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Science and Religion

Some Historical Perspectives

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CAMBRIDGE
UNIVERSITY PRESS

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

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK www.cup.cam.ac.uk
40 West 20th Street, New York, NY 10011-4211, USA www.cup.org
10 Stamford Road, Oakleigh, Melbourne 3166, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain

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First published 1991
Reprinted 1991, 1992, 1993 (twice), 1995, 19976, 1998, 1999

Printed in the United States of America

Typeset in Garamond

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

Library of Congress Cataloging in Publication Data is available

ISBN 0 521 23961 3 hardback
ISBN 0 521 28374 4 paperback

For Janice

Contents

consin. Many have rightly said that his untimely death deprived the history of science of one of its true masters. The many respects in which this book is the better for his recommendations constitute a further tribute which, had he lived to see it, would not, I hope, have been unwelcome.

Introduction

In a classic discussion of the origins of modern science, the historian Herbert Butterfield drew a much-quoted parallel. Such was the impact of the seventeenth-century Scientific Revolution that the only landmark with which it could be compared was the rise of Christianity. In shaping the values of Western societies, science and the Christian religion had each played a preeminent part and made a lasting impression. Exaggerated or not, such comparisons raise an obvious question. What was the relationship between these powerful cultural forces? Were they complementary in their effects, or were they antagonistic? Did religious movements assist the emergence of the scientific movement, or was there a power struggle from the start? Were scientific and religious beliefs constantly at variance, or were they perhaps more commonly integrated, both by clergy and by practicing men of science? How has the relationship changed over time?

Such questions are easier to formulate than to answer. Since the seventeenth century every generation has taken a view on their importance without, however, reaching any consensus as to how they should be answered. Writing some sixty years ago, the philosopher A. N. Whitehead considered that the future course of history would depend on the decision of his generation as to the proper relations between science and religion – so powerful were the religious symbols through which men and women conferred meaning on their lives, and so powerful the scientific models through which they could manipulate their environment. Because every generation has reappraised the issues, if not always with the same sense of

urgency, there has been no shortage of opinion as to what that proper relationship should be.

In popular literature three positions are commonly found, which, though not equally unsatisfactory, turn out to be problematic. One often encounters the view that there is an underlying conflict between scientific and religious mentalities, the one dealing in testable facts, the other deserting reason for faith; the one relishing change as scientific understanding advances, the other finding solace in eternal verities. Where such a view holds sway, it is assumed that historical analysis provides supporting evidence – of territorial squabbles in which cosmologies constructed in the name of religion have been forced into retreat by more sophisticated theories coming from science. The nineteenth-century scholars J. W. Draper and A. D. White constructed catalogs of this kind, in which scientific explanations repeatedly challenged religious sensibilities, in which ecclesiastics invariably protested at the presumption, and in which the scientists would have the last laugh.

Typical was White's account of the reluctance of the clergy to fix lightning rods to their churches. In 1745 the bell tower of St. Mark's in Venice had once again been shattered in a storm. Within ten years, Benjamin Franklin had mastered the electrical nature of lightning. His conducting rod could have saved many a church from that divine voice of rebuke, which thunder had often been supposed to be. But White reported that such meddling with providence, such presumption in controlling the artillery of heaven, was opposed so long by clerical authorities that the tower of St. Mark's was smitten again in 1761 and 1762. Not until 1766 was the conductor fixed – after which the monument was spared. White's picture of religious scruples and shattered towers symbolizes the popular notion of an intrinsic and perennial conflict. An ounce of scientific knowledge could be more effective in controlling the forces of nature than any amount of supplication.

A second, quite different view also appeals to history for its vindication. Science and religion are sometimes presented not as contending forces but as essentially complementary – each answering a different set of human needs. On this view, scientific and theological language have to be related to different spheres of practice. Discourse about God, which is inappropriate in the context of laboratory practice, may be appropriate in the context of worship, or of self-examination.

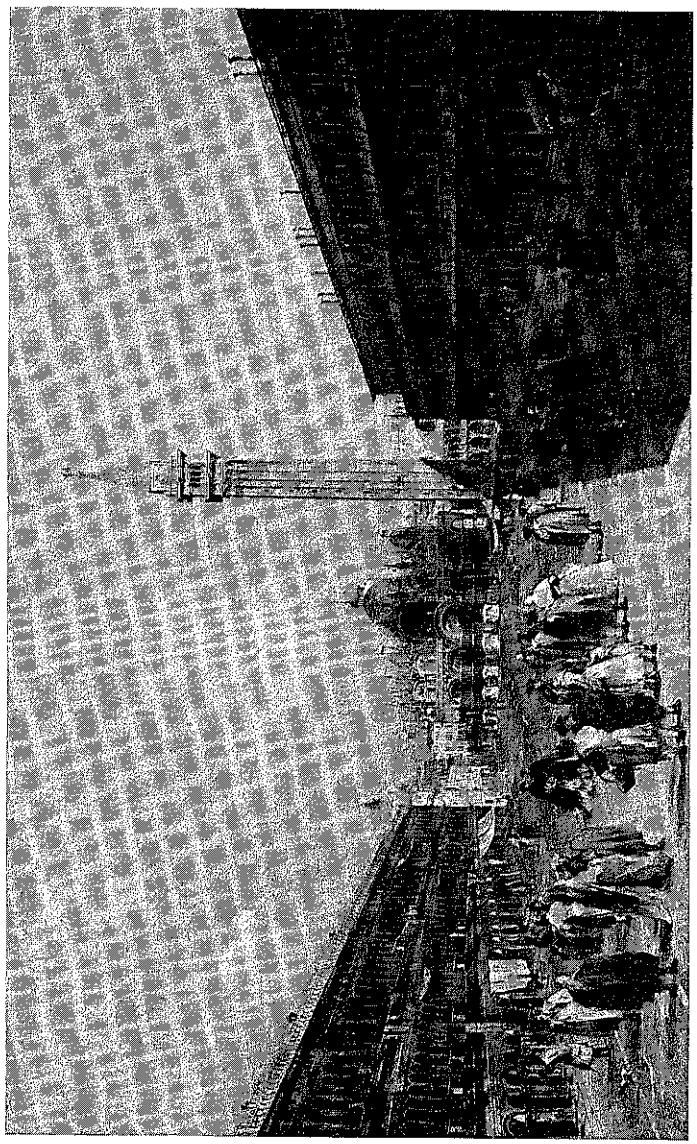

Figure Int. 1. Francesco Guardi (1712–93), *Venice Piazza San Marco* Dating from c. 1760, this painting shows St Mark's Cathedral and its bell tower. Reproduced by courtesy of the Trustees, The National Gallery, London.

Historical analysis is often invoked to support this case for separation because it can always be argued that the conflicts of the past were the result of misunderstanding. If only the clergy had not pontificated about the workings of nature, and if only the scientists had not been so arrogant as to imagine that scientific information could meet the deepest human needs, all would have been sweetness and light.

It has been argued, for example, that much of the heat could have been taken out of the Darwinian debates if only the Christian doctrine of creation had been properly formulated. That doctrine, it is said, refers to the ultimate dependence of everything that exists on a Creator. It need not entail the separate creation of every species. Some twentieth-century theologians, notably Rudolph Bultmann, have gone so far as to say that the doctrine of creation has nothing to do with the physical world. Its correct application is to the creation within men and women of an authentic stance toward their earthly predicament. By such means the spheres of science and religion are insulated one from the other.

A third view, which can also be overstated, expresses a more intimate relationship between scientific and religious concerns. Contrary to the first – the conflict model – it is asserted that certain religious beliefs may be conducive to scientific activity. And contrary to the second – the separationist position – it is argued that interaction between religion and science, far from being detrimental, can work to the advantage of both. This more open position clearly appealed to Whitehead, for he raised the question whether the assumption of seventeenth-century natural philosophers, that there was an order imposed on nature, might not have been an unconscious derivative of medieval theology. And he also argued that interaction between religion and science could purge the former of superfluous and obsolete imagery. Once again, the appeal to history is essential to the enterprise. The thesis of the American sociologist, R. K. Merton, that puritan values assisted the expansion of science in seventeenth-century England, would be a good example of historical scholarship in which the mutual relevance of science and religion is affirmed, rather than constant conflict or complete separation.

There are, of course, many variants of these positions. But in their presentation it is almost always assumed that there are lessons to be learned from history. The object of this

book is not to deny that assumption but to show that the lessons are far from simple. The chapters that follow do not pretend to tell a complete or definitive story. They should be read as a historically based commentary rather than as a conventional historical narrative. The principal aim is to assist in the creation of critical perspectives, not to describe a continuous series of seemingly decisive transformations.

Serious scholarship in the history of science has revealed so extraordinarily rich and complex a relationship between science and religion in the past that general theses are difficult to sustain. The real lesson turns out to be the complexity. Members of the Christian churches have not all been obscurantists; many scientists of stature have professed a religious faith, even if their theology was sometimes suspect. Conflicts allegedly between science and religion may turn out to be between rival scientific interests, or conversely between rival theological factions. Issues of political power, social prestige, and intellectual authority have repeatedly been at stake. And the histories written by protagonists have reflected their own preoccupations. In his efforts to boost the profile of a rapidly professionalizing scientific community, at the expense of the cultural and educational leadership of the clergy, Darwin's champion, T. H. Huxley, found a conflict model congenial. Extinguished theologians, he declared, lie about the cradle of every science as the strangled snakes beside that of Hercules.

The purpose of this book is not to recover the corpses. It is to display the diversity, the subtlety, and ingenuity of the methods employed, both by apologists for science and for religion, as they have wrestled with fundamental questions concerning their relationship with nature and with God. Such is the richness of the subject that it is well to set aside one's preconceptions. There are surprises in store. The same Franklin who devised the lightning conductor was not ashamed to say that, as for the nature of electricity, he was still in the dark. He *was* ashamed about the confidence with which he had earlier thought the subject mastered. As he reflected on the succession of his theories, he observed that one use of electricity had been to make a vain man humble. Franklin had recognized, as Francis Bacon had before him, a congruence between the virtue of humility and the demands of an experimental method. He had recognized that the majestic towers of scientific theory could crumble as spectacularly as the towers of great cathedrals.

It is just such a succession of incompletely successful theories that the history of science reveals, the survivors having some advantage over their predecessors, but rarely in a manner that made evaluation at their inception a straightforward matter. The popular antithesis between science, conceived as a body of unassailable facts, and religion, conceived as a set of unverifiable beliefs, is assuredly simplistic. Theoretical innovations have usually been controversial, often divisive, within scientific communities. Consequently, when they have impinged on the sacred, there has usually been considerable room for debate. To portray the relations between science and religion as a continuous retreat of theological dogma before a cumulative and infallible science is to overlook the fine structure of scientific controversy, in which religious interests certainly intruded, but often in subtle rather than overtly obstructive ways.

An obvious difficulty arises at this stage. How can one speak about the relationship between science and religion, either as practices or as systems of belief, without first defining terms? It is possible to go only so far in meeting this objection. *Religion* has been defined in terms of belief in supernatural beings or in terms of a commitment to some transcendent "other," which serves to integrate one's life. It may refer to organized institutions that, through creed and ritual, claim to give coherent answers to questions of human destiny. Or it may simply refer to any deeply held convictions that find expression in moral imperatives. Although there is often overlap between such definitions, there need not be. In some of the world's religions, Buddhism for example, belief in a transcendent Creator is not affirmed. Because this book is concerned with the relationship between science and religion in the West, most of the contexts in which the word religion is used will be those in which some variant or some critique of the Christian faith was at stake. Too restrictive a definition can, however, be counterproductive because it may exclude too many questions before they have been asked. If the study of history is to be instructive, it is important not to establish foregone conclusions through the rigidity of definitions.

The same difficulty arises with the word *science*. There have been so many definitions offered by philosophers, and by scientists themselves, that it would require another book to consider them. Many refer to some unique "scientific method" to which exemplary science is supposed to conform. But, as

the Cambridge philosopher William Whewell observed, almost a hundred fifty years ago, the *history* of science already showed that each new branch of scientific inquiry had required its own distinctive methodology. And that very process of increasing differentiation reflected a more fundamental change in the meaning of science – from when it had referred to all knowledge and when theology was "queen of the sciences," to its more modern connotations of empirical investigation and high specialization.

