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M is for messy

by Martin Gardner

On Lee Smolin's *The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next* and Peter Woit's *Not Even Wrong: The Failure of String Theory and the Search for Unity in Physical Law*.

Lee Smolin
The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next.
Houghton Mifflin, 392 pages, $26

Peter Woit
Not Even Wrong: The Failure of String Theory and the Search for Unity in Physical Law.
Basic Books, 291 pages, $26.95

For more than thirty years, string theory has been what Murray Gell-Mann called "the only game in town." By this he meant that it was the only good candidate for a TOE, or Theory of Everything. Not only does it claim to unify relativity and quantum mechanics, it also explains the existence of all fundamental particles. Instead of being "pointlike," they are modeled by filaments of energy so tiny that there is no known way to observe them or even to prove they are real.

A string can have two ends or be closed like a rubber band. Of great tensile strength, strings vibrate at different frequencies. They live in a space of ten or eleven dimensions, of which six or seven are "compacted" into inconceivably minute structures attached to every point in our four-dimensional spacetime. The simplest vibration of a closed string produces a graviton, the quantized particle of gravity. One of string theory's earliest triumphs was forcing the reality of gravitons.

After an obscure, bumbling start, string theory slowly began to gain momentum until it became the hottest topic in physics. Thousands of papers were published and thick textbooks written. The fastest way to advance in departments of great universities was to work on strings. Richard Feynman and Sheldon Glashow were almost alone among famous physicists who were skeptical of the trend. Not until a few years ago did skepticism begin to surge. Simmering doubts reached a boiling point last September when two eminent physicists published slashing attacks on string theory. Their books may mark a dramatic turning point in the history of modern physics.

For years, Lee Smolin rode the string bandwagon. After teaching at Yale and Penn State, he became a researcher at the Institute for Theoretical Physics in Waterloo, Canada, a think tank he helped found. *The Trouble with Physics*, his third book, is a powerful indictment. He sees string theory as not a theory—only a set of curious conjectures in search of a theory. True, it has great explanatory power, but a viable theory must have more than that. It must make predictions which can be falsified or confirmed.

In addition to this whopping lack of evidence, string theory has suffered other setbacks. It has been absorbed into a richer set of conjectures called M-theory. The M stands mainly for membranes (branes for short), or for Magic, Mystery, Mother of all theories, or any other term you like that begins with M. In M-theory, strings are one-dimensional branes that can roam free or be attached to two-dimensional branes. Branes may be of any dimension from 1 through 9. One wild speculation is that our 3-brane universe floats within a monstrous higher-dimension brane. To a mere science journalist like myself, the great mathematical beauty of early string theory has degenerated into M for Messy. Its membranes, in Smolin's opinion, are as ugly as the epicycles Ptolemy fabricated to describe the curious paths of planets as they seem to circle Earth.

The most troubling aspect of string/M-theory is that the compacted dimensions, known as Calabi-Yau manifolds, can take at least a hundred thousand different shapes. This has led to the mind-boggling concept of a vast "landscape" consisting of a multiverse containing a hundred thousand, perhaps an infinity, of universes, each with its own Calabi-Yau space! Every universe would have a random selection of physical constants, such as the velocity of light. By anthropic reasoning, we of course live in a universe with just the right set of constants that make possible galaxies, stars, planets, and, on one small planet, such improbable creatures as you and me.

Other string/M-theory embarrassments are carefully detailed by Smolin. Cosmologists have discovered that most of our universe consists of "dark matter," so called because it is totally invisible. String theorists failed to predict it and have nothing useful to say about it. A more recent discovery is that the universe is expanding at a slightly increasing rate. Such acceleration can only be caused by the pressure of a mysterious "dark force." Again, writes Smolin, dark force was not predicted by string theory, and the theory has no good explanation for it.

A chapter in Smolin's persuasive book divides physicists into two classes: craftsmen who test theories; and seers, like Newton and Einstein, who create theories. What physics now desperately needs, Smolin is convinced, is a new Einstein who can replace M-theory with a TOE that can be confirmed by a workable experiment.

Another chapter is devoted to lonely seers, working patiently outside the establishment on conjectures as revolutionary as string theory. Roger Penrose, Oxford's famous mathematical physicist, is the best known seer. His twistor theory, alas also untestable, is M-theory's chief rival. Like many other seers, Penrose thinks Einstein was right to regard quantum mechanics as "incomplete." Other intrepid seers are starting to question even special relativity. Because both relativity and quantum mechanics are essential to M-theory, finding either theory in need of revision would be, Smolin writes, another severe blow to string/M-theory.

In a chapter on sociology, Smolin introduces the concept of "groupthink"—the tendency of groups to share an ideology. This creates a cultlike atmosphere in which those who disagree with the ideology are considered ignoramuses or fools. Most physicists tied up in the string mania, Smolin believes, have become groupthinkers, blind to the possibility that they have squandered time and energy on bizarre speculations that are leading nowhere.

