

# Response to Stephen Hawking's Physics-as-Philosophy

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***Sophia: The Journal of Traditional Studies*, Volume 16, No 2, 2011,  
pp. 5-48.**

*The Grand Design*,<sup>1</sup> to be sure, is not simply another "Physics for the Millions" production, nor is Stephen Hawking, its primary author, just another scientist addressing the public at large. What stands at issue is rather to be seen as the crossing of a threshold, an event comparable, in a way, to the publication of Charles Darwin's *magnum opus* a century and a half ago. There have always been physicists who make it a point, in the name of science, to dispatch the "God-hypothesis"; what confronts us, however, in *The Grand Design* is something more. It is the spectacle of a physics, no less, presuming to explain how the universe itself came to be: "why there is something rather than nothing" as Hawking declares. The answer to this supreme conundrum, we are told, can now be given on rigorous mathematical grounds by physics itself: such is the "breakthrough" the treatise proposes to expound in terms simple enough to fall within the purview of the non-specialist. We need also to remind ourselves that following the demise of Albert Einstein, it is Stephen Hawking who has become, in the public eye, the premiere physicist: the lone figure that personifies the wizardry of mathematical physics as such. Add this fact to the brilliance of the book itself, and one begins to sense the magnitude of its likely impact, the effect upon millions of the claim that *a mathematical physics has trashed the sacred wisdom of mankind!* This contention must not go unanswered. It calls for a definitive response, a rigorous refutation; and such I propose to present in the sequel with the help of Almighty God: the very God whose existence has supposedly been disproved.

The essay is divided into three parts. The first gives an over view of *The Grand Design*, chapter by chapter, setting forth its key conceptions and the overall logic of its argument. The second offers a five-fold refutation, based upon both philosophic and scientific grounds. The third, finally, seeks to place the phenomenon of Hawking's best-seller in perspective by reflecting upon the nature, motivation, and limits of the scientific enterprise as such.

# I

Before embarking upon a critique of Hawking's doctrine, I propose to enunciate not just selected propositions destined to be the targets of criticism, but indeed the central ideas of *The Grand Design*. I propose, moreover, to place these tenets before the reader, not as so many isolated fragments, but so as to exhibit their function in the doctrine as a whole. Lastly, I shall endeavor not to condense this summary to the point where it loses all flavor, but to convey, apart from the bare logic of the text, a sense of its brilliance, its power to enthrall: only thus can one appreciate fully what in fact stands at issue.

We begin with Chapter 1, entitled "The Mystery of Being," which does in fact deal with basic ontological issues. "Traditionally these are questions for philosophy," Hawking,<sup>2</sup> writes, "but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge." (5)<sup>3</sup> Following this opening salvo, Hawking begins to delineate the radical change in the conception of "being"-he means of course *physical* being-implied by the transition from classical to quantum physics. "According to the traditional conception of the universe, objects move on well-defined paths and have definite histories."<sup>4</sup> Not so in quantum theory. Availing himself of the fact that quantum mechanics can be formulated in a number of different ways which turn out to be mathematically equivalent, Hawking chooses the approach pioneered by the American physicist Richard Feynman as best suited to convey his thought. And whereas he postpones his presentation of quantum theory *a la* Feynman till Chapter 4, he forthwith makes a central point: "According to Feynman, a system has not just one history, but every possible history." (6) One sees that Hawking has started to make his case: it begins to appear that the new ontology has indeed left traditional conceptions of "being" far behind.

Noting that things are not "what they seem as perceived by the senses" (7), Hawking announces one of his foundational innovations: the concept of "model-dependent realism," which is "based upon the idea that our brains interpret the input from our sensory organs by making a model of the world." One should add that the full force of what Hawking has in mind becomes apparent in Chapter 3 with the assertion that "There is no picture- or theory-free concept of reality" (42), where also we are told that model-based realism is "the idea that a physical theory or world picture is a model (generally of a mathematical nature) and a set of rules that connect the elements of the model to observations." (43) Getting back to Chapter 1: Following the announcement of this crucial conception, Hawking goes on to

consider the history of human knowing, "from Plato to the classical theory of Newton to modern quantum theories" (7), and proceeds to pose the following question: "Will this sequence eventually reach an end point, an ultimate theory of the universe, that will include all forces and predict every observation we can make, or will we continue forever finding better theories, but never one that can not be improved upon?" Now, it is at this juncture that Hawking breaks with his predecessor, Albert Einstein: there *is no* "ultimate theory" as previously conceived which covers the entire ground, he maintains. What is called for is a radically new kind of theory, something he terms "M-theory," a notion that dovetails with the conception of "model-dependent realism"; as Hawking explains: "M-theory is not a theory in the usual sense. It is a whole family of different theories, each of which is a good description of observations only in some range of physical situations." (8) The ultimate goal of physics—a science, namely, which in principle covers the entire ground and only be realized as an M-theory; and Hawking believes that physics today is closing in upon such a final and all-inclusive formulation.

This brings us to the most amazing claim of all: the notion that such an M-theory constitutes the culmination not only of physics, but of philosophy as well: that it is in fact the only *kind* of theory that can enlighten us regarding "the mystery of being." And what does it reveal? It informs us, first of all, that "ours is not the only universe," that indeed "a great many universes were created out of nothing." But—as if this were not enough!—there is more: the final M-theory, we are told, will in principle reveal all that *can* be known, not only regarding our universe, but indeed regarding *everything*.

The task of the book has now come into view: it can evidently be none other than to lead the reader, step by step, through the formulation of the ultimate M-theory, as far as Hawking can take us at this time.

Chapter 2 deals with "The Rule of Law." It begins with a quotation from Viking mythology concerning wolves that pursue the sun and the moon, the point being that when they catch either one, there is supposedly an eclipse. "Ignorance of nature's ways," Hawking concludes (following several more such examples), "led people in ancient times to invent gods to lord it over every aspect of human life." (17) After informing us that "Our species, *Homo sapiens*, originated in sub-Saharan Africa around 200,000 BC," Hawking proceeds to trace the first rudimentary beginnings of scientific enlightenment: the recognition, however dim and distorted, of "the Rule of Law." The first phase of this human evolution proceeds from Thales of Miletus and Pythagoras to Anaximander, Empedocles, Aristarchus, and Ptolemy; next come the Middle Ages, the Renaissance, and the beginning of the modern age, where *science*, properly so called, comes at last to birth,

thanks to the labors of Kepler, Galileo, and Descartes. There is however no need to summarize this account, which in fact does not differ substantially from the customary expositions. Suffice it to note that "The modern concept of laws of nature emerged in the seventeenth century. Kepler seems to have been the first scientist to understand the term in the sense of modern science." (25) As regards Galileo, not only did he "uncover a great many laws," but he "advocated the important principle that observation is the basis of science, and that the purpose of science is to research the quantitative relationships that exist between physical phenomena." (26) Descartes comes next; and here the account focuses upon the Cartesian conception of "law" and the notion of "trajectories" uniquely determined by their initial conditions. The stage is now set for Newton, whose epochal achievements Hawking barely touches upon at this juncture; they are to be considered later, in their relation to post-Newtonian physics.

True to its title, the chapter is indeed focused upon "the Rule of Law." There are, in particular, three fundamental questions regarding that Rule the author wishes to consider: first, "What is the origin of the laws?"; secondly, "Are there any exceptions to the laws, i.e., miracles?"; and thirdly, "Is there only one set of possible laws?" As the reader may have surmised by now, these are among the issues Hawking proposes to resolve on the basis of M-theory. For the moment, however, his concern is with the second: the question of physical determinism. And on this issue he cites Laplace as the great inaugurator: "The scientific determinism that Laplace formulated is the modern scientist's answer to question two. It is, in fact, the basis of all modern science, and a principle that is important throughout this book." (30). To be precise, the principle affirms that "Given the state of the universe at one time, a complete set of laws fully determines both the future and the past." It is to be noted that there appears to be a conflict between "scientific determinism" as thus conceived and what is commonly referred to as quantum-mechanical "indeterminism," a question Hawking will address in Chapter 4.

But let us continue. No sooner has he formulated the notion of universal determinism than he observes: "Since people live in the universe and interact with other objects in it, scientific determinism must hold for people as well." And to be sure, this means that in reality *there is no such thing as free will.* " As Hawking goes on to explain: "Though we feel that we can choose what we do, understanding of the molecular basis of biology shows that biological processes are governed by the laws of physics and chemistry and therefore are as determined as the orbits of the planets." (32) Indeed, "Recent experiments in neuroscience support the view that it is our physical brain, following the known laws of science, that determines our actions, and

not some agency that exists outside those laws." And of course this implies that there can be no free will: "It is hard to imagine how free will can operate if our behavior is determined by physical law, so it seems that we are no more than biological machines and that free will is just an illusion."

Certainly Hawking admits the impossibility of actually calculating human behavior; but this does not mean that the human organism fails to reduce to a physical system, but simply that it is far too complex a system to be tractable. "Because it is so impractical to use the underlying physical laws to predict human behavior," Hawking goes on, "we adopt what is called an effective theory. In physics an effective theory is a framework created to model certain observed phenomena without describing in detail the underlying processes." So too, in the case of persons, we can speak of "free will" on the level of an effective theory: "The study of our will, and of the behavior that arises from it, is the science of psychology." (33)

In Chapter 3 ("What is Reality?") Hawking explores the scientific implications of model-dependent realism. He begins by contrasting Ptolemaic geocentrism with Copernican heliocentrism, and concludes that "Although it is not uncommon for people to say that Copernicus proved Ptolemy wrong, that is not true." (41) The point is that "one can use either picture as a model of the universe"; it is only that the "the equations of motion are much simpler in the frame of reference in which the sun is at rest." (42) And this brings us to the central premise: "*There is no picture- or theory-independent concept of reality.*" It is to be noted that this seemingly innocuous notion has profound implications; for it means that a scientific theory is not a description of an independently-existing reality (as scientists and laymen alike had thought), but a "model" that *defines* reality. According to model-dependent realism, the concept of a *model-independent* reality proves to be vacuous. What happens now if different models agree with the corresponding observations? "If there are two models that both agree with observation," Hawking maintains, "then one cannot say that one is more real than another." (46) In effect, one can identify the two model-dependent realities, even as we habitually identify two views of a solid object corresponding to different points of observation.