There are at least three reasons why the historian might recoil from the demand that "science" and "religion" be rigorously defined before the exercise may begin. The first can be illustrated by a celebrated remark of Isaac Newton. His most famous book, in which planetary orbits were explained by his gravitational theory, was entitled *Mathematical principles of natural philosophy* (1687). It was not entitled *Mathematical principles of natural science.* When seventeenth-century students of nature called themselves natural philosophers, they were identifying themselves with intellectual traditions in which broader issues than immediate scientific technicalities were discussed. Newton himself remarked that it was part of the business of natural philosophy to discuss such questions as the attributes of God and His relationship to the physical world. Very few physicists today would conceive their role in such terms. The point is that if we prejudge what we mean by science and religion, we might be in no position to appreciate the distinctiveness of Newton's vision. There would be a degree of artificiality in asking how Newton reconciled his "science" and his "religion," if he saw himself pursuing a form of "natural philosophy," in which the two interests were integrated.

The second reason for resisting definitions that might prove too constrictive can also be illustrated from the late seventeenth century when Thomas Burnet wrote his *Sacred theory of the earth* (1684). In it he assumed the role of a Christian apologist, using a knowledge of history to identify certain mistakes that should not be made when theologizing about nature. Thus he applauded St. Augustine for his warning that science and religion should not be too tightly interlocked, that it was dangerous to invoke the authority of Scripture in disputes about the natural world. The danger as Burnet saw it was this: As scientific understanding advanced, propositions that Scripture had been made to affirm would be proved

false. Its authority would then be jeopardized on far more important matters. But, says Burnet with evident condescension, Augustine had fallen into the very trap he had identified. He had used the Bible in his dismissal of inhabitants at the Antipodes. Burnet, so much wiser in the late seventeenth century, is even more aware of the danger and knows how to avoid it.

And yet, anyone reading Burnet's *Sacred theory* today would be struck by the fact that he falls headlong into the selfsame trap. Instead of keeping the spheres of science and the Bible apart, he brings them together. He offers a mechanistic account of how the Genesis flood had come about, and he defines the main epochs of earth history with reference to information gleaned from his Bible. His picture of a submerged earth, in which Noah's ark is conspicuous, shows how the flood was made constitutive of the earth's physical history. The point of the example is not to score points against Burnet but to raise the more sympathetic question: How was it possible for Augustine to behave in a manner that, to a later generation, looked inconsistent? And similarly for Burnet. Part of the answer is that the domains of science and religion were separated by different boundaries in Augustine's day from those in Burnet's day, and in Burnet's day from our own. Precisely because the boundaries have shifted with time, it would be artificial to ask about the relationship between "science" and "religion" as if modern definitions of their provenance had some timeless validity.

A third reason for tolerance on matters of definition is that it can be artificial in a quite different sense to ask about the relationship between science and religion in the past. Because both are rooted in human concerns and human endeavor, it would be a profound mistake to treat them as if they were entities in themselves – as if they could be completely abstracted from the social contexts in which those concerns and endeavors took their distinctive forms. To understand the predicament of Galileo in his relations with the Roman Catholic Church, it is not enough to say that science was in conflict with religion. The political ramifications of the Counter-Reformation were such that Galileo's science (which was not self-evidently correct) acquired meanings and implications that it might otherwise not have carried. The metaphor of a changing boundary or interface is itself too superficial to cope with this particular problem. The way in which

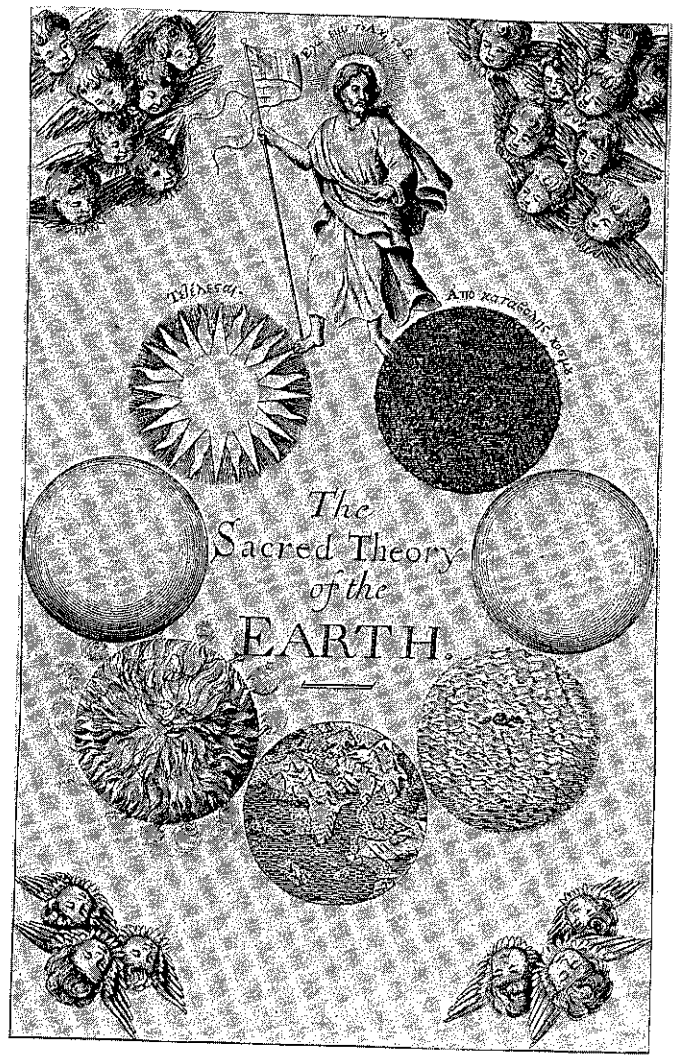

Figure Int. 2. Frontispiece from Thomas Burnet's *Theory of the earth* (1684). Burnet identified seven phases in the earth's physical history. In clockwise sequence, the chaos of the primeval earth as described in Genesis 1 was followed by the smooth-surfaced globe corresponding to a state of paradise. In this second phase the earth's axis of rotation was still vertical, with the consequence that the Garden of Eden, occupying a middle latitude in the Southern Hemisphere, enjoyed a perpetual spring – until the third phase, that of Noah's flood, when the earth's crust collapsed and its axis tilted. The fourth phase is represented and depicted by the earth's current surface. Following a global conflagration, there is the promise of a new heaven and a new earth, with paradise restored before the final consummation. Reproduced by permission of the Syndics of Cambridge University Library.

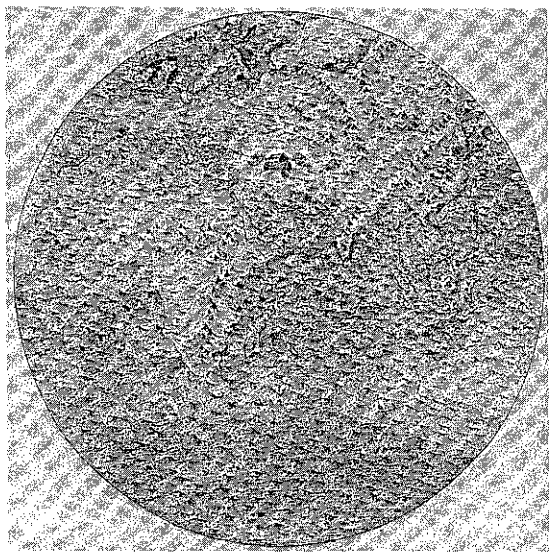

Figure Int. 3. Illustration from page 101 of Thomas Burnet's *Theory of the earth* (1684). According to Burnet, the deluge had covered the whole of the earth, though he discounted the divine creation of new water. There had been a subterranean aquatic layer concentric with the earth's original crust. The floodwaters had been released when the crust had cracked. The synchronization of these physical events with a crisis in the moral history of humanity, as recounted in Genesis, was, for Burnet, a powerful argument for divine providence. Reproduced by permission of the Syndics of Cambridge University Library.

the relationship between scientific and religious claims has been perceived in the past has depended on social and political circumstances that the historian cannot ignore. The evolutionary speculations of Charles Darwin's grandfather, Erasmus Darwin, occasioned little hostility in England during the 1780s. But in the conservative backlash, following the French Revolution, they were noisily condemned as atheistic.

The existence of a political dimension to many of the debates in which scientific and religious interests were involved

means that to abstract both the "science" and the "religion" and then try to establish their mutual relationship can be highly artificial. Indeed, it is tempting to say that we should be more concerned with the use to which scientific and religious ideas have been put in different societies than with some notional relationship between them. Satisfying that concern would require a larger and more detailed book than this is designed to be. But it is important to appreciate that scientific conclusions, however provisional, have often been used by religious apologists in pursuing their own designs. The pressures to protect their authority have sometimes been felt so keenly that they have appropriated the latest science to demonstrate the vitality of their position. In some cases they have run into more trouble by adopting scientific innovations than if they had opposed them.

The fact that science has been used as a resource both by Christians and their critics may call into question another common assumption – that modern science has been largely responsible for the secularization of society. Have the sciences not progressively diminished that sense of awe and mystery that once induced deference to the gods? It is an argument with a long history and a fine pedigree. But it has not passed unchallenged. Critics point out that it may be an unquestioned survival from nineteenth-century positivism when a sense of liberation through science was at its height. They add that it mistakenly assumes religion to depend more on the physical environment than on the quality of social relations. And it ignores those respects in which scientific knowledge may magnify rather than diminish a sense of awe. The place of science in the process of secularization may also require reevaluation in the light of religious resurgence in polities where science-based technologies are not conspicuous by their absence. In the pages that follow, we shall try to keep an open mind on issues of this kind.

In Chapter I we consider a series of examples in which statements about God and statements about nature are closely interrelated. They are designed to show how theological and scientific concerns have been mutually relevant in the past. Because statements of an ostensibly religious character fulfilled many different roles in the context of interpreting nature, these examples help to establish the richness and diversity of the interaction. But precisely because they show religious beliefs functioning, as it were, *within* science, they

also illustrate the artificiality of discussing the relationship between science and religion as if the province of each had already been established. The implications of these examples for the "conflict thesis" will then be assessed, for they exclude the reductionist view that representatives of science and representatives of the churches have invariably been locked in battle. In seeking to attain what in matters of this kind is ultimately unattainable – a balanced view – it is also necessary to consider whether revisionist histories, structured around a critique of the conflict thesis, have not gone too far in the opposite direction. The apologetic intentions of both secularists and religious thinkers have so colored the literature that a fresh approach is required.

In Chapter II we address a specific historical problem: The interpretation of those shifts in the understanding of nature that, during the sixteenth and seventeenth centuries, added up to what has traditionally been called the Scientific Revolution. A common view is that by the end of the seventeenth century, a recognizably *modern* science had emerged, separated at last from a preoccupation with matters of philosophy and religion. The object of the chapter is to identify the difficulties that arise in sustaining that view. While it is true that investigations into nature were often subordinate to religious concerns in the late medieval period, it would be misleading to imply that they were bound together in an indissoluble complex until they were prized apart in the seventeenth century. It is also argued that, although there were certain levels on which the problems of science and those of theology were increasingly differentiated during the seventeenth century, the assertion of an absolute separation would be too extreme. Scientific innovations continued to be presented in theological terms and divine attributes continued to be given physical meanings – as when Newton insisted that space was constituted by God's omnipresence.

In Chapter III we raise the question whether parallels can be drawn between the reform of learning through experimental science and the reform of religion that occurred through the Protestant Reformation. The reaction to the sun-centered cosmos of Copernicus provides an appropriate case study because opposition to Galileo, its most famous popularizer, has symbolized the suppression of scientific freedom by the Roman Catholic Church. In taking the Copernican innovation as a test case, however, it soon becomes clear that complications arise when assessing receptivity to new hypotheses. While

there is circumstantial evidence to suggest that certain Protestant societies were more tolerant toward new scientific learning, the difficulties that arise in testing such generalizations can be formidable. Just how formidable will be shown in the context of evaluating Merton's thesis that puritan values were propitious for science in seventeenth-century England.

