BOOK REVIEWS

The Life of The Cosmos. LEE SMOLIN. New York: Oxford University Press, 1997. 358 p. Cloth $30.00.*

How many universes are there and are they actually living things? Do extremely improbable phenomena require explanation (and is this where God comes in)? Where do we come in? What about the universe? Why is it tuned to allow for our existence? Is that really improbable, or is it in fact typical? What then of life: typical or improbable, requiring explanation or not? Is Friedrich Nietzsche finally dead? What do Big Sur and Verona have that you will not find in your local shopping center? (Hint: think of Pablo Picasso or Martha Graham.) Is atomism finished and is relationism all-the-way-down a coherent alternative? Why do bright students hate physics? What do C. S. Peirce, G. W. Leibniz, Immanuel Kant, Ernst Mach, Albert Einstein, Niels Bohr, and Charles Darwin have in common? Why are contemporary philosophers so polite, anyway? Has science really shown that hidden valuables are nonlocal (if so, should Sigmund Freud not be on the list of notables)?

Clearly, the last is a typo ('hidden variables', of course; 334): the best slip, we think, of a rather large lot. We feature it to demonstrate that not all of us are that polite. It is not out of politeness that we recommend Lee Smolin's book, which treats all these questions (and even answers some); for it is brilliant and enchanting—and annoying. It is a book for Smolin's scientific colleagues as well as for the educated lay person. Most of all, it is a book for philosophers.

Smolin is an outstanding theoretical physicist, accomplished in both quantum theory and general relativity, and passionate about putting these together in a scientific cosmology that addresses fundamental questions about our universe as a whole and its inhabitants. Smolin does not think that fundamental physics, as usually conceived (the "atomism" above), can do the job. For the standard model of elementary particle interactions (and even its possible successor in superstring theory) contains too many unexplained parameters (in the case of the standard model, twenty or so, including coupling constants and the masses of the elementary particles). Instead, Smolin thinks that both quantum theory (nonlocality) and relativity (Mach's

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principle) point to the relationism of Leibniz, which tutors us to think of the universe as an interconnected whole that can be understood only from the inside. We need to give up the chimera of a God's-eye point of view, the Newtonian (and Einsteinian) ideal of a detached, outside observer. Smolin couples his relationism with a Peircean, evolutionary perspective on natural laws, a generalized Darwinism that Smolin calls *cosmological natural selection.*

Smolin is a many-universe theorist or many universer. He conjectures that a new universe is born whenever a star collapses to a black hole. (We can guess that in every galaxy of our universe alone, there may be 10^8 black holes). Adapting the physicist John Wheeler's suggestion that certain fundamental constants of nature might be reprocessed in gravitational collapse, Smolin proposes that the free parameters of the standard model vary in the offspring universe to which a black hole gives birth. His idea is that the form of the laws remains the same but that there are small changes to the parameters in the reprocessing, in a manner analogous to the small mutations of genetic material common in biological evolution. (Despite Smolin's professions of a thorough relationism, an insiders-only view, this many-universe picture is the view of no one in particular, that is, a God's-eye view.) The values of the parameters determine a universe's ability to form stars and black holes and hence progeny, so that, over time, a typical universe plucked from the hypercosmic grab bag will be optimally tuned for the production of stars and black holes. Since our own universe appears to be so-tuned, this has at least some chance of explaining why our universe is as it is. We appear to get some understanding of life thrown in for the bargain, since the same tuning of the parameters that optimizes star formation is, Smolin claims, also highly conducive to stable atoms, organic molecules, and the tendency toward local thermodynamic disequilibrium, conditions necessary for the emergence of life itself.

What is life? For Smolin, it is a self-organized, nonequilibrium system governed by a symbolic program (like the genetic code) which can reproduce both itself and its program (156). Nonequilibrium means that energy flows through the system. According to the ideas of "critical self-organized systems," this process rapidly and inevitably creates structures (self-organization) over various scales. Thus, Smolin conjectures that the structure and hierarchy we find in the universe is the result of criticality. In his boldest move, Smolin even suggests that our universe itself is alive, a living system that made itself and is constantly on the remake. In this picture, there is no "origin" of life, nor any need for an outside maker, since life has always

been. Nor, in Smolin's scenario, need we succumb to Nietzschean pessimism or nihilism, for perpetual life implies perpetual disequilibrium; so we are not doomed to a bleak, cold "heat death."

