

**Galileo, Newton and all that: if it wasn't a scientific revolution, what was it?
(a manifesto)**

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ABSTRACT

This essay is an exploration of how to conceptualize the so-called scientific revolution. A central figure in this discussion is Thomas Kuhn, whose *Structure of Scientific Revolutions* has shaped much recent discussion of scientific change in the sixteenth through the eighteenth centuries. It is argued that the simple model of a revolution—an old orthodoxy, followed by a period of instability until it is replaced by a new orthodoxy—does not actually represent how change happened in scientific thought in this crucial period. The essay then suggests a different model for understanding change in the period, the Protestant Reformation. Just as in the Reformation the Catholic Church persisted, so Aristotelian natural philosophy persists through much of the so-called scientific revolution. And just as there were multiple sects of protestants who coexisted with one another, there were many alternatives to the dominant Aristotelianism that coexisted and fought as much with one another as with Aristotelian natural philosophy. Without the master narrative provided by the theme of the scientific revolution, the writing of the history of this period is going to be a very open-ended process.

Keywords:

Scientific revolution, Thomas Kuhn, Protestant Reformation

RESUMO

Este artigo explora como conceituar a chamada Revolução Científica. Uma figura central neste tema é Thomas Kuhn, cujo livro *Structure of Scientific Revolutions* deu forma às discussões das transformações científicas ocorridas entre o século XVI e XVIII. Discute-se aqui que o modelo de Revolução apresentado por Kuhn - onde um paradigma seguido de um período de instabilidade é substituído por outro - não consegue representar como realmente se deu a mudança do pensamento científico durante este período crucial para a ciência. O artigo então sugere um modelo diferente, o da Reforma Protestante, de modo a se compreender as mudanças relativas a esse período. Assim como a Igreja Católica subsistiu à Reforma, assim a Filosofia Natural Aristotélica subsistiu durante grande parte da chamada Revolução Científica. Então, como coexistiram diversos grupos e tendências protestantes, assim também coexistiram várias alternativas ao Aristotelismo dominante, incluso a Filosofia Natural Aristotélica. Se nos afastarmos da narrativa clássica sobre a Revolução Científica, poderemos fazer com que a História deste período ainda constitua-se num processo aberto.

Palavras chave:

Revolução Científica, Thomas Kuhn, Reforma

Galileo, Newton and all that: if it wasn't a scientific revolution, what was it?

(a manifesto)

This essay comes out of an attempt to deal with a real practical problem: how to write the period that is usually called the Scientific Revolution of the early modern period, roughly the sixteenth to the eighteenth centuries. In general I don't like historiography as a discipline. I much prefer to have my feet on the ground and deal directly with people, events, and ideas. Often historiography seems to be useless; sometimes it is even harmful, putting *a priori* constraints on how to approach a body of material. I strongly believe in following your nose, letting the material speak for itself, and trying to tell a good story, and not worrying about historiography. But I'm stuck. I have been trying to tell a story about the evolution of knowledge in the seventeenth century now for some time, and I am finding that I just don't see my way clear about how to do it.

Years ago I got interested in a host of minor figures that fought and argued in Paris in the early seventeenth century, alchemists and astrologers, mathematicians and theologians and philosophy professors, some of them moderately well-known figures, connected with Descartes, and some almost completely unknown. I also got interested in the way in which institutions like the University and the Parlement and the court were drawn into the battles, and the way in which the shadow of the French wars of religion was in the background of what appeared to be a scientific debate. One event in particular fascinated me. In Paris, a group of three people, a philosophy professor, an alchemist, and a student (whom I collectively called the Gang of Three) got together and announced a public disputation (in Latin) in which they proposed to refute Aristotle, once and for all. They put up posters all around Paris announcing their event, at a rented hall just outside the city walls. By one account, a thousand people showed up for the big event. But the Parlement of Paris, with the advice of the Faculty of Theology at the University of Paris, shut them down, and refused to allow their disputation to go on. In addition, the event resulted in a number of strong denunciations, and, interestingly enough, no defenses, so far as I can tell. This seemed remarkable: that the truth of the Aristotelian philosophy could raise that much passion. The figures in question were not the figures usually studied; none has the status of a Descartes or a Galileo or a Boyle; none of their views survived to make it into modern thought in any recognizable way. These were the people who worked at the front-lines of the scientific revolution, people who might be considered the losers of the scientific revolution, or, at least, those left behind¹.