The theme of Chapter IV is the mechanization of the natural world – that seventeenth-century development which has often been seen as a decisive advance on organic models of the cosmos. The reconstruction of nature through mechanical metaphors has also been seen as a crucial step in the secularization of knowledge; for, if nature ran like clockwork, what room was there for God's direct activity or special providence? Once again, the issues turn out to be far more subtle than that simple question suggests. In the case of Robert Boyle, mechanical images of nature were enlisted in the defense of Christianity. Not only did they reinforce the view that nature was a designed system; they could also be used to emphasize God's absolute sovereignty. If physical phenomena were to be explained exclusively in terms of matter and motion, and if, as both Boyle and Newton insisted, matter itself was inert, then God could be made directly responsible for the motion. But the clockwork image could be read in other ways. One of the many ironies in our story is that a model for the universe, which in the seventeenth century was used to affirm God's sovereignty, was used by the deists of the eighteenth century in their attacks on established religion.

Chapter V takes us into the eighteenth century and into that period of "Enlightenment" when the sciences were hailed as instruments of progress and when institutionalized religion, especially in Catholic countries, was vilified for its superstition and priestcraft. In an age when unprecedented confidence was placed in the power of human reason, the methods and achievements of the sciences were a powerful resource for those who, with a variety of motives, launched their assault on established Christianity. But to reduce the relations between science and religion to a polarity between reason and superstition is inadmissible, even for that period when it had such rhetorical force. It was often not the natural philosophers themselves, but thinkers with a social or political ax to grind, who transformed the sciences into a secularizing force. Although certain scientific discoveries could be

invoked to support a materialist philosophy, they were usually susceptible to less radical interpretations. And in the confrontation between skepticism and Christianity, science could still be on the side of the angels – especially in England where arguments for design retained a strategic role in the defense of the faith. Whereas in France, the materialist La Mettrie would claim that the study of nature made only unbelievers, the contrary claim of Robert Boyle, that one could only be an atheist if one had *not* studied nature, was the more common sentiment in the English-speaking world.

The diverse functions of natural theology, including its role in the popularization of science, is the subject of Chapter VI. The claim that from scientific study one could learn something about God falls strangely on twentieth-century ears. It was, however, a commonplace in the writing of British scientists until the generation that saw the publication of Darwin's *Origin of species* (1859). The object of the chapter is to uncover some of the reasons why this integration of science and religion proved so viable, despite the existence of trenchant critiques. We shall also consider the extent to which a commitment to natural theology affected the scientific enterprise and the extent to which advances in science affected the plausibility of arguments from design.

For much of the eighteenth century it had been commonly assumed that human history and the history of the earth were coextensive. But during the late eighteenth and early nineteenth centuries, new visions of earth history emerged, presenting a challenge to popular religious belief. As evolutionary models came to the fore in astronomy, geology, and biology, traditional beliefs about humanity's place in nature were increasingly difficult to defend. The emergence of these historical sciences, culminating in Darwin's theory of evolution, is the subject of Chapter VII. The assumptions made in reconstructing the past were often highly controversial even among naturalists themselves. We shall therefore stress the competition between rival scenarios, in which political and religious preferences sometimes constituted a hidden agenda. Although there were countless attempts to harmonize these disturbing vistas with biblical texts, they were eventually abandoned – at least among academic theologians – as the methods of historical research were brought to bear on questions of biblical authorship.

In Chapter VIII we try to take as broad a view as possible

of the Darwinian challenge to popular Christianity, in the knowledge that there are circles in which the issues are far from dead. To focus on the post-Darwinian debates is not to deny that the physical sciences also raised new and exciting issues. During the nineteenth century the science of thermodynamics, for example, created new vistas for the ultimate fate of the universe. The emergence of statistical models in explaining the behavior of gases reopened questions about the nature of scientific "laws." But few would dispute that the impact of evolutionary theory had the more penetrating and enduring effects. We shall therefore survey the many uses to which the Darwinian theory (and corruptions of it) were put. Because the popularization of evolutionary science was so intimately associated with the promotion of social and political ideologies, this chapter provides the most telling illustration of the point made earlier – that it can be highly artificial to abstract the science and the religion from the ensuing debates with a view to determining their mutual bearing. We shall, however, examine the capital that secularists could make out of Darwin's theory and the response of religious thinkers who looked for conciliation rather than confrontation.

In the pluralistic and largely secular societies of the West, a preoccupation with the demands of traditional religion has given way to a humanism that has been described as *beyond* atheism. In helping twentieth-century humanists to rationalize their unbelief, few thinkers have been as influential as Freud, whose attitude toward belief in God is the starting point for a concluding postscript. Despite a prevailing ethos, in which science and secularization are seen as linked together in the constitution of modern culture, the twentieth century has witnessed certain developments in the sciences that have given solace to the religious apologist. Innovations in subatomic physics have been seen as a license for more organic and less deterministic models of reality. Moreover, new scientific techniques have raised ethical questions of such gravity that the general public has become aware of an interface along which science and human values meet. As long as the world's religions continue to stake a claim in the articulation of those values, it is unlikely that the two spheres of science and religion will be completely divorced.

CHAPTER I

Interaction between Science and Religion: Some Preliminary Considerations

Introduction

During their history, the natural sciences have been invested with religious meaning, with antireligious implications and, in many contexts, with no religious significance at all. The object of this book is to offer some insight into the connections that *have* been made between statements about nature and statements about God. As we noted in the introduction, however, problems arise as soon as one enquires about the relationship between "science" and "religion" in the past. Not only have the boundaries between them shifted with time, but to abstract them from their historical contexts can lead to artificiality as well as anachronism.

How, for example, do we deal with that late nineteenth-century evolutionist Henry Drummond, who insisted that it was wrong to speak of *reconciling* Christianity with evolution since the two were one? In a glowing vision of *The ascent of man* (1894), Drummond acknowledged the Darwinian struggle for life, but he also referred to a struggle for the life of others. The former was essential to the evolutionary process, as individuals competed for resources. But, Drummond argued, so too was the latter: Once the human mind had evolved, self-sacrifice, cooperation, and maternal love would each contribute to the survival of societies in which those virtues were encouraged. Christianity and evolution were ultimately one because both denoted a method of creation; both had as their object the making of more perfect beings. Because altruistic love was germane to both, he could argue for a perfect union. Evolution embraced progress in spirit as well as in matter.

Many of Drummond's contemporaries did know how to deal with him. His secular critics saw the misguided attempt of an evangelical Christian to adapt his theology to an insuperable threat from science. Nor, despite a close friendship with the evangelist D. L. Moody, could he pacify the more conservative evangelicals in his audience. "Many fell upon me and rent me," he complained, after addressing a Northfield conference in 1893.

It is not clear, however, that the historian need follow their example. From a late twentieth-century perspective are we not more likely to disregard than dissect him? It would be easy to do so on the basis that his fusion of science and religion was really a confusion. Our own century has seen so many movements against the conflation of scientific and religious language that we may, on purely philosophical criteria, judge him to have been misguided. By those who treat scientific and religious discourse as two distinct language games, or who detach doctrines of creation from statements about the physical world, Drummond's attempt to integrate his faith with evolutionary science would be dismissed as an unfortunate error.

The problem for the historian, however, is that sophisticated twentieth-century distinctions may not always be the most sensitive instruments for understanding the issues as they were formulated in the past. There were Henry Drummonds in every generation who did make connections between their theology and their science. If we begin with too cavalier an attitude toward them, we may miss a certain richness in our intellectual heritage and one that had a profound bearing on how the word *science* was understood, by both practitioners and their public.

Consider, for example, three contrasts commonly drawn by scholars when comparing our modern scientific age with earlier times when magic prevailed. Science, it is said, operates within a world-view that regards natural phenomena as the product of impersonal forces. By contrast, religious and magical systems involve personalized gods, spirits, or demons. Whereas the scientific enterprise is legitimated by agreed testing procedures, the theological enterprise has been characterized by dogmatism. Whereas religions have required

worship, ceremony, and sacrifice, these are forms of activity alien to Western science.

On such grounds science and religion are commonly differentiated. Closer inspection of the history of science, however, suggests a more complex picture. Science may be concerned with impersonal forces, religion with personalized gods; but the very word *force* carried religious meanings, even for Isaac Newton (1642–1727) who, in describing the operation of a gravitational force in mathematical terms, also ascribed it to an omnipotent God. By his critic Gottfried Wilhelm Leibniz (1646–1716), he was accused of making the action of gravity a perpetual miracle.

The contrast between self-criticism in science and an uncritical spirit in religion cannot be made absolute. Scientific theories have often been cherished when in the eyes of their critics they ought to have perished. Recalling a symposium held at St. Louis in 1961, the distinguished organic chemist Herbert C. Brown has commented on the reaction when he suggested that many of the proposed nonclassical structures for carbonium ions had weak experimental support. He had hoped for a critical reexamination of the field. Instead, many fell upon him and rent him. His suggestions were treated as "a heresy, triggering what appeared to be a 'holy war' to prove me wrong." Conversely, a spirit of self-criticism and renewal can hardly be said to be absent from the religious sphere when one of the problems faced by institutionalized orthodoxies has been to contain the eruption of reform and sectarian revolt.

There may be no obvious equivalent in science of the call to worship in religion. And yet, there were those in the late seventeenth century, Robert Boyle (1627–91) and John Ray (1627–1705) among them, who envisaged scientific inquiry itself as a form of worship. The image of nature as temple, the scientist as priest, was explicit in Boyle. Just as fine music was best appreciated by the trained musician, so God's craftsmanship in creation could be celebrated by the skilled anatomist. There was even revelation in this temple of nature. Insights that a modern chemist might attribute to serendipity were ascribed by Boyle to "pregnant hints" received from a greater chemist than he.

There is, therefore, a strong case for bringing an open mind to the richness of the subject. The main purpose of this chapter is to identify some of the levels on which statements about

nature and statements about God have coexisted. We can then consider the implications of this analysis for one of the general views identified in the introduction – that there has been nothing but conflict between science and religion.

The Diversity of Interaction

The very possibility of a rational science of nature is usually considered to depend on a uniformity in the relations between cause and effect. In the past, religious beliefs have served as a *presupposition* of the scientific enterprise insofar as they have underwritten that uniformity. Natural philosophers of the seventeenth century would present their work as the search for order in a universe regulated by an intelligent Creator. A created universe, unlike one that had always existed, was one in which the Creator had been free to exercise His will in devising the laws that nature should obey. A doctrine of creation could give coherence to scientific endeavor insofar as it implied a dependable order behind the flux of nature.

To say that religious belief could function as a presupposition of science need not entail the strong claim that, without a prior theology, science would never have taken off. But it does mean that the particular conceptions of science held by its pioneers were often informed by theological and metaphysical beliefs. When natural philosophers referred to *laws* of nature, they were not glibly choosing that metaphor. Laws were the result of legislation by an intelligent deity. Thus the philosopher René Descartes (1596–1650) insisted that he was discovering the "laws that God has put into nature." Later, Newton would declare that the regulation of the solar system presupposed the "counsel and dominion of an intelligent and powerful Being."

