

Book Reviews

as in quantum physics, for the time being, we can be confident resting in what we know, even when there appear to be paradoxes or explanations that seem partial, tentative, and generative of new questions as well as answers.

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THE WORLD ACCORDING TO PHYSICS by Jim Al-Khalili. Princeton, NJ: Princeton University Press, 2020. 336 pages. Hardcover; \$16.95. ISBN: 9780691182308.

The World According to Physics is Jim Al-Khalili's "ode to physics" (p. vii). While Al-Khalili has been publishing popular science for over twenty years, this is his first attempt to provide the layperson a cohesive overview of physics as a whole, linking together relativity, quantum mechanics, and thermodynamics into one unified (or rather, not yet unified) picture of the cosmos. "Ode" is appropriate, for the author's unrelenting adoration of his subject is apparent throughout; this is a child's dream fulfilled, and in many ways is a broader summa of the world according to the mature Al-Khalili, bringing together not only physics, but also his views on truth, society, and our future.

Khalili opens with a discussion of how the human mind craves narrative. Yet science has displaced much of the old myths and religions:

Contrary to what some people might argue, the scientific method is not just another way of looking at the world, nor is it just another cultural ideology or belief system. It is the way we learn about nature through trial and error, through experimentation and observation, through being prepared to replace ideas that turn out to be wrong or incomplete with better ones, and through seeing patterns in nature and beauty in the mathematical equations that describe these patterns. All the while we deepen our understanding and get closer to that "truth" – the way the world really is. (p. 2)

While physics is not just another "story," it does have a cosmic scale that gives it a captivating wonder of its own, providing the basis for chapter 2 ("Scale"). Physics encompasses the infinitely small (e.g., subatomic particles) as well as the infinitely large (e.g., the expansion of spacetime at the farthest reaches of existence). Further, its scope is not merely all of space but all of time as well, getting within decimal points of the first instant after the big bang, while providing prophetic approximations of how the cosmos might end. While Al-Khalili does not play his cards this early, his later chapters (pp. 242-43 in particular) will reveal that this extensive scope establishes physics as the most fundamental discipline, the reigning queen of the sciences.

The deeper project begins in chapter 3 ("Space and Time"). Al-Khalili wishes to display the underlying skeleton that comprise the unification project of

physics, charting each merger until the final matchup is made (similar to a playoff line-up, where 16 teams soon become 8, then 4, then 2, then 1). Just as Newton wedded heaven and Earth through gravity, Einstein wedded space and time, explaining a diversity of phenomena with ever-simpler equations. While Al-Khalili's popular explanations of special and general relativity are merely adequate, his grasp of the broader narrative of unification in which these theories stand is incredibly useful, helping the layman see the trajectory of the book and physics as a whole, even when they cannot understand each individual step.

While chapter 3 unified space and time, chapter 4 ("Energy and Matter") unifies the energy and mass which warp said spacetime. Yet the unifications of relativity hit a snag when they come to "The Quantum World" (chapter 5) and to "Thermodynamics and the Arrow of Time" (chapter 6). While Einstein seems to rule over the kingdom of all things great, quantum mechanics rules over all things small, and no one has managed to negotiate a treaty just yet. Things do not work "down there" as they do "up here"; the laws of the macro are not the laws of the micro. Further, thermodynamics suggests that there is a directionality to time—for things move toward greater entropy—yet it is unclear how this can be made consistent with relativistic time or the conceptual reversibility of time in the quantum world.

Al-Khalili then moves in chapter 7 ("Unification") to possible reconciliations of these issues. He does an admirable job of explaining how the electromagnetic and weak nuclear forces were unified into the electroweak force, as well as explaining the ongoing attempt to unify the strong force with the electroweak force in a grand unified theory. This would leave only the holy grail: the attempt to unify gravity with the other three forces. String theory attempted such a unification by appealing to ten dimensions, yet by the 1990s there were five different string theories, which themselves needed to be unified, spawning M Theory (which required an additional eleventh dimension). An opposing contender soon arrived in loop quantum gravity. While string theory posits a quantum particle (the graviton) that exists within spacetime, loop quantum gravity inverts the order, making space more fundamental than a quantized particle within space, and so quantizing spacetime itself. These quanta of space are then "looped" together, determining the shape of spacetime.

