ROBERT BOYLE AND THE MACHINE METAPHOR[1]

by Michael Ruse

Abstract. The seventeenth-century chemist and philosopher Robert Boyle argued that the world is like a clockwork machine. This led to the problems of the place of a Creator and of how one can explain the directed, "final-cause" nature of organisms. Boyle thought that he could wrap everything up in one neat package, with a clear place for a designing God, but of course the coming of Darwinism casts doubt on this. Nevertheless, Boyle's thinking does have some very interesting implications for the way in which we today should consider the science/religion relationship.

Keywords: Aristotle; Robert Boyle; final cause; machine metaphor; natural theology.

There is a oft-told story that science—real science—started in the sixteenth century.[2] It began in 1543, to be precise, when (on his deathbed) Nicholas Copernicus received his copy of his newly printed work, *De Revolutionibus Orbium Caelestium* (*Of the Revolutions of the Heavenly Spheres*), which put the sun at the center of the universe. Until that point, apparently, the clammy but firm grip of medieval religion had held people's thinking within strict bounds—limits that allowed no attention whatsoever to the evidence from nature and that were mandated entirely by Catholic dogma with occasional glosses from the worst aspects of Greek philosophy. These Medievals thought that the earth was flat and that Christopher Columbus would fall over the edge! There was bitter warfare between science and religion, and new discoveries have had to push back the superstition of Christianity inch by inch. As Charles Darwin's bulldog Thomas Henry Huxley said bitterly, as the infant Hercules left strangled snakes all around his cradle, so science leaves strangled religious doctrines all around the arrival of new theories and hypotheses.

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Copernicus did get the printed version of his great work just before he died, and he did put the sun at the center of the universe, although a helpful Lutheran did suggest (in the Introduction) that the ideas were not intended to be true and that they were all really just an aid to calculation. Moreover, Galileo a hundred years later was forced to recant his heliocentric proposal. After this, though, the direction changed. Students of medieval science have shown that, far from the church being against science, it was the church itself that cherished and promoted and furthered science (Lindberg 1995). No one else could read and write or had the leisure to do science. Copernicus himself, although not ordained, was in minor orders, and in the century before him a cardinal, Nicholas of Cusa (Cusanus), had proposed similar sun-centered views about the universe. Philosophy, Aristotle's particularly, was an important ingredient, but the purpose of reaching back to the ancients was to find a tool to push and refine observation and theory, not to still it. In any case, the new scientists were no less keen on Greek philosophy. Platonic sun-worship—going back to the Pythagoreans—was the chief motivator in the Copernican revolution, at least until people started to get a real hold on some of the new factors, such as the revelations of Galileo's telescope (Kuhn 1957). The story about the flat earth was a nineteenth-century invention; from the beginning of civilization, everybody knew that ships dip below the horizon and that the earth casts its shadow across the moon in a lunar eclipse.

Galileo should not have been made to recant, but modern scholarship is suggesting that the whole story was a lot more complex than popular history would have it. Galileo's troubles were in major part a result of the ins and outs of court intrigue rather than a simple science-religion clash; in any case, the clash could not be simple, for we were now right in the middle of the Counter Reformation, and nobody's moves could just be taken at face value. Even ardent Darwinians are now aware that Huxley's views on anything to do with religion are suspect. Many a scientist trying to get funds for a project has been grateful that the pope gave the other side the Galileo story, a story perfectly adapted to berate the forces of religion and reaction. The present pope is highly pro-science (but what would you expect of the most famous Cracow university faculty member after Copernicus?).

Let us go back to the beginning and try to get things right. After Europe started to emerge from the so-called Dark Ages, one of the greatest stimuli to the renewed advance of scholarship was the glory of Greek thought, especially the glory of Greek philosophical thought: Socrates, Plato, and above all Aristotle. At first, this came somewhat indirectly. There had been no Dark Ages for what we now call the Middle East. For several centuries, there had been a magnificent flowering of civilized thought and action, as the religion of Islam had taken root and grew and produced science, literature, mathematics, painting, architecture, medicine, and much more. The Arabs knew about the Greeks, and it was initially in translation

from Arabic (already taken from Greek) and into Latin that the ancient authorities were encountered by Western scholars. Only later did people turn to their own libraries and discover the originals. (Saint Thomas Aquinas [1225–1274], the greatest of all of the medieval thinkers, knew no Greek.) At first, there was considerable tension about the thinking of these pagan authorities. Aristotle claimed that the universe is eternal, which goes against the Christian belief in a God who creates out of nothing. Aristotle also claimed that the ultimate God—the Unmoved Mover—has no interest in humans but simply spends its time contemplating its own perfections.