A doctrine of creation could underwrite the scientific enterprise in a second respect. If the human mind had been created in such a way that it was matched to the intelligibility of nature, then the possibility of secure scientific knowledge could be affirmed. Some two hundred years after Descartes had formulated his concept of mechanical laws, a proven capacity to discover the laws of nature and to express them mathematically was taken by the first systematic historian of science, William Whewell, as evidence of an affinity between the human and the divine mind. As the astronomer Johannes Kepler (1571–1630) had put it, in exposing the geometry of

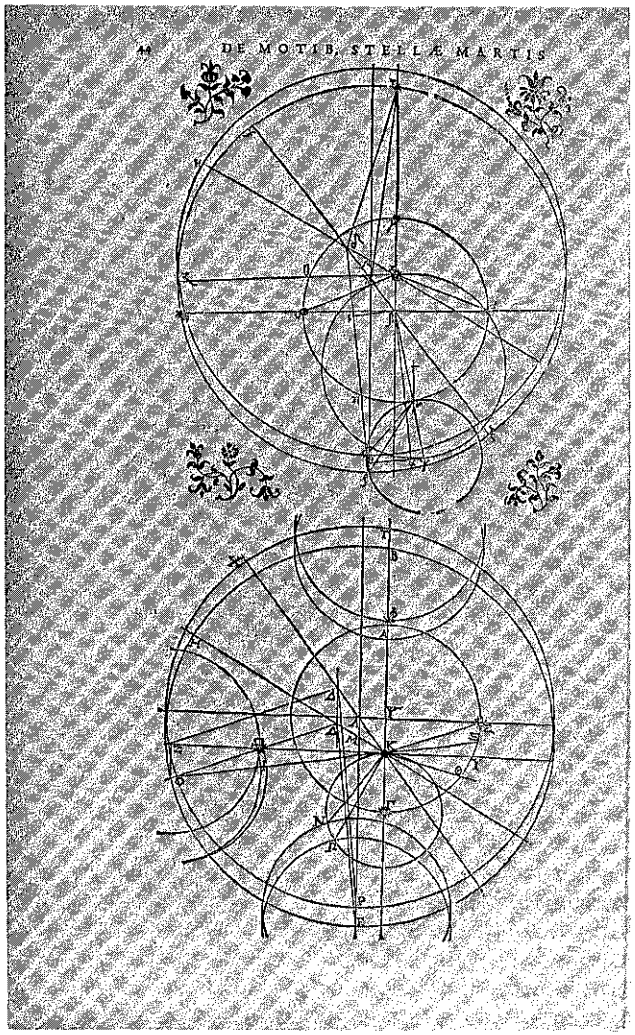

Figure I. 1. Illustration from page 44 of Johannes Kepler's *Astronomia nova* (1609). The imposition of order on a wayward planet. Kepler considers the orbit of Mars in the context of differentiating between three competing models of the world system: the Copernican (in which all the planets – earth included – orbit the sun), the Ptolemaic (in which sun and planets orbit a stationary earth), and the alternative geostatic system of Tycho Brahe (see Fig. I.2), in which the planets – but not the earth – revolve around the sun, which in turn orbits the earth. Kepler was to argue that the divinely ordained order behind the appearances was best revealed by supposing Mars to have an elliptical orbit, with the sun stationary at one focus of the ellipse. Reproduced by permission of the Syndics of Cambridge University Library.

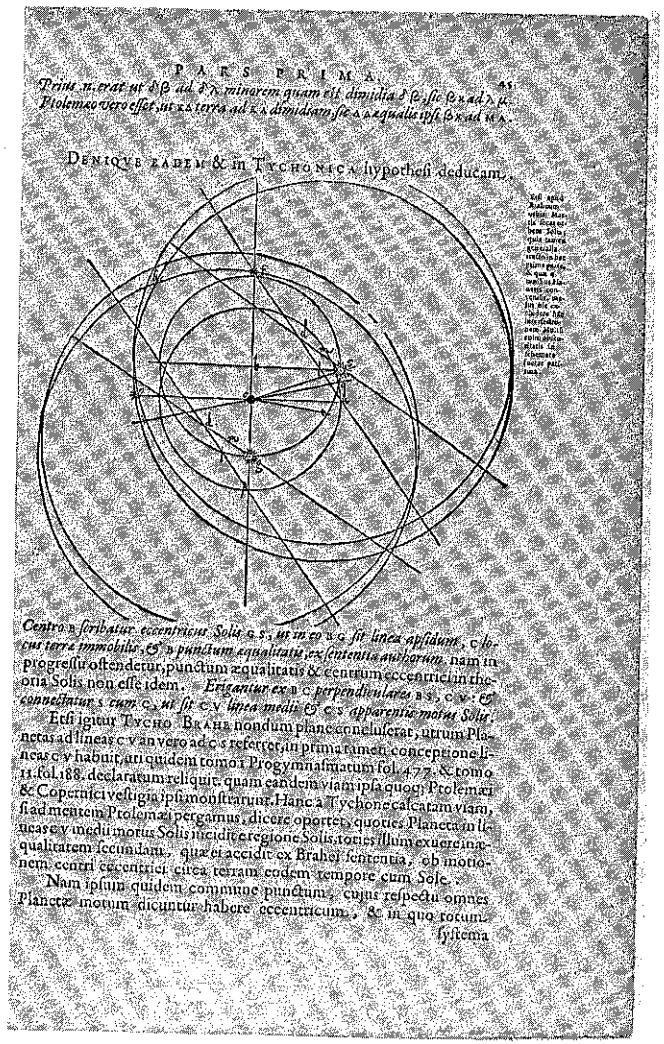

Figure I. 2. Illustration from page 45 of Johannes Kepler's *Astronomia nova* (1609). Reproduced by permission of the Syndics of Cambridge University Library.

creation one was thinking God's thoughts after Him. The idea of a First Cause, Whewell suggested, was not extracted from natural phenomena. Rather it had been *assumed* in order that those phenomena could become intelligible to the mind.

In addition to providing presuppositions for science, religious doctrines have also offered *sanction* or justification. This has been a recurring function as scientists have repeatedly had to justify the place of science in their culture. Proponents of scientific inquiry would often argue that God had revealed Himself in two books – the book of His words (the Bible) and the book of His works (nature). As one was under obligation to study the former, so too there was an obligation to study the latter. According to a manuscript of that great diplomat for science, Francis Bacon (1561–1626), the rise of experimental science was sanctioned not merely by religion, but by God Himself. For, in the book of Daniel (12:4) there is a prophecy that seemed to speak of a time when many would pass to and fro and knowledge would be increased. Recent improvements in navigation and the expansion of commerce persuaded Bacon that the time had come. He knew that the Genesis account of man's fall from grace could be read as an indictment of a thirst for knowledge. But he was able to anticipate that objection by suggesting that the prohibition applied only to knowledge sought in self-aggrandizement, not to that which was of service to humanity.

A religious sanction of a different kind was offered by Thomas Sprat in his *History of the Royal Society* (1667). Sprat suggested that, of all pursuits, the study of experimental philosophy was most likely to engender a spirit of piety, perseverance, and humility – the hallmark of Christian virtue. The contemplation of God's works could be a constructive diversion from the unhappy doctrinal disputes that had torn Christianity apart since the Reformation. Science could offer both sanctuary and its own brand of sanctification. Many years later when another scientific institution was founded in Britain, the British Association for the Advancement of Science, a similar refrain was still to be heard. Speaking in 1833, the Cambridge geologist and cleric Adam Sedgwick referred both to the wisdom of God as manifested in creation and to the wisdom of the association in seeking to transcend political and religious divisions. Otherwise the "foul demon of discord" would find his way into "our Eden of philosophy." Natural philosophy had its own garden of Eden, the arguments of natural theology providing a sanction for its preservation.

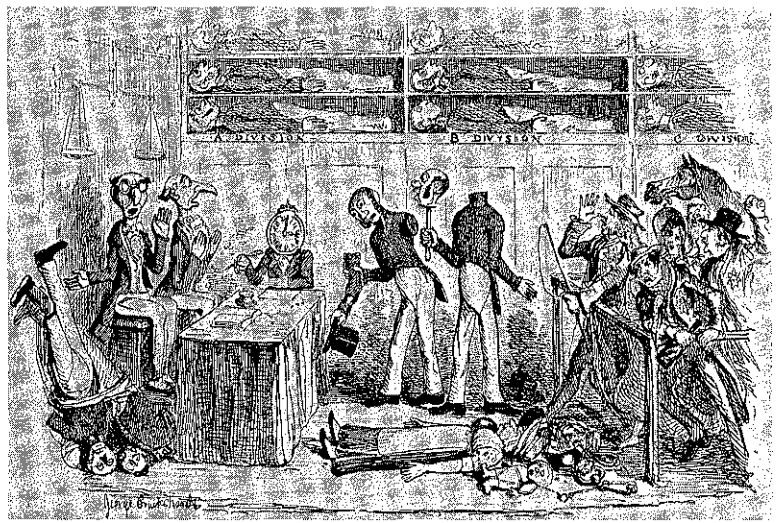

Figure I. 3. Cartoon by George Cruickshank from page 209 of *Bentley's Miscellany,* vol. 4, 1838. The necessity for scientists to find a justification for their endeavors is thrown into relief by this cartoon, which refers to a model exhibited before section B of the "Mudfog Association," a satirical creation of Charles Dickens who lampooned the British Association for the Advancement of Science with his "Full Report of the Second Meeting of the Mudfog Association for the Advancement of Everything." In his satire of the pretensions of mechanical science Dickens proclaims the value to society of automatons filling the role of policemen. Hence the images in the cartoon; for, in Dickens's account, the robot policemen were to be kept on shelves in the police office until required. Reproduced by permission of the Syndics of Cambridge University Library.

If religious beliefs have supplied presuppositions and sanctions for science, they have also supplied *motives*. The analysis of human motives is, of course, a precarious undertaking; but some of the connections made in the past between scientific and religious ideals were strong enough to bear reconstruction in such terms. It has certainly been claimed that values associated with ascetic Protestantism provided new motivation for scientific inquiry, particularly in Holland and England during the seventeenth century. A Protestant emphasis

on improving the world, under the aegis of providence, could confer dignity on scientific activity that promised both glory to God and the relief of human suffering. Conceptions of a better world over which Christ would reign for a thousand years (the millennium) were later secularized to yield visions of a purely earthly utopia, in which a perfect human society might be possible in the absence of coercive measures. Notwithstanding the unbridled optimism of many such visions, it cannot be denied that one source of the modern idea of progress was this millenarian theology of puritan reformers anxious to transform the world in readiness for Christ's second coming.

The possibility of religious motivation behind scientific inquiry is perhaps most visible in systems of natural theology in which scientific knowledge was used to establish the existence and attributes of God. In polemics against infidels and skeptics, who were commonly thought subversive of a stable society, science could be an impressive ally. Noting that the lens and pupil of the eye were "so finely shaped and fitted for vision that no artist can mend them," Newton asked whether blind chance could have known sufficient of light and its refraction to have effected the design. To one who had made a special study of refraction, the answer was obvious. There was a Being who had made all things and who was to be feared.

A motive for the study of nature could therefore exist in the desire to confirm a God to be feared. But also a God to be praised. In John Ray's *The wisdom of God manifested in the works of creation* (1691), there was a sense of exultation in the wonders of nature. So marvelous was the migrating instinct of birds that he could only ascribe it to the superior intelligence of their Creator. Nor did Ray merely exploit the inexplicable. It had been scientific ignorance, he suggested, that had permitted the clumsy models of the universe characteristic of Ptolemy's astronomy. With the advent of the Copernican system, the universe, according to Ray, had acquired a new elegance, more in keeping with what might be expected of a divine architect.

Claims for religious motivation behind the pursuit of science are difficult to test, but there have been circumstances in which they seem appropriate. Where a protagonist may have political reasons for wishing to differentiate one theological position from another, he may place a high value on scientific results that assist the differentiation. In late eighteenth-

century England, much of Joseph Priestley's motivation as a religious dissenter came from a desire to establish a form of Christianity that could withstand rational criticism. European philosophers who had rejected the Christian religion had, he believed, rejected a corrupt form. His aim was to reconvert them to a Unitarian Christianity devoid of superstition. The doctrine of the Trinity – that God is three persons in one – had infected the early Christian church through contact with Plato's philosophy. Because science could help to eliminate superstition, there undoubtedly were connections in Priestley's mind between scientific activity and the promotion of a religion shorn of Platonist corruption. The rapid progress of scientific knowledge, he declared, would be "the means under God of extirpating all error and prejudice, and of putting an end to all undue and usurped authority in the business of religion as well as of science."

What Priestley called the business of religion could enter scientific debate on yet another level. It could reinforce prescriptions for an appropriate scientific method. Each science in its infancy has had to establish the assumptions and procedures by which it could claim to extend our knowledge of nature. These have been the subject of intense debate, with religious preferences sometimes intruding. To say that religious beliefs have infiltrated discussions of scientific method is not to say that they have directly affected scientific practice, for statements about methodology have often been rationalizations, used to justify a research program already in existence. Such rationalization is, however, of great interest to the historian because it reveals something of the social processes involved in gaining respect for scientific work both inside and outside a scientific community.