In spite of such criticisms Smolin, like Edward Witten, by far the most energetic and creative of the stringers, believes that even if string/M-theory is finally abandoned, portions of it will remain fruitful. Peter Woit, a mathematical physicist at Columbia University, is less optimistic. He sees little hope that any aspect of M-theory will survive. The harshness of his rhetoric is signaled by his book's arresting title, *Not Even Wrong*. It's a famous quote from the great Austrian physicist Wolfgang Pauli. A certain theory was so bad, he said, that "it was not even wrong." By this he meant it was so flimsy it couldn't be confirmed or falsified.

Most of Woit's book is a moderately technical, equation-free survey of quantum mechanics, the standard model of particle theory, and the history of superstrings. The prefix "super" indicates the linkage of strings to an earlier theory called supersymmetry. Not until the last third of his book does Woit take up reasons for regarding string theory a failure, destined to give way to a testable TOE.

Although Woit sees Edward Witten as the guru of what resembles a religious cult, he has only the highest respect for Witten's genius. Amazingly, Witten's early training was in economics. He soon shifted to mathematics and physics at Princeton University. There, he obtained his doctorate and became a professor for several years before moving to New Jersey's Institute for Advanced Study where he has remained ever since. He has been given a MacArthur award and a Fields medal, the mathematical equivalent of a Nobel prize.

When Woit was a graduate student at Princeton, he once followed Witten up a stairway from a library to a plaza. When he reached the plaza, Witten had mysteriously vanished. "It crossed my mind," Woit writes, "that a consistent explanation … was that Witten was an extraterrestrial being from a superior race who, when he thought no one was looking, had teleported back to his office."

Woit's main objection to string theory, of course, is that it has not, in Glashow's words, "made even one teeny-tiny experimental prediction." Woit quotes Feynman: "String theorists do not make predictions, they make excuses."

In his book *Interactions*, Glashow writes:

> Until string people can interpret perceived properties of the real world they simply are not doing physics. Should they be paid by universities and be permitted to pervert impressionable students? Will young Ph.D's, whose expertise is limited to superstring theory, be employable if, and when, the string snaps? Are string thoughts more appropriate to departments of mathematics, or even to schools of divinity, than to physics departments? How many angels can dance on the head of a pin? How many dimensions are there in a compacted manifold, 30 powers of ten smaller than a pinhead?

Woit quotes from another Nobel Prize winner, the Dutch physicist Gerard 't Hooft:

> Actually, I would not even be prepared to call string theory a "theory" rather a "model" or not even that: just a hunch. After all, a theory should come together with instructions on how to deal with it to identify the things one wishes to describe, in our case the elementary particles, and one should, at least in principle, be able to formulate the rules for calculating the properties of these particles, and how to make new predictions for them. Imagine that I give you a chair, while explaining that the legs are still missing, and that the seat, back and armrest will perhaps be delivered soon; whatever I did give you, can I still call it a chair?

Woit has only harsh things to say about the recent acceptance of an anthropic principle by several leading string theorists, notably Weinberg and David Susskind. Susskind has even written a popular book about it—*The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*. The notion that there could be millions of other universes, each with its own Calabi-Yau structure—or what amount to the same thing, with its own basic state of what physicists like to call the "vacuum"—is not one that appeals to Witten. "I'd be happy if it is not right," Woit quotes from a 2004 lecture, "but there are serious arguments for it, and I don't have any serious argument against it."

In the nineteenth century, a conjecture called the vortex theory of the atom became extremely popular in England and America. Proposed by the famous British physicist Lord Kelvin, it had an uncanny resemblance to string theory. It was widely believed at the time that space was permeated by an incompressible frictionless fluid called the ether. Atoms, Kelvin suggested, are super-small whirlpools of ether, vaguely similar to smoke rings. They take the form of knots and links. Point particles can't vibrate. Ether rings can. Their shapes and frequencies determine all the properties of the elements. Vortex theory isn't mentioned by Woit, although Smolin considers it briefly.

Kelvin published two books defending his conjecture. It was strongly championed in England by J. J. Thomson in his 1907 book *The Corpuscular Theory of Matter*. Another booster of the theory was Peter Tait, an Irish mathematician. His work, like Witten's, led to significant advances in knot theory. In the United States, Albert Michelson considered vortex theory so "grand" that "it ought to be true even if it is not." Hundreds of papers elaborated the theory. Tait predicted it would take generations to develop its elegant mathematics. Alas, beautiful though vortex theory was, it proved to be a glorious road that led nowhere.

Will string theory soon meet a similar fate? Glashow wrote a clever poem that he recited at a Grand Unification Workshop in Japan. It ends with the following lines:

> Please heed our advice that you too are not smitten—
> The book is not finished, the last word is not Witten.

Martin Gardner (1914-2010) passed away in May 2010. His latest book is *When You Were a Tadpole and I Was a Fish* (Hill & Wang).

more from this author

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