

## PHYSICS

## As Far As Her Eyes Can See

Michael Shermer

Lisa Randall has been justly appraised by *Time* magazine as one of the “100 most influential people in the world” for her work in theoretical particle physics. From her position at Harvard University, she often travels: to the European Laboratory for Particle Physics, CERN, in Switzerland, where her theories are being put to the test in the Large Hadron Collider (LHC); to speaking engagements with professional and public audiences about her work in particular and the awe and wonder of science in general; and to rock formations where her chalked fingers can find ways to defy gravity. On the side, she writes popular books, such as her acclaimed *Warped Passages* (1).

In *Knocking on Heaven's Door*, Randall picks up the story from where she left off when the LHC was years away from first collision, expanding her horizon from, as she poetically puts it, “what’s so small to you is so large to me” to “what’s so large to you is so small to me.” In other words, the book ranges from the smallest known particles to the entire bubble universe, from  $10^{-35}$  meters (the Planck length, where quantum gravity rules) to  $10^{27}$  meters (the entire visible universe, 100 billion light-years across, where dark matter and dark energy dominate), a stunning 62 orders of magnitude. (Randall correctly notes the age of the universe at 13.75 billion years, clarifying her apparently paradoxical figure of 100 billion light-years thusly: “The reason the universe as a whole is bigger than the distance a signal could have traveled given its age is that space itself has expanded.” She unpacks that sentence in the book.)

At the time of this writing, eBooks occupy about 20 percent of sales space; that is, one out of every five books sold has no cover or binding save the faux effects offered digitally by the various eBook readers. Of late, however, a tiny and growing sliver of the pie is being carved out by audio books (primarily through Audible.com and iTunes), most unabridged and read by professional actors and readers. These provide a welcome alternative to those of us yoked to our iPods and MP3 players inside cars and gyms or on bicycles and hik-

ing trails. Since fumbling around with cassette tapes and Sony Walkmans in the early 1980s, I have consumed on the order of 500-plus nonfiction audio books, so a measure of an author’s skill to communicate complex material clear enough to penetrate a multitasking cortex has become a mark of quality (or lack thereof). Many are called. Few are chosen. Randall’s explanatory prose places her among the elect. She is not alone, but she is rare among the many who have attempted the herculean task of explaining to us uninitiated the daunting science of theoretical particle physics. She devotes most of *Knocking on Heaven's Door* to covering this science, along the way offering fascinating accounts of how the LHC was built, how the experiments are run, and, most notably, the engineering prestidigitiation involved in teasing out nature’s secrets via energies never before witnessed on Earth.

**Knocking on Heaven's Door**

How Physics and Scientific Thinking Illuminate the Universe and the Modern World

by Lisa Randall

Ecco, New York, 2011. 464 pp.

\$29.99. ISBN 9780061723728.

Bodley Head, London. £20.

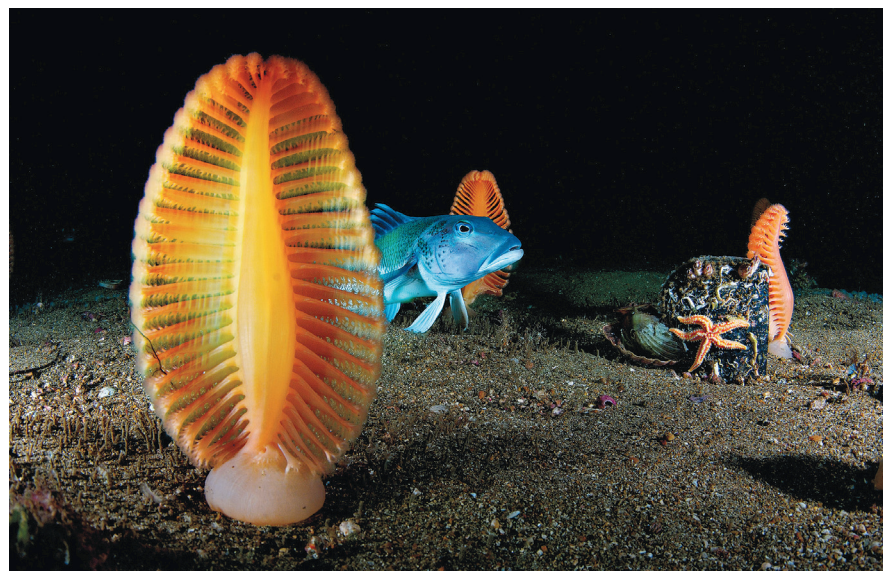
ISBN 9781847920690.