To the question why the classical (or "model-independent") realism was abandoned Hawking gives an answer based upon quantum theory: "Though [classical] realism may be a tempting viewpoint, as we'll see later, what we know about modern physics makes it a difficult one to defend. For example, according to the principles of quantum theory, which is an accurate description of nature, a particle has neither a definite position nor a definite velocity unless and until those quantities are measured by an observer." (44)

Yet Hawking does not rest content with a new philosophy of physics, but affirms that the idea of model-dependent realism applies also, as we have seen (in reference to Chapter I), to pre-scientific ways of knowing, inclusive of sense perception: "Model-dependent realism," he reiterates, "applies not only to scientific models but also to the conscious and subconscious mental models we all create in order to interpret and understand the every day world." (46) And he goes on to emphasize: "There is no way to remove the observer-us-from our perception of the world, which is created through our sensory processing, and through the way we think and reason." He then speaks of perception, of the signals sent along the optic nerve to the brain, and the processing that takes place within that organ, for example, the construction of a third dimension not given in the retinal image: "The brain, in other words, builds a mental picture or model... This shows that what one means when one says 'I see a chair' is merely that one has used light scattered by the chair to build a mental image or model of the chair." (47)

Next Hawking addresses the likely question whether "things" - for instance, tables - "exist" when they are not perceived. And his solution is simple: "The model in which the table stays put is much simpler, and agrees with observation. That is all one can ask." The same logic applies to fundamental particles, which cannot be perceived, but yet can be "observed": electrons, for example, "exist" even before they affect an instrument of detection (such as a television screen). The case of quarks (believed to be the components out of which protons, neutrons and pi-mesons are formed) is a bit more complicated, because "individual" quarks cannot be observed; but logically the case stands the same: the model in which quarks exist "is much simpler, and agrees with observation. This is all one can ask."

Although some models have greater explanatory power than others, Hawking insists that they cannot be said to be more "real" (51), presumably because it makes no sense to quantify or otherwise "rank" model-dependent realities. He thus compares the Biblical account of cosmogenesis with big bang cosmogony, which "explains the fossil and radioactive records and the fact that we receive light from galaxies millions of light-years from us," and is consequently "more useful than the first." Yet, even so, "neither model can be said to be more real than the other."

At this point one senses the need for criteria which enable one to rank theories, to determine how "good" a model is; and we will mention, in passing, that Hawking gives four: i.e., whether a theory "is elegant," whether it "contains few arbitrary or adjustable elements," whether it "agrees with and explains all existing observations," and whether it "makes

detailed predictions about future observations that can disprove or falsify the model if they are not borne out.”

This brings us finally to the crucial notion of “dualities” which Hawking introduces near the end of the chapter. He cites the example of “wave-particle duality”: the fact that light, for instance, can be described or “modeled” in both wave and particle terms. “Dualities like this—situations in which two very different theories accurately describe the same phenomenon—are consistent with model-dependent realism.” (58) The point proves to be decisive for the following reason: “There seems to be no single mathematical model or theory that can describe every aspect of the universe. Instead, as mentioned in the opening chapter, there seems to be the network of theories called M-theory ... Wherever their ranges overlap, the various theories in the network agree, so they can be said to be parts of the same theory... Though this situation does not fulfill the traditional physicist’s dream of a single unified theory, it is acceptable within the framework of model-dependent realism.”

Chapter 4 (“Alternative Histories”) begins with a description of the famous “double-slit” experiment, which according to Richard Feynman “contains all the mystery of quantum mechanics.” The idea goes back to an experiment performed in the nineteenth century by Thomas Young, in which light was passed through a screen with two slits to a surface behind the screen. This gave rise, not simply to a single bright line behind each slit, but to a pattern of bright and dark regions, of multiple “lines.” There is however no mystery here: given that light consists of waves (as most scientists had surmised from the start), these “lines” are simply the pattern resulting from the fact that when two waves are superposed, the resultant amplitude attains a maximum whenever “crest meets crest,” and a minimum when “crest meets trough.” What has astounded physicists, on the other hand, is that the same happens when the experiment is conducted with particles instead of waves.<sup>5</sup> What is critical is the *size* of the particles: the effect ceases to be measurable with particles large enough to be perceptible.<sup>6</sup> What is perhaps most baffling of all is that the effect persists even if the particles in question are passed through the slit “one at a time”: one finds that so long as both slits are open, the interference pattern remains. In some mysterious way an electron, say, passing through slit A, “knows” whether slit B is open or closed. This alone makes it clear that, on an atomic or subatomic scale, the conceptions and laws of classical physics break down: and that is where quantum theory comes into play, a physics which does in certain ways treat particles as waves.

Following this fundamental recognition, Hawking goes on to expound the basic ideas that differentiate quantum physics from Newtonian mechanics, beginning with the Heisenberg "uncertainty principle," which affirms that certain pairs of variables, such as the position and velocity of a particle, cannot be measured with perfect accuracy: the more precisely we know one of these variables, the greater will be the "uncertainty" pertaining to the other.

In fact, according to quantum theory, an electron, say, *does not have* simultaneously a precise position and velocity: observables remain somehow diffuse or "ghostlike" unless an act of measurement limits their dispersion. One sees that Heisenberg uncertainty entails the breakdown of the classical determinism; as Hawking informs us, "the outcome of physical processes cannot be predicted with certainty because they are not *determined* with certainty." (72) Nature "does not dictate the outcome of any process or experiment, even in the simplest of situations. Rather, it allows a number of different eventualities to be realized, each with a certain likelihood of being realized."<sup>7</sup>

One is struck by the fact that this admission seems to contradict the Laplacian principle of scientific determinism, enunciated in Chapter 2 as "the basis of modern science" (30), which asserts that "given the state of the universe at one time, a complete set of laws *fully determines* <sup>8</sup> both the future and the past"! Not so, Hawking maintains: "Quantum theory might seem to undermine the idea that nature is governed by laws, but that is not the case. Instead it leads us to accept a new form of determinism: Given the state of a system at some time, the laws of nature determine the probabilities of various futures and pasts rather than determining the future and past with certainty." For most scientists, admittedly, this was an unwelcome admission, and only in the face of incontrovertible evidence did they eventually accede to it: Laplace notwithstanding, there *is* finally no "complete set of laws" that "*fully determines* <sup>8</sup> both the future and the past."

Despite the probabilistic nature of quantum mechanical predictions, however, its claims can be rigorously tested, which is to say that probability distributions can be observed by statistical means. Quantum theory is still physics: a rigorous science which gives rise to quantitative predictions that can be verified or falsified by experiment; and as Hawking points out: "It has never failed a test, and it has been tested more than any other theory of science." (74) He goes on to point out that the probabilities of quantum theory are of a kind unknown in everyday life. The toss of a coin, for example, gives rise to a probability distribution, not because it is intrinsically indeterminate, but simply because we cannot control the parameters



descriptive of the toss with sufficient accuracy to determine the resultant trajectory."Probabilities in quantum theories," however, "are different. They reflect a fundamental randomness in nature." What stands at issue has puzzled the greatest physicists-and especially the greatest, one might add-from Albert Einstein to Richard Feynman, who brooded over this "fundamental randomness" for years, and was lead finally to observe: "I think I can safely say that nobody understands quantum mechanics."

Hawking turns now to a formulation of quantum mechanics introduced by Feynman in the 40's, which "has proved more useful than the original one." (76) It is based upon an exceedingly bold idea, the kind only a scientific genius of first rank can successfully bring into play. Consider the double slit experiment, carried out with particles of some kind. One knows from quantum theory that a particle has no definite position between the moment it embarks upon its path and the moment it is detected at the second screen. But instead of interpreting this to mean that particles "take *no* path as they travel between the source and the screen," Feynman realized that it could mean instead that "particles take *every* possible path connecting those points." Herein, he felt, lies the secret of quantum theory: "This, Feynman asserted, is what makes quantum physics different from Newtonian physics." (75) And since "Feynman's view of quantum reality is crucial in understanding the theories we will soon present," Hawking makes it a point to give us "a feeling for how it works." (77)

Consider the double-slit experiment. To determine the probability amplitude for a particle at a point A on the second screen, we need to add the contribution to that amplitude for every path from the source 0 to A. Now, what matters is the phase contributed by any given trajectory (for example, whether the corresponding wave has a crest or a trough at A), and what renders this calculable is the fact that for all but special paths, the contributions from nearby paths cancel.<sup>9</sup> These ideas, however, carry over from the case of the double-slit experiment to the general case of a particle moving from one point to another: "Feynman's mathematical prescription ... showed that when you add together the waves from all the paths you get the 'probability amplitude' that the particle, starting at A, will reach B." The same holds true, moreover, for an arbitrary physical system composed of any number of particles: "Feynman showed that, for a general system, the probability of any observation is constructed from all the possible histories that could have led to that observation. Because of that his method is called the 'sum over histories' or 'alternative histories' formulation of quantum physics." (82)

Having thus introduced the reader to Feynman's version of quantum theory, based upon the notion of "alternative histories," Hawking touches upon another "strange" feature of the new physics, the fact that "the (unobserved) past, like the future, is indefinite and exists only as a spectrum of possibilities. The universe, according to quantum physics, has no single past, no history." And this implies (what is perhaps the weirdest fact of all) "that observations you make on a system in the present affect its past. "Such so-called "delayed choice" experiments can be carried out, for example, in the case of the double-slit scenario. But Hawking is mainly concerned to pursue the notion of "delayed choice" to its ultimate conclusion: "We will see that, like a particle, the universe doesn't have just a single history, but every possible history, each with its own probability; and our observations of its current state affect its past and determine the different histories of the universe, just as the observations of the particles in the double-slit experiment affect the particle's past." (83)

