas' claim that the intellectual soul subsists in the weaker sense that a hand can be said to subsist to imply that the soul is a partial substance. Since Suarez treats Aquinas' subsisting soul as the paradigm for all substantial forms, as we shall see, he is led to recast all substantial forms as partial, incomplete substances that form an essential unity with the matter. Again, Descartes' definition of the substantial form as a self-subsistent thing or substance that attaches itself to matter is much closer to Suarez's account than to that of Aquinas. This makes it likely that the Scholastic account he targets in his *a priori* argument is not the Thomist view but something akin to the Suarezian view of the substantial form.

Suarez's defense of the substantial form creates a host of problems, since he treats the rational soul, a rather unusual type of substantial form, as paradigmatic. He is then faced with the challenge of showing that non-rational creatures nevertheless have something in them, i.e., a form, akin to the rational soul. Suarez bases his reasoning on the premise that, like the living person, other natural things are subject to generation and corruption. Hence they belong to the same order as human beings. Since humans are composites of matter and a substantial form, other natural things that undergo generation and corruption must likewise have a substantial subject suited by nature to be informed by a substantial act. This substantial act is nothing other than the substantial form that perfects

and actualizes the subject.[7] The major weakness in this argument is that it simply presupposes a fundamental similarity where there are significant differences, the most notable difference being that corporeal forms, unlike rational souls and like accidents, do not survive the destruction of the matter they inhere in. Suarez, like Aquinas, holds the view that all substantial forms other than the human rational soul are educed from pre-existing matter, and destroyed when the body disintegrates. The sixteenth century had seen the development of alternative theories to explain the transformation of corporeal things into one another (e.g., alchemical explanations, appeals to the animistic and celestial principles of the natural magic tradition, and Telesio's naturalist explanation of all changes in matter by means of the principles of hot and cold). Therefore, the mere fact that other natural things are also generated and corrupted simply does not suffice to establish that a substantial form is required in these cases of generation, as it is in the case of a human being.

The remainder of Suarez's arguments address some of these criticisms in that they all relate to standard doubts about the existence of the substantial form. These come in two varieties: empirical doubts and theoretical doubts. Suarez replies with a variety of *a posteriori* (reasoning from effect to cause) and *a priori* (from cause to effect) arguments. Given that the *a priori* arguments merely establish the possibility of the substantial form's existence, I will spend more time on, and focus first on, the *a posteriori* arguments he gives to address empirical arguments that had been raised by others against the actual existence of substantial forms. However, since Descartes reduces the Scholastic doctrine of the substantial form to absurdity in the *a priori* argument discussed in chapter 1, I will also briefly examine Suarez's replies to the purely theoretical objection that the notion of a substantial form is logically incoherent.

Empirical concerns surrounding the substantial form

Suarez notes two distinct but related empirical objections. First, substantial forms are not known by experience; for example, fire is known by its accidents, not by its substantial form. Second, substantial forms are not necessary to account for any of the actions and differences we perceive in things.[8] In response, Suarez grants that the substantial form cannot be known by experience and concentrates on showing that it is necessary to account for the actions we perceive in things. As we shall see in

[7] *MD* 15, pp. 20–21. [8] *MD* 15, sec. 1, p. 18.

Parts II and III, when alternative mechanical and atomist principles were proposed to account for the actions of things, substantial forms were quickly replaced. Suarez presents four different arguments to establish the need for substantial forms to account for natural actions. First, the substantial form is needed in order to explain why water, after having been heated by an external cause of heat, returns to its original cold state. If coldness were merely an accident of water, and not a quality that was due to its substantial form, an external cause would be required to explain its return. Second, the substantial form is required to explain substantial change, especially the dissolution of a thing. Third, we observe cases where the removal of one quality undermines another quality of a thing, e.g., when milk ceases to be sweet, its whiteness also begins to recede. This can only be explained if sweetness and whiteness are joined by a more basic substantial form, i.e., that of milk. Finally, when a thing acts intensely in one way, its power to act in another way is reduced, e.g., when we meditate long and hard, our nutritive faculty is compromised. This is explained by the fact that the substantial form is finite and so it cannot apply itself to both activities at once. This last argument is not very convincing, as Suarez admits that it is difficult to experience this phenomenon in inanimate things, and so the point appears to be limited to animate things. Moreover, he does not do a very good job of addressing objections.[9] For our purposes the first three arguments are more important, for these lay out what Suarez takes to be the best arguments from physics for the existence of the substantial form. However, as Suarez's lengthy discussion indicates, these were by no means uncontroversial.

To bolster his first argument, Suarez refutes alternative explanations for why water returns to its original coldness when the external source of heat is removed. These alternative explanations follow two paths: they posit either an external cause or an internal cause, other than the substantial form, to account for the effect. Under the rubric of external causes, Suarez dismisses the suggestion that the surrounding air cools the water, for air is not naturally as cold as water, and it too has been warmed by the external source of heat. Likewise, he denies that more remote external

[9] The main one is that when we are meditating, our digestion slows down, and this is because our animal spirits are diverted away from the nutritive faculty to the thinking faculty, not because of a finite substantial form. On the one hand, Suarez replies that one form must be directing these spirits from one faculty to another (but why could they not move on their own, or why could there not be two competing forms?). On the other hand, he claims that the vital spirits do not produce intellectual activity; rather, this is the soul's operation on things of a higher order which even diminishes the action of the imagination. Here Suarez appears to be relying on contemporaneous theories in psychology, but he gives no details.

causes, such as celestial and universal causes, can account for it, since they are not ordered to specific actions like this. Next he considers several explanations that posit an alternative internal cause to explain why water returns to coldness. According to an argument that Cajetan attributes to Averroes, the water becomes cold again because pockets of cold water remain in it which cause the heated parts to cool down. Therefore, positing a substantial form is not necessary to explain this phenomenon. Suarez replies that if this were the case, the water would not feel uniformly hot to us, and the cold pockets would have caused the other parts to become less hot. Moreover, he points out, you would need some impeding cause to explain why some parts of the water do not actualize their potential to become hot, and there is no such cause.[10] Therefore, one does need the substantial form to explain this.

Other internal causes include the principle of coldness itself, and another higher quality that virtually contains the sensible quality of coldness. In either case, the internal cause is some kind of active quality; hence this corresponds to the non-absurd account of substantial forms Descartes refers to in his second metaphysical argument. Suarez, however, considers both versions of this view problematic. Those who maintain the principle of coldness as the cause argue that the water returns to its original state of coldness because the principle of coldness remains in the water to some degree, even when it is heated. In other words, the essence of coldness is not affected by its intensity, and so its essence remains intact even when the degree of coldness is diminished. Suarez does not give a source for this view, but offers three criticisms. First, a diminished quality cannot produce a more intense degree, for then air should be able to heat itself to the highest degree. Second, since matter is indifferent to the accidental qualities of hot or cold, the diminished coldness left in the water would not be sufficient to overcome the more intense degree of heat in the water. Third, if the subject in which they inhere is prime matter, not a prime matter/substantial form composite, there would be no impediment to the more intense quality (heat) completely perfecting itself and expelling the quality that was diminished in degree (cold), provided all external causes were removed.[11] But clearly there is an impediment, since coldness is not expelled but rather returns – this impediment is the substantial form.

With respect to the second possible internal cause, Suarez grants that one could posit a higher quality that virtually contains coldness while not denying the substantial form. Again he gives no sources but refers to the

[10] *MD* 15, sec. 9, pp. 22–23. [11] *MD* 15, sec. 10, p. 23.

view that compounds, in addition to possessing the primary qualities of formal hot, cold, moisture, and dryness, also occasionally possess intermediate accidents that virtually contain heat or cold. These virtual qualities account for the production of heat or cold in something else. Suarez seems to have in mind a case where a compound's nature does not display the quality in question but nevertheless produces it in another by means of a higher quality that virtually contains it; e.g., fire, which is not wet, melts things and produces wetness. The intermediate quality virtually containing wetness would explain why fire could produce a quality that did not belong to its nature. According to Suarez, there are two problems with this view: it unnecessarily multiplies entities, for the substantial form alone could explain this, and it leads to an infinite regress, for now the virtual quality needs another higher quality that virtually contains it to account for its action. To avoid the first objection one could do away with substantial forms and replace them with these higher qualities. In other words, instead of positing a substantial form that is the root of the moistness, density, and coldness of water, we explain each of these by means of a virtual quality. There are two possibilities. Either each observed quality has its own individual root or virtual quality (but this would again involve positing more entities than is needed), or there is one virtual form for all of the observed qualities. But if this is the case, then this form will be the primary act of the matter, joining with it to produce the natural substance we call being. This is exactly what the substantial form does, and so this one virtual form would be a substantial form.[12]

This concludes my overview of Suarez's lengthy defense of his claim that only the substantial form can adequately explain why water returns to its original state of coldness after the source of heat has been removed. It is striking just how many objections to substantial forms had been raised by this time, and how many alternative explanations were developed within Scholasticism to account for the empirical phenomena that had been attributed to the substantial form. Suarez's defense of the second claim, the cornerstone of Aquinas' argument for a substantial form – namely, that it is required to distinguish substantial from accidental change – is much shorter. Suarez simply asserts that we know from experience that substantial change is distinct from accidental change, even in inanimate things. For example, the heating of water or iron can be so intense that even if the source of heat is removed, the thing cannot recover its original state. Rather it is transformed into something else.

[12] *MD* 15, sec. 11, pp. 23–24.

This indicates the existence of a substantial form for the dissolution of the substantial form explains why, in some cases, the accidents never return. In these cases, the action of the external cause was so intense that it destroyed even the primary form along with its power to reinstate the lost accidents. The presence of a substantial form also explains why the destruction or diminution of one accident can cause a transformation of the entire thing. The reason is the inseparability between that accident and some intrinsic principle. Now this intrinsic principle cannot be prime matter, for it is indifferent to all accidents, and remains throughout any change. Nor can it be an accident in the way that heat, by virtue of its inseparability from rarity, might be considered the principle of rarity. For both heat and rarity can be lost, and then restored if the primary form remains intact. Therefore, the intrinsic principle which is inseparable from the accidents that constitute a thing's nature must be the substantial form.[13]

The third and last type of empirical argument in favor of the substantial form concerns its ability to unite seemingly unrelated accidental forms in one subject. Suarez reasons that the substantial form is needed in order to unite disparate qualities such as the whiteness and sweetness of milk. He observes that accidental properties can be united in one natural being either by a hierarchy, as when the will is subordinated to the intellect, or without any mutual subordination, as in the case of the heat and humidity of the air, and whiteness and sweetness united in milk. In both cases there must be a single form uniting them, for if they were gathered together in the same subject purely by accident, if one were destroyed, the other would remain. But experience shows that whiteness does not remain when the sweetness of milk is destroyed. This is a sign that these accidents are not connected by virtue of prime matter alone, but by virtue of a composite of prime matter and a substantial form.[14] Suarez's empirical arguments indicate that, unlike Aquinas, he emphasizes the role that the material substantial form plays in explaining the various actions and other accidents of a body over arguments from generation and corruption.[15] Correspondingly, this is the function of the substantial form that Descartes seeks to replace in his scientific arguments and his second metaphysical argument. Indeed, he offers only one argument from coming to be, and as we saw, this was based on the creation *ex nihilo* of the immortal soul. When we turn to Descartes' early scientific writings it will become

[13] *MD* 15, secs. 12–13, pp. 24–25. [14] *MD* 15, sec. 14, p. 26.

[15] For the importance of the unifying function of the substantial form in Suarez, see John D. Kronen, "The Importance of the Concept of Substantial Unity in Suárez's Argument for Hylomorphism," *American Catholic Philosophical Quarterly* 65/3 (1991), pp. 333–360.

clear that he initially equates his mechanistic principles with the essential forms of individual corporeal substances, like grains of salt and snowflakes. While mechanistic principles handle cases such as the generation and corruption of an organism poorly, Descartes recognizes that they are viable competitors when it comes to the other functions of the substantial form that Suarez emphasizes.

We can draw several conclusions from this survey of Suarez's *a posteriori* arguments in favor of the substantial form. First, the amount of space he devotes to such arguments, and the sheer number of objections and counter arguments he addresses, indicate that empirical arguments against the substantial form were both common and taken seriously at this time. Suarez even cites several authorities in favor of the denial of substantial forms, namely, Alexander of Aphrodisias, John Philoponous, Galen, and Empedocles.[16] Note that the first two are ancient commentators whose interpretations of Aristotle had gained a strong following in the Renaissance. Second, unlike Aquinas, Suarez's arguments for the existence of substantial forms in inanimate bodies are heavily dependent neither on Aristotle's texts nor on specific metaphysical doctrines. Rather than starting from a particular passage in Aristotle or a metaphysical premise, most of Suarez's arguments are ecumenical in nature. They are based on empirical observations, inferences to the best explanation, and sound methodological principles, like "One should not multiply entities beyond necessity." Only rarely does Suarez appeal to metaphysically laden concepts such as prime matter, and even when he does, his arguments as a whole do not stand or fall with this concept (though, of course, some of his other assumptions do not appear well grounded to us as post-empiricists). Finally, despite the fact that our skeptical, post-atomist rejection of natural kinds and real qualities prevents us from embracing them, these arguments represent the best science of the time and would probably have been convincing to most of Suarez's contemporaries. One has to keep in mind that during the period that Suarez was writing his *Metaphysical Disputations* a physics based on atomist or mechanistic principles had not yet been developed, and so alternative explanatory principles to the elements, forms, substances, and accidents of Scholastic Aristotelianism were rather limited. It is true that alchemists had already replaced Aristotle's four elements with their own, and Neoplatonists plus adherents of natural magic appealed to forms emanating from the celestial sphere and occult qualities to explain certain

[16] *MD* 15, sec. 4, p. 19.

phenomena that resisted more commonsensical explanations, but they all still operated within a basic explanatory framework that required elements, forms, and the substance/accident distinction. In Part II we will see that Francisco Sanchez, an infamous skeptic of the time, directs his arguments against Aristotelian and Platonist principles alike, and clears the way for an entirely new set of principles arising from the revival of ancient mechanics, on the one hand, and the development of atomistic natural philosophies, on the other. However, unless one resorts to such thoroughgoing skepticism, Suarez's empirical defense of the substantial form is convincing. His response to logical concerns is less so.

A logical concern about the substantial form

After replying to empirical objections against the existence of the substantial form, Suarez considers the objection that the notion of a substantial form, as he has defined it, is logically incoherent. His reply reveals that this concern applies primarily to material forms, not to rational souls. The argument is based on the observation that the two defining traits of the substantial form are logically incompatible: it is supposed to be self-subsistent and yet it must also inhere in and inform matter. But if it is self-subsistent, then it is a substance, not a form inhering in matter. If it is a form inhering in matter, then it must be an accidental, not a substantial, form.[17] This objection anticipates Descartes' *reductio,* which, as discussed in chapter 1, reveals material substantial forms to be inconsistent with the definition of substantial forms as subsisting entities created *ex nihilo* by God. Suarez's response to this objection, unlike his responses to the empirical objections, does rely heavily on a certain metaphysics. He makes an argument from the hierarchy of forms. The main premise appears to be that the non-contradictory nature of higher forms shows that lower forms are also non-contradictory. Suarez observes that the substantial acts of the highest order, e.g., the substantial forms of angels, are subsistent and do not inform anything. Hence, these substantial forms are not contradictory. If we go down the hierarchy, we come to rational souls – these are substantial forms of the middle order which subsist but, unlike the forms of angels, do actuate and inform a body. Suarez simply asserts that these are also not contradictory. He concludes from this that the lowest order of substantial forms, material forms which are both actuating and not completely subsistent, will likewise not be contradictory.

[17] *MD* 15, sec. 2, p. 18.

This argument is not very satisfying, which could account for the fact that Descartes revived the objection. Suarez adds another argument to show that there is no probable reason to claim that it is contradictory for the substantial form to be an act, and to be substantial, and for the two to be united in the same thing. Since he takes it as evident that acts and substantial entities exist, the nub of the proof is to show that the two can occur together in the same thing. Suarez gives three reasons in support of this. First, these natures are not intrinsically incompatible with one another. Second, the nature of act involves perfection, so if it can consistently be joined with accidental being (which has less perfection), why can it not be joined with substantial being? Third, the nature of a substantial entity seeks perfection without qualification and this seems to conflict more with the nature of a potentiality than with the nature of an actuality. But the nature of a substantial entity does not conflict with prime matter, which is potentiality, so it does not contradict the nature of actuality either. Suarez's replies to the logical concern about substantial forms do not seem to get to the heart of the objection. There is an inherent tension in the view that the substantial form is an independent albeit 'partial substance,' and the act of matter. Moreover, he does not give a satisfactory reason to show that material substantial forms, the lowest rung on the hierarchy of forms, are logically coherent. He seems to simply assume that if the higher orders of substantial forms are non-contradictory (which is not self-evident to begin with), the lowest one must likewise be non-contradictory. But even if we grant his premise about all the higher orders of forms, the conclusion does not necessarily follow. One could just as well deny that material things have substantial forms on the grounds that a substantial being that has to inhere in matter to exist is a contradiction in terms. For, in standard Scholastic terms, inherence is the mark of an accident, not of a substance. As we saw, this is the thrust of Descartes' *a priori* objection to material substantial forms.

In short, Suarez's strongest arguments in favor of the substantial form arise from empirical, not logical or metaphysical, considerations. It is therefore not surprising that Descartes' *a priori* argument quickly reduces Suarezian substantial forms to absurdity. In Parts II and III, I will show that, in the absence of a strong metaphysical defense of material substantial forms against skeptical arguments, the rise of mechanics and atomism quickly introduced alternative principles to do the work that substantial forms had done in scientific explanations. In this manner, material substantial forms quickly became, as Descartes put it to Voetius, "of no practical benefit." But before we turn to skeptical and

Cartesian arguments against Aristotelian scientific explanations and for the superiority of mechanical ones, Suarez's threefold distinction between the physical, metaphysical, and logical forms must be clarified. As will become clear in chapter 6, Suarez's division among forms is crucial to Gorlaeus' philosophical arguments against substantial forms and hence faciliated his establishment of an atomist physics.

3.2 THREE DIFFERENT TYPES OF FORMS

Suarez equates the substantial form with the physical (natural) form of a matter/form composite.[18] Hence a metaphysical form is called a form only "by analogy and by a certain metaphor."[19] By analogy to the physical composition from matter and form, we can consider compositions that abstract from matter to be metaphysical compositions. Suarez identifies two kinds: (1) compositions from nature and supposite, e.g., the human nature and the created, finite manner in which a particular human being exists, and (2) compositions from genus and difference, e.g., 'animal' and 'rational,' which together give us the definition of a human being. Suarez goes on to characterize the definition as a logical form. It is a composition of reason, whereas (1) is an actual composition from elements that can actually be distinguished in the thing.[20] In this actual composition, the nature, which is analogous to form, constitutes the entire essence of the thing, e.g., the humanity of the person. The supposite (the way in which the individual essence subsists – in this case as a created, finite thing), which plays a role analogous to that of matter, is merely a mode of the essence. Since, in this case, the form is identical to the entire essence of the composite, Suarez concludes that the nature which actualizes or completes the essence of a thing is the metaphysical form in the proper sense.[21] In short, we find in Suarez three distinct types of form: (1) the physical form, which is the substantial form (the unobservable incomplete substance that is joined to prime matter and supports the accidental forms of the composite); (2) the essence/nature, which is a metaphysical form (e.g., my humanity), and (3) the differentia of a definition, which is a purely rational logical form (e.g., 'rational' in the definition of a human being).

[18] According to Pasnau, the prevailing late Scholastic trend pointed in this direction. After tracing the views of later Scholastic philosophers, he concludes: "In all these texts, the dominant conception of form is decidedly concrete rather than metaphysical. Substantial forms are understood as causal agents that would figure centrally in any complete scientific account of the natural world." Pasnau "Form, Substance and Mechanism", p. 39.

[19] *MD* 15, p. 177. [20] *MD* 15, p. 178. [21] Ibid.

The metaphysical v. the physical form

Suarez argues that the metaphysical form of a substance differs from its physical/substantial form in three key respects. First, the metaphysical form is the form of the whole and, as such, it is identical to the nature of the thing, which includes both matter and form. For example, the metaphysical form or nature of a human being is humanity, whereas the physical form is the individual human being's rational soul. Humanity, unlike the soul that is the form of the human body, expresses the whole essence of a human being, consisting in both the characteristic matter and form of a human being. Suarez thus emphasizes the gap between form and essence.[22] Second, he claims that the metaphysical form is not called a form because it exercises the proper causality of a form, but because it alone constitutes the thing essentially. One of the reasons he gives to support this claim is that since, in the case of material substances, the essence as the form of the whole includes prime matter, it cannot actualize the subject the way a formal cause does.[23] This point betrays the extent to which the substantial form had come to be equated with a certain causal role in physics. A metaphysical form is not a substantial/physical form precisely because it does not exercise formal causality in material substances. Third, the metaphysical form differs from the physical form in that both spiritual and material things have a metaphysical form. For example, God, who does not have a substantial form, nevertheless has a metaphysical form, namely, the divine essence. Hence we speak of the divine nature, and angelic nature, as well as human nature. The difference is that whereas in a human being, the human nature is really distinguished from the supposite (for a human being can either exist or not), the divine essence is distinguished from its mode of subsistence only by reason, for to exist belongs to the very essence of God.[24] In created

[22] Suarez relates this point to the mystery of the incarnation. The problem that concerns him appears to be the following. If Christ is to be both fully human and divine at the same time, then the essence of humanity cannot include created existence, for God is not created. So Suarez maintains that the whole essence of a human being is in Christ, even though, in his case, there is no created existence as in other human beings. In other words, the identification of essence and metaphysical form allows Suarez to claim that Christ's subsistence as a non-created being in no way affects his essential humanity. Interestingly, this implies that being a creature of God is not part of any human being's metaphysical form or essence – it is merely the way we happen to come into existence. *M.D.* 15, p. 178.

[23] *MD* 15, p. 181. Suarez adds that the humanity of Christ is the metaphysical form of Christ, but it cannot be the true form of the Divine Word, which is said to formally constitute the man Christ.

[24] *MD* 15, p. 178.

immaterial things, like angels, the metaphysical and substantial form are one and the same. Only in material things is there a distinction:

> In material entities, however, this form of the whole differs from the physical and partial form, as is shown from the common use of these words and from the very distinction of physical form from metaphysical form. It does not differ from the physical form, however, except insofar as the form of the whole expresses the whole nature composed of matter and form, while the physical form only expresses the formal part.[25]

Suarez's equation of 'nature' and 'essence' indicates an important difference from both Aristotle and St. Thomas Aquinas. Aristotle defines a nature (*physis*) as "a sort of source and cause of change and remaining unchanged in that to which it be longs primarily and of itself, that is, not by virtue of concurrence."[26] As Aquinas points out, Aristotle's primary purpose is to distinguish things that come about by nature from accidental becomings, such as those due to chance, or art. Thus, unlike 'essence' or 'form,' Aristotle does not extend the term 'nature' to products of art. While one can speak of the essence or form of a house (though obviously in a qualified sense), one cannot sensibly speak of its nature, for it does not possess an intrinsic source of non-accidental change: e.g., the house does not produce other houses – the builder does. Aquinas, following Aristotle, defines nature as "nothing other than a principle of motion and rest in that in which it is primarily and *per se* and not *per accidens*."[27] Suarez shows that he is aware of this standard definition when he writes: "As nature is commonly considered, it expresses an order to operation."[28] However, he continues, "it only differs from essence in that the name "essence" was taken up from its order of being, while the name "nature" was taken from its order to operation."[29] This allows him to conclude that "the primary and adequate principle of operations in each thing is its essence, a fact which is obvious in the case of immaterial things."[30] In material things, the essence is distinguished from the physical principle

[25] *MD* 15, p. 179.
[26] Aristotle, *Physics, Books I and II*, trans. William Charlton (Oxford: Clarendon Press, 1992), 192b20–23, p.23
[27] St. Thomas Aquinas, *Commentary on Aristotle's Physics. trans.* Richard J. Blackwell, Richard J. Spath, and W. Edmund Thirlkel, 2 vols. (New Haven: Yale University Press, 1963), Vol. 1, Bks I–IV, p. 71.
[28] *MD* 15, p. 179.
[29] Ibid. The Coimbran commentators make a similar point, so this appears to be a common Jesuit teaching. Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca and London: Cornell University Press, 1996), p. 232.
[30] *MD* 15, p. 179.

of operations in that it includes the material part of its nature, whereas the latter includes only the formal part.

Suarez presents this view as entirely traditional, both reciting the etymology of the term 'nature,' in true humanist style, and quoting philosophical authorities like Aristotle and Aquinas, in true Scholastic fashion.[31] This mode of presentation makes it hard for the contemporary reader of philosophical texts to appreciate its novelty, for we tend not to know Aristotle's and Aquinas' texts well enough to detect the subtle reinterpretations involved, and we tend to assume, rather naïvely, that the rhetoric of novelty is an adequate measure of the true extent of a philosopher's originality. Notwithstanding our shortcomings as readers, we are now in a position to see that the view Suarez advances represents a very different way of thinking from that of Aristotle and Aquinas. First, he breaks the close connection between essence and form, clearly distinguishing the metaphysical form or essence from the physical or substantial form of a substance. Thus the essence can no longer be thought of as a kind of specifying principle of the matter, or formal cause of the individual substance. The essence or metaphysical form is, for Suarez, almost identical with the substance, excluding only the manner in which it exists. But then Suarez introduces another twist. He tells us that the substance minus its particular mode of existence is its nature. This implies that my humanity is not some abstract universal or species individuated by being embedded in matter; rather it is me in the sense of the active principle of all my operations. That is, my human essence is akin to the active principle of all the changes I undergo. It differs from my substantial form in that it includes my matter as well as my form.

This move, while not necessitating, at least allows us to better understand, the move to a Cartesian metaphysics. It explains why a Jesuit-educated philosopher like Descartes did not see any inconsistency in eliminating substantial forms along with their formal causality from the realm of physics, while retaining essences/natures (metaphysical forms) at the metaphysical level. Cartesian essences or principal attributes, while quite different from Aristotle's and medieval Scholastic essences, are not so far removed from Suarezian essences. On one reading, Descartes can equate extension with matter because, like Suarez, he considers the essence to be the material substance minus its particular mode of existence. Cartesian principal attributes, like Suarezian essences, constitute the very nature of a substance as distinguished from its manner of existence.

[31] *MD* 15, pp. 180–181.

Concluding his discussion of the metaphysical form, Suarez stresses that there can be only one metaphysical form per substance. In other words, there is not one essence corresponding to the species of humanity, and another essence corresponding to the genus of animality in me. I now turn to Suarez's second metaphorical sense of form: the logical form.

The logical form

In addition to emphasizing the difference between a substance's metaphysical essence and its substantial form, Suarez also sharply distinguishes the logical form, i.e., the differentia that defines a substance by placing it under a species, from the substantial form, i.e., the physical form of a composite substance. In the short term, Suarez's separation of the concrete physical form from more abstract notions of form served to insulate the substantial form both from logical and metaphysical puzzles internal to Scholasticism and (as I will show next) from external humanist attacks on Scholastic logic. In the long term, however, severing the logical forms/definitions employed as middle terms in Scholastic scientific demonstrations from both physical substantial forms and metaphysical essences may have facilitated their replacement with alternative scientific principles and explanations.

As Suarez explains, the differentia in a definition (e.g., 'rational' in 'A human being is a rational animal') constitutes the second type of form by analogy. For together with the genus 'animal' it gives us a composite that is *per se* one. Furthermore, the essential difference, 'rational,' actualizes, terminates, and distinguishes the genus 'animal' in much the same way as a form actualizes and makes determinate the potentiality of matter. Like matter, the genus in a definition is indifferent to many things until the differentia, so to speak, contracts and determines it.[32] However, a problem arises in considering the genus and differentia to be related in the way matter and form are, for 'rational' and 'animal' would then be parts of the whole 'human being' (recall that Suarez considers matter and form to be parts of a composite substance). But if 'animal' were a part of 'human being,' then we would not be able to say, "A human being is an animal." Instead we would have to say, "A human being is animalistic," just as we say "A human being is corporeal" *versus* "A human being is a body."[33] What may seem like a purely linguistic point actually poses a serious metaphysical problem on the Scholastic theory of predication.

[32] *MD* 15, pp. 183–184. [33] *MD* 15, pp. 185–186.

Before examining Suarez's solution, it is worth highlighting the historical origins of the equation between definition and essence in Aristotle that is the source of this problem. In *Metaphysics Zeta* Aristotle writes (cited from the Latin text Aquinas commented on):

> Hence in one sense there will be no definition of anything, and definition and essence will be found only in substance; and in another sense the other things will have a definition and an essence. It is evident, then, that a definition is a concept of the essence of a thing, and that essence belongs to substance either alone, or chiefly, primarily, and without qualification.[34]

In this passage Aristotle characterizes a definition as a concept of a thing's essence, and adds that substances are either the only things or the primary things to possess essences. This implies that the parts of the definitional concept must correspond to the parts of a substance's essence. As Aristotle puts it at the very beginning of *Metaphysics Zeta*, chapter 10:

> Since a definition is the intelligible expression of the thing, and every intelligible expression has parts, and just as the intelligible expression is related to the thing, so is a part of the intelligible expression to a part of the thing, the problem now arises whether the intelligible expression of the parts must be present in the intelligible expression of the whole or not.[35]

Now, as any educated person of Suarez's time knew, Aristotle's method for arriving at definitions is the method of division. In other words, one starts from the general class to which the entities one is trying to define belong, and keeps subdividing it into progressively less general, mutually exclusive subclasses, until one reaches the point where all and only the targeted members of the more general category are included in the subclass. For instance, to arrive at the defining trait of humans, one would start with 'animal' and divide it into 'aquatic' versus 'terrestrial.' One would next divide 'terrestrial' into 'feathered' and 'featherless,' and the latter into 'biped' and 'multiped.' Finally, 'biped' is divided into 'rational' and 'non-rational.' The broadest class one begins with, in this case 'animal,' becomes the genus of the definition, and the final division, 'rational,' the essential difference, or differentia, in the definition of a human being. The suggestion, by Aristotle, that the concept produced by such a division corresponds to the essence of a substance raises two separate problems. The first relates to the concern already mentioned earlier: if 'rational animal' corresponds to the essence of a human being, then must not 'rational' and 'animal' be parts of a human being, in the way that form and matter are?

[34] 1031a7–14, *CAM*, p. 448. [35] 1034b20–27, *CAM*, p. 488.

But surely they are not. The second problem is that the division by which one arrives at a definition could produce an infinite regress of forms.

Suarez bases his solution to the first problem on an interpretation of Aristotle which he attributes to Alexander of Hales and Aquinas. In the context of rejecting what he refers to as "The Opinion Asserting a Multiplication of Forms According to Essential Predicates," Suarez appeals to their reading of Aristotle's text. In the above extract from *Zeta* 10, they read Aristotle to refer not just to definitional parts that are really distinct, but also to parts that are only rationally distinct.[36] Suarez takes this reading to its extreme, ultimately concluding that all parts of all definitions are only rationally distinct from one another. Later on, when addressing the difference between the logical and physical form, Suarez states: "Though the definition seems to contain and explicate the whole essence of the thing, it can, nevertheless, be multiple,"[37] that is, there can be many differentiae of the same thing. In support of this claim he argues that the logical form, i.e., the differentia in a definition, does not produce a real composition with the genus. Since the composition is merely one of reason, the parts of a definition too are merely rational parts, distinguished from one another only "by the division and abstraction of the mind."[38] Since our mind can divide and abstract things in various ways, there can be a plurality of essential differences. Nevertheless, Suarez claims that this does not prevent an "essential unity and composition from genus and difference."[39] This implies that the essential unity of a definition is not dependent on a direct correspondence of each of its parts to the parts of the metaphysical essence of a substance. In other words, depending on how we conduct our division, there can be more than one valid definition of the same substance even though there is only one physical/substantial form and one metaphysical essence! This is a surprisingly modern result. By rejecting the standard equation of the defining concept of a substance with its metaphysical essence, Suarez severs the longstanding link between Aristotelian definitions and real essences. As we shall see in the following chapter, this would have serious epistemological consequences, for how is certainty ever to be attained in science if the definitions that function as middle terms in demonstrative syllogisms are not guaranteed to pick out true essences?

While Suarez appears unperturbed by the potential for skepticism, he addresses the second problem of the possibility of an infinite regress in the parts of a definition. This problem goes back to Aristotle, but seems to be

[36] *MD* 15, p. 129. [37] MD 15, p.187. [38] Ibid. [39] Ibid.

exacerbated by Suarez's earlier conclusion that the parts of a definition are only rationally distinct.[40] According to Suarez, Aristotle argues against the possibility of an infinite regress in the parts of a definition in order to block the possibility of an infinite regress of forms. In other words, since the predicates by which we define things are finite, then, given that the parts of a definition are in a one-to-one correspondence with the forms of the substance, the forms must be finite too. However, Suarez objects, since it is possible for there to be two, or three, or four differentiae, what is there to prevent there from being an infinity of them, and with that, an infinity of forms?[41] Suarez then adds:

> This is especially so, because this number of predicates does not arise from distinct things or modes which exist in reality in one and the same substance, but arises from our concepts with some foundation in reality. But we can divide and abstract in an infinite number of ways, and there is a foundation in these things for this to be done by us on account of the various similarities and differences which one thing has with others. And this difficulty is especially pressing if one species is not only related to other species which have been produced, but to all possible species which can be multiplied to infinity and in infinite ways.[42]

Since Suarez has already argued that the parts of a definition are rational parts that do not correspond directly to the actual essential parts, I assume that he is here concerned about the possibility of an infinite regress of logical forms. In other words, whereas Aristotle was concerned about an infinite regress of metaphysical forms, this problem no longer arises for Suarez, for the parts of the metaphysical form remain the same regardless of how many differentia we mentally abstract from the same reality. Nevertheless, a similar problem still arises with respect to the logical forms we rely on in our scientific demonstrations, and I assume that this is what concerns Suarez here. For if there were an infinite regress of logical forms, then our scientific knowledge would never be complete.

Suarez takes the most probable argument against the infinite regress of predicates to be the following. In any division, there is a strict hierarchy where one of the quidditative predicates is always prior to another, in the sense of being more universal in its scope (e.g., 'animal' is prior to 'featherless'). Given this hierarchical structure, there has to be a highest genus to explain the fact that we order the other predicates according to the extent to which they approach it (i.e., we cannot go higher than 'substance'). This highest genus corresponds to the first matter of the matter/form composite that is the definition. Similarly, there must

[40] See Aristotle, *Metaphysics II*, ch. 2, 994a1. [41] *MD* 15, pp. 187–188. [42] *MD* 15, p. 188.

be a specific and lowest difference which would correspond to the final form. Therefore, the intermediate forms must be finite and determinate in number.[43]

Suarez's ensuing discussion is quite detailed and technical. I will limit myself to two major objections to this argument and Suarez's replies. I will return to Sanchez's variations on these objections in the following chapter in order to determine whether Suarez's replies suffice to block his humanist skeptical concerns. The first objection is that even if we grant that the predicates found in one line of division are finite, there is nothing preventing the existence of multiple lines of subordinate predicates, or multiple predicates that are not subordinated to one another. And so an infinite regress is still possible when we construct our definitions. Multiple lines of subordinate predicates could come about in two ways: there could be multiple highest genera, each with its own line of predicates, or the same highest genus could be divided in different ways: e.g., 'substance' could first be divided into 'corporeal' and 'incorporeal,' or, equally well, into 'living' and 'non-living.' As an example of multiple predicates that are not subordinated to one another, Suarez points to 'rational' and 'mortal,' which contract 'animal' and occur together in the class of human beings but not in other classes of substances.[44]

In response to this objection, Suarez first asserts that there is only one highest genus or predicate, stating that this is obvious by reason, usage, and experience. He then gives two reasons to show that there is also only one ultimate difference. First, every difference is taken from a form. Since every form that differs in species from another form has its own proper essential level of being that is not shared by other forms, there is only one proper differentia per level of being. Suarez could be referring to two different kinds of forms here: logical forms, or metaphysical forms. If he is referring to logical forms, then he appears to be begging the question, for whether or not they can always be separated into distinct levels of being is precisely what is at issue. If he is referring to metaphysical forms, then he needs to explain how each predicate, as a purely logical form that is not identical to a metaphysical form, could nevertheless be said to reflect the essential level of being of one particular metaphysical form. Suarez provides no answer here, but his earlier claim that a predicate "arises from our concepts with some foundation in reality" provides a clue.[45] While predicates and their corresponding logical forms are mental creations, they do have their foundation in real forms and real similarities and differences

[43] Ibid. [44] *MD* 15, pp. 189–190. [45] *MD* 15, p. 188.

between natural substances. To us as post-empiricists, this does not resolve the problem, for we tend to assume that there is no way to delineate and pick out kinds except by language, and so the whole notion that one particular predicate describes an essential *versus* accidental difference collapses. However, Suarez, like other Scholastic Aristotelians, holds that just by observing the world around us, we can pick out clearly delineated natural kinds. The method of division lines up our predicates and logical forms to match the natural hierarchy of species and, by so doing, reveals the essential differences that divide the natural world.

This brings us to the second way in which there could be an infinite regress: i.e., there could nevertheless still be multiple non-subordinated predicates, as in the case where a human being is defined as both 'rational' and 'mortal.' In other words, we could conduct our division of 'substance' as follows: first divide it into 'corporeal' and 'incorporeal,' then divide 'incorporeal' into 'rational mortal' and 'rational immortal.' Since mortality does not suffice to differentiate humans from mortal non-rational beings, it appears that 'rational' and 'mortal' taken together define a human being and hence are not subordinated to one another. The problem with taking mortality to be definitive of humans is that it is what Suarez calls a 'common difference.' In other words, it appears on both sides of our division, since we also characterize non-rational corporeal, living substances as mortal. Hence mortality is not proper to the genus of a human being since, even though the only rational beings who are mortal are humans, mortality is shared by other sentient and living beings. To avoid this error Suarez advises that "one should proceed in the division of common differences 'until one arrives at those without differences.'"[46]

Now that we have seen how Suarez replies to the first infinite regress objection, let me briefly address the second one. This objection is a variation on the problem of the continuum. Even if we accept Suarez's arguments that, in every division, there will be only one highest genus, and one ultimate, proper differentia, there could still be an infinite number of potential intermediate predicates between them, just as a line can potentially be divided to infinity. Suarez's first reply is based on his earlier point that each distinguishing predicate of the division corresponds to one actual, distinct level of being. Since there cannot be infinite levels of perfection in a finite thing, the levels of being are finite. Hence the intermediate predicates in a division will also be finite. Suarez stresses that even if these levels are distinguished from one another only by reason, an

[46] *MD* 15, p. 191.

infinite regress is not possible, for "each of those levels is truly indivisible in terms of its concept."[47] The reason he gives is that a finite essence can only be divided by a finite number of differences, even with respect to its mental concept. He adds that even if differences could be multiplied without being subordinated to one another, as in the cases like 'rationality' and 'mortality,' not even the mind could divide a finite perfection "into more than a finite number of *quasi* parts which do not have something in common."[48] However, Suarez maintains that it is more likely that all the differences that constitute one essence are hierarchically subordinated, for otherwise they could not form an essential unity. Either way, the number of predicates in a division will always be finite.

I have traced these arguments in some detail to convey the complexity and abstractness that the Scholastic Aristotelian doctrine of forms had attained with respect to the definitions employed in scientific demonstrations. It is clear from Suarez's concerted attempts to resolve them that, by this point, multiple problems had arisen within the Scholastic Aristotelian theory of definition (e.g., the infinite regress problem) and its relationship to metaphysical essences (i.e., the problem of matching up the parts of a definition to the real forms of a substance). In attempting to solve problems that arose within the framework of Scholastic Aristotelianism, Suarez takes some interesting steps. By clearly separating physical, metaphysical, and logical forms from one another, and by treating all logical forms as merely rational distinctions, he comes close to the early modern way of thinking. By treating the three types of form as distinct from and independent of one another, he deftly sidesteps the problems prior Scholastics ran into when, following certain passages in Aristotle's texts, they tried to line up the parts of a definition, i.e., genus and differentia, with the matter/form distinction of physics on the one hand, and the metaphysical essence of the whole substance on the other. However, Suarez's implicit commitment to commonsense realism and natural kinds blinds him to the skeptical implications of severing the logical form from both the physical and metaphysical form. Although the logical form is, for him, merely a mental abstraction that is only rationally distinct from other parts of definitions, and although this implies that it is not identical to the actual metaphysical form, Suarez assumes that the abstract logical form has its foundation in reality. Hence, provided that we complete the division properly, our concepts cannot fail to pick out the proper differentiae that correspond to the actual levels of being. As

[47] *MD* 15, p. 192. [48] Ibid.

we shall see in the next chapter, Sanchez's skeptical humanist critique of Aristotelian completely undermines this assumption. Nevertheless, I will also argue that this common humanist critique alone does not suffice to eradicate the Scholastic doctrine of substantial form. By separating it from the metaphorical logical and metaphysical forms, Suarez ensures that knowledge of the existence of substantial forms is freed from our capacity to know these metaphysical and logical essences. In other words, thanks to Suarez's threefold division, the impact of the humanist critique of Aristotelian logic is minimized: Scholastic essences and definitions can be challenged while the primary sense of form, namely the substantial form of physics, remains intact.

Two general conclusions can be drawn from this in-depth examination of key elements of Suarez's account of the substantial form. First, by developing Aquinas' account of the human soul as a subsisting substantial form, and making it primary, Suarez defines all substantial forms as incomplete substances that need not be joined to matter but that, when joined to matter, maintain and restore the substance's accidents. Accordingly, material substantial forms are re-conceived as internal active soul-like entities which, by their mysterious agency, ensure that the accidents of the composite are restored and united to one another. Just as an external agent can cause water to become warm, the substantial form can cause it to become cold again even when no pockets of coldness remain in the water. In other words, the substantial form is transformed into something more like an internal efficient cause than a formal cause. As we saw, Suarez places greater weight on empirical arguments in favor of the existence of substantial forms which, in the absence of viable alternative theories, appear strong. However, I will show in Parts II and III that, in the long run, limiting substantial forms to the physical realm made them more vulnerable to replacement by atomist and mechanistic principles. Second, Suarez goes further than the distinction Aquinas draws between abstract forms, like the genus and differentia of a definition, and the natural forms/essences of individual substances. Suarez treats physical forms as the only true substantial forms, and downgrades metaphysical essences plus logical forms or definitions to substantial forms in a merely metaphorical sense. Part II will explore two kinds of challenges to Aristotelian scientific demonstrations and the definitions they employed in order to shed light on Descartes' early project of replacing the contested Aristotelian scientific explanations with secure demonstrations based on the principles of mechanics.

PART II

Challenging the substantial form

In Part I, I showed that Suarez's efforts to save the substantial form emphasized its role as a physical principle justified primarily on empirical rather than metaphysical or purely logical grounds. By relating both his account and that of Aquinas to the *a priori* argument Descartes offers to Regius, I argued that something akin to Suarez's conception of the substantial form as a self-subsistent, partial substance, rather than the Thomist view, is probably the target of Descartes' charge that material substantial forms are inconsistent with the Scholastic definition of a substantial form. Hence Suarez's definition of the substantial form makes it easy for Descartes to reduce this particular Scholastic doctrine to absurdity. Such late Scholastic metaphysical innovations thus constitute a vital *sine qua non* in the shift from hylomorphism to mechanism. However, while they serve to clarify the nature of Descartes' negative metaphysical arguments against material substantial forms, they are insufficient to account for the positive view he developed to replace them. I now turn to the remaining scientific arguments against substantial forms that Descartes recommends to Regius, namely, the nature/machine analogy and his appeal to the success of mechanistic explanations.

In this part of the book, I will argue that Descartes bases his initial replacement of material substantial forms with mechanisms on objections to the form of scientific explanation employed in Aristotelian physics rather than on metaphysical concerns. Indeed, Suarez's separation of the physical substantial form from logical and metaphysical forms, combined with the strength of his empirical arguments for their existence, meant that they could safely be employed in physics regardless of metaphysical objections and logical puzzles concerning the parts of definitions. Forms were closely bound up with the prevailing Aristotelian logic of scientific demonstration in that the most secure form of scientific syllogism employed the definition of a substance (i.e., its logical form) as the middle

term. As discussed in the previous section, Suarez's treatment indicates that several problems associated with these logical forms had been raised within the Scholastic tradition. However, perhaps due to an emphasis on the physical form and empirical arguments in its favor, there was little incentive to do away with the Aristotelian theory of scientific demonstration in physics until it was severely challenged in the late sixteenth and early seventeenth centuries. I will show that these challenges made the appeal to Aristotelian forms in scientific demonstrations increasingly problematic, enabling Descartes to proclaim the superior fruitfulness and explanatory power of demonstrations based on mechanical principles.

As background to Descartes' unsupported reliance on the nature/machine analogy and his appeal to the superiority of explanations based on mechanical principles in the letter to Regius, I will discuss two distinct challenges to what Suarez characterized as the logical form. The first is a direct external challenge to Aristotelian forms by humanist philosophers that takes the shape of a general skeptical attack on Aristotelian logic and *scientia*.[1] The second is an indirect internal challenge arising from developments in the mixed mathematical sciences that took place within the Aristotelian tradition. In chapter 4, I will examine the arguments Sanchez offers in his skeptical treatise *That Nothing is Known* to illustrate the first kind of challenge. Although Sanchez studied and wrote in France, and hence is part of Descartes' broader French context, I have not found any direct evidence that Descartes read this work during his sojourn in Paris. Nonetheless, Sanchez's notoriety makes it likely that Descartes would have at least heard of him. He was referred to as "Sanchez le sceptique," and his reputation extended beyond the sixteenth century into the seventeenth, and well beyond the borders of France.[2] For instance, in the seventeenth century one of Descartes' accusers, the Dutch theologian and philosopher Martin Schoock, and the German theologian Gabriel Wedderkopff, included Sanchez on their list of the most dangerous enemies of Christianity.[3] There are also good textual reasons to focus on Sanchez as an example of the skeptical humanist attack on Aristotelian logical forms, for, unlike that of other skeptical humanists of the period

[1] Unlike our term 'science,' the Latin term refers to knowledge of the causes (i.e., one or more of Aristotle's four causes) of a natural phenomenon arrived at by means of a demonstrative syllogism. Unlike other syllogisms, the demonstrative syllogisms of science are supposed to begin from self-evident or previously demonstrated premises, and hence they establish true conclusions with necessity.

[2] Francisco Sanches, *That Nothing Is Known*, ed. Elaine Limbrick and Douglas F. S. Thomson (Cambridge: Cambridge University Press, 1998), (henceforth *QNS*), "Introduction," p. 1.

[3] Ibid.

(the most famous one being Michel de Montaigne), Sanchez's skepticism, like that of Descartes, has a constructive aim. As he announces at the end of his treatise:

> For my purpose is to establish, as far as I am able, a kind of scientific knowledge that is both sound and as easy as possible to attain: but *not* a science that is full of those chimeras and fictions, unconnected with factual truth, which are put together, not to teach facts, but solely to show off the writer's intellectual subtelty.[4]

Unfortunately, Sanchez never published the work on "the *method of knowing*" that he promised would follow his skeptical treatise.[5] However, as a precursor to the Cartesian project of clearing the ground with skeptical arguments before proceeding to construct new foundations for knowledge, the skeptical arguments Sanchez introduces to undermine the principles of all his predecessors deserve our attention.