In the 1830s, the British geologist Charles Lyell argued that to establish geology as a rigorous science, it had to be assumed that the forces that had sculpted the earth's surface in the past were identical, both in kind and intensity, to those acting now. But there were contemporary geologists who had misgivings. Was it not too restrictive to preclude the possibility that forces of greater intensity had acted in the past? In expressing that objection, other contemporaries were undoubtedly swayed by the realization that Lyell's axiom would so greatly increase the age of the earth that it might threaten even a generous reading of Genesis. When the Scottish physicist David Brewster protested against Lyell's principle of

uniformity, he invoked biblical considerations to justify an alternative methodology.

In earlier periods, this role of religious belief in *regulating scientific methodology* was extremely common. The colorful chemical and medical reformer Paracelsus (c. 1493–1541) suggested that, in creating the world, God had left a magic sign on every herb – a clue to its efficacy. In some cases the divine signature was perfectly legible: The thistle would relieve a prickly cough. In others a little more imagination was required:

> Behold the satyrion root, is it not formed like the male privy parts? No one can deny this. Accordingly magic discovered it and revealed that it can restore a man's virility.[1]

This may not sound much like science, but it represented a significant departure from the book learning of his day. For Paracelsus it implied a departure into the hills with a stout pair of boots to explore, decode, and harness the magic power. It implied empiricism of a sort.

Empiricism of a different sort was practiced by Kepler, who welcomed the astronomical data of Tycho Brahe (1546–1601) as a means of confirming preconceived beliefs about the geometry of the universe. The data were vital, but so was the preconception that the planetary orbits could be inscribed within, and circumscribed without, the five regular Greek solids. It was empiricism of a sort, but regulated by Kepler's fusion of a Pythagorean harmony with a Christian doctrine of creation. It was a brand of empiricism that his critic Marin Mersenne (1588–1648) renounced as not empirical enough. Mersenne argued that, because the structure of the solar system is only one of infinitely numerous possibilities (and therefore ultimately dependent on the choice of the deity), it would be wrong to cherish a preconceived pattern. A more open mind was required to discover which of the many possible patterns God had actually chosen to instantiate. Such references to the freedom of the divine will were often used in the seventeenth century to justify attacks on rationalist theories of nature, whose authors presumed to know how God *must* have shaped the world.

The term *modern science* usually connotes a complete openness to empirical testing. Scientists in the past, however, experienced difficulty (and there are contexts in which they still do) when experimental criteria failed to discriminate deci-


EMBLEMA XLII. *De secretis Naturæ.* 177

In Chymicis versanti Natura, Ratio, Experientia & lectio, sint Dux, scipio, perspicilia & lampas.

EPIGRAMMA XLII.

DUx Natura tibi, ratioque arte pedissequa illi
Esto lubens, erras, ni comes ipsa viæ est.
Det ratio scipionis opem, Experientia firmet
Lumina, quo possit cernere posita procul.
Lectio sit lampas tenebris dilucida, rerum
Verborumque frues providus ut caveas. Z Cas.

Figure I. 4. Plate from page 177 of Michael Maier's *Atalanta fugiens* (1618). To learn nature's secrets, the chemist follows in her footsteps. In the accompanying text, Nature is the guide, reason the staff, experience the spectacles, and reading the lamp, all prerequisites of successful inquiry. Reproduced by courtesy of The Bodleian Library, Oxford; Shelfmark Vet. D2. e. 18.

sively between two or more theories. Recent work in the philosophy and sociology of science has emphasized that experimental results are rarely adequate for making a definitive choice between competing theories. Not uncommonly there have been problems in replicating both experimental procedures and the results claimed for them. Certain problems have long been acknowledged even in popular accounts of scientific practice where emphasis is placed on the role of aesthetic criteria in theory selection. How often one hears that when two theories look equally plausible, one opts for the simpler. In the process of theory selection, religious (and antireligious) preferences have again intruded. The criterion of simplicity could itself be referred, as it was by Newton, to a God who had ensured that nature did nothing in vain or, as it was by Michael Faraday in the nineteenth century, to a God who had ensured that the book of his works would be as simple to comprehend as the book of his words.

An example from the astronomical debates of the early seventeenth century may illuminate this *selective* role of religious belief. In 1600, the renegade monk Giordano Bruno was burned at the stake for numerous heresies, including the proposition that the universe is infinite and that it contains an infinite number of worlds. One of the reasons why this proposition was distasteful to many of Bruno's contemporaries was that it deprived humanity of a privileged place in the cosmos. In resisting Bruno's vision, Kepler did all he could to protect the cosmic identity of his own solar system and (in accordance with his religious beliefs) of humanity's special place within it. Despite the Copernican transformation, Kepler could still argue for a unique earth. It was the planet with the central *orbit* in a system that had as its focus a symbol of the living God: the most resplendent sun in the universe. Bruno's vista of an infinite plurality of star systems, scattered through an infinite universe, was unacceptable because of its relativistic implications. Accordingly, when Kepler first heard of Galileo's telescopic observations, he was alarmed lest the satellites reported should be planets orbiting another sun. How great his relief when he learned they were moons of Jupiter! His insistence that our sun should be preeminent also predisposed him toward the belief that previously invisible stars, now revealed by Galileo's telescope, had been too small rather than too distant to be seen. In such a way have religious beliefs sometimes shaped the interpretation of scientific data.

They have operated, too, in less subtle ways, sometimes fulfilling an explanatory role before being overtaken by more sophisticated scientific developments. We can speak here of the *constitutive* role of religious beliefs – in the sense that they have constituted an explanation for phenomena that have subsequently proved explicable without theological reference. For Newton there was no satisfactory account of why the planets should orbit the sun in the same direction and in roughly the same plane: This aesthetically pleasing scheme could only be explained by appealing to God's initial design. When Laplace, late in the eighteenth century, applied his nebular hypothesis to the problem, deliberately dispensing with concepts of design, it could look as if Newton's God had been made redundant.

Propositions deduced from Scripture have also fulfilled an explanatory function. The legend of Noah's ark once purported to say something about the geographical distribution of animals. For the Oxford geologist William Buckland the flood was still constitutive of the earth's physical history in the 1820s. The concept of separate creation, which Darwin found inadequate, had often been presented as a biblical view. It is this constitutive role of religious belief that so often comes to mind when the words science and religion are juxtaposed; for the explanatory pretensions of the world's religions have made them vulnerable to scientific advance. This is one reason why it has become routine among Christian writers to warn against a god-of-the-gaps. Past precedents indicate that conflict will assuredly arise, if statements about God are used to fill the gaps in scientific explanation.

It should not be assumed, however, that when religious beliefs have functioned as primitive science, it has always been to the detriment of further inquiry. They could stimulate investigation before being discarded. Take the case of Noah's ark. A conventional view would be that the proliferation of new species, discovered between 1650 and 1750, sank the ark by the sheer weight of their numbers. Certainly, by the 1740s, the Swedish taxonomist Linnaeus found it incredible that the fifty-six hundred species he had named could have been crammed into the elaborate vessels designed by biblical literalists. And yet, in the preceding century, the legend had played its part in stimulating inquiry into the geographical distribution of species. It had focused discussion on the plausibility of explanations based on dispersal from a single point.

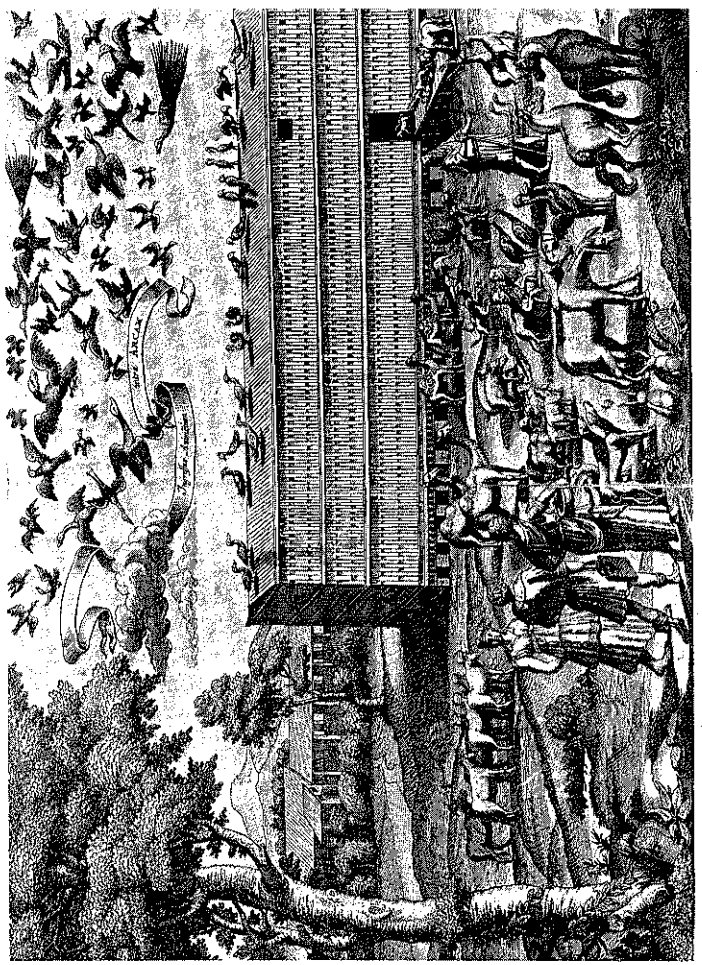

Figure I. 5 Illustration following page 122 of Athanasius Kircher's *Arca Noë* (1675). Preparing to board an ark in which there was room for every species. Courtesy of Dr. Janet Browne and reproduced by courtesy of the Wellcome Institute Library, London

The desire of biblical literalists to show that the story could have been history acted as a spur to the study of zoogeography, even though the eventual, and ironic, outcome was that they sank their own ship. And even when the ark was abandoned, it still left its mark on the science. Linnaeus himself retained a dispersal of all species from a single mountain, formerly surrounded by sea.

If religious concepts have sometimes functioned as primitive science, the converse has also occurred. As religious beliefs have constituted science, so scientific creeds have constituted an alternative religion. Scientists themselves have often drawn parallels between the experience of a scientific vocation and certain forms of religious experience. In late eighteenth- and early nineteenth-century Europe, it was not unusual to hear naturalists speaking of their scientific awakening in terms that might be used of a religious conversion. One could experience a sense of ecstasy at the disclosure of nature's secrets and a sense of the sublime in contemplating its works. Whenever scientific rhetoric assumed the form of a counterreligion, it could easily become a substitute religion, as it began to do in France during the revolutionary era. Later champions of a scientific naturalism would sometimes refer to the "church scientific," as if to emphasize their usurping the role of the clergy in the arbitration of cultural values. Charles Darwin's advocate T. H. Huxley made science the subject of what he chose to call "lay sermons." When one of the most energetic spokesmen for applied science in nineteenth-century Britain, Lyon Playfair, addressed the members of a mechanics institute in 1853, he unashamedly declared that "science is a religion and its philosophers are the priests of nature."

It would not be difficult to extend this analysis and to identify other types of interaction. A concern with theological questions has sometimes prompted new lines of scientific inquiry, as when Richard Bentley (1662–1742), wishing to use the latest science to defend his Christian theism, asked Newton whether he thought it possible that the frame of the world could have been produced, from a uniform distribution of matter, by mechanical principles alone. His question prompted a fresh line of reasoning, Newton acknowledging that he had barely considered the point before receiving his letter.