But, fairly soon, especially in Aquinas's great synthesis ("Thomism"), it was seen that pagan philosophy and Christian religion could be brought together in one overall satisfying world picture.[3] Aristotle's astronomy is the key. In his system, the universe is huge: 98 million miles across, according to the Arab authorities. Nevertheless, it is finite, a sphere beyond which there is nothing—not space, but nothing. The earth is another sphere, an inner sphere at the center of the outer universe sphere—a position pretty attractive to anyone whose religion is rooted in what Thomas Carlyle called "Jewish old clothes," that is, humans as made in the image of God and the earth here for their habitat and enjoyment and stewardship. On the outer sphere are the stars, whizzing around every day—the earth holding still and the stars moving in uniform motion. The big question is about the sun, the moon, and the moving stars, or what we call the planets. Relative to the stars, these bodies move in circles of their own—in compounded circles from our perspective. The big problem was that planets occasionally loop the loop (they "retrogress"): occasionally they stop their forward motion and go backward for a while before they again move forward. Antiquity offered two solutions. One (favored by professional astronomers and suggested by Apollonius and Hipparchus) was the system of epicyles and deferents, in which the sun, the moon, and the planets go around in circles (the perfect figure) at uniform motion, but in the case of the planets they go on subcircles (epicycles), with the centers of the subcircles being points going at uniform motion on the main circles (deferents). From the earth, this would give the illusion of retrogression. The other solution, proposed by Eudoxus and favored by Aristotle, has the sun, moon, and planets embedded in concentric crystalline spheres, arranged within the outer stellar sphere like an onion or an artichoke, with the inner spheres spinning around different axes. This too would give the illusion of retrogression.

Both systems had virtues, and both had faults. The advantage of the system of epicyles and deferents was that it could explain why the planets are bright when they retrogress. They are closer to the earth at such times. The drawback of the homocentric-spheres theory is that it cannot explain such brightness, for the planets are always at a fixed distance from the earth (and were supposed perfect and hence unchanging). The advantage

of the homocentric-sphere theory is that it explains how things work: the spheres keep everything in place and spin uniformly. The drawback of the epicyles-and-deferents theory is that there seems no reason for the planets to keep moving as they do. The cause is mysterious, and hence even those who used the theory tended to be instrumentalists (in a fashion akin to Copernicus's Protestant prefacer) and regarded the theory simply as a tool or instrument for making calculations and predictions, without true ontological reference. As it happens, Aristotle adopted Eudoxus's homocentric-sphere theory, for that was the one around in his day, but in any case it fit into his thinking about causes, always a major element in the Greek thinker's system. Aristotle, who incidentally had been a practicing biologist as well as a philosopher, regarded the universe as if it were a giant vegetable, with things happening not just for prior causes but also with respect to ends. It is a kind of living being, and one must think about things developing and moving into their right places in the right ways.

In fact, Aristotle distinguished four kinds of causes (Hankinson 1995). Suppose, for instance, we decided to fund a statue of *Zygon*'s editor that would stand on the dock at Star Island[4] and greet conferees. There would be the *efficient* cause, the sculptor actually chiseling the Hefner features out of marble. There would be the *formal* cause, the Hefner figure itself that was being copied. There would be the *material* cause, the marble from which the statue was being made. And there would be the *final* cause, the reason for the statue—to focus the minds of conferees and to impress on them that ahead lies a week of serious thought and reflection, and no idle holiday. In practice, when it came to actual science, Aristotle tended to leave final causes to the sphere of the biological—it makes sense to ask the purpose of the eye but not of a stone on the seashore. In an overall sense, one could almost say that final cause is the most important, for it is this that gives understanding of the way that the world works and of how the earth relates to the heavens above. From the moon on out, the heavens move uniformly, without change—perfect. From the moon down, things are in a constant state of becoming rather than being, of change and growth and decay, never still and never final. The outer motions (that is, of the innermost crystal sphere) keep things churning on earth, and nothing can be settled. Why then do things not simply keep churning until all is one uniform homogenous paste? It is because of the four elements—earth, fire, air, and water. These have their natural places and an end-directed tendency to move to them. Earth moves to the center, water above it, then air, and finally fire. This division (which of course was not new to Aristotle) is not purely a priori—anything but. Stones do fall to the ground. Smoke does rise. Bubbles go up in water, and rain falls. And note that the four elements and the notion that they have natural places gives the final part of the Aristotelian system, why the earth is at the center and so forth, and yet gives a picture that fits very nicely with the Jewish