Chapter 5 ("The Theory of Everything") commences with an overview of post-Newtonian classical physics, beginning with the discovery of the electromagnetic field culminating in the field equations of James Clerk Maxwell. All manner of electromagnetic waves, from X-rays to visible light to radio waves, could now be described with unprecedented accuracy. A fundamental difficulty, however, presented itself: it was assumed that the electromagnetic field presupposed a medium permeating all space, the so-called ether, a tenet which has scientific implications: "If the ether existed, there would be an absolute standard of rest ... and hence an absolute way of defining motion as well. The ether would provide a preferred frame of reference throughout the entire universe, against which any object's speed could be measured." (93) In conjunction with the Galilean hypothesis of a stationary sun, around which the earth revolves with an orbital velocity  $v$  (relative to the ether), one is led to ask whether it may be possible to measure  $v$ . In 1887, moreover, Albert Michelson and Edward Morley did in fact conduct such an experiment, based upon the following idea: if  $c$  designates the velocity of light (relative to the ether), then its velocity relative to the earth should be  $c-v$  for a light beam moving in the same direction as the earth, and  $c+v$  when it moves in the opposite direction. However, to the consternation of the scientific community, the experiment disclosed that the two relative velocities are in fact equal.<sup>10</sup>

At this critical juncture Hawking proceeds to delineate the basic conceptions of Einsteinian relativity, beginning with the special theory (published in 1905), which resolves the aforesaid impasse by stipulating that the velocity of light is one and the same in every so-called inertial frame of reference. This leads mathematically to the notion of a 4-

dimensional space-time continuum, and to a corresponding modification of the Newtonian equations. The special theory was then extended (in 1917) to arbitrary frames of reference in what has come to be called the general theory of relativity, which is based upon the revolutionary idea that gravitational fields can be explained *geometrically* as resulting from a "curvature," not of the now discarded 3-dimensional space, but of the 4-dimensional space-time, precisely. In brief but intuitively comprehensible terms Hawking pilots us through this development, an exposition which concludes with the claim that Einsteinian relativity (inclusive of the general theory) has meanwhile been verified by an array of experiments, ranging from measurements by atomic clocks mounted on airplanes circling the earth, to data derived from GPS satellites said to detect "gravitational" effects. "Modern technology," Hawking tells us, "is sensitive enough to allow us to perform many sensitive tests of general relativity, and it has passed every one." (102)

Hawking's vision of physics, however, differs radically from that of Einstein; like the Maxwellian theory which it has replaced, Einsteinian physics itself is not the last word: "Though they both revolutionized physics, Maxwell's theory of electromagnetism and Einstein's theory of gravity-general relativity-are both, like Newton's own physics, classical theories. That is, they are models in which the universe has a single history. As we saw in the last chapter, at the atomic and subatomic levels these models do not agree with observation." (103) What is needed, Hawking contends, is a quantum theory which embraces not only Newtonian mechanics, but the electromagnetic theory of Maxwell and Einstein's gravitational theory as well. To be precise, there are four basic forces of nature: gravity, electromagnetism, and the so called weak and strong nuclear force. Now, quantum mechanics as originally conceived (around 1925) was essentially a theory of matter: of mass particles, that is, such as protons, neutrons and electrons. What is now called for, to complete the picture, is a quantum theory in which not only matter but also force fields are "quantized," that is to say, treated from a quantum theoretic point of view. This is where the so-called quantum field theories enter the picture; as Hawking explains, "in quantum field theories the force fields are pictured as being made of various elementary particles called bosons, which are force-carrying particles that fly back and forth between matter particles, transmitting the forces. The matter particles are called fermions." (104)

The first field to be successfully quantized was the electromagnetic, resulting in quantum electrodynamics or QED, a theory evolved in the 40's with Feynman in the lead. The first boson, thus, to be discovered, was the photon: "According to QED all the interactions between charged particles-

particles that feel the electromagnetic force—are described in terms of an exchange of photons.” (105) And one might add that QED ranks among the most spectacularly accurate physical theories yet devised.

Before proceeding to the next feat of field quantization, Hawking touches upon two brilliant conceptions, both introduced by Feynman, that render such quantization possible. The first pertains to the so-called “Feynman diagrams” which enable one to calculate the aforesaid “integrals over histories” entering into the formalism of quantum field theories, diagrams which Hawking regards as “one of the most important tools of modern physics.” A second hurdle that needed to be overcome was the daunting fact that “When you add the contributions from the infinite numbers of different histories, you get an infinite result.” (107) And this is where another of Feynman’s master-strokes comes into play: to deal with this fundamental difficulty, he invented a mathematical procedure termed “renormalization.” The process involves “subtracting quantities that are defined to be infinite and negative in such a way that, with careful mathematical accounting, the sum of the negative infinite values and the positive infinite values that arise in the theory cancel out, leaving a small remainder, the finite observed values of mass and charge.”

As Hawking points out, it was this breakthrough, achieved in QED, that encouraged physicists to attempt the quantization of other fields. It eventually became apparent, however, that to this end these fields had to be somehow unified: one began to surmise that “the division of natural forces into four classes is probably artificial and a consequence of our lack of understanding.” (109) And thus began the search for “a theory of everything that will unify the four classes into a single law that is compatible with quantum theory.” A first breakthrough in that regard was achieved in 1967, when Abdus Salam and Steven Weinberg “each independently proposed a theory in which electromagnetism was unified with the weak force, and found that the unification cured the plague of infinities. The unified force is called the electroweak force. Its theory could be renormalized, and it predicted three new particles,  $W^+$ ,  $w^-$ , and  $Z^0$ .” The search for these particles was now on at major nuclear research facilities, and by 1983 all three were found to exist.

Next came the strong nuclear force. “The strong force can be renormalized on its own in a theory called QCD, or quantum chromodynamics. According to QCD, the proton, the neutron, and many other elementary particles of matter are made of quarks, which have a remarkable property that physicists have come to call “color.” This curious nomenclature (which obviously must not be taken literally) serves to label the three kinds of

quarks predicted by the theory: they are characterized as "red, green, and blue." The next step towards unification consisted in the formulation of so called grand unified theories or GUT's, which attempted to unify the strong and electroweak forces; but these attempts have proved unsuccessful: in consequence of adverse observational evidence "most physicists adopted an ad hoc theory called the standard model, which comprises the unified theory of the electroweak forces and QCD as a theory of the strong force... The standard model is very successful and agrees with all current observational evidence, but it is ultimately unsatisfactory because, apart from not unifying the electroweak and strong forces, it does not include gravity." (112)

It is here, in its encounter with gravity, that quantum field theory runs into its greatest obstacle. In consequence of Heisenberg uncertainty the gravitational field cannot maintain its state of minimum energy, called the vacuum, without "what are called quantum jitters, or vacuum fluctuations-particles and fields quivering in and out of existence." (113) These phantom particles, which occur in pairs, are called "virtual," and despite the fact that they cannot be directly observed, their effects upon electron orbits, though exceedingly small, "can be measured, and agree with theoretical predictions to a remarkable degree of accuracy." There is however a major problem, which is that "the virtual particles have energy, and because there are an infinite number of virtual pairs, they would have an infinite amount of energy. According to general relativity, this means that they would curve the universe to an infinitely small size, which obviously does not happen!"

It is this impasse that has prompted another major conceptual leap, perhaps the most gigantic of all. The new theory, proposed in 1976, is termed supergravity, a designation in which the prefix refers to "a kind of symmetry the theory possesses, called super symmetry," which implies that "force and matter particles, and hence force and matter, are really just two facets of the same thing.

Practically speaking, that means that each matter particle, such as a quark, ought to have a partner particle that is a force particle, and each force particle, such as a photon, ought to have a partner particle that is a matter particle." (114) The problem is that as yet "no such partner particles have been observed" (115), due perhaps to the fact that these particles are supposed to be about a thousand times heavier than the proton; "but there is hope that such particles will eventually be created in the large Hadron Collider in Geneva." It happens, moreover, that the idea of supersymmetry antedates the theory of supergravity, having originated in the so-called string or "superstring" theories. What is most striking in this entire con

glomerate of theories is the fact that supersymmetry requires at least ten space-time dimensions "in place of the usual four": how, then, does one get from ten or more to four? "In string theory the extra dimensions are curled up into what is called the internal space, as opposed to the three-dimensional we experience in ordinary life. As we'll see, these internal states are not just hidden dimensions swept under the rug—they have important physical significance." (116) What is likewise of major importance is the fact that "string theorists are now convinced that string theories and supergravity are just different approximations to a more fundamental theory, each valid in different situations"; and as might now be expected, "that more fundamental theory is called M-theory..." (117) It is here, precisely, that Hawking proposes his radical innovation: "It could be," he tells us, "that the physicist's traditional expectation of a single theory of nature is untenable, and there exists no single formulation." His point is that a family of theories or "models" which "agree in their predictions whenever they overlap" could do just as well. Hawking admits that we do not yet know for certain whether M-theory might not in the end turn out to be "classical," although he evidently regards this as unlikely. In any case, we do know certain facts: "First, M-theory has eleven dimensions, not ten." In addition, one knows that "M-theory can contain not only strings but also point particles, two-dimensional membranes, three-dimensional blobs, and other objects that are more difficult to picture and occupy even more dimensions, up to nine." (118) Most importantly, it is known that the constitution of the internal space determines both "the values of the physical constants, such as the charge of the electron, and the nature of the interactions between elementary particles. In other words, it determines the apparent laws of nature," that is to say, the laws we discover by empirical means. "But the more fundamental laws are those of M-theory." In fact: "The laws of M-theory therefore allow for *different universes* with different apparent laws, depending on how the internal space is curled. M-theory has solutions that allow for many different internal spaces, perhaps as many as 10500, which means it allows for 10500 different universes, each with its own laws."

This brings us to Chapter 6, entitled "Choosing Our Universe." It begins with an account of big bang theory, tracing the major steps of its development, from the early contributions of Einstein, Hubble and Friedmann, through its various stages up to "inflation" theory, which claims to reduce the origin of our universe to a "quantum event." A map of the sky (on page 138), based upon data collected over seven years and released in 2010—in which a myriad dots of various colors purport to represent temperature differences of less than a thousandth degree Centigrade some 13.7 billion years ago!—concludes the presentation. "So look carefully at the map of the microwave sky," Hawking observes. "It is the blueprint for all the structure in the

universe. We are the product of quantum fluctuations in the very early universe. If one were religious, one could say that God really does play dice.” (139) And now begins the most original part of Hawking’s theory.