Now, I have a sense that there is something important about their stories, and many others that drew my attention. But I couldn't figure out how to tell them in a way that makes sense, how they fit with the larger events that form a part of the master narratives we are usually taught. They don't seem to have very much to do with mathematicization of nature, or the rise of experimental science, or the supposed dominance of the mechanical philosophy. The point of doing history is to make sense of the past. As students of history, we are cautioned against "mere" antiquarianism: an interest in old things just because they are old. At least in the areas of the history of science and philosophy in which I work, the point is to tell a *coherent* story about how people dealt with nature and came to understand the world. But there is a lot of really interesting things that went on in the period that just don't seem to fit into the stories that we have been telling.

And so I decided to turn to historiography to rethink how I am going about thinking through the history of the period, the larger structures that I am carrying to the project. How should we write the history of this obviously central period in the history of

¹ For an account of the event, see my "Defending Aristotle/Defending Society in Early 17th C Paris," in *Wissensideale und Wissenskulturen in der frühen Neuzeit (Ideals and Culture of Knowledge in Early Modern Europe)*, ed. Claus Zittel and Wolfgang Detel (Berlin: Akademie-Verlag, 2002), 135-60.

our coming to understand the world? My hope is that getting clear about some of these larger structures may help me to see my way to how to shape my view of the period and put some of the good stories and interesting observations that I have collected over the years into a satisfying larger picture.

Over the last twenty years or so there has been a chorus of those who want to deny that the events in question, the discoveries of Copernicus, Galileo, Descartes, Bacon, Huygens, Newton and Leibniz constituted a scientific revolution. And there is just as loud a chorus of voices on the other side, insisting that there really was a scientific revolution. The ambivalence about the notion of a scientific revolution is nicely captured in the opening pages of a recent book by Steven Shapin: “There was no such thing as the scientific revolution and this is a book about it.”² It would be tedious to go through the literature and try to summarize their positions³. For some on the Rejectionist Front, the issue is to deny that there was a radical break between the old ideas and the new, and to insist on a kind of continuity between them. For others it is more insidious, an attempt at a post-modern undermining of science itself as an institution, and an argument against an enlightenment picture of intellectual progress. For those on the other side, defending the idea of a scientific revolution is part of defending that same enlightenment picture and defending the very institution of science itself. I apologize for raising these questions once again, particularly since the debate has been rather quiet recently. But my point isn’t to contribute to that argument. Rather, I hope to get to the other side, and figure out how we *should* think of the period with the very practical goal of figuring out, for myself, how to write its history.

There is no question about it: the seventeenth century was a period remarkable for its scientific fecundity, something that was recognized even by those who lived through it. Figures such as Bacon and Descartes certainly recognized their own outstanding intellectual qualities, and were eager to tell their contemporaries about the remarkable new start that they were providing for the sciences, a new and deeper understanding of nature that broke sharply with that of past generations. In 1668 the English poet John Dryden wrote:

“Is it not evident, in these last hundred years (when the Study of Philosophy has been the business of all the *Virtuosi* in *Christendome*) that almost a new Nature has been reveal’d to us? that more errors of the School have been detected, more useful Experiments in Philosophy have been made, more Noble Secrets in Opticks, Medicine, Anatomy, Astronomy, discover’d, than in all these credulous and doting Ages from *Aristotle* to us? so true it is that nothing spreads more fast than Science, when rightly and generally cultivated”⁴.

The progress represented by scientific investigations of the seventeenth century was a standard trope in the Enlightenment of the eighteenth century. This is, in essence, the master narrative that has survived until quite recently.