The book’s subtitle hints that it may be yet another long and tiresome treatise on science and religion, with either convoluted (and ultimately failed) attempts at conciliation or pugnacious left hooks and fast jabs at the faithful. Neither are Randall’s *modus operandi*. She states her case succinctly and moves on. Stephen Jay Gould’s “nonoverlapping magisteria,” for example, would work if only religions would stick to doing what they do best (providing aid and comfort to the poor and needy). However, conflicts arise the moment “religions attempt to address the external reality of the universe.” When they do, Randall notes, “[t]his leaves religious views open to falsification. When science encroaches on domains of knowledge that religion attempts to explain, disagreements are bound to arise.” As science expands its realm, the magisteria are becoming ever more overlapping. The deeper problem, however, is that if divine providence were on the offing, “it is inconceivable from a scientific perspective that God could continue to intervene without introducing some material trace of his actions.” In other words, if God did act in the world scientists would want to know

## BROWSINGS

**Ocean Soul.** Brian Skerry. National Geographic Society and Conservation International, Washington, DC, 2011. 264 pp. \$50, C\$55. ISBN 9781426208164.

Photojournalist Skerry presents some 150 images of marine animals and ecosystems along with stories of his encounters with them. He hopes his work will increase awareness of the threats facing the oceans and inspire actions to counter these. Below, sea pens (*Pteroeides bollonsi*) and blue cod (*Parapercis colias*) on the shallow seafloor in New Zealand’s Fiordland National Park.



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how he did it. “Did He apply a force or transfer energy?” Randall asks rhetorically. “Is God manipulating electrical processes in our brains? ... On a larger level, if God gives purpose to the universe, how does He apply His will?” Inquiring minds want to know. Religion has no answer. I know because I have asked many times.

Another myth Randall thankfully busts is the notion of truth and beauty in science. What can a “beautiful truth” in science possibly mean? Take a look at a page of equations and formulas from a recent theoretical physics paper. Mind-boggling to the untrained maybe, complicated and detailed undoubtedly, surprising or inspiring occasionally, but beautiful? “Beauty is often agreed on only a posteriori,” Randall explains, although she adds the proviso “even though aesthetic criteria for science might be poorly defined, they are nonetheless useful and omnipresent. They help guide our research, even if they provide no guarantee of success or truth.” Considering weak interactions, which violate parity symmetry, she remarks, “The breaking of such a fundamental symmetry as left-right equivalence seems innately disturbing and unattractive. Yet this very asymmetry is what is responsible for the range of masses we see in the world, which is in turn necessary for structure and life.”

*Knocking on Heaven's Door* came out before the faster-than-light neutrino experiment was announced (2) and paraded through the press as an ostensible refutation of Einstein, implying in some circles that science is nothing more than one failed theory after another. Why thence should we believe anything scientists say about evolution, global warming, or vaccines? Randall ends her book with a thoughtful discussion of how science really works to resolve anomalies unexplained by the prevailing paradigm. Einstein did not overturn Newton; he just expanded on the physical properties of the universe at high speed and large scale. If you want to get a spacecraft to the moon, Newton will take you there. As flawed as it sometimes can be, science is still the most reliable tool ever devised for understanding the world. Few have captured this essence better than Randall in *Knocking on Heaven's Door*.