The point we need to consider is whether, in the light of such diversity of interaction, it is appropriate to focus exclu-

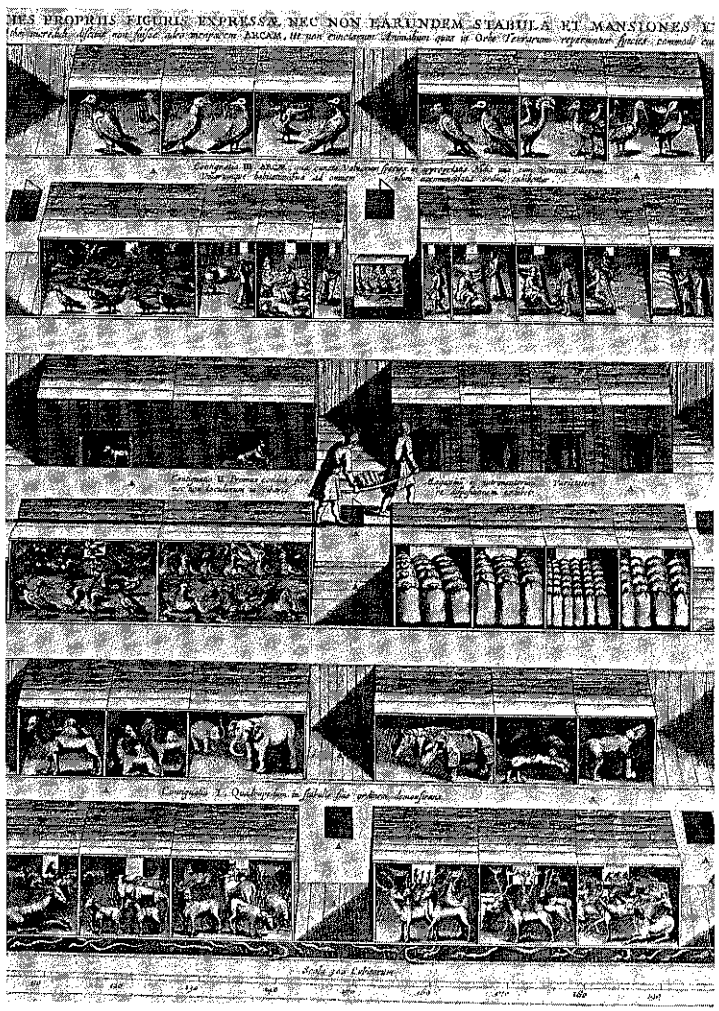

Figure I. 6. Illustration between pages 108 and 109 of Athanasius Kircher's *Arca Noë* (1675). Some of the carefully calculated compartments in Kircher's ark. Reproduced by permission of the Syndics of Cambridge University Library.

sively on the impact *of* science *on* religion. Standard treatments of the subject are often preoccupied with that formulation, as if the streams of relevance and implication could flow in one direction only. But if religious beliefs have provided presupposition, sanction, even motivation for science; if they have regulated discussions of method and played a selective role in the evaluation of rival theories, the possibility of a more wide-ranging, and I hope rewarding, inquiry opens up. This is not to deny that the custodians of institutionalized religion have often done their best to censure what they perceive to be damaging scientific conclusions. But it is to suggest that an image of perennial conflict between science and religion is inappropriate as a guiding principle. We shall now consider further reasons why this is so.

Conflict between Science and Religion

With reference to the effect of scientific innovation on religious belief, two propositions are often juxtaposed. First, when there has been confrontation, it has been religion that has yielded in the end. Second, despite recurrent concession, the religion itself has survived. This may indicate that the conflict has been over peripheral matters, that a core belief in a transcendent power could retain its plausibility, untouched by changing conceptions of the physical world. Or it might suggest that the religious symbols, by which men and women have conferred meaning on their lives, meet such pressing psychological needs that they remain impervious to scientific frames of meaning, which, in the last analysis, only dictate how things are and how they came to be so, without pretending to answer the why and the wherefore. Or it might suggest that, despite a total lack of plausibility in their claims for knowledge, religious movements have survived either through institutional inertia, or insofar as they assist in conferring a sense of identity on national or local communities. For one of the founders of the sociology of religion, Emile Durkheim, history showed beyond doubt that religion had come to embrace a progressively smaller sector of social life. Political, economic, and scientific functions had gradually freed themselves from religious control. At the same time, there was something eternal in religion, destined to survive all the particular symbols in which religious thought had successively enveloped itself. A fully secularized society was a contradic-

tion in terms, for there could be no society that would not feel the need to uphold the collective sentiments that gave it its unity and individuality.

One reason why there can be no simple answer to the question whether there has been irresolvable conflict between science and religion is that the answer may well depend on which of these types of explanation is favored. So much depends on the prior plausibility ascribed to core religious beliefs. And in religious communities, perhaps more than any other, the experiences and perceptions of the insider will contrast with those of the outsider. What for the insider might be the purification of a defensible religion by its exposure to scientific criticism, would for the outsider be one more step along the path to destruction as an inherently implausible account of human destiny was shown up for what it is. Despite the impossibility of an objective assessment, there are, however, considerations that suggest that the conflict has been exaggerated in the interests of scientism and secularism. Because it has also been underplayed in the interests of religious apologetics, a degree of critical detachment is required.

In his *History of the conflict between religion and science* (1875), J. W. Draper put forward a principle of interpretation that still enjoys popular support. The history of science, he wrote, is a narrative of the conflict of two contending powers, the expansive force of the human intellect on one side and the compression arising from traditional faith, and human interests, on the other. Draper was an English scientist who became the first president of the American Chemical Society. Living through the post-Darwinian debates, he invariably took up the cudgels on behalf of scientific rationalism. He had even spoken – interminably – at the famous meeting of the British Association for the Advancement of Science, held at Oxford in 1860, when Huxley allegedly scored his victory over Bishop Wilberforce with the retort that he would rather have an ape for an ancestor than a man who used his privileged position to pronounce on matters he knew nothing about. For Draper, the Darwinian debates had focused attention on a crucial issue – whether the government of the world is by incessant divine intervention or by the operation of unchangeable laws.

One reason why his historical narrative, and others like it, must not be read uncritically stems from the fact that he projected current issues backward in time. Far from being

impartial, he had an obvious target. Whereas science had been unstained by cruelty, hands in the Vatican had been steeped in blood. Draper's history was a diatribe against the Roman Catholic Church. It reflected in part his reaction to the encyclical *Quanta cura* of 1864. The accompanying "Syllabus of errors" had deemed erroneous the belief that public institutions devoted to teaching literature and science should be exempt from the Church's authority. Liberal protests notwithstanding, it had been announced in 1870 that the pope, speaking ex cathedra, is gifted with infallibility when defining doctrines to do with faith and morals. Such developments were, for Draper, red rag to a bull – hence his recourse to history for the counterattack. A parade of martyred scientists would show by whose hands the real errors had been committed.

Although he differentiated his position from that of Draper, suggesting that the struggle had been between science and dogmatic theology rather than between science and religion, A. D. White insisted that there had been a theological and a scientific view of every question, invariably at odds. He, too, had lived with the Darwinian controversies and indulged in a similar backward projection. As with Draper, White had a personal investment. He was smarting from the clerical opposition that had been marshaled against his nonsectarian charter for Cornell University. The prominence he had given to instruction in science had evidently made matters worse. He was forced to conclude that there was "antagonism between the theological and scientific view of the universe and of education in relation to it." The result was *A history of the warfare of science with theology in Christendom* (1895), suffused with foolish remarks by uninformed priests, but hardly a model of discrimination.

To understand why Draper and White wrote as they did is not of itself sufficient to impugn their conclusions. Their arguments have to be judged on their merits. On closer inspection, however, they turn out to be deeply flawed. They share a defect in common with all historical reconstruction that is only concerned with extreme positions. They neglect the efforts of those who have regarded scientific and religious discourse as complementary rather than mutually exclusive. Their preconception that, as science has advanced, phenomena once considered supernatural have yielded to naturalistic explanation, is not without support. But it assumes a dichotomy be-

tween nature and supernature that oversimplifies the theologies of the past. If a supernatural power was envisaged as working *through*, as distinct from *interfering with*, nature, the antithesis would partially collapse. Or, in the vocabulary often employed by earlier natural philosophers, an explanation in terms of secondary causes need not exclude ultimate reference to a primary cause.

Anthropologists who have studied witchcraft among African tribes have commented on the reaction to suggestions that the disease of an individual may be the result of a virus, not of witchcraft. A common reaction is, Who sent the virus? This is instructive because it shows how an explanation in terms of secondary causes is not perceived to exclude a customary reference to the will of a person. The significance given to explanations in terms of natural causes depends on higher-level assumptions embedded in a broader cultural framework. In the history of Western culture, it has not simply been a case of nature swallowing supernature. Something had to happen to change the higher-level assumptions if conflict between science and religion was to achieve that self-evident status proclaimed by Draper, White, and their successors.

There is, here, a philosophical as well as an anthropological point. It was made by T. H. Huxley who, for all his anticlericalism, nevertheless acknowledged that there were limits to the conflict he had himself been stirring. There was a wider teleology not touched by the doctrine of evolution. For it was always possible to argue that a primordial molecular arrangement had been designed in such a way that the universe, as we know it, would be the outcome. In that sense, Huxley suggested, evolution had no more to do with theism than had the first book of Euclid. A complementarity between scientific and theological interpretation was still possible, even if he himself preferred to remain agnostic.

The conflict histories were flawed in a further respect. The scientific achievements of the past were crudely evaluated according to their contribution to later knowledge. A more sensitive approach requires that scientific innovations be judged against the background of prevailing knowledge at the time they were announced. The kind of history in which later knowledge is made the yardstick by which to judge earlier theories is now widely recognized as profoundly unhistorical. In the minds of those who practice it (and it is still

quite common in scientific textbooks), the scientists of the past are effectively divided into heroes and villains. The former anticipate later developments, the latter fail to see the light. Given a cast of heroes and villains, there was no question but that clerical opponents of fruitful innovation would be placed among the latter. And if some brilliant anticipation of later theory failed to make its mark, there was a convenient explanation to hand: the opposition of "the Church."

The problem is that such accounts overlook the dialogue between established and innovative science. In criticizing scientific novelty, existing theories are usually available as a resource. Consequently, a case could usually be made out on scientific grounds for resisting hypotheses that appeared premature. It would, for example, be quite wrong to imagine that opposition to the Copernican theory derived only from religious prejudice. In 1543 an earth-centered cosmos was the physical orthodoxy of the day, supported by philosophical arguments that, at the time, were peculiarly compelling. Until an effective principle of inertia had been formulated, the earth's motion was contradicted by common sense. Surely, if the earth were moving, an object dropped from a tower would no longer hit the ground immediately beneath the point of release. Prevailing Aristotelian philosophy also affirmed a fundamental division between two regions in the cosmos. Beyond the moon all was perfect and immutable. Beneath the moon, all was corruption and change. To wrench the earth from the sublunar region and to place it among the planets was to violate the entire cosmos. Certainly the Catholic Church had a vested interest in Aristotelian philosophy, but much of the conflict ostensibly between science and religion turns out to have been between new science and the sanctified science of the previous generation.

Appeal to ecclesiastical censure as a way of explaining the misfortunes of scientific theories is a card that can be overplayed. Galileo seems to have felt that his difficulties with the Catholic Church had their origin in the resentment of academic philosophers who had put pressure on ecclesiastical authorities to denounce him. A conventional conflict thesis can also conceal vital distinctions between different religious traditions and between liberal and conservative representatives of those traditions. One has to ask whether different pressure groups within the Roman Church became equally hostile to Galileo, or whether, as some believed at the time,

he was a victim of a Jesuit plot – of an act of revenge for insults he had meted out to prominent members of that order. The pope under whose jurisdiction he eventually fell, Urban VIII, had once been a friend and ally. Even after he had been summoned to the Holy Office in April 1633, Galileo could still arouse sympathy in high places. The commissary general in charge of the prosecution, Firenzuola, apparently admitted that he did not consider the Copernican system unacceptable. The pope's nephew, Cardinal Barberini, appears to have shared with Firenzuola the suspicion that the trial had more to do with personal revenge than doctrinal necessity. The issues in this famous case are extremely involved and we shall consider them further in Chapter III. But the need for discrimination is plain enough. During the 1620s the opinion had been expressed in Catholic circles that the Copernican system ought not to be condemned. To do so would constitute a stumbling block to the reconversion of Protestants who favored the new astronomy.

In assessing the attitudes of religious thinkers to the natural sciences, discrimination is required in another respect. For there is a difference between hostility and indifference. Many spokesmen for the Christian religion have echoed the conviction that St. Basil expressed with his statement that a life of meekness and piety knew higher concerns than whether the earth was a sphere, cylinder, or disk. Sometimes the investigation of nature has sunk to the bottom in a stratification of priorities. Another of the early church fathers, Tertullian, observed that it had "served Thales of Miletus quite right, when, star gazing as he walked . . . , he had the mortification of falling into a well."