It is beyond doubt that extraordinary things happened in the seventeenth century. But this is the question: was there a *revolution*?

What, for that matter, *is* a revolution? The central metaphor behind the idea of a scientific revolution is that of a political revolution. A political revolution happens when

² Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996), 1.

³ For two summaries of where we have been on this question, see the introductory essays, Steven J. Harris, “Introduction: Thinking Locally, Acting Globally”, *Configurations*, 6 (1998), 131-39, and Donald A. Yerxa, “Introduction: Historical Coherence, Complexity, and the Scientific Revolution”, *European Review*, 15 (2007), 439-44, and the collections of papers that follow each.

⁴ Quoted in H. Floris Cohen, *The Scientific Revolution: a Historiographical Inquiry* (Chicago: University of Chicago Press, 1994), 1.

one political authority is replaced by another. At one time it was George III, and after a transition period in which it isn't clear who is the authority, he was replaced by the Continental Congress. It wasn't always clear who exactly was in power in France during the revolution, but after a certain point it was clear that it wasn't Louis XVI. Or, in Russia, where the Czar abdicated and after a short period of instability was replaced within months by a Bolshevik government. There is often a transition period in which it isn't clear who is in charge, but it can't go on forever. A country can't do without some civil authority for very long. Or, to put it another way, human nature abhors a power vacuum. If you think of scientific change in the seventeenth century in those terms, then it suggests a master narrative in which there is a dominant authority which is challenged and ultimately gives way to a new dominant authority.

This conception of change has served as a model for thinking about intellectual change, particularly in the period of rapid scientific change that happened in the sixteenth through the eighteenth centuries. Our own conception of the period as a scientific revolution goes back to the work of Gaston Bachelard and Alexandre Koyré in the 1930s. But let me focus on the most extensive and careful characterization of a scientific revolution, the account that we find in Thomas Kuhn's *Structure of Scientific Revolutions*⁵.

In *Structure*, as he came to call the book, Kuhn offers a large-scale account of the structure of scientific change. Basic to that account is the notion of a paradigm, a notion which, for our purposes, I will take for granted⁶. According to that account, we start in a world without paradigms. There are phenomena, there are questions, and people are investigating them, but there is no generally agreed-upon body of theory within the community (what makes it a community?) and no generally agreed-upon way of attacking the questions. From this primordial soup there emerges a paradigm, to put it (over) simply, a model that people can follow about how to proceed. The paradigm, in turn, gives rise to a practice, what Kuhn calls normal science.⁷

Normal science is what Kuhn characterizes as puzzle solving⁸. It involves such activities as making the paradigm more precise in its core area, and the determination of physical constants that are part of the paradigm theory to greater and greater accuracy. It might also involve trying to derive new empirical consequences from the accepted paradigm in order to test the core commitments against experience or the investigation of theoretical problem raised by the paradigm accepted. Normal science might also involve the attempt to extend a paradigm to new domains.

Normal science is puzzle solving. But on occasion we come across puzzles that are not amenable to solution. These are what Kuhn calls anomalies. The longer these anomalies persist, the longer we are faced with puzzles that cannot be solved, the more disruptive they are for the paradigm. This period of disruption is what Kuhn refers to as a crisis. It is in this period of crisis that scientists are willing to consider alternatives to the accepted paradigm. When such an alternative arises (from where? how?) it gives rise to a battle between paradigms. Characteristically, the old paradigm and paradigm newly proposed are characteristically incommensurable: that is to say, the change from the one to the others is taken to be discontinuous. In this way Kuhn compares the choice between the old and newly proposed paradigms to a Gestalt shift or a religious conversion, something that can't be made on purely rational or evidential grounds⁹. When the old paradigm loses, and the newly proposed one wins, we have a scientific revolution.

⁵ Thomas Kuhn, *The Structure of Scientific Revolutions [Structure]* (Chicago: University of Chicago Press, 1962).

⁶ See *Structure*, 23ff.

⁷ See *Structure*, chapt. II.

⁸ See *Structure*, chapt. III.

⁹ See *Structure*, chapt. X.