“The usual assumption in cosmology is that the universe has a single definite history. One can use the laws of physics to calculate how this history develops in time. We call this the ‘bottom-up’ approach to cosmology.” Hawking disapproves of this approach on the grounds that it presupposes a unique starting point of cosmic evolution: “Instead, one should trace the histories from the top down, backward from the present time.” What Hawking objects to is the notion that the universe *has* “a unique observer-independent history.” He argues instead that it is *we* who determine or “choose” our history by the fact that we inhabit *this* universe. There *may be* other histories leading to universes other than ours; and in fact, M-theory tells us that this is indeed the case.

“An important implication of the top-down approach is that the apparent laws of nature depend on the history of the universe.” (140) Consider the dimension of the universe: why is space in our universe three-dimensional, when according to M-theory it could have up to ten dimensions? “The Feynman sum allows for all these [possibilities], for every possible history of the universe, but the observation that our universe has three large space dimensions selects out the subclass of histories that have the property that is being observed.” (141) Hawking makes it a point, moreover, to emphasize that this is not mere speculation, not indeed science fiction, as one might suppose, but physics of the most solid kind. In fact, “The theory we describe in this chapter is testable.” What Hawking has in mind, especially, is the magnitude and distribution of irregularities in the microwave background, which are among the features of our universe that have now come within range of observation, and have in fact “been found to agree exactly with the demands of inflation theory<sup>11</sup>.”(143) More precise measurements, however, “are needed to fully differentiate top-down theory from others, and to either support or refute it.” Be that as it may, Hawking leaves us with the belief that *our* universe stems from a “quantum event” which took place some 13.7 billion years ago.

This brings us to Chapter 7, “The Apparent Miracle,” which addresses the question why the universe proves to be habitable, to carry a “human-friendly design.” Traditionally, of course, mankind has believed that this “human-friendly design” derives from the fact that the world was created by a benevolent God; but Hawking takes issue with that belief. “The many improbable occurrences that conspired to enable our existence,” he tells us, “would indeed be puzzling if ours were the only solar system in the

universe.” (153) But given the fact that there are billions of stars in our universe, many of which have solar systems, the hypothesis of “design” begins to become questionable. “Obviously, when the beings on a planet that supports life examine the world around them, they are bound to find that their environment satisfies the conditions they require to exist.” And therein, precisely, lies the key to the apparent mystery: “It is possible to turn the last statement into a scientific principle: Our very existence imposes rules determining from where and at what time it is possible for us to observe the universe.”

What Hawking has enunciated at this point is the so-called anthropic principle, or “weak anthropic principle,” to be exact, concerning which much has been written in recent decades. He points out that the principle proves to be scientific in the sense that it leads to predictions which are testable, and in fact prove to be true; for example, it implies, as Robert Dicke was the first to show, that “the universe must be about 10 billion years old,” which agrees quite well with the more accurate 13.7 billion figure of big bang theory.

The mystery, however, has not yet been resolved; for it happens that our existence requires not only the right kind of sun and a man-friendly planetary system, but also, on a more fundamental level, the right physical laws and constants of nature, a fact which a mere “principle of selection” cannot seem to explain. It is one thing, obviously, to “select” a friendly planetary system, and quite another to select a value of the fine structure constant that allows organic chemistry to happen. Now, it is at this juncture, precisely, that Hawking brings something new to the table: the notion, namely, that ours is only one of some 10<sup>500</sup> universes, each with its own laws; for indeed, on this basis our existence serves to “select” the physical laws of nature just as it selects our position within the space-time of the universe in which we find ourselves. Thus, by way of M-theory, Hawking has apparently justified what had come to be known as the *strong* anthropic principle, which affirms that “the fact that we exist imposes constraints not just on our *environment* but on the possible *form and content of the laws of nature* themselves.” (155)

We need not follow Hawking as he relates “the tale of how the primordial universe of hydrogen, helium, and a bit of lithium evolved to a universe harbouring at least one world of intelligent life”: it is essentially the familiar account which begins with big bang astrophysics and culminates in the Darwinist scenario of evolution. What is presently of interest is that the laws and universal constants of nature need to be “fine-tuned” to permit the astrophysical and Darwinist phases of this process to take place. Consider,



for example, the fact that life on earth is carbon-based, and that the formation of a carbon nucleus results from the so-called triple alpha process, involving a three-particle collision, the likelihood of which would be vanishingly small unless the strong nuclear force were within 0.5 percent of its observed value, the electric force within 4 percent, and so forth. Or to give another example: the existence of life on a planet requires extreme stability of its orbit; however, "it is only in three dimensions that stable elliptical orbits are possible." (160) Here, then, is the reason, Hawking argues in effect, why in *our* universe, space has *three* dimensions, instead of five or nine.

The logic of Hawking's argument is crystal clear: once the single universe of bygone days has been replaced by a veritable "multiverse," the fine-tuning of natural laws and constants can be readily explained by the weak anthropic principle, which is to say that the "apparent miracle" has disappeared: "the multiverse concept can explain the fine-tuning of physical law without the need for a benevolent creator who made the universe for our benefit." (165)

Even this "debunking of the God-hypothesis," however, is not yet the last word: in the final chapter (entitled "The Grand Design") Hawking proposes to answer the "why? questions" posed at the start of the book: "*Why is there something rather than nothing? Why do we exist? Why this particular set of laws and not some other?*" (171) The substance of the chapter, to which we will confine our summary, is given in the concluding paragraphs; and as might be expected, the answer to the three "why? questions" derives from M-theory and the corresponding version of the anthropic principle. "Spontaneous creation [that is to say, creation conceived *a la* M-theory as a quantum event] is the reason there is something rather than nothing, why the universe exists, why we exist." (180) This is Hawking's answer to the first two questions; and his answer to the third is M-theoretic as well. It derives from the strong "multiverse" version of the anthropic principle, which explains why we encounter "*this particular set of laws and not some other.*" The answer to the ultimate questions may thus be supplied by the physics now in progress: "If the theory is confirmed by observation, it will be the successful conclusion of a search going back more than 3000 years. We will have found the grand design." (181)

## II

The first point to be made by way of response refers to the nature of science as distinguished from philosophy. "Philosophy is dead," Hawking asserts, and it is now science that carries "the torch of discovery in our quest for

knowledge.” (5) Yet granting that a good deal of what passes for philosophy these days may indeed be “dead,” the fact remains that science and philosophy as such are very different disciplines, to the point that neither can fill in for the other. There is in fact a complementarity, an opposition one can say, between philosophy, properly so called, and science when the latter is shorn of its mythology<sup>12</sup> and understood for what by right it is. To indicate, however summarily, the nature of this opposition, one needs to distinguish categorically between *thought* and *language* (a distinction, incidentally, which falls into the province of philosophy alone). Briefly stated, thought is an intentional act that seeks to apprehend an object by way of a concept, which may be defined in Scholastic terms as the *form* of the act. Language, on the other hand, is something subsidiary to thought: it is its vehicle, which serves to express and communicate thought. Now, it can be said that for philosophy, thought has primacy over language, whereas for science it is just the other way round. Let me explain. For the philosopher, the concept is ultimately no more than a means to a trans-conceptual end, which is finally the *unmediated knowledge of the object itself*; as the Chinese might put it, concepts serve the philosopher as “a finger pointing to the moon.” The scientist, on the other hand, has no interest in “the moon,” nor does he know that there is such an object. For him the concept plays a very different role; for what he seeks is not a transcendent object, but “phenomena” in the contemporary sense of that ancient term.<sup>13</sup> How these so-called phenomena, moreover, stand in relation to the transcendent object is a question which concerns the philosopher alone, inasmuch as the very idea of “object” in the philosophic sense is foreign to the scientist. So too the scientist’s *modus operandi* is opposed to the philosophic: instead of “opening” the concept in quest of a transcendent object, he “closes” it to consolidate his grip upon phenomena. And that is where *language* enters in a foundational capacity: as Jean Borella makes clear, the *epistemic closure* of the concept by which a science is defined is effected through a *criterion of scientificity* specified on the level of linguistic or formal expression.<sup>14</sup>

One sees, in light of this analysis, that Hawking is right when he speaks of reality as “model-dependent”: it is precisely the epistemic closure of the concept that makes it so. This model-dependence derives in fact from the very criterion of scientificity by which a science is defined. But what is right and proper for science is fallacy and illusion for philosophy, which by its very nature is in quest, not of a model-dependent, but of a *transcendent* reality. What the scientist fails to understand—unless he happens to be also a philosopher—is that a model-dependent reality is not absolutely real, which is to say that the phenomena at which he arrives by way of epistemic closure of the concept are *defined or conditioned by that very process of closure*. As I have shown elsewhere,<sup>15</sup> the history of physics, from its

Galilean beginnings right up to the latest "multiverse" theories, exhibits the various stages of this progressive closure, which manifests itself in a concomitant recession of the corresponding objects from actual human experience, culminating in the conception of entities pertaining to universes other than our own.

What concerns us at the moment, however, is not the truth or validity of these theories, but simply the aforesaid opposition between science and philosophy. The upshot of these summary considerations is simply this: *to suggest that science can, even in principle, replace philosophy "in our quest for knowledge" is to exhibit a fundamental lack of comprehension regarding the nature and scope of either discipline.*

My second point of contention pertains to an aspect of Hawking's model-dependent realism which proves to be untenable. It is to be noted, first of all, that in its recognition of "model-dependency" in regard to *cosmic* realities, the notion is reminiscent of a basic metaphysical principle: what in fact I have termed "anthropic realism."<sup>16</sup> The latter affirms that the cosmos exists, not in splendid isolation as a Kantian *Ding an sich*, but indeed "for us," that is to say, as an object of human intentionality. Man and cosmos, therefore, belong together: they form a complementarity. And this is essentially what "model-dependent realism" affirms as well: here too the human observer comes into play by virtue of the fact that it is he who forges the conceptions-the "models"-in terms of which reality is apprehended. Yet there is a difference between model-dependent and anthropic realism, which proves to be crucial: for whereas Hawking regards the human observer as a component or part of the universe,<sup>17</sup> anthropic realism insists that man, the authentic anthropos, transcends the cosmos, that he is literally *and necessarily* "not of this world." To be sure, his physical body does evidently pertain to the cosmos, the world in which we find ourselves; the point, however, is that man as such does not reduce to that physical body: *the observer or witness, in other words, proves to be transcendent.*

