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With Strings Attached

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THE ELEGANT UNIVERSE

Superstrings, Hidden Dimensions,

And the Quest for the Ultimate Theory

By Brian Greene

Norton. 448 pp. $ 27.95

Reviewed by Marcia Bartusiak

For most of his professional career, Einstein was a failure. After fashioning his revolutionary theory of general relativity by the age of 36, he spent the remaining years of his life, four decades, in a useless search for a single theory that would unify all the universe's forces. "I have become a lonely old chap," the elder Einstein wrote to a friend, "mainly known because he doesn't wear socks and who is exhibited as a curiosity on special occasions."

Einstein simply tried to find a "theory of everything" too early, before all the particles and forces in nature, such as the weak and strong nuclear forces, were even known or fully understood. Better informed today, researchers are taking another crack at it, and Brian Greene, a Columbia University theoretical physicist in the thick of the endeavor, chronicles this heady task in fascinating and challenging detail. He has titled his book The Elegant Universe for good reason: In the same way that Einstein constructed general relativity, today's physicists are achieving their grand unification by discerning the beautiful mathematical symmetries hidden within the laws of physics. In the process, they may at last bridge the Grand Canyon of physics: the immense gap between quantum mechanics, the probabilistic rules that govern the behavior of atoms and nuclear particles, and gravity, the force that acts over the vast distances between the stars and galaxies.

With nary an equation in sight, Greene lays out the basics with playful narratives about relativistic carnival rides and quantum mechanical cocktail bars. All of this is in preparation for the curiouser and curiouser world to come, one that Alice might have found in Wonderland. In knitting the microcosm to the macrocosm, theoretical physicists are concluding that quarks, electrons and neutrinos may not be the ultimate bits of matter after all. Instead, the basic constituents may be tiny, one-dimensional strings, each infinitesimal loop a trillion trillion times smaller than an atom. "Differences between the particles arise because their respective strings undergo different resonant vibrational patterns," Greene gracefully explains. "What appear to be different elementary particles are actually different 'notes' on a fundamental string. The universe -- being composed of an enormous number of these vibrating strings -- is akin to a cosmic symphony." More than that, the forces we experience depend on the manner in which these superstrings -- named after the supersymmetries in physics from which they arise -- connect, split up, wiggle around, and rotate within a space-time composed of 10 (maybe 11) dimensions. We don't notice the added spatial dimensions because they are tightly curled up into a hyper-dimensional pretzel at each and every point within the larger space we live in.

Superstring theory did not arrive with a bang but in fits and starts. Inspired by earlier work, Michael Green and John Schwarz published the first landmark paper in 1984. The author, then starting his graduate studies at Oxford, remembers "an electrifying sense of being on the inside of a profound moment in the history of physics . . ." But interest waned when physicists found there were five possible string theories -- hardly encouragement that they were fashioning a unique solution. The field was re-energized in 1995, though, when Edward Witten, the head guru of superstring theory, discovered that all five theories were actually just separate pieces of a larger scheme, now dubbed the M-theory. The "M" stands for either mystery, the mother of all theories, or membrane, for, along with one-dimensional string, the revised theory allows for other objects -- membranes -- encompassing anywhere from two to nine dimensions. In keeping with particle physics's legacy of amusing monikers, theorists call them "p-branes" for short. Recently, there was great excitement among physicists when certain branes were shown to be related to black holes, a true link between the physics of the very small and very big. It gives them hope that they are on the right track.

Greene does an admirable job of translating a wholly mathematical endeavor into visual terms. Throughout his work, he writes with poetic eloquence and style. Yet his desire to reach the general reader may be overly ambitious. His discussions of gauge symmetries and Calabi-Yau geometries will be best appreciated by the science-minded who seek an insider's perspective on the cutting edge of physics. They will surely enjoy Greene's description of his own work: pinching, pulling, and tearing the hidden balls of curled-up space-time (on computer, that is) and seeing the consequences.

So far, superstring theory has provided some intriguing insights. For one, general relativity naturally falls out of it. But the theory can make no firm predictions or calculations as yet, such as the mass of the electron. At best, it is a hazy blueprint pointing the way to future work. "Like a child who receives his or her dream gift for Christmas but can't quite get it to work because a few pages of the instructions are missing," writes Greene, "today's physicists are in possession of what may well be the Holy Grail of modern science, but they can't unleash its full predictive power until they succeed in writing the full instruction manual." Indeed, physicists would need an accelerator the size of our galaxy to see a string directly. Critics wonder if string theorists are lured by the siren call of harmony and beauty over experimental verification. Greene is optimistic that as their mathematical tools improve they will be able to make predictions that are testable in our low-energy world.

Greene is a self-confessed cheerleader for superstring theory, which can leave the wrong impression that this is the only route to a theory of everything, or T.O.E. Other theoretical groups are exploring a few different avenues as well. I suspect all of these approaches will eventually converge to form an even grander framework. Would their success then be the end of science? Hardly, answers Greene: "Finding the T.O.E. would in no way mean that psychology, biology, geology, chemistry, or even physics had been solved . . . The discovery of the T.O.E. -- the ultimate explanation of the universe at its most microscopic level, a theory that does not rely on any deeper explanation -- would provide the firmest foundation on which to build our understanding of the world. Its discovery would mark a beginning, not an end."

Marcia Bartusiak is a contributing editor of Discover magazine and the author of "Thursday's Universe" and "Through a Universe Darkly."

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