It was easy for Draper and White to mock the church fathers for their naiveté on matters of natural philosophy, forgetting that they did have higher concerns – forgetting, too, that their naiveté often reflected the pagan wisdom of their day. According to Draper, no one had done more than St. Augustine to bring science and religion into antagonism. It was he who had made the Bible an arbiter of human knowledge. Yet Draper failed to mention that, in his exegesis of Scripture, Augustine had not been a hide-bound literalist. In fact he had specifically warned against taking the "days" of Genesis literally. Because eggs and seeds took time to develop, reflecting a "wonderful constancy in an established order," the creation narrative had to be read with care. Drawing

on a Stoic concept of seeds, which he applied even to the origin of Adam and Eve, he had a sense of natural order that could hardly be considered hostile to further inquiry. He may have shown indifference with his remark that Christians need not be ashamed if they knew nothing of the number and properties of the elements. But he could also be dismayed if Christians were heard by pagans to be talking nonsense about nature.

To reduce the relationship between science and religion to one of conflict may also obscure the possibility that, when students of nature were persecuted by ecclesiastical authorities, it was for theological heresies rather than for scientific heterodoxy. Two examples have frequently been pressed into the mold of religion versus science: the burning of Michael Servetus (c. 1511–53) in Protestant Geneva and of Giordano Bruno (1548–1600) by the Roman Inquisition. Servetus is remembered for his description of the lesser, pulmonary, circulation of the blood. Rejecting Galen's theory, that blood passes directly from right to left ventricle, he proposed a vital role for the lungs, where a vital spirit emerged from the mixture of air and blood. His insight, however, was achieved in a theological work discussing the relationship between "spirit" and air. His concern was to understand the dispensation of God's Spirit to mankind. But he was burned in 1553 not so much for attacking Galen, as for attacking Calvin. Geneva was still technically under the Holy Roman Empire where the Justinian code allowed burning for those who denied either infant baptism or the divinity of Christ. Servetus had denied both. Calvin himself had no doubt that Servetus should be executed, but he was actually unsure whether burning, as recommended by the town council, was the appropriate sentence.

An advocate of Copernican astronomy, an infinite universe, and a plurality of worlds, Bruno has often been seen as the archetypal scientific martyr. Although his proposal of plural worlds *was* considered heretical, it is difficult to believe it was that which determined his fate. A renegade monk, he made no secret of his unorthodox Christology. It was rumoured that he had declared Christ a rogue, all monks asses, and Catholic doctrines asinine. Behind his hostility lay a conviction that the Roman Church represented a corruption of an earlier, undefiled religion that he associated with the Egyptians. Bruno was familiar with the collection of texts

known as the *Corpus Hermeticum,* then attributed to an Egyptian philosopher, Hermes Trismegistus. Where some saw in the Hermetic texts an anticipation of Christianity, Bruno saw an alternative. Indeed, he hoped they would provide the basis of a religion that could unite the warring factions of the Church. His world-picture was colored by a magical philosophy that almost became his religion. He described Moses as a magus who, learning his magic from the Egyptians, had outconjured the magicians of Pharaoh. The true cross, for Bruno, was the Egyptian cross – full of magic power for tapping astral influence. The Christian cross was a weak derivative. The evidence suggests, not surprisingly, that his interrogators were more concerned by his theology, by matters of church discipline, and by his contacts with other known heretics, than by his Copernicanism.

The dependence of the conflict thesis on legends that, on closer examination, prove misleading is a more general defect than isolated examples might suggest. Consider the case of Charles Lyell, who lectured on geology at King's College London in 1832 and 1833. Appointed to the chair of geology in April 1831, he had resigned by October 1833. The anecdotal view has been that his brevity of tenure reflected animosity from an Anglican establishment, disturbed by Lyell's rejection of a recent, universal flood. It was not, however, that simple. Even the one bishop who had been apprehensive, Edward Copleston, acknowledged that the progress of geology could be accommodated by a readjustment of biblical interpretation. His principal concern had been pastoral – that Lyell might abuse his position of responsibility by drawing conclusions of general human significance, not strictly deducible from his science. Lyell resigned not because of some inherent conflict between science and religion, but because he enjoyed neither the prestige nor the remuneration he had expected from the post. His lectures would have been more lucrative had they attracted more women. But it was during his tenure that the College Council debarred them. With the prospect of a depleted income, Lyell considered that his energies would be better spent in completing his *Principles of geology.* His resignation arose not so much because an audience was to be debarred from geology, as because women were to be debarred from the audience.

Women *were* in the audience when T. H. Huxley and Bishop

Wilberforce had their encounter at Oxford in 1860. One fainted, according to some reports, and had to be carried out – so tremendous had been the spectacle of a man of God slain by a man of science. The bishop had asked whether Huxley would prefer to think of himself descended from an ape on his grandfather's or his grandmother's side, thereby touching the sensitive nerve of female ancestry. Huxley's retort that he would rather have an ape for an ancestor than a bishop – or words to that effect – has come to symbolize not merely the conflict between Darwinism and the Bible but the victory of science over religion. "The Lord hath delivered him into mine hands" was a phrase that came into Huxley's mind, as he reminisced about the incident later. But it was thirty-one years later and recent scholarship has questioned whether the anecdote might not have been a retrospective invention. Contemporary accounts were certainly not unanimous in recording a triumphant Huxley and a humiliated bishop. Huxley had turned the tables admirably, according to Sir Joseph Hooker, but he had been unable to throw his voice over so large an assembly. He had not dealt with the bishop's weak points nor, according to Hooker, had he carried the audience with him. One convert to Darwin's theory, Henry Baker Tristram, who had applied the concept of natural selection to larks and chats in the Sahara desert, was actually deconverted as he witnessed the debate! There was, undeniably, an issue: whether the nonspecialist had any right to expatiate on scientific matters. But that is precisely why the legend, once created, would become part of the folklore of scientific professionalism.

From popular texts on the Darwinian revolution, one would never suspect that another clergyman spoke out during the Oxford meeting of the British Association. Frederick Temple, headmaster of Rugby School, and future archbishop of Canterbury, preached the official sermon on 1 July 1860. Taking a more liberal line than the bishop, Temple argued that the finger of God was to be discerned in the laws of nature, not in the current limits of scientific knowledge. Tacitly, he made room for Darwin's science and was even said by one observer to have espoused Darwin's ideas fully. The point is that memorable anecdotes can create false perspectives. Wilberforce was not the only representative of Anglican opinion, and even he was not as obscurantist as is sometimes

implied. His printed review of the *Origin of species* attracted Darwin's comment that "it picks out with skill all the most conjectural parts, and brings forward well all the difficulties."

The fundamental weakness of the conflict thesis is its tendency to portray science and religion as hypostatized forces, as entities in themselves. They should rather be seen as complex social activities involving different expressions of human concern, the same individuals often participating in both. In its traditional forms, the thesis has been largely discredited. It is, in fact, so easy a target that scholars reacting against it have constructed a revised view that has also been driven to excess. If past conflicts can be spirited away, it is tempting for the religious apologist to step in and to paint a more harmonious picture. After all, if religious beliefs did furnish presupposition, sanction, and motivation for science, they might be looked upon more favorably in an otherwise secular society. The argument sometimes takes the form of a diagnosis – that much of the perplexity of our modern age is due to the severance of science from the religious values that once shaped it. Christians, both Catholic and Protestant, have argued thus, as have Muslim scholars looking back to a golden age when Islamic thinkers were at the forefront of the physical sciences. This apologetic use of revisionist history is, however, so full of pitfalls that it, too, deserves critical attention.

Harmony between Science and Religion

Religious apologists have often argued that when science and religion are properly understood, they can be in perfect harmony. The implication is that such conflicts as there have been in the past were merely the result of misunderstanding. Historical analysis showing that at least some of the conflict has been exaggerated can be used to support the argument. The problem is, however, that claims for inherent harmony are vulnerable to the same kinds of objection as claims for an inherent conflict. The idea that there is some correct and timeless view, against which historical controversies can be judged, can prove an insensitive guide to the issues as they were perceived at the time.

When the history of science is hijacked for apologetic purposes, it is often marred by a cultural chauvinism. The realization that religious beliefs were relevant to the rise of science is transformed into the more parochial claim that a particular religion, or religious tradition, was uniquely propitious. Thus one often encounters the claim that a large number of Quakers (and other dissenters) contributed significantly to eighteenth- and nineteenth-century physical science and that Jews have been preeminent in mathematics, physics, and psychiatry in the twentieth century. It is wise for the historian to be suspicious if claims for a special relationship are superimposed upon such alleged correlations. This is not to deny that there may be good reasons why members of religious minorities should have sought a career in science and why they excelled in particular areas. But these reasons may have little to do with intrinsic features of their religion. In eighteenth-century England, for example, the practical sciences may have appealed to some dissenters because they were denied access to other professions.

Cultural chauvinism can have insidious effects on the historiography of science. Even when they have not been beating a religious drum, Western historians have been censured for their myopia in treating modern science as if it were an exclusively Western phenomenon. Significant contributions by Arab scholars are easily overlooked if there is the preconception that science was uniquely the product of a Hebraic–Christian culture. In the centuries preceding the scientific renaissance in the West, Muslim scholars did far more than merely reproduce their heritage from the Greeks. In algebra they developed a concept of polynomials and pioneered an algebraic geometry that has traditionally been ascribed to Descartes. Different types of experimentation were introduced as a conventional barrier between theoretical science and the practical arts was weakened. A fruitful marriage of mathematics with physics was achieved by Alhazen (c. 965–1040) for whom optics became a study of the geometry of vision. By the early fourteenth century, al-Farisi was constructing experimental models – glass spheres filled with water to simulate rain drops – for the mathematical analysis of the rainbow. Not surprisingly, Muslim scholars see in sixteenth-century Europe not a scientific renaissance but a reactivation.

Because the history of science has become embroiled in religious polemics, it is important to appreciate that the chauvinism appears not only between religions but within them. In claims that one tradition rather than another led to scientific innovation, one often detects an apologetic intention.

One of the most prolific writers on Islamic science has insisted that most, if not all, the seminal contributions of Arab scholars are to be ascribed to a Shi'ite gnostic tradition. The rival theology of Sunni Muslims, particularly that of the Ash'arites, then suffers by comparison. Similarly, the thesis of Western historians that Protestant Christianity was more conducive to the expansion of science than Catholicism has often carried a hidden agenda. The great defect in such writing is that it is often structured by questions of the form Who discovered such and such a fact first? or Who first anticipated such and such a concept? Although the underlying message is quite different from the conflict thesis of White and Draper, there is that same streamlining of history into heroes and villains.

Religious apologists have also fallen into the same trap as White and Draper in projecting backward a model – in this case of harmony – that, although consonant with their own reconstructed religion, may not fit the religious beliefs of the past. The danger consists in imagining some essence of Christianity, for example, that, because it may be shown to be immune to scientific criticism today, is assumed always to have existed and therefore, properly understood, is always impervious to criticism. Apologists wishing to stress the harmony between science and religion may gloss over those facets of Christianity *as it was* that distinguished it from Christianity *as they now wish it to be*. They may wish to say that their religion no longer needs a geocentric universe, a physical location for heaven and hell, a personal devil, or even divine intervention in the physical world. The danger is that they may minimize, or even overlook, the importance of such beliefs for the Christian societies of the past. However condescending contemporary apologists may be to archaic conceptions of divine intervention, it is almost impossible to exaggerate the extent to which belief in such intervention once permeated European societies, creating popular images of the disruption of nature that could hardly have been congenial to a critical science of nature.

Apologists wishing to exploit a revisionist history of science invariably stress the profoundly religious orientation of many prominent scientists. While it is true that many of the great names of the past have been theists rather than atheists, their orientation has often been unorthodox when judged against the norms of their day. Idiosyncrasy has been at least

as common as conformity. The originality of a critical mind, expressing itself in creative and sometimes idiosyncratic science, has often manifested itself in theological deviation. The eighteenth-century chemist and Unitarian minister Joseph Priestley (1733–1804) was as keen to remove spirits from Christianity as he was from chemistry. A mind used to questioning scientific hypotheses might experience discomfort with contentious elements in a classical creed – just as Newton, before Priestley, dismissed the doctrine of the Trinity as a Platonist corruption of a biblical Christianity. One of the points to emerge in later chapters will be that eminent scientific figures have rarely been typical representatives of the religious traditions in which they were nurtured.