Smolin's story is not supposed to be just another origin myth (the earth carried on the back of a turtle, darkness on the face of the deep punctuated by the sudden creation of light and life). Although he emphasizes that his story is speculative, he regards it as speculative science because he regards it as an explanatory account that can generate falsifiable predictions (unlike the weak anthropic principle, which he criticizes for not being falsifiable). Cosmological natural selection not only explains the fine tuning of the twenty free parameters necessary in the "standard model" of particle physics, it also predicts that any changes (increases or decreases) in these parameters would decrease the rate at which black holes are produced. Several of these changes (for instance, changes in the masses of proton, neutron, electron, and neutrino, or in the strength of the electromagnetic field) lead to unstable nuclei and hence to a world without carbon and the carbon-based organic molecules that run the thermodynamic processes underwriting the production of black holes. In the text and an appendix, Smolin surveys eight changes in those parameters, the ones on which we can currently get a handle, and argues that each of these would lead to a decrease in black-hole production, in accordance with the theory. He also looks at modified versions of the framework adapted to superstring theory.

Both of the notions on which Smolin relies (explanation and falsifiability) are tricky and, moreover, it is by no means clear that they patrol any boundary between science and mythology (as we can see from recent, falsifiable upgrades to creationism). What, after all, does Smolin's selectionist argument explain? Suppose we make some assumptions about measures on parameter space (to define "small" changes) and also put in some appropriate initial conditions. The argument then shows that over sufficient time, in almost all the descendants of a randomly chosen universe, the parameters are nearly optimal for the production of black holes. Thus, if our universe is, in fact, almost optimal for black-hole production, then our universe is not so special after all (certainly less special than it appears to proponents of the anthropic principle). Of course, like any statistical estimate of the distribution of parameters in a population, the argument does not show why the parameters in any individual case take the precise values they do. As such, it fails Leibniz's test for explanatory power; it fails to give a sufficient reason why the universe is thus, and not otherwise. Instead, Smolin's selectionist argument

may challenge the need to apply Leibniz's principle here at all, that is, the need to require an explanation for the precise values of the parameters. In the light of Smolin's model, one might be no more inclined to demand an explanation for that than to demand an explanation for the exact configuration of the stars in the sky above. Perhaps.

What of falsifiability? Falsifiability of a hypothesis depends on holding fixed the auxiliary assumptions needed to produce the targeted conclusion (otherwise, we could deflect the arrow of falsification to one of these). In practice, one tries to show that the auxiliaries are themselves well confirmed or otherwise scientifically entrenched. In Smolin's case, the target on which falsifiability rests is the claim that our universe is nearly optimal for black-hole production. As we noted above, however, that claim is not actually a consequence of the theory (only that most universes are nearly optimal). To move from this statistical conclusion to the targeted conclusion about our universe, Smolin simply assumes that our universe is typical (94, 96, 101). That auxiliary assumption, however, is neither confirmed nor entrenched. Thus, if changes in the values of our parameters did not lead to a lower rate of black-hole production, we could always "save" Smolin's theory by supposing that our universe is not typical. So the falsifiability he claims for the theory depends critically on the auxiliary, on whether we are typical among the many universes. In this context, Pierre Duhem's argument applies and there is no way to falsify the specific assumptions of Smolin's model.

One cannot help but admire Smolin's vision and his considerable achievement in melding together beautifully several different scientific programs and applying ideas from different scientific domains. His work nicely illustrates the holism to which his relationism is committed. The preceding reservations respond to one of the less revolutionary features of his work. Whereas Smolin challenges much of the received scientific wisdom of our time, he is quite conventional in his acceptance of the received methodological wisdom one finds among scientists. He accepts a sharp demarcation of science and the criteria of explanatory power and testability which are conventionally said to bound it. By his own tenets, then, if (as we suggest) those criteria do not work well for him, shall we just put his effort out to pasture as myth or mere speculation? That would be crazy. It will be clear to every reader that Smolin is not merely speculating and that his arguments are grounded in science and subject to thoughtful scientific debate and constraint. Only an impoverished philosophy of science could direct a librarian to put Smolin in with Thomas Bull-

finch. It looks like Smolin needs to be liberated from the bad philosophy of science of scientists (polite indeed!) and to hang out with us philosophers a little bit more.

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