Now, it happens that even from a strictly scientific point of view, the reductionist conception of the observer turns out finally to be untenable. Take the case of visual perception: in keeping with prevailing opinion, Hawking assumes that vision reduces to brain function. We are told, for example, that the human brain "reads a two-dimensional array of data from the retina and creates from it the impression of a three-dimensional space." (47) This tenet, however, has been critically challenged by an empirical scientist, named James Gibson, on the basis of experimental findings gathered in what is perhaps to date the most exhaustive inquiry into the nature of visual perception. What Gibson's experiments have brought to

light is the decisive fact that perception is based, not upon a retinal image (as just about everyone had assumed), but on information given in the ambient optic array, which moreover specifies, among other things, the three-dimensional structure of the environment. It appears that our visual system is designed, not simply to receive a retinal image, but to sample that ambient optic array and extract from it what Gibson terms its *invariants*. It is these invariants that are actually perceived, which is to say that *the percept is not constructed, but objectively real*: it is not simply "inside the head," but outside, as mankind had in fact always assumed. This means that what is perceived is not a visual image, be it retinal, cortical or mental, and that the so-called third dimension, in particular, is in fact no different from the other two: it too need not be constructed-by way of a process no one has yet been able, even remotely, to conceive but is in fact directly perceived, as are all other invariants. <sup>18</sup>

Though widely discussed and never refuted, let me note parenthetically that Gibson's "ecological theory of visual perception" has gained no more than a partial following among cognitive scientists; and one might add, in light of considerations postponed till Part III, that acceptance of the Gibsonian paradigm by the scientific establishment at large is effectively ruled out on non-scientific grounds. What presently concerns us, however, is the fact that Gibson's empirical findings suffice to invalidate the reductionist conception of the human observer upon which Hawking's notion of model-dependent realism is based. Take, for instance, the claim that "one can perceive an object or a whole habitat at no fixed point of observation,"<sup>19</sup> or that events are not perceived at a moment in time: amazing as these contentions may seem, they are simply expressive of the fact that *neither the static environment nor motion are perceived piecemeal*, as they would have to be, if perception reduced to brain function. Whatever may transpire in the brain, it is necessary, in the final stage, to bring into unity what is spatially and temporally dispersed on the level of neural activity; and this implies that *the observer is not himself subject to spatio-temporal bounds*. It is this transcendence of the spatio-temporal "here" and "now" that enables him to perceive "an object or a whole habitat at no fixed point of observation" and detect movement, something which *cannot* be perceived "at an instant of time." To say, however, that the observer "transcends spatio-temporal bounds" is to declare that he is not a cosmic entity.

It happens, moreover, that substantially the same conclusion has been arrived at by way of a mathematical theorem, and curiously enough, by none other than Stephen Hawking's erstwhile mentor and collaborator, Roger Penrose. Following upon his astrophysical explorations culminating in the famous Hawking-Penrose "singularity theorem," the Oxford

mathematician shifted his focus from the cosmos at large to the human brain. Neurological research had by this time established that the brain does indeed resemble a man-made computer in many respects, and the search was on to discover how this computer "made of meat" does in fact accomplish the various prodigies of human intelligence. Fixing his attention upon the solution of *mathematical* problems, in particular, Penrose asked himself whether perhaps the mathematician can solve problems that *cannot in principle* be solved by a computer, which is to say, by so-called algorithmic means. Through an ingenious application of what is commonly termed Gödel's theorem, he was able to prove that this is indeed the case (and one might add that the formulation and proof of this mathematical fact is itself a "non-algorithmic" accomplishment). But let us note what this entails: *it proves that human intelligence does not reduce to brain function*. Hawking's reductionist premise has thus been disproved with complete mathematical rigor.<sup>20</sup>

This brings us to my third point of criticism, which pertains to Hawking's ontology: his reduction of all things—all "being"—to quantum particles. Not only, thus, does Hawking reduce the observer to the status of a cosmic entity, but he goes on to reduce cosmic entities as such to "particles" which cannot be *directly* observed, cannot be *seen*; and this means that not only the observer, but the directly observable as well is ultimately reduced to brain function. Besides the fact, however, that no one has so much as the foggiest idea how the firing of a million neurons can conceivably produce such a thing as a red apple, it happens that there are weighty *scientific* grounds that militate against this hypothesis: again, the findings of James Gibson are a case in point. Philosophically speaking, Hawking's ontology reduces fundamentally to the Cartesian, which survives to this day as the hidden metaphysical premise universally presupposed by the scientific establishment at large. What stands at issue is the postulate of "bifurcation," which affirms that reality divides into an "external" world, consisting of things that can be described without residue in mathematical terms, and an "internal" world, subsisting in what Descartes calls a *res cogitans* or "thinking entity" (which Hawking identifies with the living human brain). Let us understand it clearly: *this is the undeclared ontological assumption upon which the entire edifice of Hawking's world-view is based*.

It is to be noted that this Cartesian premise cannot be tested empirically, which is to say that it cannot in principle be affirmed on scientific grounds. How, then, do we know that it is true? One might recall that Descartes himself experienced great difficulty in convincing himself that his "external" world of *res extensae* which no human eye can ever behold—does in fact exist, and sought to justify his belief in such a world by means of a

philosophic argument which appeals, finally, to "the veracity of God": the very God who has since been dismissed by crypto-Cartesian scientists, from Laplace to Hawking, as an "unnecessary hypothesis." What primarily concerns us, however, is the fact that in the twentieth century-when, according to Hawking, philosophy was at the point of death!-"bifurcation" came under rigorous attack at the hands of outstanding philosophers, beginning with Edmund Husserl and Alfred Whitehead, whose inquiries have shown the Cartesian premise to be not only unfounded but indeed untenable. Whatever else one may say regarding twentieth-century philosophy, it did, most assuredly, break the long-standing strangle-hold of the bifurcationist ontology-but only, of course, for those willing and able to heed.

The question arises now whether physics has need of the Cartesian assumption: could its findings be interpreted equally well, perhaps, in terms of a realist ontology rich enough to include what Gibson refers to as the "environment": the perceptible universe, namely, which as he notes "is not the world of physics"? It turns out that such is indeed the case;<sup>21</sup> and let us note, without delay, what this implies: *if it be true that the discoveries of physics can be consistently interpreted on a non-bifurcationist basis, this alone implies that it is in principle impossible to base a bifurcationist world-view upon these discoveries*, as Hawking claims to do. In the final count, the matter is as simple as that.

But there is more: as I have likewise shown in *The Quantum Enigma*, not only can physics as such be interpreted perfectly well in non-bifurcationist terms, but in fact it can *only* be "well interpreted" on that basis: for it happens that the Cartesian postulate constitutes a source of confusion and ultimately of paradox. I am referring primarily to the so-called "measurement problem"-the fact, namely, that the act of measurement interrupts the Schrodinger trajectory by "collapsing the state vector"-a phenomenon that has mystified physicists since the advent of quantum theory. Not merely, then, was Feynman right in observing that "no one understands quantum theory," but it turns out that quantum physics *cannot* in fact be understood in bifurcationist terms.

I will not attempt to summarize the ontological interpretation of physics enunciated in *The Quantum Enigma*. Suffice it to note that it is based upon a categorical distinction between two kinds of cosmic entities: the things that are in principle perceptible (*corpo real* objects), and those that ultimately reduce to quantum particles (*physical* objects). And this means, of course, that a corporeal object does *not* reduce to a mere aggregate of quantum particles, as almost everyone nowadays believes. It is *more* than such an

aggregate, and that "more" derives from something called *substantial form*, to put it in Scholastic terms.<sup>22</sup> The resultant ontology—an ontology that includes both the "environment" and "the world of physics" – differs thus from the pre-scientific through the inclusion of an additional stratum which the empiriometric enterprise of the past centuries has brought to light (or "constructed," as some believe<sup>23</sup>): the *physical*, namely, as distinguished from the *corporeal*. The two strata, moreover, are intimately linked (failing which physics would be impossible), and it turns out, philosophically speaking, that *the physical stands to the corporeal as potency to act*. The physical proves thus to be a *sub-corporeal* domain,<sup>24</sup> which is to say that measurement entails an ontological transition: a passage from potency to act.

This constitutes the key recognition, I say, that opens the door to an *ontological* understanding of quantum theory. If physics as such is indeed "the science of measurement," as Lord Kelvin observed, it follows that the so-called "measurement problem," so far from constituting a merely technical conundrum, refers perforce to the central mystery of quantum physics, which derives from the fact that measurement takes us *out of* the physical domain (inasmuch as the act terminates necessarily in a perceptible state of a *corporeal* instrument, as given, for example, in the position of a pointer on a scale). What transpires in the act of mensuration cannot therefore be conceived as a *physical* process, which evidently explains why the measurement problem has proved recalcitrant to the physicist.<sup>25</sup>

Getting back to *The Grand Design*, I find it remarkable that an ontology incapable of comprehending the act by which physics as such is defined should have disqualified the wisdom of the ages!

Hawking's ontology is Cartesian; but one should add: not quite. Like Descartes, he would reduce the objective universe to *res extensa*—to quantum particles, in his case—which necessitates that all else, all that does not reduce to quantity or mathematical structure, be relegated to *res cogitans*, what Hawking terms the observer. But whereas Hawking follows Descartes in thus subjectivizing the percept, he forthwith takes a second step which the French savant was wise enough to avoid: having rid the objective universe of all that is *not* mathematical, he fills it again with a plethora of qualities by bringing the *res cogitans* back into the world of *res extensae*: "Both the observer and the observed," he tells us, "are part of a world that has objective existence." (43) Now, leaving aside the question whether this reduction of the *res cogitans* or observer to *res extensae* actually makes sense—whether it is in fact *thinkable*<sup>26</sup>—it happens that this step proves to be inadmissible even from a scientific point of view: this is in

fact precisely what our critique of "model-dependent realism" has brought to light. But if the observer proves to be transcendent-if he does *not* reduce to quantum particles-neither do such things as red apples. By the Cartesian postulate of bifurcation-i.e., the subjectivization of the percept-all such entities have been relegated to the *res cogitans*, from whence they cannot henceforth be retrieved: Hawking can't have it both ways! If, therefore, the *res cogitans* turns out to be transcendent, so does the perceived world in its entirety. And this means that the stipulated universe of quantum particles excludes perforce not only the observer, but ipso facto all that is directly observed. In the expressive words of Whitehead, one is left with two things: on one side a *conjecture*, on the other a *dream*. Never mind whether the conjecture be true or false: even if it be true-even if there *is* a quantum world-there must be, in addition, something else: there is also perforce "the dreamer and his dream." So much for Hawking's ontology.