This, in short is Kuhn's large-scale account of how science is supposed to work, the Kuhnian master narrative, an old paradigm in crisis, undermined and replaced by another. Writing the scientific revolution on this account then is just finding what was the dominant paradigm before the supposed revolution, and then figuring out what replaces it over the course of the seventeenth century and how it comes to be replaced.

Let me begin by saying a few things in general about Kuhn's schema. There are, in my view, some good things and bad in Kuhn's schema for scientific change. The idea of a paradigm has come in for much criticism since Kuhn first put it forward in *Structure*. To be sure, it is a complex concept, ambiguous and slippery. But it is also very useful. The fact of the matter is that certain books, such as Newton's *Principia*, or certain scientific projects, such as Gilbert's studies of magnetism or Descartes' mechanistic explanations have served as concrete models on which others have based their own research projects. And Kuhn certainly deserves credit for having emphasized that.

I feel somewhat more ambivalent about incommensurability. There is a very large literature about the concept, and Kuhn spent much energy in his later years reformulating the concept and trying to defend it against critics. But I think that the incommensurability of competing paradigms is much overemphasized. There is much less incommensurability between competing paradigms than Kuhn thought.

And finally, on the issue of crisis, I think that Kuhn is simply wrong to insist on that as a central element in his conception of the structure of scientific revolutions. In general, I think that it is very difficult to find real crises in the history of science. When they appear, they are retrospective, imposed later and by those who won. Kuhn himself must have had some ambivalence about the need for crises in his account of scientific revolutions. Kuhn published his book, *The Copernican Revolution*, in 1959, three years before he published the *Structure of Scientific Revolutions*. It is telling that in *Structure*, he refers not to his own account of Copernicus, but to the account in A. Rupert Hall's book, *The Scientific Revolution: 1500-1800*¹⁰. When you look back at his own account of the Copernican revolution, the crisis stage is completely missing.

These are worries that I have had about Kuhn for a long time¹¹. But I now think that there is something more basically wrong with Kuhn's view: the fundamental schema simply does not fit the supposed scientific revolution of the seventeenth century, the very paradigm and model of a scientific revolution.

There is something that might be called a dominant paradigm in the study of nature, at least early in the century. That, of course, is Aristotelian natural philosophy, what every literate person would have studied in school. Even if we focus just on Aristotelian natural philosophy and its opponents, there are a large number of very different alternatives available in the marketplace of ideas. Those who opposed the Aristotelianism of the schools were generally called *novatores*, "innovators." When you read the literature of the period, a number of names come up again and again. Some, like Kepler, Galileo, Gilbert, and Bacon are quite familiar to us. Some like Telesio, Bruno, Bodin, Fludd, Patrizi, Vanini, Ramus, Valla and Basso are less familiar but not unknown. Others, such as Gorlaeus, Hill, Olive, Charpentier, Chassinus, and Villon are virtually unknown now.¹² The

¹⁰ A. Rupert Hall, *The Scientific Revolution: 1500-1800* (London and New York: Longmans, Green), 16. See Kuhn, *Structure*, 67.

¹¹ See "Descartes and the Scientific Revolution: Some Kuhnian Reflections," *Perspectives on Science* 9 (2002): 405-22. These ideas were also developed in an unpublished keynote address, "Whither Paradigms," given to the HOPOS meeting at the University of San Francisco in June 2004.

¹² In his *Quaestiones Celeberrimae in Genesim* (Paris: 1623), col. 1838, Marin Mersenne lists Campanella, Bruno, Telesio, Kepler, Galileo, Gilbert, Bacon, Fludd, Hill, and Basso; in his *La Vérité des Sciences* (Paris: 1625), 109, he lists Patrizi, Basso, Gorlaeus, Bodin, Carpentier, Hill, Olive, "et plusieurs autres". In a letter to Beeckman, 17 October 1630, Descartes lists Telesio, Campanella, Bruno, Basso, and Vanini; see C. Adam and P. Tannery, *Oeuvres de Descartes* (Paris: CNRS/Vrin, 1964-74), I: 158. In his lectures given in 1628, published