As representative of the second kind of challenge, chapter 5 will focus on crucial developments within Scholastic Aristotelianism prompted by the revival of the Aristotelian *Quaestiones Mechanicae*. Drawing on texts that Descartes would have encountered as a member of the Mersenne Circle in Paris, I show that debates internal to the commentaries on this particular Aristotelian text introduced several conceptual shifts that made possible the development of a mechanistic physics. First, mechanics was elevated from an art into a mixed mathematical science with roots in both physics and mathematics. Second, the objects studied by mechanics, over time, came to be identified with the natural objects studied by the physicist. Third, attempts to square the mathematical form of explanation employed in this text with Aristotle's syllogistic theory of demonstration led some commentators to conclude that mathematical demonstrations were the prime examples of what Aristotle meant by a perfect scientific demonstration. I will argue that, contrary to popular belief, the development of alternative principles and forms of explanation that occurred within the Aristotelian tradition itself posed a far greater and more insidious threat to the survival of material substantial forms than the overt attacks of anti-Aristotelian skeptics like Sanchez.

Chapter 6 examines Descartes' early scientific writings in light of his contact with Aristotelian mechanics. I show that in the Essays of his *Discourse on the Method* Descartes employs a form of demonstration inspired by mechanical demonstrations to establish the explanatory

[4] *QNS*, p. 290. [5] Ibid.

superiority of mechanical principles over substantial forms. I then argue that Descartes tries to give a metaphysical account of matter to support his new theory of demonstration by re-conceiving matter in mathematical terms in *The World*. However, these early attempts to justify a physics modeled after mechanics fall significantly short of the later metaphysical justification Descartes gives, and hence do not imply the elimination of material substantial forms.

CHAPTER 4

Sanchez's skeptical humanist attack

Francisco Sanchez (a.k.a. Franciscus Sanctius, 1551–1623) was a philosopher and physician who studied medicine at the University of Bordeaux, and at La Sapienza in Rome, a course of study that exposed him to both Aristotelian and Galenic natural philosophy. In 1573, after two years in Italy, where the more innovative fields of natural history, botany, and anatomy were already being taught, he returned to France and completed his doctorate at the University of Montpellier. While in Montpellier he taught a course for surgeon apprentices, and in 1575 he moved to Toulouse, where he is said to have devoted himself to philosophical and mathematical studies. During this time, Sanchez corresponded with the Jesuit mathematician Christoph Clavius about an unpublished mathematical work he (Sanchez) had written. After failing to secure a chair in medicine at both the universities of Montpellier and Toulouse, the embittered Sanchez took a position as a doctor at a charitable institution in 1582, where he would remain for thirty years. In addition to this position, he accepted a chair in philosophy at the University of Toulouse in 1585, which he occupied until 1612. At age sixty-one, he finally secured a position as Professor of Medicine at the University of Toulouse.[1]

In 1581 Sanchez published the skeptical treatise he had been working on since 1574. *That Nothing is Known* secured Sanchez's place as intellectual rabble-rouser. As will become clear, his systematic attack on the very foundations of Scholastic philosophy has serious implications for both the coherence and utility of the forms/definitions employed in Aristotelian scientific demonstrations. While both the *Metaphysical Disputations* and *That Nothing is Known* were written over the course of many years, Sanchez's *magnum opus* was published more than a decade before Suarez's and represents the kind of wholesale humanist attack on Scholastic *scientia* that Scholastic Aristotelian philosophers of this

[1] Biographical information taken from Elaine Limbrick and Douglas F. S. Thomson, "Introduction," *QNS*, pp. 1–24.

period were forced to defend themselves against. One of my goals in this chapter will be to place Sanchez and Suarez in dialogue with each other, in order to determine how well Suarez's revamped Scholasticism holds up against this kind of skeptical humanist critique. Surprisingly, it holds up rather well, which might explain why Scholastic Aristotelian physics survived the humanist attacks. But Sanchez's target is much broader than Scholastic Aristotelianism: he aims to undermine the principles of all systems of knowledge, whatever form they take, whether Aristotelian, Platonic, or other. Sanchez spares no one – not even the humanists whose rhetorical flourish he emulates. My second goal will be to show that, in light of Sanchez's arguments, the standard Renaissance appeal to more ancient and venerable philosophical sects in order to undermine the authority of Aristotle becomes unconvincing. As Sanchez demonstrates, the general skeptical doubts used to undermine Aristotelian principles just as easily undermine the principles of other ancient philosophies. Hence, for new principles to take hold, they must be immune to such logical doubts. That is, they must be pre-philosophical so as to be, or at least appear to be, evident to everyone. In the next chapter I will show that, even though Sanchez himself did not think they were above doubt in this respect, the axioms of mathematics and the geometrical demonstrations used to explain the functioning of everyday machines had a clear advantage over the increasingly tangled web of philosophical methodologies and doctrines.

Sanchez mounts his skeptical attack in two distinct phases. First, he completely dismantles the Scholastic *organon*. He systematically undermines Scholastic Aristotelian logic, starting with its theory of definition and predication, then attacking the syllogism, the backbone of the Aristotelian theory of demonstration, and culminating in the rejection of the Aristotelian definition of *scientia* as an acquired disposition which is the accumulation of many syllogistic inferences.[2] After considering and demolishing several other standard definitions of knowledge, including the Platonic definition of knowledge as recollection, Sanchez settles on the definition "KNOWLEDGE IS PERFECT UNDERSTANDING OF A THING."[3] At this point, Sanchez switches from launching skeptical arguments against particular philosophical theories to a more general argument against the possibility of knowledge as perfect understanding. He identifies three distinct factors in knowledge: the object of cognition, understanding

[2] *QNS*, p. 189. [3] *QNS*, p.200. Capitalized in the original.

(*cognitio*), and the perfection of knowledge.[4] First he presents arguments to show that the object of cognition is such that a perfect understanding of any thing is impossible. Then he presents arguments to show that the knowing subject is incapable of acquiring knowledge in this sense. Finally, he maintains the impossibility of perfecting one's knowledge through education. In section 4.1, I will examine Sanchez's particular attack on Scholastic logic and argue that Suarez's new theory of form provides resources to counter his arguments. In section 4.2, I will draw out the implications of Sanchez's more general argument for Suarez's empirical arguments in favor of the substantial form, and pre-mechanistic principles of natural philosophy in general.

4.1 Sanchez's demolition of Scholastic Aristotelian logic

In his "Preface to the Reader" Sanchez presents a vivid description of his youthful devotion to the contemplation of nature and the intellectual indigestion that ensued from his indiscriminate binging on past and present teachings. In a passage that bears an eerie resemblance to lines in Descartes' *Discourse on the Method* and the beginning of the *Meditations* he writes:

> Subsequently I withdrew into myself; I began to question everything, and to examine the facts themselves as though no one had ever said anything about them, which is the proper method of acquiring knowledge. I broke everything down to its ultimate first principles. Beginning, as I did, my reflection at this point, the more I reflected, the more I doubted. I was incapable of grasping anything in its whole nature. I was in despair, but I still persisted.[5]

Having evoked the sympathy of the educated reader, who could no doubt relate to young Sanchez's predicament, he then proceeds to dethrone Aristotle, whom he characterizes as "the dictator of Truth."[6] Sanchez thus opens his treatise with a series of arguments against the cornerstones of the Aristotelian logic that every educated person of his day was forced to learn in university.

Speaking directly to an imaginary defender of Aristotelian logic as the means to attaining truth (e.g., someone like Suarez), Sanchez throws down the guantlet:

> Let us deduce the thing from the name; for as far as I am concerned every definition, and almost every enquiry, is about names. More fully: we cannot

[4] *QNS*, p. 204. [5] *QNS*, p. 167. [6] *QNS*, p. 169.

comprehend the *natures* of things; at least, I cannot … You, however, claim that there is a definition which "demonstrates the nature of a thing." Show me one such; you have none; so I draw my conclusion.[7]

If our imaginary Aristotelian were to give a Suarezian response, it would take the wind out of Sanchez's sails, for Suarez would concede that the metaphysical essence or nature of a thing is not the same as the logical form or differentia of a definition. And so an inquiry into the metaphysical essences of things is not the same as an inquiry into definitions and names, although the logical forms that constitute a definition do have their foundations in reality. Therefore, it is unreasonable for Sanchez to expect definitions alone to demonstrate a thing's nature. By separating them from the logical forms that compose definitions, Suarez has effectively diffused Sanchez's first argument against the possibility of knowing metaphysical essences.

But Sanchez continues with two further arguments against the Aristotelian method of division. First, he gives an argument in favor of the Aristotelian view which, when fleshed out, appears to be very similar to Suarez's first reply to the infinite regress of logical forms objection. Suarez's first reply, as you may recall, was that every division has a highest genus and an ultimate differentia. Similarly, Sanchez's imaginary Aristotelian interlocutor insists that 'animal, rational, mortal' refer to distinct things, as evidenced by the fact that each has its place in the hierarchy produced by division. That there is such a hierarchy is clear from the fact that, when one defines each concept by higher genera and differentiae, one will eventually reach the highest genus, namely 'Being.' Sanchez then objects that no one knows what the term 'Being' signifies, and so this only reinforces his conclusion that the division is made up of purely verbal concepts that do not denote anything.[8] Suarez would likely respond to Sanchez by telling him he was confused about the Aristotelian theory of division. The phases of a division do not directly pick out things in the world, for they are rationally distinct, not really distinct parts. However, since rational distinctions have their foundations in real things, each phase of a division does correspond to a different level of being. Therefore, even though the differentiae of definitions are rational parts, and there can be multiple differentiae, their total number must be finite, and each one must correspond to a distinct level of being. Furthermore, Suarez would argue that 'Being' as a transcendental is not, properly speaking, the highest genus, but 'Substance' is, and surely there is nothing mysterious about

[7] *QNS*, p. 174. [8] *QNS*, p. 175.

individual substances – we see them all around us every single day. Again, Sanchez's rather simplistic understanding of Scholastic logic is no match for Suarez's subtle distinction between metaphysical and purely rational logical forms.

Finally, Sanchez argues that if 'Being, Substance, Body, Living, Animal, Man, and Socrates' must all refer to the same thing, then they either all mean the same thing, in which case there are too many names for one thing, or they all mean different things, in which case Socrates cannot be a single thing with one identity.[9] Again Suarez would reply that Sanchez is missing the point here. These predicates are not real parts, each picking out one distinct thing in reality, but rational parts corresponding to progressively less general levels of reality. It is clear from Sanchez's Aristotelian mouthpiece how far Suarez has traveled from Aristotle's texts. Sanchez's Aristotelian replies with a quotation from Aristotle, "I am envisaging a plurality of attributes in one and the same man, attributes to which I give, severally, their appropriate names."[10] This leads Sanchez to challenge his opponent to show him "what it is in a man that you call animal, living, body, substance, or being?"[11] Suarez would simply reply: Not something that is really distinct from the man, for these are logical forms, i.e., mental abstractions based on different aspects of the same reality, not actual parts constituting real substances.

While Sanchez has some additional arguments against the Aristotelian syllogism and the Aristotelian definitions of *scientia*, his demolition of the Aristotelian theory of definition serves to undercut these higher forms of knowledge at their very root. Hence many of his arguments are variations on his main point that the terms which constitute the very elements from which Scholastics construct their scientific demonstrations and theories have no reference in reality. Since names cannot pick out real things, whatever we build up from names cannot give us knowledge either. This point recurs as a refrain throughout Sanchez's text, and is reminiscent of earlier humanist charges that Scholastics quibble endlessly about words of their own invention. In other words, given the shaky foundations from which they begin, the Scholastics have not succeeded in building a sound structure of knowledge, so they have nothing to teach us. Sanchez uses the same analogy Descartes will later use in the *Discourse* to make this point: "Take, then, the case of a person who teaches how to build a house,

[9] Ibid.
[10] Ibid. The editor claims that this is a quote from *Posterior Analytics* 96a, which is incorrect.
[11] Ibid.

yet has never built one himself, nor knows how, nor has pupils who know how to do it. Why should I believe that a house ought to be built in the way he teaches?"[12] Nevertheless, Sanchez's argument misses the mark as far as Suarez's theory of form goes, for Suarez admits that the genus and differentia of a definition do not refer directly to individual things and their parts. Instead they refer to concepts that have their foundation in aspects of reality.

In conclusion, Sanchez's strategy of undermining knowledge of Aristotelian essences and forms by attacking Aristotelian definitions and divisions falls flat in the face of Suarez's threefold division between logical, metaphysical, and physical forms. Of course, had he had the benefit of reading the *Metaphysical Disputations* before writing his treatise Sanchez might have modified his arguments to account for this. Nevertheless, this would have posed a bigger challenge for him, since it is harder to slay a hydra with three heads than a hydra with only one. Sanchez succeeds in casting doubt on the possibility of gaining scientific knowledge of a thing's nature by means of Aristotelian definitions and the method of division, but he does not thereby preclude other means to come to know metaphysical essences and substantial forms. As we saw in the previous chapter, separating the substantial form from metaphysical and logical concerns allows Suarez to concentrate on empirical justifications for the existence of substantial forms. I will argue in the next section that Suarez's best empirical arguments cannot withstand Sanchez's more general skeptical argumentation. However, since the arguments in the second part of *That Nothing is Known* are so general in nature, from a logical standpoint they are as equally destructive of the substantial form's competitors as they are of Aristotelian physical forms. Given that Aristotelianism was still the dominant philosophy of the schools at this time, from a psychological standpoint they are perhaps more destructive of the competition. For if, as Sanchez holds, rejecting the Aristotelian principles one has been taught in school entails recognizing the impossibility of coming to know anything, one might as well, for lack of a better alternative, remain an Aristotelian.

4.2 Sanchez's arguments against the possibility of "scientia"

Before we turn to Sanchez's more general skeptical arguments, two arguments he directs against the Aristotelian definition of *scientia* as

[12] *QNS*, p. 187.

demonstrating something by means of its causes are worth mentioning. First, he attributes to Aristotelians the view that efficient and final causes are not necessary for understanding a thing.[13] This is not a standard Scholastic view, and Suarez, who emphasized the importance of efficient causation in natural philosophy, would probably take issue. Nonetheless, Sanchez's 'Aristotelian' premise is the basis for the following argument that a thing cannot be known by its causes:

> But these [the material and formal cause] it does not possess. Therefore you do not know it. But if you do not know this [i.e., the form] you will not know that of which it is the form; for when the parts are unknown, the whole is unknown. I may say the same of the *matter*, which is simpler still, and less of an entity; and it may be that it has no cause – at least, efficient, material, and formal cause, according to Aristotle.[14]

Sanchez does not even feel the need to argue that form and matter are unknown – he simply asserts it. As Suarez admits, substantial forms cannot be directly experienced, nor can prime matter on the standard account, although it should be emphasized that Suarez's redefinition of matter as an incomplete substance turns it into something more concrete than Aquinas' prime matter. Since he acknowledges our inability to directly observe the substantial form, Suarez concentrates on arguing for its existence on the basis that it is the best explanation for certain observed phenomena. We will see momentarily that Sanchez's more general skeptical arguments undermine this set of arguments.

Sanchez's second argument against the Aristotelian conception of *scientia* is not one addressed by Suarez's discussion of form, but it is relevant to Descartes' vision of the unity of all sciences and to the place of Aristotelian mechanics among the disciplines of knowledge, which will be examined next. In chapter 5 it will become clear that subordinate sciences, such as mechanics, relied on premises demonstrated by the higher sciences in their demonstrations. As Sanchez points out, each Aristotelian science ultimately rests on first principles which cannot themselves be proven by the practitioners of that particular science. Therefore, they do not know what they purport to know. Sanchez criticizes the standard Aristotelian appeal to a higher science as the source of a subordinated science's principles:

> "It belongs to a higher, or generalised, kind of science to test the first principles of other sciences." So then, he who possesses this generalised science will

[13] *QNS*, p. 197. [14] Ibid.

perhaps know everything, while you know nothing; for he who is ignorant of first principles is also ignorant of the subject itself. But what *is* that generalised science?[15]

The standard Scholastic Aristotelian response, which dates back to Aquinas, would be: 'Metaphysics, the science of Being *qua* Being." As we have already seen, for Sanchez 'Being' is meaningless, so this does not resolve the problem. But instead of making this obvious point, Sanchez proceeds to make a far more interesting point. He attacks the very notion that there are divisions among the sciences, with one ruling general science that lays down the rules for the others.

It is strange how *your* experts divide their functions among themselves; they draw boundaries between one another, just as the commonality of fools appropriates and shares out land. Nay, rather, they have erected an empire of sciences, among which the queen and supreme arbitrator is the "generalized" science; to it disputes are, in the last instance, referred.[16]

As a result, Sanchez claims, current scientific disputes are like turf battles rather than genuine substantive debates with the potential to advance knowledge. He likens the practitioners of different sciences to little children, each of whom jealously guards his own little garden, forbidding anyone else to enter it. Since no one knows what the 'generalized science' is, there is no higher authority to arbitrate these disputes. As a result scientific theories are justified by vacuous appeals to higher principles that no one can verify:

Hence if in the physical science anyone argues about the stars, they say he does this either in the capacity of a physical scientist or of an astrologer; and of another, "He borrows this from Arithmetic"; but still another "purloins that from Mathematics." What does this mean?[17]

In addition to ridiculing these undesirable results of the Scholastic hierarchy of sciences, Sanchez also offers a diagnosis of the problem. Dividing knowledge into distinct sciences does not work, because the world forms a unity. This implies that the causes of all things are interconnected, which in turn implies that our scientific knowledge of causes must also form an interconnected whole.

For since all things that are in this world unite to make up a single collective whole, some of them cannot exist without others, while again some of them cannot continue in existence along with others; each thing performs its own function, separate and differing from another's function, yet all things contribute

[15] *QNS*, p. 202. [16] Ibid. [17] Ibid.

to a single whole. Some are the cause of others; and some are caused by the action of others. The links between all of them are inexpressibly complicated.[18]

As a result, it is not enough for the astronomer to take as given the physicist's theories regarding the nature of stars and motion and proceed to study only the numerous and diverse motions of stars. To have genuine knowledge, the astronomer must also investigate the underlying physical questions and prove the physical claims he relies on.

When we turn to developments within the mixed mathematical science of Aristotelian mechanics in chapter 5, we will have an opportunity to assess whether Sanchez's characterization of the current predicament of the subordinate sciences is accurate. What is clear thus far is that Sanchez sets the bar for scientific knowledge very high – it must be built on foundations that reflect the real parts of nature and capture the exceedingly complicated links between the parts that make up the whole universe. On this conception of what scientific knowledge involves, appealing to a material substantial form to explain why certain accidents return or are united in one individual body is far too simplistic. For how can we even isolate the causal role of one individual body from the entire network of causes which affect it?

Moreover, practitioners of particular sciences may not simply rely on principles demonstrated by others working in higher sciences – they must know these principles for themselves.

> For all things are linked together in such a way that no single thing is detached from the function of hindering or helping another. Nay, one and the same thing was made by many others, and to help many others. Therefore, in order to understand any one thing perfectly we must understand everything; and who is capable of this?[19]

According to Sanchez, Suarez and his ilk illegitimately rule out what needs to be included in a complete explanation. That is, the surrounding air, and other interconnected parts of the universe, leading all the way up to the celestial realm, all play a causal role in the hot water becoming cold again, and one cannot neatly separate these from the powers exercised by the water itself. Therefore, there is no basis for arguing that the substantial form must exist because it explains the water's return to coldness – even if it existed it would merely be one causal factor among many. Suarez has no direct response to this kind of criticism. He could of course question whether the bar for scientific knowledge should be set so high. Indeed, it

[18] *QNS*, pp. 202–203. [19] *QNS*, p. 206.

seems that by insisting that we have knowledge only when we understand all the causal links, Sanchez sets a standard for science that is impossible for any one scientist or even an army of scientists to attain.

While the situation looks pretty hopeless, an analogy Sanchez makes to support his point might inadvertently offer the reader some hope. Comparing the universe to a clock, Sanchez illustrates the impossibility of coming to know the workings of the universe as a whole by showing how difficult it is merely to understand the inner workings of the infinitely less complex machinery of a clock. "For if you should wish to know how it strikes the hours you must make a comprehensive inspection of all its wheel-movements, from the first to the last, and so determine what moves the first wheel, how this moves another, and this again two more, and so on to the last wheel."[20] Sanchez adds another level of complexity by describing a portable clock he once saw, which not only struck the hours, but also displayed them by means of a hand on a dial, and showed the waxing and waning of the moon, plus the passage of the sun through the zodiac. Faced with such a clock, "certainly you will have a more difficult feat to achieve – nor will you be able to perceive how even the least of these things is done without taking apart the whole machinery from the beginning, and examining it and coming to understand its individual parts and their functions."[21] The workings of the more sophisticated clock are harder to understand, since there is no obvious connection between the things moving on the face of the clock and their underlying causes. We must literally dismantle the clock and reconstruct it in order to uncover the causal connections. But this is precisely what we cannot do with the universe as a whole, and so the clock example serves to reinforce Sanchez's general conclusion that scientific knowledge in the Scholastic sense of knowing a thing's causes is impossible.

And yet, Sanchez gives another example that, to the optimistic reader, offers a glimmer of hope. He describes an illustration of the model universe that Archimedes of Syracuse constructed in a glass sphere, "in which there moved and were visible all the spheres and planets, exactly as in the mechanism of our actual world; air, blown through a number of pipes and conduits, propelled the whole apparatus in symmetrical movement."[22] We may not be able to pull apart the complex machinery that would explain the functioning of the entire universe; however, we can certainly construct simpler models of the universe that, by analogy, allow us to understand the mechanisms at work in nature. As we will see

[20] *QNS*, pp. 209–210. [21] *QNS*, p. 210. [22] Ibid.

in the next chapter, the revival of Aristotelian mechanics played a crucial role in fostering the analogy between nature and machine, and justifying the transferability of mechanical explanations to the realm of natural phenomena.

While the Aristotelian commentators we will turn to next are far more traditional in their conceptions of the nature of scientific knowledge than Sanchez is, it is clear from Sanchez's text that the revival of ancient mechanics introduced an alternative conception of knowledge for anti-Aristotelians like Sanchez to draw on. For Sanchez, knowing the causes of things does not consist in identifying Aristotle's four causes. Rather, causal knowledge involves knowing how a thing functions, which, in turn, involves knowing how to construct it. Sanchez's argument indicates that an important shift is under way – the scientific ideal of 'knowing why' is giving way to 'knowing how.' With this shift, substantial forms become redundant in science, for as unobservable and abstract principles of the stability and unity of a substance, positing them contributes nothing to our practical mechanical knowledge of how a thing is put together. Hence Sanchez, if confronted by Suarez, would dismiss his entire defense of the existence of substantial forms as irrelevant. Even if they do exist, on this new model of scientific knowledge they are useless. By identifying substantial forms with physical forms, thus placing them squarely within the domain of science or natural philosophy, Suarez has unwittingly hastened their demise. In isolation from the metaphysical and logical forms to which it was formerly related, the role of the substantial form is severely circumscribed. Hence it is more easily pushed into the background by the principles and methods of the rising science of mechanics.

Sanchez's more general arguments consist mostly in common skeptical tropes. They include standard doubts on the side of the object of cognition, such as new discoveries that contradict prior certainties, the object's remoteness in space and time, the vastness and minuteness of objects, the endless variety in nature, constant change and countless ways of coming to be, the difficulty of establishing causal connections, monsters and other anomalies, and wondrous phenomena like the rainbow. They also include familiar doubts on the side of the knowing subject. For example, Sanchez enumerates the different types of perceptual distortion by media. External media such as glass, water, air, and distance alter the appearance of an object (e.g., the familiar bent-stick-in-water example).[23] Internal media, such as the size, shape, position, and color of an eye, the substance

[23] *QNS*, pp. 245–250.

of its membranes, the optic nerve, the amount of vapors and humors, and the absence or presence of disease in any particular eye, all affect its vision (Sanchez makes good use of his medical knowledge here).[24] The same goes for all of the other senses. But Sanchez's treatise is not just remarkable in that he does a very thorough job of rehearsing all possible sources of skepticism. What is even more remarkable is the fact that Sanchez structures his arguments in a way that points in the direction of a theory of cognition.

Sanchez begins his general skeptical argument on the side of the subject of cognition with a distinction between what he calls apprehension and reception. Understanding consists in apprehension, but Sanchez confesses that he cannot say anything more substantive about apprehension than that it is "an intellectual grasp, penetrating vision, or intuition."[25] In other words, it appears to be an immediate, unanalyzable act of the intellect. Reception is limited to taking in whatever is presented by the senses without any understanding. As Sanchez puts it, the senses merely absorb impressions the way the air absorbs colors without seeing them, i.e., the senses make no judgments and so they cognize nothing. By means of reception, animals can acquire the image of a man or a stone and its size, but they have no understanding. Human beings also take in sensory images without understanding when the images are obscure or consist in false impressions.[26] According to Sanchez, the senses are major sources of deception, for they perceive only the external accidents of particular things, not the things themselves and their essences; hence they do not attain understanding. To illustrate the extent to which nature deceives the senses, Sanchez tells the story of Zeuxis the painter, who painted such realistic grapes that the birds ran their beaks into the painting trying to eat them. Sanchez concludes:

> Now, this is how Nature presents things to our understanding. And, in another place, Aristotle has observed that our intellect is disposed towards the natures of things just as the eye of the night-raven is towards the light of the sun: it makes judgments about things *by means of images*.[27]

The reference here is to Aristotle's *Metaphysics* 993b10, where he writes: "For as the eyes of bats are to the blaze of day, so is reason in our soul to the things which are by nature most evident of all."[28] In other words, just as a bat is blinded by sunlight, the intellect is blinded by the sensory images with which it is bombarded. Since these images are of accidents,

[24] *QNS*, pp. 252–253. [25] *QNS*, p. 240. [26] *QNS*, pp. 240–241. [27] *QNS*, p. 237.
[28] Aristotle, *Metaphysics*, vol. II, p. 1570.

not of essences, when the intellect makes inferences based on these images it is led astray.

Sanchez explains that the intellect is blind in the face of sensory images because it is more attuned to less familiar, immaterial things, such as the first principles of compound bodies and the heavenly bodies. While less familiar to us, these are

> more intelligible in terms of their own nature, insofar as they are more perfect, more endowed with *Being*, and less complex; and these three qualities produce perfect understanding of a thing. Less so for us, insofar as they are more remote to the senses. But those things that are closer to the senses are more readily understood by us, for the simple reason that the *better* part of our understanding depends on the senses. Yet in terms of their own nature such things are only in the very smallest degree accessible to the understanding; inasmuch as they are highly imperfect, almost nothing can be understood at all.[29]

Sanchez points to a conundrum that affects Aristotelian and non-Aristotelian principles alike. The further removed such principles are from the senses, the more intelligible they are in themselves. But their very removal from the senses makes them less familiar and harder for us to grasp. In view of the fact that the vast majority of the time our intellect is forced to rely on sensory images to make inferences, the knowledge produced is by its very reliance on the senses deceptive and imperfect. Suarez's empirical arguments for the substantial form are a case in point. Since the sensory observations from which he infers the existence of a substantial form are by their very nature deceptive, we cannot rely on his conclusions. Nothing can be known about the true natures and essences of things through sensory perception of their changing accidents. Descartes will later make the same point in his famous wax argument. It must be said, though, that Suarez's arguments fare no worse in this regard than those of his competitors to the extent that arguments in favor of the existence of certain natural principles, be they internal elements or external celestial forms, normally begin from the observed phenomenon of change.

Sanchez's general skeptical argument pulls the rug out from under Suarez's attempt to establish the substantial form by empirical means, and indeed invalidates any attempt to establish principles of nature via this path. But does Sanchez propose an alternative? Despite the tantalizing suggestion of a purely intellectual apprehension, he does not. In keeping with his purpose to drive home the skeptical conclusion that nothing is

[29] *QNS*, pp. 237–238.

known, Sanchez laments, "We are blind in the midst of light."[30] His taxonomy of knowledge explains why Sanchez considers our predicament to be hopeless. As already indicated, he conceives of perfect cognition as a complete examination of something from all sides, enabling us to understand it inside and out. Based on the analogy to having perfect knowledge of the clock, this would involve dissecting nature to uncover its secret workings – an impossible task considering the size and complexity of the universe. So what we are left with is imperfect cognition, which comes in two varieties: external imperfect cognition, which amounts to sensory knowledge (i.e., the reception of images from the senses plus judgments and inferences made from them), and internal imperfect cognition, which originates from the mind alone (i.e., our direct awareness of our own acts of thought and will).

According to Sanchez, the two types of imperfect cognition possess contrary advantages and disadvantages. When engaged in external cognition, the intellect possesses the advantage of having something concrete it can grasp. The disadvantage is, of course, that what it grasps are sensory images, which, due to the distortions of internal and external media, cannot lead it to true comprehension.[31] By contrast, when engaged in internal cognition, Sanchez claims that "the understanding finds nothing which it can grasp, and dashes this way and that, groping like a blind man to find if it can lay hold of anything; and no more than this."[32] In this respect, Sanchez considers the outward activity of the understanding far superior to its capacity to grasp internal ideas. However, internal cognition gives us the advantage of certainty, for we are more secure in our knowledge of internal objects, such as our own will and inclination: "We are certain about the real existence of those things that either exist, or else originate, within ourselves."[33] This is a rather surprising claim, given that Sanchez previously wrote: "And indeed to contemplate the soul, its faculties, and its actions, is indeed very difficult and full of perplexity; as difficult as any study that there is."[34] In keeping with his earlier characterization of perfect knowledge as knowing how to construct something, he goes on to say that only God, the creator of the soul, can understand it, "for no one can perfectly understand the things he has not created."[35] But here Sanchez is talking about scientific knowledge of the soul, whereas by 'internal cognition' he means direct introspection of one's own mental states.

[30] *QNS*, p. 243. [31] *QNS*, pp. 241–243. [32] *QNS*, p. 243. [33] *QNS*, p. 244.
[34] *QNS*, p. 239. [35] Ibid.

This brings us to the root of the problem with internal cognition. While there can be no doubt that I am seeing red while I see red, that I want a drink of water when I crave it, and that I am thinking about Sanchez's arguments as I reflect on them, these certainties do not advance my scientific knowledge of causes one bit. These direct introspections have the distinct advantage of not being subject to any of the distorting media that plague external cognition, thus fulfilling Sanchez's characterization of apprehension as an unanalyzable "intellectual grasp, penetrating vision, or intuition."[36] However, Sanchez does not see the value of these certainties for the advancement of scientific knowledge, since they tell us nothing about external objects. To update his example: for the purposes of science, knowledge gained by means of the senses is still the most trustworthy, for it is far more certain that the computer screen I type on is white, than that it is made up of four elements and a substantial form or atoms in motion. Sanchez thus acknowledges that, as flawed as it is, sensory knowledge is the best we can hope for, and so I suspect that his intended treatise on scientific method would have been empirical in its orientation.

By undercutting the very foundation of traditional means for arriving at the principles of nature, namely sensory knowledge, Sanchez does away with material substantial forms and any other empirically derived principles of nature in one fell swoop. Given that the observable phenomenon of change is the standard starting point in natural philosophy, existing anti-Aristotelian principles of alchemical, naturalist, Neoplatonist, and Stoic persuasions fare no better than the substantial form in this regard. In short, the Renaissance technique of marshalling other ancient authorities and principles to challenge Aristotelian philosophy is undermined by Sanchez's global skepticism. All philosophical authorities and principles fall alike in the face of his arguments. Even if we could come up with principles that did not rely on any empirical evidence at all, they would be useless in science, according to Sanchez, since they would take the form of direct introspections. Sanchez's skepticism even extends to mathematics, and so his admission that we can be certain about the internal objects directly apprehended by the intellect does not provide him with anything that could constitute a foundation for scientific knowledge.[37] Hence, he

[36] *QNS*, p. 240.

[37] According to the editors of the recent English edition of *That Nothing Is Known*, Sanchez's view of mathematics paralleled that of Juan Luis Vives. While Vives acknowledged the certainty of mathematical proofs, he took their application to be limited to mixed mathematical sciences like optics, perspective, architecture, music, and dynamics. As discussed in the next chapter, this was

must embrace the skeptical conclusion that nothing is known. As I will argue in Part III, Descartes' way around these kinds of skeptical worries consists in the realization that our internal, purely intellectual cognition can be enlarged to include not just our direct introspections, but the principles and objects of mathematics as well. Provided he can bridge the considerable gap between mathematical truths residing in the mind and the true essences of nature, Descartes can overcome Sanchez's skepticism about scientific knowledge. In the next chapter we will see how the revival of Aristotelian mechanics initially seemed to provide a promising way to bridge this gap. The new science of mechanics also provided the conceptual means for a viable alternative to replace the role that the Aristotelian forms that Sanchez rails against played in scientific explanations.

a common view at the time. Despite the certainty of its proofs, Vives also claimed that mathematical principles were always open to challenge since they were based on conjecture. *QNS*, "Introduction," p. 34.

CHAPTER 5

The mechanical alternative to substantial forms

The arguments discussed in the previous chapter illustrate the intense dissatisfaction among practical men of science, like Sanchez, with the foundations of Aristotelian scientific explanations, as well as the impotence of Suarez's empirical defense of the substantial form in the face of global skepticism. However, since Sanchez provides no positive solution, only negative skeptical arguments, it is not surprising that, in the absence of better alternatives, Aristotelian scientific explanations prevailed. Still, the parallel Sanchez draws between the difficulty of discovering the clock's underlying mechanisms from the motions of the decorative clock-face, and the difficulty of uncovering the causes behind sensible natural phenomena, suggests a way out. If the universe were just like the clock, we could come to explain natural phenomena by positing their underlying mechanisms. Indeed, Descartes highlights the irrelevance of substantial forms when explaining the actions of mechanical devices in the second argument against substantial forms he proposes to Regius: "All the reasons for proving substantial forms could be applied to the form of a watch, which nevertheless, no one calls substantial."[1] In the second thesis he justifies the replacement of substantial forms by the kinds of principles appealed to in the case of a watch by denying the distinction between natural and mechanical phenomena. Automata, he insists, are also works of nature. When building them we simply apply active things to passive things as we do when we sow grain or breed a mule. The difference between machines and natural objects is simply one of degree for Descartes, despite the gulf that Voetius highlights between the few wheels of a watch and the countless parts of even the meanest animal.[2]

The view that machines are works of nature differing from other natural objects only by degree of complexity allows Descartes to maintain the superiority of his 'clear' explanations from observable effects to the

[1] Third Thesis, AT III, p. 505. [2] AT III, p. 504.

insensible parts of matter over the Scholastic inference from 'obscure' things to 'even obscurer' substantial forms. As he puts it in *The Principles of Philosophy*, Part IV, article 203:

> Those who are experienced in examining automata, since they know the use of a certain machine and observe some of its parts, easily conclude from them in what way the others, which they do not see, were made. Thus I have tried, from the sensible effects and parts of natural bodies, to discover what are their causes and insensible particles.[3]

In other words, since nature is just a more complex machine, the same procedures that apply in mechanical demonstrations apply to natural phenomena. But what justifies Descartes' claim that machines are just works of nature? And what forms did scientific explanations of machines take at this time? Works on Aristotelian mechanics, which were known to Descartes via the Mersenne Circle, provide some answers. In examining this background to Descartes' rejection of substantial forms, I will also propose that Aristotelian mechanics posed a far more serious challenge to material forms and their role in scientific explanation than Sanchez's skeptical challenge, for they suggested a positive alternative to the scientific demonstrations found in Aristotelian physics. But first some historical background is in order.

5.1 HISTORICAL POINTS OF CONTACT BETWEEN MECHANICS AND MECHANISM

The Aristotelian *Quaestiones Mechanicae* were first translated into Latin by the humanist Vittore Fausto (1480–1551?) in 1517.[4] Though nineteenth-century philologists denied it was written by Aristotle, and it is still commonly thought to have been written later by someone of his school, it was universally attributed to Aristotle in the sixteenth and seventeenth centuries.[5] This curious little treatise consists in a grab bag of thirty-five questions

[3] AT VIIIA, p. 326.

[4] Paul Lawrence Rose and Stillman Drake were the first to trace the reception of this work in Renaissance Europe in "The Pseudo-Aristotelian Questions of Mechanics in Renaissance Culture," *Studies in the Renaissance* 18 (1971), pp. 65–104, esp. p. 72. On the reception of ancient mechanics see also W. R. Laird, "Archimedes Among the Humanists," *Isis* 82 (1991), pp. 629–638, and "The Scope of Renaissance Mechanics," *Osiris*, 2nd series, 2 (1986), pp. 43–68.

[5] Interestingly, Peter McLaughlin has recently made a compelling argument that based on the available evidence, Aristotle's authorship should not have been ruled out. "The Question of the Authenticity of the *Mechanical Problems*," Introduction to Panel on "The Problematical History of Aristotle's 'Mechanical Problems,'" History of Science Society Annual Meeting, November 2, 2007, Arlington, VA.

ranging from explanations of simple mechanical devices such as the balance, lever, pulley, and wedge to the application of these devices in such diverse professions as seafaring and dentistry.[6] The unifying thread of these seemingly diverse questions is the marvelous properties of the circle, which is said to be "the original cause of all such phenomena."[7] The subject matter of mechanics is said to include, on the one hand, perplexing phenomena which occur according to nature but from hidden causes and, on the other hand, effects that are contrary to nature but for the benefit of humans. The mechanical art is defined as the skill that helps us overcome our perplexity in order to act against or beyond nature and produce useful results. The following century saw the publication of a series of commentaries on this work, as well as other texts that took up its subject matter in various ways. In these works one finds a form of explanation that, while not in contradiction with Aristotelian physics, nevertheless offers an alternative – one based on geometrical principles rather than the four causes.

Either at first hand or via his intellectual companions, Descartes was familiar with some of the subject matter of Renaissance commentaries on mechanics. He proposed a solution to question 24 of the *Quaestiones Mechanicae*[8] and wrote a short treatise on the five simple machines that were the focus of Renaissance texts on mechanics.[9] It is hard to determine exactly when Descartes would have first come into contact with the standard problems tackled by the *Questiones Mechanicae* commentary tradition. We know that by the time Descartes arrived at La Flèche, mathematics, which previously had only been taught at the university, was being taught there. At first this task fell to novices who were being trained to teach mathematics. But from 1612 onwards, Father Jean François, who had specialist knowledge of mathematics, took over the training of future professors of mathematics, and taught the subject for forty-five minutes a

[6] For example, the author not only explains how the balance works, but applies the principle of the lever derived from this to the following questions: "Why is it that the rudder, being small and at the extreme end of the ship, has such great power that vessels of great burden can be moved by a small tiller and the strength of one man only gently exerted?," and "How is it that doctors extract teeth more easily by applying the additional weight of a tooth-extractor than with the bare hand only?" *Mechanics*, trans. E. S. Forster, in *The Complete Works of Aristotle*, ed. Jonathan Barnes, 2 vols. (Princeton: Princeton University Press, 1984), vol. II, pp. 1304, 1310.

[7] Ibid., p. 1299.

[8] François de Gandt, "Les mécaniques attribuées à Aristote et le renouveau de la science des machines au XVIe siècle," *Les Études Philosophiques* (1986), p. 394.

[9] In his letter to Descartes of 1637, Huygens asks Descartes for a gift of three pages on the "foundations of mechanics" and the four or five machines demonstrated from them (among which he counts the balance, lever, and pulley). AT I, pp. 396–399. Descartes obliges Huygens on October 5, 1637, by sending him a brief account of the pulley, inclined plane, wedge, paddle-wheel (*roué*) or potter's wheel (*tour*), screw, and lever. AT I, pp. 431–447.

day.[10] Rodis-Lewis speculates that Descartes must have been one of those gifted students to whom François offered supplementary lessons, as part of the training for future professors of mathematics.[11] She bases this on the degree of mathematical knowledge he exhibited to Beeckman, which indicated he had studied Clavius, as well as on Descartes' own comments about his mathematical ability in the *Discourse*.[12] Whether or not Descartes was among this group, we can be sure that the mathematics he was taught would have been practical in its orientation. It would certainly have included some of the mixed mathematical sciences, such as mechanics and astronomy. This is clear both from the poem written by a student at La Flèche in the year 1610–1611, celebrating Galileo's discovery of the moons of Jupiter, and Descartes' comment in the *Discourse* that "above all I delighted in mathematics, because of the certainty and self-evidence of its reasonings. But I did not yet perceive its real use; and since I thought it was of service only in the mechanical arts, I was surprised that nothing more exalted had been built on such firm and solid foundations."[13]

Little is known about Descartes' time in the army shortly after he received his degree in law in Poitiers in 1616. Scholars have trouble even establishing his whereabouts, let alone what he was reading or discussing.[14] Descartes chose to join the army of Mauritz of Nassau, the Prince of Orange, who, as a mathematician and expert in military arts and fortification, surrounded himself with scholars like Simon Stevin and J. d'Alleaume.[15] But then the Prince was also an accomplished politician and outstanding warrior, so these would have been equally good reasons for the young Descartes to enter into his service.[16] Nor is there any evidence that Descartes established a relationship with the mathematicians

[10] Geneviève Rodis-Lewis, *Descartes: His Life and Thought*, trans. Jane Marie Todd (Ithaca: Cornell University Press, 1998), p. 9.

[11] Ibid., p. 15. [12] Ibid., pp. 9, 15.

[13] Camille de Rochemonteix, *Un collège de jésuites aux XVIIe et XVIIIe siècles: le Collège de Henri IV de la Flèche* (Le Mans: Leguicheux, 1889), vol. 1, pp. 147–148. He thinks this sonnet was composed by Descartes. *Discourse*, CSM 1, p. 114; AT VI, p. 7.

[14] Rodis-Lewis, *Descartes: His Life and Thought*, pp. 24–48. [15] Ibid., p. 24.

[16] William Shea writes: "Many young Frenchmen were to be found at the University of Leyden or in the ranks of one of the two French regiments of Maurice of Nassau, who, in his own eyes as well as those of his contemporaries, was the greatest general of his age." Shea's source is Adams, who cites Guez de Balzac. Shea also cites a letter from Balzac to his brother which indicates that Descartes was not the only Frenchman to become an enthusiastic mathematician after a sojourn in Holland: "To avoid these great talkers, I would jump into a coach, take to the sea, flee to the end of the world … They make me sick when they have just returned from Holland or when they start to study mathematics." William Shea, *The Magic of Numbers and Motion: The Scientific Career of René Descartes* (Canton, MA: Watson Publishing International, 1991), pp. 8–9.

in Mauritz's circle during this time.[17] However, in 1618 he formed a close friendship with the Dutch physicist, Isaac Beeckman, whose *Journal* indicates a familiarity with and interest in a wide range of mechanical problems and their solutions.

The first point in time at which we have direct evidence of Descartes' engagement with the subject matter of the *Questiones Mechanicae* is during his sojourns in France from roughly 1620 to 1623 and again from roughly 1623 to 1628.[18] According to Baillet, Descartes initially stayed with Le Vasseur in Paris (who apparently liked to receive scientists) before leaving his home to escape the social obligations that this arrangement implied. An agreement he signed with his brother puts Descartes in Rennes in 1622; however, he returned to Paris sometime after his trip to Italy in 1623, and had the famous meeting with Cardinal Bérulle before departing for the Netherlands in late 1628. Rodis-Lewis thinks that this meeting, which Descartes recalls later in a letter to Villebressieu without giving a date, is likely to have occurred in November 1627.[19] However, she finds it highly unlikely that Bérulle encouraged Descartes to develop mechanics and medicine, as Adrien Baillet claimed in his biography.[20]

Whatever the contents of Descartes' exchange with Bérulle, it is clear that Descartes formed several lasting friendships during his stay in Paris that would have ensured his familiarity with the mechanical tradition. Among Descartes' circle of friends during this period was the engineer Villebressieu. The letters they continued to exchange well after Descartes had left France bear testimony to Descartes' interest in and respect for Villebressieu's mechanical ingenuity.[21] In a letter he sent him from Amsterdam in the summer of 1631, Descartes, while critical of his alchemical leanings, attributes to Villebressieu some general principles of

[17] Rodis-Lewis points out that they were not even in the same town at the time. *Descartes: His Life and Thought*, p. 24.

[18] While Isaac Beeckman was certainly familiar with the content of the *Quaestiones Mechanicae*, it is not clear that any of these specific problems were topics of discussion between him and Descartes. Rather, Beeckman's journal, and the correspondence between the two men, indicate that Beeckman mainly posed mathematical problems and problems in hydrostatics, taken from Simon Stevin, to Descartes.

[19] Descartes refers to this meeting in a letter to Villebressieu, sent from Amsterdam in summer 1631, parts of which were excerpted and other parts of which were summarized by Baillet. AT 1, p. 213; CSMK, p. 32.

[20] Rodis-Lewis, *Descartes: His Life and Thought*, pp. 56–57.

[21] In his summary of part of the letter to Villebressieu of summer 1631, Baillet lists several inventions that Villebressieu made, and reports that Descartes praised him in particular for a machine for lifting great quantities of water with great ease, and for a wheel chair, which he urged his friend to make available to the public since it would be particularly helpful to wounded soldiers. AT 1, p. 214.

nature (*generalitez de la nature*) which, Descartes concludes, "square[s] greatly with my manner of philosophizing and agrees marvelously with all the mechanical experiences that I have made of nature on this subject."[22] While Descartes does not spell out what observations and experiments he has made, there are other clues that the term 'mechanical' in Descartes' phrase should be read to include the traditional subject matter of Aristotelian mechanics.

Some clues are found in the work of Claude Mydorge, another faithful correspondent whom Descartes also befriended during this period. According to Baillet, next to Marin Mersenne, Mydorge was the person Descartes saw most regularly while he lived in Paris from 1627 to 1628.[23] Baillet furthermore reports that Mydorge helped Descartes get glasses cut for his research in optics, presumably by securing the services of Ferrier.[24] In addition to optics, Mydorge's interest and expertise encompassed the other branches of mathematics, as is clear from his commentary on the *Examen du Livre des Recreations Mathematiques et de ses Problemes en Geometrie, Mecanique, Optique, & Catoptrique*.[25] In 1639 Mydorge published this collection of mathematical diversions (*recreations mathematiques*) and added several physical experiments (*experiences Physiques*) as well as comments that he claimed were intended only for his friends.[26] The contents of the work include arithmetical, geometrical, mechanical, and optical problems (including perspectives) as well as problems pertaining to music and cosmography.

It is safe to assume that the mechanical devices Mydorge discusses in the *Examen* would have been among the topics he discussed with Descartes during their meetings. The mutual influence between the two men is evident from at least two of the problems in Mydorge's *Examen*, one of which deals with a mechanical device that Descartes used as an example in his work. First, Mydorge's commentary on Problem 38, which

[22] AT 1, p. 217.

[23] Mydorge and Descartes' collaboration led to their discovery of the law of refraction in 1626/1627. John A. Schuster, "'Waterworld': Descartes' Vortical Celestial Mechanics," in *The Science of Nature in the Seventeenth Century: Patterns of Natural Change in Early Modern Natural Philosophy*, ed. Peter R. Anstey and John A. Schuster, Studies in the History and Philosophy of Science 19 (Dordrecht: Springer, 2005), p. 66.

[24] Adrien Baillet, *The Life of Monsieur Descartes*, trans. S. R. (London: R. Simpson, 1693), p. 63.

[25] This work was originally published by Jean Lereuchon under the pseudonym H. van Etten in 1624. *Dictionary of Scientific Biography*, ed. Charles Coulton Gillispie (New York: Charles Scribner's Sons, 1976), vol. IX, p. 599.