We come now to my fourth major point: I contend that Hawking's theory hinges upon an inadequate conception of causality. To be sure, this is hardly surprising, given what we have said earlier in regard to the measurement problem. It is to be noted, moreover, that when it comes to the notion of causality, Hawking himself shows signs of vacillation. At one point, thus, we are told that Laplacian determinism-the principle that "Given the state of the universe at one time, a complete set of laws fully determines both the future and the past" (30) — constitutes "the basis of all modern science," whereas forty-two pages later Hawking tells us that "Given the state of a system at some time, the laws of nature determine the *probabilities* of various futures and pasts rather than determining the future and past with certainty" (72), which of course is not the same thing. My point is that Hawking is forced to hedge on this question: for as we have come to see, what finally stands at issue in the affirmed "collapse of a probability" is a passage from potency to act, something which *physical* causality cannot effect. What, then, should one say: is this "collapse" a matter simply of "chance"? Must we to suppose, in other words, that whatever has no *physical* cause, has no cause at all? I have gone to great lengths in *The Quantum Enigma* to show that such is by no means the case. The question proves of course to be incurably philosophic: *metaphysical*, to be precise. Briefly stated, it turns out that the spatio-temporal universe-replete with its corporeal *and* physical domains—does not in fact constitute a closed system, as scientists are wont to assume. One is forced, finally, to acknowledge not only the existence of a metacosm, but of a corresponding mode of causation, which does not take place "in time"—that is to say, by way of a temporal sequence—but acts "instantaneously." In keeping with a traditional symbolism, I refer to this mode of causality as "vertical," and to the natural modes as "horizontal." What, then, are instances of *vertical*



causation? In the realm of physics, as we have seen, they are precisely the acts of quantum-physical measurement. But there are other major realms of vertical causation, the prime example being human behavior of the kind normally associated with the idea of "free will."<sup>27</sup>

Consider the case of "art" in the broad sense of "human making": can the production of an artifact be ascribed to physical or "horizontal" causation alone? I maintain that it cannot. But how can one rule out the theoretical possibility that there may indeed exist a chain of natural causation, involving billions of neurons in the artisan's brain, which does account for the production of the artifact? It happens that one can, and one can do so, in fact, with the utmost rigor by way of a mathematical theorem: I am referring to the work of William Dembski<sup>28</sup> which underlies what has come to be known as intelligent design or ID theory. Everyone, to be sure, recognizes instances of "intelligent design": if we come upon an assembly of stones on a hillside which spells out some message, we understand full well that it was not a rockslide that put it there; or again, if we encounter a piece of paper with a sonnet typed thereon, we know that this was not produced by a monkey banging on the keys. This raises the question whether there may be a "signature," a criterion which can perhaps be expressed in mathematical terms, that permits us to infer "design." Now, it is in response to this question that Dembski was led to define what he terms "complex specified information" or CSI, and prove that *no natural process, be it deterministic, random or stochastic, can produce CSI*. In our terminology, this means that CSI is a signature of vertical causation. Let me emphasize, moreover, that this is not a conjecture, a mere assertion, but indeed a mathematical fact, a *theorem*. And what does it tell us? It implies, for example, that when an artisan produces an object which carries an original<sup>29</sup> design (an event which entails a net increase of CSI), this artifact was *not* produced by means of horizontal causality alone: somewhere along the line an act of vertical causation *must have* entered into the causal chain. No need to know the anatomy and physiology of the brain with its myriad neurons: so long as that brain functions by the laws of physics it *cannot* account for the production of an original artifact. But this not only negates Hawking's claim that "our behavior is determined by physical laws," but disproves it *with mathematical precision*.

It is to be noted that Dembski's theory deals not simply with "design," but indeed with "intelligent design": what does this mean? It appears that Roger Penrose, in his study of what computers or brains can and cannot do, has hit upon the answer when he concludes that "the very essence of consciousness" consists in an internal "seeing," an "ability to divine (or

intuit) truth from falsity (and beauty from ugliness!) in appropriate circumstances.”<sup>30</sup>

Whether it be a question of judgments that cannot be formed by algorithmic means or of acts productive of CSI, what counts is a certain “seeing,” an intellectual apprehension, be it of truth or of beauty (and if beauty be indeed “the splendor of truth” as Plato declares, the two are closely knit). It follows, now, that at the very core of a human being, intelligence or “intellect” comes into play: something which does not reduce to brain function and enables acts which physical causality cannot effect. But for Hawking there is only physical causality and its absence, called “chance,” which supposedly explains why a probability distribution collapses for no assignable reason at all. One sees now (here it is again, this word!) that if such were the case, one would have to conclude, among a host of other absurdities, that all non-algorithmic judgments—including those which underlie Hawking’s own doctrine are reached “by chance,” which would of course imply that they carry no weight at all. Generally speaking, the denial of vertical causality in the human domain entails the denial of intelligence, and constitutes therefore a *reductio ad absurdum* of the aforesaid denial itself. It is needless to say more.

This brings us finally to Hawking’s stand on “creation.” From the outset he attacks the notion of a Creator, and hardly misses an opportunity to deride the belief that a beneficent God “*created the heavens and the earth.*” He argues that such an hypothesis is both unnecessary and unreasonable, that in fact a virtually infinite number of universes emerge from a preceding vacuum through the operation of physical laws, which is to say that creation reduces ultimately to “a quantum event.”

To begin with, it behooves us to note that the idea of “creation” proves to be incurably *metaphysical*. We need to realize, in the first place, that the creative Act cannot be conceived in *temporal* terms: *creation* is not something that happens “in time.” As Meister Eckhart states with the utmost clarity: “God makes the world and all things in this present now,” that is to say, in the *nunc stans* or “now” which is *not* a moment in time. And what is it that “God makes”? We are told that it is “the world *and all things.*” Now, a great deal of confusion has ensued, even occasionally in theological discourse, because one tends to forget the second part of this assertion. There are those who think that whereas God brought the world into existence ages ago, it has been running on its own ever since; but this notion is doubly mistaken: first, because it places the creative Act in the past; and secondly, in that it reduces what God has made to a mere initial state. Admittedly, the idea that “God makes the world and all things in this

present now" is hard to comprehend, and in fact entails the difficult conception of an aevitemal metacosm or primary world; but this simply implies that whosoever wishes to challenge that immemorial doctrine must take care not to refute an *Ersatz*.

Yet this is precisely what Hawking's argument is designed to accomplish, whether he knows it or not. His strategy is to depict the Judeo-Christian doctrine as a kind of primitive science, a "model" designed to explain observable facts. It is actually all he *can* do; for so long as the doctrine is conceived on its own level-that is to say, in authentically metaphysical terms-it is *ipso facto* immune from attack on strictly physical grounds. Physics is not, after all, equipped to speak of metacosmic realities: from its own point of view, such notions are judged perforce to be meaningless. To make his case on *physical* grounds, Hawking requires a corresponding criterion by which the perennial doctrine is to be judged.

He broaches the subject of "creation" with a famous Augustinian dictum: "The world was made, not *in* time, but *with* time" (50), which he respects as legitimate in its own right. "This is one possible model," he tells us. Now, everything hinges upon that word, "model," which has obviously been chosen on account of its *scientific* connotations. By way of this inappropriate and misleading designation-this semantic trick!-Hawking depicts the metaphysical doctrine of "creation" as a kind of primitive physics, a rudimentary science which as such can be compared with *our* science. We are left with two competing "models": the Biblical and that of 21st century physics. His straw man thus emplaced, Hawking forthwith makes his point: "The second model," he informs us, "can explain the fossil and radioactive records and the fact that we receive light from galaxies millions of light-years from us..." all of which, needless to say, the first "model" can *not* do. But even if one grants that "radioactive records" and "galaxies millions of light years from us" are indeed factual, and can be explained by means of contemporary physics, this in itself would hardly disqualify the contention that "God created the *world*"-*unless*, of course, that tenet has first been reduced to the status of a "competing model." Such is the reductionist contention regarding the nature and function of creationist doctrine Hawking brings into play surreptitiously, and without a shred of evidence in support of that sweeping claim. We need not detain ourselves further with this baseless hypothesis; at least a few words should however be said concerning the "explanatory value" of the metaphysical doctrine Hawking wishes to disqualify. It is to be noted, first of all, that the creative Act is evidently "causal" in the extreme, inasmuch as it brings into existence "the world and all things." But that causality, if one may call it such, proves to be vertical in that it is evidently not mediated by a temporal sequence of

events. More to the point, it can be affirmed on metaphysical grounds that *the creative Act constitutes the prototype and principle of all vertical causation*, which may consequently be viewed as a secondary mode of creation, a kind mediated by created agents. What comes into play by virtue of this mediation is *the miracle of intelligence*, which is precisely what distinguishes vertical from horizontal causality. Certainly there are different modes of intelligent mediation, ranging from the angelic-which is not, after all, a figment of the primitive imagination I-to the human, and these give rise to corresponding modes of vertical causation.<sup>31</sup> But the question remains: can there be a *science* based upon vertical causality, even as there are sciences based upon physical causation? Now, it happens that there can, and that such sciences have in fact existed since ancient times: traditional or "sacred" sciences, one may call them; it is only that *our* sciences, geared as they are to *physical* causality, are categorically incapable of understanding a science based upon vertical causation. The traditional sciences, to be sure, have their own *modus operandi*, which needless to say, differs radically from the empiriometric. So too they have an "explanatory value" and usefulness of their own, which do not, to say the least, compare unfavourably with the benefits to be derived from the physical sciences of our day.<sup>32</sup>

Of course this is hardly the place to discourse in depth on the traditional sciences and their relation to the physical; I wish only to make one further point: namely, that these two *kinds* of science do not stand in conflict or contradiction, that it is not a question of "either or." As I have shown elsewhere,<sup>33</sup> horizontal and vertical modes of causality can and do coexist without interference, which is to say that each produces its own proper effect. Take a simple example: a marksman fires at a target. Now, from the standpoint of horizontal causality, the ensuing impact is explained in terms of a temporal sequence of events initiated by the pull of a trigger, whereas the same effect is equally the result of an intentional act: neither explanation disqualifies the other, and of course there can be no question as to which is "more true."