story of creation. The earth is not only in the "correct" place in things, right at the center, but physics shows that this is no accident—the Aristotelian god may have no interest in what is going on, but the God of the Jews and of the Christians intended all along that this and precisely this should work as it does because it was designed that way. The world is no chance.

Now, whatever else you might want to say, this has at least as much root in reality—in observation—as a good many theories that we take seriously today. In themselves, are crystalline spheres any more ridiculous than electrons? (I am not saying that we should accept crystalline spheres. I am just saying that in themselves there is no reason to rule them out of science or sneer about the job that they supposedly do.) Moreover, not only could it be made to fit into the Judaeo-Christian picture in the ways indicated above, but it puts up challenges and gives ways of thinking and experimenting as all really good science does. A major problem, for instance, is why the javelin thrown by the warrior or athlete does not at once fall to the ground, in the way that earth supposedly always falls downward. Well before Copernicus and Galileo and the rest of the moderns, people were trying to puzzle out notions of force and energy and momentum and the like.

Having said this, I am not saying or pretending—or, rather, historians of the period would not say or pretend—that all was well with the neo-Aristotelian system or that the change marked by Copernicus was wrong or irrational. With the mention of Platonism above, I have indicated that there was more to things than just facts and observation, but increasingly it was clear that heliocentrism did have major advantages. For a start, the long-recognized division of the planets into inferior—Mercury and Venus that always stay close to the sun—and superior—Mars, Jupiter, and Saturn that roam the heavens and only retrogress when they are on the other side of the heavens (in "opposition")—works and is not just an unexplained fact of nature. The inferior planets are closer to the sun than the earth, and the superior planets are farther away. And when people like Tycho Brahe and Johannes Kepler got to work, the advantages of the new way of thinking started looking stronger and stronger (though not at once overwhelming: Tycho did not think the sun at the center but rather the earth, and then in a kind of hybrid fashion, with the sun going around the earth and the planets going around the sun. This, of course, made a complete mess of the crystalline-sphere theory.)

The real problem with Galileo, apart from the fact that he put things into the vernacular (Italian in his case) and so made his ideas available to the *hoi polloi* (common person) and then presented the Aristotelians as total morons, was that with his telescope he messed up the nice division between the perfect unchanging heavens and the imperfect changing earth (Westfall 1971). Mountains on the moon, spots on the sun, and moons

around Jupiter started to make the heavens look just as rough and ready as the earth. And this was only the tip of the iceberg. Thanks to Copernicus himself, no longer do we have a nice, tight universe (well, tight if you can call 98 million miles tight), but we have something that is vast: the absence of stellar parallax meant that the universe had to be at least 400,000 times as big as previous estimates. Even before Galileo, people like Thomas Digges in England were making it infinite. No longer do we have the earth at the center, for there is no center, or at least not much of one, and we humans are stuck on a bit of dirt swinging around in space. With Kepler's studies of the planets, circular motion went out of the window. And now we see that there is no difference between our sphere and that above (or below or around) us. Nothing is sacred—literally or rhetorically!

With the new cosmology was coming a new physics, a new mechanics, often at the hands of the same people, notably Galileo. (Not that Galileo did not have his conservative elements: he never accepted Kepler's devastating destruction of heavenly circular motion.) Atomism started to gain ground, for all that it (being another idea of the ancients) had all sorts of unfortunate connotations of atheism and chance and randomness (Lucretius, the Roman poet author of *De Rerum Natura*, and others had reveled in the pointlessness of creation). Predictive accuracy was put at a premium as scientists (that term is a nineteenth-century creation of William Whewell; in those days they were called "natural philosophers") started to devise ever more careful experiments and ways of measuring phenomena. Also significant was that those sponsoring science grew ever more reliant on the technological applications to which science can be put, and they really cared about results. Relatedly, mathematics became far more sophisticated thanks particularly to the great French philosopher René Descartes, who thought up ways of putting geometry into algebra. Others edged closer to the discovery and use of the calculus.