[26] Jean Lereuchon, *Examen du livre des recreations mathematiques et de ses problemes en geometrie, mecanique, optique, & catoptrique, Où sont aussi discutees & restablies plusieurs experiences physiques y proposees. Par Claude Mydorge* (Rouen: Chez Charles Osmont, 1639).

explains how one makes water in a glass boil without fire, concludes with the following:

> Having reduced these matters to the truth of the appearance, as regards the present, we leave it to those who are more curious to research the true causes. And we wait to bring to light some day, with the help of God and by means of more leisure, what we have examined and resolved about it in our physicomathematical disquisitions.[27]

The first known appearance of the term "physico-mathematics" appears in Beeckman's *Journal* shortly after his first meeting with Descartes in 1618. Clearly Descartes is sharing with Mydroge the content of some of his conversations with Beeckman. Furthermore, Descartes draws on specific examples found in the Problems that Mydorge comments on in the *Examen*. Most notably, Problem 39 explains the mechanism behind a trick vase that immediately empties itself when one fills it with liquid to a certain height.[28] Descartes uses this example in the *Rules for the Direction of the Mind* to illustrate the importance of separating what is peripheral to a given problem from what is essential to solving it.[29] It is therefore reasonable to conclude that many of the other mechanical problems discussed by Mydorge in this work were also known to Descartes as early as the 1620s, and one can easily imagine Descartes as one of the friends participating in the discussions of these problems alluded to in the prefatory remarks to Mydorge's *Examen.*

The interest in 'physicomathematical' explanations of curious mechanical devices and diversions which Mydorge and Descartes shared at this time put Descartes in direct contact with the Aristotelian tradition in mechanics. At least three of the problems in Mydorge's work are directly inspired by the *Quaestiones Mechanicae.* Problem 54 concerns a balance that allows merchants to cheat, and the example is attributed directly to Aristotle's mechanical questions.[30] Problem 3 is identical to Question 19 of the *Quaestiones Mechanicae* and the explanation is acknowledged as

[27] Ibid., Part I, p. 75. [28] Ibid., Part I, pp. 75–77.

[29] "Again, the question may concern the way in which a certain vessel is constructed, such as a bowl we once saw, which had a column in the centre of it, on top of which was a figure of Tantalus looking as if he was longing to have a drink: water which was poured into the bowl remained within it, as long as the level was below Tantalus' mouth; but as soon as the water reached the unfortunate man's lips, it all ran out. At first glance it might seem that the artistry here lay entirely in the construction of the figure of Tantalus, when in fact, that is merely a coincidental feature and by no means a factor that defines the problem. The whole difficulty is this: how must the bowl be constructed if it lets out all the water as soon as, but not before, it reaches a certain height?" CSM 1, p. 55; AT X, pp. 435–436.

[30] Aristotle, *Mechanics*, p. 1302, 850a1–2.

Aristotle's.[31] Problem 4 is a variation on Question 14 and, once again, the explanation is attributed to Aristotle's mechanics.[32]

Even in the unlikely event that Mydorge and Descartes did not discuss the particular problems that derived from the *Quaestions Mechanicae,* Descartes would have certainly learned of them through his closest friend and correspondent, Marin Mersenne. Peter Dear has shown that Mersenne was heavily influenced by the Aristotelian *Mechanica*, drawing on its principles when proving the existence of God in the *Quaestiones in Genesim* of 1623 and incorporating its dynamical explanation of the balance in other works. In fact, Mersenne devotes no fewer than ten columns to a Proof from Mechanics.[33] During the course of this proof Mersenne cites several of the Aristotelian commentators. For instance, he responds to Bernardino Baldi's criticisms of the Aristotelian mechanical explanations and refers to the laws of Archimedes, Guidobaldo dal Monte, and Josephus Blancanus.[34] In addition, he offers proofs from geometry, the inferior sciences, all the arts, optics, gnomonics, architecture and the nautical art.[35] In his proof from seafaring, Mersenne cites Francesco Maurolico, who also wrote a commentary on the *Quaestiones Mechanicae*.[36] So we know that Mersenne was studying the later commentators on the *Quaestiones Mechanicae* as early as the 1620s. Since Descartes was in Paris during the time that Mersenne published the *Quaestiones in Genesim*, and remained a part of Mersenne's circle of correspondents after this, it is safe to assume that Descartes would have been familiar with the content of these commentaries through his discussions with Mersenne, if not by a first-hand reading.[37] In later works Mersenne specifically addressed some

[31] Ibid., p. 1309, 853b14–18.

[32] The original question is, "Why is it that a piece of wood of the same size is more easily broken against the knee, if one breaks it holding the ends at equal distance from the knee than if it is held close to the knee?" *Mechanics*, p. 1307, 852b21–23. Mydorge considers the example of a stick whose extreme ends are placed on two glasses that are two or three feet apart, and which is broken in the middle without breaking the glasses. He then also discusses the example of kitchen servants breaking a bone that is resting on their knees in the same way, without damaging their knees. *Examen*, Part 1, pp. 17–20.

[33] Marin Mersenne, *Quaestiones Celeberrimae in Genesim cum accurata textus explicatione* (Paris: Sumptibus Sebastiani Cramoisy, 1623), Ratio XX, cols. 83–92.

[34] Peter Dear, *Mersenne and the Learning of the Schools* (Ithaca: Cornell University Press, 1988), pp. 119–120.

[35] Mersenne, *Quaestiones… in Genesim*, a. 2, Ratio XVII, cols. 55–76; Ratio XXII, cols. 91–96; Ratio XXVI, cols. 109–114; Ratio XXXIII, cols. 159–190; Ratio XXXIV, cols. 189–202; Ratio XXXV, cols. 201–216; Ratio XXXVI, cols. 217–226.

[36] Ibid., a. 2, Ratio XXXVI, col. 220.

[37] Regarding Mersenne's strong influence on Descartes during this period, see John A. Schuster, "Descartes and the Scientific Revolution 1618–1634: an interpretation," 2 vols. (unpublished PhD thesis, Princeton University, 1977), pp. 56–57.

of the Aristotelian mechanical questions and referred to the later commentators. For example, in his *Questions Theologiques, Physiques, Morales et Mathematiques* of 1634 Mersenne cites Question 30 of Aristotle's mechanics in addressing the question "What is the line of direction which serves mechanics?"[38] In the very next question, dealing with the balance, he refers once again to Aristotle's *Quaestiones Mechanicae* and names the four most recent commentators: Baldi, Blancanus, Monantholius, and Guevara.[39]

In short, unlike the highly probable status of Suarez's direct or indirect influence on Descartes, and the likelihood that he at least knew of Sanchez's skepticism, we can state with certainty that Descartes engaged extensively with Aristotelian mechanics during his years in Paris, if not sooner. However, as both Alan Gabbey and Dan Garber have highlighted, the direct points of contact between the contents of Aristotelian mechanics and Descartes' mechanistic physics turn out to be rather superficial.[40] I will argue that, nonetheless, indirectly, the *Mechanica* commentary tradition played an important role in shaping Descartes' mechanistic alternative to both Aristotelianism and skepticism. In this sense, the rise of Aristotelian mechanics did more to hasten the demise of the substantial form than previous developments. For certain developments within Aristotelian mechanics provided Descartes with conceptual resources for the eventual replacement of the substantial form, with the more secure mathematical principles of mechanics. In this chapter, I trace three key developments: the elevation of mechanics from an art to a science, the gradual identification of the object of mechanics and the object of physics, and the transference of mathematical forms of demonstration to the physical realm.

5.2 THE ELEVATION OF MECHANICS FROM "ARS" TO "SCIENTIA"

The rediscovery of the Aristotelian *Quaestiones Mechanicae* in the Renaissance prompted the promotion of mechanics from an art to a theoretical science. As a newly founded science, it came to occupy a pivotal

[38] Mersenne, *Questions Theologiques*, p. 237.

[39] Dear, *Mersenne and the Learning of the Schools*, p. 126. *Questions Theologiques*, p. 241.

[40] Alan Gabbey, "Descartes' Physics and Descartes' Mechanics: Chicken and Egg?," in *Essays on the Philosophy and Science of Descartes*, ed. Stephen Voss (Oxford: Oxford University Press, 1993), pp. 311–323; Daniel Garber, "Descartes, Mechanics, and the Mechanical Philosophy," *Midwest Studies in Philosophy*, vol. XXVI: *Renaissance and Early Modern Philosophy*, ed. Peter A. French and Howard K. Wettstein (Boston, MA: Blackwell Publishing Inc., 2002), p. 190.

position, straddling mathematics and natural philosophy. The dual nature of mechanics is already highlighted in the Aristotelian text when the author comments that the mechanical questions "have something in common with both Mathematical and with Natural Speculations; for while Mathematics demonstrates *how* phenomena come to pass, Natural Science demonstrates *in what medium* they occur."[41] Despite this suggestive observation, the author is clear that mechanics, as the skill that helps us overcome the difficulty and ensuing perplexity inherent in acting against nature, is an art.

In his *Opuscula*, which contains the first rather brief commentary on the *Quaestiones Mechanicae* published in 1525, Niccolò Leonico Tomeo (1456–1531) closely follows the Aristotelian text in classifying mechanics as an art. It is an art because it accomplishes things that are contrary to nature for the sake of the utility of men. Unlike nature, which is simple and uniform, mechanics, by overcoming nature, can produce many different works that are useful to us, such as lifting stones, erecting foundations, and lifting beams and trunks to the roofs of buildings.[42] However, in discussing its mode of explanation Leonico follows the Aristotelian text, relating mechanical demonstration to natural philosophy, on the one hand, since machines are made of matter which is natural, and to mathematics, on the other hand, because the explanations given as to how these machines work abstract from the matter.

> In this place, the philosopher said that the mechanical questions were common to the contemplation of mathematics and of natural [things], [for] around this underlying natural matter indeed, all things are certainly made. They talk about iron levers (for example) and wooden or brass spheres: about heights and balances and things of this sort, which exist naturally without controversy, and have physical matter. Regarding the mode or force of working, they turn away to mathematical matters. They investigate circles, diameters and circumferences: and even the weights and measures that are granted to exist in natural matter, certainly seem to abstract from it and not undeservedly seem to lead them away from it, and to display and represent only the reasons of the forms.[43]

While mechanics is still an art for Leonico Tomeo, he situates its mode of demonstration squarely under mathematics since mechanics abstracts from the nature of the matter.

[41] Aristotle, *Mechanics*, p. 1299.
[42] Niccolò Leonico Tomeo, *Opuscula Nuper in Lucem Aedita* (Venice: Bernardinus Vitalis Venetus, 1525), p. xiii.
[43] Ibid., p. xiv.

By the middle of the sixteenth century the *Quaestiones Mechanicae* had been popularized as a result of the publication of Alessandro Piccolomini's (1508–1579) Latin paraphrase in Rome in 1547. Piccolomini's classification of mechanics reveals a significant departure from Leonico Tomeo's, which closely followed the Aristotelian text in its classification of mechanics as an art. Piccolomini instead classifies mechanics, not as an art, but as a mixed mathematical science subordinated to geometry:

> But one or the other of these [two] parts of mathematics [arithmetic and geometry] comprehends in return the other parts: not, however the sellularian arts (though some want to, they do not rightly set them under the tenth book of Euclid, in which book magnitude is to be had potentially), but indeed Arithmetic recommends [*vendicat*] Music to itself, and Geometry truly Stereometry, Perspectives, Cosmography, Astronomy, and Mechanics. But nevertheless all of these, even if they cannot be called pure or genuine [*syncerae*] mathematics, since they regard matter in a certain mode, it is still most convenient [to call them] Mathematical, rather than natural, which Aristotle himself declares of Astronomy in the divine [matters], moreover, [he declares it of] music and Perspective, in the second book on natural Principles.[44]

In order to classify mechanics as a science on a par with the other mixed mathematical sciences, Piccolomini distinguishes mechanics from arts and crafts, like weaving, hunting, and cooking, which were traditionally labeled 'mechanical,' and renames the latter the "sellularian arts." He then locates the mixed mathematical sciences under mathematics rather than natural philosophy, even though they share in both.

Piccolomini offers a justification for this reclassification that is independent of Aristotle's authority.

> This is true, nonetheless, even if his declaration or his authority were not present, since what is studied by means of the instrument of mathematics, ought to be called mathematical. For in this manner, wherever the proposition follows a certain word of a subject, it is fitting that it be named from the same diction. Thus by its mode and force of demonstrating, any science whatsoever will be rightly named. Indeed when we say that a man is generated, or becomes white, we will audaciously pronounce propositions of this kind to be natural because just as a generation indicates a motion so [does] an eduction of white … By the same stipulation, in asserting that man could be divided *ad infinitum* we would construct a mathematical proposition. Wherefore even sciences from those which are intermediate in demonstrations ought to be called [mathematical]. Since therefore, Perspectives, Astronomy, Music and the faculties of such kinds

[44] Alessandro Piccolomini, *In mechanicas quaestiones Aristotelis: Paraphrasis paulo quidem plenior* (Venice, 1565), A4–A4v.

are studied by the mathematical instrument and (as I thus say) are intermediate, it is no wonder if they are rightly called mathematical.[45]

In other words, sciences are to be classified according to the instruments and forms of demonstration they employ, not according to their subject matter or ends. This is in itself an interesting departure from medieval Aristotelianism, which, following Aristotle's procedure at the beginning of the *Nicomachean Ethics*, situated sciences within the hierarchy of knowledge according to their goals, and subordinated the method of each discipline to its purpose or final cause.

Towards the end of his Preface, Piccolomini articulates the relationship of mechanics to the sellularian arts. Mechanics is a science that provides the causes and principles for the many sellularian arts. However, these arts are not rightly called mechanical, but rather should be called "banausicae" (following the Greek) or 'humble'. Piccolomini includes the production of machines, both domestic and military, under these arts, and remarks that, insofar as mechanical principles are used to think up these machines, they may be called mechanical. He concludes:

> But since the mechanical faculties, however much touching on matter or motion, as for instance heavy and light things, quickness and slowness, are nevertheless studied by the mathematical way or mode, for this reason it must be judged that they are to be numbered among the mathematical. For although the mechanical instruments, or the very mechanisms themselves, are thought out towards some work, the Mechanic [*Mechanicus*], though a craftsman, for this reason he is a mechanic, which [is]: simply considering their causes and principles, he rests and stands in contemplation itself.[46]

Piccolomini in effect elevates mechanics from an art to a science, by arguing that it is the contemplation of the causes and principles behind machines that is properly called mechanics. The use of these machines to produce useful effects is distinguished from the theory on which they are based, and this practical aspect is classified separately under the sellularian or humble arts. This stands in sharp contrast to the classification Hugh of St. Victor gives in the *Didascalicon*, composed in the late 1120s. The latter distinguishes knowledge from understanding (which includes theoretical and practical philosophy) and calls knowledge "mechanical" or "adulterate" because "it pursues merely human ends."[47] The belief that Aristotle himself wrote the *Quaestiones Mechanicae* no doubt contributed

[45] Ibid., A4v–A5. [46] Ibid., A5v.

[47] Hugh of St. Victor, *The* Didascalicon *of Hugh of St Victor: A Medieval Guide to the Arts*, trans. Jerome Taylor (New York: Columbia University Press, 1961), Bk. I, ch. 8, p. 55.

to the reclassification of mechanical knowledge under the theoretical disciplines in the Renaissance. In fact, Piccolomini devotes part of his preface to presenting the philological evidence supporting his conclusion that this work is indeed by Aristotle.[48] However, as we saw, Piccolomini also offers evidence that is independent of Aristotle's authority for his reclassification. His argument effectively shifts the criteria for classification, since he considers the method of demonstration employed by a science more definitive of its proper place in the hierarchy of knowledge than its subject matter or purpose. In later commentaries on the *Quaestiones Mechanicae*, Piccolomini's classification of mechanics as a mixed mathematical science is often repeated or taken as given.

Later commentaries on the Aristotelian mechanical questions were often preceded by lengthy prefaces (sometimes accompanied by classificatory diagrams) in which an elaborate case was made for the new-found status of mechanics as a mathematical science.[49] Oftentimes the arguments one finds in these prefaces are more interesting and original than the actual commentary on the mechanical problems themselves.[50] In this regard, one can certainly sympathize with Sanchez's complaint that practitioners of particular sciences were more concerned to partition their own domain off from others, and defend their discipline against intrusions than to engage in actual science. Nevertheless, against Sanchez, I will argue that debates which appear, at first glance, to consist in trivial turf battles actually raise important philosophical questions regarding both the object of mechanical demonstration and the very nature of the relationship between mathematical and scientific demonstration. As I will show, some of the more original answers that were proposed to these questions made possible the application of mechanical principles to physics. This paved the way for the eventual replacement of substantial forms with mechanisms.

As background to Descartes' use of the nature/machine analogy to eliminate material substantial forms, I will next examine various ways in which three later commentators on the *Quaestiones Mechanicae*, Henri

[48] Piccolomini notes that the manner of expression of the *Quaestiones Mechanicae* is consistent with that found in works of Aristotle where he uses mathematical demonstrations. Piccolomini gives Aristotle's discussion of the rainbow in his Meteorology as an example: *In mechanicas*, A6.

[49] See, e.g., Francesco Maurolyco, *Problemata Mechanica cum appendice, & ad Magnetem, & ad Pixidem Nauticam pertinentia* (Messina: Ex Typographia Petri Breae, 1613), and *Opuscula mathematica* (Venice: Apud Franciscum Franciscium Senensem, 1575).

[50] See, e.g., Ioannis de Guevara, *In Aristotelis Mechanicas Commentarij una cum Additionibus Quibusdam* (Rome: Jacob Mascardus, 1627), and Henrico Monantholio, *Aristotelis Mechanica Graeca, emendate, Latina facta, & Commentariis illustrate* (Paris: Apud Ieremiam Perier, 1599).

de Monantheuil, Giovanni di Guevara, and Josephus Blancanus blur the line between mathematical/mechanical objects and the natural objects of physics. Their views, in turn, facilitated the application of mechanical principles of demonstration to problems of physics. Guevara's and Blancanus's views on the nature of mechanical demonstrations and their implications for the development of a mechanistic physics will be examined in the last section of this chapter.

5.3 OBJECTS OF MECHANICS / OBJECTS OF PHYSICS

As mentioned, the original author of the *Quaestiones Mechanicae* already highlights the dual nature of mechanical explanations, stating that they deal with the subject matter of physics (i.e, physical objects and their motions), but employ mathematical demonstrations. Therefore, it is not surprising that the *Quaestiones Mechanicae* make use of mechanical explanations to answer some questions about natural phenomena. For example, question 15 asks, "Why is it that the so-called pebbles found on beaches are round, though they are originally formed from stones and shells which are elongated in shape?," and question 35 asks, "Why is it that an object which is carried around in whirling water is always eventually carried into the middle?"[51] Interestingly, it is not primarily the balance, lever, or wedge, so prominent in the *Quaestiones Mechanicae* and other texts on mechanics, that later become the models for Descartes' celestial mechanics. Rather his heavenly vortices are modeled after river vortices,[52] and the jagged parts of celestial matter become rounded into globules like the pebbles that have landed on the beach after being tossed around in the sea. There is one artificial device discussed in the *Quaestiones Mechanicae* that figures prominently as a model in Descartes' physics, and that is the sling.[53] The motion of an object projected by a sling is addressed in question 12, which reads, "Why is it that a missile travels further from a sling than from the hand, although he who casts it has more control over the missile in his hand than when he holds the weight suspended?"[54] Of course, the striking resemblance between the analogies Descartes employs in his explanations of heavenly phenomena and specific problems addressed in the *Quaestiones Mechanicae* masks deeper differences between his mechanistic physics and the science of machines.

[51] Tomeo, *Mechanica*, pp. 1307–1308, 1317–1318.
[52] *PP*, Part III, a. 30; AT VIII, p. 96.
[53] For a more detailed treatment of the role these analogies play in Descartes' celestial mechanics, see Schuster, "'Waterworld,'" pp. 35–79.
[54] Tomeo, *Mechanica*, p. 1307.

Nevertheless, Descartes' appeals to slings, screws, and river vortices could not have had any force, explanatory or rhetorical, in a treatise on physics had the sharp Aristotelian distinction between artificial machines and natural physical objects not been undermined by later commentators on the *Quaestiones Mechanicae.* Over time the line between artifice and nature is blurred in different ways by various commentators. In what follows, I will examine the views of three of the later commentators cited by Mersenne and draw out their implications.

One of the most intriguing views is advanced in the commentary on the *Quaestiones Mechanicae* by Descartes' compatriot, Henri de Monantheuil (1536–1606). In his letter of dedication to Henri IV of Navarre, Monantheuil effectively erases the division that persisted, however blurred, between nature, the subject matter of physics, and machines, the subject matter of mechanics. He claims that when Plato was asked what God did, he responded, *ἀεγεμετρείν*. Monantheuil translates this with the Latin expression for 'always being busy measuring the earth,' and then rejects the view that geometry is "ridiculous" and "unworthy of the majesty of God."[55] Instead, Monantheuil hypothesizes that by means of the powers of the same art (geometry) the *ἀεγεμετρείν* (God), "by reason, proportion and similarity, estimates what is to constitute, define, measure out the measurable measure of the accessible universe as great as you will, far and wide, of all bodies in it, of surfaces, and lines."[56] He reasons that an art is as noble as what it is applied to, and concludes from this that, since the divine measurer himself is always engaged in the art of geometry both when he constructs the world and when he balances it by its weights, geometry is to be regarded as a noble enterprise, worthy of God.[57] Monantheuil then makes a surprising but logical leap to the art that borrows its principles from geometry, adding:

> If Plato had added to *ἀεγεμετρείν χαί ἀειμηχανάσθαι*[58] he would have responded much more brilliantly and more in agreement with the divine majesty and magnificence. For who would have fashioned this world *ex nihilo*, brought it to completion with all its numbers, balanced it from all sides with its weights, kept it uniform in longitude, latitude, altitude, and constantly retained, stabilized, conserved it in the same state and perfection, in every appearance and respect other than 'the always busy measuring and always making by art'

[55] Monantholio, *Mechanica Graeca*, dedication, side 2. [56] Ibid. [57] Ibid.

[58] *μηχανάσθαι* is the infinitive of *μηχάνάομαι*, which Liddell and Scott's *Greek–English Lexicon* defines as follows: "make by art, construct, build," in a more general sense "prepare, make ready, and also in a frequently bad sense "contrive, devise, by art or cunning." I have translated it as neutrally as possible with "always making by art." Henry George Liddell and Robert Scott, *A Greek–English Lexicon* (Oxford: Clarendon Press, 1968), p. 1131.

[*ἀειγεωμετρείν χαί ἀειμηχανασθαι*]? For this world is a machine, and indeed of machines, the greatest, most efficient, most firm, most beautiful.[59]

By describing the world itself as a machine, Monantheuil effectively transforms mechanics from a mixed mathematical science, subordinate to geometry and physics, into the key that will unlock the hidden causes of the world's motions. God, the creator of nature, is now not only "the most accurate and incessant Geometer," as Plato recognized, but is also "by the evidence of so many magnificent works, the wisest, best, most powerful mechanic and maker of machines."[60] Furthermore, since he is made in the divine image, man is endowed with the capacity to make machines and instruments by virtue of the mind, which Monantheuil characterizes as the 'art of arts,' and the hand, the 'tool of tools.'[61] Monantheuil even suggests the beginnings of a cosmological argument for the existence of God on this basis:

> Indeed with these great and numerous things which were manifestly in the eyes of all both made and conserved by man … it is most easy [for] whoever has a mind to believe, know, and grasp that this world, certainly the greatest work of works, was made and conserved, even if when it happened he was absent, not however by any man, but by another 'maker of machines' surpassing man by as much excellence, wisdom and power, indeed infinitely, as the amount by which this machine of the world surpasses and is superior to the machines of all men, even of the Archimedeans.[62]

The remainder of the Letter of Dedication consists of the usual flattery of the powerful patron and an enumeration of the many virtues of mechanics when it comes to the things that matter most to such patrons: the affairs of war and peace. But lest we think that Monantheuil's characterization of mechanics as the divine art by which God constructs and maintains the *machina mundi* is a mere rhetorical ploy to win over a king who would be more interested in mechanical inventions than in philosophical principles, we must turn briefly to the definition and classification of mechanics he gives in the commentary itself.

[59] Monantholio, *Mechanica Graeca*, dedication, sides 2–3.

[60] The Greek terms in the text are *μηχανιχός* and *μηχανόποιός*. Monantholio, *Mechanica Graeca*, dedication, sides 4–5.

[61] Ibid., side 5.

[62] Ibid., sides 6–7. This argument is reminiscent of one of Descartes' replies to Caterus' objection to the first cosmological proof. To show that the objective reality of an idea must have a cause that is at least as perfect, Descartes gives the example of the idea of an intricate machine, which can be caused only by the mind of someone who has seen such a machine, or who at least has the requisite knowledge of machines to imagine it. AT II, pp. 75–76.

After discussing the definitions of mechanics found in ancient authors, like Vitruvius and Pliny, and the traditional division of disciplines into the liberal and mechanical arts, Monantheuil, like Piccolomini, distinguishes the 'mechanical' from what the Greeks called, the 'humble' or 'cheap' arts. Following Aristotle, he explains that nothing that aims at some good ought to be deemed 'cheap' in and of itself, but that some arts are considered more prestigious than others, and so was born the division between the seven liberal arts and the vulgar arts of agriculture, hunting, military arts, craftsmanship, surgery, woolworking and seafaring. As Monantheuil explains, even though the works of the latter are more necessary, useful, certain, or excellent (for agriculture produces necessary goods, military victory is useful, craftsmanship is certain and medicine produces the excellence of good health), the liberal arts are the commanding arts that exist in the most successful men. They have the advantage of not requiring the powers of a body, and they hold the reasons behind the arts that produce effects. The serving arts, by contrast, "require youthful powers" and are "learned and exercised by youth and custom."[63] Monantheuil explains the nature of those reasons, which only the commanding arts possess: "The form of all instruments consists in certain shapes, by which some tend to be suited towards a certain use. The reason why such shapes would be the most apt none of the serving [arts] investigates: They have enough if they hold the way of making and using."[64] Like Piccolomini, he considers the Aristotelian treatise on mechanics to contain principles borrowed from geometry that "explain the causes of the powers of instruments pertaining to the above mentioned Mechanical arts."[65] Specifically, the treatise explains how their shapes make the mechanical devices more suited to their uses and accomplishments.[66] In sum, even though mechanics deals with the physical motions of machines, as a science, its primary object is the geometrical property of shape possessed by physical objects, since this explains the mechanical motions.

Monantheuil also goes further than Piccolomini in his reclassification, associating the mixed science of mechanics with philosophy itself. He connects the "admirable art" of mechanics with the wonder that inspires philosophy, stating that we begin by resolving doubts about small things and then work our way up to astronomical phenomena and finally the generation of the universe.[67] He claims that the "philosopher not only admires rare and huge things, as the masses do, but also frequent and

[63] Monantholio, *Mechanica Graeca*, p. 4. [64] Ibid. [65] Ibid. [66] Ibid. [67] Ibid., p. 5.

small things if they have hidden causes."[68] That mechanics is on a par with physics rather than a subordinate science for Monantheuil is clear from what follows. First, Monantheuil takes issue with Aristotle, claiming: "Nature moreover always operates in one way: against Aristotle, it always tends to the utility of man and follows the various modes of operating."[69] Then he takes issue with Leonicus' suggestion that the unnamed general art mentioned in the Aristotelian text in connection with the perplexities generated by mechanical devices is architecture.

> But since the resistance of nature is not only overcome in those things which are subjected to Architecture, [but] truly also in whatever other things [are] subjected to these arts, if there were an art by which [Aristotle] teaches what is in the universe, then it would be far more general than Architecture. And what hinders us from saying that this is Philosophy? Since Philosophy is the cognition of all arts and considers the causes of both divine and human things, properties and effects. And by this division into its parts, one small part among these will be Mechanics, which tends towards the explanation of violent and wondrous motions, on the other hand, Physics [which tends] towards the explanation of natural motions. And under the latter [are] Medicine, Agriculture and others, likewise under the former the art of weaving, Architecture, cobbling and all those which accomplish their work with artificial instruments and activities.[70]

Despite the suggestive comment that nature tends to act in one way, and towards the utility of man, Monantheuil firmly maintains the Aristotelian distinction between violent and natural motions, thus retaining the division between mechanics and physics, *ars* and *scientia*. However, by placing mechanics and physics side by side, as the two primary subdivisions of philosophy, Monantheuil's commentary could suggest to those philosophers (like Descartes) who came to reject the violent/natural motion division that the principles of mechanics and physics are one and the same.

Monantheuil was a student of the anti-Aristotelian philosopher, Pierre de la Ramée (Petrus Ramus), whose educational program did much to reintroduce the ancient mathematical sciences into curricula across Europe, and who was a major influence on Isaac Beeckman's Professor of Mathematics, Rudolph Snel.[71] But Monantheuil is not the only one

[68] Ibid. [69] Ibid., p. 6. [70] Ibid., p. 9.

[71] On Rudolph Snellius' Ramism, see Liesbeth de Wreede, "Willebrord Snellius (1580–1626): A Humanist Reshaping the Mathematical Sciences" (unpublished PhD thesis, University of Leiden, 2007), pp. 40–46. Snellius provided Beeckman with a reading list of mathematical texts at the beginning of his studies, and hence his Ramist focus exerted considerable intellectual influence over the young Beeckman. For the contents of this list, see C. de Waard, *Journal tenu par Isaac Beeckman de 1604 à 1634* (The Hague: Martinus Nijhoff, 1939), vol. IV, pp. 17–18.

to tout mechanics as a divine art. Giovanni di Guevara (a.k.a. Ioannis Guevara), a priest, friend of Galileo, and Arisototelian, writes in the Dedication to Cardinal Franciscus Barberinus found at the beginning of his commentary of 1627:

> Whence, just as the human mind itself reflects the image of divine wisdom and providence so long as it arranges everything correctly, so also the hand of man expresses in a certain fashion the omnipotence of the creator, so long as the so various and remarkable things are brought to completion with mechanical thought as the leader.[72]

Furthermore, Guevara claims that the mechanical arts are revered not only because of their practical results but because "they lead us to another, broader and more divine contemplation, that of the Highest Mechanic of all things."[73]

What follows the typically flowery dedication is a very systematic and comprehensive introduction to mechanics. While still squarely within the Aristotelian tradition, the latest in our series of commentaries anticipates early modern conceptions of mechanics in important respects. After repeating the standard Aristotelian definition of mechanics as the art that acts against nature to accomplish human ends, dealing with things that share in both natural and mathematical questions, but employing a different method from the former, Guevara elaborates in a series of Additions.[74] The first elaborates on the name and origin of the faculty of mechanics in humanist fashion. Like Piccolomini, Guevara distinguishes between the reasoning and manual parts of the mechanical faculty (a distinction he traces back to Hero, cited in Pappus of Alexandria's Eighth Book) and claims that Aristotle, along with all the other philosophers and geometers, takes the mechanical faculty to refer only to "art or science which works with geometrical principles and has to do with the standing and motion of heavy and light things, that is, of heavy and light things inasmuch as they ought to be moved and stand still by artifice."[75] He then claims that this faculty is as old as human nature itself, since our first progenitors "by a certain art inborn or infused in them" used both mechanical instruments and the art of contriving (another sense of the term 'mechanics' identified by Guevara) to ensure their survival.[76] This view is echoed by Descartes when he claims that, in drawing on the laws of Mechanics, he has "certainly not used any principle for this which was not admitted

[72] Guevara, *In Aristotelis Mechanicas,* sides 3–4. All the initial translations of this text were prepared by Jessica Weiss and subsequently underwent minor revisions by me.
[73] Ibid., side 4. [74] Ibid., pp. 5–6. [75] Ibid., p. 7. [76] Ibid., pp. 7–8.

by Aristotle and all the other philosophers of all ages. Therefore, this philosophy is not new, but the oldest and most common of all."[77]

In the second Addition, which deals with the object of the mechanical faculty, Guevara offers a much more all-encompassing definition of mechanics that represents quite an advance over previous ones. He says that we know by induction that all the different mechanisms we employ as part of the mechanical art have the following in common:

> that which we attempt through the mechanical faculty and that end to whose accomplishment the mechanical contemplation is adapted is nothing other than the motion of each heavy or light body or its rest, which is achieved marvelously by small force, for the most part, by this art itself, whether the motion is according to nature, or whether it is in spite of or contrary to the nature of the same heavy or light body.[78]

One thing to note is that even though Guevara still conceives of mechanics as producing results that are contrary to nature, in doing so it may make use of natural motions. Guevara then goes on to characterize mechanics as being primarily concerned with the quantity of weight of the body to be moved, and the quantity of force found in the mover, regardless of whether this force is intrinsic, or applied from outside by impulse or instruments. He concludes:

> In this indeed the mechanical art is located, that when a calculation [*ratione*] is made of the weight or lightness of the body to be moved or detained, proportional force be applied to achieve it, and fitting devices be applied to make up for what is lacking in natural force. This could not be done without consideration of the quantity of each of two things, that is, the weight that is to be moved and the motive force where the whole proportion of the one to the other ought to be found.[79]

Guevara makes it clear that bodies are called 'light' and 'heavy' relative to each other in mechanics:

> For the mechanic does not understand 'heavy' and 'light' simply and according to itself, as for the most part the Physicist understands them (that is, by understanding by 'heavy' that which does not have any lightness in itself, and by 'light' that which does not have any heaviness in itself), but always understands each one with respect to something.[80]

In other words, the mechanic is not concerned with the intrinsic qualities of physical objects but rather with relative properties and relations between them. The innovation of proponents of the new science, like

[77] *PP* Part IV, a. 200; AT VIII, p. 323. [78] Guevara, *In Aristotelis Mechanicas*, p. 9.
[79] Ibid., p. 10. [80] Ibid.

Beeckman, Galileo, and Descartes, was to treat these relations as more basic than the observable properties of bodies and to extend them to natural physical motions. There is no hint that Guevara even considered this possibility. In fact, he maintains that the formal object of mechanics is the artificial or wondrous movement or rest of the heavy and light things.[81] Furthermore, for him, taking the motion itself as the formal object of scientific inquiry still involves abstracting from the natural objects, namely, bodies with real qualities of heaviness and lightness.

Despite his adherence to traditional Aristotelian concepts, by the end of his discussion Guevara has transformed mechanics into something far more basic and universal than the Aristotelian definition with which he begins indicates, for he states:

> Everything, however, that is to be treated in this science, is reduced to moving or holding still some heavy or light body, or to the quantity of force with which it ought to be moved or held still. And therefore, the heavy and light things themselves as such together with the moving or detaining force of them could rightly be called the suitable material subject of the mechanical faculty.[82]

The broadness of Guevara's 'material subject' of mechanics makes it identical to the subject matter of physics. For him, the 'material subject' functions like the genus in a definition and has to be qualified by the 'formal object' which is "the very account [*ratio*] under which its own material subject is to be treated in such a science."[83] In other words, mechanics studies the same material object as physics (i.e., the forces that cause the motion and rest of heavy and light bodies) but under the formal aspect of artificially produced motion. Nevertheless, once the distinction between artificial and natural motions is abandoned, one is left with the 'material subject' of mechanics, which is identical to that of physics.

At the same time that the object of mechanics and physics were being brought closer together, the difference between the objects of geometry and abstract quantity was also under discussion. Josephus Blancanus (a.k.a. Guiseppe Biancani), a Jesuit Professor of Mathematics in Parma, and author of a commentary on the *Quaestiones Mechanicae*, begins his *Treatise on the Nature of Mathematics* of 1615 with a chapter "On the Subject of Geometry and Arithmetic, which is called Intelligible Matter." He assumes from the outset that pure mathematics as well as metaphysics and natural science refer to quantity abstracted from sensible matter. However, the natural scientist and metaphysician consider quantity in an

[81] Ibid., p. 11. [82] Ibid. [83] Ibid.

absolute, unqualified sense, disregarding whether it is delimited or not. Taken this way, the properties of quantity include divisibility, locatability, and figurability, but not mathematical properties such as a particular division, various proportions, and specific relations, such as equality and inequality, or commmensurability and incommensurability, since these do not flow from the intrinsic nature of undelimited quantity. By contrast, the geometer and the arithmetician (practitioners of the two traditional branches of pure mathematics) consider quantity only insofar as it is delimited, since once one adds delimitation, these mathematical properties

> flow from it by emanation. So it is correct to say that the formal aspect (*formalis ratio*) of mathematical consideration is delimitation, and that its total adequate object is delimited quantity, insofar as it is delimited. For from this delimitation there result the various figures and numbers which the mathematician defines and of which he demonstrates various theorems.[84]

This delimited quantity, which is the subject matter of mathematics, is called intelligible matter, and unlike the sensible matter that the natural scientist studies, the intelligible matter is separated from sensible matter by the intellect and "perceived by the intellect alone."[85]

Recent historians of philosophy have failed to realize that Scholastic mathematicians of Descartes' time did not consider the matter of mathematics to be quantity at the most general, abstract level, but rather, as Blancanus makes clear, they took it to have divisions, proportions, and relations. This misunderstanding significantly affects how one reads Descartes. Normally the intelligible matter of mathematics gets confused with pure extension, prompting the inference that Descartes' geometrical objects made real are nothing but pure extension in its most abstract sense.[86] But as Blancanus indicates, Scholastics distinguished not only between sensible and intelligible matter; but also between the intelligible matter of mathematics and the intelligible matter of metaphysics. It is clear that Blancanus simply restates a standard Scholastic distinction, since it is also found in Francisco Toledo's much-used *Physics* commentary, where

[84] Josephus Blancanus, *De Mathematicarum Natura Dissertatio*, Appendix to *Aristotelis Loca Mathematica*, trans. Gyula Klima, in Paolo Mancosu, *Philosophy of Mathematics and Mathematical practice in the Seventeenth Century* (New York: Oxford University Press, 1996), p. 179.

[85] Ibid., pp. 179–180.

[86] E.g., Gary Hatfield writes: "As it was commonly put, mathematics considers the 'intelligible matter' of objects – their pure extension." Gary Hatfield, "First Philosophy and Natural Philosophy in Descartes," in A. J. Holland, ed., *Philosophy*: *Its History and Historiography* (Dordrecht: D. Reidel, 1985), p. 150.

it is attributed to St. Thomas Aquinas.[87] For Blancanus, mathematical objects differ from Aristotelian objects of physics in that they abstract from all sensible matter, but they are less abstract than the abstract quantity of metaphysics in that they consist in delimited, not absolute, quantity. I will argue later on that when Descartes replaces Aristotelian matter with *res extensa* he replaces it with something closer to the intelligible matter of mathematicians rather than with the unqualified abstract quantity of the metaphysician.

Dennis Des Chene, who offers the most historically sensitive analysis of the relationship between Scholastic and Cartesian conceptions of matter, characterizes the intelligible matter of the Scholastics as absolute quantity, which becomes determinate when it receives particular forms, for instance particular geometrical shapes. On the basis of his study of *Physics* commentaries from this period, Des Chene identifies figure as the intelligible form that has to be added to the intelligible matter of quantity in the absolute sense in order to produce a mathematical object.[88] By contrast, according to Blancanus, the form of the intelligible matter is delimitation in general, not any particular figure. This delimitation then results in various figures and numbers. He emphasizes that delimited, not absolute, quantity is what is usually called intelligible matter. Delimited continuous matter is then the intelligible matter of geometry, and delimited discrete matter that of arithmetic. Interestingly, while Blancanus points out that delimited quantity is often equated with finite quantity, they need not be the same. He claims that if there were a delimited quantity that was also infinite, like an infinite triangle, Euclid's demonstrations would apply to it as well. (Given that 'finite' means 'bounded,' the existence of an infinite triangle is incoherent, so perhaps Blancanus is merely claiming that Euclid's demonstrations would apply even to this incoherent entity.) Delimited quantity is thus by no means identical to finite quantity, which leaves open the possibility of an infinite intelligible matter that, unlike metaphysical matter, contains actual rather than merely potential divisions, proportions, and relations.[89]

[87] "By sensible matter [St. Thomas] understands a substance endowed with elementary qualities – heat, cold, wetness, dryness – and composed from them; while by intelligible matter, he understands substance conceived solely by the way of quantity, and which is considered in mathematics; so it is commonly said. But as for intelligible matter, it seems to me that one should say that quantity alone is intelligible matter. Note, however, that the Mathematician has as his object not quantity, but figures and forms, which occur in quantity. For as the ironworker is concerned not with iron but with the form that is made in iron, so too the Geometer [is concerned] not with quantity but with the figures made in it." Toletus, *In Phys.* 1c1q3, *Opera* 4:8vb, cited in Des Chene, *Physiologia*, pp. 116–117.

[88] Des Chene, *Physiologia*, p. 117.

[89] Blancanus *De Mathematicarum*, p. 180.

In sum, the delimited quantity, which defines intelligible matter, differs both from absolute quantity, in that it includes some actual, determinate features, and from particular forms, like shapes and sizes of particular dimensions, in that its features are more general than those which characterize particular mathematical objects. 'Delimited' seems to play a role in the definition of the object of mathematics similar to that played by the specific difference in the definitions of the objects of natural science. For example, just as the differentia 'rational' when added to the genus 'animal' defines all individual members of the species of humans, the differentia 'delimited' when added to 'quantity,' taken without qualification, defines all mathematical objects, falling under both geometry and arithmetic. Just as all humans have rationality, even though they clearly possess it to different degrees, there are some determinate, defining divisions, proportions, and relations common to both particular continuous and discrete quantities, and these constitute the intelligible matter of mathematics.

Blancanus goes on to extol the virtues of the objects resulting from this intelligible matter. Unlike really existing objects, they are perfect, since they abstract from sensible matter: "For example, an abstract triangle is an absolutely plane [figure] constituted by three perfectly straight lines, by three angles, and by three absolutely indivisible points which, I think, could hardly be found in the nature of things (excepting perhaps, celestial things)."[90] To the objection that such perfect objects can exist only in the intellect, Blancanus replies that the lack of perfection in the real instantiations of such mathematical objects is merely accidental, "for it is well known that both nature and art intend to imitate primarily those mathematical figures, although because of the grossness [*ruditatem*] and imperfection of sensible matter, which is incapable of receiving perfect figures, they do not achieve their end."[91] Blancanus goes on to give numerous examples of natural objects that approximate geometrical shapes, such as tree trunks (cylinders), heavenly bodies (spheres), and sea shells (conic spirals). He points out that art instantiates them even more clearly than nature, after which he makes the connection to the divine Artisan. In true Platonic fashion, he equates the perfect mathematical figures with the archetypes of all things, existing both in "the mind of the Author of Nature" and in the human mind, concluding:

> For this reason we should hold that these geometrical entities which are perfect in all respects are *per se* and true beings; whereas natural and artificial figures, which exist in the nature of things, as they are not intended [*per se*] by any

[90] Ibid. [91] Ibid.

efficient cause, are beings *per accidens*, and are imperfect and false. For example, a triangle depicted in a chart is not a true triangle, but the true triangle is that which is in the divine mind. And from these considerations we can easily understand why Plato said that God was doing geometry [*Deum geometrizare*], that is, that just like a true geometer, God contemplates only the perfect ideas of things.[92]

While Blancanus maintains the traditional Aristotelian division between the sensible objects of natural philosophy, and the intelligible objects of mathematics, and separates mathematics from physics on that basis, it must be underscored that he regards the differences between them as accidental, not essential. And though he falls short of claiming that God creates natural mathematical objects he acknowledges that "these entities are [at least] possible; and who would deny that God or an angel could produce them [in reality?] But for an object of science it is enough to be possible, for science abstracts from the existence of the subject."[93]

In conclusion, there are three major ways in which mathematical, mechanical, and natural physical objects begin to morph into one another in the hands of Monantheuil, Guevara, and Blancanus. First, all three of them refer to God as the 'divine geometer,' implying a commitment to the Platonic view that God creates the physical universe according to geometrical principles. Monantheuil and Guevara take the additional step of characterizing God as the 'divine mechanic,' thus explicitly likening the universe to a machine, and identifying the objects of mechanics with the objects of physics. Second, both Monantheuil and Guevara emphasize that mechanics studies mathematical properties of physical machines. For Monantheuil these properties consist in the geometrical shapes that account for the motions of the machine. For Guevara they consist in relative properties and their proportions. While Monantheuil places mechanics, and hence the shapes it studies, under philosophy alongside physics, Guevara maintains the standard Aristotelian view that mechanics, as a mathematical science, studies properties that are abstracted from the sensible objects of physics. However, Blancanus brings the objects of mathematics closer to the sensible objects of physics both by distinguishing the intelligible matter of mathematics from metaphysical abstract quantity and by characterizing natural physical objects as imperfect instantiations of geometrical figures.

In light of this background, Descartes' claim that machines are works of nature that differ from other natural objects only by degree is not so

[92] Ibid., pp. 180–181. [93] Ibid., p. 181.

surprising. It would not take an act of genius for a young mathematician, already filled with enthusiasm for Beeckman's 'physico-mathematics,' to recognize that taking one further step of uniting the already blended object of physics and mechanics with the intelligible matter of mathematics, would bring all the advantages of mathematical demonstrations to bear on physical problems.[94] Moreover, I will argue that, given the certainty of mathematical principles and demonstrations, this step provided a promising answer to challenges to the whole scientific enterprise from skeptics like Sanchez. In the next section, I will examine the ways in which Blancanus and Guevara take mathematical and mechanical demonstrations to yield scientific knowledge that is both causal and certain. I conclude that their theories of demonstration facilitated the later application of such demonstrations to the realm of physics.

5.4 MATHEMATICAL CERTAINTY AND MECHANICAL DEMONSTRATIONS

As covered in section 5.2, on the basis of its geometrical demonstrations, early commentators on the *Quaestiones Mechanicae* argued that mechanics was properly classified among the mixed mathematical sciences. Hence, mechanics took its place in the Aristotelian hierarchy as a subordinate science under geometry, alongside the well-established mathematical sciences of astronomy and optics. As a science, the mode of explanation employed in mechanics had to conform to the logic of scientific demonstration laid out in Aristotle's *Posterior Analytics*. Commentators on the *Quaestiones Mechanicae* tried to meet this requirement in various ways. At the same time, the recovery and translation of Euclid's works prompted a heated debate regarding the nature of mathematical demonstration and its relevance to science. Anna De Pace has traced the various positions and arguments advanced by Renaissance Italian mathematicians on this issue.[95] Since there is no direct evidence that Descartes was reading all or even some of the mathematical texts by Renaissance Italian authors that she covers, I will limit myself to the impact this earlier debate had on the later *Mechanica* commentators known to Descartes. I will first discuss Blancanus' arguments against the view advanced by Piccolomini that mathematical demonstrations were not scientific because they were not

[94] For a comprehensive account of the nature of Beeckman's project, see Klaas Van Berkel, *Isaac Beeckman en de mechaniseering van het wereldbeeld* (Amsterdam: Rodolphi, 1983).

[95] Anna de Pace, *Le Mathematiche e il Mondo* (Milan: FrancoAngeli, 1992).

causal. Then I will examine Guevara's argument for the scientific nature of the mathematical demonstrations employed in mechanics. I will conclude with some observations about the ways in which Aristotelian mechanics facilitated the transference of mathematical demonstrations to the domain of physics.

Proponents of the certainty of mathematics defended it on the grounds that mathematical demonstrations rest on principles that are known with the greatest certainty, namely, common notions (*communes conceptiones*) and definitions of mathematical entities.[96] Blancanus likewise maintains the certainty of mathematics by defending it against the charge that mathematical definitions are merely nominal definitions that explicate the names of things.[97] Rather, he claims that even Aristotle recognized that "geometrical and arithmetical definitions are entirely essential definitions, namely, definitions which explicate the whole nature [*quidditatem*] of the thing, and that they are not in the least only explications of names."[98] Blancanus traces the error of his opponents back to the fact

[96] Catena, f. 6r–v , cited from Nicholas Jardine, "Epistemology of the Sciences," in *The Cambridge History of Renaissance Philosophy*, ed. Charles B. Schmitt and Quentin Skinner (Cambridge: Cambridge University Press, 1988), p. 696.