Having unveiled the best approximations at a unified theory in physics today, Al-Khalili then ventures in chapter 8 to evaluate the subsequent state of the subject. He expresses frustration that no definitive proof has adjudicated between possible theories of everything, and that such unification seems further away now than it did thirty years ago. Even major discoveries, such as the Higgs boson, have mostly confirmed what we already suspected for decades, rather than

genuinely pushing the envelope. Yet while he has given plenty of reason to be sceptical, Al-Khalili then lists recent developments that show that plausible models of quantum gravity continue to come forward, for example, Witten's M-Theory or Maldacena's gauge/gravity duality. Further, physics continues to make substantial technological contributions to daily life. This leads naturally into chapter 9 ("The Usefulness of Physics"). Particular attention is paid to the future possibilities of quantum computing for physics, medicine, AI, and a whole host of other multi-disciplinary simulations and processes that quantum superpositions would allow (for superpositions enable a greater degree of complexity in contrast to binary).

Al-Khalili concludes with a final chapter ("Thinking like a Physicist") about how physics and the scientific method can and should help govern public discourse. In this chapter, the true aim of his project comes to light, suggesting he is not providing a picture of the world according to physics, but the world as it simply is:

One day we may find a new theory of quantum gravity, but it will never predict that my ball will take twice or half as long as Newton's equation of motion predicts. That is an absolute truth about the world. There is no philosophical argument, no amount of meditation, no spiritual awakening or religious experience, or gut instinct or political ideology that could ever have told me that a ball dropped from a height of five metres would take one second to hit the ground. But science can tell me. (p. 276)

While Al-Khalili claimed in the preface that he would try to avoid metaphysical questions (p. xiii), he inevitably (and at times, self-consciously) stumbles back upon them, making ontological claims about the world-in-itself. Indeed, even his quest for unification is arguably based on a philosophical presupposition that unity is more fundamental than diversity, a tradition which came to fruition in Neoplatonism and Christian monotheism. While Al-Khalili acknowledges the need for philosophy and science to communicate (p. xiv), in practice he seems to treat philosophy as a useful tool for science when it hits a roadblock (e.g., for unpacking the implications of quantum mechanics) rather than a discipline in its own right that has the ability to question the underlying epistemic and ontological assumptions of science itself. As such, while his manner is more open and humble than your average humanist/materialist (he was elected president of the British Humanist Association in 2012), his actual beliefs do not seem to have absorbed much at all of the philosophical or theological complexity required for the sorts of claims he is making:

The human condition is bountiful beyond measure. We have invented art and poetry and music; we have created religions and political systems; we have built societies, cultures, and empires so rich and complex that no mere mathematical formula could ever encapsulate them. But, if we want to know where we come from, where the atoms in our bodies were

formed—the "why" and "how" of the world and universe we inhabit—then physics is the path to a true understanding of reality. And with this understanding, we can shape our world and our destiny. (p. 281)

Ultimately, if one wants a helpful primer on physics, Al-Khalili provides a passionate and serviceable introduction. While his explanations of some topics were perhaps too much for newcomers, his weaving together of subjects often treated in isolation helps get things back on track, providing a grander narrative for lost readers to latch on to. Yet, if one is looking to see how this narrative fares as an all-encompassing account of the "why" and "how" of our world, then there are superior accounts available on the market. Indeed, thousands of years of writing and prayer have already sought out and encountered the One at the heart of creation.

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SCIENTIFIC VOCATION

THE PERFECT PREDATOR: A Scientist's Race to Save Her Husband from a Deadly Superbug by Steffanie Strathdee and Thomas Patterson. New York: Hachette Books, 2019. 311 pages, plus reference and index. Hardcover; \$29.00. ISBN: 9780316418089.

I have never been a fan of nonfiction, and although I love biology, I do not have much experience reading about it outside of textbooks. If you had asked me a few months ago, I would have said a book at the intersection of these genres sounded likely to be lethargically paced, overly detailed, and boring. However, Steffanie Strathdee and Tom Patterson's memoir/medical thriller *The Perfect Predator* changed my mind. The married coauthors share the story of the nine months when Patterson was near death from a formidable antibiotic-resistant bacterial infection. When his situation appeared hopeless, Strathdee enlisted a team of scientists to resurrect a treatment long forgotten by modern medicine: phage therapy. Christians will find much to admire in the selflessness and community displayed by the country-wide team that put together this novel treatment, and any reader will be inspired by the story of compassion and risk-taking to beat the odds. The story is both emotionally engaging and readable, despite all the science, and it draws much-needed attention to the antibiotic resistance crisis and the life-saving potential of phage therapy.

Strathdee, the primary narrator, sets our scene in Egypt, where the couple was on vacation in November of 2015. After a long day of sight-seeing, Patterson came down with what they assumed was a stomach bug. But by the time he had been taken to an Egyptian clinic, medevacked to Germany, and finally transferred back home to a US San Diego hospital, it turned out to be an infection with one of the most dangerous antibiotic-resistant bacteria in the world. Luckily for Patterson, though,