I

INTRODUCTION

A. A SECULAR THEOLOGY

A new and unique approach to matters divine, a secular theology of sorts, emerged in the sixteenth and seventeenth centuries to a short career. It was secular in that it was conceived by laymen for laymen. Galileo and Descartes, Leibniz and Newton, Hobbes and Vico were either not clergymen at all or did not acquire an advanced degree in divinity. They were not professional theologians, and yet they treated theological issues at length. Their theology was secular also in the sense that it was oriented toward the world, ad seculum. The new sciences and scholarship, they believed, made the traditional modes of theologizing obsolete; a good many professional theologians agreed with them about that. Never before or after were science, philosophy, and theology seen as almost one and the same occupation. True, secular theologians seldom composed systematic theological treatises for the use of theological faculties; some of them, mainly the Catholic, pretended to abstain from issues of sacred doctrine; but they dealt with most classical theological issues—God, the Trinity, spirits, demons, salvation, the Eucharist. Their discussions constituted theology inasmuch as they were not confined to the few truths that the “natural light” of reason can establish unaided by revelation—God’s existence perhaps, or the immortality of the soul. Secular theology was much more than just a theologia naturalis.¹ Leibniz, the secular theologian par excellence, planned a comprehensive and sympathetic study on “Catholic demonstrations” of dogmas. Not only was he a layman, but also a Protestant.²

¹ On the classical origins of the term see Jaeger, Die Theologie der frühen griechischen Denker pp. 10–16. The usage of the term “theology” in the Middle Ages to characterize some pagan philosophers is rare; but see Thomas Aquinas, Summa theologiae 1 q. 1 a. 1 (to Aristotle, Metaphysics e. 1026a19). See also Curtius, Europäische Literatur und lateinisches Mittelalter pp. 224–25. The name “natural theology” was revived during the Renaissance: below nn. 10, 14. In the seventeenth century it was reclaimed by deists as the sole religion.
² Leibniz, Sämtliche Schriften und Briefe (henceforth SB), 1.6, pp. 489–559. Cf. below II.H.6. Though this exercise was a part of Leibniz’s plan to restore the unity of the Church, it was more than merely a search for the greatest common denominator or a minimum of dogma.
I. INTRODUCTION

The secularization of theology—even in the simplest, first sense: that theological discussions were carried on by laymen—is a fact of fundamental social and cultural importance. It can be accounted for only by a variety of complementary explanations.

During the thirteenth century theology became both a distinct discipline and a protected profession; neither was the case earlier. Prior to the twelfth and thirteenth centuries, the term “theology” was ambiguous; it stood both for the word of God (the Scriptures) and for words about God, that is, any kind of discourse on matters divine. Soon after the beginnings of its systematization, theology was established as a protected profession in the nascent universities. It was, in fact, doubly protected from the incursions of laymen. By and large, every science except medicine and sometimes law was taught by clergymen, regular and secular. But ordination and even the right to teach the arts (philosophy) did not suffice to teach theology, that is, commence with lectures on Lombard’s Book of Sentences, without acquiring the proper degree.

Even though medieval philosophers could not avoid discussing matters divine, they were careful not to call by the name of theology those truths about God and the heavens accessible to mere reason. It is significant that, unlike the classical tradition, they avoided the term theologia naturalis and were careful not to call the ancient pagan philosophers “theologians,” even while admiring their monotheism as praeparatio evangelica. Theology became a term reserved for supernatural knowledge. When, in the fourteenth century, Buridan suggested elimination of separate intelligences from the explanation of the motion of heavenly bodies—he favored an initial impetus instead, which keeps the heavenly bodies moving in perpetuity—he hastened to add: “But this I do not say assertively, but rather so that I might seek from the theological masters what they may teach me in these matters.” Buridan was only an artist (that is, a teacher of philosophy).

The first protective belt around theology eroded slowly, almost

3 Ghellinck, Le mouvement théologique du 12e siècle pp. 91–92.
4 “Sed hoc non dico assertive, sed ut a dominis theologiai petam quod in illis doccant me, quomodo possunt haece fieri”: Buridan, Questiones super octo physicorum libros Aristotelis, ed. A. Maier, Zwei Grundprobleme der scholastischen Naturphilosophie p. 212; trans. Clagett, The Science of Mechanics in the Middle Ages, p. 536. To have opined something disputandi more, non asserendi more was often the defense of schoolmen when tried for false teaching.
imperceptibly, in the sixteenth century, when ever more disciplines in the universities ceased to be taught by clergymen. Nor did the university remain the only center of research and scientific communication: courts, academies, and printers became places of meeting and sources of sustenance. The rising number of educated laymen, as a reading public, as authors, and as teachers, was bound to increase instances of trespassing into the domain of theology; the case of Galileo was not unique, only the most scandalous.