[97] The distinction between nominal and real/essential definitions goes back to Aristotle: he characterizes the type of definition that came to be labeled the nominal definition as "an account of what its name, or some other name-like account, means – e.g., what triangle means." Aristotle, *Posterior Analytics*, trans. Jonathan Barnes (Oxford University Press, 1994), pp. 58, 93b29–30. He then specifies a second type of definition which consists in "an account which shows why something exists. Hence the former type means something but does not prove it, whereas the latter will clearly be like a demonstration of what something is, differing in arrangement from a demonstration." Ibid., p. 58, 93b38–94a4. Aquinas, in his commentary, transforms Aristotle's distinction into one between the definition of the thing's essence (in the absence of which we give a pseudo-definition of its name) and a definition of the cause or reason why: "In regard to the first he supposes first of all (93b28) that definition is a statement signifying the *quod quid* [essence]. But if no other notion could be had of a thing except the definition, it would be impossible for us to know that some thing is, without knowing the *quid est* of it; because it is impossible for us to know that a thing is except in virtue of some notion of that thing. For in regard to a thing completely unknown to us, we cannot know if it is or not. But we do find some other notion of a thing besides the definition, namely, a notion which explains the signification of a name, or a notion of the very thing named; which notion, however, is distinct from the definition, because it does not signify the *quid est* as does a definition, but perhaps some accident. Thus one might find some notion which explains what the word triangle means … Then (93b38) he lays down another type of definition, saying that another definition of definition is that it is a notion manifesting the *propter quid* [the reason why]." *Commentary on the* Posterior Analytics, *of Aristotle*, trans. F. R. Larcher (Albany, NT: Magi Books, Inc., 1970), pp. 193–194. Aquinas' distinction, which is closer to the later distinction found in Leibniz and Locke, appears to combine Aristotle's formulation with Galen's: "Such a definition is called by some 'substantial,' in contradistinction to other 'nominal' definitions: the latter derive from features incidental to the object under definition, the former from its very substance." *The Art of Medicine* in *Galen: Selected Works*, ed. P. N. Singer (Oxford: Oxford University Press, 1997), p. 345.

[98] Blancanus, *De Mathematicarum*, p. 181.

that geometrical names frequently have "a perfect etymology, when the explication of the name itself is at the same time the essential definition of the thing."[99] For example, the definition of a square is "a plane figure consisting of four [equal] straight lines and four right angles."[100] According to Blancanus, this definition explains both the concept of the thing – by giving its total essence, namely, that it consists of four equal straight lines, and four right angles – and the concept of the name, for it is called a square ("*quadratum*") because of its four lines.[101] Furthermore, in such cases the definition is the cause of, or reason for, both the name and the thing: "Again, when it is said that an equilateral triangle is one having three equal sides, at once you see the cause [*causa*] both of the name and of the thing."[102] For these reasons, Blancanus claims, mathematical definitions, which are both essential and nominal, are often confused with purely nominal definitions.

Blancanus considers definitions that simultaneously explicate the name and essence of the thing to be the highest form of definition:

> for which reason this is the most perfect definition, since it manifests not only the essence of the name, but also the total essence of the thing. For as soon as we learn that a square consists of the said things, the soul does not desire to learn anything more about its essence, but comes to rest, whence it is obvious that this definition is of the best kind.[103]

Note that, though he does not explicitly address them, Blancanus' perfect mathematical definitions provide an alternative to Sanchez's skeptical concerns that standard Scholastic definitions do not refer to anything real in the thing. However, as Blancanus points out, there are plenty of examples in mathematics where only the thing, not the name, is defined: e.g., Euclid's two definitions of a point. The first of Euclid's definitons, which Blancanus characterizes as an absolute definition, is that a point is what has no parts. The other definition is relative, since points are defined as the ends of lines. According to Blancanus, these definitions, while not the most perfect kind, are still certain, since taken together "the whole nature of the point [*punctum*] is made manifest," but they differ from the perfect definition in that they do not explain the name 'point.'[104] "For a point is so named after the act of piercing [*pungendo*], as if it were a sort of puncture [*punctura*], which notion is not even touched upon in Euclid's

[99] Ibid. [100] Ibid., p. 181. [101] Ibid., pp. 181–182. [102] Ibid., pp. 181. [103] Ibid., p. 182. [104] Ibid.

definition."[105] Blancanus gives a variety of other examples from geometry to support his conclusion that mathematical definitions are essential, not merely nominal definitions, and that essential definitions provide us with certainty.

Blancanus then addresses the objection that even if mathematical definitions are essential, they are not causal, and so they cannot form part of a demonstration. He shares his opponent's assumption that, since demonstrations provide us with causal knowledge, they must be based on causal definitions, and cites Aristotle, who in *De Anima* (tex. 12.2) says that squaring has two definitions,

> the one is formal or essential, according to which squaring is the construction of a square which is equal to a given quadrilateral; while the other is causal, according to which quadrature is the finding of the middle [mean] proportional, for the line of the middle [mean] proportional is the cause of the square equal to the given figure.[106]

Blancanus concludes from this that Aristotle himself was committed to the view that mathematical definitions are formal and causal definitions, not just nominal ones, and that for this reason,

> mathematical definitions surpass [in perfection] the definitions of other sciences, for all philosophers concede that the ultimate differences of things, without which there is no true definition, are hidden from us, indeed, so much so that the same philosophers doubt even whether 'rational animal' is the true definition of man.[107]

This quotation echoes Sanchez's skepticism regarding the possibility of certainty in sciences that are built on the shaky foundations of names. Interestingly, Blancanus offers a diagnosis and a possible cure for the prevailing skepticism about sciences which anticipates Descartes' approach:

> In demonstrations from signs [*a signo*] from which other sciences frequently start, only the cognition of the name of the subject is required, but not the essential definition, for its essence, which is hidden, is investigated by its accidents and its properties, from what is posterior [*a posteriori*]; and then, once the essence is detected, we return to the distinct and scientific demonstrations of the properties.[108] However, if the perfect cognition of the object were given in the first place, as is the case with mathematical objects on account of their

[105] Ibid. [106] Ibid., p. 183. [107] Ibid., p. 184.

[108] Blancanus here describes a common form of Aristotelian scientific proof known as the *regressus*. In such a proof one begins with observed effects, and reasons to their possible cause(s). Then, after a mental examination of the cause(s), one deduces the observed effect from the proper cause.

perfect definitions, we would proceed according to the most beautiful order of nature, from the essence of the object to the demonstration of its properties, as it happens in demonstrations from the cause [*a causa*], as are almost all geometrical and arithmetical demonstrations, except for demonstrations from the impossible.[109]

Blancanus thus considers mathematical definitions and demonstrations as the cure for Sanchez's skepticism about our ability to know the true forms and essences of things. However, he does not explain how we are to secure this type of knowledge with respect to the changing, physical objects we perceive by our senses. As we shall see, Descartes' solution is to remake physical objects in order to secure for his scientific demonstrations the same perfect cognitions and definitions that Blancanus attributed to mathematics.

But before we turn to Descartes' texts, we must first understand how the essential and causal definitions of mathematics are supposed to provide us with certainty in our scientific demonstrations. Blancanus makes the connection clear in the course of answering another objection. According to his opponent, a *demonstratio potissima* (the most perfect form of scientific demonstration mentioned by Aristotle, the exact nature of which was subject to debate) primarily and intrinsically requires a causal definition of attributes [*passiones*], whereas it requires a definition of the subject only incidentally (as when one tries to demonstrate something that derives immediately from the subject). But essential and causal definitions of mathematical objects are often definitions of a subject. Therefore, it would seem that the causal definitions used in mathematics will not yield a *demonstratio potissima* because they are not normally causal definitions of properties. Blancanus replies:

Firstly, that since the causal definition of a property is not different from its cause, if in the definition of the subject the cause of the property is contained, then by assuming the definition of the subject, the causal definition of the subject is also assumed.[110]

For example, in the case of an equilateral triangle, the definition (a triangle with three equal sides) also includes the cause of its property of having three equal angles, and so the causal definition of the subject is at the same time a causal definition of its properties. Furthermore, Blancanus argues,

in mathematics, the definitions of subjects often come out as definitions of properties, as it will be obvious below, namely, when the subject itself, say, square,

[109] Blancanus, *De Mathematicarum*, p. 184. [110] Ibid., p. 183.

is demonstrated of a figure as its property, or when it is shown that a certain construction correctly yields a square, a triangle, a perpendicular line, and the like.[111]

In other words, since specific mathematical objects, like a triangle, are often treated as properties of figures in general, in mathematical demonstrations, the definitions of such subjects effectively function as causal definitions of properties in the demonstrations. Contrast this to the definitions of natural objects where the definition (e.g., 'a human being is a rational animal') normally does not explain its properties (e.g., human beings lack fur and feathers).

In light of Blancanus' suggestive remarks, we can better understand Descartes' redefinition of material substance in mathematical terms. By redefining matter as extension, he makes the connection between its essential form and its accidents as close as the connection between a square, its properties, and the construction that yields them. Descartes' response to arguments by skeptics like Sanchez is thus to redefine physical essences/forms so as to make them as directly knowable by the intellect as mathematical essences. In this way, he can bypass all the skeptical doubts Sanchez and other skeptics raised regarding our sensory cognition of an object's true properties, and ground his science on direct apprehensions of the intellect, which even Sanchez admits to be certain. To accomplish this, Descartes has to replace the prevailing theory that the physical forms of material things are Aristotelian substantial forms, which can be known only indirectly through their sensible effects. This involves two things: a new account of the essence of material substance, and the replacement of the substance/accident ontology with the substance/mode relationship. I will turn to these metaphysical developments in Part III. But first the close relationship between mathematical demonstrations and the science of mechanics must be examined, for this is the crucial link that allows the certainty of abstract theoretical mathematics to be transferred to explanations of real physical objects and their motions. Guevara's account of mechanical demonstration is illuminating in this regard.

After his discussion of the object of mechanics, Guevara indicates that the nature of a science's object determines the specific form of reasoning it employs. He goes on to examine the nature of the "intellectual *habitus* of the mechanical contemplation."[112] Following Pappus, he characterizes the mechanical faculty as both an art and a science. He explains that it is an art in the sense that its principle is in that which is to be accomplished,

[111] Ibid., pp. 183–184. [112] Guevara, *In Aristotelis Mechanicas*, pp. 12, 13.

and what is accomplished could have been otherwise.[113] However, it is also a science in that (1) it investigates the causes of things to be done, (2) the causes which it identifies are not able to be otherwise, and (3) it provides intellectual knowledge of the local motion and rest of heavy and light things that comes from pre-existing knowledge of principles which are either known for themselves or demonstrated in another science.

The third criterion betrays the fact that Aristotelians classified mechanics as a subordinate science falling under the higher mathematical discipline of geometry. Subordinate sciences borrowed their principles from their respective higher sciences. As an example to illustrate this, Guevara points out that we know from geometry that a circle touches the plane on a point and makes an angle that is more removed from the plane than in the case of other figures. This geometrical principle then allows us to prove in mechanics that round bodies are moved more easily on a plane since they touch the plane with a very small part and strike against it less than other bodies. He concludes:

> This is plainly proved, [that] they [mechanical conclusions] constitute a certain knowledge [*notitia*] of things, or effects, proceeding from the cognition of the cause of those things, and thus through discourse and logical inference by means of the power of the middle term, that is, of the cause itself which was foreknown, we must arrive from the knowledge of the antecedent to the knowledge of the consequent, which is, according to this condition, to participate in the proper reasoning [*rationem*] of a science.[114]

Guevara makes it clear, in this passage, that mechanical conclusions, such as the fact that round objects are more easily moved on a plane, are demonstrated by means of Aristotle's properly scientific *propter quid* demonstrations (demonstrations of the reasons why – the best form of scientific demonstration), in which the middle term is a foreknown principle that is either self-evident, or demonstrated in the higher science of geometry.[115] In the above example, the geometrical principle that a circle touches a plane only at a point would function as the middle term in the mechanical demonstration of the conclusion that round objects move more easily on a

[113] Ibid., p. 12. [114] Ibid., p. 14.

[115] Aristotle gives the following two examples in the *Posterior Analytics*, Bk. I, ch. 13: What the Latin commentators called a *Quia* demonstration reasons from effect back to cause as follows: (1) The planets do not twinkle. (2) All that does not twinkle is near. (3) Therefore, the planets are near. However, a properly scientific demonstration, which they called *propter quid*, establishes the conclusion with necessity and reasons from cause to effect, as follows: (1) The planets are near. (2) All that is near does not twinkle. (3) Therefore, the planets do not twinkle. In this case, the middle term, 'is near,' is the proper cause of the phenomenon of not twinkling, and belongs to the essence or definition of a planet.

plane. In other words, by reinterpreting mechanical explanations to fit the syllogistic model of the *Posterior Analytics*, Guevara ensures that mechanical knowledge fits the requirement that *scientia* establish its conclusions with certainty. This also explains how mechanical demonstrations meet criterion (1), that a science must identify the causes of effects. By squeezing mechanical demonstrations into the syllogistic form, Guevara effectively turns the principles of geometry into causes, for the middle term of a syllogism is supposed to identify one of the four Aristotelian causes.

According to criterion (2), mechanics qualifies as a science because it identifies *necessary* causes, or, as Guevara puts it, "those things which are known from mechanical knowledge (*notitia*) from the proper causes, proceed so necessarily from the causes themselves that it could not be otherwise."[116] He illustrates this by the fact that projectiles are borne further when thrown from a slingshot than from the hand. This occurs *necessarily* since geometry establishes that the circular motion produced by the slingshot traces a circumference that is further away from the center of the circle than the circular motion produced by the hand. Hence the stone in the slingshot must move faster than the stone thrown by the hand, since geometry also shows that it must trace a larger arc in the same amount of time during which the hand, which is closer to the center of the circle, traces a smaller arc. Guevara claims that the fact that this effect is necessary and cannot be otherwise is easily proven by induction. Moreover, the causes from which the mechanical faculty draws its conclusions are either known in themselves, such as 'What is borne more quickly is moved more easily,' and 'Equals are not moved by equals,' or demonstrated in the superior science (in this case, geometry). Therefore, he concludes, "the very cognition of mechanical conclusions shares and is allotted the same evidence that is common to all sciences, which, of course, contains evidence only from the principles through resolution up to the elements, as the Philosopher often teaches in the *Analytics*."[117]

In other words, mechanics provides us with knowledge of necessary causes because the evidence on which its conclusions rest can be resolved back into more basic principles that are necessary and known with certainty. Guevara does not seem to think that the fact that one must also rely on induction to discover that the effect is necessary undermines the deductive certainty of mechanical demonstrations. Rather, the certainty of one's knowledge derives from the ensuing scientific demonstration,

[116] Blancanus, *In Aristotelis Mechanicas*, p. 14. [117] Ibid., p. 15.

which relies on higher principles that are beyond doubt. While it is not entirely clear what Guevara has in mind, this is consistent with a common Aristotelian method of scientific demonstration, known as the *regressus*, which attributed two phases to a scientific proof. (The *regressus* was also held by many to correspond to Aristotle's *demonstratio potissima*.) First, one makes a demonstration of the fact (a *demonstratio quia*) by reasoning from observed effect back to cause, and then, after a mental examination of the possible causes, one proceeds to deduce the effect from the proper cause by means of a *propter quid* demonstration. It is only after the completion of the second phase that one has scientific knowledge, properly speaking. In the case of a mechanical demonstration, this crucial second phase would consist in a demonstration of the observed phenomenon from a principle of geometry. For example, one would first construct a *quia* proof from an observed effect to a mathematical property:

(1) A ball rolls easily.
(2) Things that roll easily touch the surface only one small part at a time (known by induction).
(3) Three-dimensional figures that touch a plane on only one point are spheres (geometrical premise).
(4) Therefore, a ball is a spherical object.

This would be followed by a *propter quid* proof that confirms the mathematical property to be the proper cause of the observed effect:

(1) A ball is a spherical object.
(2) Spherical figures touch the plane only on one point.
(3) Objects that touch the surface on only one small part roll more easily.
(4) Therefore, a ball rolls easily.

In this manner, mechanics, despite the empirical and causal nature of its knowledge, remains firmly rooted in the principles of mathematics, and transfers the certainty of mathematical principles and demonstrations to its conclusions about physical objects and motions. However, the *regressus* I attribute to Guevara highlights three pressing problems. One has to assume, first that the roughly spherical physical object is an instance of the perfect geometrical figure of a sphere, and second, that this figure is the cause of its motions. Given that mathematical figures were considered to abstract from sensible matter, both are highly problematic assumptions for an Aristotelian. Specifically, on the Aristotelian theory of matter, there is no reason to think that the geometrical shape, an accidental property imperfectly instantiated by the physical matter, should explain

a body's activity. I will next argue that Descartes' new account of matter solves the problems latent in Aristotelian mechanics that Guevara's text lays bare. But we are still faced with a third problem, namely, Sanchez's question: What supreme science guarantees that the principles mechanics borrows from the science of geometry are true? Whereas Blancanus' treatment of mathematical definitions indicates that mathematical principles were commonly thought to be self-evident and in no need of a higher justification at this time, I will argue in Part III that Descartes provides a response to the skeptic with his doctrine of the eternal truths of mathematics. With Descartes' metaphysical justification, mathematical principles obtain the grounding necessary to remain immune to Sanchez's doubt.

In conclusion, the rediscovery of the Aristotelian *Quaestiones Mechanicae* engendered three important conceptual shifts: (1) it gradually erased the line between objects of art and objects of nature; (2) it thus encouraged the application of mathematical modes of demonstration to physical objects; and (3) it even prompted some of its commentators to identify natural objects with mathematical objects. In the next chapter I will examine their impact on Descartes' conception of a mechanistic philosophy. However, it is already clear at this stage that the budding science of Aristotelian mechanics played a more significant role than has been acknowledged in the shift from hylomorphism to mechanism. As shown in previous chapters, Scholastics, like Suarez, had resources to defend substantial forms from the kinds of external skeptical humanist attacks on Aristotelian logic and science found in Sanchez's treatise – and, in any case, the principles of anti-Aristotelian natural philosophies fared no better against global skeptical arguments. Yet Scholastics neither anticipated nor guarded against the internal threat posed by alternative conceptions of nature and scientific explanation that emerged from commentaries on the *Quaestiones Mechanicae*. After elevating mechanics from an art to a mathematical science, Aristotelian commentators gradually undermined the centuries-old divisions between artificial machines and natural objects, and mathematical *versus* scientific demonstrations. Hence they prepared the ground in which a new approach to physics based on both mathematical and mechanical principles could take hold. The irony is that these fundamental conceptual shifts were largely introduced not by anti-Aristotelians, but within the traditional framework of Aristotelian philosophy and even in the name of Aristotle himself!

CHAPTER 6

Cartesian science and the principles of Aristotelian mechanics

Descartes' replacement of substantial forms with mechanisms was itself the product of 'long experience.' In what follows I will argue that it proceeded in at least three distinct phases. At first Descartes presents himself as investigating the substantial forms of natural substances through a combination of reasoning and observation. These investigations lead him to articulate a new scientific method that rests on mechanical principles. Next, the explanatory success of his new method and principles makes the appeal to Scholastic physical substantial forms in scientific explanations redundant. Finally, in Part III, I will argue that the need to guard against arguments denying the very possibility of *scientia* by skeptics like Sanchez eventually led Descartes to embrace a controversial metaphysics to support his new mechanical science. As Descartes impatiently retorts in a letter to Plempius for Fromondus, dated October 3, 1637, this new science was directly inspired by the success of Aristotelian mechanics:

> If my philosophy seems too 'crass' for him, because, like mechanics, it considers shapes and sizes and motions, he is condemning what seems to me its most praiseworthy feature, of which I am particularly proud. I mean that in my kind of philosophy, I use no reasoning which is not mathematical and evident, and all my conclusions are confirmed by true observational data. Whatever I concluded to be possible from the principles of my philosophy, actually happens whenever the appropriate agents are applied to the appropriate matter. I am surprised that he does not realize that the mechanics now current is nothing but a part of the true physics which, not being welcomed by supporters of the common sort of philosophy, took refuge with the mathematicians. This part of philosophy has in fact remained truer and less corrupt than the others, because it has useful and practical consequences, and so any mistakes in it result in financial loss. So if he despises my style of philosophy because it is like mechanics, it is the same to me as if he despised it for being true.[1]

[1] CSMK, p. 64; AT 1, p. 421.

In this chapter, I will propose a new interpretation of Descartes' early scientific writings in light of the developments in Aristotelian mechanics covered in chapter 5, and draw out the implications for material substantial forms. I show that while Descartes' early works pose a challenge to such forms in that they make them redundant to scientific demonstration, they do not imply the metaphysical elimination of material substantial forms.

6.1 THE EXPLANATORY SUCCESS OF MECHANICAL DEMONSTRATIONS

Despite Descartes' later rejection of substantial forms, it is clear from his early correspondence that he did not initially consider his scientific program to be incompatible with the Aristotelian search for substantial forms. For example, on April 5, 1632, he writes to Mersenne:

> For instance, in the treatise which I now have in hand, after the general description of the stars, the heavens and the earth, I did not originally intend to give an account of particular bodies on the earth but only to treat of their various qualities. In fact, I am now discussing in addition some of their substantial forms, and trying to show the way to discover them all in time by supplementing my reasoning with observations. This is what has occupied me these last days; for I have been making various experiments to discover the essential differences between oils, ardent spirits, ordinary water and acidic liquids, salts etc.[2]

At this point in time, Descartes does not take his investigations into the shapes and sizes of oil and salt particles to displace the doctrine of substantial forms. For him the geometrical properties of a body's particles and their various arrangements take over the function of the substantial form, for they account for the unity of a physical substance and explain its observable qualities. The fact that Suarez places the substantial form squarely in the natural realm, and relies heavily on empirical arguments in its favor, allows Descartes to introduce an alternative conception of the substantial form based on a combination of empirical evidence and his new theory about the microstructure of physical bodies. He does not, at this stage, address metaphysical doctrines of form – nor, given Suarez's account of substantial forms, does he need to.

[2] CSMK, p. 37; AT I, p. 243. While Descartes later advises Regius against explicitly denying substantial forms, this does not imply that Descartes' use of the term in this earlier letter to Mersenne is disingenuous. (See CSMK, p. 205; AT III, p. 491–492.) Since Mersenne shared his anti-Aristotelian leanings, there is no need for Descartes to feign support for substantial forms, and so I take him to be genuinely interested in investigating their exact nature at this time.

A letter to Morin of September 12, 1638, indicates that more than six years later, Descartes still takes himself to be offering a particular account of the substantial forms of natural objects – one which reduces them to mechanical principles rather than eliminating them altogether. However, unlike the earlier letter to Mersenne, at this stage he also highlights our inability to know substantial forms apart from the qualities they cause. In other words, Descartes embraces substantial forms only to the extent that they manifest themselves in the qualities of matter. In response to Morin's worry that if light were nothing but the action of the sun, then there would be no light in the sun's nature, and this would make light more actual and absolute than motion, Descartes writes:

> You are making difficulties in words where there are none in reality. There is no more problem than if I said that a clock shows the time only by the movement of its hands, and that its quality of showing the time is not a more actual or absolute being than its movement, and that this movement belongs to it by its nature and essence, because it would cease to be a clock if it did not have it. I know that you will say that the form of a clock is only an artificial form, while the form of the sun is natural and substantial; but I reply that this distinction concerns only the cause of these forms, and not at all their nature; or that the substantial form of the sun, in so far as it differs from the qualities to be found in its matter, is an altogether philosophical entity which is unknown to me.[3]

Descartes offers two responses to Morin. Either the substantial form is a purely philosophical entity, in which case it cannot be known and hence is useless for the purpose of gaining scientific knowledge; or the substantial form of a natural object, like the sun, is identified with the qualities of its matter, in which case its nature is similar to the artificial form of the clock. The clock, as Descartes points out, is defined not by its purpose of showing time, but by the movements of its inner parts. The first response, based on the uselessness of substantial forms for the purpose of science, is similar to Sanchez's concern about grounding science on unobservable philosophical notions. The other response could be inspired by Sanchez's clockwork/universe analogy, and/or by the gradual identification of natural objects and artificial mechanical objects found in the *Quaestiones Mechanicae* commentaries.

Whatever its exact sources, the implications for the substantial form that Descartes draws from these earlier developments are instructive with regards to its ultimate fate: it must be either irrelevant to science, or redefined in terms of the new conception of natural objects and scientific

[3] CSMK, pp. 121–122; AT II, p. 367.

demonstrations that grows out of Aristotelian mechanics. In this chapter, I will argue that Descartes' early scientific writings indicate that he initially has hopes of offering a better account of the substantial forms or physical essences of objects based on mechanical principles and demonstrations. This optimism manifests itself in the scientific essays appended to the *Discourse on the Method*, which aim to establish the benefit of grounding science on mathematical principles via the explanatory success of mechanical-type demonstrations of natural phenomena, and in *The World*'s retelling of the creation story in which a Platonic geometer God first creates not prime matter, but the intelligible matter of mathematics. First, I will give an interpretation of Descartes' demonstration of the nature of salt in the *Discourse* to illustrate in what sense Descartes considered himself to be offering mechanical demonstrations of physical phenomena that were superior to standard Scholastic explanations in terms of substantial forms and real qualities. In the next section I will turn to his redefinition of matter in *The World*. I will argue that neither work implies the metaphysical elimination of substantial forms necessitated by the substance/mode ontology Descartes later introduces in the *Meditations*. Rather, at most, his early scientific essays make material substantial forms redundant for the purposes of doing science, whereas *The World* reinterprets them as the sizes, shapes, and arrangements of the material particles of composites. Indeed, as Descartes writes at the beginning of his *Meteorology*:

> … In no way do I wish to deny the things, over and above what I said, that they [the Philosophers] imagine to be in bodies, like their *substantial forms* and *real qualities*, and similar things, but that it seems to me that my reasons ought to be all the more approved to the extent that I make them depend on fewer things.[4]

Even though it was begun only in the spring of 1635, whereas the first part of *The World* had already been completed by 1633, I will examine Descartes' *Discourse* first because much of the appended scientific essays probably consists in material that predates *The World*. Hence, this material gives us valuable clues about the beginnings of Cartesian science and Descartes'

[4] AT VI, p.239. It could be a passage like this one that Descartes recommends to Regius when he advises him, for political reasons, not to explicitly deny substantial forms. This raises the question whether Descartes' claim in the *Meteorology* to simplify rather than eliminate substantial forms is sincere. Whereas, by the time he wrote to Regius, Descartes had abandoned material substantial forms, most of the material appended to the *Discourse* dates back to an earlier period, and the above-cited letter to Mersenne of April 1632 indicates that, during this earlier period, Descartes' desire to investigate the substantial forms of material things was still genuine. So regardless of whether his use of substantial forms later became rhetorical window-dressing, the explanations themselves were originally intended as ways of cashing out material substantial forms.

early mathematical method of solving what he characterizes, in the *Rules for the Direction of the Mind*, as the imperfect problems of physics. As Theo Verbeek notes, Constantijn Huygens had urged Descartes to publish *The World*, but Descartes abandoned this plan upon hearing of Galileo's condemnation. Descartes' good friend and follower, Henricus Reneri, who needed an introductory teaching text in order to teach his courses on natural philosophy, also spurred Descartes on to publish something he could use as a textbook to introduce Cartesian natural philosophy to his students. Both Huygens and Reneri continued to pressure Descartes into publishing the early fruits of his scientific method, Huygens suggesting that he publish the *Dioptrics* and Reneri requesting that he publish the *Meteorology* to fulfill his teaching needs. In 1635 Descartes began to work on an Introduction to the Method, which initially consisted in the *Dioptrics* and the *Meteorology* and an introduction that matches Part 6 of the current Preface to the *Discourse*.[5] In his desire to please both friends, Descartes appears to have collected the results of his forays into *physico-mathematics*, adding an introduction that emphasizes the importance of observation and his need for funds to finance further experiments. Verbeek thinks that the Introduction he added to the pre-existing material reflects Descartes' collaboration with Reneri, who had just announced an ambitious Baconian project in his inaugural speech.[6] Just before publishing them in 1637, Descartes decides to add his newly completed *Geometry* to the other two essays, and hastily writes the remainder of what is now the Preface to the *Discourse*. Hence the early parts of the Preface reflect the solitary, non-experimentalist method of the geometer more than they reflect the method at work in the *Dioptrics* and *Meteorology*. Given the timeline for the composition of the *Discourse* and *Essays* established by Verbeek, the method Descartes announces at the very beginning of his Preface must not be read back into the more empirical method at work in the essays that were composed at an earlier date.

We must even exercise caution in applying the new conception of matter and laws of motion Descartes introduces in *The World* to the original essays of the *Discourse,* for it is unclear that these pre-date his investigations into optics, which date back to the 1620s, and his interest in meteorological phenomena, which probably motivated Descartes' decision to enroll as a student at the University of Franeker in the Netherlands

[5] Theo Verbeek, in collaboration with Jelle Kigma and Philippe Noble, *De Nederlanders en Descartes* (Amsterdam: Maison Descartes, 1996) p.26, 52–56; in French: *Les Néerlandais et Descartes* (Paris: Institut Néerlandais, 1996).

[6] *Ibid.*, p. 52.

in 1629.[7] In other words, the scientific explanations Descartes gives in the *Optics* and *Meteorology* must be read independently of both the rest of the *Discourse* and Descartes' other published works. This makes it difficult to discern what method is at work in these early scientific writings, and what advantage Descartes took his explanations to have over Scholastic Aristotelian demonstrations of physical phenomena. The existing body of literature focuses on the explanation of the rainbow Descartes gives in the *Discourse* as the prime example of his application of the mathematical method outlined in the *Rules* to a physical phenomenon.[8] However, whoever takes the trouble to examine Descartes' explanations of other meteorological phenomena will quickly realize that his treatment of the rainbow is atypical. It may reflect Descartes' most successful attempt to apply the method he lays out in the *Rules* to a physical problem; however, the procedure he follows in his treatment of the rainbow cannot account for the method he employs in the vast majority of his meteorological explanations. In the latter cases, the underlying method appears to be neither mathematical, in our sense of the term, nor based on a step-by-step analysis of the problem, accompanied by careful experimentation. Rather than hastily concluding that Descartes failed miserably in applying mathematics to physical phenomena at large, I will draw on the background to existing mechanical forms of demonstration given in chapter 5 to propose a sense in which Descartes' typical demonstrations of meteorological phenomena would have been considered to be mathematical by his contemporaries. Hence they do not violate his general aim to neither "accept [n]or desire in Physics any other principles than Geometry or abstract Mathematics (*Mathesi abstractâ*); because all the phenomena of nature are explained thereby, and certain demonstrations concerning them can be given."[9]

[7] Verbeek claims that Descartes' move to Franeker was possibly motivated by his belief that Adrian Metius, Professor of Mathematics at the University of Franeker, was related to the Metius who invented the telescope. When this turned out to be incorrect, Descartes tried to convince the French lens-grinder Ferrier to join him in Franeker so that they could develop a telescope to observe meteorological phenomena, such as meteors and parhelia. Verbeek, *De Nederlanders*, pp. 40–44. At the beginning of his *Dioptrics* Descartes mentions Jacques Metius of Alkmaar as the inventor of the telescope. AT VI, p. 82.

[8] Descartes writes to Vatier on February 22, 1638, "I must say first that my purpose was not to teach my whole method in the discourse in which I propose it, but only to say enough about it to allow one to judge that the new opinions in the *Optics* and *Meteorology* were not conceived casually, and perhaps merited the trouble of being examined. I could not also show the use of this method in the three treatises which I gave, because it prescribes an order of investigating things which is quite different from the one I thought I ought to use to explain them. I have, however, shown a sample in describing the rainbow, and if you take the trouble to reread it, I hope that it will satisfy you more than it did the first time for the matter is quite difficult in itself." AT I, p. 559.

[9] *PP* II, a. 64, p. 76, marginal note.

I will focus on the explanation of salt Descartes gives in his *Meteorology* as representative of his typical approach to explaining meteorological phenomena. It is clear that Descartes considered his explanation of salt as illustrative of the manner in which his explanations of the essential forms of physical objects differ from the Scholastic explanations based on substantial forms and real qualities. Contrasting his approach to that of the Scholastics, he writes to Regius: "Essential forms explained in our fashion, on the other hand, give manifest and mathematical reasons for natural actions, as can be seen with regard to the common form of salt in my *Meteorology*."[10] And yet, when one turns to Descartes' explanation of salt, by our standards there is nothing mathematical about it. There are no calculations or equations – instead, his reasoning is largely based on qualitative considerations. Indeed, Descartes just seems to assert a logical connection between the size and shape of unobservable salt particles and the sensory qualities of salt (i.e., salt grains must be made up of oblong-shaped particles because they are square, and oblong shapes put together form squares). I will argue that, in light of Guevara's commentary, there is at least one sense in which Descartes' explanation of salt is mechanical and hence mathematical in nature. While the details differ, I will argue that, in its overall form, Descartes' explanation of salt conforms to what Guevara characterizes as the mechanical mode of proof. I base my interpretation largely on a clarification that Descartes makes to Plempius.

Descartes first responds to Plempius' question regarding the principles of his *Meteorology* by pointing out that Plempius has confused the conclusions he laid out in the first few chapters of the *Discourse* (i.e., those concerning the nature of light and the shapes of the particles making up different kinds of water) for his principles. Descartes must be referring to the first discourse of the *Meteorology,* since it is there that he gives a general overview, which includes a brief discussion of the nature of both water particles and light. This also explains why Plempius was confused, since in the paragraph that precedes the general overview Descartes states: "It is true that knowledge of these things depends on general principles of Nature which have not yet been, as far as I know, properly explained and so I must, in the beginning, make use of some suppositions, as I did in the *Dioptrics* . . ."[11] In other words, Plempius assumes that Descartes goes on to introduce his general principles as suppositions, when in fact Descartes supposes the conclusions which would be deduced from his

[10] To Regius, January 1642, CSMK, p. 209; AT III, p. 507. [11] AT VI, p. 233.

general principles. Included among his suppositions is the conclusion that the particles of salt are larger and less flexible than those of water.[12]

Descartes then explains to Plempius:

> In fact my principles are not those which I propose in the first chapter regarding the nature of light, the shape of the particles of salty and sweet water and similar things, as you seem to object, but rather [these] are conclusions which are demonstrated by all the following. However, magnitudes of shape, position and motion must be taken as my *formal* object (as the philosophers use the term), and the physical things, which I explain, as my *material* object.[13]

Since Descartes tells us he is using the philosopher's manner of speaking, this passage provides us with important clues as to how Descartes' scientific explanations relate to those of Scholastic natural philosophers. Just like Guevara, Descartes distinguishes between a material object of his physics, i.e., physical things and their observed properties in general, and a formal object, i.e., the specific aspect under which physics studies them. This makes it clear that the magnitudes of shape, position, and motion are not, as is normally assumed, the principles of Descartes' physics, but merely the formal aspect under which physics studies material things.

Descartes then spells out what the principles of his physics consist in:

> And the principles or premisses from which I deduce these conclusions, are only the axioms that the demonstrations of the Geometers depend on, such as, 'the whole is greater than the part', 'if you take away equals from equals, the remaining ones will be equal,' etc., not, however, abstracted from all sensible matter, as with the Geometers, but applied to various experiences known by sense and undoubted, as when from the fact that the particles of salt are oblong and inflexible, I deduced the square shape of its morsels, and many others which are evident to the senses.[14]

Descartes' general principles consist not in claims about the shapes of particles, but rather in the axioms of geometry. But unlike the geometer, Descartes will not abstract them from all sensible matter; rather he

[12] In the absence of a fully developed metaphysical account of matter and an *a priori* demonstration of its properties, Descartes makes his suppositions plausible by a series of analogies: e.g., the pressure that is light is like the pressure exerted by grapes pressed into a wine vat with only one small opening, and fluid water particles are like slippery little eels. Interestingly, Descartes still resorts to such analogies in the physics of the *Principles*, which was written after he developed the metaphysical foundations meant to support it. This indicates that analogies play more than a rhetorical role in establishing the foundations of Cartesian physics.

[13] AT 1, p. 476.

[14] Ibid. Both examples Descartes gives of axioms or common notions are found in Thomas Aquinas, *Commentary on the* Posterior Analytics, Lecture 18, p. 59, and the second example is found in Aristotle's *Posterior Analytics*.

will apply them to undoubted sensed objects, such as the observed square shape of grains of salt. Descartes concludes:

> Indeed, I wanted to explain the latter [e.g., the observed shape of salt etc.] through the former as effects through a cause, however, by no means to prove, since they would already be sufficiently known, but on the contrary to demonstrate the former through the latter *a posteriori*.[15]

Given that Descartes has just referred to both the geometrical principles on which his demonstrations rest and the properties of salt particles, it is ambiguous as to whether "the former" refers to the oblong shape and inflexibility of the particles or to the axioms of geometry applied to sensible things. The first interpretation prevails nowadays, since Descartes is normally taken as claiming to deduce the square shape of observed salt grains from the properties of salt particles. On this interpretation, Descartes inaugurates something like the hypothetico-deductive method of proof, since he had earlier introduced the properties of salt particles as conclusions that he would, in the beginning, simply suppose. In other words, if one reads Descartes this way, he proceeds to establish his hypothesis that salt consists in oblong, inflexible particles by confirming the sensible properties he deduces from this hypothesis through observation.

This interpretation is confirmed by a passage from Descartes' letter to Morin of July 13, 1638, where Descartes responds to Morin's charge that the demonstrations he gives in the *Discourse* are circular.

> But even if there were truly many effects to which it is easy to adjust different causes, one to each, it is nonetheless not easy to adjust the same one to many different [effects] if it is not the true [cause] from which they proceed; there are even often those for which it is sufficient to give one from which they can be clearly deduced to prove what is their true cause, and I claim that all those of which I have spoken are numbered among them. Consider that in everything one has done in physics up to now one has only tried to imagine some causes through which one could explain the phenomena of nature, nonetheless, with hardly any success. Then if one compares their suppositions with mine, that is to say, all their *real qualities*, their *substantial forms*, their *elements* and similar things, the number of which is almost infinite, with this alone: that all bodies are composed of parts, which is something that one can see with the eye and prove by an infinity of reasons in other cases (for since I add to this that the parts of this or that body are of one shape rather than another, it is easy to demonstrate it to those who admit that bodies are composed of parts) and finally if one compares what I have deduced from my suppositions, touching on vision, salt, winds, clouds, snow, thunder, the rainbow, and similar things, with what the others have drawn from their touching on the same topics, I

[15] AT 1, pp. 476–477.

hope this will suffice to persuade those who do not prejudge that the effects which I explain have no other causes than the ones from which I have deduced them, even though I wait to give a demonstration of it in another place.[16]

Note that Descartes' main point here is limited to the claim that the shapes and sizes of particles, which he has deduced from the axioms of geometry and from which he then proceeds to deduce the observable qualities of salt, etc., are less mysterious than the real qualities and substantial forms of the Scholastics. In other words, here he is assuming the perspective of the Scholastic, who thinks that substantial forms can only be inferred *a posteriori* from their effects, and pointing out that, even on this assumption, it is less problematic to suppose that physical objects are made up of geometrically shaped parts than to posit Scholastic substantial forms. However, as the last sentence indicates, the mere fact that Descartes takes his supposition to be empirically verifiable does not preclude the fact that he also thinks he can give an *a priori* demonstration that salt must have oblong-shaped parts from geometrical principles.

Descartes recognizes that demonstrations in physics cannot take the exact same form as demonstrations in abstract mathematics, since the geometrical principles involved must be applied to, and explain, the observed sensory qualities of objects. Notwithstanding, as Descartes makes clear to Mersenne on July 27, 1638, he still considers his physics to be based on a certain type of geometry:

I have only resolved to abandon abstract Geometry, that is, the investigation of questions which only serve to exercise the mind. I have done so in order to have all the more leisure to cultivate a different type of Geometry, which raises questions regarding the explanation of phenomena of nature. For if he cares to consider what I wrote about salt, the snow, and the rainbow, he will realize that all my physics is nothing but geometry.[17]

In short, the hypothetico-deductive interpretation of the above passage from the letter to Plempius does not sit well with Descartes' insistence, in various places, that his physics relies only on the principles of geometry and hence has the certainty of mathematics. For a strictly hypothetical proof of this kind would not rest on the principles of geometry, nor would it provide mathematical certainty. Hence those who interpret Descartes this way are forced to claim that he falls back on a hypothetical method because he failed to implement his program of basing his physics on *a priori* demonstrations of the kind used in mathematics. In what follows

[16] AT II, pp. 199–200. [17] AT II, p. 268.

I will argue that, to the contrary, the kind of geometrical demonstration Descartes employs is similar to the ones commonly used in mechanics, and, by this standard, he succeeds in giving mathematical demonstrations of meteorological phenomena.

This alternative interpretation emerges if one reads Descartes' explanation of salt in light of Guevara's discussion of the senses in which mechanics is a mathematical science. Taking the example of salt, on this reading Descartes' reference to "the former" in the letter to Plempius would refer back to whatever geometrical principle applied to sensible objects is used in the proof about the nature of salt. This has several advantages. First, it better fits Descartes' earlier claim to Plempius that the shape and size of salt particles constitute the conclusion, and hence not the cause or middle term, of a proper scientific demonstration (i.e., from cause to effect) regarding the nature of salt. Second, it makes better sense of Descartes' use of the Scholastic distinction between the formal and material object of a science in the letter to Plempius. In other words, in light of Guevara's definition of the formal object as the relevant aspect of the object of study, Descartes appears to be singling out the particular size and shape of a body as the properties to be investigated by the physicist and the geometrical principles as the causes / middle terms that will establish these particular properties.

By way of illustration, if Descartes were offering a proper scientific demonstration of the square shape of salt, he would start from the following principles that are either evident in themselves (e.g., premise (3)) or borrowed from a higher science (metaphysics and geometry):

(1) All bodies are made up of particles with various geometrical shapes and motions (metaphysical premise demonstrated from primary truths).
(2) Square shapes can be composed from oblong shapes (geometrical principle).
(3) Salt grains are square (given by sense perception).

From these he would demonstrate that salt is made up of oblong particles, something he does not do. Instead he assumes his conclusion, and proceeds to derive particular effects from it:

(a) Salt is made up of oblong-shaped particles (conclusion here supposed).
(b) Oblong shapes that touch a surface on many points are moved less easily than round ones (geometrical principle applied to sensed objects).
(c) Therefore, grains of salt are moved less easily than water (undoubted sensed object).

The form of reasoning exhibited in (a)–(c) allows Descartes to legitimate his supposed account of the nature of salt and the application of geometry to physical problems, since various observed sensible qualities of salt (e.g., it is harder and less mobile than water) can, by means of premise (a), be derived from the same geometrical principle (2) applied to sensible objects in (b) (e.g., oblong-shaped objects cohere more easily and are moved less easily than round ones since they touch the surface at many points). As he tells Plempius, rather than prove it, he simply supposes his conclusion (a). Since (c) is obvious from observation, he can then reason *a posteriori* from (c), the observed effect, back to (a), thus lending credibility to (a). In fact, as Descartes writes to Morin, if we are able to derive many other phenomena in the way we have derived (c) then our assumed conclusion (a) is shown to be a true cause. Moreover, both (1) and the application of geometry to physical problems are also indirectly validated by the explanatory success of demonstrations derived from them along the lines of (a)–(c).

Note also that, just as in the case of Guevara's slingshot example, the sensory evidence gained by induction is part of a larger deductive proof yielding scientific knowledge in the *a priori* version of Descartes' demonstration. Regardless of the proof's reliance on observations about sensed objects, the principle that functions as the middle term when Descartes reasons from cause to effect is taken from geometry, and this guarantees the certainty of the conclusion that is demonstrated. It also makes the demonstration a mathematical one, and so this interpretation of Descartes' method explains why he, years after the *Discourse*, still confidently proclaims in his *Principles*: "That I do not accept or desire in Physics any other principles than Geometry or abstract Mathematics (*Mathesi abstractâ*); because all the phenomena of nature are explained thereby, and certain demonstrations concerning them can be given."[18] If it were the case that Descartes had, in the meantime, realized that he was stuck with nothing but a hypothetical, *a posteriori* mode of demonstration, one would think he would have abandoned this bold language by the time he wrote the *Principles.*

While Guevara's text serves to clarify the sense in which Descartes' meteorological demonstrations are mechanical and mathematical in nature, there are of course significant differences between Guevara's mechanics and Descartes' mechanism. Guevara still thinks of the motions studied by mechanics as artificial motions that are contrary to nature – a division that disappears on Descartes' physics. Guevara is still committed

[18] *PP* II, a. 64, p. 76, marginal note.

to Aristotle's logic as a logic of discovery, whereas in his *Rules* Descartes considers syllogistic logic useful only for a synthetic presentation of what has already been discovered by the true scientific method of analysis. However, Descartes does not claim to employ his method of analysis in the *Discourse*, instead choosing a method of presentation more amenable to the less sophisticated minds of his targeted audience, which included women.[19] Hence there is no reason to rule out a method closer to the familiar Aristotelian logic when it comes to the *Discourse.* Furthermore, Guevara's distinction between the formal and material object, and his examples of how geometrical principles function as middle terms/causes in a mechanical demonstration, shed a great deal of light on Descartes' answer to Plempius. With the benefit of this background, we can make sense of Descartes' claim to have demonstrated with certainty the properties of salt particles from their causes by deducing them from geometrical principles. Furthermore, on this interpretation we need not dismiss his announcement that he had given physical demonstrations with the certainty of mathematics in the *Principles* as a desperate attempt to cling on to a project that had already failed miserably.

We are now in a position to make better sense of the overall method Descartes employs in the typical explanations he offers in his *Meteorology.* As Descartes explains in Part 6 of the Preface to the *Discourse*, which was the original introduction to the *Optics* and *Meteorology*:

> If some of the things of which I spoke at the beginning of the *Optics* and *Meteorology* should at first cause shock because I call them 'suppositions' and do not seem to feel like proving them, one should have the patience to read the whole book attentively, and I hope that one will find oneself satisfied. For it seems to me that the reasons in between follow one another in such a way that just as the last are proved by the first, which are their causes, so the first are reciprocally proved by the last, which are their effects. One must not imagine that I hereby commit the error that the logicians call 'arguing in a circle,' for since experience renders most of these effects very certain, the causes from which I deduce them serve not so much to prove them as to explain them. Rather, to the contrary, it is the causes which are proven by the effects. And I only called them 'suppositions' in order that one knows that I think I can deduce them from the primary truths I have explained above.[20]

At first glance, this passage fits the interpretation that attributes a straightforward hypothetical form of demonstration to Descartes. In

[19] See again the letter to Vatier dated February 22, 1638, cited above. CSMK, pp. 85–86; AT 1, pp. 559–560.
[20] AT VI, p. 76.

other words, he supposes the nature of salt, etc., at the beginning, shows that his supposition explains the observed properties of salt by deriving these effects from his supposition, and thereby confirms that the supposed oblong shape and inflexibility of the particles of salt are indeed the causes of the effects he derived. The charge of circularity is avoided in the sense that the effects are not proven by the causes, since they are too obvious to require a proof; rather the deductions of the effects from the supposed microstructures of bodies serve to confirm that the posited microstructures, not the substantial forms and real qualities of the Scholastics, are the true causes of the observed phenomena.