#### References and Notes

1. L. Randall, *Warped Passages: Unraveling the Universe's Hidden Dimensions* (Allen Lane, London, 2005); reviewed in (3).
2. <http://arxiv.org/abs/1109.4897>.
3. J. D. Wells, *Science* **311**, 40 (2006).

10.1126/science.1214668

## FESTIVAL

# Two Worlds Entwined

Sara Reardon

How science historians must wish for a window into the past, revealing, for example, the Royal Society's three and a half centuries of activities so that they might weave those into a narrative. Many of the human quirks and foibles of the society's scientists, the culture that both inspired and was inspired by their work, and the motivations behind particularly odd or insightful experiments are lost or buried in time. Nonetheless, the members have left their careful, often beautiful, footprints in culture: Robert Hooke's famous flea drawing in *Micrographia*; Charles Darwin's philosophical ponderings aboard the *Beagle*; William and Caroline Herschel's telescope, whose heavenly visions helped inspire Handel's *Messiah*; and other mementoes that serve as substitutes for a time machine.

For all its accomplishments, science has not given us time travel. In a panel discussion (About Time) at the Royal Society's inaugural One Culture festival, novelist and memoirist Eva Hoffman remarked, “Time is the great given, the element we live in and cannot leap out of. Whatever its direction in the cosmos is, in our lives it moves most fatefully in one direction only.” Looking back to examine past cultures of science was one of the themes running through the festival in London the first weekend of October. A score of writers and scientists with a flair for the artistic spoke of their attempts to resurrect the story of science from the historical record and to understand how the “two cultures” of science and humanities, as physicist and novelist C. P. Snow named them, are inextricably linked.

The discussion among Hoffman, literary critic Gillian Beer, and cosmologist John Barrow highlighted the intertwining of science and culture in the evolving scientific explanations of time, an infinite source of literary inspiration. Barrow explained how, once Aristotle's immutable universe had been mooted, time became an element of interest to the scientific community. Like the mechanical universe of Newton's age, literature of that time moved predictably forward in flat, linear narratives. In the Victorian era, time became a constant, leaping up into the *y*-axis of thermo-

dynamic equations. Yet to the human psyche, Hoffman noted, time's rate of passage is far from constant, flying or dragging according to our mood—a paradox explored by writers such as James Joyce and Virginia Woolf. Einstein's universe of warped spacetime prompted not only equally warped stories of time travel and alternate universes but also a proliferation of nonlinear narratives.

The observation that science's progress influences the arts is hardly news. Instead, the One Culture festival focused on the ways in which the two need one another, thus breaking away from the often tired scheme of festivals that popularize science through art. Likely to become an annual event, this gathering was a mix of high-minded, yet accessible, talks and panel discussions, and even a couple of plays from the Take the Space Theatre Company about early Royal Society greats Robert Hooke (*Hanging Hooke*) and Samuel Pepys (*Sam and I*). Scientists and other academics made up a large chunk of the audience, but the handful of families seemed fully engaged, with children asking questions at a presentation on math in music and visual art and participating in a full day of kids' activities. Minus the plays and an about-to-conclude ongoing exhibition on art and crystals at the Royal Society's lovely Westminster headquarters, visual artists and musicians were conspicuously absent, although members of London's Rambert Dance Company presented a talk on their inspiration by science.

It's easy to see how science influences culture, but since scientists are only human, products of the society in which they live, the reverse must also be true. To argue for science's need of the creative sort of thinking, Royal Society president Paul Nurse, clad in a Darwin T-shirt, trotted out his personal collection of early editions of books by John Milton and Darwin. As Nurse reminded the audience, Darwin took *Paradise Lost* with him on the *Beagle* and pondered how Milton touched on new scientific understandings 200 years previously and the impact that his own nascent theory would have on future culture and philosophy.

Great leaps of insight such as Darwin's, Nurse commented, are probably very similar to the creative step seen in art, although the humanities encourage ambiguity whereas scientists often get locked into consensus. At its best, “science is both a product of common sense and ends up challenging common sense.” Segregating the two cultures, he concluded, leaves both science and society too far from the big picture and does neither any favors.

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