The second protective belt around theology as a profession eroded with the spread of religious movements in the later Middle Ages, and collapsed with the spread of Protestantism. Of the authority of the Holy Church, Augustine once said that, unless moved by it, he would not even believe the Sacred Scriptures. The counterclaim of the Reformation—sola scriptura, sola gratia, sola fide—secured knowledge of God and access to him without the mediation of a priestly hierarchy. Protestants were encouraged, in various degrees, to read the Scriptures for themselves and to be for themselves ministers of grace. Theology became “secularized” in many parts of Europe in the original sense of the word: appropriated by laymen.

Again under the impact of Protestantism, theology became secularized in yet a deeper sense. To various degrees, it encouraged the sacralization of the world, even of “everyday life.” Human labor in hoc seculo was not perceived anymore as a mere preparation for the future life; it acquired its own religious value in that, if well done, it increases God’s honor. So also does the study of this world, by ex-

5 The late medieval proliferation of theological literature for laymen was mostly the work of theologians, as, e.g., the Dives et pauper (now available in the excellent edition of E. Heath Barnum [London 1976]), though not always: Dante and Marsilius of Padua were not theologians. Medievalists sometimes distinguish “secular” from “regular” theologians, i.e., theologians belonging to an order; obviously, this is not the sense in which I use the term “secular theology.” Cf. n. 7.

6 “Ego vero evangelio non crederem nisi me catholicae ecclesiae commoveret auctoritas”: Augustine, Contra epistolam Manichaei 5, p. 197.22. For a strongly psychological interpretation of commovere see Oberman, The Harvest of Medieval Theology, p. 370 (refers also to Gregory of Rimini).

7 Weber, “Die Protestantische Ethik und der Geist des Kapitalismus,” Gesammelte Aufsätze zur Religionssoziologie, 1:17–206, esp. pp. 63ff., 84ff. This, of course, is true independent of the merit of Weber’s central thesis. I hope that my use of the terms “secular” and “secularization” are clearly defined without being anachronistic. Originally, “secularization” was a legal term; since the Carolingian age it stood for the expropriation of Church property by worldly powers. One should be careful not to confuse “secular”
posing the ingenuity of its creator. The world, too, was not perceived as a transitory stage. It became in and of itself, as indeed attested to by the Scriptures, “very good” (Gen. 1:31), if not outright sacred. The world turned into God’s temple, and the layman into its priests.

Finally, the barriers separating various scientific disciplines were fundamental to the peripatetic program of systematic knowledge. Within the Aristotelian and Scholastic tradition, it was forbidden to transplant methods and models from one area of knowledge to another, because it would lead to a category-mistake. This injunction suited the social reality of medieval universities well, separating theology from philosophy to the benefit of both; but it eroded considerably from the fourteenth century, when mathematical consideration started to be heavily introduced into physics, and even into ethics and theology. What was a methodological sin to Aristotle became a recommended virtue in the seventeenth century. Since then we have been urged to transport models from mathematics to physics and from physics to psychology or social theory. The ideal of a system of our entire knowledge founded on one method was born. Aristotle never entertained it; neither did Scholasticism. Indeed, the very word “system” stood, until the seventeenth century, not for a set of interdependent propositions but for a set of things—for example, systema mundi or systema corporis. The ideal of one, unified system of knowledge could hardly exclude theological matters, down to Spinoza’s treatment of God more geometrico. These are some of the reasons why God ceased to be the monopoly of theologians even in Catholic quarters.


4 Cf. below II.b.1–2; v.b.2.

5 So already in Antiquity: see, e.g., (Pseudo)Aristotle, On the Cosmos 319b.9–12, p. 346. In part, “system” continued to be employed in this sense also in the seventeenth century (e.g., in the third part of Newton’s Principia). It came to mean, among other things, an edifice of integrated propositions. Leibniz is particularly fond of speaking of “his system” (below II.h.n.3). Bayle tried, systematically, to elaborate the “system” behind all points of view—even the most abstruse or appalling. It is, I believe, a necessary component of his “critical” attitude. In the definition of Condillac, Traité des systèmes, in Oeuvres complètes, 2:1, “une systême n’est autre chose que la disposition des différents parties d’un art ou d’une science dans un ordre où elles se soustiennt toutes mutuellement, et où les derniers s’expliquent par les premiers.”
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The Catholic response to the secularization of the divine seldom restored the fine medieval balance between philosophy and theology. To the contrary, whenever skeptical or fideistic arguments were invoked to undermine the faith in unaided reason, the medieval understanding of theology as a rational endeavor (albeit proceeding from premises inaccessible to the lumen naturale) was also undermined. Montaigne’s “Apology for Raymond Sebund” is an excellent example of these opposing trends—the defense of the theologian’s reserve as well as (against the theologian’s wishes) the secularization of theological issues. Sebund’s extreme claims for the evidence of natural theology (this name was given to the book later) were censured by the Church. Montaigne believed he would be even better able to defend the Church if he were to destroy (as did Hume later) the notion that there exists an innate, self-evident core of theological truths. Man, by no means superior to brutes either emotionally or intellectually, needs a supernatural source of guidance even in daily, mundane affairs. The value of Sebund’s natural theology can at best be relative: sometimes it may serve polemics. The only plausible proof for the veracity of Christianity that Montaigne elaborates at length is taken from the irrational rather than rational domain, and may be called an ethnographic proof: “I have often marveled to see, at a very great distance in time and place, the coincidence between a great number of fabulous popular opinions and savage customs and beliefs, which do not yet seem from any angle to be connected with our natural reason”—such as circumcision, the cross as sacred symbol, stories of primordial mankind, of an original sin, of a flood. “These empty shadows of our religion that are seen in some of these examples testify to its dignity and divinity,” and they do so precisely because they are not