As a broad sketch of the way in which Descartes presents his method in the *Discourse*, the attribution of a hypothetical form of demonstration is correct. But if one looks more closely at the passage one realizes that there is another crucial step within this broader hypothetical form of demonstration, namely, the reasons in between the initial suppositions and the observed effects that are supposed to do the work of establishing the link between the supposed microstructures of bodies and their observable properties. What are these intermediate reasons? They are more clearly separated in the case of the *Dioptrics* than in the *Meteorology*. There Descartes begins with a discussion of the nature of light (in other words, he supposes what the physicist would ordinarily have to demonstrate) and then proceeds in the second part to give an explanation of refraction in geometrical terms. As Descartes indicates in the above quotation from the Preface to the *Discourse*, in an *a priori* demonstration from cause to effect, the nature of light, which he simply supposes here, would be deduced from 'the primary truths.' But not wishing to confuse his audience with metaphysical matters, he settles here for an *a posteriori* proof.[21] On this type of proof, Descartes does not proceed from cause to effect by beginning with geometrical principles and demonstrating from them the sizes and shapes of particles that explain the observed effects. Rather, he supposes what he needs to prove, and then, basing his argument on this hypothesis, works his way back to the geometrical principles required to derive particular observed effects, like refraction, from the posited underlying natures of physical objects. Hence Descartes' strategy is to persuade his audience to replace Scholastic substantial forms

[21] Descartes writes to the Jesuit Vatier on February 22, 1638: "I cannot prove *a priori* the assumptions I made at the beginning of the *Meteorology* without expounding the whole of my physics; but the observational data which I have deduced necessarily from them, and which cannot be deduced in the same way from other principles, seem to me to prove them sufficiently *a posteriori*." CSMK, p. 87; AT 1, p. 563.

with something more like the artificial substantial forms of machines by pointing to the explanatory fruitfulness of the hypothesis that the natures of bodies consist only in particles with geometrical properties like size, shape, and motion.[22] In the case of the *Dioptrics*, part of his strategy for convincing his audience consists in showing how nicely one can apply geometry to solve a particular scientific problem, like refraction, if one starts with Descartes' suppositions about the nature of light.

Descartes even proclaims to Morin that whether one ultimately accepts the suppositions as true or not is irrelevant to his proofs. Making an explicit comparison between astronomical derivation of celestial motions, which can proceed from either the stability or mobility of the earth, and his procedure, he writes:

> I desired that one should receive what I wrote in the *Dioptrics* about the nature of light in the same way, in order that the force of the mathematical demonstrations that I tried to make there would depend on no physical opinion, as I declared sufficiently on page 3. And if one could imagine light in some other way, through which one explains all of the properties which experience makes known, then one would see that everything that I demonstrated about refractions, vision and the rest, could be drawn from it just the same as from the supposition I proposed.[23]

While it is not clear that the analogy to astronomical demonstrations works, this passage does illuminate Descartes' overall strategy in the *Discourse*. Rather than establishing the applicability of geometrical principles to physics directly through metaphysical arguments for a corpuscularean account of matter, Descartes uses a backhanded approach designed to appear less threatening to the Scholastic reader. The reader need only accept his controversial account of matter hypothetically to derive all the benefits of applying geometry to physical problems. Descartes even reassures his readers that his suppositions are no different from the false or uncertain hypotheses the astronomer assumes to derive true conclusions![24] For example, he explains to Morin:

[22] In the letter to Vatier of 1638 Descartes gives two reasons for his indirect method of persuasion: "However, I will tell you candidly that I chose this manner of expounding my thoughts for two reasons. First, believing that I could deduce them in due order from the first principles of my metaphysics, I wanted to ignore other kinds of proofs; secondly, I wanted to see whether the simple exposition of truth would be sufficient to carry conviction without engaging in any disputes or refutations of contrary opinions." CSMK, p. 87; AT 1, p. 563.

[23] To Morin, July 13, 1638. AT 11, p. 197.

[24] Descartes employs the same strategy in Rule 12 of his *Rules for the Direction of the Mind,* where he introduces his discussion of the simple notions of body as follows: "As before certain assumptions must be made in this context which perhaps not everyone will accept. But even if they are thought to be no more real than the imaginary circles which astronomers use to describe the phenomena they study, this matters little, provided they help us to pick out the kind of

You also say that "astronomers often make assumptions which cause them to fall into grave errors; as when they wrongly assume a parallax, or the obliquity of the ecliptic, etc." To this I reply that these are never included in the kinds of assumptions or hypotheses I was speaking of; I clearly designated them saying that "one could draw very true and certain consequences from them even though they were false and uncertain." For the 'parallax,' or the 'obliquity of the ecliptic,' and so on cannot be assumed as false or uncertain, but only as true; whereas the equator, the zodiac, the epicycles and other such circles are ordinarily assumed as false, and the mobility of the earth as uncertain, and this does not prevent true conclusions from being deduced from them.[25]

In other words, in the *Discourse* Descartes seeks to persuade his contemporaries by means of the explanatory fruitfulness of his 'false' supposition that specific geometrical shapes constitute the formal objects of physical bodies, rather than giving an *a priori* proof of this conclusion. However, as seen from Descartes' responses to concerns voiced by Plempius and Morin, Descartes' purely instrumentalist argument for replacing Scholastic substantial forms with a corpuscularean account of matter only caused confusion among his contemporaries. Descartes must have realized from the ambivalent reception of the *Discourse* that he could no longer avoid the task of deducing the foundations of his physics from 'the primary truths.' This final phase of his replacement of substantial forms with the mathematical properties of *res extensa* came to full fruition only in the *Meditations*, and will be examined in Part III. However, Descartes made an earlier attempt to ground his scientific explanations in a new metaphysical account of matter in *The World*. I will argue next that this earlier attempt is still heavily influenced by his scientific program and falls significantly short of the later metaphysics we associate with Cartesianism. In particular, it lacks the substance/mode ontology on the basis of which Descartes later completely eliminates material substantial forms.

6.2 THE INTELLIGIBLE MATTER OF "THE WORLD"

Descartes' new definition of matter is in place as early as *The World*:

Now since we are taking the liberty of fashioning this matter as we fancy, let us attribute to it, if we may, a nature in which there is absolutely nothing that

apprehension of any given thing that may be true and to distinguish it from the kind that may be false." CSM I, pp. 43–44; AT X, p. 417.

[25] AT II, pp. 198–199. Descartes here corrects Morin's misunderstanding of his claim at the beginning of the *Dioptrics* to have derived less readily observable properties from his suppositions, in the same manner that astronomers draw true and certain consequences from largely false and uncertain suppositions. AT VI, p. 83.

everyone cannot know as perfectly as possible. To this end, let us expressly suppose that it does not have the form of earth, fire, or air, or any other more specific form, like that of wood, stone, or metal. Let us also suppose that it lacks the qualities of being hot or cold, dry or moist, light or heavy, and of having any taste, smell, sound, colour, light, or other such quality in the nature of which there might be said to be something which is not known clearly by everyone.

On the other hand, let us not also think that this matter is the 'prime matter' of the philosophers, which they have stripped so thoroughly of all its forms and qualities that nothing remains in it which can be clearly understood. Let us rather conceive of it as a real, perfectly solid body which uniformly fills the entire length, breadth and depth of this huge space in the midst of which we have brought our mind to rest.[26]

Descartes' characterization of matter in his earliest work on natural philosophy is intended to distinguish his conception of matter from those of his contemporaries, and so he begins with a negative characterization of the material substance that constitutes his new world. This is not a traditional conception of matter, as seen by the denial that it shares any of the qualities belonging to Aristotelian elements and some of their non-Aristotelian competitors. Nor is it a type of prime matter. Rather it is an extended, uniform, perfectly solid substance that God divides into parts of different shapes and sizes. Descartes has effectively reified the intelligible matter of the Scholastics.

Later on in *The World* and in subsequent works, Descartes identifies matter's "extension or its property of occupying space, not as an accident, but as its [matter's] true form and essence…"[27] Passages such as these are often taken to imply that matter is no more and no less than *res extensa* for Descartes.[28] *Principles* I is often taken to give an exhaustive Cartesian ontology, and so, when it is read back into Descartes' earlier scientific treatises, it is normally supposed that Descartes' early account of matter leaves no room for the traditional distinction between the essential properties that spring from a body's substantial form and its accidental properties.[29] If all properties of matter must be either attributes, which are

[26] Descartes, *Le Monde,* ch. 6, CSM 1, pp. 90–91; AT XI, p. 33.

[27] *Le Monde*, ch. 6, AT XI, p. 36.

[28] The following blanket claim about Cartesian matter is fairly representative: "When Descartes first proposed his division of creation into mind and matter, the most troublesome claim for his Scholastic audience would have been the conception of matter as a substance whose sole essence is extension. Descartes not only promoted the existence of such a substance, but he contended that all of nature is nothing but passive, inert, extended substance, thus denying in one fell swoop the scholastic Aristotelian conception of nature as populated with active principles and substantial forms." Hatfield, "First Philosophy," p. 149.

[29] It is not clear that Descartes intended to give an ontology, let alone an exhaustive one, given that he introduces this part of the *Principles* as follows: "To enable us to get rid of these preconceived

merely conceptually distinct from material substance, or modes, which are only modally distinct from the substance and its primary attribute, then it follows that all the properties material substances can have are strictly reducible to the primary attribute of extension. However, as is clear from the following passage contrasting his account of motion to the Scholastic one, Descartes does not yet conceive of the properties of matter as 'modes' when he writes *The World*:

> But, on the contrary, the one [i.e., the conception of motion] that I suppose follows from the same Laws of Nature, as do generally all the dispositions and all the qualities which are found in matter, those which the learned call *Modos & entia rationis cum fundamento in re* (modes and beings of reason with a foundation in the thing) just as much as *Qualitates reales* (their real qualities), in which I confess I cannot find any more reality than in the others.[30]

Descartes claims that, on his account, all the dispositions and qualities found in matter follow from the same laws of nature, including both Scholastic modes and real qualities. He then adds as an aside that he finds their real qualities no more real than their modes and conceptual beings based on some aspect of a thing. This could suggest that Descartes takes all qualities to be modes, but he does not say this. Nor does he use the term 'mode' in his discussion of the elements; instead he continues to employ the familiar terms 'quality' and 'form' to designate the properties and configurations of matter.

Descartes does eventually distinguish his use of 'quality' and 'form' from their Scholastic counterparts and introduces what he will later label the modes of matter as the most basic properties that explain all qualities and forms. However, it is striking that he does not introduce the technical term 'mode' to designate these basic properties in *The World*, even when explicitly distinguishing his view from the Scholastics:

> Should you find it strange that I do not make use, as the Philosophers do, of the qualities one calls heat, coldness, humidity and dryness to explain these elements, I should say to you that these qualities seem to me to be themselves in need of explanation, and if I am not mistaken, not just these four qualities, but also all the others. Even all the forms of inanimate bodies can be explained

opinions, I shall here briefly list all the simple notions which are the basic components of our thought; and in each case I shall distinguish the clear elements from those which are obscure or liable to lead us into error." CSM I, p. 208; AT VIIIA, p. 22.

[30] AT XI, p. 40.

without the need to suppose for this effect anything else in their matter than the movement, size, shape and arrangement of its parts.[31]

If Descartes was already thinking of size, shape and motion as modes of matter, surely he would have stated this, especially given that the passage cited above shows that he was familiar with the Scholastic concept of a mode.

In Part III, I will argue that Descartes' concept of a 'mode' resembles not so much the Scholastic concept found in authors like Suarez as Gorlaeus' adaptation of this concept to an atomist physics. Hence it is not surprising that Cartesian modes make their first appearance in the metaphysical works Descartes began to work on after his return to the Netherlands. Since the substance/mode distinction is a product of Descartes' later metaphysical reflections, this basis for eliminating material substantial forms cannot be read back into earlier works. Rather, Descartes' first attempt to articulate a new metaphysical account of matter is still largely justified by the intelligibility of mathematical notions and their consequent potential for providing stable foundations for scientific knowledge. Hence I will argue that the account of matter in *The World* does not yet eliminate material substantial forms, but rather reinterprets them so as to ground physical explanations in intelligible rather than obscure notions.

First, we need to get clear on the new metaphysical account of matter that Descartes introduces in *The World.* There is an inherent ambiguity in the way in which Descartes uses the term 'body' which allows for different interpretations of its relation to 'extension.' In the *Rules* Descartes treats body as an individual physical object, and extension as an inseparable component that the intellect distinguishes from the body's corporeal nature.

> For if, for example, we consider a certain extended and shaped body, we shall indeed admit that, with respect to the thing itself, it is something one and simple. For, in this sense, it cannot be said to be a composite of corporeal nature, extension and shape, since these parts never existed one distinguished [*distinctae*] from the others; but with respect to our intellect we call it a composite made up of these three natures …[32]

Descartes also highlights the fact that 'extension' cannot denote anything other than a body, except in an abstract sense.

[31] AT xi, pp. 25–26. [32] AT x, p. 418.

Let us now proceed to the sentence, 'A body has extension,' where we understand 'extension' to denote something other than the body; however, we do not form two distinct ideas in our imagination, one of body, the other of extension, but only one of an extended body. Nor is there any difference, as far as the thing itself is concerned, than if I were to say 'A body is extended,' or better still 'That which is extended is extended.'[33]

Descartes goes on to claim that extension can be considered not to be a body only if we take 'extension' abstractly, just as we can consider number to be something other than the thing numbered only when we think in abstract terms that do not involve the imagination.[34] This implies that 'extension,' like 'number,' is an abstract concept referring to a feature of individual things in reality. As we shall see, this is exactly the way Descartes talks in *The World*.

By the time he writes the *Meditations*, Descartes claims that "everything which I clearly and distinctly understand is capable of being created by God so as to correspond exactly with my understanding of it," thus metaphysically grounding his claim that "I have a distinct idea of body, in so far as this is simply an extended, non-thinking thing."[35] As Descartes puts it succinctly in the *Principles*: "Thought and extension can be regarded as constituting the natures of intelligent substance and corporeal substance; they must then be considered as nothing else but thinking substance itself and extended substance itself – that is, as mind and body."[36] This metaphysical identification of extension with body when combined with the creation story Descartes tells in *The World* (and which he repeats in summary form in the *Discourse* and *Principles*) appears to shift the meaning of 'body' away from individual physical objects to coporeal substance in general. According to the creation story Descartes tells, individual physical objects are products of God's act of dividing the *res extensa* and setting its parts in motion in accordance with the laws of nature. But if body is equated with extension, then the particular motions and configurations that constitute individual physical objects are merely accidental to body as such. Hence we have two distinct senses of 'body' in Descartes' works, and, depending on how we intepret the relationship between body and extension, one gets privileged over the other. If we emphasize Descartes' claims in the *Rules*, then extension is a fundamental, inseparable feature of an individual body, that the intellect can grasp distinctly from other such features, like its corporeal nature and shape, but not from the body

[33] CSM I, p. 60, AT X, p. 444.
[34] CSM I, p. 60, AT X, p. 445.
[35] CSM II, p. 60; AT VII, p. 444.
[36] *PP.* I, a. 63, CSM I, p. 215; AT VIIIA, pp. 30–31.

itself, unless it abstracts. If we privilege his later works, then extension appears to exhaust the nature of body. There is a tendency, on this basis, to reify 'extension' and treat it as material substance itself rather than as an inseparable feature of individual bodies. Hence 'body' comes to refer to material substance as a whole rather than an individual body.

Most scholars privilege the later works, and so the second sense of 'body' that reifies extension tends to be read back into earlier works like *The World.* I will instead proceed on the assumption that Descartes' views in *The World* are closer to those in the *Rules*, given the proximity in time between the composition of the later Rules and *The World.* Both Gregory Brown and Desmond Clarke have challenged the standard view that material substance consists in nothing but extension for Descartes, but for other reasons.[37] While Brown's argument is based on Descartes' mature metaphysics, rather than the early scientific works under examination in this chapter, Clarke likewise draws on the *Rules*, pointing out that Descartes denies there that it is analytically true that bodies have extension. Clarke explains away later passages which appear to contradict this as cases of "rhetorical exaggeration" rather than a shift in position, and concludes: "Descartes thinks of extension as the defining accidental property of matter."[38] The notion of a defining accident is a contradiction in terms, according to Scholastic usage, since accidents are by definition non-essential properties of substances. However, this in itself does not prove that Descartes embraces Scholastic usage, and Clarke does point out a distinct advantage of reading Descartes this way: "If matter is not identical with extension (but rather metaphysically defined by this property) nor intelligible in terms of its geometrical properties alone, one could then consistently introduce a concept of density, and Descartes acknowledges the need for such a concept in a number of places."[39] In what follows, I will show that the first part of Clarke's conclusion holds of *The World*, for there Descartes equates physical matter with the intelligible matter of mathematics, not the pure extension that is the basis for the absolute quantity of metaphysics. However, I will also highlight textual evidence to show that, even at this early stage, Descartes is already committed to the view that matter is intelligible in terms of its geometrical properties alone. As I will argue in Part III, this commitment grows out

[37] Gregory Brown, "Mathematics, Physics, and Corporeal Substance in Descartes," *Pacific Philosophical Quarterly* 70 (1989), pp. 281–302; Desmond Clarke, "Physics and Metaphysics in Descartes' *Principles*," *Studies in the History and Philosophy of Science* 10/2 (1979), pp. 89–91.

[38] Clarke, "Physics and Metaphysics.", p. 102.

[39] Ibid., pp. 102–103.

of the need to avoid skeptical arguments, along the lines of Sanchez's denial that the intellect can infer anything with certainty from inherently deceptive sensory images.

In what follows, I will propose a reading of *The World* that privileges the sense of 'body' found in the *Rules* by distinguishing between two senses of 'essence' or 'form.' The first is based on the metaphysical form or essence of matter which Descartes, in various places, identifies with extension. The second is found in his physical account of the essential properties of individual bodies that are the object of scientific demonstrations. While the two essences are related, I will argue that they are by no means identical. This leaves open the possibility that not all the properties of matter are directly reducible to the metaphysical essence of pure extension. By means of a re-examination of the creation story Descartes tells in *The World* in light of what we now know about his intellectual context in the 1620s, I suggest that Descartes posits something akin to Blancanus' 'absolute quantity' as the universal, metaphysical essence of matter common to all bodies, and then introduces an analogue to the intelligible matter of the mathematician as the matter that accounts for the changing properties studied in physics. The advantage of reading the text in this way is that it limits the formal definition of material substance as *res extensa* to the metaphysical realm, thus saving Descartes from the charge that his account of the properties of physical matter is too general and too thin for the purpose of doing science. At the same time, Descartes regards this metaphysical concept of matter as the foundation that grounds the intelligible matter of mathematics, which Blancanus defined as 'delimited quantity.' Descartes' innovation is to reify this intelligible delimited quantity, turning it into the basic physical matter of natural objects studied by the physicist.

Evidence for this reading of Descartes' scientific program can be found in the creation story Descartes tells in chapter 6 of *The World.* While presented as a fable about the creation of an imaginary world for rhetorical purposes, it accurately conveys Descartes' view of the universe, as seen by the fact that it contains many elements repeated in his later writings. Descartes presents the following creation sequence in his 'fable.' The new universe is first presented in the most abstract terms possible, namely, as an indefinitely large space that God fills completely with the new matter. This is matter as purely extended substance. It has no other determinations and features but extension in length, breadth, and depth. This is Descartes' equivalent to the absolute quantity Blancanus attributes to the metaphysician – the essence of matter at the metaphysical ground level is just extension in general,

lacking any divisions and possessing an indefinite size.[40] It is also described as perfectly solid, which Descartes equates with the relative immobility of adjacent parts earlier in *The World*.[41] While this characterization of solidity may apply only once the original matter is divided, it is also possible that Descartes takes this original matter to be perfectly solid, precisely because it is completely immobile and undivided. Descartes' characterization of the original matter is, moreover, strikingly reminiscent of Blancanus' characterization of metaphysical quantity as divisible, figurable, locatable, and capable of relations and proportions. Descartes writes of it: "Add to this that this matter can be divided into all the parts, and according to all the shapes that we can imagine, and that each one is capable of receiving in it all the movements that we can also conceive."[42]

Descartes' language indicates that he conceives of this original matter as fulfilling the same role that the Aristotelian underlying nature, or prime matter, played in Scholastic metaphysics. In other words, this is not the actual matter that we observe and encounter every day, but rather, like prime matter, matter as extension in general is posited at the theoretical level. It is that which has the potential or capacity to take on different forms, where forms are recast as actual divisions, shapes, motions, and proportions by Descartes. Touting the ease with which we can imagine his matter in contrast to the difficulty we have in conceiving of the prime matter of the Aristotelians, he writes: "If I am not mistaken, the entire difficulty they experience/discover [*eprouver*] in theirs [their prime matter] comes from the fact that they wish to distinguish it from its proper quantity and exterior extension, i.e., from the property it has of occupying space."[43] In other words, the main advantage of Descartes' prime matter as opposed to Aristotelian prime matter is that it is intelligible, in the sense that we can form a clear idea of it in our imagination that is based on our mathematical ideas of quantity and dimension. However, we must be careful not to jump to the conclusion that Descartes is equating extended substance with its quantity, since he continues as follows:

> But they should not also find it strange if I suppose that the quantity of the matter which I described does not differ more from its substance than the number does from numbered things, nor if I consider its extension, or the property it has of occupying space not as an accident, but as its true Form and Essence, for they could not deny that it is very easy to conceive it in this way.[44]

[40] Descartes, *Le Monde*, ch. 6, AT XI, p. 32. [41] *Le Monde*, ch. 3, AT XI, p. 12.
[42] *Le Monde*, ch. 6, AT XI, p. 34. [43] Ibid., p. 36. [44] Ibid.

The parallel drawn here between the relationship of quantity and matter, and that of number to things numbered, echoes Descartes' claim, in the *Rules*, that extension distinguished from body is like number distinguished from numbered things. In other words, quantity is an abstraction from individual extended material things just as number is from numbered things. For this analogy to hold, quantitative properties cannot constitute the entire nature of material things, just as the number 10 does not constitute the nature of the ten hens I have counted. In other words, physical matter cannot be identical to the absolute quantity, which Blancanus identified as the intelligible matter of metaphysics. Nevertheless, it is clear from this passage that Descartes considers the property of extension to constitute the metaphysical essence of all individual bodies. Perhaps he has in mind something analogous to the way in which Suarez considers 'humanity' to be the metaphysical essence of all humans (even though it is too general to capture the diverse natures of individual human beings) but the text is too vague to determine what exactly Descartes means. This makes it tempting to read the metaphysics of the *Meditations* back into the passage just cited and assume that all the properties of physical matter must thus be strictly reducible to extension in general. However, other parts of *The World* suggest that the relationship between the metaphysical essence and physical essence of matter is not this straightforward.

The second step in the creation story comes when God actually divides the potentially divisible matter into "many such parts, some larger, others smaller; some of one shape, the others of another…"[45] What results is very like the delimited intelligible matter that Blancanus identifies as the matter of mathematics. On my reading, this is what Descartes means by 'matter' and 'material substance' in his scientific writings. Unlike the matter of the metaphysician, which is perfectly solid and immobile, this physical matter is delimited and subject to motion. In fact, the third step in the creation story, by which the material parts are set in motion, seems to be simultaneous with God's division of the metaphysical matter. One can imagine Descartes' Geometer God producing lines by means of motion and thus dividing the solid, immobile, extended substance into parts, simultaneously setting them in motion.[46] Descartes has now made the transition from metaphysics, the study of unchanging being, to physics, the study of change. With this transition we have also moved from matter, defined by the abstract, universal essence shared by all bodies (the metaphysical form of extension) to individual body and the mechanical

[45] Ibid., p. 34. [46] Ibid.

analogue for Suarez's physical essence or substantial form. This mechanical physical essence, i.e., a divided extended substance with moving parts, is, in turn, the source of particular accidents, namely the various and variable particular sizes, shapes, forces, and motions that individual bodies display over time.

My interpretation fits chapter 5 of *The World* better than the standard view that the physical essence of all material things is just pure, undifferentiated extension, for there Descartes makes it clear that he does not seek to eliminate physical forms and replace them with pure extension, but rather to re-conceive them in geometrical/mechanical terms. Before he tells his creation fable he incorporates his new definition of the physical essence or form of matter into the traditional framework of elements and forms. Descartes posits three elements, each of which has a simple form: "But the forms of the elements should be simple and not have any qualities that do not accord with one another so perfectly that each tends to the preservation of all the others."[47] The main difference between his elemental theory of matter and that of the Aristotelians is that he does not consider the qualities of 'heat,' 'cold,' 'moistness,' and 'dryness' to be basic. Rather these qualities are re-conceived as secondary qualities that can be explained "without the need to suppose for this effect any other thing in their matter but motion, size, shape, and arrangement of its parts."[48] The true simple forms of the elements consist only of primary qualities and are as follows. Fire or first-element matter need not have particles of any particular size, shape, and position, but has parts so small and moving at such great speed that they cannot be stopped by other bodies. Air or second-element matter consists in medium-sized particles that also have a moderate motion and so there are as many causes that could increase their motion as there are causes that could diminish their motion. Hence they always remain in a balanced, moderate condition. Earth or third-element matter consists in larger, more slowly moving particles which are "so closely joined together that they always have the force to resist the motions of other bodies."[49] In other words, Descartes retains the concept of a substantial form for each element, but instead of characterizing the form of each element in terms of a pair of qualities, he redefines each simple form in terms of the sizes and/or motions of particles. This indicates that he conceives of extension as a metaphysical

[47] René Descartes, The World *and Other Writings*, ed. Stephen Gaukroger (Cambridge: Cambridge University Press, 1998), p. 18.
[48] *Le Monde*, ch. 5, AT XI, p. 26. [49] Ibid., pp. 18–19.

form of matter, along the lines that 'humanity' is the metaphysical form or essence of each human being, whereas the particular sizes and motions of the three elements of matter correspond to the physical or substantial forms of individual material substances that account for their actions and qualities.

Descartes was not the first to redefine the elements exclusively in terms of the primary qualities of material particles. David Gorlaeus and Sebastian Basso, two authors known to Descartes, were inspired by ancient atomism to reduce matter to particles of different sizes, shapes, and motions well before *The World* was written. (I will examine Gorlaeus' theory in more detail in chapter 6).[50] Following in their footsteps, Descartes likewise associates different types of particles and motions with each of the traditional elements, although his associations are somewhat different from theirs. Like his atomist precursors, Descartes claims that the simple forms are retained when elements enter into mixtures. In fact, he holds that the forms of mixed bodies are reducible to the simple forms of the elements from which they are composed:

> Examine as much as you please all the forms that can be given to mixed bodies by their various motions, the various shapes and sizes, and the different arrangement of the parts of matter: I am sure that you will find none that does not contain in itself qualities that tend to bring it about that matter changes and, in changing, to reduce to one of the forms of the elements.[51]

Descartes even seems to think that, over time, the simple forms will reveal themselves: "Consequently, even if God had created only mixed bodies in the beginning, all bodies would nonetheless have had the chance to shed their forms and take on those of the elements."[52] While the details differ, in its overall form Descartes' early attempt to recast the Aristotelian theory of elements, forms, and mixtures in terms of material particles possessing only primary qualities is not unlike prior attempts by various philosophers to reconcile hylomorphism with an alternative theory of matter. There is one major difference between Descartes' corpuscularean account of the simple forms of elements and the prior theories developed by Basso and Gorlaeus. While they still acknowledge that the elements

[50] Basso's *Philosophiae Naturalis adversus Aristotelem* was first published in Geneva in 1621. In a letter to Mersenne dated October 8, 1629, Descartes writes: "As for rarefaction, I am in agreement with this physician and have now taken a position on all the foundations of philosophy; but perhaps I do not explain the ether as he does." AT 1, p. 25. The physician in question, formerly thought to be Villiers, has since then been identified as Basso. See Roger Ariew, *Descartes and the Last Scholastics* (*Ithaca*: Cornell University Press, 2000), Part II, ch. 6.

[51] *Le Monde*, ch. 5, AT XI, p. 19. [52] Ibid.

move towards certain places, for Descartes the elements "have no places in the world to which they are particularly destined, and where they can perpetually conserve themselves in their natural purity. On the contrary, since each part of matter always tends to one of their forms, once having been reduced to it, it tends never to leave it."[53] In other words, Descartes rejects Aristotelian teleology all the way down to the elemental level. This is something he has in common with Beeckman.[54]

The rejection of Aristotelian teleology necessitates the introduction of an external source of motion, and Descartes promptly addresses this need in his creation fable. Aristotelian physics commentaries, following the content and order of Aristotle's *Physics*, defined nature as an internal source of motion and rest right after defining matter as the underlying thing that persists through change. Descartes follows the traditional order but changes the content, beginning chapter 7 by redefining nature as "the Matter itself, insofar as I consider it with all the qualities I have attributed to it, taken all together, and *under the condition that God continues to conserve it in the same manner that he created it*"(emphasis mine).[55] Since matter has no inherent tendency to move towards a certain place, God, in addition to creating matter, and setting it in motion, has to then maintain it, and all its qualities, including its motion. From this Descartes derives his three laws of motion:

> For from the mere fact that he continues to conserve it [matter and its qualities] in this way, it follows necessarily that there must be several changes in its parts which, since they cannot, it seems to me, be properly attributed to the action of God, because it does not ever change, I attribute to Nature. The rules according to which these changes take place I call the 'laws of Nature.'[56]

The exact relation between God and Nature and the exact manner in which the laws of nature are supposed to be derived are deeply problematic and much debated.[57] I wish to highlight only that Descartes draws a close connection between 'nature' defined as matter and all its qualities as conserved by God, and his three laws of motion. Given the fact that

[53] Ibid., p. 28.

[54] See Van Berkel, *Isaac Beeckman*, pp. 187–190, on the differences between Beeckman's theory of motion and the Aristotelian theory.

[55] *Le Monde*, ch. 7, AT XI, p. 37. [56] Ibid.

[57] For a discussion of different positions and arguments advanced on this issue, see Helen Hattab, "Conflicting Causalities: The Jesuits, Their Opponents and Descartes on the Causality of the Efficient Cause," in *Oxford Studies in Early Modern Philosophy*, vol. I, ed. Daniel Garber and steven Nadler. (Oxford: Oxford University Press, 2003), ch. I, and "The Problem of Secondary Causation in Descartes: A Response to Des Chene," *Perspectives on Science* 8/2 (2000), pp. 93–118.

Descartes has just redefined the physical forms of bodies in terms of the sizes and motions of its parts, his redefinition of 'nature' facilitates the treatment of the motions of bodies in geometrical terms. And indeed, right after he introduces his first law of nature, Descartes again boasts about the intelligibility of his new view, this time contrasting his conception of the nature of motion to that of the Scholastics. By remaking the matter of physical change in the image of the intelligible matter of mathematics, Descartes takes himself to have ensured that all the properties inhering in that matter, even motion itself, will be as clear as geometrical properties.

> But, to the contrary, the nature of the movement of which I intend to speak here is so easy to know that the Geometricians themselves, who are among the most learned of all men at distinctly conceiving the things they have considered, have judged it more simple and intelligible than that of their surfaces and lines. This is seen by the fact that they explained the line by the movement of a point, and surface by that of a line.[58]

In other words, Descartes primarily justifies his characterization of physical/substantial forms in terms of the motions, sizes, and shapes of material particles by an appeal to the inherent intelligibility of the geometrical conception of motion. There is no hint, at this stage, that Descartes takes this to imply the rejection of the substance/accident distinction and the consequent eradication of substantial forms.

In light of the *Rules*, Suarez's distinction between metaphysical and physical forms, and Blancanus' distinction between the intelligible matter of mathematics and the absolute quantity of metaphysics, Descartes' presentation of his new account of matter in *The World* suggests that extension corresponds to the metaphysical form or essence of the unchanging matter of the metaphysician rather than the physical form of matter. Metaphysically speaking, material substance considered in terms of its universal essence does not have specific dimensions but is essentially something divisible, locatable, and figurable by virtue of its extension. This accounts for the fact that Descartes allows for properties of matter that are not strictly reducible to the essential property of extendedness. As we shall see in the next chapter, the introduction of a substance/mode ontology changes all this. However, in *The World* the metaphysical essence of matter does not yet have this tight connection to the physical forms of matter. This explains why Descartes, in his early physics, can coherently imply that there are forces and causal powers intrinsic to bodies

[58] *Le Monde*, ch. 7, AT XI, p. 39.

that are associated with the sizes of their particles, even though forces are not strictly deducible from the properties of extension alone. Statements such as the following are common in *The World*: "That it is the largest of these parts [of the flame] that have the power to burn, and not the others, is apparent from the fact that the flame that issues from brandy, or from other very subtle bodies, hardly burns at all, while that which comes from hard and heavy bodies is very hot."[59] Like his Scholastic Aristotelian predecessors, Descartes reasons from empirically observed effects back to the substantial form that is the source of a body's characteristic powers and actions. However, unlike his Scholastic Aristotelian predecessors, when he spells out the physical forms at work in his explanations of particular physical phenomena Descartes cashes them out in mechanical terms by conceiving of physical matter as something like the intelligible matter of the mathematician. In other words, the shapes, sizes, motions, and configurations of the particles making up a particular body take the place of its substantial form. Physically speaking, matter is not pure extension, but delimited extension, in the sense that God has attributed to it the basic divisions, proportions, motions, and relations that give rise to the particular shapes and motions we observe. The starting point for physics is thus not extension in general but the physical forms of the different types of simple and mixed bodies. These forms consist in the specific sizes, shapes, motions, and arrangements of a body's parts (e.g., oblong particles arranged to form salt), and the particular dimensions of these parts are associated with the different causal powers of different types of bodies.

While it is still possible to read *The World* the more common way, and dismiss Descartes' references to the 'simple forms' of the elements as a concession to Scholastic terminology which masks a more radical commitment to one *res extensa*, his later works aside, there is no pressing reason to read his early scientific writings this way. There is every reason not to read them this way, because if the physical essential form of 'body' is just pure, undelimited extension, then Descartes has a real problem individuating bodies and getting his scientific demonstrations of particular physical phenomena off the ground. There is nothing about matter's extendedness that dictates that its particles take on the particular shapes, sizes, and motions that they do. An infinite number of possibilities can be derived from the premise that matter is essentially extended, whereas the attribution of simple forms to each element, consisting in

[59] The World *and Other Writings*, p. 12.

certain configurations of particles with certain sizes and motions, allows Descartes to infer what kinds of motions result when the laws of nature are applied to such simple forms. As many commentators have noted, we end up with an explanatory gap if we conflate the metaphysical with the physical essence of bodies, for then all Descartes' demonstrations about the material world would begin with the premise that matter is extension. Gregory Brown explains the problem that emerges on this reading of Descartes clearly and succinctly:

> Thus it was not particular geometrical figures or (perfectly) rectilinear and (perfectly) circular motions that Descartes claimed to conceive clearly and distinctly in physical objects, but rather figure, motion, and extension *in general* – it was only a *generic* figure, extension and motion that Descartes supposed we could conceive clearly and distinctly to be in physical objects. That the material world is *intelligible* to us is something which, on Descartes' view, is guaranteed simply by the fact that we have an intuitive grasp of the *general* concepts of extension, figure, and motion. Compared to Newton's *Mathematical Principles of Natural Philosophy*, or to any contemporary textbook of physics, Descartes' *Principles* appear to be decidedly non-mathematical.[60]

This problem lends credibility to the attribution of a hypothetical method to Descartes; i.e., he tries to narrow down the countless possibilities that follow from the extendedness of matter by hypothesizing about the microstructure of salt and other physical substances. However, as already pointed out in the previous chapter, Descartes' supposition about the nature of salt in the *Discourse* was a matter of presentation – whatever his position in later works, at that time he did not take it to preclude a complete *a priori* proof of his assumed premise. We can make sense of this if we recognize that Descartes' early scientific demonstrations are not meant to begin with the general premise that matter is extended, but with premises about the particular geometrical properties of the particles of certain substances, like salt. Descartes, at this time, still thought he could derive these premises *a priori* from self-evident geometrical axioms and other primary truths. In this manner, Descartes took himself to be giving mathematical demonstrations of salt's observed properties. The simple forms of the elements, which are demonstrated from the 'primary truths,' in combination with the laws of nature, allow for the derivation of the essential forms of compounds like salt.

In short, my distinction between 'extension' as the metaphysical essence of matter, and the 'simple forms' as Descartes' analogue for material

[60] Brown, "Mathematics, Physics, and Corporeal Substance in Descartes," pp. 281–302.

substantial forms, accounts for his confident claim that "those who know how to sufficiently examine the consequences of our rules could know the effects by their causes, and to explain myself in the terms of the School, could have *a priori* demonstrations of everything which could be produced in this new world."[61] There is, moreover, a second advantage to my reading of *The World*. By grounding his physics on the intelligible, nondeceptive ideas of particular geometrical shapes and motions Descartes also succeeds in meeting Sanchez's requirement that scientific knowledge reflect the unity of the universe. He does so by redefining matter in such a way that the objects of each science, from metaphysics all the way down to physics via mathematics, are successively more determinate instantiations of the more general object of the science above it. In this manner, the sciences are inextricably connected like links in a chain and form a unity rather than an Aristotelian hierarchy.[62] In other words, if the metaphysical essence of matter is pure extension or undelimited quantity, and if the matter of mathematics is akin to Blancanus' delimited quantity whereas the particular objects of physics are the particular sizes and shapes that the delimited quantity of mathematics takes on, then all scientific demonstrations, from top to bottom, will be securely grounded in the principles of mathematics.

Part 2 of the Preface to the *Discourse*, which was written well after the completion of *The World*, likewise implies that the object of study consists in the geometrical properties of particular objects, not extension in general. There Descartes resolves to abstract from the sensible qualities of objects and study only their proportions, which he will represent by means of lines, when he needs to consider them separately, and by means of algebraic symbols, when he needs to understand and keep them in mind all at once.

> And considering that among all those who previously sought truth in the sciences, only mathematicians have been able to find some demonstrations, that is to say some certain and evident reasons, I did not doubt that this would only occur through the same [simple and easily known things from which they commence] which they had examined … But I did not aim to try and learn all the particular sciences commonly called 'mathematics,' and seeing that, although their objects were different, they agreed in considering nothing but the diverse relations or proportions found among them, I thought it best to examine only

[61] AT XI, p. 47.

[62] Descartes upholds the unity of the sciences in Rule 1: "It must be acknowledged that all the sciences are so closely interconnected that it is much easier to learn them all together than to separate one from the other." CSM I, p. 10; AT X, p. 361.

these proportions in general, supposing them only in subjects that would enable me to facilitate knowledge, while in not restricting them to these, so that I could later apply them all the better to others to which they might correspond.[63]

Descartes thus builds on Guevara's insight that the mechanical sciences study not the light and heavy objects themselves, but the proportions that obtain between them and their forces. He effectively takes this abstraction to the next level, applying it not just to the objects of mechanics, but to other sciences as well. [64] He also develops a universal means of representing these proportions. But what is not revealed in this part of the *Discourse* is that Descartes is not merely performing an abstraction from sensible matter; rather, he already holds the real proportions found in nature to correspond to the delimitations and proportions found in the intelligible matter of mathematics. As we saw from the passages in his unpublished *The World* cited above, Descartes had by this time already redefined the object of physics so that it conformed to the intelligible object of mathematics. Once physical matter is redefined in this manner, Descartes is in a position to apply the mathematical form of demonstration, with all its advantages, to the domain of natural philosophy.

In short, the intellectual circle in which Descartes moved in the 1620s, as he developed his scientific method, points to an alternative interpretation of Descartes' first attempt to offer a new metaphysical account of matter in support of his method. As established in chapter 5, key concepts and distinctions found in the works of Blancanus and Guevara are likely to have been familiar to Descartes via his Parisian friends. I have shown that they significantly clarify the nature of Descartes' earliest attempt to establish metaphysical foundations for his science by cashing out material substantial forms in mechanical terms. In *The World* Descartes does this by redefining the object of physics in terms of the intelligible matter of mathematics, thus erasing the already blurred distinction between the aspects of physical reality studied by the mixed mathematical sciences and those studied by the physicist. Recall Leonico Tomeo's claim that

[63] AT VI, pp. 19–20.

[64] Stephen Gaukroger observes that Descartes, in effect, makes an identification between the objects of mathematics and the objects of physics by means of "a two-fold 'reduction' in which the objects of mathematics are construed purely as proportions that can be represented symbolically as figures and line segments and in which the objects of physics are construed purely as extensions, all other physical properties being treatable in terms of extension." "Descartes' Project for a Mathematical Physics," *Descartes: Philosophy, Mathematics and Physics*, ed. Stephen Gaukroger (Brighton: Harvester Press, 1980), p. 98.

those engaged in mechanics as opposed to physics "investigate circles, diameters and circumferences: and even the weights and measures that are granted to exist in natural matter, certainly seem to abstract from it and not undeservedly seem to lead them away from it, and to display and represent only the reasons of the forms."[65] Descartes' redefinition of the object of physics as reified delimited quantity eradicates the need for such an abstraction – the essential forms of physical objects literally consist in the same circles, diameters, and circumferences as the mathematical object of mechanics and thereby acquire the intelligibility of mathematics. This is the sense in which Descartes' early "physics is nothing but geometry."[66]

At this early stage, Descartes presents these mechanical/physical objects in traditional terms. They consist in elements made up of particles of particular sizes, shapes, and motions. The specific sizes and motions of the elemental particles make up their simple forms, and these forms persist when they enter into compounds. These simple forms also account for the fact that the actions of both elemental and mixed bodies are regular, to the point that they conform to general laws. Quantity is an abstraction from these particular objects, just as number is an abstraction from numbered things. Similarly, the metaphysical essence of 'extension' appears to be the general, defining attribute of all particular bodies, which does not preclude bodies from possessing powers and forces that are not directly reducible to extension. Descartes' apparent lack of interest in clarifying the exact ontological relationship between the metaphysical essence of extension, the changing sizes, shapes, and motions of material particles, and the powers they exert in *The World* is consistent with his scientific ambitions, and his relative lack of interest in metaphysical matters during this early period. It is clear that for the purposes of scientific explanation, the metaphysical essence of matter is far too general and abstract to be of any practical use. For example, establishing that body's essence is to be extended does not suffice to explain the observable properties of the grains of salt. Rather, as we saw above, Descartes thinks that starting from geometrical axioms, one must establish that their parts have particular geometrical properties (i.e., oblong shapes that easily cohere to one another) to derive any explanatory benefit. The priority Descartes gives to the particular geometrical properties of matter is reflected in the fact that he gives his corpuscularean account of the three elements of matter in chapter 5 of *The World* before

[65] Tomeo, *Opuscula*, xiv. [66] CSMK, pp. 118–119; AT 11, p. 268.

giving his metaphysical definition of matter as part of the creation story found in chapter 6. However, sometime between beginning *The World* in 1629 and the publication of the *Discourse* in 1637, Descartes' interests shift to metaphysical concerns. The implications for the doctrine of the substantial form will be examined in Part III.

PART III

Eliminating substantial forms

I argued in Part II that Descartes' new account of matter, and his replacement of Scholastic material substantial forms with essential forms drawn from mechanics, stemmed from his project of providing mathematical demonstrations of physical phenomena. In the *Discourse* he justifies his new account indirectly by pointing to the explanatory success of scientific demonstrations based on suppositions about the essential forms of light, water, and salt. In *The World* he attempts to give a metaphysical grounding for his scientific demonstrations that does not yet indicate a commitment to the substance/mode ontology of his later metaphysical works. Rather, his project there resembles prior attempts to provide a more concrete (in this case, mechanical) analogue to the elemental forms of the Scholastics. As highlighted in the Introduction, Descartes was not the first to reject Aristotelian substantial forms. Moreover, my examination of his early scientific writings in light of his intellectual context reveals that he fully rejected them only late in his career, seeking first to unpack them in mechanical terms. I will now argue that the full metaphysical elimination of Aristotelian substantial forms characteristic of Descartes' mature philosophy had to await his response to standard skeptical arguments (of the kind marshaled by Sanchez) that preoccupied Mersenne. Descartes introduces two metaphysical doctrines to securely ground his scientific demonstrations and mathematical account of matter: the doctrine of the eternal truths of mathematics, and a substance/mode ontology like the one he would have encountered in his Dutch intellectual context. The second has the effect of eliminating material substantial forms.

Descartes moved back to the United Provinces of the Netherlands in 1629 and was to remain there for the better part of his adult life. During his extended stay in the Netherlands, he changed residencies frequently, depending on his intellectual goals and the friendships he formed. He first registered at the University of Franeker on April 16, 1629, believing Adrianus Metius, who was Professor of Mathematics there, to be related

to the Metius who had invented the telescope. When he failed in his plans to lure Ferrier, the French lens-grinder, to Franeker to assist him in making telescopes so that he could observe parhelia and other astronomical phenomena, Descartes registered as a student at the University of Leiden on June 26, 1630.[1] This move was, in all likelihood, motivated by the fact that Jacob Golius, Professor of Mathematics at the university, had recovered an Arabic manuscript containing the lost books of Apollonius of Perga's *Conics.*[2] Golius became a loyal friend, later defending Descartes' independent discovery of the law of refraction against accusations that he had stolen it from the Professor of Mathematics Golius had replaced: Willebrord Snellius (a.k.a. Willbrord Snel, author of Snel's law). However, Descartes did not remain in Leiden for long, moving back and forth between Amsterdam and Deventer (where Henricus Reneri taught) between 1631 and 1633. In 1635 Descartes followed his friend Reneri to Utrecht. He returned to Leiden briefly in 1636 and 1637 for the purpose of meetings with the publishing company Elzevier, with which he had initially planned to publish his *Discourse.* In 1640 Descartes took up residency in a house in Leiden located directly opposite the house of Golius, and in 1641 he moved to Castle Endegeest, situated not far from Leiden. He was to live there again from 1643 to 1649.[3]

If we track Descartes' movements across the Netherlands, a clear pattern emerges. He initially targeted universities that housed mathematicians whom he believed could, in some way, advance his scientific research. Clearly Descartes' initial goals were rooted in his interests in geometry and mixed mathematics, not metaphysics. Once in the Netherlands, Descartes formed strong intellectual friendships, so much so that he would move house just to be close to his friends – Reneri is a case in point. This indicates that, despite his claims to have moved to the Netherlands to get away from social obligations, Descartes gained much of his intellectual stimulation from his Dutch environment. That this environment was a diverse and rich one can be seen from the example of the University of Leiden alone. Established in 1575 by William of Orange, at the heels of the Dutch revolt against Spanish rule, the university quickly established itself as the flagship university of the newly founded Dutch Republic.[4] Although founded as a Calvinist institution, the university statutes were

[1] Verbeek, *De Nederlanders en Descartes*, p. 22.
[2] Theo Verbeek, Erik-Jan Bos and Anton van der Lem, *Descartes en Leiden* (Leiden: Universiteits Bibliotheek Leiden, 2003), p. 9.
[3] *De Nederlanders en Descartes*, pp. 22–23.
[4] Ruestow, *Physics at Seventeenth- and Eighteenth-Century Leiden,* pp. 2–3.

soon revised, releasing all students but students of theology from taking an oath to adhere to Calvinist doctrine. The student body was correspondingly diverse, including Catholics, Jews, Socinians, and members of the Eastern Orthodox church. This policy of religious tolerance, combined with a series of strategic hires (the University of Leiden counted renowned philologists Justus Lipsius and Josephus Justus Scaliger among its faculty, as well as the famous botanist Carolus Clusius), no doubt contributed to the University of Leiden's reputation as one of the premier universities in seventeenth-century Europe.[5]

The curriculum at Leiden was innovative in two respects. Due to its excellent faculty in this field, the university was known for classical and philological studies, which included not only Greek, Latin, and Hebrew but also Arabic. But more importantly, with regard to Descartes' interests at the time, the University of Leiden was the seventeenth-century successor to the University of Padua in the domain of medical studies. After constructing an anatomical theater in 1597, the University of Leiden successfully established clinical instruction in medicine from 1638 onwards – something that had been tried unsuccessfully at Padua.[6] In 1634 a medical student by the name of Franciscus de le Boe Sylvius defended John Harvey's theory of the circulation of the blood in his medical disputation at Leiden.[7] He returned to Leiden in 1638 after further studies at Padua, and in 1658 became a Professor of Medicine at the university.[8] Sylvius won his Professor of Medicine at Leiden, Adrianus Walaeus, over to Harvey's theory, and Walaeus was a friend of Descartes.[9] Regardless of whether Descartes' response to Harvey's theory in the *Discourse* was directly inspired by Sylvius' disputation and/or conversations with Walaeus, it is clear from the *Discourse* that he was engaging with advances in medicine that were the topics of the day at the University of Leiden. That Harvey's theory continued to be topical in Leiden right up to Descartes' composition of the remaining parts of the Preface to the *Discourse* in 1637 is seen by the fact that the Leiden printer Ioannis Maire, who also published the *Discourse*, reprinted Harvey's *De motu cordis* together with objections by two other physicians in 1636.[10]

In addition to its fame as a center for philological and medical studies, the University of Leiden was also infamous for having prompted the

[5] Ibid., pp. 4–6. [6] Ibid., pp. 5–7.
[7] J. Schouten, *Johannes Walaeus* (Assen: Van Gorcum, 1972), p. 14.
[8] Ruestow, *Physics at Seventeenth and Eighteenth-Century Leiden*, p. 7.
[9] Verbeek, Bos, and van der Lem, *Descartes en Leiden*, p. 23.
[10] Schouten, *Johannes Walaeus*, pp. 15–16.