And then, in the second half of the seventeenth century, the great Cambridge scientist Isaac Newton put it all together, introducing his laws of motion and his force of gravitational attraction and showing how the heavenly motions as described by Kepler and the terrestrial motions as described (especially) by Galileo could be integrated into one overall theory or system (Westfall 1980). There were still some very suspicious elements. The key notion of gravitation presupposed that one can have action at a distance—that one body can affect another body across a space—and this notion seemed to many (Descartes in particular) to be suspiciously mystical. (In fact it was just that, for Newton probably got the idea from alchemy, in which he dabbled, and which enterprise was much given to occult forces of one kind or another.) But, overall, the Newtonian system was a triumph and finally put to end the old Christianized Aristotelian picture of the two-sphere system (stars and earth), with, as I have said, the

basic underlying metaphor of growth or of the universe as a living object. It put an end to the idea of nature as an entity in its own right.

But what metaphor was to go in its place? And where would this leave the God question? If one gave up Aristotle, was one pitched into atheism? Some thought so. Some thought so with horror. Some thought so with pleasure and satisfaction. Whether or not the English philosopher Thomas Hobbes truly belonged to this latter group, many were happy to argue that he did so belong, by intention or otherwise (Westfall 1958). Not a few thinkers in the seventeenth century worked on this problem of an alternative world picture, and they made many and various suggestions. But the one above all who devoted time and energy and skill and status and well-earned position to the issue was Robert Boyle (1627–1691). He is best known to most of us as the author of the gas law: for a fixed mass of gas, pressure is inversely proportional to volume. (In fact, it was probably Boyle's assistant Robert Hooke, himself well known for his spring law, who came up with the gas law, but it was Boyle's laboratory.) Boyle was more than just a chemist, however. Well-born and wealthy (he was the second son of the Earl of Cork, one of the most influential men in Britain before the Civil War), Boyle was not simply a man of great learning and scientific skill and accomplishment but also much concerned with the philosophical underpinnings of his subject. He penned several essays on what we today would call philosophy of science, including the important *A Free Inquiry into the Vulgarly Received Notion of Nature*, a work written mainly in the mid-1660s although not published until 1687, and recently edited by noted Boyle scholars Edward B. Davis and Michael Hunter (Boyle [1687] 1996).

It is in this work that Boyle most openly and in greatest detail announces that the metaphor to substitute for that of Aristotle is that of a machine, a clock or some like artifact—an artifact made by God. Writing against the Aristotelian notion that somehow nature itself has a being and a kind of mind or life force of its own, and making reference to a wonderful clock built between 1571 and 1574 by the Swiss mathematician Cunradus Dasypodius, Boyle responds:

> And those things which the school philosophers ascribe to the agency of nature interposing according to emergencies, I ascribe to the wisdom of God in the first fabric of the universe; which he so admirably contrived that, if he but continue his ordinary and general concourse, there will be no necessity of extraordinary interpositions, which may reduce him to seem as if it were to play after-games—all those exigencies, upon whose account philosophers and physicians seem to have devised what they call nature, being foreseen and provided for in the first fabric of the world; so that mere matter, so ordered, shall in such and such conjunctures of circumstances, do all that philosophers ascribe on such occasions to their omniscient nature, without any knowledge of what it does, or acting otherwise than according to the catholic laws of motion. And methinks the difference between their opinion of God's agency in the world, and that which I would propose, may

be somewhat adumbrated by saying that they seem to imagine the world to be after the nature of a puppet, whose contrivance indeed may be very artificial, but yet is such that almost every particular motion the artificer is fain (by drawing sometimes one wire or string, sometimes another) to guide, and oftentimes overrule, the actions of the engine, whereas, according to us, it is like a rare clock, such as may be that at Strasbourg, where all things are so skilfully contrived that the engine being once set a-moving, all things proceed according to the artificer's first design, and the motions of the little statues that at such hours perform these or those motions do not require (like those of puppets) the peculiar interposing of the artificer or any intelligent agent employed by him, but perform their functions on particular occasions by virtue of the general and primitive contrivance of the whole engine. (Boyle [1687] 1996, 12–13)

Style, I am afraid, is not Boyle's strongest point, but the case being made is clear.