10 Friedrich, Montaigne, pp. 94–96, 316 n. 58. Sebund’s original title was Liber creaturarum seu naturae seu liber de homine propter quem sunt creaturae aliae (Lyon, 1484). The double truth theory, which Friedrich attributes to the Latin Averroists, was rather an invention of their adversaries from Étienne Tempier to Sebund.

11 Montaigne, Essais 2.12: “Je me suis souvent esmerveillé de voir, en une très grande distance de lieux et de temps, les rencontres d’un grand nombre d’opinions populaires monstrueuses et des moeurs et creances sauvages, et qui, par aucun biais, ne semblent tenir à nostre naturel discours. C’est un grand ouvrier de miracles que l’esprit humain; mais cette relation a je ne sçay quoy encore de plus hétéroclite; elle se trouve aussi en noms, en accidents et en mille autres choses. . . . Ces vains ombraiges de nostre religion qui se voyent en aucuns examples, en tesmoignent la dignité et la divinité” (ed. Rat, pp. 644–45; trans. Frame, pp. 432–33).
accountable by reason. Montaigne turned natural theology on its head while using some if its own ancient arguments. Previously, some of these “coincidences” were invoked to show that polytheism and fetishism were just historical perversions of man’s original, natural monotheism. Montaigne denies it, denies that anima naturaliter Christiana. He believes that the “light of reason” only leads to confusion, to a Babel of creeds.

Yet Montaigne himself was a layman. Moreover, he unwillingly shared with Sebund the urge to abolish the demarcation line between natural and supernatural knowledge—although with opposite intents. Throughout the following century, the zeal for the defense of the doctrinal authority of the Church created critical arguments more dangerous than their target. Richard Simon promoted biblical criticism to refute the claim that the Bible can be understood by itself alone, sine glossa. Jean Astruc, wishing to defend (against Spinoza) Moses’ authorship of the Pentateuch, invented the most destructive tool of biblical criticism yet: the philological distinction among the various original documents from which the Masoretic text was composed, by Moses, as he believed, or by others later (as we do). How much more deadly to theology were such helpers than its enemies! Yet, without being exposed to these and other dangers, theology would never have contributed as much as it did to the sciences and letters in the seventeenth century.

Finally, the secular theology of the seventeenth century was also a distinct phenomenon inasmuch as it was not so universally accepted as to be beyond challenge and identification. Not all who had a share or interest in the advancement of the new sciences approved of it. Fellows of the Royal Society, said Sprat, “meddle no otherwise with divine Things, than only as the Power, and Wisdom, and Goodness of the creator is displayed in the admirable Order and Workmanship of the creatures. It cannot be deny’d, but it lies in the natural Philosopher’s Hands, best to advance that part of Divinity; which, though it fills not the Mind with such tender and powerfull Contemplations, as that which shews us Man’s Redemption by a Mediator; yet it is by no means to be pass’d by unregarded, but is an ex-

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cellent Ground to establish the other. . . . These two subjects, God
and the Soul, being the only forborn, in all the rest they wander at
their Pleasure."\textsuperscript{13} The \textit{separation} of science from religion may have
been as often demanded as it was violated; yet even those who de-
manded it with sincerity (rather than as a matter of prudent tactics)
did not do so on medieval grounds. If previous generations distin-
guished between "natural" and "sacred" theology,\textsuperscript{14} Sprat and
others distinguished between science (or philosophy) and religion:
religious contemplation, albeit more "powerfull," was placed out-
side the boundaries of scientific discourse. Deists were soon to re-
recognize in "natural religion" the only true religion.

My aim in the present study is not to describe the secular theol-
ogy of the seventeenth century in its breadth and in its manifold
manifestations; I rather chose from it a few significant themes.
When Christian Oetinger, the Pietist theologian, came to deal with
God's attributes, the traditions he discussed were not those of Schol-
ostic theology—Catholic or Protestant—but those of secular the-
ology. "The attributes of God are ordered in one way by Leibnizi-
ans, in another by Newtonians; it is not irrelevant to compare their
methods."\textsuperscript{15} Some divine attributes and their relevance to natural
science, political theory, and historical reasoning form the topic of
my study. The secular theology in which these and other themes
were embedded still awaits a detailed and comprehensive descrip-
tion as a new cultural phenomenon. My treatment of these themes
is not even construed to prove the existence of a secular theology (if
proof is needed) but to call to the attention of the reader the changes
of connotation that some divine attributes underwent in a new in-
tellectual climate.