Arminian crisis. By 1619 this prolonged theological crisis had resulted in a schism within Calvinism when the Arminians, who questioned divine predestination, were branded as heretics at the Synod of Dordrecht. What started out as a theological dispute between Jacob Arminius (1560–1609), member of the theology faculty at the University of Leiden, and his more orthodox colleague, Franciscus Gomarus (1563–1641), grew into a political crisis due to the close connection between religious and political concerns that existed in the loose federation of Dutch provinces at this time. To preserve political stability and unity, Prince Mauritz sided with Gomarus and the orthodox Calvinists. The Remonstrants, who took up Arminius' cause after his death in 1609, were forced into hiding and exile when Descartes left the Netherlands the first time in 1619. However, after the death of Mauritz in 1625, the Remonstrants returned, and controversial writings attributed to Arminian sympathizers and Socinians continued to circulate in the following decades.[11] Verbeek points to interesting parallels between the threat that Cartesianism posed to Orthodox Calvinists and the earlier threat of Arminianism.[12] In fact, a suspected connection between Descartes' teachings and the writings of one such Arminian/Socinian sympathizer became the basis for Gijsbert Voetius' accusations against Descartes, prompting what is commonly referred to as the Utrecht quarrel.[13]

In 1641 one of Descartes' Dutch followers, Henricus Regius, Professor of Medicine and Botany at the University of Utrecht, in Descartes' presence and apparently with his encouragement, held a public disputation in which he defended the thesis that the human mind and body formed an accidental, not a substantial, union. This thesis undermined the standard identification of the soul as the substantial form of the body, which not even Descartes denied. When Regius was taken to task for this in private by Voetius, Regius protected his mentor, Descartes, claiming he had merely taken the view from David Gorlaeus (1591–1612). Thus he unwittingly associated Descartes with one of the enemies of orthodox Calvinism.[14] Written accusations against Regius and Descartes by Voetius ensued. The letter to Regius discussed in chapter 1 represents Descartes' attempt to coach Regius on how to defend Cartesian philosophy against Voetius' charge that it effectively turns human beings into accidental unities by denying substantial forms. Why was Voetius so

[11] Verbeek, *Descartes and the Dutch*, pp. 1–4. [12] Ibid., p. 5.
[13] Theo Verbeek, *La Querelle d'Utrecht: René Descartes et Martin Schoock* (Paris: Impressions Nouvelles, 1988).
[14] Verbeek, *Descartes and the Dutch*, pp. 16–17.

concerned about the potential connection between Descartes' rejection of substantial forms and that of Gorlaeus? Voetius had been a fellow student of Gorlaeus while both studied theology at the University of Leiden and so he knew full well that Gorlaeus had been an Arminian sympathizer and supporter of Conradus Vorstius. Vorstius was Arminius' replacement at the University of Leiden until, after only half a year, accusations of Socinianism from, among others, James I of England forced him to relinquish his position in 1612.[15] Voetius' fatal association of Regius' and Descartes' teachings with Socinianism via Gorlaeus' writings may well have been spurious and politically motivated; however, unfortunately for Descartes, it was not entirely lacking in credibility. Hence Cartesiansim came to be associated with heresies that threatened not just Aristotelian philosophy, but the sociopolitical order.

In this part, I will show that, even though Descartes never publically affirmed Gorlaeus' view that the human mind and body form an accidental union, the substance/mode ontology Descartes adopts from the *Meditations* onwards resembles Gorlaeus' metaphysics in key respects. In both cases, these new metaphysical foundations imply the elimination of substantial forms from the metaphysical as well as the physical realm. It is, moreover, highly likely that Descartes knew of Gorlaeus' philosophy, for as Verbeek puts it, "His book, detestable though it was to people like Schoock and Voetius, was in everybody's hands."[16] Hence, it was not unreasonable for Voetius to conclude that, based on his commitment to Gorlaeus' substance/mode ontology, Descartes must have secretly embraced its logical implication, namely, that the soul cannot be a substantial form that composes a substantial unity with the body.

[15] Christoph Lüthy, "David Gorlaeus' Atomism, or: The Marriage of Protestant Metaphysics with Italian Natural Philosophy," *Late Medieval and Early Modern Corpuscular Matter Theories*, ed. Christoph Lüthy, John E. Murdoch, and William R. Newman (Leiden: Brill, 2001), pp. 274–275.

[16] Verbeek, *Descartes and the Dutch*, p. 9.

CHAPTER 7

Atoms, modes, and other heresies

In this chapter I examine the metaphysical basis for Gorlaeus' elimination of substantial forms before unpacking Descartes' argument against material substantial forms based on the substance/mode distinction (argument 5 among the ones he offers to Regius). Gorlaeus firmly rejects the Aristotelian substance/accident distinction in favor of a substance/mode ontology, and hence anticipates Descartes' later metaphysics. Little is known about David Gorlaeus. Most of the scanty biographical details we have were uncovered by F. M. Jaeger in 1918.[1] Christoph Lüthy, in an article on Gorlaeus' atomism, supplements Jaeger's findings with a few more recent discoveries. Two works by Gorlaeus survive: the *Exercitationes Philosophicae* (Philosophical Exercises) published in 1620, and the *Idea Physicae* (Physical Idea), which did not appear in print until 1651. I will focus on the *Exercitationes,* both because of its earlier publication date and because it contains the metaphysical foundations of Gorlaeus' physics, whereas the *Idea Physicae* is a summary of his physics. Both works were published posthumously, since Gorlaeus died in 1612, at the young age of twenty-one. From the fact that Gorlaeus refers to Galileo's telescopic discoveries, Lüthy establishes that these works were written sometime between 1610 and 1612. That someone so young could have authored them is remarkable. Lüthy attributes the innovative ideas they contain in part to Gorlaeus' educational trajectory. In 1606 Gorlaeus enrolled as a student at the Frisian University of Franeker, where he would have been exposed to the natural philosophy of Italian naturalist philosophers, like Girolamo Cardano, through the teachings of Professor Henrico de Veno. In 1611, he enrolled as a theology student at the University of Leiden just before the controversy over the hire of Vorstius broke out.[2] Hence Gorlaeus followed

[1] F. M. Jaeger, "Over David van Goorle als Atomist en Over het Geslacht van Goorle in Noord-Nederland," *Oud Holland* (1918).

[2] Lüthy, "David Gorlaeus' Atomism," pp. 260–261, 263, 266.

the same educational trajectory that Descartes followed about two decades later, when he enrolled as a student first at the University of Franeker and then at the University of Leiden. The affinities between Descartes' philosophy and Gorlaeus' could indicate that Descartes was directly acquainted with Gorlaeus' text, or could be explained by the fact that he was exposed to the same theories taught at the universities of Franeker and Leiden and adopted some of the same elements.

As already mentioned, Voetius knew Gorlaeus as a student of theology at Leiden who had sided with the Arminian camp. In fact, Lüthy argues that Gorlaeus' commitment to atomism and the accidental union of soul and body was driven by his theological orientation. There are certainly indications that theological issues played an important role in Gorlaeus' philosophical views, as was the norm in this period. However, this should not obscure the fact that, like all theology students, Gorlaeus had to study philosophy first. Moreover, there are clear indications that philosophy was more than a passing interest to him, since he engaged with the philosophical arguments of his time and also provided a philosophical basis for rejecting Aristotelian hylomorphism. In what follows, I will concentrate on the elements of Gorlaeus' metaphysics that anticipate Descartes' eventual adoption of a substance/mode ontology and consequent elimination of substantial forms. However, I do not thereby mean to imply that the other aspects of Gorlaeus' philosophy are unworthy of our attention. As Lüthy points out, "Gorlaeus' idea of molecular properties, described in 1611, predates whatever we may find in Beeckman's *Journal*, Basson's *Philosophia naturalis*, Galileo's *Saggiatore*, or Sennert's natural philosophical works."[3] Even more so than Telesio, Bruno, and Basso, Gorlaeus deserves further study as an innovative anti-Aristotelian philosopher of this period. Indeed, his alternative to Aristotelian natural philosophy is more consistently anti-Aristotelian than theirs, since it not only embraces an alternative theory of matter but rejects even a universal substantial form.

7.1 SUAREZ'S THEORY OF MODES

Before we delve into Gorlaeus' rejection of Aristotelian accidents in favor of modes, a few words about the Scholastic concept of a 'mode' are in order. The modal distinction has a long history that goes back to medieval debates between realists and nominalists. Briefly, to avoid classifying relations like inherence and union as either separable things or merely

[3] Ibid., p. 252.

conceptual entities, realists developed intermediate distinctions, the most famous of which was John Duns Scotus' formal distinction.[4] Another was the modal distinction. For example, a relation like inherence could not be a *res* (thing) because that implied separability, and yet realists wanted to maintain that the being of green in the thing (i.e., the inherence of greenness in a certain subject, like Kermit the frog) was something distinct from the accident of greenness in the abstract. Hence they referred to an accident's inherence as a *modus essendi* (mode of being). The nominalist position was that the being of green in the thing was merely conceptually distinct from greenness, and secondarily signified nothing more than something that has greenness, in this case Kermit. To avoid this nominalist result, Fonseca and Suarez claim that the inherence itself is a mode which must exist *in natura rei* (in the nature of the thing). In other words, while not a *res* itself, it is grounded in a real feature of the nature of the *res* (in this case the *res* is the quality of greenness).[5]

While Pedro da Fonseca identifies and discusses three different types of modes found in the Scholastic tradition, Stephen Menn has shown that he does not develop a systematic account of modes. Suarez amends and builds on Fonseca's discussion, providing the first systematic and comprehensive account of modes.[6] Suarez's account differs from Fonseca's in two ways that appear to anticipate Cartesian metaphysics. First, unlike Fonseca and other Scholastics, Suarez claims that figure is only a mode of quantity. In objecting to the example Fonseca gives to illustrate the first sense of 'mode' (entities distinct from others, e.g., whiteness and sweetness), he writes, "In this class, he also places figure, though wrongly, for figure belongs to the third class, since it modifies quantity as a mode, not as a thing entirely distinct from quantity."[7] Indeed, Suarez recognizes Fonseca's third sense of 'mode' as the only proper sense, though he considers some of his examples inappropriate.[8] Suarez describes modes, in the proper sense, as follows:

In created things, besides their entities, which are, as it were, substantial and (if I may use the term) radical, there are apprehended certain real modes that are

[4] For an excellent overview of this debate, see Stephen Menn, "Suarez, Nominalism, and Modes," in *Hispanic Philosophy in the Age of Discovery*, ed. Kevin White, Studies in Philosophy and the History of Philosophy (Washington DC: Catholic University of America Press, 1997), pp. 227–239.

[5] Ibid., p. 239.

[6] **For example, Menn points out that whereas the modal distinction coexists with the formal distinction in Fonseca,** in Suarez the modal distinction replaces the formal one. Ibid., p. 238.

[7] Francisco Suarez, *Francisco Suarez on the Various Kinds of Distinctions*, trans. Cyril Vollert (Milwaukee, WI: Marquette University Press, 1947), *MD* 7, sec. I, 19, p. 30. (henceforth *MD* 7).

[8] Ibid.

something positive and of themselves modify the very entities by conferring on them something that is over and above the complete essence as individual and as existing in nature.[9]

He illustrates this with the example of quantity, which can be considered under two aspects: "the entity of quantity itself" and "the union or actual inherence of this quantity in the substance."[10] The first aspect corresponds to quantity as a thing (*res*) or being and includes what belongs to the essence of the individual quantity found in nature. This thing is separable from its subject in that it can be preserved even if separated from its subject, as in the case of the Eucharist. The second aspect, the inherence of quantity, is not a *res* but a mode, for it merely modifies quantity, "ultimately determining its state and manner of existing, without adding to it a proper new entity."[11]

Suarez's more narrow and consistent definition of a mode leads him to reformulate the modal distinction in a way that anticipates the definition Descartes gives in the *Principles*. For Suarez, a real distinction exists between two things that can exist without each other. A modal distinction exists when one can exist apart from the other, but not vice versa.[12] When neither can exist without the other, the distinction is merely one of reason. While Descartes casts his three distinctions in terms of conceivability, they map onto Suarez's distinctions: things that can each be understood apart from the other are really distinct; a modal distinction exists between a substance, which can be conceived separately, and its mode, which cannot be understood apart from the substance; and finally there is only a conceptual distinction between substances and their attributes, since we cannot form a clear and distinct idea of either apart from the other.[13] This parallelism, combined with Suarez's novel claim that figure is a mode of quantity, makes it tempting to interpret Descartes' substance/mode metaphysics as a further development of the Suarezian theory of modes. However, the differences between them are too fundamental to warrant this conclusion. First, Suarez does not take the further step of identifying quantity with material substance. Quantity remains

[9] *MD* 7, sec. I, 17, p. 28. [10] Ibid. [11] Ibid.

[12] Suarez writes: "Separation of one thing from another, if the separation is merely non-mutual (as it is commonly called), that is, a separation in which one extreme can remain without the other, but not conversely, is a convincing argument for a modal distinction … it is intrinsic to a modal entity that it cannot exist by itself, or be actually separated from what it modifies … We may add as a confirmation that local motion is in this way compared with a mobile object, and sitting with the sitter, and action with its terminus; but no one who regards the matter aright would require more than a modal distinction between such extremes." *MD* 7, sec. II, 6, p. 44.

[13] *PP* 1, a. 60–62; CSM 1, pp. 213–215; AT VIIIA, pp. 31–33.

for him an accident, separable from matter itself, and so, despite the fact that figure is recast as a mode of quantity, it is in no way a mode of material substance. As we shall see in the next section, Gorlaeus does make the crucial identification between substance and quantity, thus transforming modes of quantity, like figure and length, into modes of substance. The second key difference from Suarez's account is that Descartes' account of modes necessitates the elimination of all Scholastic accidents and real qualities, for accidents like size, shape, and motion are recast as modes of matter, and sensory qualities like whiteness and heaviness as modes of the mind/body union. Suarez's definition of modes, by contrast, rests on the very assumption that there are accidents, like quantity, which are separable from their subjects, for it is only on this assumption that we can identify a second aspect of such accidents, namely their inherence in the subject and consequent modification of quantity, considered abstractly. In sum, Suarez clearly maintains a substance/accident/mode ontology, not a substance/mode ontology.

One could argue that Descartes, having developed his corpuscularean physics, seizes upon Suarez's doctrine of modes as a way to flesh out the metaphysical relation between the shapes, sizes, and motions of his physics, and *res extensa*. But then why does Descartes not characterize these properties as modes in *The World*? He clearly was familiar with the Scholastic term at that time, as seen from his identification of qualities and dispositions of matter with "those which the learned call, *Modos & entia rationis cum fundamento in re* (modes and beings of reason with a foundation in the thing) just as much as *Qualitates reales* (their real qualities), in which I confess I cannot find any more reality than in the others."[14] But there is no hint that Descartes incorporates this Scholastic technical term and the modal distinction it implies into his own philosophical system at this stage. Instead he lumps 'modes and beings of reason with a foundation in the thing' together, a mistake he repeats in his Replies to Caterus, and which he does not correct until the *Principles*: "I am aware that elsewhere I did lump this type of distinction with the modal distinction, namely at the end of my Replies to the First Objections."[15] In actual fact, Descartes conflates Scotus' formal distinction with the modal distinction in his reply to Caterus, which further heightens the confusion surrounding the way Descartes uses these Scholastic distinctions. This suggests that Descartes first began to

[14] AT XI, p.40. [15] *PP* I, a. 62; CSM I, p. 215; AT VIIIA, p. 30.

familiarize himself with the complex Scholastic theory of modes while writing the *Principles.*[16] And yet he already employs the term 'mode' as a technical term in the *Meditations.* So sometime between completing *The World* and writing the *Meditations* Descartes began to develop his substance/mode ontology. Given his apparent lack of motivation to delve into the subtle disputes and 'huge tomes' of the Scholastics during this period, it is far more likely that Descartes' substance/mode ontology was inspired by a non-Scholastic source. Due to both its geographical proximity and conceptual similarities, the most likely candidate is Gorlaeus' theory of modes.

7.2 THE METAPHYSICAL FOUNDATIONS OF GORLAEUS' ATOMISM

Unlike Suarez, Gorlaeus explicitly rejects the Scholastic distinction between substance and accident on the grounds that being cannot be divided into the species of substance and accident. He adds that some qualities, like light, heat, and cold, which the Scholastics classify as accidents, are not even beings. To divide being properly one must divide it not according to accidents but according to physical natures.[17] Gorlaeus' rejection of Aristotelian accidents stems from his metaphysical monism. Being is one, and so entity is always unity. Multitude, since it is opposed to unity, is opposed to being. Accidental beings that can be separated from the entity are thus non-beings. Gorlaeus refers to them as 'coexistences' since they do not belong to the essential properties of the whole.[18] From such coexistences arise related affections like cause, effect, subject, instrument, sign, signed, whole, part, same, diverse, equal, unequal, similar,

[16] Norman Wells gives additional evidence which supports my claim: "Further in a letter to an unknown correspondent Descartes again refers back to his reply to Caterus as well as to his remarks in the *Principles.* But this time it is indicated that the use of 'modal' in the *Meditations* was an improper use of the term and did not indicate a proper modal distinction. Preferably, it should be called a formal distinction. But to avoid confusion, Descartes indicates that in his *Principles* he labeled it a distinction of reason. Thus in the *Principles* the formal distinction of the *Meditations* is indicated to be a distinction of reason and in the letter the modal distinction of the *Meditations* is labeled a distinction of reason." Norman Wells, "Descartes on Distinction," in *The Quest for the Absolute*, Boston College Studies in Philosophy 1, ed. Frederick J. Adelmann SJ (The Hague: Martinus Nijhoff, 1966), pp. 105–106. The letter in question is a letter of 1645 or 1646 to an unknown correspondent and indicates that Descartes was still refining his use of this Scholastic terminology after the *Principles.*

[17] David Gorlaeus, *Exercitationes Philosophicae* (Leiden: Iohannis Ganne & Harmanni à Westerhuysen, 1620), pp. 13–14.

[18] Ibid., pp. 17–18.

and dissimilar. These do not belong *per se* to the object and are the subject matter of logic.

For Gorlaeus, only essential entities can be the subject matter of science, hence anything that does not belong *per se* to the object ought not to be treated in science. The reason for this is that each precept of a science should be a necessary axiom.[19] This leads Gorlaeus to deny the standard Aristotelian view that science consists in knowledge of causes. For him cause and effect are mere logical concepts. He argues for this on the grounds that before he created the world God was being, and was neither cause nor effect.[20] Thus being a cause does not place anything real in God, and designating him as a cause is "only a denomination of the mind for explaining in what manner God relates to other things."[21] Indeed, it is like stating that something is to the right of me – it changes and becomes located to the left of me as soon as I turn around.[22] Consistent with his monism, Gorlaeus identifies one science of being that cannot be divided into species, but only into parts.[23] The parts correspond to the different components of being: the creator, created beings (angels), and created accidents. That is, theosophy deals with the nature of God and his attributes, angelography is the study of angels, and physics is the study of accidents.[24] But prior to these parts, which taken together cover the traditional subject matter of metaphysics, is first philosophy, a universal philosophy that consists in a general treatment of things. According to Gorlaeus, this first universal science of being considers being as a whole, including all its affections.[25]

In his Second Exercise, entitled "On Being," Gorlaeus surveys the types of being identified by first philosophy: real being, beings of reason, accidental beings, and modes. As already indicated, the only real beings are those whose essences exist *per se*, i.e., things that do not essentially have their being in another or towards another. Such essences are not formed by the intellect; they are not given in thinking, but rather have their proper existence in themselves, not through another.[26] These are directly opposed to beings of reason, which are fashioned by the intellect and have their being from it. Beings of reason also have their own essences through which they are what they are, and they have an efficient cause of their kind of being. Gorlaeus then argues that even though it can

[19] Ibid., pp. 16–17.
[20] Ibid., p. 19. Given Gorlaeus' earlier claims that science treats of being, and accidents are not beings, this implies that physics is a science in a merely derivative, not a primary, sense.
[21] Ibid., p. 20. [22] Ibid., p. 19. [23] Ibid., p. 11. [24] Ibid., p. 14. [25] Ibid., p. 11.
[26] Ibid., p. 22.

be conceived that one being of reason is the cause of another, this does not explain the variety among beings of reason. Therefore, their ultimate source is the intellect. Gorlaeus explains fictional entities by claiming that the mind can join two concepts acquired from the senses to create an image in the intellect that does not correspond to anything that exists inside or outside the mind. For instance, by joining the concept of an ass with that of flying, we create the fictional entity of a flying ass.[27]

In between real being and beings of reason lie two further divisions. Accidental being, for Gorlaeus, is being by aggregation, not being *per accidens* in the Scholastic sense. Such beings exist only because their parts exist. This is the type of being physics studies. The union of the parts can come about in different ways: they can merely be contiguous, as in a heap of wood; they can be ordered, as in the case of the world; they can have the same qualities; or one can penetrate and act through the other, as the soul does in the body. Since each union does not change the essence of its parts, if the mind conceives of the aggregate as one thing distinct from its parts, it fabricates a being of reason. However, as long as the mind recognizes that the whole consists in many things united, it conceives of an extra-mental, albeit accidental, being.[28] Finally, Gorlaeus defines a mode as a certain condition of an accidental being. Its entire being is to inhere in the entity, but extrinsically, not intrinsically; i.e., it has no being apart from what belongs to it through the accidental being of which it is a mode. Nevertheless, it is more than a being of reason, for it is not fabricated by the intellect.

The first example Gorlaeus gives of a mode is the union of mind and body. This union is a mode of both the mind and the body, since it differs from each one, and is separable from each, but it exists only through them. The second example he gives is of the length of a piece of wax. Length is a mode because it can be distinguished from the wax and its parts, but it exists only while it "inheres in it [the wax], through its existence and [the existence] of its parts, namely those which are extended in length."[29] Gorlaeus' explanation of the sense in which length is a mode illustrates the difference between his account of modes and Suarez's. By Suarez's definition, the length itself is not a mode of body; only its inherence in a particular body is. However, since Gorlaeus rejects Aristotelian accidents, redefining accidental being as being by aggregation, length becomes something that inheres in a body only by virtue of the particular arrangement of the body's parts. Indeed, there is no 'inherence' of

[27] Ibid., pp. 23–24. [28] Ibid., pp. 25–26. [29] Ibid., p. 28.

length distinct from the arrangement of extended parts that is the length itself. Hence the inherence of a property and the property itself collapse into one, and what results is labeled as a mode by Gorlaeus. Similarly, for Descartes, a mode is not the inherence of an accident like shape in a body; rather, the shape resulting from the configuration of its particles is a mode of an extended body.

Gorlaeus goes on to distinguish between two kinds of modes, which correspond more or less to Descartes' distinction between an attribute, and a mode in the strict sense. Descartes distinguishes between three senses of 'mode':

> Indeed by *modes* here we understand exactly the same as what is elsewhere understood by *attributes* or *qualities*. But when we consider a substance as being affected or changed [*variari*] by others we call them *modes*; when by that change [*variatione*] we can denominate it such a kind [*talem*], we call them *qualities*, and finally, when we only regard more generally those things belonging to substance, we call them *attributes*.[30]

As examples of attributes, Descartes lists existence and duration. Likewise, Gorlaeus identifies the first kind of mode as a mode of being. It is the condition (*habitudo*) by which the being in which the mode inheres is referred to a place or time, examples of which include rest, location, duration, and position. This condition can be changed because the time, place, etc., can be changed. According to Gorlaeus, this first type of mode belongs to a being by virtue of its existence alone.[31] While Descartes' dualism prevents him from including rest, location, and position under the rubric of modes common to all existing things (since minds exist but are not in space), his sense in which duration is an attribute fits Gorlaeus' characterization of this first kind of mode as a mode of being. As Descartes puts it, "We should deem the duration of a certain thing only as a mode under which we conceive the thing insofar as it continues to exist."[32]

Gorlaeus identifies the second kind of mode as one which belongs to the thing by virtue of both its essence and its existence. It is the condition by which the being of which it is a mode is referred to another being, and includes the position of one being relative to another, the coordination of many beings, and dispositions between them. Gorlaeus lists the following examples of this second type of mode: contact, union, order, various shapes of body, rareness, and density. The cause of these modes is the position of the atoms relative to one another, or of the whole

[30] *PP* I, a. 56, AT VIII, p. 26. [31] Gorlaeus, *Exercitationes*, p. 29. [32] *PP* I, a. 55, AT VIII, p. 26.

aggregate relative to other bodies.[33] I have already highlighted the fact that Gorlaeus' theory of modes differs from Suarez's definition of a mode as the inherence of an accident in a thing. There are also some minor differences between Gorlaeus' second sense of mode and Descartes' modes in the strict sense, but they resemble each other more than Suarez's modes. For Gorlaeus, this second type of mode includes order, which Descartes classifies as an attribute, and properties like contact, rareness, and density, which Descartes reduces to primary qualities and their relations. However, the sense in which length and shape are modes of this second type corresponds to the way in which Descartes conceives of the modes of material substance. Hence Gorlaeus' sense of 'mode' is much closer to Descartes' than to Suarez's. We shall see that Gorlaeus' ontology, in general, bears some striking similarites to the sparsely populated Cartesian world of substances and their modes.

As Descartes later does in the *Principles*, Gorlaeus goes on to apply his theory of modes to basic concepts of physics, such as duration, location, and local motion, albeit in a different manner than Descartes, since he develops an atomist, not mechanist, physics. According to Gorlaeus, the duration that truly belongs to a thing is that by which it exists in this moment, not that. This duration is not fabricated and cannot be separated from the thing. The other mode of duration is that the thing endures interruptedly through several moments. This second mode of duration is not the same as the very existence of the thing – these can be separated, since in the first moment that a thing has existence, it does not yet have its duration. Furthermore, unlike an essence, duration in this second sense can be increased or diminished, hence duration is modally distinct from both a thing's essence and its existence now.[34] Location, or existence of a thing in place, similarly has two modes. In one sense it is identical with the thing, i.e., in the sense that the thing is here and not there. Just as the first mode of duration is not distinct from a thing's existence in one moment, so the existence of a thing in this place *versus* that place is not distinct from the thing itself. However, there is a second mode of location according to which the thing is in this place, but in different ways. This does not belong to bodies properly speaking, because atoms, being indivisible, cannot be in a place in different ways. However, it does apply to visible species, and also to souls, in so far as there is one soul that is in a smaller body when we are young, and in a larger one as our bodies grow. In other words, location in place is a mode distinct from

[33] Gorlaeus, *Exercitationes*, p. 29. [34] Ibid., p. 30.

things only when we are dealing with composites. For the simple atoms, being here *versus* there is the same as their being.[35] Finally, local motion is defined as migration from place to place, and is characterized as a passion of things rather than an action.[36]

In the fifth exercise, "On the Accident," Gorlaeus appears to contradict the substance/mode ontology he has developed so far by positing 'real accidents.' Lüthy, for example, takes him to retain Scholastic accidents, which are real but less perfect beings than substance, given that they must always inhere in a substance.[37] A careful reading of the passage shows that Gorlaeus is pitting his own view of what he calls 'real accidents' against the Scholastic Aristotelian view. To them (the philosophers) he attributes the view that "an accident does not have any other being than inherence."[38] Then, introducing his own view, he writes, "Which nevertheless cannot be said of a real accident since this is proper to modes."[39] In other words, only modes have this dependence on their subject. He then reminds the reader what he has already proven: "For every real being has its own proper essence and existence; to inhere in another does not belong to it *per se*, [but] is accidental to it. We demonstrated in its place that the things which can be separated from one another are diverse real beings."[40] Gorlaeus reasons that when such real beings have a dependence on another being it is clearly extrinsic and can be supplied by God. In other words, real beings which can exist separately, and are distinct from one another, but are not substances, can be seen to exist outside any subject and to migrate from one subject to another with the aid of God's omnipotent power.

Gorlaeus effectively creates a third category, which is neither substance nor mode, to account for light. Light, which God creates at the beginning, is not a substance, but neither does it inhere in a subject – not in air, not in earth, not in water, not in the heaven created on the first day, the empyreum.[41] For lack of a better term, Gorlaeus calls light a 'real accident.' The choice of terminology is unfortunate, for unlike Scholastic real accidents, light "is an accident outside a subject," and such accidents can also migrate from a subject into a non-subject, as heat migrates from the sun to us, and visible species migrate from the thing seen to our eyes.[42] Interestingly, Descartes tries to explain these kinds of phenomenon, which do not fit neatly into the substance/mode ontology, in mechanistic terms (e.g., light for him is due to pressure exerted by particles). For

[35] Ibid., pp. 30–31. [36] Ibid., p. 35. [37] Lüthy, "David Gorlaeus's Atomism", p. 250.
[38] Gorlaeus, *Exercitationes*, p. 93. [39] Ibid. [40] Ibid.
[41] Ibid., pp. 93–94. [42] Ibid., p. 94.

Gorlaeus the 'real accident' category is limited to these few special cases of accidental properties that appear to migrate. All other accidental properties are modes that do not migrate.

> For the rest I do not affirm that those accidents, which are modes of being, have another being than inherence, or that they could migrate from a subject to a non subject. Moreover, I plainly deny it, for since a mode does not have proper existence, but [exists] in its subject, of which it is [a mode], it cannot exist in diverse subjects.[43]

The vast majority of Scholastic accidents are recast as modes by Gorlaeus, and as we shall see next, as for Descartes, these modes have a close connection to quantity.

Gorlaeus devotes his sixth exercise to quantity. Rejecting the Scholastic Aristotelian view that quantity is a real accident of matter (the standard Scholastic view was that quantity was the first accident of matter), he claims: "Quantity is to us truly the same as substance, and does not differ from it except by our reason alone."[44] This anticipates Descartes' claim that "quantity and extended substance do not really differ [*in re non differt*] but only conceptually [*ex parte nostri conceptus*], as number differs from the thing numbered."[45] Gorlaeus offers two distinct arguments for his groundbreaking conclusion. The first is based on the premise that quantity, whether continuous or discrete, is always a unity or composed of unities. Unity is merely an affection of being and therefore is not distinct from the being. From this it follows that quantity or number is not distinct from being either.[46] He adds that since the wholes that we see are not real beings, but composites of atoms, there is no quantity in the whole besides the quantity of the atoms. In the same way that unity is not distinct from that which is one, the quantity of an atom is not distinct from the atom. Therefore, number adds nothing over and above unities, nor does the quantity of the whole add anything real to the aggregate beyond the quantity of atoms. If it did, this would result in contradiction, for the aggregate body would be a *quantum* and nevertheless lack all quantity.[47] In his second argument that quantity is substance, Gorlaeus argues that each body must have one corresponding extension in space. Responding to the objection that the whole body could either be in one indivisible point or remain in the whole of space and be whole in an individual point, Gorlaeus reduces both possibilities to absurdity. The first implies that all parts of the body would be in a single point and hence they would have

[43] Ibid., p. 94. [44] Ibid., p. 95. [45] *PP* II, a. 8, AT VIIIA, p. 44.
[46] Gorlaeus, *Exercitationes*, p. 96. [47] Ibid., pp. 96–97.

to interpenetrate one another, which is absurd. The second implies that one body could be in more than one place at once, namely, in an indivisible point and the whole of space, which is also absurd.[48] In other words, Gorlaeus maintains that body is always extended and so is not distinct from its quantity: "If the whole body until now filled the same space, it is necessarily a *quantum* because that space is a *quantum*."[49] Given that Gorlaeus identifies body with its extension, and hence treats it as indistinct from quantity, one can logically infer that the modes of body must be modes of extension.

Whether he learned it from his teachers, or is the originator of it, Gorlaeus presents a complete metaphysics to ground his atomism. In doing so, he presents a consistent alternative to Scholastic Aristotelian metaphysics that leaves no room for standard Aristotelian concepts. Most importantly, for our purposes, his monism and atomism lead him to reject the Scholastic substance/accident distinction. The only real physical things are simple indivisible substances (atoms) and a few so-called 'real accidents' like light. There are no accidents in the Scholastic sense. By accidental being, Gorlaeus means an aggregate of atoms. Everything else is either a mode of these aggregates or a being of reason fabricated by the intellect. This leads Gorlaeus to re-conceive concepts like length, shape, duration, and quantity in a manner that anticipates Descartes' usage, thereby foreshadowing Descartes' argument against material substantial forms based on the substance/mode distinction. Gorlaeus' thoroughgoing and metaphysically grounded atomism thus provided the conceptual resources for eliminating any vestiges of the Aristotelian hylomorphism – resources that were still lacking in the attempts of earlier anti-Aristotelians, like Telesio, Bruno, and Basso. I now turn to Gorlaeus' arguments against substantial forms.

7.3 THE SUPERIORITY OF ATOMISM OVER HYLOMORPHISM

In his twelfth exercise, "On Composition," Gorlaeus begins to argue against the Scholastic view that substances are made up of matter and form as part of a prolonged defense of his own view that all substances are aggregates of atoms. Just like Suarez, he begins with considerations regarding the matter and form of a human being. He characterizes the

[48] Ibid., pp. 98–99. [49] Ibid., p. 99.

view, defended by Suarez, that matter and form are incomplete substances, as the standard Scholastic Aristotelian position:

> Corporeal substance is commonly [said to be] threefold: matter, form and composite. The former substances are called incomplete, the latter complete. They say that the former are composed and become one, the one perfecting and completing, the other being perfect and completed. Therefore, one is act, the other is potency. In fact, that one thing which comes to be there, they call the composite, since it alone is perfect and complete being; the parts truly complete it, and are not per se, but because of this it is a composite.[50]

Gorlaeus' critique of this position reveals his motivation. First he points out that, on this view, a man is a being that is *per se* one, and so the man will be his soul as it exists in the body. However, this leads to a contradiction, for the soul is supposed to be the same inside and outside the body. Yet the soul outside the body is not a man, because, on the Scholastic view, the concept of a man essentially includes the union of the soul with the body. As Gorlaeus points out, this leads to a conflict with Scripture, since it speaks of our desire to be released from the prison of the body to be with Christ. But if the composite is one being, and man is a composite, then the essence of man would be destroyed by death, for death destroys the composite. Gorlaeus exclaims: "Therefore, how can that be with Christ which is not? And how can death be called a release, if there would be a substantial corruption? … Since these openly do not cohere, we say goodbye to this Peripatetic nonsense, and follow the holy truth."[51]

As a result of his desire to remain true to the literal meaning of Scripture, Gorlaeus rejects the view that human beings, and other substances, are constituted from matter and form. Rather, composites are made up of parts, each of which has its essence before the composition and retains it even when united and mixed to form a continuum through aggregation. He concludes:

> Thus a soul is given in man, also a body is given, which two are united thus so that the body is the domicile, vehicle and instrument of the soul, through which the soul exerts its operations; but from those very two there is not made one being, which is called man, but each one retains its perfect and complete essence, by which it is that which it is. In fact, man is not the same as soul, nor the same as body, but is the same as the soul and body simultaneously taken up and aggregated.[52]

Presumably this gets around the problem by allowing the soul to dissociate itself from the body to join Christ. Since neither the essence of the soul

[50] Ibid., pp. 221–223. [51] Ibid., p. 224. [52] Ibid., p. 223.

nor the essence of man depends on an essential union with the body, the aggregate of atoms making up the body can disintegrate, thus destroying the man without in any way affecting the soul. In fact, Gorlaeus makes it clear that he does not consider the body to be part of the essence of a man, "for the same essence in number is to be resurrected; the same body in number cannot be resurrected."[53]

Gorlaeus uses the example of the Anthropophagus Indians to discredit the hylomorphism of Suarez and other Scholastics. As discussed in chapter 3, Suarez differentiates the metaphysical form from the physical form on the grounds that a certain type of matter is part of the essence of a human being, and hence part of the metaphysical form but not of the physical form or soul of a human being. Gorlaeus reiterates this view of the human essence, objecting that including matter within our essence is inconsistent with the doctrine of resurrection. For the Anthropophagus who eats the flesh of his enemy makes that flesh part of his body and hence of his essence. But then how can the body of the man he devoured be resurrected, unless the same portion of matter could be in two places?[54] But as Gorlaeus has already stated, that is absurd; therefore, we must reject the Peripatetic view in light of the doctrine of resurrection. He emphasizes that his atomism, by contrast, is completely consistent with the resurrection of persons since the atoms that make up the devoured and dissolved human bodies lie outside the human essence. It is not clear in what sense Gorlaeus embraced bodily resurrection, for all he says is, "I do not deny that God is to restore to us the same body in number, because I know that this does not exceed his omnipotence, but what would be done I leave in the middle."[55] One possibility would be that the soul itself is something bodily since it is what constitutes the essence of a human being that will be resurrected, but Gorlaeus does not come out and say this.

In addition to these theological considerations, Gorlaeus presents philosophical arguments against what he takes to be the standard Scholastic view of the soul as the substantial form of a human being. Once again, he draws on Suarez's distinctions among forms, which we examined in chapter 3. The most relevant argument for our purposes deals with the soul/body union and occurs in exercise 14. As he leads up to the argument, Gorlaeus reasserts his view that bodies are aggregates of atoms,

[53] Ibid., p. 234. [54] Ibid., pp. 232–233.

[55] Ibid., p. 234. The question of the resurrection of the body was a source of great controversy in the Netherlands at this time, since the Socinians denied it, and the Remonstrants were hesitant to embrace it. Verbeek, *Descartes and the Dutch*, p. 17.

atoms being the only true substances. He takes his view to remove the problematic implication that accidents, which are less noble than substances, could actuate and perfect substances. As Gorlaeus argues, this implication cannot be ruled out on the Scholastic Aristotelian theory. On Gorlaeus' theory, accidents are merely by-products of aggregates and so they do not affect substance in any way. Since human beings are aggregates, for Gorlaeus, the human soul is not a substantial act that informs and perfects the body. Rather, the body is corporeal through its own essence, and so it is already an actual, perfected substance before it is joined with the soul. The soul as form can then at most be an accidental act of the aggregate or mind/body composite.

Gorlaeus supports his reasoning with the following argument against the Scholastic view of the mind/body union:

> Meanwhile I do not deny that matter of this being through aggregation is called a being, from which they are aggregated, but that matter which the Peripatetics considered is not Physical, but [it is] that which is called matter in logic by our consideration. Whence their form is not a certain being, but only a union of being. Thus the matter of a dog are soul and body, their form a union. But in simple things this kind of union is not discovered. Therefore, their form is the same essence of the thing, which is expressed by the definition.[56]

Gorlaeus draws a distinction between the forms of simple versus aggregate beings. In simple things, i.e., atoms, the form is a certain being, and it is identical to the essence of the atom. This essence is captured by the definition of the atom. To use Suarez's language, at the atomic level, the physical form corresponds to both the metaphysical form, or essence, and the logical form or definition of the thing. But, Gorlaeus claims, this is not the case, in aggregate beings, like the dog. What the Peripatetics call the dog's matter is not a physical matter but a logical matter. In other words, the materials which are thought to make up the dog (presumably, its flesh, blood, bone etc.) do not correspond to anything real. They are creations of logic, the only real matter consisting in atoms. Likewise, Gorlaeus seems to imply, there is no physical substantial form corresponding to the animal soul that perfects and actuates the dog's matter. Rather both soul and body are matter for the composite, and the only form that remains is the union (presumably the union/arrangement of body and soul atoms to form the aggregate being of the dog).

What is interesting about this argument against the soul as the substantial form of a living thing is that Gorlaeus effectively uses the force of

[56] Gorlaeus, *Exercitationes*, p. 267.

Suarez's threefold doctrine of form against the Peripatetics. He, in effect, uses Suarez's distinctions between the physical form, on the one hand, and the metaphysical and logical forms (i.e., forms in a metaphorical sense) on the other, to drive a wedge between the logical and physical realms. True physical matter and form, and true essences captured by definitions exist only at the atomic level. The concepts of form and matter we employ with respect to aggregates belong to logic and do not designate any real components of things. As in the case of Descartes' *a priori* argument against substantial forms, discussed in chapter 1, Gorlaeus' argument betrays the extent to which early seventeenth-century attacks on the substantial form relied on Suarez's defense of it. Drawing on Suarez's threefold distinction among forms, Gorlaeus leads his Peripatetic opponents to the logical conclusion that, unlike in simple beings, in composite beings the essence / logical form does not correspond to the physical form. Rather, the soul as essence / logical form is not a being distinct from the matter of the aggregate, but only a union of being. This then allows Gorlaeus to establish the superiority of his atomist theory, since on his view the soul is a distinct substance that survives the death of the body. By isolating the physical form from metaphysical essences and logical definitions, and downgrading the latter to forms in a metaphorical sense, Suarez made it easier for Gorlaeus to introduce an atomist account of matter while relegating the Scholastic account of matter and form to the realm of logic.

Before we turn to Gorlaeus' arguments against material substantial forms, it is worth highlighting that, like Suarez, he begins his discussion of substantial forms with the question of the soul's immortality, and then introduces a second theological argument based on the doctrine of resurrection. Hence his atomism appears to have a strong theological motivation. It is also worth noting that he associates the Peripatetic view with Suarez's definition of the soul and body as incomplete substances that form an essential unity. Moreover, his philosophical argument against the soul as a substantial form relies on Suarez's threefold distinction among forms. Hence Suarez's definition of the substantial form as an incomplete substance, and his designation of the physical form as the only form in a non-metaphorical sense, make it easier for Gorlaeus to limit true forms to the atomic level. It also makes it easier for him to argue that atomism avoids the theological conundrums one runs into when one treats the soul and body as incomplete substances which combine to constitute the essence of a human being. Finally, it must also be noted that in rejecting the standard view that the soul is the substantial form of the body, Gorlaeus goes further than Descartes in his development of an anti-Aristotelian metaphysics.

Before presenting his arguments against material substantial forms, Gorlaeus gives proofs in support of his view that atoms are indivisible, and that consequently, they have a certain heaviness (*crassitatem*) and quantity.[57] He also addresses the question of the vacuum, pointing out that if there were globe-shaped atoms, a space would remain between two or more atoms that touch one another.[58] Therefore, on this hypothesis, even if another atom were inserted between them, the existence of a tiny vacuum could not logically be ruled out. Gorlaeus suggests that perhaps all the atoms are square-shaped, in which case there would be no vacuum between them. Nevertheless, he continues, atoms cannot be sensed, and so their shapes can be grasped only by the intellect. In the end, Gorlaeus leaves this question unanswered.[59] In contrast to Basso, who, like Descartes, fills the spaces between atoms with the subtle matter of the *pneuma* or ether, Gorlaeus does not definitively rule out interstitial vacua. However, his earlier equation of quantity and extension with substance suggests a Cartesian-style argument that there can be no extension in space without body. Despite his vacillation on the question of void space between atoms, Gorlaeus does definitively reject matter and form at every level: "We suppose that no matter and form is given in the nature of things, which the Peripatetics establish to be parts of bodies."[60] Instead of being made up of two different incomplete substances, matter and form, Gorlaeus attributes to each body one simple essence. "Do they not know that a body is one simple substance clothed with various accidents?"[61]

In preparation for his arguments against matter and form, Gorlaeus first lays out his procedure at the beginning of the fourteenth exercise. He invokes Ockham's razor, a methodological principle he frequently appeals to throughout his *Exercitationes*: "In the first insight we collect this usual argument, the number of things ought not to be increased without manifest necessity."[62] He points out that since matter and form are not sensed, or mentioned in the Sacred Letters, or given in us as innate principles, the burden of proof is on philosophers who posit them to show that there is some indication of them. Gorlaeus then resolves to examine all arguments in their favor, and if he does not find any solid reasons in their favor he will dismiss them as the "nonsense of old women and leisured

[57] Ibid., Thirteenth Exercise, pp. 234–240. [58] Ibid., p. 243.

[59] However, as Lüthy has pointed out to me, Gorlaeus does unambiguously allow for the type of temporary void caused by the motion of a body, but which is filled quickly due to nature's abhorrence of a vacuum, and for the vacuum into which God placed with world, some of which remains outside the confines of the created universe. Ibid., pp. 156, 215–216.

[60] Ibid., p. 250. [61] Ibid., p. 251 [62] Ibid.

inventions of men."[63] He presents four further arguments directed specifically against material substantial forms: the first is theological in nature, the second undermines Aquinas' justification for such forms, the third addresses objections to Gorlaeus' alternative view, and the fourth is based on Ockham's razor.

Gorlaeus' first argument is based on the authority of Scripture. He accuses the proponents of Aristotelian prime matter of misreading Genesis when they claim that God established the empty, unformed matter in the beginning and then proceeded to form bodies. Rather, the Scriptures speak of the creation of heaven, earth, and water, not matter. In fact, the Spirit of God is said to hover over the surface of the waters, which prompts Gorlaeus to ask, "How could he hover over them if the waters did not yet exist, but only their matter?"[64] Gorlaeus also denies that the reference to the empty, unformed earth and abyss is a reference to unformed matter, arguing instead that

> the earth is called empty, because it was at that point not decorated with plants and animals, for whose sake it was established. Unformed, because mixed with the waters it would not yet have the shape owed to it. Abyss, because it was not yet illuminated but at this point hidden by the waters.[65]

Once again, Gorlaeus' Protestant theology, which requires a literal reading of Scripture, appears to be an important driving force behind his philosophical commitments. It is curious, indeed, that these kinds of theological concern lead him to embrace atomism and reject hylomorphism.

Gorlaeus may have been motivated by theological concerns, but he also presents philosophical arguments against hylomorphism. His next argument attacks Aquinas' basis for the material substantial form: namely the distinction between substantial and accidental coming to be.