Now, where does God fit into all of this? Start (and end) with one thing: Boyle was God-obsessed. An ardent theist, no one could be more convinced of an all-superintending Creator than he. More than this, Boyle was incredibly pious. "Goodness gracious" was about all you could get from him when he hit his thumb with a hammer. He was a genuine Christian who truly tried to let his actions be guided by his faith and beliefs. So when Boyle argued that God was the Creator of all, the designer of the machine, he was being absolutely genuine; it was not something tacked on to keep the troops or the authorities happy. But was this not halfway to Deism, to an Aristotelian unmoved mover with a vengeance? And is this not the thin end of a very big wedge that leaves open the opportunity of dropping God entirely and producing at least an agnostic's world picture, if not an outrightly atheistic one? Do we not have an all-too-easy slide from Boyle yesterday to Richard Dawkins today? Certainly, if you look at things with the advantage of hindsight, there is something to this. Take soul out of the universe and substitute an unfeeling machine, and you are indeed on the way to a godless creation. Let me emphasize that this was absolutely not Boyle's position. He was as much against Deism as he was against Aristotelianism. He thought that God creates the universe and then holds it always in his hands. If God quits at any moment, everything collapses. For this reason, Boyle was untroubled by miracles; God can (or did) do these just as he pleases, because he is involved all of the time.

The trouble begins, of course, when you start to find that that which you thought was miraculous is in fact something that obeys the rule of law, a possibility that Boyle fully recognized, even though he thought it a point in his favor and against the Aristotelians.

And when I consider how many things that seem anomalies to us do frequently enough happen in the world, I think it is more consonant to the respect we owe to divine providence to conceive that, as God is a most free as well as a most wise agent, and may in many things have ends unknown to us, he very well foresaw and thought it fit that such seeming anomalies should come to pass, since he made them (as is evident in the eclipses of the sun and moon) the genuine consequences

> of the order he was pleased to settle in the world, by whose laws the grand agents in the universe were empowered and determined to act according to the respective natures he had given them; and the course of things was allowed to run on, though that would infer the happening of seeming anomalies and things really repugnant to the good or welfare of divers particular portions of the universe. (Boyle [1687] 1996, 13)

All of this is no doubt true, but the fact is that, as the need for a God of miracles recedes, the need for a God at all recedes. The world is a clockwork and leave it at that.

Are we not forgetting one very important point? Boyle would say so. A machine has to have a machine maker. The Strasbourg clock did not just appear by chance. No more does the universe. I have pointed out that the Aristotelian world is inherently end-directed—"teleological," as we would say today. Is Boyle's world any less end-directed or teleological? A hundred years later Archdeacon Paley (1802) said so. Clocks imply clockmakers, worlds imply world makers. It is as simple as that. Even if you kick God out of the world, he is still around as the great Designer in the sky. Actually, of course, you are back at Deism, unless you flesh things out with a bit of revelation, which Boyle would have been happy to do. But let us leave that aside. The question is whether the machine truly implies a machine maker. All analogies or metaphors are different from that on which they are based, else they would be literal. My love is not really a rose, and my honest face is not really an open book. Could it not be that, to use Dawkins's (1986) memorable phrase, we have a "blind watchmaker" situation? a machine without a machine maker? Is that even a possibility?

Aristotle, with his insistence on final causes, would have said no. But did not even he, with his reluctance to use final-cause analysis for the nonliving (there is no discussion of them in the whole treatise on meteorology) open the way for an alternative answer? There were some in the seventeenth century who would have thought so. One was the influential theoretician of science Francis Bacon (1915). He likened final-cause thinking to the Roman vestal virgins—decorative but sterile! Another was Descartes, who did not so much deny the possibility of final causes as our ever being able to tell what they are. How can we presume to know God's intentions? If not a machine without a machine maker, then at least a machine without yielding the slightest clue about the intention or nature of the machine maker. "When dealing with natural things, we will, then, never derive any explanations from the purposes which God or nature may have had in view when creating them <and we shall entirely banish from our philosophy the search for final causes>. For we should not be so arrogant as to suppose that we can share in God's plans." Stick rather to efficient causes, "starting from the divine attributes which by God's will we have some knowledge of, we shall see, with the aid of our God-given natural light, what conclusions should be drawn concerning those effects which

are apparent to our senses."[5] For all the God-talk, if this is not metaphysical atheism, it is pretty close to methodological atheism.