\textsuperscript{13} Thomas Sprat, \textit{History of the Royal Society} (London, 1667), pp. 82–83. See Cragg,
\textit{From Puritanism to the Age of Reason}, pp. 96–97.

\textsuperscript{14} "Partiemur igitur scientiam in \textit{Theologiam et Philosophiam}. Theologiam hic intelli-
gimus Inspiratam sive Sacram, non Naturalem": Bacon, \textit{De dignitate et augmentis scientia-

\textsuperscript{15} "Alter attributa Dei ordinant Leibnizianum, aliter Newtonianum. Non abs re erit, insti-
tuere comparationem inter methodum illorum et horum. Leibnizianum incipit a contin-
gentia ad ens absolute necessarium . . . et haec dicitur asetis. . . . Methodus ordinandi
Newtoniana incipit a libertate Dei, qua usus est in formando universo. . . .": Oetinger,
\textit{Theologia ex idea vitae deducta}, p. 50. In recent literature, Kolakowski, \textit{Chrétiens sans église:}
\textit{La conscience religieuse et le lieu confessionnel au xviier siècle}, comes closest to the study of sec-
ular theology as a cultural phenomenon.
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B. THE THEMES

Whether or not God is immutable, our perceptions of God are not. In the following three chapters I wish to examine the changes in the meaning and usage of three divine attributes between the Middle Ages and the seventeenth century. It will serve as a convenient way to describe the changes in the nature of theological speculations vis-à-vis other disciplines—physics, history, political thought. It is also a convenient way to gauge changes in these disciplines themselves.

The divine predicates to be discussed are the omnipresence, the omnipotence, and the providence of God. They were not chosen at random. Divine predicates pose general as well as particular problems. Common to all is the problem of legitimacy of every positive mode of locution about God, or conversely, the efficiency of merely negative predicates. Of the particular problems, some are more time-bound than others. God’s goodness and justice are hard to defend at all times from the vantage point of our painful world, which is the only vantage point we have. Such are not the problems I shall deal with here. I am rather concerned with those predicates that posed time-specific difficulties in the seventeenth century, and along with the difficulties opened up new opportunities of thought.

Because the seventeenth century wished language to become precise and thoroughly transparent, God’s omnipresence became a problem. If it could no longer be given a symbolic or metaphorical meaning, how else could the ubiquity of God be understood, God’s being “everywhere”? The problem was compounded by the new commitment of the seventeenth century to a view of nature as thoroughly homogeneous and therefore nonhierarchical. God’s omnipresence became an almost physical problem for some. Never before nor after were theological and physical arguments so intimately fused together as in that century. Why this was so and how it came about is the subject of the second chapter.

Medieval theologians engaged in a new and unique genre of hypothetical reasoning. In order to expand the logical horizon of God’s omnipotence as far as could be, they distinguished between

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1 Throughout this book, I use “seventeenth century” as a shorthand term. The characteristics and developments I ascribe to it became more pronounced toward the second half of that century. Whether or not there was a crise de la conscience européenne, Hazard’s periodization is reasonable and valid on many counts—including the decline in belief in witchcraft in the second half of the seventeenth century.
that which is possible or impossible *de potentia Dei absoluta* as against that which is so *de potentia Dei ordinata*. This distinction was fleshed out with an incessant search for orders of nature different from ours which are nonetheless logically possible. Leibniz’s contraposition of the *nécessité logique* (founded on the law of noncontradiction) and the *nécessité physique* (founded on the principle of sufficient reason) has its roots in these Scholastic discussions, and with it the questions about the status of laws of nature in modern philosophies of science. But medieval hypothetical reasoning did not serve future meta-theoretical discussions alone. The considerations of counterfactual orders of nature in the Middle Ages actually paved the way for the formulation of laws of nature since Galileo in the following sense: seventeenth-century science articulated some basic laws of nature as counterfactual conditionals that do not describe any natural state but function as heuristic limiting cases to a series of phenomena, for example, the principle of inertia. Medieval schoolmen never did so; their counterfactual yet possible orders of nature were conceived as incommensurable with the actual structure of the universe, incommensurable either in principle or because none of their entities can be given a concrete measure. But in considering them vigorously, the theological imagination prepared for the scientific. This is the theme of my third chapter.

New in the seventeenth century was the critical-contextual understanding of history. Historical facts were no longer seen as self-evident, *simpex narratio gestarum*. Instead, they obtain significance only from the context in which they are embedded—a context to be reconstructed by the historian. And the meaning of historical periods or of their succession was likewise, since the revolution in historical thought, to be derived from internal connections within history rather than from a transcendental premise or promise. Indeed, the “fitting together” of events and institutions in any given period and the evolution of periods from each other constituted the new sense of divine providence. Yet, some modes of interpretation that were essential to the new historical-contextual reasoning were already present in medieval Jewish and Christian discussions about the working of providence in history. Exegetical as well as historical speculations since Antiquity were guided by the principle of accommodation, by the assumption that revelation and other divine institutions were adjusted to the capacity of men at different times to re-
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cieve and perceive them. Once the principle of accommodation was secularized, as indeed it was since the seventeenth century, the "cunning of God" could become "the secret plan of history," the "invisible hand," the "cunning of reason." This transition is the subject of chapter four.