In connection with the second argument, Gorlaeus attributes the following reasoning to proponents of hylomorphism. In the absence of matter and form, all bodies would come to be from nothing and perish into nothing, for there would be no common matter from which they come to be and into which they perish. Only God can make something from nothing or reduce it to nothing. But every day we see many bodies come to be and perish, and being transformed into one another. For example, water is transformed into air when it exhales vapors. Therefore, these bodies do not come to be from, and perish into, nothing. Therefore, there must be some common matter which acquires different substantial

[63] Ibid. [64] Ibid., p.253. [65] Ibid., p. 254–255.

forms.[66] Against this view Gorlaeus asserts that all things come to be from nothing and perish into nothing (he later argues for this in the fifteenth exercise). He denies that bodies are transmuted into one another; rather, every body is made by God's creation. Mixed bodies are not *per se* one, but are aggregate beings, and so nothing substantial comes to be through mixture. Nor does anything substantial perish when the mixture dissolves. Gorlaeus accounts for apparent transformations of one element into another, as in the example of water vapors, by claiming that the water has not been transformed into air; rather the vapors are made up of the most subtle parts of water, separated from each other by the power of heat.[67] He concludes, "We entirely deny that any essential mutation of body is given," and points out that this is precisely the premise that must be proven in order to establish matter and form from it.[68] Gorlaeus' atomism removes the distinction between substantial and accidental natural change. All substantial change is supernatural, requiring God's power to create *ex nihilo*; all natural change is accidental, since it consists merely in the aggregation and separation of indivisible atoms. Gorlaeus, like Descartes, equates *creatio de novo* with *creatio ex nihilo*. In this manner, Gorlaeus' earlier arguments in favor of an atomist account of physical change undermine the very heart of Aquinas' basis for positing prime matter and the substantial form. One can see why, in the face of the revival of non-Aristotelian ancient natural philosophies, Suarez ditched Aquinas' argument for substantial forms in favor of a different type of justification. Finally, Gorlaeus' account has the advantage of conforming to the literal meaning of Scripture.

Gorlaeus' third argument is structured as a response to three objections against a result of his atomism: that every body has one simple corporeal essence. The proponent of hylomorphism would insist that matter and form must be given in bodies to avoid this undesirable result. The result is undesirable for three main reasons. First, only God has a simple essence. Second, there would be no generation or corruption, and all change would be accidental, if every body had a simple essence. Third, bodies would lack matter (in the sense of the potential for form) and so there would be no principle of corporeity. To the first objection, Gorlaeus responds that it is a mistake to locate God's perfection in his simplicity and then attribute a composite nature to all imperfect beings, including angels. Rather, God is perfect because he exists necessarily and hence has no efficient cause. Gorlaeus thus makes the traditional distinction

[66] Ibid., p. 255. [67] Ibid., pp. 256–257. [68] Ibid., p. 258.

between simple and composite being irrelevant to distinguishing Creator from creature, and instead emphasizes the dependence of created being on an efficient cause *versus* the independence of divine necessary being from an efficient cause. Atoms are creatures because they require God's efficient causation to exist, not because they are composites. This in no way threatens God's perfection, for that consists in his necessary being, not in the mere fact of his simplicity. To the second objection, Gorlaeus essentially replies, Yes, and so what? He sees no problem with reducing all natural change to accidental change.[69]

Gorlaeus' response to the third objection, that if bodies had simple essences then there would be no principle of corporeity, is more complex. Gorlaeus grants that bodies lack an internal principle of corporiety on his view, but maintains that they have an external principle. He argues that bodies do not require an internal principle of corporiety to be bodies, just as angels do not require an internal principle of spirituality to be spiritual beings. Gorlaeus thus appears to take Suarez's definition of a thing's essence or nature one step further. Recall that for Suarez, a thing's nature includes all its essential properties minus its mode of subsistence, or the particular manner in which it exists. In other words, a thing's matter is included in its metaphysical essence. On this basis, Gorlaeus appears to reason that just as the angelic essence will consist in spirituality, the metaphysical essence of a body will include its materiality; therefore, there is no need to posit a separate material form over and above the individual essence of a body, just as there is no need to posit a form of spirituality over and above the angelic essence. Gorlaeus could not have made this inference had he started from a view that was common before Suarez: that the essence of an individual substance is the form of the species and that matter does the work of individuating this form. On such a view, a separate form of corporiety is needed to account for an individual's materiality since the species form does not include matter. Once again, the influence of Suarez's innovations on Gorlaeus' arguments is palpable.

Gorlaeus next addresses three related fears that prevent philosophers from embracing his conclusion that each body has a simple essence: (1) bodies would be incomplete beings without an internal principle or form of corporiety, (2) bodies could not be constituted under a certain genus and species of substance, and (3) bodies would be indistinguishable from one another. Gorlaeus points out that (1) is based on the mistaken belief that matter comes to be through form. Although he does not

[69] Ibid., pp. 260–261.

explicitly mention it, he seems to be drawing support from the Suarezian doctrine that the substantial form is not the formal cause of the existence of matter. Once one acknowledges that matter does not require form to exist, then correspondingly, matter does not require the addition of a form of corporiety in order to exist as a body. Point (2) stems from the belief that individual bodies must be really constituted through form, and that this physical form corresponds to the logical form or differentia of a definition. Gorlaeus' answer to this fear is particularly dense and will be examined in some detail below. Finally, (3) rests on the fact that without unifying material substantial forms, individual bodies would be distinguishable only by their accidents. Since the same accidents are shared by many bodies, and contrary accidents can inhere in the same subject at different times, in the absence of a unifying corporeal form, accidental properties would be treated as essential, with the result that individual bodies displaying the same qualities would become indistinguishable. Likewise, a body would become a distinct body whenever one quality was replaced by its contrary. In other words, absent a unifying form, we are faced with either the Parmenidean One or the Heraclitean flux. Gorlaeus replies that once one embraces the atomist theory, this fear turns out to be groundless, for "the essences of elements and mixed things are thus disposed so that their accompanying qualities are as indifferent to hot as to cold, so that it is thus openly false that a certain essence is also changed by qualities having been changed."[70] In other words, the simple essences of atoms and their dispositions do the job of unifying diverse accidental properties much more effectively than forms can, for they can account for contrary observable properties of their aggregates without implying an essential change in the body itself.

The exact nature of (2) is unclear, since Gorlaeus does not spell out why a body needs to be constituted under a certain genus and species of substance; but if we unpack it, the following objection can be formulated: If each body has one simple essence and is complete and perfect in itself, there will be no definitions of bodies in terms of genus and species. It follows that there will be no differentia constituting a body as a certain species of substance. Hence each body will be characterized only by its genus and have the same logical form as all other bodies. This feeds into the fear that bodies will become indistinguishable, expressed by (3). Interestingly, Leibniz later takes Descartes to task for this very problem: if the essence of matter is extension, and all bodies are defined by the

[70] Ibid., pp. 263–264.

simple essence of being extended, then the particular motions by which matter is individuated are purely accidental, and all bodies are really one. As Gorlaeus seems to realize, the objection presupposes that the physical form of a body is also its logical form or differentia of its definition. If this were true, then positing simple essences for each body would tend to make them indistinguishable, since in the absence of a differentia that modifies the genus, all bodies would have one form corresponding to the genus of matter.

Gorlaeus' reply to this objection is particularly dense since its dialectical nature makes it difficult to distinguish his representations of the opposing view from statements of his own view. This much is clear: he rejects "the matter and form which were effected by the Peripatetics and from which really distinct, real bodies are said to be composed."[71] His clarification that he is here dealing with the physical form and matter that constitute real bodies implies that he wishes to separate this question from the question of logical form and matter (the differentia and genus), which he says is addressed in logic.[72] This implication creates an ambiguity when Gorlaeus claims that "the same thing is widely declared in Logic, where the logical matter and form are the very substance of the thing, and it was demonstrated that they do not differ from the thing except by reason alone."[73] Is Gorlaeus agreeing with the widely held view that the logical matter and form are merely conceptually distinct from the substance they define, or is he still merely presenting the reasons that support the opposing view? At first, the latter seems more plausible, since this claim does not sit well with Gorlaeus' view that atoms are the only true material substances. Moreoever, the claim that the logical form and matter are only conceptually distinct from the substance itself provides support for the opposing view that bodies, rather than having simple essences, are made up of distinct parts (matter and form) corresponding to the logical matter and form (genus and differentia). However, this reading is difficult to reconcile with Gorlaeus' claim, at the beginning of his reply, to reject the form of corporeity as an internal principle of bodies but not as an external principle. An alternative reading would attribute to Gorlaeus the view that Aristotelian logical forms through which bodies are defined in terms of their differentia/species can be accepted even though physical substantial forms must be denied. Hence even though each body has a

[71] Ibid., pp. 262–263.

[72] This is consistent with the distinction Gorlaeus later draws between the physical and logical matter of a body (i.e., an aggregate of atoms). Ibid., p. 267.

[73] Ibid., p. 262.

simple essence, logical forms can still function as external principles by which we classify bodies and distinguish them from one another. On this reading Gorlaeus presents a view that anticipates the Lockean distinction between real and nominal essences.

At first glance the second reading of Gorlaeus' point about logical forms seems irreconcilable with his atomism. How can matter and form, in the sense of the genus and species of Scholastic logic, be identical with the very substance of the thing if atoms are the only true corporeal substances? However, the two can be reconciled if we read Gorlaeus to be using 'substance' not in his own strict sense, but in a more traditional sense. If 'substance' here designates observable aggregates of atoms (e.g., a human being), then Gorlaeus' claim that genera and species (e.g., rational animal) are only conceptually distinct from such substances is consistent with the nominalist position on universals he defends in his fourth exercise. There he insists that everything that exists is one in number and singular. He characterizes universals like 'man' and 'animal' as abstract concepts whereby things which are in reality only similar are apprehended under one account (*ratione*) by the mind. He then distinguishes between real and rational abstraction. According to the latter, Plato's animality can be apprehended apart from 'Plantoneicity' without either including or excluding the differences between Plato and other animals. In this manner, 'animal' can be truly predicated of 'Plato' without implying that there is a distinct, real genus of animality in Plato. However, universals considered as real abstractions signify a certain thing which is really communicated to individual things and is the same in each.[74] According to Gorlaeus, this view leads to contradiction, which implies that universals must be taken as purely rational abstractions.

Gorlaeus' position on universals indicates that he goes much further than Suarez in distinguishing logical from physical forms. As universals, logical forms are creations of reason that do not imply a real or even a modal distinction between the matter/genus and form/species within the actual thing.[75] That this nominalist view is presupposed in the fourteenth exericise is indicated by Gorlaeus' claim that there is not one common essence of all things, i.e., the genus, on top of which gets added the essence of the species, e.g., that of water, *versus* that of another type of body. Hence, whereas for Suarez logical forms corresponded to levels of being, for Gorlaeus the distinction between a generic and a specific essence is a purely logical one that appears to have no correspondence to layers of

[74] Ibid., pp. 78–81. [75] Ibid., p. 263.

physical forms. As a result, one need not embrace physical matter and form in order to differentiate things by the logical principles of genus and species. By widening the gap between Suarez's logical and physical forms, Gorlaeus can deny that there is an internal principle of corporiety in bodies, but preserve the external logical principles we use to classify bodies in science.

Gorlaeus' fourth and final argument is that substantial forms are unnecessary to account for natural phenomena. He invokes the principle that nature does nothing in vain to conclude that substantial forms should not be posited. To illustrate why the Scholastic Aristotelians posit material substantial forms, Gorlaeus uses the same example Suarez employs, namely, the example of heated water that cools down again. He summarizes the same arguments Suarez gives to show that this phenomenon cannot be accounted for by external causes, nor can it be explained by internal principles other than the substantial form. Gorlaeus does not reject the arguments, instead calling them 'most excellent.' Rather, he claims, there is no need to posit matter and form to account for such phenomena, for it can equally well be explained through one simple corporeal essence.[76] As Gorlaeus puts it, "If actions come forth from form alone, which is simple, why are they not rather established to come forth from one simple corporeal essence?"[77] In other words, in applying Ockham's razor, we should choose the theory that can explain the same range of phenomena while positing less entities. Gorlaeus takes his atomism to win out in this regard since the actions of bodies are explained in terms of one principle, namely, the simple essences of the atoms from which they are composed, rather than two principles, matter and form.

Gorlaeus then generalizes this argument to all accidents. As Suarez also acknowledges, we sense only accidents, not forms. But since matter alone is enough to account for accidents, why posit a form on top of it? In addition to being unnecessary, this leads only to contradiction. For form is not distinct from that which is formed, and that which is formed is body. Hence form too, is body. But we know that a body cannot penetrate another body (because every body is a *quantum* with three dimensions, as argued above). But if there were form, then it would have to be intimately present in all the parts of matter to actuate it and hence it would penetrate body. But this is impossible; therefore, form as distinct from matter does not exist. Gorlaeus thus adds a *reductio ad absurdum* based on his own metaphysical commitments to his application of Ockham's razor.

[76] Ibid., p. 271. [77] Ibid., pp. 272–273.

Whether atomist explanations are actually simpler is another question, since for each composite one is dealing with a multitude of different simple essences rather than with just matter and form, but it is clear that Gorlaeus takes his theory to be more economical as well as more consistent than the Scholastic Aristotelian theory.

In conclusion, Gorlaeus provides a complete metaphysical grounding for his atomism and appeals to the superiority of atomist principles to eliminate both the paradigm case of the substantial form, the soul, and Peripatetic material substantial forms. Unlike prior anti-Aristotelian philosophies such as those of Bruno, Telesio, and Basso, Gorlaeus' metaphysics involves the complete rejection of the Scholastic Arisotelian substance/accident ontology in favor of a substance/mode ontology. As we saw, his account of modes and his identification of substance with extension/quantity logically commits him to the view that all the properties of body are modes of extension well before Descartes develops his metaphysics. However, unlike Descartes, Gorleaus does not explicitly draw this inference, nor does he rely on this original result of his metaphysics in his subsequent arguments against substantial forms. Rather, he offers a combination of theological and philosophical arguments against Aristotelian hylomorphism. While he also draws on his own atomist physics, his arguments tend to presuppose a Scholastic Aristotelian framework, which he then proceeds to undermine by showing what incoherent or undesirable results follow from it. Both Gorlaeus' strategy of beginning with the case of the human soul, and his individual arguments against his Scholastic opponents, indicate that he was heavily influenced by Suarez's discussion of the substantial form. Some of his philosophical arguments against the Peripatetic view could not have been made before Suarez separated the substantial form from the metaphysical and logical forms and characterized it as physical. Once a consistent atomism is introduced to account for natural phenomena, the physical substantial form, in isolation from its metaphysical and logical underpinnings, does not fare well. Due to Suarez's innovations and his own commitment to a monist, nominalist metaphysics, Gorlaeus is able to treat logical forms as distinctions of reason fabricated by the mind, while redefining the physical essences/forms of things in atomist terms. In the next chapter, I will examine Descartes' elimination of material substantial forms, which unlike that of Gorlaeus, does proceed directly from his commitment to a substance/mode ontology. Furthermore, a concern to avoid skepticism, which is not a factor in Gorlaeus' arguments, played a significant role in Descartes' conversion to a substance/mode ontology.

CHAPTER 8

Descartes' metaphysical alternative to substantial forms

I argued in Part I that Descartes' arguments based on the obscurity of substantial forms fail unless one presupposes his dualist metaphysics, but that his *a priori* argument against substantial forms is successful. In particular, I showed that it does not create a straw man if one reads it as targeting Suarez's doctrine of the substantial form and that, read this way, it reveals that, by this stage of his career, Descartes had a good grip on the strategy Suarez employed to argue for the existence of substantial forms. However, Descartes introduces this argument for polemical purposes after having re-acquainted himself with Scholastic philosophy in replying to the Objections to his *Meditations.* His own route to the rejection of substantial forms stemmed from scientific concerns, not from a critical engagement with Scholastic metaphysics. In Part II, I traced Descartes' arguments based on his identification of natural objects with machines, and on the superiority of mechanical explanations, back to developments in Aristotelian mechanics, and interpreted the nature of the scientific demonstrations he employs in the *Discourse* in this light. There, Descartes' scientific explanations take the form of demonstrations encountered in the newly founded science of mechanics. Mechanical demonstrations were considered mathematical in nature because they were based on the principles of geometry, and this is the sense in which Descartes takes his scientific explanations to be mathematical. Finally, I proposed a reading distinguishing Descartes' early theory of matter from his mature metaphysics. With the benefit of the background from Sanchez's skeptical arguments and Gorlaeus' substance/mode ontology, we are now in a position to examine the kinds of concerns that might have driven Descartes' shift from scientific to metaphysical justifications for the replacement of hylomorphic with mechanistic principles.

Descartes' encounter with skeptical arguments against the very possibility of *scientia* dates back to his youthful years in Paris, when he

was an active member of the Mersenne Circle.[1] Whether the skeptical arguments that confronted Descartes at this time took the exact form that they did in Sanchez's treatise or not, we can make considerable sense of Descartes' eventual rejection of substantial forms against the background of skeptical humanist attacks on the Aristotelian ideal of *scientia* (i.e., knowledge consisting in causal claims that are established with demonstrative certainty). We saw that Descartes tries to preserve this kind of knowledge by introducing a new theory of scientific demonstration. But, as shown in Part II, Descartes' early scientific writings do not eliminate Aristotelian substantial forms from the metaphysical realm; rather, they replace Aristotelian scientific demonstrations with demonstrations that have been grounded in geometrical principles and hypotheses regarding the mathematical nature of matter. This indicates that Descartes was, initially, concerned not with metaphysical arguments pertaining to substantial forms, but with their role in scientific demonstrations. This is consistent with Suarez's concern to defend substantial forms on empirical grounds and Sanchez's general skeptical attack on the empirical foundations of the prevailing conception of science. I argued in chapter 6 that Descartes' main goal in the *Discourse* was to substi tute appeals to obscure Scholastic notions, such as substantial forms and real qualities, with intelligible geometrical principles that could provide secure foundations for mechanical demonstrations of physical phenomena. In *The World,* he aimed to facilitate the application of such demonstrations to physical objects by re-conceiving substantial forms in terms of the sizes, motions, and arrangements of the parts of his mathematical matter. In neither work does Descartes lay out a full metaphysical justi fication for his new conception of matter, though Part 4 of the Preface to the *Discourse*, which contains the rudiments of arguments later elaborated in the *Meditations*, indicates that by 1637 he had made considerable progress in his metaphysical reflections. I will argue in this chapter that Descartes introduces his doctrine of the eternal truths and develops a substance/mode ontology to provide a metaphysical foundation for two key features of his new physics. The doctrine of the eternal truths is meant to secure the certainty of the geometrical axioms on which Descartes' scientific demonstrations rely, whereas his substance/mode ontology

[1] Beeckman's *physico-mathematics*, by contrast, has a practical orientation and shows no signs of concern with theoretical skeptical arguments. As John Schuster has shown, Descartes' preoccupation with skepticism in all likelihood stemmed from his interactions with Mersenne, who was engaged in combating various forms of skepticism during the time Descartes was in Paris. See Schuster, "Descartes and the Scientific Revolution."

establishes extension as the principal attribute of body, thus eliminating material substantial forms for good.

Descartes' correspondence establishes that by 1630 he was working out the metaphysical foundations of his physics. However, his letter to Mersenne of April 15, 1630, indicates that, at this point, he had only just begun his metaphysical reflections:

> As regards your question about Theology, even though it surpasses the capacity of my mind, it nevertheless does not seem to me to lie outside my profession, since it does not touch on what depends on revelation, which I call Theology properly speaking, but it is rather metaphysics and must be examined by human reason. But I judge that all those to whom God gave the use of such reason are obligated to use it chiefly to try and know him and know themselves. I tried to begin my studies there, and I tell you that I would not have known how to find the foundations of Physics had I not sought them via this path. But it is the subject matter which I studied the most of all and in which, thanks to God, I found myself not at all satisfied. At least I think I have discovered how one can demonstrate the metaphysical truths in a manner that is more evident than the demonstrations of Geometry; I say this according to my own judgment since I do not know if I could persuade others of it. The first 9 months I was in this country I did not work on anything else, and I believe that you had already heard me say earlier that I planned to put something in writing. But I do not consider it the right moment to do it until I have first seen how the physics is received.[2]

Descartes writes this letter from Amsterdam and indicates that he spent his first nine months in the United Provinces of the Netherlands constructing proofs of metaphysical truths that he proclaims to be even more evident than geometrical proofs. He points out that physics was the subject he had studied the most, and expresses gratitude that his dissatisfaction with it prompted him to search for its metaphysical foundations. In this manner, he arrived at the knowledge of himself and God that reason gave him, which led him to the foundations of his physics. Descartes' statements reveal that his metaphysical discoveries are very recent and that they center on the foundations required for physics. Given the overlap with the composition and focus of *The World*, one can surmise from this that they included the insight that matter is essentially extended, and that the three laws of nature are grounded in God's immutability. Indeed, on December 18, 1629, Descartes tells Mersenne that he intends to send him a small treatise he is working on, and asks Mersenne to correct any

[2] AT 1, pp. 144–145.

points that would strike readers in the grips of Aristotelianism as conflicting with theology. He then adds:

> In regards to this, please send me word whether there is anything determinate in religion touching upon the extension of created things, that is, whether it is finite or rather infinite, and whether in all those regions called 'imaginary spaces' there are true created bodies. Although I did not feel like touching on this topic, I believe nonetheless that I will be forced to prove it.[3]

This suggests that Descartes was concerned with metaphysical/theological issues bearing on the creation story of *The World* and the accompanying new theory of matter we examined in chapter 6. The remainder of Descartes' reply to Mersenne of April 15, 1630, also reveals that, perhaps due to Mersenne's comments on the above-mentioned treatise, he was especially concerned to address the metaphysical topic of the mathematical truths, which Descartes says Mersenne called eternal, in his physics.[4]

The very beginning of the above-cited passage from that letter indicates that Descartes came to this realization after Mersenne had asked him a theological question. Unfortunately, Mersenne's side of the correspondence is lost, so we do not know what the exact question was. However, Descartes makes it clear that it is a question he has the right to address as a philosopher. As he puts it, the question concerns truths about God which are established by reason, and Descartes places these under metaphysics. Descartes then goes on to discuss a metaphysical question that he says he will not neglect to touch on in his physics, i.e., the divine creation of the truths of mathematics, which Mersenne had called eternal (presumably in the letter to which Descartes was responding). Perhaps Mersenne's theological question was about God's relation to these truths. Indeed, many commentators have read Descartes as weighing in on a traditional Scholastic question regarding the exact relation between eternal truths (e.g., statements about essences, like "Man is a rational animal," which are always true whether God creates any men or not) and God's knowledge. The question takes the form of a Euthyphro-style dilemma, and Descartes clearly affirms one horn in a letter to Mersenne of May 6, 1630: "As for the eternal truths, I say once more that *they are only true or possible because God knows that they are true or possible, not however, in return, that the truths known by God are true as it were independently of him*."[5] In other words, for Descartes it is the case that the eternal truths are true because God knows them to be true, not that God knows them to be true because they are true.

[3] AT 1, pp. 86. [4] AT 1, p. 145. [5] AT 1, p. 149 (emphasis original).

As T. J. Cronin points out, the italicized part of the quotation from Descartes' letter resembles the way Suarez phrases the problem in his *Metaphysical Disputations*.[6] Cronin concludes from this that Descartes had this work in front of him and directly opposed Suarez's doctrine of the eternal truths. Norman Wells qualifies this hypothesis, identifying certain Thomists whom Suarez discusses in his convoluted treatment of the issue as Descartes' true opponents.[7] In light of this, Descartes is often read as taking a stand on the various sub-issues that form part of Scholastic debates regarding the eternal truths. I will not comment further on this line of interpretation because, despite Descartes' later efforts to bone up on Scholastic philosophy, his general lack of familiarity with and interest in subtle Scholastic theological and metaphysical doctrines in 1630 make it highly unlikely that Descartes was positioning himself within a Scholastic debate. I follow Gregory Walski's suggestion that we find these close paraphrases of Suarez's text in the letter because Mersenne, who, unlike Descartes, was trained in theology, introduced them.[8] The letter of 18 December, 1629, shows that Descartes relied on Mersenne to correct him whenever his physics unwittingly got him into turbulent theological waters. Hence it is far more likely that Mersenne brought up the dilemma addressed by Suarez and other Scholastics to alert Descartes to a potential theological concern raised by his physics.

Further evidence in favor of Walski's identification of Mersenne as Descartes' opponent can be found in Descartes' persistent confusion of various Scholastic distinctions. He would undoubtedly have had to master this material to follow the labyrinthine Scholastic dialectics found in Suarez's treatment of metaphysical issues. But, as highlighted in the previous chapter, Descartes clearly did not master it, conflating modes with beings of reason with a foundation in the thing, in *The World*, and confusing the formal distinction with the modal distinction in his reply to Caterus' objections to the *Meditations*.[9] Descartes did not correct his confusion of modal distinctions and distinctions of reason until he

[6] T. J. Cronin, "Eternal Truths in the Thought of Descartes and of His Adversary," *Journal of the History of Ideas* 21/4 (1960), pp. 553–559.

[7] Norman J. Wells, "Descartes and the Scholastics Briefly Revisited," *New Scholasticism* 35 (1961), pp. 177–190.

[8] Gregory M. Walski, "The Opponent and Motivation behind Descartes's Eternal Truths Doctrine," *Il Seicento e Descartes*, ed. Antonella Del Prete (Florence: Edumond Le Monnier, 2004), pp. 43–60. Walski's hypothesis is confirmed by the fact that in subsequent replies to Mersenne, Descartes appears to be quoting his words back to him. For instance, see the letter of May 27, 1630.

[9] CSM II, p. 85; AT VII, p. 120.

wrote the *Principles* and took himself thereby to have also corrected his conflation of formal and modal distinctions in the reply to Caterus. This indicates that Descartes, even at that stage, took formal distinctions to be distinctions of reason. In a letter to an unknown correspondent of 1645 or 1646 Descartes clarifies that he means by a 'distinction of reason' a distinction *rationis ratiocinatae*, i.e., one with a foundation in the thing. He explains that, in this restricted sense, he regards formal and modal distinctions as types of the distinction *rationis* in contrast to the real distinction.[10]

Descartes' particular use of these Scholastic terms does not reveal a clear grasp of the ways in which various Scholastic thinkers defined them, but can be traced back to Mersenne. In *L'Impieté des Déistes,* Mersenne appears to treat the distinction between God's attributes as a formal distinction:

> Although the divine attributes are the same thing as the essence of God, nonetheless, we can disinguish them in such a way that the actions of the one are not the actions of the other, formally speaking; not that one attribute could exist without the other, or that it would have something real and essential which the other does not, for they are all just the same thing, but because we conceive God in another manner when he punishes than when he rewards, and we consider him under a different formal reason when he produces the nature of something than when he knows it.[11]

Mersenne then adds that if his opponent would only recall "the distinction which we drew between the divine attributes, which is no more than of reasoned reason, *rationis ratiocinatae*, then he would take care not to infer a diversity of subsistences among the divine attributes."[12] The two passages together imply the view Descartes adopts: that formal distinctions are just a type of distinction of reason. This in turn indicates that Descartes relied on Mersenne for his understanding of Scholastic concepts, and was responding to a view advanced by Mersenne when he formulated his own doctrine of the eternal truths of mathematics.

For all the above reasons, I will read Descartes' doctrine of the eternal truths of mathematics in light of mathematical texts and skeptical arguments he would have encountered in the Mersenne Circle rather than in light of Scholastic debates regarding eternal truths about essences. In other words, I will not weigh in on how succesfully Descartes resolves

[10] AT IV, pp. 349–350.
[11] Marin Mersenne, *L'Impieté de Deistes, Athees et Libertins de ce Temps* (Paris: Pierre Bilain, 1624), p. 429.
[12] Ibid., p. 434.

the apparent tension between the necessity of eternal truths and their dependence on God as compared to his Scholastic predecessors. Indeed, Descartes seems scarcely aware of the modal concerns that contemporary discussions of the problem have treated as central. Rather, he is forced to confront the status of the truths of mathematics, which, following Mersenne, he begins to label as eternal truths, because he can succeed in avoiding skeptical objections only by grounding his physics on unassailable foundations. But, as Mersenne probably pointed out to Descartes, he must do so without compromising God's omnipotence in order to avoid theological controversies. In trying to balance these two needs, Descartes arrives at the Cartesian doctrine of the eternal truths, as we know it.

First, the need to make geometrical principles, which ground the mechanical demonstrations of the *Discourse*, immune to general skeptical arguments of the kind Sanchez gives, leads Descartes to treat mathematical axioms and truths about mathematical objects as eternal truths that are objects of direct intellectual apprehension. While this protects them from the general skeptical arguments that undermine any inferences based on sensory images, it leaves Descartes with another problem: how can these purely intellectual mathematical truths ever give us scientific knowledge of the sensible objects of physics? In other words, he falls prey to Sanchez's dilemma: either our apprehensions are directed towards the physical world around us and are deceptive, or they are unmediated introspections that tell us nothing about physical objects. In the essays of the *Discourse*, Descartes side-steps this issue by using a hypothetical mode of demonstration that simply assumes the formal object of physics to consist in geometrical sizes, shapes, and motions. In *The World*, he chooses another hypothetical mode of discourse, presenting his story of the creation of a geometrical universe as a fable. The doctrine of the eternal truths that Descartes outlines to Mersenne in 1630, shortly after completing the first part of *The World*, is meant to secure the certainty of the mathematical truths on which the scientific demonstrations of the *Discourse* and *The World* are based. However, as the cautious and hypothetical approaches of these two works indicate, the certainty of mathematical truths by no means guarantees that the physical matter to which Descartes applies his mechanical demonstrations is itself geometrical in nature. Second, Descartes does not provide more extensive metaphysical arguments for his geometrical conception of matter until he writes the *Meditations*. In section 8.2, I will argue that, unlike Descartes' earlier scientific arguments, this new metaphysical justification implies that the properties of physical things are simply modes of *res extensa*. Descartes,

in effect, adopts something very close to the substance/mode ontology already advanced by Gorlaeus, but, unlike Gorlaeus, bases his elimination of material substantial forms directly on this ontology.

8.1 THE DIVINE CREATION OF MATHEMATICAL TRUTHS

In Meditation 6 Descartes finally demonstrates that the imagined intelligible mathematical matter of the creation fable he tells in *The World* actually exists. His argument proceeds in two phases. First, his clear and distinct ideas of mathematical objects show that it is possible for mathematical objects to exist outside our thought. Descartes takes himself to have established this by the beginning of Meditation 6, where he writes, "And at least I now know that they [material things] are capable of existing, in so far as they are the subject-matter of pure mathematics, since I perceive them clearly and distinctly."[13] This is reminiscent of Blancanus' claim that the perfect objects of mathematics are at least possible. Then Descartes goes on to prove that such material mathematical objects must exist as causes of our ideas of them, for otherwise "I do not see by what reason he [God] could be understood to not be deceitful himself if they [the ideas] were transmitted from somewhere other than corporeal things."[14] In other words, Descartes bridges the gap between (on the one hand) the clear and distinct ideas of mathematical objects along with the truths that follow from them and (on the other) the material objects of physics by concluding from God's non-deceptive nature that "everything which I clearly and distinctly understand is capable of being made such by God."[15] The fact that, until the *Meditations*, there was a wide gap that needed to be bridged is clear from Descartes' earliest writings. There one can find the ancestors of Descartes' clear and distinct ideas of the *Meditations*, but their referents are not spelled out.

In the *Rules*, Descartes refers to simple natures, the earliest precursors to the clear and distinct ideas of the essences of mind and body found in the *Meditations*. However, it does not appear that the simple natures reflect ontological divisions at this stage in Descartes' career. One of his self-proclaimed goals in Rule 12 is to distinguish between the notions of simple things and those which are composed of them in order to determine what can be known with certainty *versus* where

[13] CSM II, p. 50; AT VII, p. 71. [14] AT VII, p. 80. [15] AT VII, p. 78.

falsity can come in.[16] He defines the simple natures as things which we know so clearly and distinctly that they cannot be divided by the mind into others which are more distinctly known. The examples Descartes gives include shape, extension, and motion – we conceive everything else to be composed of these. However, he is clear that simple natures are indivisible epistemic parts rather than component parts of the entity itself. Descartes spells out that with respect to the thing itself, a body with extension and shape is one single and simple entity which cannot be said to be a composite of corporeal nature, extension, and shape because these constituents never exist in isolation from one another. He then adds: "Yet *with respect to our intellect* we call it a composite which is [made up] of these three natures, because we understood the individuals separately before we were able to judge that the three are discovered simultaneously in one and the same subject."[17] This suggests that when we treat extension, shape, and motion as separate units, we do so by considering them abstractly in the intellect alone. When we sense or imagine them, we cannot separate them from one another or from the particular body. Descartes confirms this reading later on when he lists the different ways in which we can speak of extension. When we say that 'a body has extension,' "we indeed understand *extension* to signify something other than a body; however, we do not form two distinct ideas in our imagination, one of a body, the other of extension, but only of one extended body …"[18] On the other hand, when we say that 'extension is not a body,' then "it [extension] corresponds to no particular idea in the imagination, but this entire enunciation is completed by the pure intellect, which alone has the capacity of separating abstract entities of this kind."[19] That is, when 'extension' is taken in a non-abstract sense and represented in the imagination, then saying that 'extension is not a body' is the same as saying that 'it is at the same time a body and not a body.'[20]

What is odd about this entire discussion, from the vantage point of Descartes' later metaphysics, is that he never uses the terms 'essence' or 'primary attribute' of body to designate extension. Nor does he designate shape and motion as modes of extension or body. One gets the sense that Descartes could just as well have used 'shape' as his example instead of 'extension,' and indeed he concludes his discussion by pointing out that

[16] Interestingly, Descartes, as in the *Discourse*, makes certain controversial assumptions to this end, telling the reader that "it is of little consequence even if they are not believed to be more true than those imaginary circles which astronomers use to describe their phenomena, provided that with their labor you distinguish in what way a cognition of anything whatsoever could be true or false." What follows is his discussion of the simple notions of body. AT x, p. 417.

[17] AT x, p. 418 (emphasis added) [18] AT x, p. 443. [19] Ibid. [20] AT x, pp. 444–445.

Table 8.1 *Division among notions of simple things in the* Rules

Purely intellectual	Purely material	Common to both
Recognized by the light of the intellect without the aid of a corporeal image	Recognized to be present only in bodies	Ascribed indifferently to corporeal things and spirits
For example, what knowledge, doubt, ignorance is, or the action of the will	For example, shape, extension and motion and also privations like rest	For example, existence, unity, duration and also common notions

it is the same with shape, number, surface, line, point, and unity. When these terms are taken strictly in such a way that they exclude something from which they are not distinct, we get the same result as with 'extension.' The examples Descartes then lists are: "*extension* or *shape is not a body; number is not numbered things, surface is not the boundary of a body, line of a surface, point of a line; unity is not a quantity* etc."[21] What his linguistic analysis reveals is that there is no difference between the way 'extension' and 'shape' are used in sentences that deny their identity to 'a body.' It is doubtful that Descartes' linguistic analysis is supposed to reveal metaphysical distinctions at this stage, but if it is, then the implication is that 'extension' and 'shape' bear the same relation to 'body.' In other words, extension is no more or less essential to body than shape is. However, I consider it far more likely that Descartes had simply not thought through the metaphysical implications yet. If he had, one would expect something corresponding to what he later labels real *versus* modal *versus* rational distinctions to ground the linguistic distinctions he discusses. But there is no hint in the *Rules* that Descartes is concerned with mapping our linguistic uses and epistemological units onto a metaphysics. As already highlighted in the previous chapter, Descartes begins to articulate a theory of metaphysical distinctions only much later. In the *Rules* Descartes is concerned with the ordering and manipulation of units of thought, not with their referents.

We are left, in the *Rules*, with the following taxonomy, which classifies "the things which are said to be simple with respect to our intellect" into three main categories (see Table 8.1).[22] The examples he gives of common notions in the *Rules* are 'Things that are the same as a third thing are the same as each other,' and 'Things that cannot be related in the same way

[21] AT x, p. 444 (emphasis original). [22] CSM 1, p. 44, AT x, p. 419.

to a third thing are different in some respect.'[23] In other places he often gives the following Euclidean axiom as his prime example of a common notion: 'If you add equals to equals, the results will be equal.' In other words, all his examples of common notions consist in propositions rather than the indivisible ideas we find among the simple natures.[24] In the *Rules* Descartes states that the common notions are "as it were links joining certain simple natures to others, the clearness of which supports whatever we conclude by reasoning."[25] This is consistent with the role that the axioms of geometry play in the scientific demonstrations of the *Discourse* that we examined in chapter 6, since they link the shape of an object to its consequent motion. The clarity and certainty of such axioms are transferred to the conclusion arrived at when we reason from them. Nonetheless, only the purely intellectual simple natures are said to be recognized by the light of the intellect alone. The others require corporeal images; and yet, material simple natures, intellectual simple natures, and those common to both are all "self-evident and never contain any falsity," according to Descartes.[26]

Once in possession of these simple natures, our knowledge consists in drawing out the necessary relations between concepts (e.g., '4 plus 3 must make 7'; and 'Since Socrates doubts everything, then necessarily he understands that he doubts, and, therefore, he knows that something can be true or false') and compounding simple natures with one another either by ourselves or as they are presented to us in experience. Given that the simple natures are self-evident, it is only in compounding them that we can be led astray. Descartes' initial response to skeptical worries about the senses is to claim that "the intellect can never be deceived by any experience, provided that it only gazes upon the thing presented to itself precisely insofar as it has the object, either within itself or in the imagination."[27] The potential for deception and falsity thus lies in the way we put together what we gaze upon. According to Descartes, the only means of compounding things that allows us to be certain of their truth is deduction, and, setting aside direct inferences based on necessary relations between concepts, we must rely on mathematical axioms and other

[23] CSM I, p. 45; AT X, p. 419.

[24] One might object that 'existence,' 'duration,' and 'unity' are not propositions and yet are characterized by Descartes as simple natures common to body and spirit. This makes it easy to confuse them with the 'common notions' which Descartes also adds to the class that is common to body and spirit. However, 'common notion' is a technical term one finds in Scholastic and mathematical texts – it designates axioms and foundational principles. These are always propositions, whereas the simple natures common to body and spirit are not.

[25] AT X, p. 419. [26] AT X, p. 420. [27] AT X, p. 423.

common notions to deductively link together simple natures. Accordingly, when Descartes turned to metaphysics in 1630, one of his tasks was to provide a secure grounding for the indubitability of these links; hence the doctrine of the eternal truths of mathematics. The second was to map the simple natures onto an ontology; hence the shift to a substance/mode ontology, which we will examine in section 8.2.

As he later clarifies in the *Principles*, Descartes locates the common notions squarely in the mind. This saves his physics from the deceptiveness of the senses by allowing Descartes to treat the mathematical axioms and other common notions on which he grounds his physics as innate ideas rather than abstractions from sensory perceptions. To distinguish them from mental fictions created by our finite intellects, Descartes moreover characterizes the common notions as eternal truths. Hence he writes in *Principles* I, article 49 that

> *Nothing comes from nothing* is not considered as a really existing thing, or even as a mode of a thing, but as an eternal truth which has its seat in our mind and which is called a common notion or axiom. The following are examples of this class: *It is impossible for the same thing to be and not to be at the same time*; *What is done cannot be undone*; *He who thinks cannot but exist while he thinks*; and countless others.[28]

From his first work, the *Rules*, to one of his last, the *Principles*, the distinction between the simple natures and the common notions/axioms that link them together is constant. Whereas the simple natures of the *Rules* later evolve into clear and distinct ideas of real attributes and modes of mind and body, Descartes' doctrine of the eternal truths of mathematics is in place by 1630, and essentially does not change. I will argue that it constitutes Descartes' first attempt to provide a metaphysical/theological foundation for his physics – one that does not yet imply his later substance/mode ontology and the elimination of material substantial forms.

Based on the epistemological emphasis of the *Rules*, I take Descartes to be primarily concerned with safeguarding the common notions, which include the axioms of mathematics, from skeptical attacks in the period directly following its composition. On this reading, the doctrine of the eternal truths should not be conflated with Descartes' later preoccupation with establishing the true essences of corporeal and thinking substance in the *Meditations*. Once we separate the two concerns, the doctrine of the eternal truths of 1630 cannot be assumed to imply anything about the true metaphysical nature of material objects and their substantial

[28] AT VIII, pp. 23–24.

forms. This in turn explains why Descartes felt comfortable giving only a hypothetical presentation of his physics in the *Discourse* and *The World*, and still allowed for the existence of substantial forms in letters written as late as 1636, even though he had by 1630 formulated his doctrine of the eternal truths. In other words, it is important to situate Descartes' doctrine of the eternal truths chronologically, in between the abandonment of the *Rules* in 1628 and the beginnings of Descartes' mature metaphysics, as summarized in the parts of the Preface to the *Discourse* written just before its publication in 1637. Once we do so, it becomes clear that the doctrine of the eternal truths is merely supposed to guarantee the certainty of the common notions, not to establish that matter consists in extension alone.

To avoid Sanchezian-type skepticism about knowledge derived from the senses, Descartes locates the eternal truths (the axioms of mathematics and other common notions) in the mind. In contrast to the Aristotelian view that mathematical truths are abstractions from sensory images, he states that such truths have their seat or origin in our thought alone. But this raises the worry that, absent any metaphysical foundation, the axioms of mathematics and other common notions could be mental fictions. Descartes avoids this by making God the direct author of these innate truths. As he writes to Mersenne on April 15, 1630:

> Don't be afraid to assert and publish everywhere, I ask you, that God has established these laws in nature, just as a king establishes his laws in his kingdom. And there isn't any particular one that we could not comprehend if our spirit brings itself to consider it, and they are all inborn in our minds, just as a king would impress his laws in the hearts of his subjects, if he had as much power to do so.[29]

However, to avoid the impious result that God is himself bound by these truths (a concern Mersenne probably brought to his attention), Descartes' account of the divine creation of the eternal truths paradoxically emphasizes that God freely established these truths, and could have just as well imposed another set of truths.

Mersenne, who was busy combating various forms of impiety and skepticism during this period, follows up with a question regarding what type of cause God's establishment of the eternal truths falls under. Descartes responds on May 27, 1630:

> You ask me *in what genus of cause God disposed the eternal truths*. I reply that it is *in the same genus of cause* as he created all things, that is to say, *as efficient and*

[29] AT 1, p. 145.

total cause. For it is certain that he is just as much the author of the essence as of the existence of creatures; hence this essence is nothing other than the eternal truths, which I do not conceive as emanating from God like rays from the sun. However, I know that God is the author of all things and that these truths are something and consequently that he is their author.[30]

This passage suggests that, in defending his view of the mathematical truths, which Mersenne referred to as eternal, Descartes is primarily concerned to distinguish his view from Neoplatonist emanationist views. Neoplatonists regarded creations of God as co-eternal emanations from his being rather than distinct creatures that are created *ex nihilo* in time. Given his mathematical interests, it is quite likely that Descartes came into contact with Neoplatonist metaphysics. For example, Francesco Barozzi's Latin translation of Proclus' commentary on the First Book of Euclid's *Elements* was well known among mathematicians of this time. According to Proclus' Neoplatonist philosophy of mathematics,

> the soul by itself and from the Mind [*mens* or *nous*] produces these [the mathematical forms], and there is the same fullness of forms which originate from intelligible examples; however, from themselves [they] are assigned to passing being [*Esse transitum*]. Therefore, the soul is not a tablet, empty of reasons; on the contrary, it is always written on, and always delineating its own nature, while it is also delineated by mind. *For the soul is also the same mind, coming together close to that first mind itself, and having been made in its image and [being] its external shadowy outline.*[31]

Confronted with these kinds of claims about mathematical truths, Descartes may have felt it necessary to formulate a radically voluntarist view of the divine creation of the eternal truths, in order to avoid associating his view that the eternal truths of mathematics are innate to the mind with the Neoplatonist continuity between the infinite and finite mind. Given his intellectual environment, this hypothesis is preferable to the view that Descartes was responding to Scholastic views at this time, and explains what might have motivated his radical voluntarism.

Having asserted God to be the total and efficient cause of the eternal truths of mathematics, Descartes goes on to make the claim that has generated so much discussion of their problematic modal status.

[30] AT 1, pp. 151–152.

[31] Francesco Barozzi, *Procli Diadochi Commentatorium ad universam mathematicam disciplinam,* (Padua, 1560), p. 9 (Emphasis added).

You ask also what necessitated God to create these truths; and I say that he was just as free to make it not true that all the lines drawn from the center to the circumference were equal as he was to not create the world. And it is certain that these truths are no more necessarily conjoined to his essence than the other creatures. You ask what God did to produce them. I say that *he created them from the very same [act] that he willed and understood them to be from eternity* or alternatively (if you only attribute word *created* for the existence of things) *he arranged and made them*. For in God it is the same thing to will, understand and create without one preceding the other, *unless indeed by reason*.[32]

Descartes seems blissfully unconcerned with the problem of their modal status, since in *The World* he makes it clear that mathematical truths are necessary:

Apart from the three laws which I have explained, I do not wish to suppose any others but those which follow infallibly from the eternal truths on which mathematicians are accustomed to base their most certain and most evident demonstrations: these truths, I say, according to which God himself has taught us that he has arranged all things in number, weight and measure and the knowledge of which is so natural to our souls that we cannot but judge them infallible when we conceive them distinctly, nor doubt that if God had created many worlds, they would be as true in each of them as this one.[33]

Setting aside the problematic nature of the necessity of freely created truths that God could equally well not have established, this passage gives us important clues on how to read Descartes' claim to Mersenne that "it is certain that he [God] is just as much the author of the essence as of the existence of creatures; hence this essence is nothing other than the eternal truths."[34] Descartes could here be taken to equate the eternal truths with the essences of matter and thinking substance that he lays out in the *Meditations*.[35] If that were the case, he would have had to put 'essence' in the plural so as to acknowledge the distinction between the distinct essences of created matter and created minds. The above-cited passage from *The World* suggests an alternative reading that accounts for the fact that 'essence' is in the singular. In this passage, Descartes means by 'essence' a general mathematical blueprint whereby God created the universe according to "number, weight and measure." That this is what Descartes had in mind is also rendered plausible by the fact that Mersenne

[32] AT 1, pp. 152–153 (emphasis original). [33] AT XI, p. 47. [34] AT 1, p. 152.

[35] A common interpretation counts the essences of mind and matter among the eternal truths. See, e.g., Lawrence Nolan, "The Ontological Status of Cartesian Natures," *Pacific Philosophical Quarterly* 78 (1977), pp. 169–194, esp. pp. 171–172; Marleen Rozemond, "Descartes's Ontology of the Eternal Truths," in *Early Modern Metaphysics: Essays in Honor of Vere Chappell*, ed. Paul Hoffman, David Owen, and Gideon Yaffe (Peterborough: Broadview Press, forthcoming).

compares different numbers to the essences of things and claims that this is the origin of the common maxim "*essentiae sunt sicut numeri*" (essences are just like numbers).[36] In other words, Descartes is appealing to a commonly used sense of 'essence' to motivate the view that the eternal truths of mathematics are freely created by God just as the world is, for these truths are, after all, nothing but the numerical blueprint of this world.

Further evidence that Descartes' eternal truths should not be read to include the essences of mind and body comes from the *Principles*. There Descartes maintains that the eternal truths are neither substances and their essential attributes, nor their modes, but rather that they consist in common notions or axioms, i.e., self-evident propositions, that exist only in the mind. The purely mental existence of the eternal truths that distinguishes them from the attributes and modes of matter is also highlighted in *Principles* I, article 48, where Descartes writes, "Whatever falls under our perception we regard either as things, or affections of things, or else as eternal truths which have no existence outside our thought."[37] One might object that even though this precludes counting the essences of extension and thought among the eternal truths, surely true propositions involving such essences, like "Body is extended substance" and "Mind is thinking substance," could still count among them? But then why would Descartes equate the eternal truths with common notions? If statements about the essence of body and mind count as eternal truths, then such truths are not limited to common notions linking simple natures together, but also encompass simple natures and propositions about them. Absent further evidence that these two types of truths collapse into one another, we must assume that Descartes separates the common notions / eternal truths from the simple notions for a reason.