overlaps between different lists suggests that we have here a generally agreed category of thinkers. But what is interesting here is that though all opposed Aristotle in one way or another, it is difficult to see anything more than that that they all have in common. There is opposition to Aristotelianism, but there is no single paradigm around which these *novatores* rally. Mersenne argued in 1625, while he may be surpassed at sometime in the future, Aristotle is the best we have for now. As he puts it in a famous line, "Aristotle is an eagle in philosophy, and the others are like chicks, who wish to fly before they have wings"¹³. One might add here that the wingless chicks seem as eager to peck at one another as they do to challenge authority of the eagle.

But matters are more complicated still. In a larger sense, there was no such thing as 'science' in the sense of a single, unified discipline whose object was the study of nature. The closest term we have for the modern term 'science' is 'natural philosophy.' Natural philosophy, otherwise known under the names of physics or physiology, dealt first with the general truths about natural things (matter, form, privation, cause, etc.), then with the more specific truths about more specific things, including the cosmos as a whole, the elements, the make up of individual kinds of bodies, including all kinds of living bodies, plant, animal, and human. But natural philosophy was differentiated from a number of other kinds of studies of nature. There was mathematics, not only pure mathematics, such as arithmetic, geometry, and increasingly, algebra, but also what we would call applied mathematics: optics, astronomy (and astrology), music, and mechanics. And then there was alchemy, which like natural philosophy treated body, but often in a very different way. And then there was the medical tradition, which also treated the human body, again, in a very different way from natural philosophy. And then there were the collectors of curiosities, including curious plants and animals.

These different kinds of study of nature were carried out by different people in very different places. Natural philosophy and medicine were both university subjects, though not taught by the same people to the same students. The medical faculty might also deal with alchemy, insofar as it relates to medicines, with botany (insofar as it relates to *materia medica*), and even to astrology. But alchemy also had its own dedicated practitioners, who carried out studies in their laboratories. The mathematical arts could be carried out in a number of places: at the university, as a supplement to (but quite distinct from) the curriculum in natural philosophy, at the court or the arsenal, insofar as it related to more practical matters, both military and non-military, on the work-site. What we call biology could be carried out at the various gardens, founded sometimes for medical research, sometimes for biological research, sometimes simply out of curiosity, to display the wealth of imperial conquest. Sometimes the private collections and cabinets of curiosity of private collectors served as research tools for biological research. These different enterprises were not always entirely unrelated, of course. But they were often different and distinct: there was no one natural kind, be it "science" or "natural philosophy" under which they all fell, and their practitioners were all quite different, ranging from university professors to doctors to alchemists in business for themselves to gentleman collectors.

And just as there were a multitude of different enterprises that concerned nature, there were a multitude of different changes that happened over the course of the seventeenth century. In Kuhnian terms, there were multiple paradigms, and multiple paradigm shifts, changes in the role of mathematics, experiment, important changes in the

under the title *Cribrum Philosophorum* (separately paginated, but published in his *Opuscula varia...* (Paris: 1646)), Jean-Cecile Frey lists Campanella, Patrizi, Bacon, Telesio, Ramus, Chassinus on 19, and in the course of his discussion later adds Villon, Gassendi, Pomponazzi, and Valla. And finally, in the preface (unpaginated) to his French translation of Jean D'Espagnet, *La Philosophie naturelle restablie en sa pureté* (Paris: 1651), Jean Bachou lists Telesio, Patrizi, Campanella, Bacon, Fludd, Gorleus, Taurellus, Ramus Sorel, and Descartes.

¹³*La Vérité des Sciences*, 109-10.

theory of motion and matter, as well as striking new empirical discoveries. And with all these changes came new institutions as well, places to investigate nature and means of disseminating new discoveries, scientific academies in London and Paris and scientific journals such as the *Philosophical Transactions* and the *Journal des sçavants*.