These different themes converge in a new assessment of the difference between divine and human knowledge with which my study will conclude. Verum et factum convertuntur—the identity of truth with doing, or of knowledge with construction—had been seen, in the Middle Ages, at best as the character of divine knowledge. In the seventeenth century it became also the mark of human knowledge, epitomized in the mathematical physics that showed not only how things are structured, but also how they are made. The identity of truth and fact was also claimed by a new brand of political theoreticians for whom the body politic seemed through and through a man-made artifact: human society is a spontaneous human construction. A new ideal of knowledge was born—the ideal of knowledge-by-doing, or knowledge by construction.

Some general remarks concerning methodological presuppositions are in order. My study is concerned with the shift from medieval to early modern modes of thought. In what sense was continuity preserved? What was revolutionary? Do the categories of continuity and change still have a heuristic value? The study is concerned with the scientific imagination, with ideals of science no less than with science itself. This distinction ought to be justified.

C. A DIFFERENTIAL HISTORY

Various parts of this study deal with questions of continuity and change; so much so that I may be accused of chasing indiscriminately after medieval precursors and anticipations. How much did seventeenth-century science and scholarship owe to the Middle Ages? How revolutionary was it? Never before or after did so many works praise themselves as "new observations," "new discoveries," "new method," "new science." If revolutions are a conscious and "resolute attempt . . . to break with the past," then the revolution-

1 Tocqueville, L'Ancien régime et la révolution, trans. S. Gilbert, p. vii. The connotation of purposeful assent distinguishes the modern political usage of the term "revolution" from the more passive connotation of complete change attached to this astronomical
ary consciousness was certainly present: from the vantage point of the seventeenth century, the Aristotelian-Scholastic science was a barren enterprise from its outset, a dead-end. Its main concern had been with definition rather than with the precise relation between phenomena; *philosophia philologia facta est*—it had lost itself in the search for essences and obscure qualities. Yet ever since the creative energies of medieval thought were rediscovered by recent historians, this seventeenth-century assessment has been called into question. Was Galileo’s law of free fall the first concrete proof since Archimedes that “nature is written in a mathematical language”?2 Was not its mathematical apparatus anticipated by the *calculatores* in the fourteenth century? Was not the principle of inertia underlying Galileo’s law anticipated by some medieval impetus theoreticians? Was the radical search for self-evident truths really a new beginning in philosophy, or did Descartes borrow his seemingly new broom from the despised arsenal of later medieval Scholasticism? Was the discovery of historical anachronisms so new, or did it derive from

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2 "Postremo, ut coarquantur verba magis curare, quam sensus, efficere ut cum Seneca exclamare merito liceat 'nstra, quae erat, Philosophia, facta Philologia est, ex quo disputare docemus, non vivere, 'non memoro quot quaestiones apud Aristoteleos de nomine fere sunt'". Gassendi, *Exercitationes paradoxicae adversus Aristoteleos* 1.14, ed. Rochot, pp. 45–46. While there is no denying that Aristotle often makes the meaning of words the beginning of philosophical inquiry, this does not mean that he remains on the level of words only. E.g., his physics changes the common meanings of “downwards” and “upwards” into “towards and away from the center of the universe.” Cf. Wieland, *Die aristotelische Physik: Untersuchungen über die Grundlegung der Naturwissenschaften und die sprachlichen Bedingungen der Prinzipienforschung bei Aristoteles*, pp. 1–10; and also below III.C.1.

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the medieval attention to the *qualitas temporum*? But these and similar questions are, I believe, misleading. They assume continuity and innovation to be disjunctive, mutually exclusive predicates. The "new" often consists not in the invention of new categories or new figures of thought, but rather in a surprising employment of existing ones.

Of the variety of ways in which a new theory can be said to have been prepared by an older one, two ideal modes are particularly pertinent to our discussion: the dialectical anticipation of a new theory by an older, even adverse, one; and the transplantation of existing categories to a new domain—employing them under a new perspective. Whatever remains vague in the preliminary explanations will, I hope, win more precision in the following chapters.

(i) A good number of examples can be gathered to illustrate the following circumstance. Well reasoned, elaborated theories may, or may not, specify possible instances of falsification; the demand of an *experimentum crucis* is, after all, relatively modern. Since the beginning of consistent theoretical reasoning, however, sound theories have often specified explicitly that which, in their own terms, must be regarded as a wrong, if not impossible or absurd, position. A conceptual revolution consists more often than not in the deliberate adaptation of such well-defined “absurdities” (or, better yet, the absurd consequences of contradictory assumptions) as the cornerstone of a new theory. Such were the beginnings of the atomistic theory. Parmenides had proved that to ascribe any degree of reality to negation amounts to attributing being to nonbeing. Being suffers no differentiation or change. That which “is not” cannot be “thought of.” The atomists committed themselves consciously and deliberately to this absurdity in order to save movement and variety. Their atoms were Parmenidean “beings” embedded within the void, i.e., within a nonbeing endowed with “a kind of being.”