But Hawking evidently has no inkling that there *are* sciences other than the contemporary, let alone that the two kinds are not opposed but complementary: his inability to recognize the existence of vertical causation predisposes him to judge the worth of all doctrine in terms of its capacity to explain phenomena by way of the one and only causality he knows: the horizontal mode, as conceived by the physicist.

Getting back to Hawking's argument: It now appears that God-the Creator of "*the heavens and the earth*" - *has* indeed survived the attack: once the smoke has cleared, one sees that his straw man argument carries no weight

at all. *But that is only half of the story: for not only his argument against the doctrine of a divine Creator, but Hawking's own version of cosmogenesis—which is supposed to replace the Judeo-Christian teaching—is fatally flawed as well.* Consider the previously noted fact that the physical universe proves *not* to be a closed system after all, which is to say, once again, that vertical causation comes perforce into play. As we have pointed out under the rubric of “causality,” it comes into play in every quantum-physical measurement, as also in every act based upon human intelligence, beginning with the production of an artifact. But Hawking would have us believe that contemporary physics is able, in principle, not only to explain the functioning of the observable universe, inclusive of man, but to disclose in addition how that universe came to be. Now, this latter claim seems strange, given the fact that even after the universe is in place, entities emerge which *demonstrably* cannot be produced by way of physical causation. If physical causes prove to be incapable of producing even a water-pot from pre-existing clay, one wonders how these same causes could give rise to the universe at large! And in fact, they can not: for in asserting that the universe itself has been brought into existence by physical causes, Hawking affirms that what has thus been brought into existence is not simply an initial state, but includes perforce whatever exists or transpires in that universe. It follows that *a single demonstrable act of vertical causation suffices to disqualify Hawking's thesis.*

We need not belabour the point. As one should have surmised from the start, the claims Hawking puts forth on the subject of “creation” prove in the end to be unsubstantiated and untenable. Not only has contemporary physics *not* in truth disproved the authentic tenets of creationist doctrine, but it turns out that the defamed teaching is ultimately needed to understand physics itself: what it can and cannot do. In the final count, *bonafide* metaphysical conceptions do perforce enter the picture, whether the scientist likes it or not, for the simple reason that both the universe and the vertical causation operative therein derive from a transcendent reality concerning which physical science as such knows nothing at all.

### III

It behooves us, finally, to put Hawking's claims in perspective by taking a closer look at the contemporary scientific enterprise as such. We need to transcend what we have learned in schools and universities, not to speak of what is to be gleaned through the media, to discover “what we are never told”: only thus can we begin to perceive the full picture. To place *The Grand Design* within the context of the existing culture, it is above all imperative to get over the notion that science is simply a quest of truth: open, unbiased

and fair. We need to realize that the enterprise has an ideology, an agenda, an establishment, and vested interests to protect; as anyone past childhood should realize, "politics" does enter the picture.

In line with these general observations I would like to point out that Hawking overstates the *scientific* case in support of his claims by suppressing all contrary evidence. He does so most blatantly, to be sure, in his treatment of the Darwinist theory, which evidently constitutes a necessary component of his world-view: nowhere does he give even the slightest indication that fundamental difficulties remain to be resolved, let alone that adverse evidence of many kinds has been piling up for more than a century, to the point that not a few reputable scientists have braved the establishment by rejecting the transformist hypothesis.<sup>34</sup> Even the publication of William Dembski's theorem-which shows that evolution *a la* Darwin proves to be impossible on strictly mathematical grounds-seems to have had no effect on Hawking: he continues blithely to treat Darwinian evolution as a scientifically established fact. We need now to ask ourselves how the scientific case stands when it comes to *physical* theories such as Einsteinian relativity and big bang cosmology: have these perhaps been rigorously verified beyond reasonable doubt? Admittedly, this is a difficult and perforce technical question; yet I propose to shed light on the issue by showing that even here, in this rarefied technical domain, an element of *ideology* does of necessity come into play. It does so, moreover, not simply as a syndrome of beliefs and values which impel the scientist to pursue his inquiry, or define the direction of this quest, but indeed as a determinant of the resultant theory in its cosmological aspects. Simply put, I maintain that *the world-view at which science arrives by purportedly rigorous means proves finally to be reflective of the ideological assumptions that guided the enterprise from the start.*

Let me begin by recalling an event: When in 1965 Arno Penzias and Robert Wilson picked up signals from outer space said to derive from the microwave background, the *New York Times* announced the event with the headline: "SIGNALS IMPLY A BIG BANG UNIVERSE." By way of contrast, let me now recall what happened in 1887, when Albert Michelson and Edward Morley conducted their experiment designed to measure the velocity of the earth in its orbital motion around the sun. What they found, to the dismay of the scientific community, was that this velocity is not the expected 30 or so kilometers per second, but turns out to be precisely *zero!* And let us note that there was nothing uncertain or tenuous in this conclusion: based upon the laws of what is nowadays, in retrospect, termed "classical" physics, the fact that *the earth does not move* was strictly implied by the outcome of the experiment. But whereas this result sent shock waves through the upper strata of the scientific world, the public at large was told little. Most

assuredly, there was no banner headline proclaiming that "MEASUREMENTS IMPLY AN IMMOBILE EARTH," which unlike the 1965 caption, would not have been a mere journalistic exaggeration, but indeed a scientifically accurate statement.

What eventually happened, in response to the Michelson Morley finding, is the advent of a new physics, consisting of the special and general theories of relativity, which gets around this *ideologically* unwelcome result through the stipulation that the observed speed of light is the same in all so-called "inertial" frames of reference. And needless to say, this event did receive its full share of publicity: as everyone knows, Albert Einstein, almost overnight, became a scientific superstar, and his theory of relativity a scientific breakthrough of the first magnitude. But the question remains: *is it true?* Does Einsteinian physics actually and fully square with the observable facts (at least in situations where quantum effects may be neglected), as Hawking, and indeed the scientific establishment at large, aver? My point is that this question proves to be far more difficult than one is led to suppose: as in the case of Darwinism, the matter is by no means as clear-cut as Hawking would have us believe. Only one thing is certain: the choice lies between geocentrism and Einstein.<sup>35</sup>

Having identified "the constancy of the speed of light" as an ideologically motivated postulate (verified or not, as the case may be), I would like now to point out a second ideological premise which likewise proves essential to Hawking's world-view. What stands at issue, this time, are not the laws of physics, but the structure of the universe as conceived in astrophysical cosmology. This too, it turns out, hinges upon an ideological postulate; and strangely enough, it is Hawking himself who tells us so in an earlier treatise: "We are not able to make cosmological models," he writes, "without some admixture of ideology."<sup>36</sup> What he is referring to, in particular, is the assumption that stellar matter, when viewed on a sufficiently large scale, is uniformly distributed throughout space (much like the molecules in a gas, which appears to have a uniform mass distribution given by an average density). Now, this is an assumption, an *ideological postulate* no less, as Hawking informs us. But what is it that renders the premise "ideological"?<sup>35</sup> On this issue mention should be made of a remarkable 2-volume treatise by Robert A. Sungenis and Robert J. Bennett, entitled *Galileo Was Wrong* (the fifth edition of which was published in 2008), a work which constitutes presumably the most exhaustive study of this question to date. The book covers over eleven hundred folio pages and gives well over a thousand references, a good part of which derive from the scientific journal literature, in support of the contention that Einsteinian physics has been *de jure* disqualified. But whereas much of what the authors bring to light is indeed

cogent and does bear adversely upon the Einsteinian claims, the work as a whole is unfortunately marred by an excessive polemic which at times overshoots the mark.

This too Hawking explains: "We shall, following Bondi, call this assumption the *Copernican principle*," he goes on to say. Here we have it: what stands at issue, once again, is a repudiation of "geocentrism" in the wide sense of a cosmic architecture reflective of intelligence-of *intelligent design*, that is-and thus of an intelligent or "personal" Creator.

Think of it: here Hawking himself is telling us that this repudiation or denial of design on a cosmic scale is *not* in fact a scientific discovery-a reasoned conclusion based upon observable facts-but constitutes "an admixture of ideology"! Yet surprising as this admission may seem in light of what we have been taught to believe, it is easy enough to recognize that one cannot base a cosmology upon strictly scientific ground. I would note, first of all, that since one is unable, in the astrophysical domain, to act upon the source of the signals received by our measuring instruments, it is not possible to carry out the kind of "controlled experiments" upon which physics as such is based. Moreover, to limit the conceptual possibilities pertaining to the mathematical representation of the cosmos in its entirety-which in principle are infinite-one is forced to make assumptions which may as well be ideological, seeing that there are actually no *scientific* grounds upon which they could be made. Refer to it as "science" if you will, one sees in any case that astrophysical cosmology is by no means physics, properly so called. Hawking's "surprising claim" proves thus not to be surprising in the least: it merely informs us that, strictly speaking, big bang cosmology is not in fact physics by telling us what makes it so: "an admixture of ideology," namely, in the form of the Copernican principle. To put it plainly, we are told that *the denial of intelligent design on a cosmic scale constitutes the ideological assumption upon which big bang cosmology is based.*

This brings us to the question of evidential basis, of verification. It is to be noted, first of all, that in the absence of controlled experiment, verification in the full scientific sense is ruled out in advance: the best one can hope for is that signals from outer space, when interpreted according to terrestrial physics, do not conflict with the theory. It happens, however, that they do, which is to say that it has been necessary to introduce a number of ad hoc hypotheses: i.e., assumptions formulated specifically for the purpose of squaring the theory with conflicting observational findings.<sup>37</sup> What is more, the process of adding extra assumptions in response to adverse data appears to be ongoing; as Brent Tully (known for his discovery of supergalaxies) observed: "It's disturbing that there is a new theory every



time there is a new observation.” To which one might add that Tully has every right to be disturbed: for such a *modus operandi* in effect eliminates empirical verification as a criterion of truth. Under such auspices it becomes hard to say whether there exists so much as a shred of *real* evidence in support of the theory.