Let me return to the question we were examining: was there a scientific revolution in the seventeenth century? There are complications at every level, multiple alternatives to the dominant Aristotelianism, multiple projects all focusing on nature in different ways, multiple transformations in these different projects, and changes, institutional and social as well as intellectual. So where does this leave us?

It seems clearer and clearer to me that the model of a revolution seems strangely ill-suited to capture what went on in the seventeenth century. The situation with respect to the dominant paradigm at the beginning of the period is not an insuperable problem. I think that it is plausible to identify it as the Aristotelian natural philosophy. Even though it is only part of the mix of disciplines that go to make up the study of nature in the period, I think it is fair to say that it has a kind of dominance over the field. It is the Aristotelian conception of nature, the Aristotelian natural philosophy writ broadly that separates mathematics and natural history from natural philosophy, that infuses mathematical sciences such as astronomy with the basic assumptions that shape them, such as geocentrism. (This, of course, confronts us with the question of what it is that constitutes a paradigm if something as broad and amorphous as “the Aristotelian conception of nature” can count as a paradigm. However, I’m not going to address that question now.) But the variety of alternatives available to the dominant Aristotelianism, their persistence throughout the seventeenth century, and the complexity of the field of disciplines and the dynamic changes that go on in many of these disciplines suggest to me that the simple model of a political revolution, or the model of paradigm-crisis-new paradigm that is at the heart of Kuhn's *Structure* doesn't really fit the world.

Now, metaphors are only approximate, and one shouldn't expect too much from them. But while we don't want to get too fixated at what is a convenient term of reference and mistake it for the reality of the phenomenon, we should expect *something* from a metaphor. And I'm afraid that the comparison with a political revolution that lies behind much of our discussion of the period just doesn't deliver.

But if it wasn't a scientific revolution, then what was it? This is an important question, not because we are trying in some way to capture “the putative essence” of the events, but because thinking about it in the right way may help us to figure out how to conceptualize what happened, and, ultimately, may help us to write the history of the period.

My suggestion is that we look in another direction for inspiration, at the Protestant Reformation. Which is to say, I think that the Protestant Reformation of the sixteenth and seventeenth century may provide us with a more satisfactory way of thinking about what happened in our understanding of nature in the seventeenth century.

The Protestant Reformation is usually taken to begin with Luther, of course. But this is not to deny that there were constant challenges to the Church from the beginning. Closer to the official period of the Reformation were figures such as Wyclif, Hus, Savonarola, and many, many others. Some were mere heretics, some established sects. Others defined themselves as independent churches. And then there was Luther. And Calvin. And Zwingli. And Fox. And many, many more who put forward their own versions of the true religion. Each had their followers, their practices, and complex relations with one another. What is important here is that there was no such thing as *the* Protestant church; there were protestant churches in the plural, with beliefs and practices of all kinds. And while some had some doctrinal elements in common, what they really had in common was the fact that they opposed the dominant authority, the Catholic Church. And their very

existence changed the Catholic Church. While some may have hoped to replace the Church of Rome, and hoped that it would wither, it persisted and changed.

This is sufficiently like what happened in the so-called scientific revolution to make me think that it might suggest helpful ways of thinking about what happened in the disciplines concerning nature in the seventeenth century.

Like the Catholic Church, Aristotelian natural philosophy had a kind of dominance in the intellectual world. And in just the way that the Catholic Church infused and dominated a variety of institutions, from religious orders to civil governments, Aristotelian natural philosophy was infused in a variety of other disciplines (astronomy, even natural history) and institutions (such as the University). More interesting still is the way in which opponents to the Aristotelian natural philosophy resemble the various Protestant opponents to the Catholic Church. Some began as heretics, and never left the fold. Some from the beginning consider themselves as alternative ways of seeing the world, entailing alternative practices incompatible with orthodoxy, and incompatible with one another. This description seems to hold both for Lutherans, Calvinists, followers of Hus or Zwingli, and for Galileans, Cartesians and Baconians, followers of Telesio or Bruno, Alchemists and natural magicians. Some of these challenges to orthodoxy attract followers, and wind up giving rise to durable movements, often with their own institutions. And some of them don't: they are short-lived heresies that come and go. But what is importantly different between this model and the model of a political/scientific revolution is that *multiple challenges to authority can coexist with one another, and with the authority challenged, and can do so for quite some time.*