Similarly, Aristotle’s theory of motion may be said to have paved the way toward the principle of inertia more than any of its alleged forerunners, in—

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cluding the impetus theory. For he anticipated some of its conceptual implications as the absurd (or impossible) consequence of a misleading assumption, the (atomistic!) assumption of movement in the void.  

The audacity to think the unthinkable is well known to historians of mathematics. All expansions of the realm of numbers beyond the rational numbers were once considered to be such impossibilities of thought and, at the time of their conception, “amphibians between being and nonbeing” (Leibniz), tolerated only by virtue of their performance. The history of mathematics may be read as a running commentary on the incompleteness theorem. Time and again the inability to solve problems within one field led to the construction of new fields, since “no antecedent limits can be placed on the inventiveness of mathematicians in devising new rules of proof.” New mathematical disciplines have often accompanied scientific revolutions. Some grew out of a conceptual revision in science (the calculus), some made revisions within a science possible (non-Euclidean geometry). Nevertheless, conceptual revolutions in the sciences or in philosophy are different from those in mathematics even where they, too, involve the assertion of the absurd. The inherited body of mathematical theorems is not proven to be wrong, or only approximately true, but rather richer, by the legitimation of a mathematical entity or operation that was previously taken intuitively to be a non-number or a nonprocedure. Yet, physical theories are concerned not only with consistency and richness, but with truth and meaning. Where such theories introduce an absurdity in terms of a previous explanatory endeavor, the latter is destroyed, or at least proven inaccurate.

Nor should the dialectical preparation for scientific revolutions be confused with the readiness, already manifested in Greek astronomy, to entertain several explanatory models and to operate with those explanations best capable of “saving the phenomena” (σώζειν τὰ φαινόμενα), disregarding the question of their physical reality. I do not underestimate the emancipatory value of the recognition of a plurality of models in spite of, or if you wish, because of, the ep-

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1 Cf. below iii. c. 1.
istemic resignation involved in it.\(^8\) I agree with Feyerabend that the pursuance of a plurality of alternative explanations is, at least today, imperative. At any rate, the history of astronomy is a paradigmatic case of the benefits of theoretical "anarchy."\(^9\) But the history of astronomy in antiquity and the Middle Ages shows also that it is one thing to look for many alternative explanations within given assumptions, and another to become conscious of such assumptions and revise them. In spite of its liberality, astronomy had as many difficulties as mechanics in becoming aware of its most deeply rooted preconception, the assignment of circular, "perfect" motion to the planetary orbits.\(^10\)

We ought, then, to pay close attention to the terms in which a theory defines "improbabilities" and, still more important, "impossibilities." The more precise the argument, the likelier it is to be a candidate for future revisions. Once the impermissible assumption is spelled out with some of its consequences, it is but a matter of time and circumstances (a different climate of opinion, tensions within the old theory, developments in other fields, new factual evidence) until the truly radical alternative is reconsidered. The starting point of scientific reasoning, the Socratic curiosity (\(\text{δανύμα}ζειν\)), consists not only in asking why and how within a given theory or as if no theory existed. It consists rather at certain critical junctures in asking why not? despite a definite, enduring, argued consensus to the contrary.

It is tempting to describe the rise of early modern mechanics or astronomy as dialectically prepared by earlier theories. But the historical perspective is bound to blur such a schematic exposition considerably. The historian, as so often, finds himself entangled in the web of nuances after embarking from a clear-cut thesis. We shall find that, although Copernicus feared that traditional astronomers would condemn his model for its absurdity, and although Descartes regarded the inertial principle to be inconceivable in the terms of


\(^10\) Cf. below II.B.1. n. 1 (the Atomists as exception).
Aristotelian physics, nevertheless the main tenets of neither the Copernican theory nor Galilean mechanics were mainly formulated out of such a contraposition with past theories, and certainly not out of literary reminiscences of passages where “absurdities” were defined. In effect, many of the “absurdities” in the terms of Aristotelian or Ptolemaic science had already become, through the medieval exercises in hypothetical reasoning, mere improbabilities. In one sense, however, the “assertion of the impossible” will, I believe, stand the test of modification by nuances. Even where schoolmen in the Middle Ages traded Aristotle’s “impossibilities” for possibilities de potentia Dei absoluta, they regarded them only as incompossible with our universe. With the usage of ideal experiments in the seventeenth century many such incompossibles became limiting cases of our universe; even if they do not describe our universe, they are necessary to explain it.