The apologist has a problem even where expressions of religious belief have an orthodox ring. For the cynic will always say that the scientists of the past simply feigned their belief in order to escape persecution. As a general rule, this cynical objection is far too crude, not least because it often rests on a false assumption – that it is impossible for theological statements to be both placatory and genuine. Nevertheless, such statements *were* sometimes placatory and social pressures toward conformity could be strong. As late as 1865, the botanist J. D. Hooker wrote a revealing letter to Darwin in which he complained of the stance taken by their contemporary, Alfred Russel Wallace, who had wondered that scientists should be so afraid to say what they think. "Had he as many kind and good relations as I have," Hooker wrote, "who would be grieved and pained to hear me say what I think, and had he children who would be placed in predicaments most detrimental to children's minds . . . he would not wonder so much."

The point is not that the theological pronouncements of scientists are to be discounted but rather that they do sometimes have to be seen as efforts at mediation. What may look like a straightforward affirmation of harmony between Christianity and science may turn out to have been a counter in a dialogue between new and entrenched religious positions. The apologist who extracts the affirmation for his own purposes may overlook the dynamics of the dialogue. In the writings of Galileo, for example, he would find a clear statement of compatibility between Copernican astronomy and Catholic Christianity. In his *Letter to the Grand Duchess Christina* (1615), Galileo argued that the language of the Bible had been ac-

commodated to the minds of the uneducated, with the consequence that texts that superficially implied a stationary earth and a moving sun were not to be treated as literal scientific descriptions. Beneath the surface Scripture had deeper meanings to which a knowledge of nature might help to give access. There was room for both science and religion since the Bible taught how to go to heaven, not how the heavens go. Its jurisdiction was principally on moral and spiritual matters. But this affirmation has to be seen in context. When Galileo wrote his letter, he was already on the defense. There were already rumors that the new astronomy was incompatible with Scripture, and he had already been denounced from the pulpit. Statements of harmony, as with statements of conflict, have to be placed in their context. They may define positions that have often been repeated, but they cannot be given a timeless quality.

The Galileo affair illustrates a further difficulty for the apologetic use of history. In criticizing the conflict thesis, we noted that a misleading sketch of opposition to science can be traced if the sample is confined to religious extremists. Everything depends on where the circle is drawn. But it is possible to draw so tight a circle around an enlightened few that the picture becomes distorted in the opposite direction. There was indeed a range of enlightened opinion within the Roman hierarchy at the time of Galileo's trial; but the trial itself was not averted. The point is that it is not just a case of drawing circles around thinkers whose stance one may happen to approve. To understand the events in question, it is also necessary to consider in whose hands political power was concentrated. It was not always the more enlightened who got their way. Galileo was fighting against a religious bureaucracy, which, through an elaborate mechanism of censorship, sought to control the boundaries of legitimate opinion. As we shall see in Chapter III, the threat from the Protestant churches was an integral part of the political complex.

The use of history to identify a privileged standpoint from which science and religion could always be harmonized runs into trouble for yet another reason. The diversification of the sciences and the theoretical changes within them make it extremely difficult to locate a unique set of principles by which harmony could be guaranteed. Among the physical scientists of the seventeenth century it was achieved by stressing the harmony of the universe itself – a divinely conceived harmony, expressible in mathematical terms, and which, Copernicus had declared, it was the duty of the astronomer to display. By the nineteenth century, however, and especially in the life sciences, the metaphysics that had underpinned the work of Copernicus, Kepler, and Newton had become obstructive. The idea that living organisms had been structured according to a divine plan, transparent to the human mind, still featured in the work of eminent naturalists. It was defended in Britain by Richard Owen and in America by the Harvard professor, Louis Agassiz. Although it was not incompatible with the view that new species had arisen during the earth's long history, it was incompatible with evolutionary theory as conceived by Darwin. Agassiz expressed his sadness that Darwin's theory had so quickly won acclaim, while Darwin could find in Agassiz's idealism nothing but "empty sounds." A metaphysics stressing the invariance of divine ideas created dissonance where it had once created harmony.

The strong claim that some one religious tradition was uniquely propitious for science also has its difficulties. The problem is that, although certain doctrines may have licensed scientific inquiry, others within the same tradition could stifle it. This ambivalence certainly existed in seventeenth-century Christian theology. Although a doctrine of creation could countenance the search for order behind the flux of natural phenomena, the doctrine of Adam's Fall was sometimes used to suppress it. Fears were expressed by puritan divines that to thirst after natural knowledge was to run the risk of elevating reason at the expense of faith. And if human reason had been impaired by the Fall, what guarantee was there that one *could* think God's thoughts after Him? Everything hinged on how such doctrines were formulated. As we saw earlier, Francis Bacon was able to turn the doctrine of the Fall to advantage: Science would help restore that dominion over nature lost to humanity through Adam's sin. In assessing whether a particular doctrine might have encouraged scientific inquiry, such ambivalence must be taken into account. Even the claim that the natural order reflected the contingency of a divine will could pull in two directions. It could be used, as it was by Bacon and Mersenne, to justify an empirical rather than a rationalist approach to nature. But it could also be used to dismiss the claims, even of empiricists, that they knew how nature works. For if God could have made the world work in any number of ways, would it not always

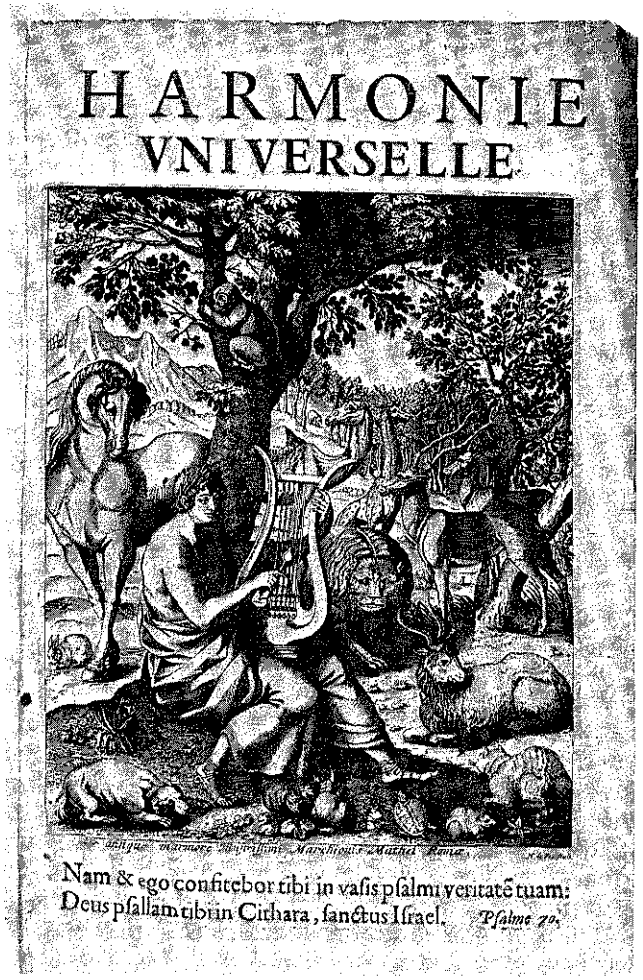

Figure I. 7. Engraved title page from Marin Mersenne's *Harmonie Vniverselle* (1636–7). An intimate relationship between musical harmony and the mathematical representation of physical data was epitomized by the correlation, ascribed to Pythagoras, between string length and pitch. To halve the length of the string, for example, was to raise the pitch by exactly one octave. In the seventeenth century, Mersenne undertook a systematic experimental inquiry, showing that pitch depended on frequency of vibration, which in turn was determined by the length, tension, and thickness of the string. Concepts of universal harmony could be sustained on the basis of verifiable relationships between regular motion and pleasing sounds. Reproduced by courtesy of The Bodleian Library, Oxford; Shelfmark M. 3. 16. Art.

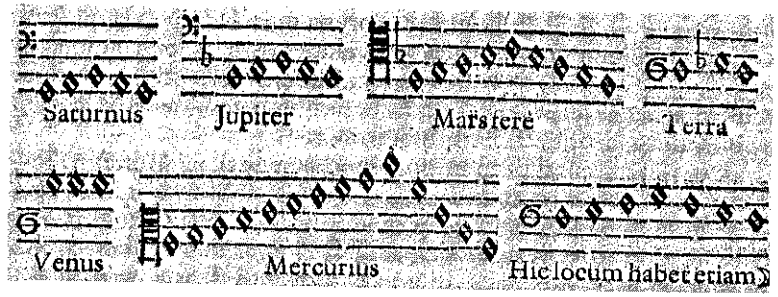

Figure I. 8. Illustration from page 207 of Johannes Kepler's *Harmonices mundi* (1619). In Kepler's construction of the solar system, each planet had its own melodic line associated with a changing speed that increased as it approached its closest point to the sun. The less the variation in speed, the more monotonous the theme. Kepler even conjectured that, by a backward projection from current orbital positions, it might be possible to determine the age of the earth – on the supposition that the most harmonious sound would have corresponded to the original creation. Reproduced by permission of the Syndics of Cambridge University Library.

be presumptuous to pretend that one had actually pinned Him down? That was an objection with which Galileo had to contend.

In revisionist histories constructed for apologetic purposes, it is not usually denied that there were conflicts in the past. But it is often implied that these were the result of particular social and political circumstances. Once these contingencies are removed from the picture, no – or very little – substantive conflict remains. Now, there is no denying that past controversies were rooted in circumstances that were peculiar to the age in which they occurred. But to suggest that the conflict was over political rather than intellectual matters is to introduce a false antithesis. The fact is that ideas about the relationship between science and religion have themselves been weapons in these political confrontations. To explain the intellectual polarities by reference to historical contingencies is not necessarily to explain them away.

The debate over human origins in nineteenth-century Britain provides a helpful example. Historians have correctly pointed out that to understand the kind of exchange that took place between Huxley and Wilberforce it is important to recognize that a major social transformation was taking place in which the clergy were losing their domination of the intellec-

tual life of the nation. One symptom of this was their increasingly marginal involvement in scientific activity – a trend reinforced by the establishment of professional elites within the scientific movement. When the British Association for the Advancement of Science had been founded in the early 1830s, clerics had constituted some thirty percent of its membership. In the period 1831–65 no fewer than forty-one Anglican clergymen had presided over its various sections. Between 1866 and 1900 the number was three. During that latter period, the function of science in British society was increasingly perceived in terms of national prosperity, economic strength, and military security. Formidable writers on science, such as Huxley and Darwin's cousin Francis Galton, still stressed a moral utility for their subject, but the traditional arguments for its religious utility were wearing rather thin.

It would be unwise to interpret the exchange between Wilberforce and Huxley without taking this social transformation into account. Huxley had every reason to bash a bishop. It would be in keeping with his desire to promote the status of the professional scientist and to exclude clerical interference. But because there were social and political reasons for Huxley's aggression, it does not follow that there were no substantive intellectual issues. To suggest that the struggle was not between science and religion but over cultural leadership may expel the conflict through the front door, but it still returns through the back. Earlier in the chapter, reasons were given why the mythology surrounding this event should be questioned. In the words of one historian, the legend was a one-sided effusion from the winning side. But, in such a statement, the fact that were *sides* has crept in round the back. And the apologist who might wish to make Huxley the aggressor should know that one observer, the zoologist Alfred Newton, clearly reported that it was Huxley who had first been chaffed by the bishop.

The purpose of this chapter has been to establish three propositions: that religious beliefs have penetrated scientific discussion on many levels, that to reduce the relationship between science and religion to one of conflict is therefore inadequate, but that to construct a revisionist history for apologetic purposes would be just as problematic. To enhance the standing of a particular religion or religious tradition by making it the mother of science may be short-sighted in at

least two other respects. It may overlook the fact that science could become a very rebellious offspring; and, as an apologetic strategy, it could easily backfire if science (as some believe it has been) were to be devalued in public estimation through association with polluting and exploitative technologies.

Much of the writing on science and religion has been structured by a preoccupation either with conflict or with harmony. It is necessary to transcend these constraints if the interaction, in all its richness and fascination, is to be appreciated. In the following chapter, we shall examine this interaction more closely for the period during which the foundations of modern science were laid.