The Catholic Church persisted throughout, as did some number of Protestant sects, all the time retaining their identities. They interacted with one another, and in so doing, changed one another: the post-Reformation Catholic Church was not at all the same as the church that had been challenged in the early sixteenth century. In the same way, Aristotelian natural philosophy persisted throughout the seventeenth century, as did its challengers. Unlike in the case of a political state, there can be multiple intellectual authorities which all exist at the same time. And as with the Catholic Church, the existence of these heresies altered the Aristotelian natural philosophy, which was not at all the same at the end of the century as it was in the beginning. There is, of course, a big difference between the situation of the Catholic Church and that of the Aristotelian natural philosophy: the Catholic Church persists to this day, whereas Aristotelian natural philosophy doesn't. I hesitate to say that it was refuted, exactly. But by the end of the seventeenth century, it was certainly in eclipse, and was almost totally eclipsed by the end of the eighteenth. (By the way, I say this as if I understood what exactly this means, and how exactly one would argue for it. Neither is true.) But one should not overestimate the significance of this difference. One can certainly imagine a world in which the Catholic Church withered, and was replaced by the its Protestant opponents. (Certainly many Protestants in the period hoped for this.) Another possible difference is the fact that while the Protestants never came together to form a single Protestant Church, in a way one may argue that science did, in the end, bring all its parts together and establish a new orthodoxy. Perhaps, but at the end of the seventeenth century, at least, that hadn't happened. And if it happened, it didn't happen quickly. In any case, an analogy can be just an analogy: it doesn't have to fit in every respect to be useful.

(It is worth pointing out that there is a sense in which this analogy is more than just an analogy. The Aristotelian natural philosophy was closely connected with the Catholic orthodoxy. It was not lost on both the Catholic Church and its opponents that the opposition to Aristotelian natural philosophy was closely connected with opposition to the Church itself. This is true independently of what one might think of the Merton thesis about the relation between the new science and Puritanism.)

I suggested that the point of an analogy is not exact correspondence but utility. Is this analogy I am proposing useful? In particular, does it address my needs, a way of thinking about what happened in the seventeenth century that might help me to write the history of the period? The historiography of the Protestant Reformation is enormously complex; there are many strands, and many approaches, unsurprisingly give how close to home it is for many to write it¹⁴. But even without going into detail on the different approaches to the Reformation found in the literature, there are things that can be said.

First of all, and perhaps most importantly, it offers us a tremendous liberation from what has seemed to me to be an enormously narrow picture. If we think about these events in these terms, we no longer have to look for a master narrative of authority replaced, in essence the narrative behind Kuhn's *Structure*. In fact, there is a sense in which there is no master narrative at all. On this new conception of the history of the period, there are multiple strands of thought and practice that don't have to be unified into a single alternative, in just the way that the variety of Protestant sects and churches coexist in a realm of competing and coexisting beliefs and rituals. There is now room in the story for the sixteenth century Italian opponents of Aristotelianism, such as Telesio, Bruno and Campanella, for the different varieties of the alchemical philosophy, for the magical and astrological, for eccentric thinkers like Robert Fludd, Sir Kenelm Digby and Athanasius Kircher, as well as now canonical thinkers like Descartes and Galileo. There is also room for my Gang of Three in Paris, and studies of the debates between Aristotelianism and its opponents focused in particular locales, as well as studies of ideas that travel across boundaries and become larger movements. Indeed, it encourages us to ask how exactly the thought of one man—be he a Descartes or a Luther—comes to stir a multitude. The metaphor of the Protestant Reformation encourages us to see the intellectual transformation of the age as a somewhat unfocused challenge to authority that becomes focused and condensed around certain figures and ideas only later, and even then, doesn't necessarily lose its diversity and contentiousness. If there was something general and widespread, it was a dissatisfaction with orthodoxy and a hunger for something new in some circles, a fear of anything new in others. (In this way it is a kind of scientific twin of the Protestant Reformation, a different manifestation of the same spirit.) It also encourages us to see the intellectual transformation as a part of a general cultural transformation. We can't forget that with the intellectual transformation of science, there were profound reactions, law suits about what to teach and what to believe, people condemned, burned and exiled. Approaches to understanding nature were deeply intertwined with culture, religion, and politics: when I speak of orthodoxy with respect to views of nature, this is more than a metaphor. Just as all of this is part of a full understanding of the religious reformation, all of this and more becomes part of the central story of understanding the transformation of thought in the period, and not just peripheral side events, as they are on the master narrative of the scientific revolution.