(ii) In other cases—by far more numerous—the mediation between new theories and the theories they replaced consists in the persistence of dominant figures of thought that are given a new perspective, placed in an unexpected new context. Early modern physics inherited many of the medieval techniques of hypothetical reasoning that involved, in questions mechanical, the beginning of a new mathematical technique. But it gave them a concrete, new interpretation. Early modern historical thought inherited some of its key categories from the medieval theological reading of history. But it applied them to secular history in a radically new way. Finally, the view of the state as a human artifact through and through rather than as a natural product of a built-in inclination ad societatem, though it had never before been defended so radically and systematically, replaced pure natural law traditions. “Sciemendum est quod civitas sit aliquo modo quid naturale eo quo naturalem impetum ad civitatem constituendum: non tamen efficitur nec perficitur civitas nisi ex opera et industria hominum”;¹ Aegidius Colonna, like many before and after him, believed that states have both a natural and an artificial aspect to them. By eliminating the human natural social impetus altogether, Hobbes stressed more than anyone before him that “man maketh his commonwealth himself,” just as

¹ Quoted by Gierke, Johannes Althusius und die Entwicklung der naturrechtlichen Staats-theorien, p. 95 n. 52.
I. INTRODUCTION

Marx would later do by eliminating the natural desire to barter by reducing all economic relations to human, historical conditions. The transition from the old to the new theory was a case of radicalization of already present possibilities of interpretation.

By these and other means, I shall try to discern and differentiate such points of transition as precisely as I can. By differentiating points of transition, questions of continuity or change lose much of their edge. As to the question why such transitions came about at the time they did, more often than not I do not know. Perhaps it is the sign of revolutionary periods that radical departures, "paradigm shifts," take inspiration and take courage from each other.

D. IDEAS AND IDEALS OF SCIENCE

The transition from medieval to early modern science and thought was not only a transition of ideas, methods, and arguments; the very ideals of science changed. Ideals of science differ in many ways from ideas in science. They indicate how a scientific community imagines science as it ought to be if ever completed; they express the ultimate criteria of rationality of their time. The very same body of measurements and procedures, assumptions and explanations—in short, ideas—accepted by an entire generation of scientists may be judged as wanting by some of them in the name of an ideal. In the name of an ideal of monocausality, or the elimination of all but mechanical causes from the consideration of nature, the seventeenth century felt uncomfortable with its most successful physical theory, the general law of gravity, even while accepting it. Newton himself was certain that gravity is not an "obscure quality" even though it seems to act in distans; but he hoped that it would one day be explained mechanically. In the name of the ideal of a complete description of reality, a reality independent of the observer, Einstein led a fierce controversy against the ultimate value of the uncertainty principle in quantum physics, a principle that, he admitted, explains and predicts certain phenomena most successfully.

Kant, who may have been the first to distinguish between ideals and ideas of science, also recognized that ideals may be at odds with each other without jeopardizing the actual scientific enterprise they guide. Ideas constitute science; ideals—Kant called them regulative ideas or principles—chart its goals. If we mistake constitutive for
regulative ideas, he argues in a concluding chapter of his first critique, science may seem to us contradictory even where it is not. "The interest of reason," while demanding consistency from any concrete scientific explanation (or set of constitutive ideas), is often compelled to sustain regulative ideas which would be incompatible and would lead to contradicting results if employed with equal rigor in every scientific explanation. His examples are the principle of parsimony against the principle of plenitude.

Kant could not admit that ideals of science, let alone the categories by which we secure the intelligibility of the universe, can change with time. But they do: even the partial abandonment of final causes as a legitimate criterion of rationality proves it, or, more recently, the introduction of statistical causality. Who still speaks, except in a speculative vein, of the harmony of the universe? At times, the ideal may seem unchanged, but its meaning has been radically transformed. In the name of the ideal of consistency, theories of light until recently forced one to choose between either a corpuscular or a wave model of explanation. Both analogies have now ceased to be subsumed under the principle of the excluded middle and have become complementary. Neither the wave nor the corpuscular analogy can explain the nature of light exhaustively; light shares the characteristics of both.

In one important sense, the distinction between ideals of science and ideas in science must again be blurred and relativized. All criteria of rationality are, in a way, ideal, and for the following reasons. The nineteenth century believed in a steady, organic growth of the scientific enterprise under the same canon of rational principles. Very little of this confidence remains today. Historians and philosophers of science have argued for the relativization of science, even of rationality itself. The decision between competing theories, we have learned, depends in fact not on their intrinsic merits only, or perhaps not at all, but on external factors: ideology, faith, social conditions, economic forces, generational changes. Nor perhaps

\[1\] Kant, *Kritik der reinen Vernunft*, in *Werke*, ed. Weichsneidel 4:670–696. It is noteworthy that, while the transcendental analytics is oriented toward the explication of Newtonian physics, this discussion takes biology as its paradigm. For a modern argument that calls for balancing the principle of parsimony with a counter-principle, see Menger, "A Counterpart of Ockham's Razor in Pure and Applied Mathematics: Ontological Uses," p. 415. One could say that Kant pronounced a principle of complementarity—but, unlike Bohr, on the metatheoretical level only.
can any two theories really be compared to each other, strictly speaking: competing theories, some argue, are always incommensurable. If even truly analytical propositions cannot be construed, then no translation is possible from one language to another or from the terms of one theory into the terms of another.