Yet in his latest book Hawking has not one word to tell us on that score: we are given to believe that big bang cosmology is simply physics, and as such has been rigorously substantiated, once and for all, on unimpeachable scientific grounds. The need for “an admixture of ideology,” in particular, is nowhere mentioned in *The Grand Design*: on the contrary, Hawking makes it a point to convey the impression that “M-theory” alone—the ultimate science!—guarantees everything he has to say.

A similarity between big bang cosmology and Darwinism has by now come into view, an analogy which it may be enlightening to reflect upon. No less than the astrophysical cosmology, Darwinist biology constitutes a reputedly scientific theory advanced on insufficient evidence, which is to say that both are in reality advanced on ideological grounds. It needs moreover to be recognized that the respective theories derive in fact from one and the same ideological postulate: whether it be a question of living species or of the universe at large, *evolution—the negation of intelligent design!*—proves to be the founding dogma of the one as of the other. In a word: *big bang cosmology is Darwinism on a cosmic scale*. And needless to say, this fact does prove to be enlightening, all the more since at present the biological Darwinism is understood far better than the astrophysical.<sup>38</sup> The salient point which emerges with special clarity in the biological domain is that Darwinism is never science; no matter what garb it dons, it remains in essence what it was from the start: *an ideology*. And this means that evidence loses its primacy: it is still desirable, still sought after, but ceases to be necessary, inasmuch as the theory stands ultimately on ideological ground. One is reminded of the Darwinist Ernest Mayr, who enunciated this principle with exceptional clarity when confronted by calculations demonstrating the staggering improbability of a certain Darwinian claim: “Somehow or other,” he replied, “by adjusting these figures, we will come out all right. We are comforted by the fact that evolution has occurred.”<sup>39</sup> Still more revelatory, the contemporary evolutionary biologist Richard Lewontin, speaking of science in general, has this to say: We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill some of its extravagant promises for health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment to materialism. It is not that the methods and institutions of science somehow compel us to accept a material

explanation of the phenomenal world, but, on the contrary, that we are forced by our *a priori* adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door.<sup>40</sup>

One more point needs to be made: the case of science *properly so called* is different. When it comes to *fundamental* physics, in particular-which is and can be none other than quantum theory what confronts us is indeed the authentic "*science of measurement*." Yes, ideology did no doubt motivate the founders-from Planck and Bohr to Heisenberg, Schrodinger and Feynman-and direct the focus of their quest towards the quantitative pole of cosmic manifestation;<sup>41</sup> yet it did not interfere with the legitimate *modus operandi* of a mathematical physics: it did not *force* the result. As a matter of fact, the very opposite is true: insofar as quantum mechanics contradicts the long-standing canon of Laplacian determinism, its discovery was profoundly distasteful to the physics community at large, as Hawking himself points out. It needs thus to be noted that quantum physics most certainly did *not* commend itself on ideological grounds, but imposed itself, rather, on the basis of irrefutable empirical evidence. For more than eight decades, moreover, it has continued to distinguish itself by the unprecedented scope and uncanny accuracy of its predictions: in countless experiments it has never yet proved wrong. No need, in this domain, for ad hoc hypotheses: the inner logic of the theory itself, interacting with experimental findings, drives the development. Leaving aside the penumbra of scientific notions which surround the discipline without corrupting it, quantum theory constitutes, quite evidently, the most brilliant and spectacularly successful achievement of physical science as such. What a pity that Hawking has spoiled *beautiful physics* with baseless and amateurish speculations of a pseudo-philosophic kind!

## Notes

1 (New York: Random House, 2010)

2 We do not wish to slight the second author by referring to Hawking alone; this needs to be understood.

3 This shall mean that the quotation occurs on page 5 of *The Grand Design*.

4 Whenever a quotation is not followed by its page number, the preceding page number is to be understood.

5 The first experiment of this kind was carried out in 1927 by two physicists at Bell Labs using electrons.

6 As Hawking relates, the largest particles used thus far (in an experiment conducted in Austria in 1999) are certain molecules, called "buckyballs," made up of 60 carbon atoms.

7 However, when it comes to the macroscopic processes to which classical physics applies, the resultant probability distribution for the outcome of a measurement is so sharply concentrated around its mean as to determine a unique value within the accuracy of measurement. In other words, quantum theory reduces in effect to classical physics in the macrocosmic domain.

8 My emphasis.

9 To speak of "phase" and "cancellation" is of course to speak in terms of a wave representation. We must recall that in quantum theory particles are also treated as waves.

10 Hawking stops short of pointing out what this means: it implies (on the basis of Newtonian physics) that  $v = 0$ , which is to say that, contrary to the Galilean tenet, the earth does *not* move. We will return to this point in Part III.

11 The term "inflation theory" refers here to a quantum-mechanical model said to describe the early universe some  $10^{-32}$  seconds after the initial singularity or "big bang."

12 It happens that science as such does not exist by itself, but is inevitably accompanied by a syndrome of scientific ideas, a kind of mythology of its own. On this subject I refer to my book, *Science and Myth* (San Rafael, CA: Sophia Perennis, 2010).

13 It is to be noted that this inherently Greek term has acquired virtually the opposite of its original and etymological sense as "that which shows itself *in itself*." It is thus indeed the philosopher, and *not* the contemporary scientist, who in truth has his eye upon the phenomenon! See *Science and Myth*, op. cit., chap. 7.

14 Jean Borella, *Histoire et thiorie du symbole* (L'Age d'Homme, 2004), chap. 4, art. I.

15 *Science and Myth*, op. cit., chap. 3.

16 See *Christian Gnosis* (Sophia Perennis, 2008), where I introduce the notion of anthropic realism (in Chapter 2), and show that it underlies the traditional cosmologies, from the Vedantic to that of Meister Eckhart. To be precise: anthropic realism proves to be *the only* realism tenable "in the face of gnosis."

17 "Both observer and observed," he tells us, "are part of a world that has an objective existence." (43)

18 For a summary and analysis of Gibson's findings I refer to Chapter 4 of *Science and Myth*, op. cit..

19 James Gibson, *The Ecological Theory of Visual Perception* (Hillsdale, NJ: Lawrence Erlbaum, 1986), p. 197. We need to bear in mind that Gibson arrived at the claims in question, not speculatively, but on the basis of empirical evidence which in fact rules out the reductionist hypothesis.

20 For an in-depth study of "neurons and mind," I refer to *Science and Myth*, op. cit., chap. 5. My object in that chapter is to show that the findings of neurophysiology, *shorn of the customary presuppositions*, can indeed be integrated into the traditional anthropologies, beginning with the Vedantic.

21 See *The Quantum Enigma* (Sophia Perennis, 2005), where this question has been dealt with in all necessary detail.

22 For an introductory treatment of this question I refer to *Science and Myth*, op. cit., pp. 31-44.

23 The view that the physical universe is in fact "constructed"-that "the mathematics is not there till we have put it there"-was first enunciated by Sir Arthur Eddington. Though never accepted by the scientific community at large, Eddington's claim has recently received strong support from the findings of Roy Frieden (see *Physics from Fisher Information*, Cambridge University Press, 1995). For an in-depth discussion of the "constructivist" view I refer to my monograph, *The Wisdom of Ancient Cosmology* (The Foundation for Traditional Studies, 2003), chap. 3.

24 Thomistically speaking, the physical domain constitutes a kind of *materia secunda* situated between prime matter and corporeal being. See *The Quantum Enigma*, op. cit., pp. 117-125.

25 No wonder too that the so-called quantum world appears strange to the point of paradox, seeing that *potentiae* as such do not add up to make a world. The quantum description, one now sees, leaves out an essential ingredient, *the essential ingredient in fact*, of corporeal being: what philosophy knows as "essence," namely. See *Science and Myth*, op. cit., chap. 2.

26 For my part, I maintain that it is *not* actually thinkable. Strictly speaking, Hawking's so-called ontology is neither science nor philosophy, but a misuse of language: a new brand of sophistry which seduces the credulous into believing the absurd.

27 *The Quantum Enigma*, op. cit., chap. 6. See also "Intelligent Design and Vertical Causation" in *The Wisdom of Ancient Cosmology*, op. cit..

28 *The Design Inference* (Cambridge University Press, 1998). On this subject I also refer to Chapter 10 in *The Wisdom of Ancient Cosmology*, op. cit..

29 The adjective is essential: Dembski's theorem asserts that the CSI of the object cannot be *produced* by natural causes. To invoke this result, it is therefore necessary to exclude the case where the CSI in question is supplied externally, as would be the case, for example, if the design were copied by the artisan from an external source. One sees, in particular, that

the theorem does not apply in the case of mechanized or artificial production.

30 *The Emperor's New Mind*, op. cit., p. 412.

31 *The Wisdom of Ancient Cosmology*, op. cit., pp. 194-198.

32 For a glimpse of what a traditional science can accomplish—the stupendous scope, accuracy, and explanatory value it can achieve—I refer to the chapter “Calera and Planet” in *Science and Myth*, op. cit..

33 *The Quantum Enigma*, op. cit., pp. 114-17.

34 The serious anti-Darwinist literature of our day, though largely ignored by the media, has witnessed a spectacular growth in recent decades. To mention at least a few representative titles: Michael J. Behe, *Darwin's Black Box: The Bio-Chemical Challenge to Evolution* (New York: Free Press, 1996); William A. Dembski, *The Design Revolution* (Downers Grove, Ill.: InterVarsity Press, 2004); Douglas Dewar, *The Transformist Illusion* (San Rafael, CA: Sophia Perennis, 2005); Phillip E. Johnson, *Darwin on Trial* (Downers Grove, Ill.: InterVarsity Press, 1993).

36 *The Large-Scale Structure of Space-time* (Cambridge University Press, 1973), p. 134.

37 I have touched upon these questions in *The Wisdom of Ancient Cosmology*, op. cit., chap 7.

38 Mention has already been made of the growing literature which has in effect “unmasked” the biological Darwinism. See fn. 34 for a few representative titles.

39 Quoted by Phillip Johnson in *Darwin on Trial*, op. cit., p. 38.

40 Quoted by Bruce L. Gordon in “Balloons on a String: A Critique of Multiverse Cosmology” (*The Nature of Nature*, B. L. Gordon and W. A. Dembski, eds., Intercollegiate Studies Institute, 2011 ), p. 584.

41 See, for instance, *Science and Myth*, op. cit., pp. 31-41.