Boyle would have none of this. He thought it ridiculous to pretend that there are no final causes, when it comes to organisms particularly, or that we cannot ever know the nature of these final causes, that is, what God's intentions are. If the eye is not made for seeing, then absolutely nothing makes sense. Against the Frenchman and his followers ("Cartesians"), it is a positive moral obligation to study nature and to work out its adaptations. As Boyle wrote in another of his essays, *A Disquisition about the Final Causes of Natural Things*,

> For there are some things in nature so curiously contrived, and so exquisitely fitted for certain operations and uses, that it seems little less than blindness in him, that acknowledges, with the Cartesians, a most wise Author of things, not to conclude, that, though they may have been designed for other (and perhaps higher) uses, yet they were designed for this use. As he, that sees the admirable fabric of the coats, humours, and muscles of the eyes, and how excellently all the parts are adapted to the making up of an organ of vision, can scarce forbear to believe, that the Author of nature intended it should serve the animal to which it belongs, to see with. (Boyle [1688] 1966)

Boyle continued that supposing that "a man's eyes were made by chance, argues, that they need have no relation to a designing agent; and the use, that a man makes of them, may be either causal to, or at least may be an effect of his knowledge, not of nature's." But not only does this take us away from the urge to dissect and to understand—how the eye "is as exquisitely fitted to be an organ of sight, as the best artificer in the world could have framed a little engine, purposely and mainly designed for the use of seeing"—but it takes us away from the designing intelligence behind it (Boyle [1688] 1966, 397–98).

Boyle did not see his position as threatening to the mechanical position but as complementing it. Moreover, one should see that he distinguished between acknowledging the use of final causes *qua* science and the inference *qua* theology from final causes to a designing God. First: "In the bodies of animals it is oftentimes allowable for a naturalist, from the manifest and apposite uses of the parts, to collect some of the particular ends, to which nature destinated them. And in some cases we may, from the known natures, as well as from the structure, of the parts, ground probable conjectures (both affirmative and negative) about the particular offices of the parts" ([1688] 1966, 424). Then, the science finished, one can switch to theology: "It is rational, from the manifest fitness of some things to cosmical or animal ends or uses, to infer, that they were framed or ordained in reference thereunto by an intelligent and designing agent" (p. 428). To complexity (what Boyle would call "contrivance") in the realm of science, and then to design in the realm of theology.[6]

This approach laid the way open for others (especially those concerned directly with the living world) to give full rein to their thinking and imagi-

nation, tying in their discoveries in the living world with God's intentions, and conversely using God's careful plan and execution as a heuristic to understand the living world in ever greater detail. Prime among these was the clergyman-naturalist John Ray (1628–1705), especially in his *Wisdom of God, Manifested in the Words of Creation* ([1691] 1709). First, an argument to adaptive complexity was stated unambiguously. "Whatever is natural, beheld through [the microscope] appears exquisitely formed, and adorned with all imaginable Elegancy and Beauty. There are such inimitable gildings in the smallest Seeds of Plants, but especially in the parts of Animals, in the Lead or Eye of a small Fry; Such accuracy, Order and Symmetry in the frame of the most minute Creatures, a Louse, for example, or a Mite, as no man were able to conceive without seeming of them." Everything that we humans do and produce is crude and amateurish compared to what we find in nature. Then, second, came the traditional argument to design. The living world was likened to a product of design. A machine implies an architect or an engineer, and, inasmuch as the world of life is machinelike, it too implies a being, as much above us as the world of life is above our artifacts and creations. "There is no greater, at least no more palpable and convincing argument of the Existence of a Deity, than the admirable Art and Wisdom that discovers itself in the Make and Constitution, the Order and Disposition, the Ends and uses of all the parts and members of this stately fabric of Heaven and Earth" (Ray [1691] 1709, 32–33).

This made a neat package, as the teleological way of thought in biology was tied back into the proof of the divine. "That under one skin there should be such infinite variety of parts, variously mingled, hard with soft, fluid with fixt, solid with hollow, those in rest with those in motion: —all these so packed and thrust so close together, that there is no unnecessary vacuity in the whole body, and yet so far from clashing or interfering with one another, or hindering each other's motions, that they do all help and assist mutually on the other, all concur in one general end and design" (Ray [1691] 1709, 335–36). Moreover, this is design of absolutely top quality, and the same must be said of the intelligence behind it. This is the full-blooded Christian God, not some ethereal spirit worshipped by heathen.