But, you may ask, does not any extreme relativistic position defeat itself on purely logical grounds? Does it not lead us straight into paradoxes such as the liar's paradox? The ideological critique of Marx and Mannheim, the pragmatic epistemology of James and Vaihinger, the relativistic theories of science of Cassirer and Feyerabend, so it seems, must abrogate themselves because they ultimately refer also to themselves. Now, this is not at all the case. Relativization should not be confused with the accusation of error. The proposition, "all propositions are only conditionally true (valid)" or "all propositions are relative," avoids the pitfalls of the proposition "all propositions are false." The latter, by including itself, becomes self-contradictory; the former does not. The assertion that all truths are relative may itself be relative, that is, only conditionally true, and yet be universally valid for as long as we cannot name the conditions under which it is false. The relativization of all criteria of rationality—of psychological, historical, sociological, epistemological—is not paradoxical. At the worst, it is doomed to be infinitely regressive or eternally provisional.

Yet, something positive should also be learned from these accusations of self-reference. Those who argue that the choice between theories depends on cultural, economic, or other extrinsic exigencies must still recognize that the arguments actually advanced for and against theories claim to be founded on reason alone. And more than that: even their very arguments for relativization appeal to reason. Not Vaihinger, not Kuhn, not even Feyerabend urge us to accept their point of view because it is beautiful or because it serves the

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3 E.g., Merton, "Karl Mannheim and the Sociology of Knowledge," in *Social Theory and Social Structure*, p. 503: "This leads at once, it would seem, to radical relativism with its familiar vicious circle in which the very propositions asserting such relativism are ipso facto invalid." They are not. I must, though, concede that an absolutely relativistic point of view will make it impossible to identify a common meaning or referent of a proposition, and thus defeat all judgment.
D. IDEAS AND IDEALS OF SCIENCE


economy best or because it is good for faith or health. By appealing to rational criteria, I repeat, they are not inconsistent, as long as they also recognize the difference between judgments of origin (or causes) and judgments of validity. The latter, whatever in fact the origin or causes for its acceptance may be, can only be defended on its own grounds. "P is valid because q is valid and q implies p" is a valid scheme of presenting an argument, even if it is clear that p was in fact accepted not by virtue of q. "P is valid because a scientific community accepted it once under such-and-such historical conditions or accepts it today" is perhaps a good historical account, but not an argument for p. Validity can only be examined in terms of itself. Whatever the origins of criteria for rationality may be, ideally they stand apart from the actual forces that shaped them. Science is a rational endeavor because both are true: it is true that it should examine its criteria and find that in fact they are not absolute or self-sufficient; and nonetheless it is also true that science must invoke only such criteria to mediate the business of persuasion. Rational procedures and proofs, albeit an ideal construct, distinguish science from other performances of persuasion such as rainmaking or playing acting.

And so, in a certain sense, all science, every scientific argument or procedure, has an ideal—and, if you wish, fictional—aspect to it. It is the ultimate justification why the historian of science ought to distinguish between ideals and actual arguments, and then detect the former even in the latter. But ideals of science are hard to iden-

4 James, The Varieties of Religious Experience, pp. 4–18. James, whose pragmatic stance could hardly afford it, turned this distinction against the "neurological" account of the genesis of religious states and ideas.

5 My (quasi-Kantian) use of "ideals" differs form Holton's "themes" in that it can be articulated precisely as a demand: Holton, Thematic Origins of Scientific Thought: Kepler to Einstein, pp. 47–68. It also differs somewhat from Elkana's "images" in that it refers not only to science, but also to that which science refers, and in that it is, again, capable of precise formulation: Elkana, "Science as a Cultural System: An Anthropological Approach," in Scientific Culture in the Contemporary World, ed. Mathieu and Rossi, pp. 269–89. Nor, of course, are they coextensive with Kuhn's paradigms. If we agree that the episteme of the French structuralists is not a monolithic entity, that distinct, independent elements of "discourse" can be detected in it, then, I would suggest, regulative ideals form its backbone. They fulfill the demand of being regulations but not formalizable rules, unstructured structures. Foucault, in his Archéologie de savoir, has mitigated considerably the monolithic interpretation of the shift from one episteme to another described in his Les Mots et les choses. In his later conception, the unity of discourse is "vertical" only; continuities from one episteme to another are thinkable. Cf. also M. Frank, Was ist Neustrukturnalisum? pp. 135–237.
I. INTRODUCTION

tify. They are often vague. Ideals, like virtues, are most spoken of when in doubt or danger. The wish to articulate them goes hand in hand with the need to defend them; yet polemics can also distort them. It is my aim to identify some of the leading ideals of science in the seventeenth century, to trace their origin and examine the connections and tensions between them. It seems advisable, at least to the historian, not to seek immediate definitions for something which seventeenth-century thinkers did not define clearly either. Instead of defining some early modern ideals of rationality, I shall try to describe their genesis and interaction.