So how should we write the history of the period? There are still the big stories of Galileo and Descartes and Huygens and Newton to tell. And they are still important, indeed central. However, there are other stories to tell about the smaller encounters, the local encounters, the stories about how change came at a smaller level, the obstacles faced by change and how they were negotiated or not. These are part of the story too. These add the texture to the larger stories. Intellectual transformation doesn't come only at the highest levels: we want to know how orthodoxy comes to be challenged on the street and in the lecture hall, and defended by the professor and the dean and the judge. If Aristotelianism becomes eclipsed, it is because people on the street challenge it. If something like Cartesianism comes to replace it in certain circles, it is because certain individual people

¹⁴ For a survey, somewhat dated but still useful see A.G. Dickens, John Tonkin, and Kenneth Powell, *The Reformation in Historical Thought* (Cambridge, MA: Harvard University Press, 1985).

begin to take it seriously. But it's not going to happen overnight. It is these stories I want to tell.

Furthermore (and this is a different point), not everyone is going to sign on to the same new program. Historians of philosophy and science often talk about the debate between traditional science (Aristotelian, etc.) and THE new science. But there isn't any such things as THE new science; there are multiple new sciences, at least in the beginning, until things really get sorted out. When we study intellectual change at this level, we discover that the intellectual world is varied. It is not the battle between David and Goliath, or between the Russian Revolutionaries and the Czar, but more like Mersenne's Eagle and chicks. But eventually some of the chicks grow wings. To put it another way, there is no single master narrative of the changes: there are individual stories of heterodoxy and orthodoxy, opposition and defense. There are narratives about the development of different sects of opponents to orthodoxy. And there is going to be a story of how the orthodoxy eventually collapsed, for the most part, or became eclipsed. (Here the story of the Scientific Reformation will be different from the story of the Protestant Reformation: Roman Catholicism never collapsed.) But matters are too complex for there to be a single coherent narrative.

What this means is the writing of the history of this period is going to remain a very open-ended process, at least when we focus on the street level: the front lines. It will be a slow and cumulative process, understanding what happened and why in Paris, in Leiden, in Naples and Transylvania. We can't rush it, and we cannot expect it to be neat and easily packaged. Eventually, patterns may emerge, or not. (This is my apologia for a collection of studies that will eventually be appended to this essay.) The studies that I am undertaking in the context of this project, some of which are completed, some of which are in progress, are not neat, and they do not lead to a clean conclusion that can be easily articulated. They are about people (and institutions) dealing with the clash between the old and the new as best they can. Some of the people few have heard of. Some, like Descartes or Hobbes, are well known. Here I can say that it illuminates the larger figures to see their thought in the context of the chaos of the debate at this ground level. But not all of the studies I have in mind are like that. Sometimes they look, even to me, like random observations of random people, full of sound and fury, but maybe signifying nothing. I'm not always sure where they lead, to be honest, but I have a strong sense that together with studies like this that others are doing at the moment, they will ultimately contribute to a larger understanding of the process by which the modern conception of the world emerged and came to eclipse what had been the dominant conception on the sixteenth and early seventeenth centuries. And I hope that they will be interesting on their own, at very least good stories.

But enough of this idle historiographical talk. There is work to be done. It is time to head for the libraries and the archives, and return our feet to the ground.

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