Of course, the trouble is that in taking the position that they took, Boyle and those who followed him were rather leading with their chins. They thought they were perfectly safe, as did Paley a century later. There are aspects of the world, of the organic world, that simply cannot be explained without recourse to final causes, and that implies design. There can be no blind watchmaker, no machine without its producer. But what if you find that these aspects of the world *can* be explained without a designer? What if you find that there is no need of a watchmaker? Then, having yourself introduced the metaphor of a machine, you are stuck. You

have laid the way open for a Godless world. You may not have meant to—certainly that was the furthest thing from Boyle's mind, he was not a fifth column for the humanists—but, as history shows, that is precisely the path down which he was leading science. For in 1859, the path led straight to the door of Darwin, who opened it and handed out the *Origin of Species*, which argues that natural selection unaided can produce contrivance-like features, that a blind mechanism can produce that which we have taken to be the definitive mark of design.

And so we come down to the twenty-first century and the crisis that many think is upon us now. Embrace science and you are on the way to methodological naturalism or atheism, and that is but a short step from metaphysical naturalism or atheism. Insist on religion and you must reject science, the most important and successful and powerful phenomenon in modern culture. Go with science and you are into the machine metaphor, and that leads to the end of God and the world picture associated with him. Go with God and you turn your back on the modern world and on the reality that is thrust upon you every time you drive a car or cook a meal or use a computer. You must choose, painful as that will be. The legacy of Boyle is with us today, and its problems cannot be avoided. You go with the cold, comfortless integrity of Dawkins and his fellows, or you slide back into the sticky morass that is the hallmark of so much contemporary writing on the science-religion relationship.

Let me make three concluding remarks about this supposed dilemma, one historical, one philosophical, and one theological. At the historical level, note that the events that have been described, and Boyle's participation in them in particular, bear little relation to the traditional picture of a desperate battle between science and religion. Anything but. Boyle and his fellow thinkers in the seventeenth century wanted to overthrow the Aristotelian world picture—the Aristotelian paradigm, if you will—and to replace it with a world picture of their own that was more in tune with the new science that was developing so rapidly. They were moving from the metaphor of the world as an organism to the metaphor of the world as a machine. They were doing this not as part of a programme to overthrow God or to promote atheism but because the old way of doing things was no longer adequate. They needed a whole new way of seeing and thinking about issues. They thought fervently that, far from overthrowing God, they were opening up a whole new and better way of relating God and creation. (The argument from design was obviously not new—it was in fact one of Aquinas's five ways and historically goes back at least to Plato—but the new significance *qua* science now had a much bigger and more vital role.) History shows that the new metaphor was going to lead, if not to disaster, then (after Darwin) to God-and-the-world problems that Boyle and fellows did not anticipate and would not have welcomed. And, logically, the history does not deny the dilemma posed at the end of the last

paragraph. But it does suggest that we should not look to find in the past (that is, at the time of the introduction of the machine metaphor) actual arguments whose intention was to put science and religion apart. The consequences of the metaphor might put science and religion apart, but there was no conscious design to do this. Hence, although we may (perhaps legitimately) be reading a separation into the metaphor, remember that it is our reading rather than something that was there, objectively, from the first. Those who introduced the metaphor would not share our interpretation. At the least, therefore, we might want to look again at our understanding and see if our conclusions are as written in stone as that new statue on the dock of Star Island.

Second, philosophically, without at all detracting from the historical issues just discussed, I maintain that if you accept Darwinism—at least, if you accept a purely naturalist theory of evolution—Richard Dawkins does have a point. (Not necessarily the point he thinks he has, but an important point nevertheless.) If you go for a God-guided form of evolution—endorsed by many today on the science-religion interface but by absolutely no working evolutionist—then presumably you can keep up a neo-Boyle-type natural theology.[7] Not only does God stand behind the creation, but the creation shows this. At some level, the rational person cannot have the world without supposing the world designer and creator. But if you accept Darwinism—and let me make it very clear that I accept it wholeheartedly—the Boyle position becomes much less compelling. Indeed, I would go so far as to say that you simply cannot argue in a logically compelling fashion from the creation to the creator. Logically, it could all just have been blind law and nothing else. This does not in itself disprove God, but, in a sense, it does make God redundant. (To be fair to Dawkins, his main argument that Darwinism disproves God comes on the different grounds that Darwinism exacerbates the problem of evil. This seems to me a perfectly legitimate argument to make. Whether it does what is needed is another matter, one that I raise and discuss in my *Can a Darwinian be a Christian? The Relationship between Science and Religion* (2001). With respect to this discussion, I will assume that one can adequately answer the evil problem.)