The main evidence to suggest that the distinction collapses is a later passage from the *Meditations* that is often read back into Descartes' formulation of his doctrine of the eternal truths in the correspondence to Mersenne. As in the letters to Mersenne, Descartes gives truths about mathematical essences a special status in this passage from the beginning of Meditation 5:

At this point I think that it must be considered that I discover within me innumerable ideas of all kinds of things which, even if they perhaps do not exist

[36] Mersenne, *L'Impieté des Deistes*, p. 425.

[37] "Quaecunque sub perceptionem nostram cadunt, vel tanquam res, rerumve affectiones quasdam, consideramus; vel tanquam aeternas veritates, nullam existentiam extra cogitationem nostram habentes." AT VIII, p. 22. I take 'perception' here in the broad sense, which could include a purely mental introspection.

anywhere outside me, nevertheless cannot be said to be nothing; and although in a certain manner they are thought at will, they are however not invented by me, but have their own true and immutable natures. When, for example, I imagine a triangle, even if perhaps no such figure exists anywhere on earth outside my thought, or has ever existed, there is really a determinate nature, or essence, or form of it which is immutable and eternal, and not invented by me or dependent on my mind. This is clear from the fact that various properties can be demonstrated of that triangle, namely, that its three angles equal two right angles, that its greatest side subtends its greatest angle, and similar things. These properties are ones which I now clearly recognize whether I want to or not, even if I in no way thought of them before when I imagined the triangle; accordingly, they were not invented by me.[38]

In Meditation 6, Descartes proceeds to show that these mathematical properties actually exist in an embodied form, and so the innate eternal properties of mathematical figures, like the triangle, correspond to the real primary properties of bodies. Hence, it is natural to read the comparison Descartes makes to Mersenne, between the creation of the eternal truths of mathematics and the creation of the essence of other creatures, as anticipating the later doctrine that the primary attribute/essence of matter consists in the mathematical properties of extension in length, breadth, and depth. However, there is no indication in the letter of 27 May, 1630, that Descartes is doing anything more than making an analogy between the way in which God establishes mathematical truths and his creation of creatures. Indeed, the examples Descartes gives of the eternal truths of mathematics are always common notions or mathematical truths, such as 'The radii of a circle are equal' – they never include 'Matter is extended substance.' Nor is there any textual evidence that the circle itself counts as an eternal truth. Rather, as Descartes puts it in Meditation 5, mathematical shapes are eternal forms or natures. As such, the truths they imply are eternally true once God wills them, but none of this implies that what follows from the nature of matter is eternally true, since matter does not exist in the mind as an eternal form or nature. A separate argument is required to show that the properties of matter actually do correspond to those of mathematical objects.

By situating Descartes' doctrine of the eternal truths in its proper context and separating it from his doctrine of the essences of material and thinking substances, we can appreciate the skeptical quandary Descartes found himself in by 1630. He had secured for the axioms of mathematics and other common notions the status of eternal truths that

[38] CSM II, pp. 44–45; AT VII, p. 64.

are directly implanted in our minds by the divine Creator. This means that mathematical axioms are indubitable, by Sanchez's standards, since, as purely intellectual truths, we can know them by direct introspection. Descartes thus frees the geometrical principles, on which the mechanical demonstrations of the *Discourse* rest, from any dependence on deceptive sensory images. By characterizing these truths as both eternal and freely created by God, Descartes avoids both the skeptical concern that these truths could turn out to be mental fictions, and the charges of impiety he would invite if these truths were identified with the Neoplatonic co-eternal emanations of the divine mind. However, having steered clear of this Scylla and Charybdis, Descartes is still confronted with a seemingly unbridgeable gap between the physical objects of the sensible world, and the geometrical foundations of his physics. Unless he can bridge this gap, Descartes is stuck with Sanchez's dilemma of having either secure but purely internal apprehensions that are useless for physics, or insecure external apprehensions. As shown in the previous part, the first two attempts to bridge this gap found in the *Discourse* and *The World* rest heavily on appeals to the explanatory success and intelligibility of the mathematical principles of mechanics. Hence these earlier attempts either make material substantial forms redundant to scientific demonstration or reinterpret such forms in terms of particles with primary qualities rather than eliminating them on metaphysical grounds. In the following and final section I will argue that Descartes, dissatisfied with these solutions, finally bridges the gap with a more systematic metaphysical foundation in the *Meditations.* The new metaphysics involves the replacement of a substance/accident ontology with a substance/mode ontology that is similar to that of Gorlaeus. This allows Descartes to equate the simple natures of the *Rules* with real ontological divisions and to overcome skepticism about the referents of our simple ideas of a body's size, shape, and motion. One important result of Descartes' adoption of something like Gorlaeus' substance/mode ontology is the complete elimination of material substantial forms.

8.2 A BRIDGE TOO FAR? FROM ETERNAL TRUTHS TO MATERIAL SUBSTANCE

The *Meditations on First Philosophy* has become, in more recent times, the most heavily commented-on of Descartes' works, and today constitutes the focal point of any interpretation of Descartes' philosophy. However, since my aim is limited to tracing Descartes' arguments in so far as they

contributed to the elimination of material substantial forms, I will not offer an interpretation of this work as a whole. I will not, therefore, rehearse all the by now familiar interpretations of the various skeptical doubts, the *cogito*, the proofs for the existence of God, the arguments for dualism, etc. Rather, I seek only to situate some of these arguments within the developments studied so far, and determine how they enable Descartes to establish his alternative to the substance/accident ontology, which he first makes explicit in this work. If my treatment of the arguments found in the *Meditations* seems cursory, it is only because my goal is to shed light on Descartes' shift to a substance/mode ontology rather than to delve into the overall aims of this work. There is of course the concern that isolating this lone strand from such an integrated and complex tapestry might seem to violate Descartes' purpose of ridding the reader of cognitive biases by means of a prolonged meditational exercise. In particular, it is not always clear that the first-person narrator of the *Meditations* is supposed to be Descartes himself. Nonetheless, since one finds essentially the same arguments in the *Principles*, which presented Descartes' philosophy in a form suited to classroom instruction, one can assume the views the narrator arrives at to be those of Descartes. I will limit myself largely to the reasoning by which Descartes introduces his substance/mode ontology in the *Meditations*, both because it makes its first appearance there and because the format of the *Principles* does little to illuminate the process that might have led Descartes there. At the very least, the remedy Descartes prescribes for the Scholastic reader through the example of the meditator will reveal the philosophical concerns driving his new ontology, even if we cannot assume that Descartes administered the same meditative cure he models for his readers to himself.

One of the covert aims of the *Meditations* is to establish the foundations for Descartes' physics. As he writes to Mersenne on November 11, 1540:

> But I beg you to not yet say anything to anyone about this plan [i.e., to write a textbook of philosophy alongside Eustachius à Sancto Paulo's], especially not before my Metaphysics is printed. For perhaps, if the Regents knew it, it would be possible for them to give me other tasks. Instead, when the matter is done, I hope that they will all be at ease. This could also perhaps prevent the approbation of the Sorbonne, which I desire, and which seems to me extremely capable of serving my ends, for I tell you that the little bit of Metaphysics which I sent you contains all the principles of my Physics.[39]

[39] AT III, p. 233.

Hence I will examine key arguments developed during the course of his *Meditations* in light of this purpose and turn to select passages from the *Principles* to clarify individual points. As shown previously, Descartes does not provide a complete metaphysical basis for eliminating substantial forms from physics in his early scientific treatises. In particular, I have argued that his doctrine of the eternal truths, which dates back to 1630, safeguards only the mathematical axioms and other common notions that ground his mechanical scientific demonstrations. It does not guarantee that the simple notions of the *Rules* have ontological referents, and so in *The World* and the *Discourse* Descartes merely hypothesizes about the true nature of matter. I will argue, in this section, that the *Meditations* finally complete Descartes' metaphysical foundations for his new physics by establishing, among other things, that the material simple notions, or clear and distinct ideas of body, correspond to the true properties of body.

It is clear from the way in which Descartes proceeds in the *Meditations* that the new metaphysics he will introduce to ground his physics is meant to be immune from skeptical concerns. In Meditation 1, Descartes, in the guise of the meditator, gradually exposes the reader to the foundations of his natural philosophy by raising successively more extreme skeptical worries. By the end of the *Meditations* each skeptical worry is overcome, thus establishing the immunity of the foundations the meditator uncovers from these doubts. In particular, by the end of Meditation 5, the meditator takes himself (I assume the meditator to be male, given Descartes' intended audience and his reservations about the intellectual abilities of women) to have secured the mathematical foundations for Descartes' physics: "And now innumerable things can be clearly known and certain to me, both concerning God himself and other intellectual matters, and also concerning that whole corporeal nature which is the object of pure mathematics [*purae Matheseos objectum*]."[40] All that then remains is to show that this purely intellectual knowledge describes the natures of actual physical objects rather than belonging among those introspections which, according to Sanchez, give us absolute certainty but are quite useless for the purpose of gaining scientific knowledge of external objects.

The meditator begins by raising and answering a series of skeptical arguments that are all too familiar to philosophers today. Briefly, he first answers arguments against the veracity of the senses by pointing to the indubitability of our direct awareness of our own thoughts and

[40] AT VII, p. 71.

actions, which even Sanchez considered beyond doubt: "There are many other beliefs about which doubt is quite impossible, even though they are derived from the senses – for example, that I am here, sitting by the fire, wearing a winter dressing-gown, holding this piece of paper in my hands, and so on."[41] But he does not stop there, asking: Could all this not be happening in my sleep? His initial response is "All this would not happen with such distinctness to someone asleep."[42] This safeguards the veracity of my distinct sensations that I am now sitting, typing, and reading rather than merely dreaming or imagining that I am doing so. Next a further doubt is raised: one can be tricked while asleep; in particular, dreams provide us with visions of objects that, like the objects in paintings, can appear to be real. This is reminiscent of Sanchez's example of Zeuxis' painting of the grapes, which was so realistic that it fooled the birds. If dreams include this kind of vision, then they would indeed be indistinguishable from waking perceptions. The meditator's answer to this doubt is surprising and, moreover, seems to beg the question. He points out that, like paintings, the visions of dreams "could not have been modeled had it not been for a similarity to real things, and therefore that at least these general things – eyes, head, hands and the whole body – are not certain imaginary things, but true things that exist."[43] And even if the eyes, head, hands, and body were not likenesses of real things, at least the colors used in the composition must be based on real colors. This response begs the question against the skeptic, for it presupposes that dreams are as easily distinguishable from waking sensory perceptions as paintings are from real objects. In other words, just as the birds realize that the painted grapes are not grapes once their beaks hit the canvas, we must be in a position to realize that a realistic dream was only a dream as soon as we wake up. It is only on this presupposition that one can conclude that dreams, like the objects depicted in paintings, no matter how realistic, are made up of likenesses of things found in reality. However, as anyone who has ever dreamed of waking up from a dream can testify, the mere impression that one is waking up does not guarantee that one is not still in a continuing dream in which one believes one has really woken up, when one could just as well still be asleep. In principle, the skeptic could reply, all our wakings up could be a succession of dreams in which we periodically dream we are waking up.[44] Why then does Descartes introduce the

[41] CSM II, pp. 12–13; AT VII, p. 18. [42] CSM II, p. 13; AT VII, p. 19. [43] AT VII, p. 19.

[44] While Bernard Williams admits that Descartes falls prey to this kind of objection, he also points out that Descartes' answer in Meditation 6 takes the perspective of the waking person, and so, even though there is no criterion to distinguish waking from dreaming while we are dreaming,

analogy between dreams and paintings, given that there is this crucial dissimilarity?

The rest of the response to the skeptical worry about dreams reveals Descartes' true aim:

> By similar reasoning, although even these general things – eyes, head, hands and so on – could be imaginary, it must nevertheless be admitted that necessarily certain more simple and universal things are real from which, as from real colors, all those images of things which are in our thought, whether true or false, are moulded.
>
> The universal corporeal nature and its extension; likewise, the shape of extended things; their quantity, or their magnitude and number; the place in which they exist, the time through which they may endure, and similar things seem to be of this kind.[45]

Descartes, in effect, uses the dream doubt to introduce the distinction he had already drawn in *The World* between (on the one hand) observable objects along with their secondary qualities and (on the other) the primary qualities of the matter from which they are composed. Here he also adds to the primary qualities the spatiotemporal framework in which physical objects are situated. Everyday objects and their secondary qualities are likened to the imaginary objects of paintings and dreams, whereas the 'universal corporeal nature' along with its extension, plus particular sizes, shapes, and numbers, are likened to the colors on the painter's palette from which the imaginary objects are constructed. So even if we never wake up from our dream, and everything we experience is an illusion, the basic building blocks from which the illusion was constructed must still be real.

Given the weakness of the argument, which rests on an analogy between the construction of a painting and a dream world, Descartes, at this stage, appears to use skepticism as a vehicle of persuasion rather than of sound philosophical argumentation. In other words, the skeptical argumentation of the meditator mentally prepares the reader to accept Descartes' view that extension and the mathematical properties of extended things constitute the real building blocks of the physical universe. The back-and-forth between skeptical arguments and replies designed to allay them appears to be a ploy to arouse alternating states of

this does not necessarily undermine the criteria the meditator relies on, while awake, to know that he is not dreaming. However, since this is not the answer Descartes gives to the dreaming doubt in Meditation 1, I will not discuss it further. Bernard Williams, *Descartes: The Project of Pure Enquiry* (London: Routledge, 2005), pp. 297–302.

[45] AT VII, p.20.

fear of skepticism, and then of relief, in the meditator, and accordingly in the reader. The more the meditator can draw the reader into the skeptical state of mind, the more likely the reader is to cling onto Descartes' new theory of 'corporeal nature' as the only way out.

Other than the painting analogy, what evidence has Descartes provided thus far to back up his claim that primary qualities are the true building blocks of an illusory world? Why shape, size, and number? Could one not equally well argue that since all objects, even the ones in our dream world, have color and we distinguish the boundaries and shapes of bodies by changes in color, that the divine artist painted this universe by constructing shapes, sizes, and number out of the building blocks of adjoining dabs of color? The conclusion Descartes has the meditator draw reveals why this possibility is not even considered:

> Therefore, from this we would perhaps not be wrong to conclude that Physics, Astronomy, Medicine, and all other disciplines which depend on the examination of composite things, are indeed doubtful; and yet Arithmetic, Geometry and others of this kind, which deal only with the simplest and most general things, and care little whether they are in nature or not, contain something certain and indubitable. For whether I am awake or asleep, two and three added together are five, and a square has no more than four sides, nor does it seem that it could occur that such transparent truths could fall under suspicion of being false.[46]

This passage, which is presented as a conclusion from the foregoing, contains the heart of Descartes' reply to the skeptic. The simplest, most general things, which are true regardless of whether we are dreaming or not, are the eternal truths of mathematics. The definitions of mathematical objects do not change, whether we are awake or asleep, and so a square will always have four sides, no matter what our mental state.[47] Similarly, mathematical demonstrations, like 2 + 3 = 5, also survive the dream doubt. At first glance this does not appear to answer the above objection. By the same reasoning, we could treat colors and other secondary qualities as the building blocks of composite objects – after all, red is still red in my dreams, just as a square is still a square. Moreover, the apple in my dream is still red. Nevertheless, insofar as I judge that the red apple of my dream exists independently of me when I see it, I cannot be certain that this is

[46] Ibid.

[47] Note that in the Latin, this truth takes the form of a tautology: "Quadratum que non plura habet latera quàm quatuor." AT VIII, p. 20. In other words, since the Latin name for 'square' expresses its true essence and thus fulfills the criteria for a perfect definiton discussed by Blancanus, its property of four-sidedness follows directly from it.

true. On the other hand, as the meditator later points out in Meditation 5, the Pythagorean Theorem is true regardless of whether triangles exist or not. Mathematical propositions, unlike other judgments, do not involve existence claims. This is why Descartes could compare the sizes, shapes, and numbers of things to the colors on the painter's palette. Whether or not the colors represent anything real, they are there and can be combined, just as quantitative, mathematizable properties can be combined into true mathematical propositions, even in an illusory world of dreams.

Despite the fact that it provides a philosophical reply to the dream doubt that is far more convincing than the painting analogy, the very same passage also expresses a deeper skeptical worry that arises from the meditator's reply. Since the reply does not rule out that composite things are illusory, sciences that study composite things remain doubtful. Only pure mathematics survives the skeptical test. This objection reveals the limits of Descartes' doctrine of the eternal truths of mathematics as a reply to skepticism. While God's voluntary creation of mathematical truths that are innate to us guarantees that such truths are not subject to the deceptiveness of the senses and dream states, it does not safeguard the application of these mathematical truths to the composite physical objects studied by physicists, astronomers, and physicians. For our perceptions of these objects are still subject to all the same skeptical arguments. What Descartes needs to show is that our perceptions of the primary qualities of composite objects, to which he had applied indubitable mathematical principles in his earlier scientific writings, are not illusory. For if we can be deceived that composite objects really have primary qualities, in the way that we can be deceived about their colors, tastes, smells, and sounds, then the mere application of secure mathematical principles to their sensible qualities will not produce scientific demonstrations of mathematical certainty.

Descartes' meditator does not express these implicit concerns, and they emerge only once we approach the *Meditations* from the vantage point of his earlier writings. If we take the *Meditations* at face value, we are supposed to continue being drawn with the meditator into "the inextricable darkness of the[se] problems" by successively more extreme, albeit less and less plausible (at least by seventeenth-century standards) skeptical arguments.[48] After the dream argument the meditator considers the possibility first that God made us subject to deception and next that the all-powerful God of Christianity is a fiction. The former leads him

[48] CSM II, p. 15; AT VII, p. 23.

to consider that even mathematical properties and truths are subject to doubt. This doubt is allayed by God's goodness – surely God's supreme goodness would prevent him from allowing me to be deceived about the number of sides that a square has or the correct sum of 2 and 3? The second doubt follows from the fact that there are many other instances of deception, so if any deception is inconsistent with both God's goodness and his omnipotence, then perhaps there is no such God. If there were not a perfect God who created us, then we could be "so imperfect as to be led into error [*fallar*] all the time."[49] Having led the reader down this path of darkness, the meditator resolves to take matters into his own hands and suppose the falsity of all his former opinions so as to rid himself of his old habits and accept only what is certain. What follows is the artificially induced doubt premised on the hypothetical replacement of God with a malicious demon. But note that even before he turns to a methodical doubt, Descartes' skeptical arguments are anything but random. By means of his carefully structured initial succession of natural doubts, he has already revealed what must be established to remove them. First, the existence of a supremely powerful and benevolent God must be proven once and for all, for mathematical truths, which the meditator identifies as the most transparent and constant knowledge, can still be doubted if we doubt this. Second, to block the doubt that we can be deceived when we attribute mathematical properties to composite material objects while engaged in science, we must demonstrate that matter consists in such properties alone. The proofs Descartes gives for the existence of God are well known. His second task requires that three sub-claims be proven: that the essence of matter is extension, that we know this by a purely intellectual perception (and hence cannot be deceived by the senses as we can in the case of secondary qualities), and that all other properties of matter are modes of extension.

Descartes establishes the first two sub-claims in his famous wax experiment found in Meditation 2. The stated goal of the argument is to rid himself once and for all of his preconceived notion "that the corporeal things of which images are formed in thought, and which the senses themselves investigate, are known much more distinctly than whatever belongs to me [*quid meî*], which does not fall under the imagination and of which I am ignorant."[50] Choosing a piece of wax as his stand-in for any particular corporeal thing, the meditator launches into a thought

[49] AT VII, p. 21. The Latin verb *fallor* can mean both to err and to be deceived.
[50] AT VIII, p.29.

experiment. In addition to its stated goal, the examination of the wax that follows serves to identify what remains when everything that does not belong to the wax is taken away; i.e., it serves to identify its essential properties, and since the wax is a stand-in for any particular body, the essential properties of material substance in general. Descartes' meditator now presents reasons to support his earlier claim about the true building blocks of the physical world, and concludes that the wax is "merely something extended, flexible and mutable."[51] To establish this conclusion he employs a familiar manner of distinguishing accidental from substantial change: trial by fire.[52] When an object is heated by fire, the properties that disappear without a destruction of the substance itself cannot be part of its essence. In the case of the wax, all the secondary qualities of the wax, i.e., its taste, its smell, its color, and the sound it makes, are destroyed by the fire, plus it changes from being solid and cold to liquid and hot. The primary qualities peculiar to the individual piece of wax, such as its particular size and shape, also change. Nevertheless, what remains is still wax. Therefore, the substance of the wax, its 'corporeal nature' or physical essence, as it were, is simply to be flexible, changeable, and extended. The next move is to point out that the wax is capable of innumerable changes, including innumerable ways of being extended. It exceeds the capacity of the imagination to picture all the different possible states contained in the essence of the wax, as a flexible, changeable, extended thing. And yet we grasp that they are all included in the nature of the wax. Therefore, the nature of the wax must be "perceived by the mind" by "an inspection of the mind alone," one which, unlike the perception of the wax given by the senses and imagination, is "clear and distinct."[53] With one thought experiment, Descartes has both justified his conception of matter as an essentially extended substance, capable of a potentially infinite number of different extended states over time, and established that this substance is known not by the senses or the imagination, but by the intellect alone. The latter safeguards this newly found knowledge of the essence of matter from the deceptions that plague the senses and imagination.

Thus far Descartes has merely placed on firmer philosophical ground what he had already asserted during the course of the creation fable

[51] CSM II, p. 20; AT VII, p. 31.

[52] For a description of how Aristotelians and Paracelsians used fire to separate out the elements of substances, see William R. Eaton, *Boyle on Fire: The Mechanical Revolution in Scientific Explanation* (London: Continuum, 2005), pp. 5–6.

[53] AT VIII, p. 31.

found in *The World*: the essence of matter is extension. However, as long as the substance/accident distinction is retained this hardly helps us to put the sciences of astronomy, physics, and medicine on firmer ground, for they study not pure extension, but objects with accidental properties, i.e., particular sizes, shapes, and motions. As shown by the trial by fire that the meditator engaged in, these particular primary qualities are just as changeable as the secondary qualities of a particular body. Hence, on a substance/accident ontology, they count as accidental forms, which means that they cannot be demonstratively proven from the essences/definitions of things. This, in turn, entails that the scientist is limited to hypothetical forms of demonstration in which one observes certain accidental properties, reasons back to a possible cause, and then confirms the cause by deducing the accidental properties from it. As already shown in chapter 6, Descartes wants to replace this type of Scholastic scientific reasoning with secure demonstrations that provide mathematical certainty. The solution lies in something very much like Gorlaeus' substance/mode ontology. Replacing Scholastic Aristotelian accidents with Gorlaean modes allows Descartes to deny that the particular sizes, shapes, and motions studied in sciences, like physics, are merely accidental properties that can inhere in different substances, with different individual essences/natures. Rather, the particular sizes, shapes, and motions of objects are all merely modes or ways of being extended. As particular instantiations of the more general property of 'extension,' the modes of matter are inseparable from the extended substance, and hence have a direct logical connection to the definition of matter in a way that accidents never do with respect to the substantial forms that support and unite them. The modes of matter are like the properties of mathematical objects which, as Blancanus pointed out, are all directly deducible from the corresponding mathematical essence/definition.[54] Once Descartes establishes that the true properties of matter are all modes of extension, he just needs to prove that God's non-deceptive nature guarantees that such extended substances and their modes

[54] Recall Blancanus' claim that "In demonstrations from signs [*a signo*] from which other sciences frequently start, only the cognition of the name of the subject is required, but not the essential definition, for its essence, which is hidden, is investigated by its accidents and its properties, from what is posterior [*a posteriori*]; and then, once the essence is detected, we return to the distinct and scientific demonstrations of the properties. However, if the perfect cognition of the object were given in the first place, as is the case with mathematical objects on account of their perfect definitions, we would proceed according to the most beautiful order of nature, from the essence of the object to the demonstration of its properties, as it happens in demonstrations from the cause [*a causa*], as are almost all geometrical and arithmetical demonstrations, except for demonstrations from the impossible." *De Mathematicarum*, p. 325.

really exist in order to show that the eternal mathematical truths, on which sciences like physics rest, cannot fail to be true of them. Scientific knowledge of composite physical substances is thus placed on a firm metaphysical foundation and safeguarded from skeptical doubts.

Descartes returns to the example of the wax in his first proof for the existence of God found in Meditation 3. There the meditator reiterates the distinction between the secondary qualities of the wax, which he claims to think of only in a very confused and obscure way, and the limited number of things he perceives clearly and distinctly. He then enumerates the latter: "Extension in length, breadth and depth; shape, which arises from the limit of this extension; position, which obtains among different shaped things; and motion, or change in that position; to which may be added substance, duration and number."[55] The meditator then argues, on the basis of the obscurity and confusedness of his perceptions of them, and the causal principle that he articulated at the beginning of Meditation 3, that he does not know whether his ideas of secondary qualities are even ideas of real things. If they are ideas of non-things, he reasons, then they arise due to a deficiency in his nature, and there is no need to posit an external cause for them. If they are ideas of real things, then their lack of clarity and distinctness indicates that the reality they represent is so minimal that it cannot be distinguished from a non-thing. Again, there is no need to posit an external cause of such ideas, since they could originate from himself, and therefore, the only ideas that may require external causes are the above-listed clear and distinct ideas. The meditator next turns to the properties that the wax argument showed to truly belong to the substance of wax. Among the "clear and distinct elements" in his ideas of corporeal things, he counts the properties of substance, duration, and number, which he claims he could have derived from his idea of himself. Finally, when he turns to the remaining properties, he characterizes them as 'modes,' not 'accidents.'

> However, all the others from which the ideas of corporeal things are constituted, namely, extension, shape, position and motion, are not formally contained in me, since I am nothing but a thinking thing; but since they are only *modes* of a substance, and I am moreover a substance, it seems that they could be contained in me eminently.[56]

While Descartes does not clarify how these 'modes' are to be defined in the above passage, their direct relationship to the clear and distinct

[55] AT VII, p. 43. [56] AT VII, p. 45 (emphasis added).

perception of the extended nature of corporeal things is specified at the beginning of Meditation 5. Descartes takes the meditator's ability to clearly and distinctly imagine a general mathematical property, such as continuous quantity, to also enable him to clearly and distinctly imagine the parts of the extended thing with continuous quantity:

> Certainly, I distinctly imagine the quantity, which the philosophers commonly call continuous [quantity] or its quantity, or rather the extension of the thing quantified in length, breadth, and depth; in it I count various parts; to those parts I assign any sizes, shapes, positions and local motions you wish; and to the local motions I assign any durations.[57]

In other words, the clear and distinct mathematical idea of 'quantity' is not just an abstract concept but the result of an act of the imagination, which includes the ability to clearly and distinctly imagine the extension in length, breadth, and depth of a quantified thing and all its parts. These parts are the modes of extension, which will next be shown to correspond to the real qualities of actual bodies. In this manner, the transparent truth of mathematical notions like 'continuous quantity' and 'extension' transfers to all the particular properties of the parts into which these general notions can arbitrarily be divided, and these particular simple natures are re-conceived as modes that correspond to the true, inseparable properties of bodies rather than accidents.

> Not only are those things thus regarded in general, clearly known and transparent to me, but there are moreover also innumerable particulars regarding shape, number, motion and similar things, which I perceive when I pay attention. Therefore, their truth is so open and so much in agreement with my nature, that when I first uncover them it seems not so much that I am learning something in addition as remembering what I knew before, or like noticing for the first time things which were in me long ago, although I had not previously turned my mental gaze on them.[58]

Descartes makes it clear in this passage that it is not just the general principles and concepts of mathematics, such as the common notions, axioms, and general ideas like 'quantity' and 'extension,' that are transparent, but also the particular shapes, numbers, motions, etc., that fall under them. Descartes emphasizes the fact that even the meditator's knowledge of these particular features of the quantity of extended things does not depend on sensory perceptions. Rather, he compares his grasp of their truth to Platonic recollection, claiming that even these particular truths are innate and knowing them merely requires that the mind gaze upon them. This

[57] AT VII, p. 63. [58] AT VII, pp. 63–64.

safeguards even the judgments the mind makes about the particular sizes, shapes, and motions of mathematical objects from skeptical doubts. For these mathematical objects and their particular features constitute the parts of a thing with continuous quantity, and hence, like continuous quantity itself, are purely mental perceptions rather than images derived from the senses. The potential objection that all these objects could be illusory composites of a dream world is then blocked by the argument that God exists, and cannot be a deceiver. Hence these mathematical objects must correspond to the true natures of corporeal objects.

So far, Descartes has established the veracity of our ideas of the modes of body by treating them as directly contained in our clear and distinct idea of the continuous quantity of *res extensa*. However, he has not shown how these ideas can both be innate, and therefore true independently of any sensory perceptions, and nevertheless pick out the real properties of the bodies that interact with our senses. This is one of the tasks of Meditation 6. Descartes' meditator begins by drawing a distinction between the imagination and pure understanding: I can understand that a triangle is a figure bounded by three sides, and I can also imagine it, i.e., picture it with my mind's eye. This explains why the two different ways of grasping mathematical objects get confused, which accounts for the fact that Aristotelians mistakenly took the understanding of mathematical essences to consist solely in abstractions from the sensory images stored in the imagination. To show that mathematical ideas, while not devoid of sensory content, can exceed the capacities of the senses and imagination, the examples of a chiliagon and myriagon are introduced, i.e., two figures which the understanding can distinguish from one another but which the imagination can only represent confusedly as indistinguishable, many-sided figures. The meditator concludes from this:

> Therefore, this mode of thinking may differ from pure understanding only in this: that the mind, when it understands, turns in some way towards itself and inspects one of the ideas which inhere in it; however, when it imagines, it turns towards the body and gazes upon something in it, conforming to an idea understood by it or perceived by the senses.[59]

From the fact that the imagination, unlike the intellect, grasps something bodily, it is inferred that the body probably exists. But, the meditator adds that he does "not yet see from that distinct idea of corporeal nature which I discover in my imagination, that any argument could be taken up which necessarily concludes that some body exists."[60]

[59] AT VII, p. 73. [60] Ibid.

Here lies the nub of Descartes' metaphysical solution to the problem of bridging the gap between mathematics and the physical world. While the common notions and axioms of mathematics, plus universal, essential properties of material substance like 'extension,' are known by the pure understanding alone (as shown by the wax argument, the imagination could not possibly run through all the various extended states a body could take on), our ideas of the modes of body are like the idea of the triangle. We can grasp them by the pure understanding, since they are implied in our general idea of an extended thing, but we can also imagine them. Since the imagination turns towards the body, this makes it probable that the modes of extended things are mind-independent properties of bodies conveyed by the senses to the imagination, as well as mathematical objects grasped by the pure understanding.

There is one potential difficulty, though – if the variable particular primary qualities represented by the senses are real modes of body, then what prevents secondary qualities from likewise being modes of body? After all, we can imagine them as well. Descartes has the meditator raise this concern right after his argument that the ideas of body found in the imagination make the existence of body probable: "In fact, I am accustomed to imagine many others besides that corporeal nature which is the object of pure mathematics, such as colours, sounds, tastes, pain and so on, but none so distinctly."[61] What follows is an account of the childhood prejudices that lead us to mistakenly conclude that the senses are the basis for everything found in the intellect, and a reminder of the reasons for doubting the senses presented in Meditation 1. The upshot is that only clear and distinct ideas are reliable guides to the way the world is really constituted. This then forms the basis for Descartes' argument for mind/body dualism, which is based on the premise that we can clearly and distinctly understand the mind apart from the body and vice versa. His dualism combined with the close substance/mode relationship allows Descartes to neatly tuck away our ideas of secondary qualities by treating them as pure sensations, which are modes of thought, not of body:

> Besides this, I discover in myself faculties for certain special modes of thinking, for example, of imagining and sensing, without which I can clearly and understand myself as a whole but not, vice versa, them without me; that is, without an intelligent substance in which they inhere. For they [the modes of thinking] include some understanding [*intellectionem*] in their formal concept [*suo formali conceptu*]; whence I perceive that they are distinguished from me as modes from

[61] AT VII, p. 74.

a thing [*res*]. I also recognize that there are certain other faculties, such as of changing position, of assuming various shapes, and similar ones, which can no more be understood without a substance in which they inhere than the preceeding ones, and accordingly also cannot exist without it. But it is clear that these, if indeed they exist, must inhere in a corporeal or extended substance, not however an intelligent one, since, to be sure, a certain extension, clearly not however any understanding, is contained in their clear and distinct concept.[62]

Note that dualism alone does not suffice for Descartes to rule out that secondary qualities could inhere in the body as well as in the mind, for if secondary qualities were mere accidents, then there would be no inherent connection between them and a substance's essence. Hence, on the Aristotelian view, an accident like 'hot' or 'red' can inhere in different types of substances, including both ensouled substances and inanimate ones. In effect, the substantial form, as the unifier of bundles of seemingly unrelated properties, accounts for the inherence of a variety of properties that are accidental to a substance, within that particular substance. Descartes would never be able to show that mathematical truths accurately described the only set of properties that constituted the true corporeal nature if he retained a substance/accident ontology and the accompanying substantial forms.

Descartes' solution is to incorporate something very much like Gorlaeus' metaphysics and redefine accidental properties as modes that cannot be separated from the substances of which they are modes. In *Principles* I, article 56, Descartes characterizes modes as follows:

Indeed by *modes* here we understand exactly the same as what is elsewhere understood by *attributes* or *qualities*. But when we consider a substance as being affected or changed [*variari*] by others we call them *modes*; when by that change [*variatione*] we can denominate it such a kind [*talem*], we call them *qualities,* and finally, when we only regard more generally those things belonging to substance, we call them *attributes*.[63]

In other words, modes in the strict sense are particular, non-essential affections or changes of substances. As affections, rather than accidents, they have a strict dependence on the substance that changes. Descartes confirms this conception of the dependence of such modes in his discussion of modal distinctions found in article 61:

The first [of the twofold modal distinction] is known from the fact that we can indeed clearly perceive a substance without the mode which we say differs from it, but we cannot, vice versa, understand the mode without it. Thus shape and

[62] AT VII, pp. 78–79. [63] AT VIII, p. 26.

motion are modally distinguished from the corporeal substance in which they inhere; thus also affirmation and recollection from the mind.[64]

Later on in the *Principles* Descartes reveals that, just as in Gorlaeus' metaphysics, quantity is only modally distinct from material substance. Moreover, as in Gorlaeus' example of the length of a piece of wax, particular quantities are likewise modes that are inseparable from the observable, composite bodies of which they are modes. Descartes adds to the metaphysical commitments he shares with Gorlaeus that such modes cannot be understood apart from the essence of the substance they modify. Since the wax need not have this particular mode (i.e., it need not be 3 inches long in the sense that it could be 2 inches long), particular modes, like the length of a body, are not essential properties and can vary. Nevertheless, whatever particular length it has, as a mode, a body's length is inseparable from its essence of extension and is intelligible only through it, since being 3 inches long is simply a way of being extended.

Read against the background of skeptical humanist arguments found in Sanchez's treatise and Gorlaeus' substance/mode ontology, the argumentation in the *Meditations* takes on new significance. At this stage, Descartes is not concerned with global skeptical arguments against the possibility of all scientific knowledge, for he has already given his scientific demonstrations a secure foundation in the innate truths of mathematics. The skeptical dialectic at the beginning of the *Meditations* merely serves to remind us that as long as we can prove the existence of God, at the very least, the eternal truths of mathematics remain secure against any skeptical challenge. Moreover, the wax argument establishes that the 'extended, flexible, mutable' nature of the wax is known by the intellect alone, and hence is not subject to the vicissitudes of the senses. However, the deceptiveness of the senses makes it impossible for us to assume that proofs grounded in the principles and objects of mathematics describe the true natures of the composite, sensible bodies studied by particular sciences. To bridge the gap between the sensory objects of science and the intellectual objects of mathematics, Descartes needs to establish that the extended essence out of which he constructed his imaginary world is real, and safeguard it from sensory deception. He does so right away in the wax argument. But this argument establishes only that the general intellectual ideas of extension, flexibility, and mutability correspond to the essence of any body. To ground the particular shapes and sizes studied by particular sciences, Descartes further needs to re-conceptualize the

[64] AT VIII, p. 29.

accidental primary properties of bodies so that they flow from the essence of extension as inevitably as the properties of a circle flow from its definition. As shown, Descartes' dualistic metaphysics allows for secondary qualities to be housed in the mind; however, it does not, by itself, suffice to rule out that accidental secondary properties could also inhere in bodies alongside accidental primary properties like particular sizes, shapes, and motions. To rule this out, Descartes reinterprets accidental primary properties as modes of extended substance that are sensed and retained by the imagination as well as intuited by the pure intellect when it surveys the parts of its mathematical notion of extension. Correspondingly, secondary qualities are reinterpreted as modes of thought that require no cause besides, and always depend on, the thinking subject. This ensures that the earlier division of the *Rules* into purely intellectual and purely material simple natures reflects actual ontological divisions among sensible objects: observed primary qualities are always and only inseparable modes of extension, whereas secondary qualities are sensations and hence inseparable modes of thought.

Having connected the Gorlaean theory of modes to his dualism, Descartes succeeds in establishing a metaphysical foundation to guarantee that the eternal truths of mathematics form a secure basis for exhaustive explanations of all the real properties belonging to composite objects studied by sciences like physics, astronomy, and medicine. In this process, substantial forms are eliminated, for, as Gorlaeus already realized, they become both unnecessary and incoherent once the non-essential, particular properties of bodies are redefined as modes. This new metaphysical foundation for his physics enables Descartes to establish a *scientia* consisting in firmly grounded mathematical demonstrations that can stand up to the arguments of skeptics like Sanchez. Moreover, it fulfills Sanchez's criterion that true knowledge must reflect the unity of the universe by reflecting the interrelationships between all its parts. As modifications of extended substance, the physical properties of Descartes' material particles are as closely related to the essential definition of material substance as the properties of mathematical objects are to the definitions of mathematical objects. Hence mathematical demonstrations of the causes of particular physical properties studied by the various sciences are all ultimately grounded in the innate axioms of mathematics and general ideas like 'extension' in the way that tracks the grounding of all the particular physical properties of matter in the corporeal essence of extension. Moreover, the existence of a non-deceptive God guarantees that the mathematical objects of the pure understanding correspond to

the true properties of sensible bodies. Thus unmasked, the sciences are "revealed in all their beauty," for we can now finally see how they "are linked together" and "no harder to retain in our minds than a series of numbers."[65] Science is saved, but without compromising free will and the immortality of the soul. Just as the substance/mode ontology provides Descartes with a secure metaphysical grounding for his scientific demonstrations, it also turns our acts of will into modes of an indivisible thinking substance that has no need of the body. Unlike Gorlaeus, Descartes still characterizes the mind or soul as the substantial form of the body, but material substantial forms have been banished for good.

[65] CSM 1, *Early Writings*, p. 3.

Conclusion

My excavation of the context surrounding Descartes' rejection of Aristotelian material substantial forms has laid bare the various strata involved in his eventual replacement of forms with mechanisms. By situating each of the arguments he recommends to Regius both temporally and spatially within Descartes' corpus, and by identifying his most likely interlocutors during each phase, I have offered a plausible reconstruction of the steps by which Descartes came to eliminate material substantial forms. The end result is a more nuanced and, in many ways, less romanticized portrait of the renowned father of modern philosophy. I have argued that, against radically anti-Aristotelian skeptics like Sanchez, Descartes strives to preserve the Aristotelian ideal of *scientia* as causal knowledge of natural phenomena founded on necessary principles and certain demonstrations. In this sense, he is a conservative rather than a radical. In seeking to ground scientific knowledge on foundations that could withstand skeptical attacks, Descartes takes his inspiration from the budding Aristotelian science of mechanics. By gradually conflating the objects of mechanics, physics, and mathematics, Aristotelian commentators on the *Quaestiones Mechanicae* held out the promise of providing secure mathematical demonstrations of physical phenomena. In keeping with Suarez's redefinition of the material substantial form as a concrete, physical entity justified by empirical arguments, Descartes attempts at first not to eliminate substantial forms but to cash them out in mechanical terms. It is only after 'long experience' that he recognizes the limits of this approach and begins to develop a new metaphysics to support his mechanical physics. Hence, it is not until Descartes develops his mature metaphysics that he abandons material substantial forms completely.

As we have seen, what we now know as the Cartesian metaphysics was itself cobbled together over time. Descartes' first response to the skeptic is his doctrine of the divine creation of the eternal truths of mathematics. Their divine origin protects the geometrical principles, from which his

scientific demonstrations derive their certainty, against skeptical attack. Then, to ensure that these innate mathematical truths and common notions describe the sensible world, Descartes is led first to re-conceive the physical universe in terms of Blancanus' mathematical matter and finally to embrace a substance/mode ontology similar to that found in Gorlaeus' atomist metaphysics. However, in contrast to Gorlaeus' elimination of all substantial forms, Descartes is careful to preserve religious orthodoxy, rejecting only material substantial forms while maintaining that the soul is the immaterial substantial form of the body, forming a *per se* unity with it. This convenient marriage of the mechanical philosophy with orthodox theology does not sit well with Descartes' dualism but is consistent with Suarez's revisionist account of the substantial form. By turning the immortal soul into the paradigm for all substantial forms, Suarez widened the gap between the soul and material substantial forms, defending the latter primarily on empirical, not metaphysical, grounds. This made it easier for subsequent natural philosophers to replace material substantial forms with alternative principles. Ironically, while Descartes emerges as less radically anti-Aristotelian than is generally thought, Suarez begins to look more like the sympathetic guard who left the door ajar, thus leaving an escape route for renegades like Gorlaeus. Indeed, one could argue that Suarez sacrificed the coherency of material substantial forms in order to safeguard the immortality of the soul, by treating substantial form and matter as incomplete substances that could exist independently. The end result was that the soul, as the paradigm for substantial forms, met its end as well.

What general lessons can be drawn from this particular study? First, we cannot continue to approach the study of early modern philosophers as though their subsequent reputations and self-proclaimed allegiances solely determine the philosophical value and historical significance of their work. My in-depth philosophical analysis of a variety of texts has revealed that mainstream Aristotelians like Suarez, Blancanus, and Guevara were much more original than has been recognized, whereas Sanchez's notorious anti-Aristotelian treatise simply offers a more systematic treatment of common skeptical arguments without proposing a solution. Interestingly, Suarez's arguments for the substantial form and the reflections of Blancanus and Guevara on mathematical and mechanical demonstrations turn out to have shaped Descartes' new science and metaphysics in substantive ways. By contrast, the skeptical arguments of anti-Aristotelian humanists like Sanchez appear to have had primarily a negative value, in the sense that Descartes sought

to develop a foundation for science that was immune to their force. Finally, obscure figures like Gorlaeus, a young atomist theologian whose influence was probably limited to seventeenth-century Dutch intellectual circles, nevertheless provide important insights into possible influences on and precedents to early modern metaphysics. The case of Gorlaeus also illustrates the role that Protestant theology played in his decision to embrace atomism and calls for further research into the relationship between Protestant theologies and early modern monism and natural philosophy.[1]

A second general lesson is that fundamental philosophical shifts, such as the replacement of substantial forms with mechanisms, are multi-faceted, complex phenomena that develop over time in a non-linear fashion. Even in limiting my focus to the very end of the substantial form's career in relation to Descartes' mechanism, a variety of distinct philosophical voices and phases could be discerned in the philosophical argumentation. The dominance of the Scholastic voice, even in this late period, is striking, and illustrates the flexibility and resilience of Scholastic Aristotelianism. As mentioned, the substantial form and Scholastic Aristotelian philosophy, in general, survived the onslaught of skeptical humanists and other Renaissance philosophers like Telesio and Bruno, even enjoying a temporary revival based on the originality and strength of Suarez's novel approach. By contrast, the skeptical arguments Sanchez marshals to undermine Aristotelian forms and essences appear to have been well known but not taken all that seriously by many natural philosophers, not even by anti-Aristotelians like Gorlaeus. These findings are counter-intuitive and are easily overlooked by studies that ignore short-lived anti-Aristotelian philosophies, such as that of Gorlaeus, and which operate under standard misconceptions about the nature of Scholastic Aristotelianism.

Indeed, it is my sincere hope that this study will finally lay to rest one of the most enduring and prevalent misconceptions, namely, that late Scholastic Aristotelianism was one coherent enterprise that, much like the proverbial ostrich with its head buried in the sand, perpetuated outdated

[1] The connection between Calvinism and atomism appears to be more than coincidental, as Sebastian Basso, another notorious atomist of the early modern period, had converted to Calvinism. For an illuminating discussion of various ways in which Calvinist and Lutheran theologies informed theories that we associate with modern physics, see Cees Leijenhorst and Christoph Lüthy, "The Erosion of Arisotelianism: Confessional Physics in Early Modern Germany and the Dutch Republic," in *The Dynamics of Aristotelian Natural Philosophy*, ed. Cees Leijenhorst, Christoph Lüthy, and M. M H. Thijssen (Leiden: Brill, 2002) pp. 375–411.

medieval doctrines, while insulating itself against the scientific and philosophical innovations of its day.[2] To assume this is to ignore the fact that until well into the seventeenth century, Scholastic Aristotelianism was the very fiber of higher education. Hence even deviant Aristotelians and vitriolic anti-Aristotelians were Scholastically trained and developed their theories in response to the Scholastic philosophy they were taught. In its highly developed form Scholastic Aristotelianism was no longer identifiable with a single set of fundamental doctrines, but, rather like analytic philosophy today, consisted in an amorphous collection of fluid methods and approaches which formed the basis of every intellectual's philosophical vocabulary.[3] Hence to identify oneself as an Aristotelian at this time was akin to identifying oneself as an analytic philosopher in America today. Scholastic Aristotelians worked in fields as diverse as theology and applied mathematics. Therefore, one cannot assume that every intellectual writing in the Scholastic tradition knew of or even cared about the subtle debates of medieval theologians like St. Thomas Aquinas, John Duns Scotus, and William of Ockham. As we saw, Scholastic commentators of the Aristotelian *Quaestiones Mechanicae* were in dialogue not just with Aristotle and Plato, but with ancient mathematicians such as Pappus, Neoplatonist commentators like Proclus, and engineers in the architectural tradition of Vitruvius, as well as contemporary humanists – they were decidedly not in dialogue with medieval philosophers. To associate Renaissance and early modern Scholasticism exclusively with medieval philosophical doctrines is to ignore the original contributions to the history of philosophy that grew out of later branches of Scholastic Aristotelianism such as the *Mechanica* commentary tradition.

What does all this mean for the history of philosophy? At the risk of preaching to the choir, it means that we have only begun to scratch the surface when it comes to understanding the philosophical concerns and arguments that ushered in the modern worldview. It means that we need more research that crosses traditional chronological and disciplinary boundaries. It means that we must set aside the presumption that philosophers of this period can be neatly divided into Scholastics *versus* their opponents, original *versus* traditional thinkers, and canonical

[2] Especially in the Renaissance, it was anything but. See Schmitt," Renaissance Aristotelianisms", pp. 10–33.

[3] For instance, the seventeenth-century Aristotelian philosopher Honoré Fabri even rejected matter and form!

figures *versus* minor figures working at the margins of the new science. Removing these barriers liberates us from the fossilized categorizations created by nineteenth-century historians of philosophy and science, while offering us the opportunity to develop a more dynamic, richer understanding of our own past.

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