This brings me to the third point, that of theology. Grant that the machine metaphor in itself does not deny God—the Christian God even—but that it makes the God hypothesis no longer compelling as a matter of logic. In Dawkins's language (1986), one can be "an intellectually fulfilled atheist." (I will leave emotional fulfillment out of it.) There are now two questions. First, can one nevertheless be a believer? And second, if one can, is this going to be a position of weakness, a wreck of the religion that one had before Boyle started to be so helpful, or of strength? The answer to the first question is obviously positive. Traditional natural theology may now be out of the window, but the way is opened for what Wolfhart

Pannenberg (1993) called a "theology of nature," in which one responds to nature as a believer, finding not proof in a logical sense but that one's faith is enriched and deepened by one's experience of God's creation. This is a position that long predates post-War German theology. It is to be found even before Darwin, in the writings for instance of the above-mentioned historian and philosopher of science Whewell (1833). After Darwin, it was strongly embraced by (among others) Anglo-Catholic theologian Aubrey Moore (1890), one of the contributors to *Lux Mundi*. Explicitly, Moore saw science—particularly Darwin's science about organic origins—as something that brings God intimately and constantly into the picture, at all times and in all places. "Darwinism appeared, and, under the guise of a foe, did the work of a friend." It shows us that God is either everywhere or nowhere. "We must frankly return to the Christian view of direct Divine agency, the immanence of Divine power from end to end, the belief in a God in Whom not only we, but all things have their being, or we must banish him altogether" (Moore 1890, 268–69).

The second question—position of weakness or position of strength?—is more difficult to answer. I know what the response will be of atheists and fundamentalists, extremists who tend to stand back to back on these sorts of issues. Both Dawkins and Phillip Johnson (author of *Darwin on Trial* [1991]) will say that you are working from a position of weakness, and the fact that neither of them has tracked the moves in systematic theology since the Reformation will perturb neither one. There is a well-established tradition, at least since the writings in the nineteenth century of Søren Kierkegaard and much championed in the twentieth century by the neo-orthodox in the footsteps of Karl Barth, that insists that the way for genuine faith is opened only by the vanquishing of natural theology. So long as you can prove God, faith—real faith that requires the leap into the absurd—cannot function properly. The very point must be that, logically, the world is neutral. Then and only then can you start to respond in the right way to nature—as something that illuminates in the most glorious fashion that which you already believe. Then and only then will the eye and the wing and the scent of the rose show you that life is not meaningless but full of purpose.

In the end, the metaphor of the machine and the work of Robert Boyle open up the way for a new and fulfilling theology. It is not the way that Boyle envisioned, but that is no criticism. We have refined and improved the science that Boyle did, not rejecting it but building on it. Why, then, should we not do the same with his theology?

NOTES

1. This is a discussion review based somewhat loosely on Boyle [1687] 1996.
2. The *loci classici* of this view are Draper 1875 and White 1896, but it seems still to be the background position of most active scientists.
3. The best overall book on the Copernican Revolution is still that of Thomas Kuhn (1957). The illustrations particularly are very helpful in understanding what was going on.
4. Star Island, off the coast of Portsmouth, New Hampshire, is the venue for an annual conference on religion and science.
5. Principle XXVIII, *Principles of Philosophy,* in Descartes [1644] 1955; arrow brackets denote an addition approved by Descartes in the French translation from the original Latin.
6. Just one little thought. While it is excellent to have a new edition of *A Free Inquiry into the Vulgarly Received Notion of Nature*, it is a pity that the editors did not add a new edition of the *Disquisition about the Final Causes of Things*, thereby giving the full range of Boyle's philosophical-cum-theological position.
7. Lest I be thought unduly harsh to the science/religion community, I invite people to look at works like Rolston 1987, Ward 1996, and Barbour 1990, all of whom are trying to find some way to put some meaning into evolutionary process.

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